Cloud Computing

- Introduction to Cloud Computing
- Virtualization
- Understanding Hypervisors

What is Cloud Computing?

- **Cloud Computing** is a general term used to describe a new class of network based computing that takes place over the Internet,

  - basically a step on from Utility Computing
  - a collection/group of integrated and networked hardware, software and Internet infrastructure (called a platform).
  - Using the Internet for communication and transport provides hardware, software and networking services to clients

- These platforms hide the complexity and details of the underlying infrastructure from users and applications by providing very simple graphical interface or API (Applications Programming Interface).

What is Cloud Computing?

- In addition, the platform provides on demand services, that are always on, anywhere, anytime and any place.

- Pay for use and as needed, elastic
  - scale up and down in capacity and functionalities

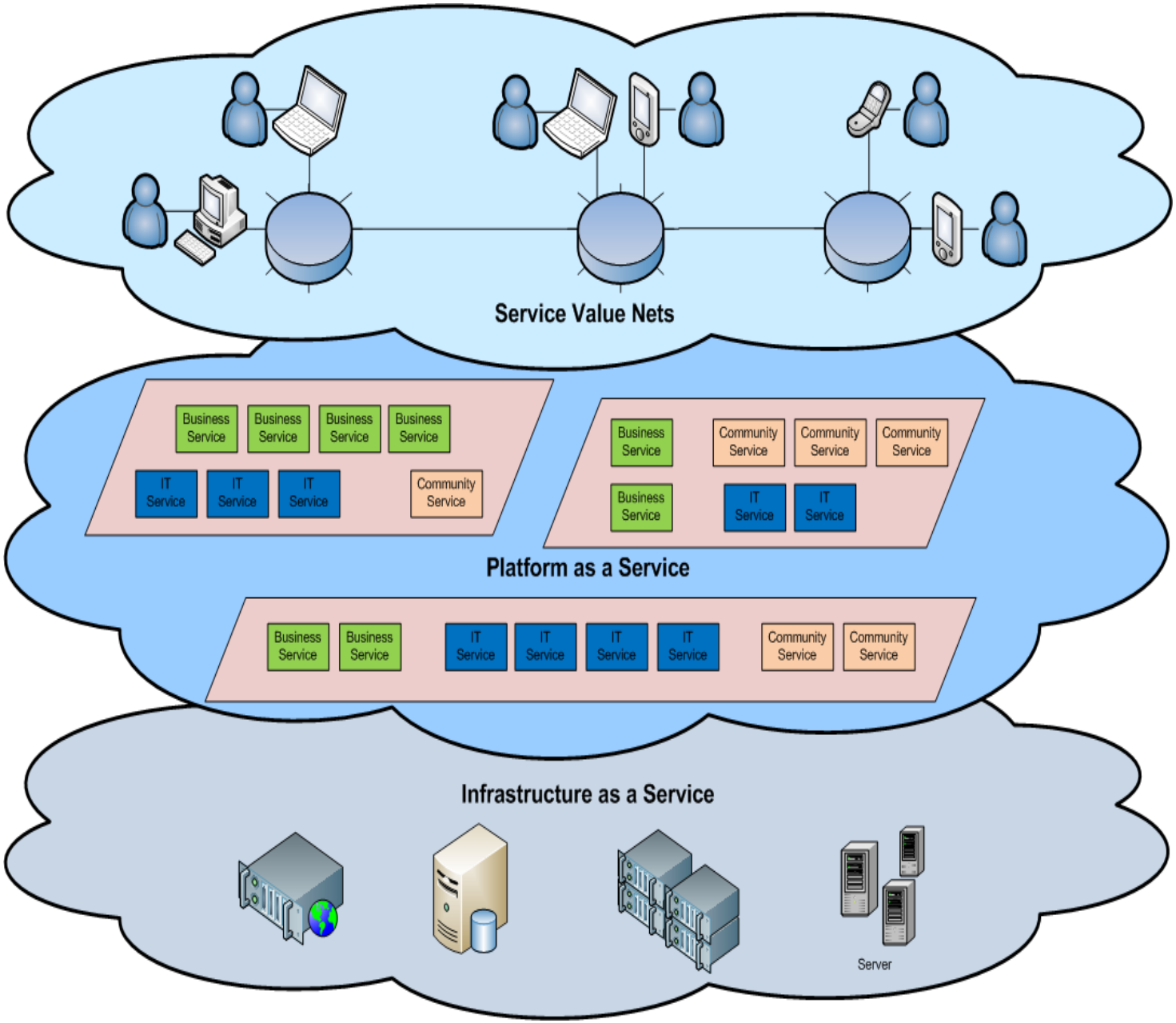
- The hardware and software services are available to
  - general public, enterprises, corporations and businesses markets

What is Cloud Computing?

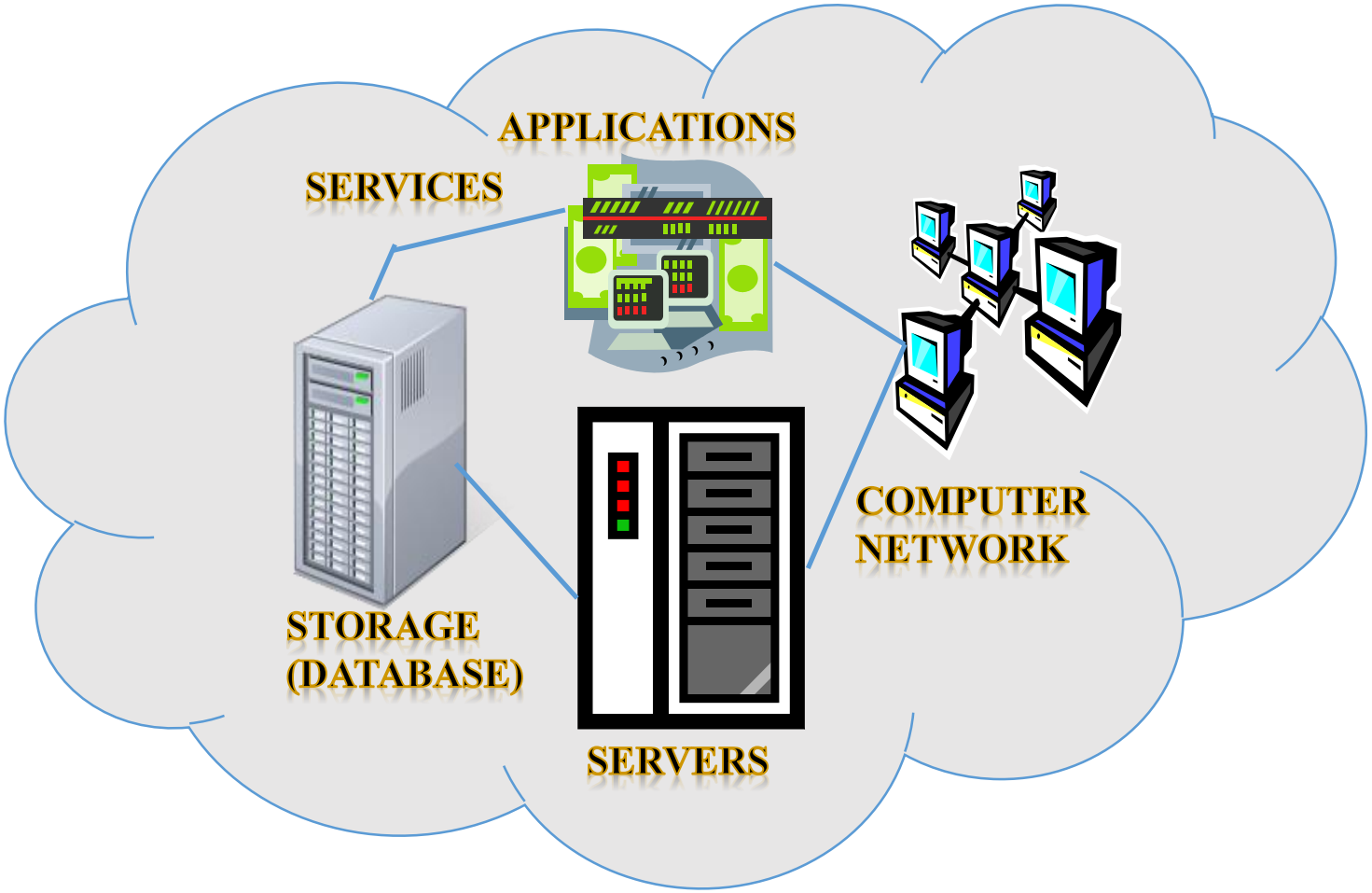
- Cloud computing is an umbrella term used to refer to Internet based development and services

- A number of characteristics define cloud data, applications services and infrastructure:
  - **Remotely hosted**: Services or data are hosted on remote infrastructure.
  - **Ubiquitous**: Services or data are available from anywhere.
  - **Commodified**: The result is a utility computing model similar to traditional that of traditional utilities, like gas and electricity - you pay for what you would want!

Cloud Computing Architecture



What is Cloud Computing?



- Shared pool of configurable computing resources
- On-demand network access
- Provisioned by the Service Provider

Basic Concepts

- There are certain services and models working behind the scene making the cloud computing feasible and accessible to end users.

- Following are the working models for cloud computing:
  - Deployment Models
  - Service Models

- Deployment Models: Define the type of access to the cloud, i.e., how the cloud is located?

- Cloud can have any of the four types of access: Public, Private, Hybrid, and Community.

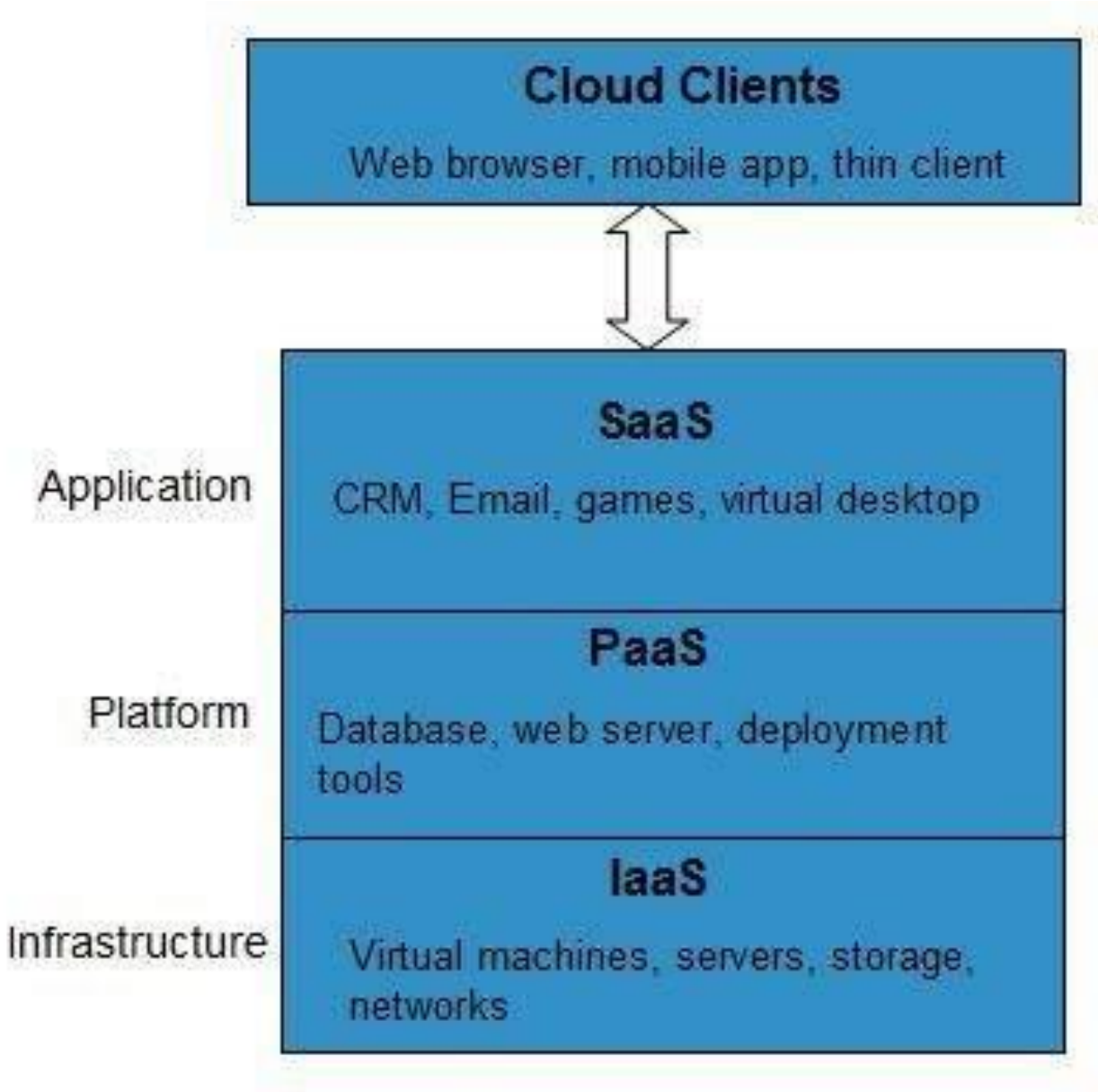
Service Models

- Cloud computing is based on service models.
- These are categorized into three basic service models which are –
    - Infrastructure-as–a-Service (IaaS)
    - Platform-as-a-Service (PaaS)
    - Software-as-a-Service (SaaS)

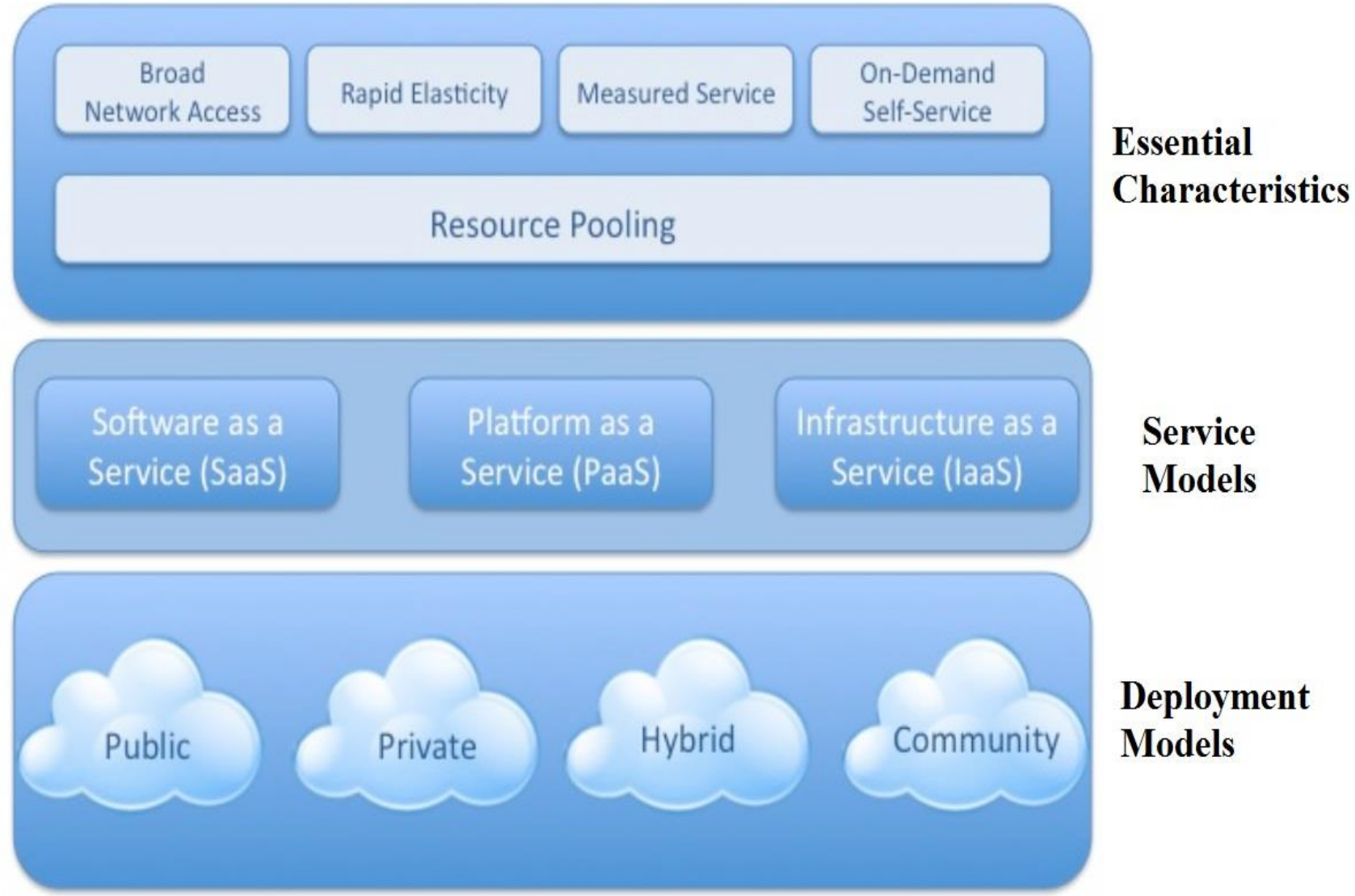
- Anything-as-a-Service (XaaS) is yet another service model, which includes Network-as-a-Service, Business-as-a-Service, Identity-as-a-Service, Database-as-a-Service or Strategy-as-a-Service.

- Each of the service models inherit the security and management mechanism from the underlying model, as shown in the following diagram:

Service Models



Cloud Computing Architecture



Visual Model of Cloud Computing Definition

Cloud Computing Characteristics

Common Characteristics:

- Massive Scale
- Resilient Computing
- Homogeneity
- Geographic Distribution
- Virtualization
- Service Orientation
- Low Cost Software
- Advanced Security

Essential Characteristics:

- On Demand Self-Service
- Broad Network Access
- Rapid Elasticity
- Resource Pooling
- Measured Service

Essential Characteristics

1. **On-demand self-service**

- Offers client the ability to provision computing capabilities such as cloud servers, dedicated servers, cloud storage, hardware load balancers and network storage on demand.

- Automatically scale and build their cloud computing infrastructure without requiring human interaction with each provider of service.

2. **Ubiquitous network access**

- It means the cloud providers resources are available over the network and can be accessed through standard mechanisms by both thick and thin clients.

- Example of computing resources may include storage processing, memory, network bandwidth and virtual machines.

Essential Characteristics

3. **Location independent resource pooling**

   - Location independent computing resources are pooled or shared and can be dynamically assigned to clients.

   - i.e. providers computing resources are pooled and effectively shared between several clients known as multi-latency

4. **Rapid elasticity and provisioning**

   - It signifies the ability to scale resources both up and down, as needed by client application.

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

Essential Characteristics

5. Pay-per-use measured service

- Client consume resources and pay only for resources that they use.

- Cloud computing platform employ consumption based billing mechanism to charge for cloud service use.

- It employs a metered, fee-for-service, or advertising based billing model.

Cloud Services delivery Models

Software as a Service (SaaS)

Platform as a Service (PaaS)

Infrastructure as a Service (IaaS)

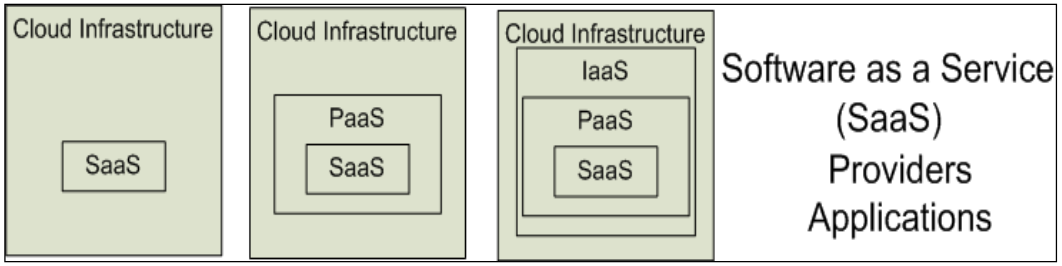
SalesForce
CRM
LotusLive

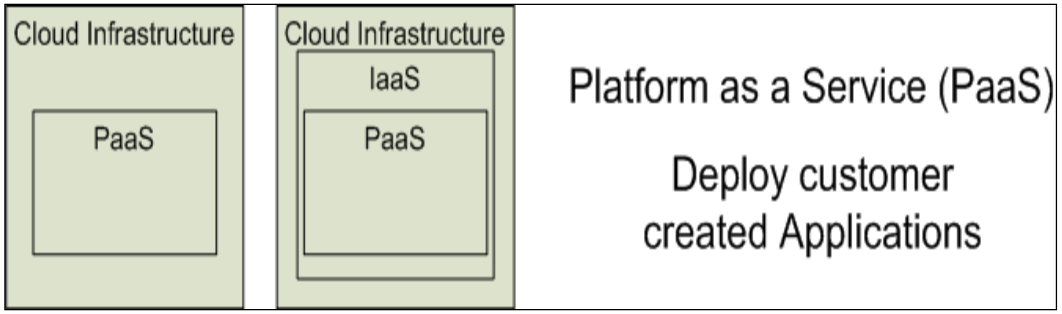
Google App

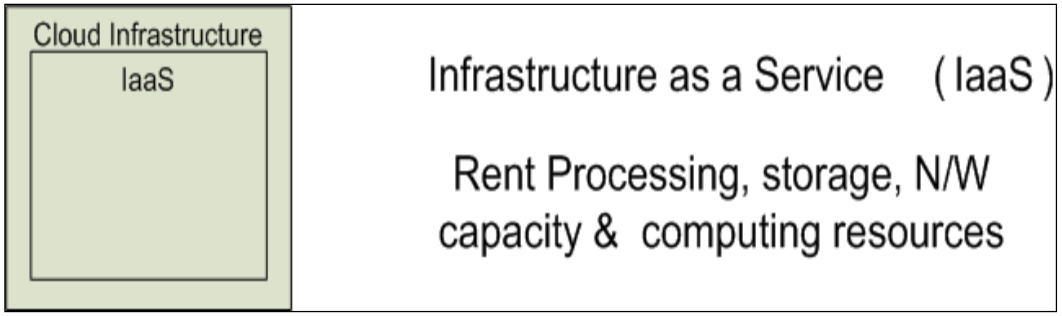
Windows Azure
The Future Made Familiar

amazon web services™

rackspace HOSTING





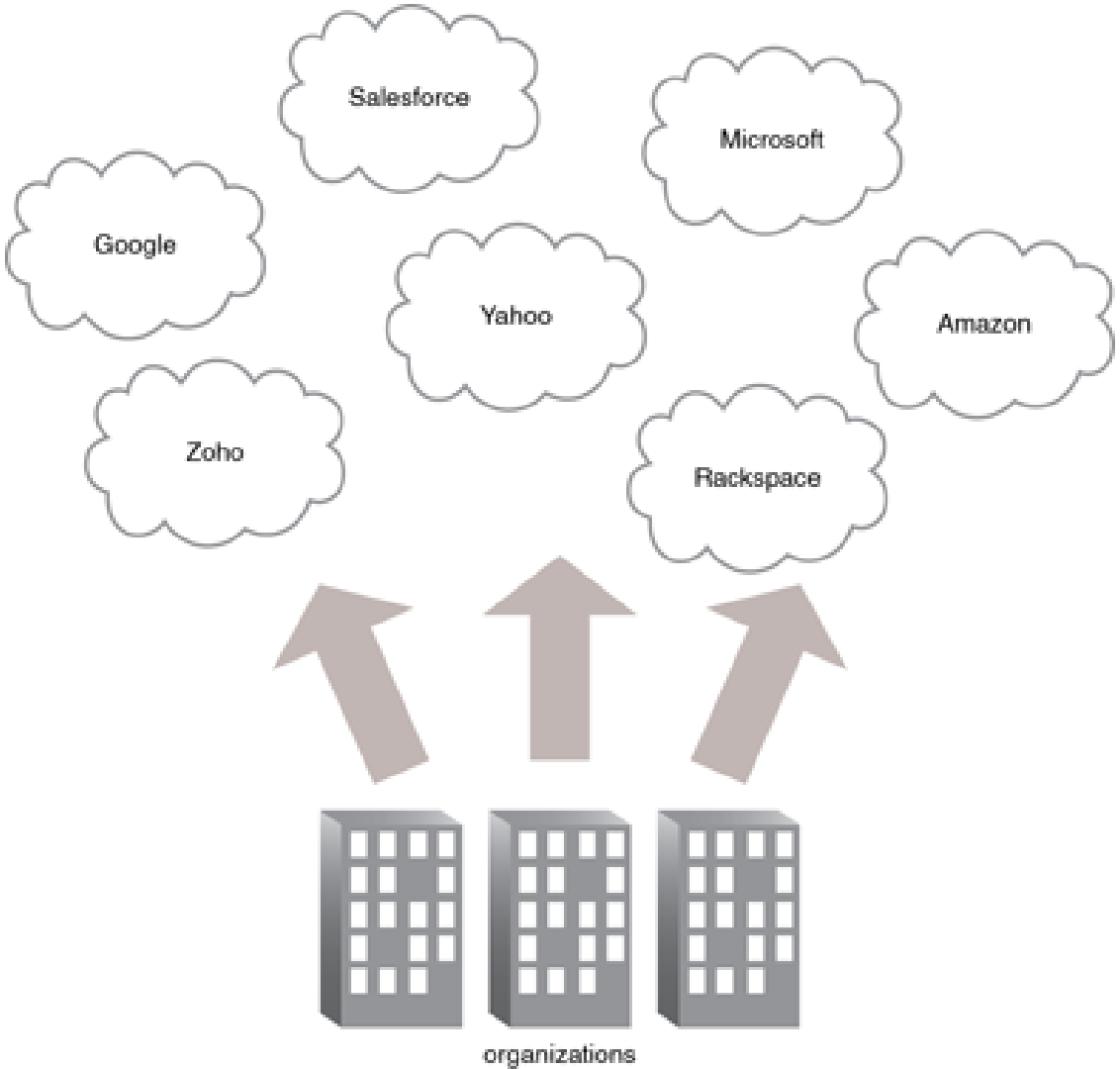


Cloud Deployment Models

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

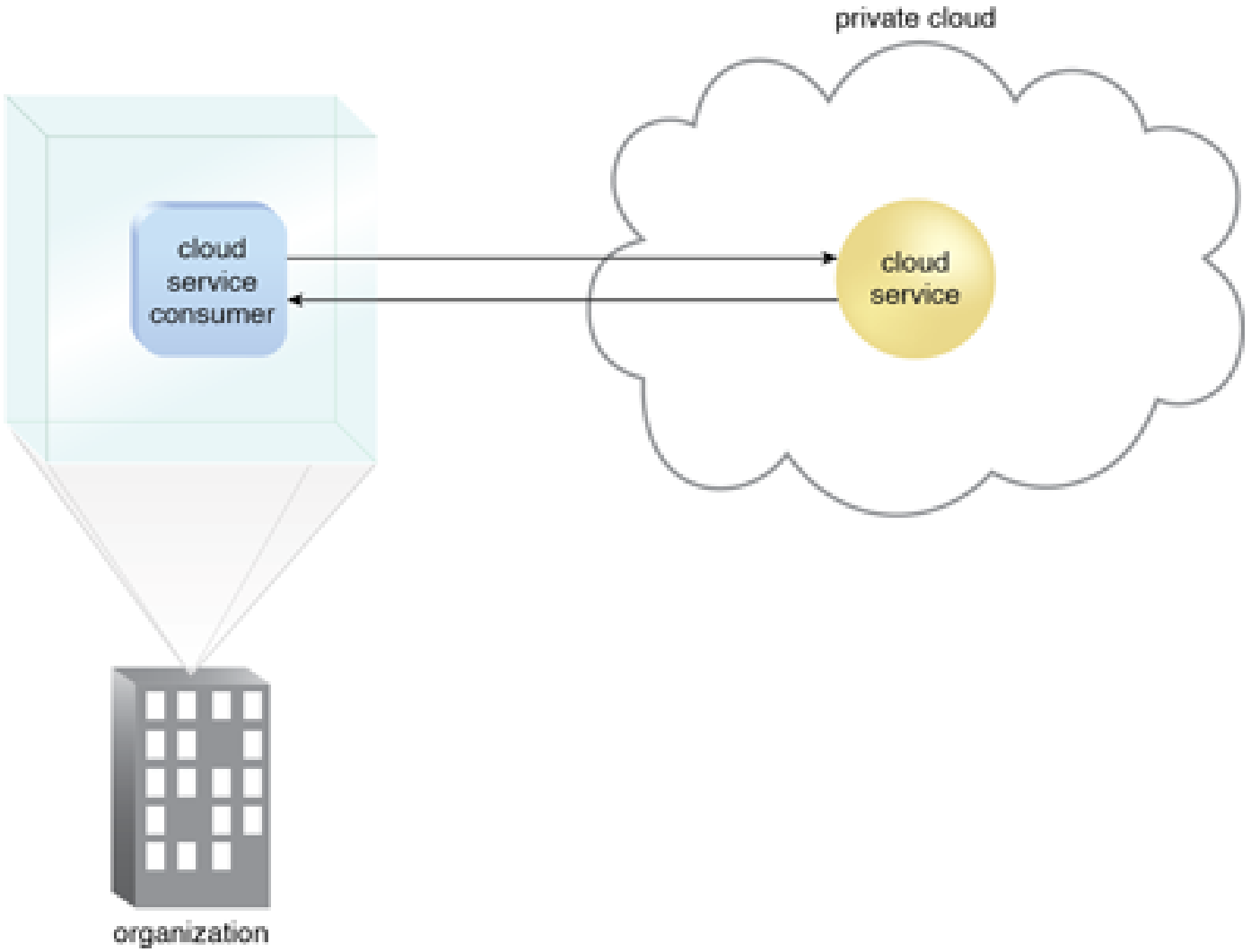
Public Cloud

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



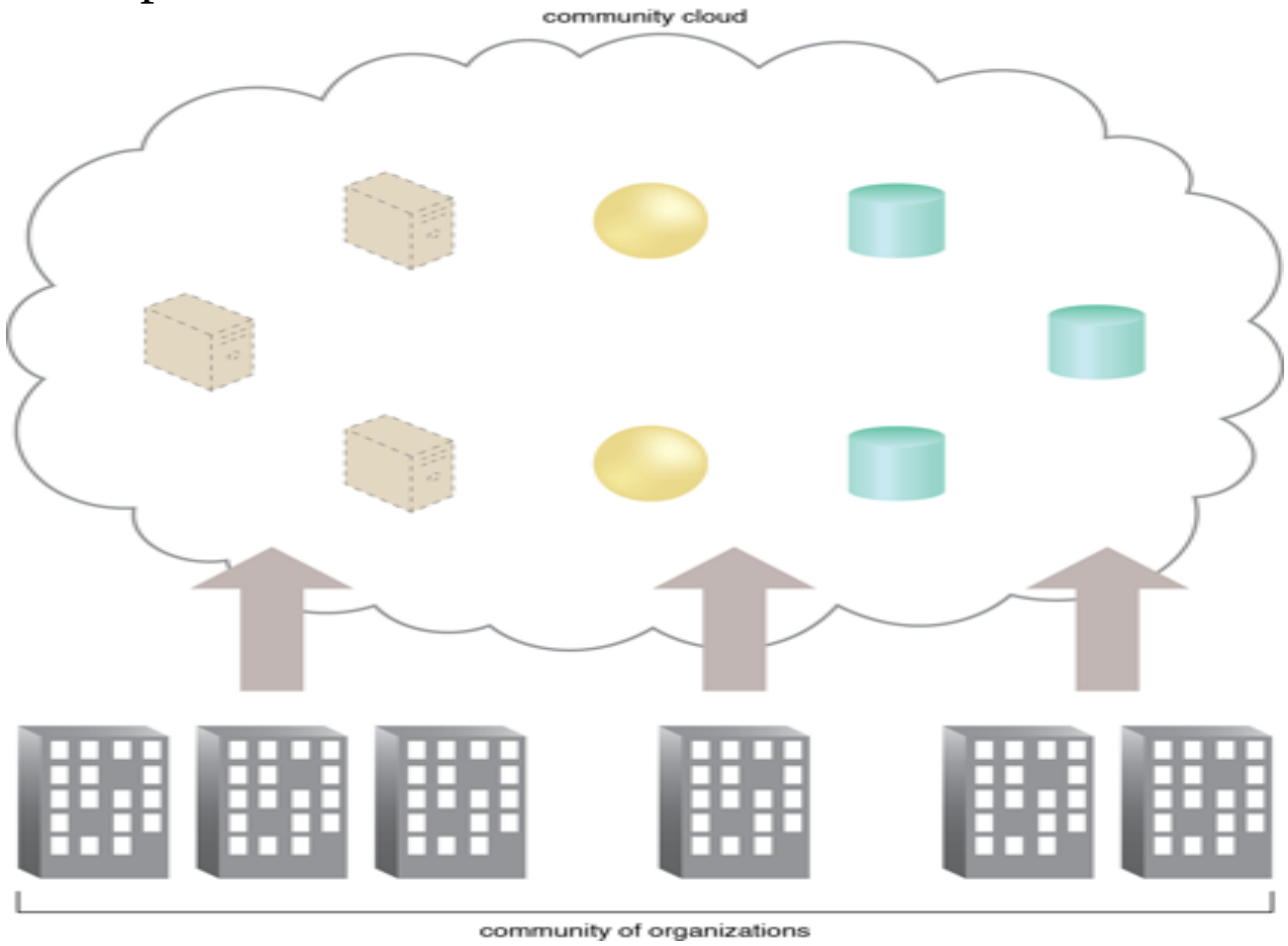
Private Cloud

- 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.



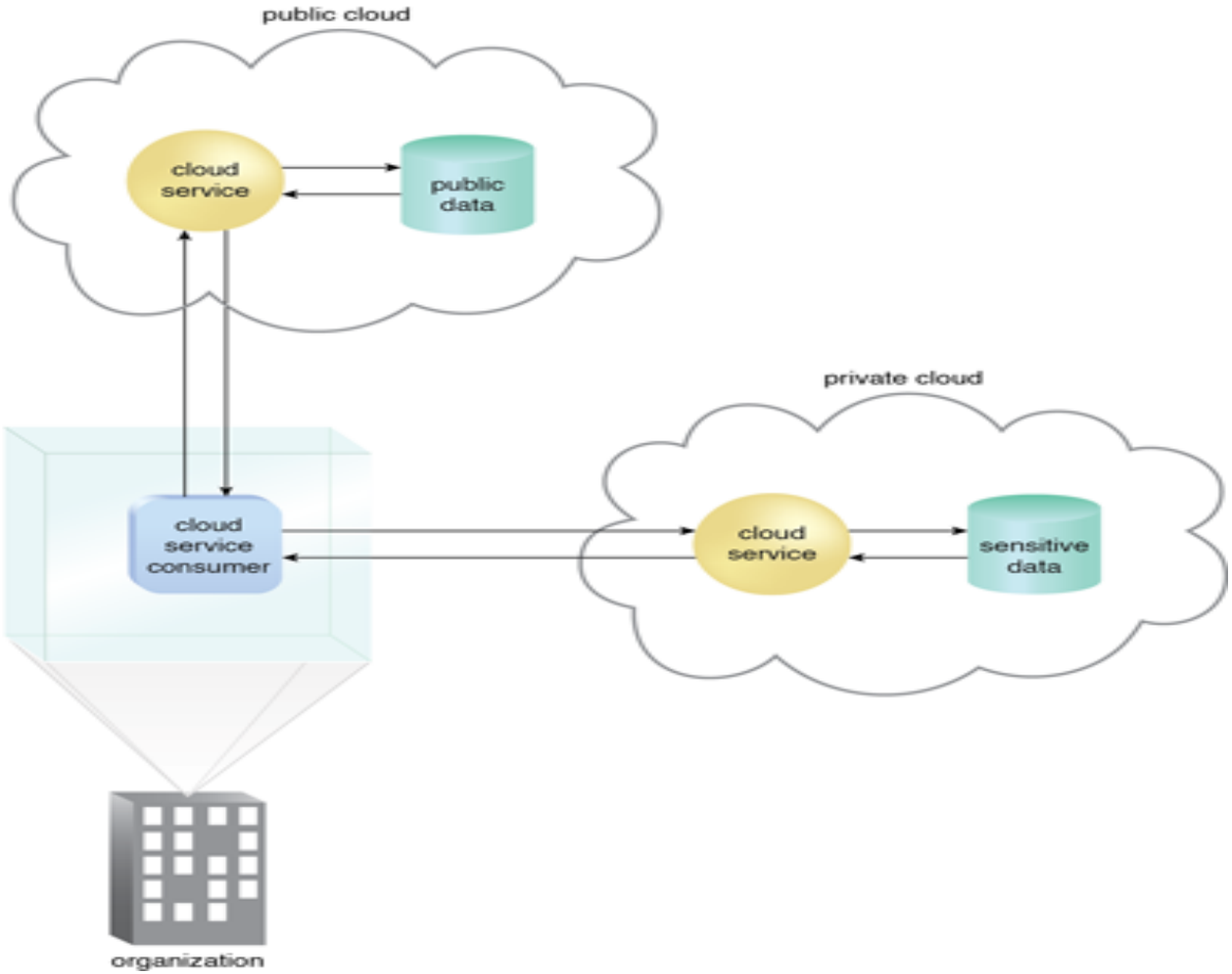
Community Cloud

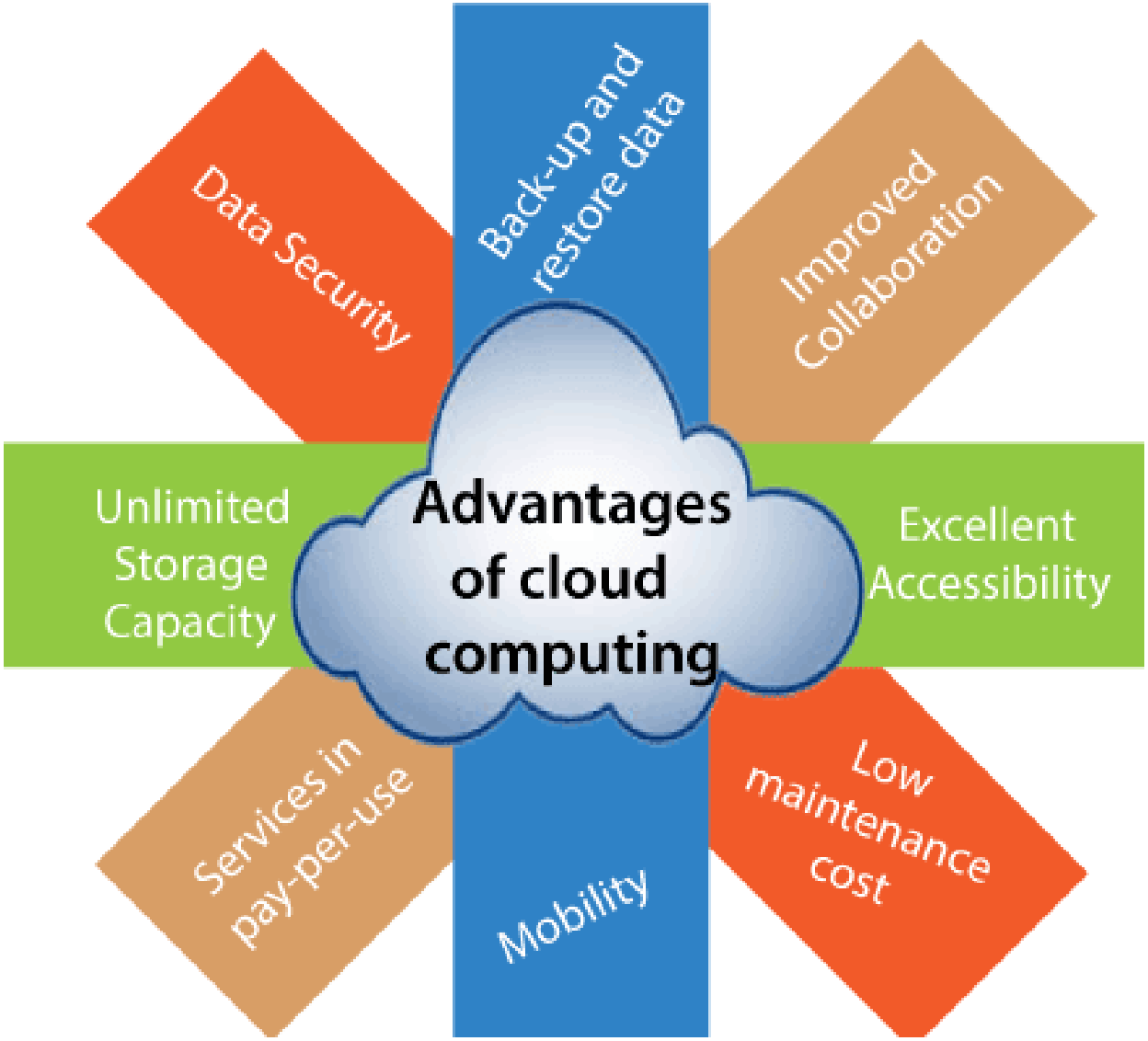
- The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, or compliance considerations).
- It may be managed by the organizations or a third party and may exist on-premises or off-premises.



Hybrid Cloud

- The cloud infrastructure is a composition of two or more clouds (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load-balancing between clouds).




Advantages of cloud computing
Data Security
Back-up and restore data
Improved Collaboration
Unlimited Storage Capacity
Excellent Accessibility
Services in pay-per-use
Mobility
Low maintenance cost

Advantages of Cloud Computing

- Back-up and restore data: Once the data is stored in the cloud, it is easier to get back-up and restore that data using the cloud.

- Improved collaboration: Cloud applications improve collaboration by allowing groups of people to quickly and easily share information in the cloud via shared storage.

- Excellent accessibility: Cloud allows us to quickly and easily access store information anywhere, anytime in the whole world, using an internet connection. An internet cloud infrastructure increases organization productivity and efficiency by ensuring that our data is always accessible.

- Low maintenance cost: Cloud computing reduces both hardware and software maintenance costs for organizations.

Advantages of Cloud Computing

- Mobility: Cloud computing allows us to easily access all cloud data via mobile.

- Services in the pay-per-use model: Cloud computing offers Application Programming Interfaces (APIs) to the users for access services on the cloud and pays the charges as per the usage of service.

- Unlimited storage capacity: Cloud offers us a huge amount of storing capacity for storing our important data such as documents, images, audio, video, etc. in one place.

- Data security: Data security is one of the biggest advantages of cloud computing. Cloud offers many advanced features related to security and ensures that data is securely stored and handled.

Disadvantages of Cloud Computing

- Internet Connectivity
- Vendor lock-in
- Limited Control
- Security

Disadvantages of Cloud Computing

- Internet Connectivity: As you know, in cloud computing, every data (image, audio, video, etc.) is stored on the cloud, and we access these data through the cloud by using the internet connection.
- If you do not have good internet connectivity, you cannot access these data. However, we have no any other way to access data from the cloud.

- Vendor lock-in: Vendor lock-in is the biggest disadvantage of cloud computing. Organizations may face problems when transferring their services from one vendor to another.
- As different vendors provide different platforms, that can cause difficulty moving from one cloud to another.

Disadvantages of Cloud Computing

- Limited Control: As we know, cloud infrastructure is completely owned, managed, and monitored by the service provider, so the cloud users have less control over the function and execution of services within a cloud infrastructure.

- Security: Although cloud service providers implement the best security standards to store important information.
- But, before adopting cloud technology, you should be aware that you will be sending all your organization's sensitive information to a third party, i.e., a cloud computing service provider.
- While sending the data on the cloud, there may be a chance that your organization's information is hacked by Hackers.

Comparison

	Cluster Computing	Grid Computing	Cloud Computing
Basic Idea	Aggregation of resources.	Segregation of Resources.	Consolidation of Resources.
Running Processes	Same processes run on all computers over the cluster at the same time.	Job is divided into sub-jobs each is assigned to an idle CPU so they all run concurrently.	Depends on service provisioning. Which computer offers a service and provisions it to the requesting clients.
Operating System	All nodes must run the same operating system.	No restriction is made on the operating system.	No restriction is made on the operating system.
Job Execution	Execution depends on job scheduling. So, jobs wait unit it's assigned a runtime.	Execution is scalable in a way that moves the execution of a job to an idle processor (node).	Self-Managed.
Suitable for Apps	Cascading tasks. If one tasks depends on another one.	Not suitable for cascading tasks.	On-demand service provisioning.
Location of nodes	Physically in the same location	Distributed geographically all over the globe.	Location doesn't matter
Homo/Heterogeneity	Homogenous	Heterogeneous	Heterogeneous

Comparison

Virtualization	None	None	Virtualization is a key
Transparency	Yes	Yes	Yes
Security	High	High, but doesn't reach the level of cluster computing.	Lower than both types.
Interoperability	Yes	Yes	No
Application Domains	industrial sector, research centers, health care, and centers that offer services on the nation-wide level	industrial sector, research centers, health care, and centers that offer services on the nation-wide level	Banking, Insurance, Weather Forecasting, Space Exploration, Business, IaaS, PaaS, SaaS
Implementation	Easy	Difficult	Difficult – need to be done by the host.
Management	Easy	Difficult	Difficult
Resource Management	Centralized (locally)	Distributed	Both centralized and distributed.
Internet	No internet access is required	Required	Required

Service Oriented Paradigm

The service-oriented model allows for a clear distinction to be made between

- ***service providers*** (organizations that provide the service implementations, supply their service descriptions, and provide related technical and business support);
- ***service clients*** (end-user organizations that use some service); and
- ***service aggregators*** (organizations that consolidate multiple services into a new, single orchestrated service offering what is commonly known as a business process).

Web Services Can be -

- **a self-contained business task:** withdrawing or depositing funds in an account
- **a full-fledged business process:** automating the purchase of office supplies
- **an application:** forecasting application, stock replenishment, claims, etc.
- **a service-enabled resource:** providing access to a particular back-end database within an organization

- "Big Web Services" are strongly oriented towards a business perspective
- Also prevalent in certain scientific disciplines, such as Grid computing

Web Services Examples

Web service
http://live.capescience.com/ccx/GlobalWeather

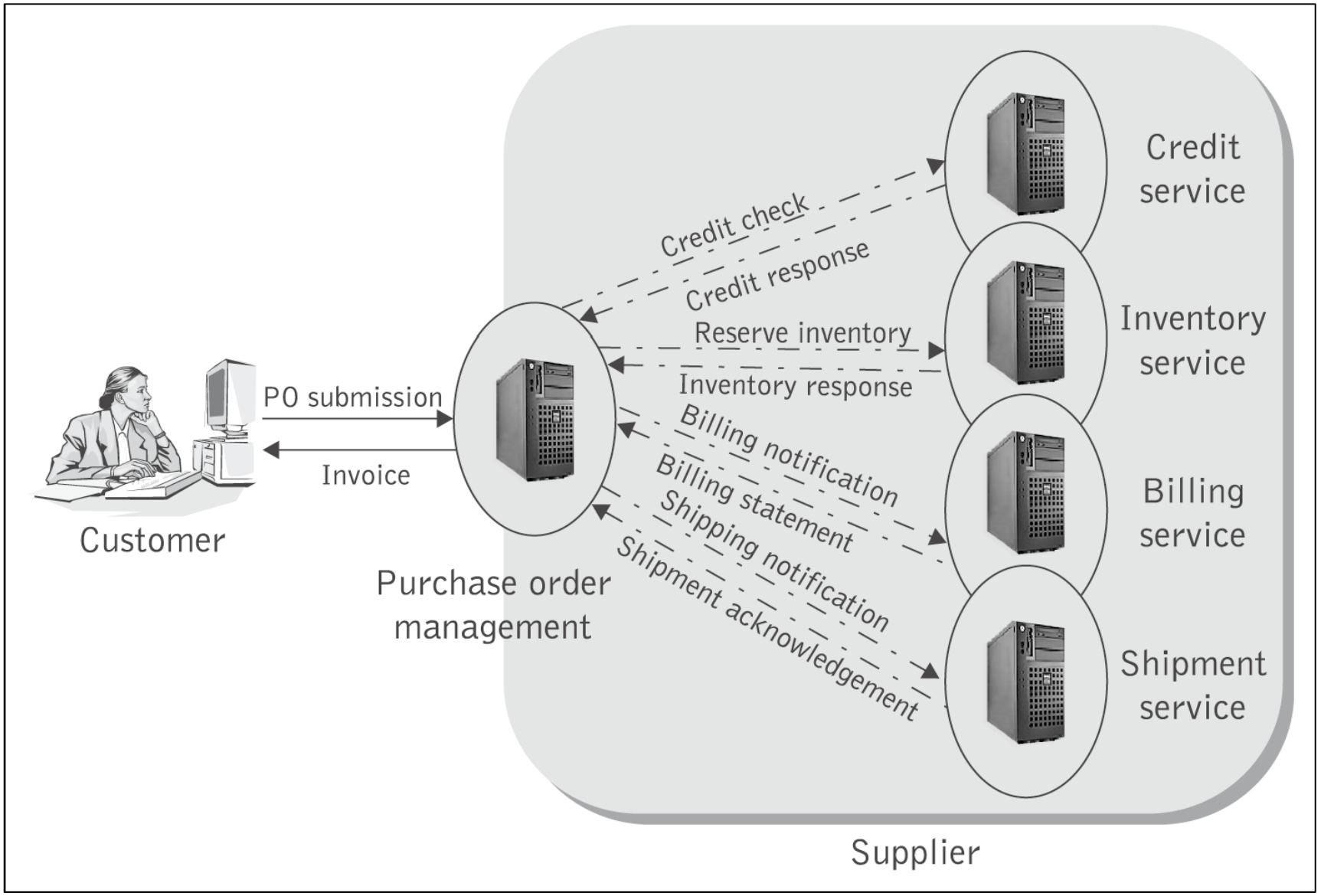
- Provides airport and flight weather information

Amazon Web Services (AWS & ECS)
http://www.amazon.com/webservices

- Provide e-commerce services such as lookup of books

Google Web API
http://www.google.com/apis/

Purchase Order Application via Web Services



Virtualization

- **Virtualization** is a technique, which allows to share single physical instance of an application or resource among multiple organizations or tenants (customers).

- It does so by **assigning a logical name** to a physical resource and providing a **pointer to that physical resource** on demand.

- The machine on which the virtual machine is created is known as **host machine** and **virtual machine** is referred as a **guest machine.**

- This virtual machine is managed by a software or firmware, which is known as **hypervisor.**

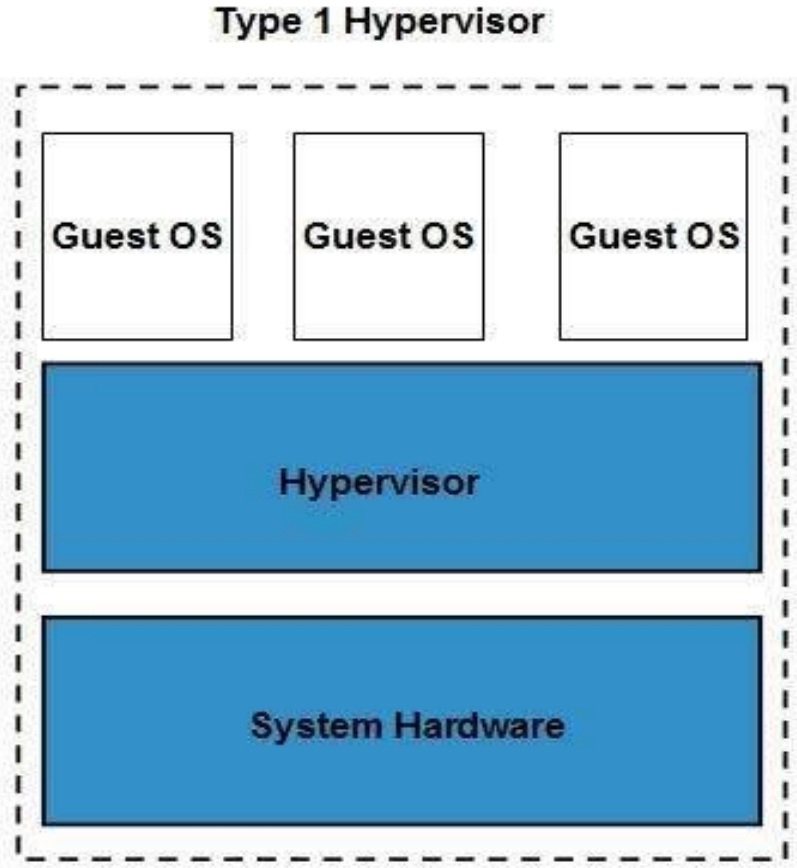
Virtualization

- Hypervisor

  - The **hypervisor** is a firmware or low-level program that acts as a Virtual Machine Manager.

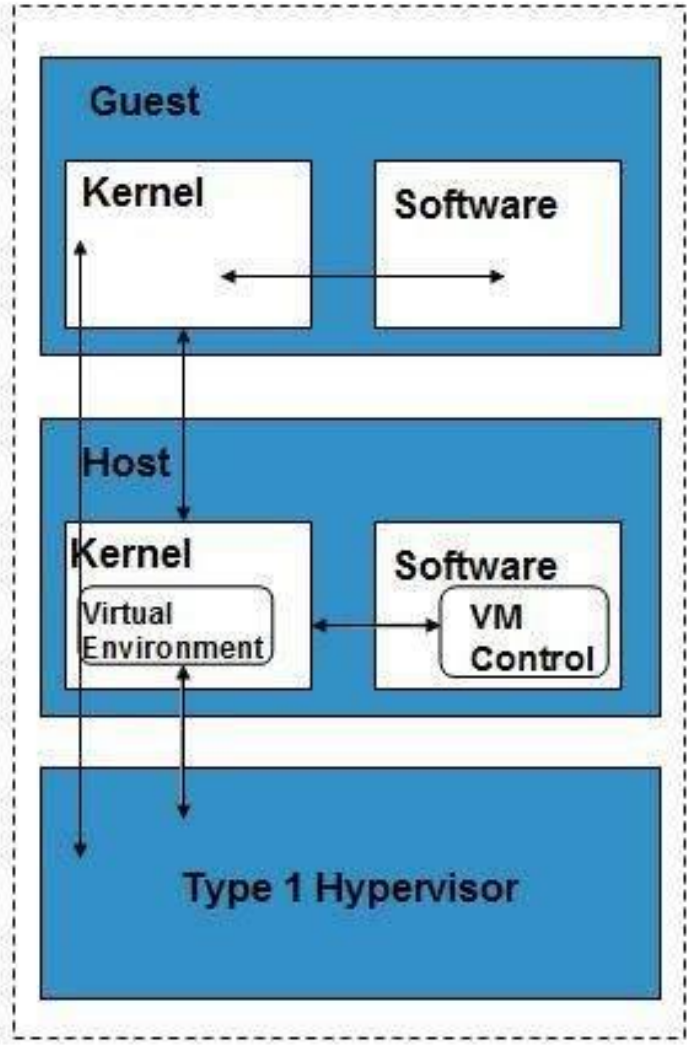
  - Type 1 hypervisor executes on bare system.

  LynxSecure, Oracle VM, Sun xVM Server, VirtualLogic VLX are examples of Type 1 hypervisor.



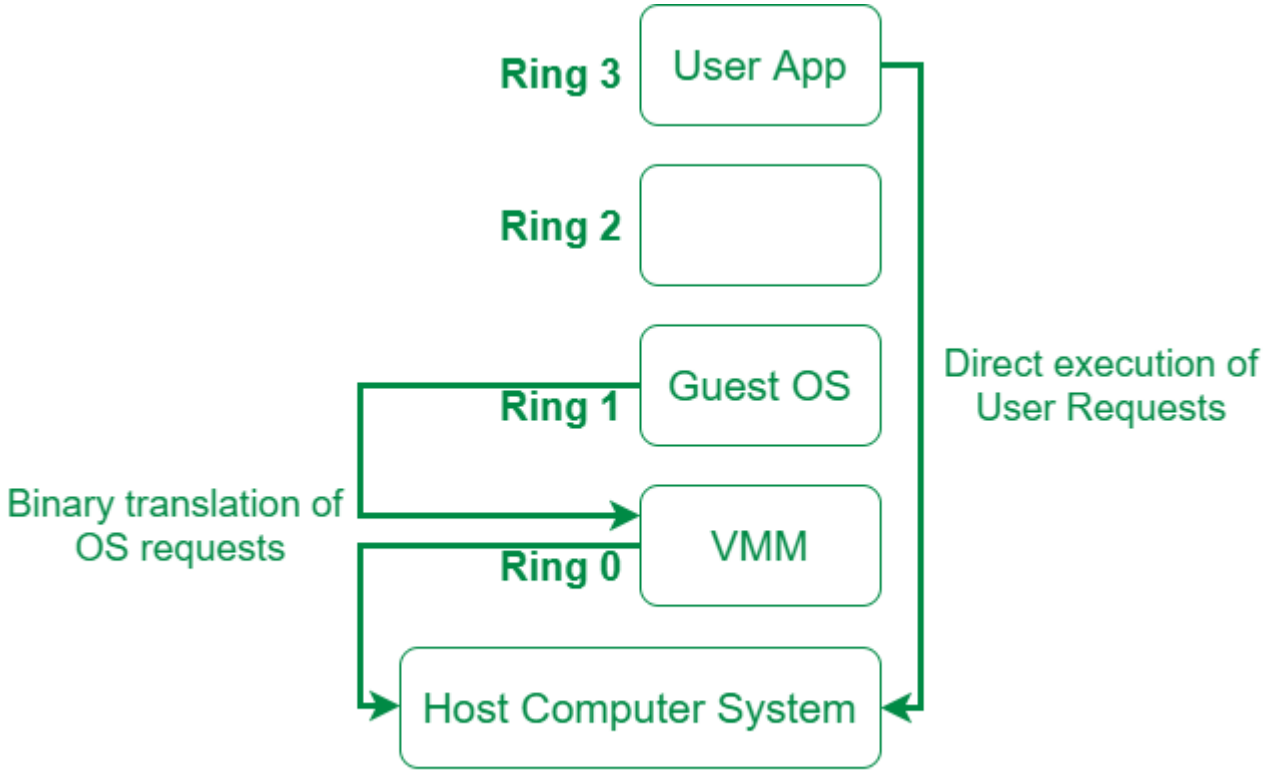
Virtualization Types:

1. Full Virtualization: In **full virtualization,** the underlying hardware is completely simulated. Guest software does not require any modification to run.



Virtualization Types:

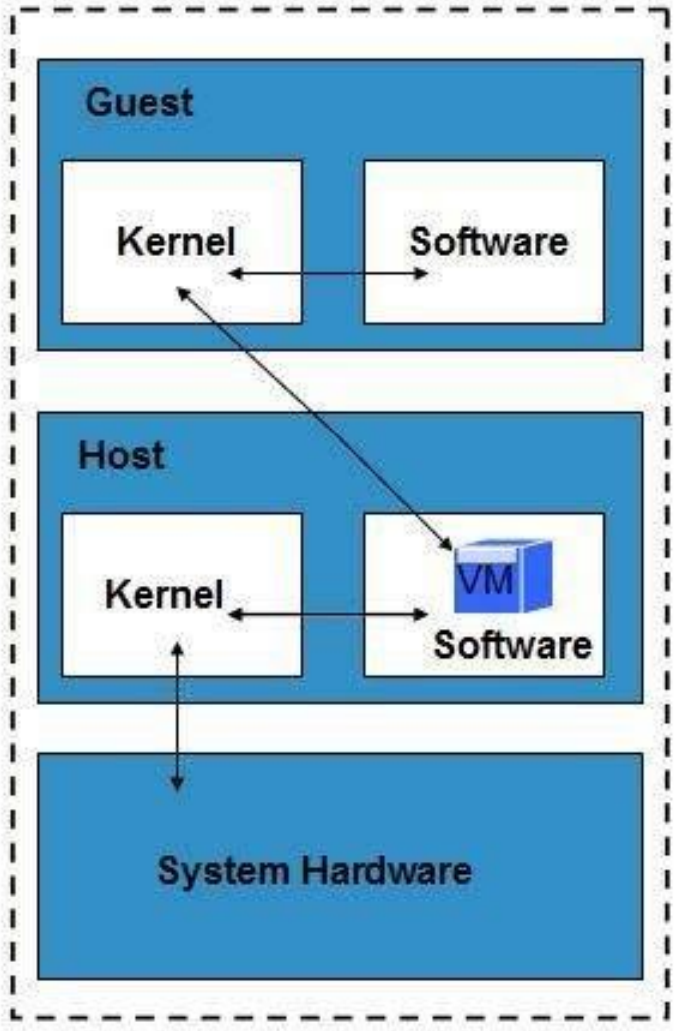
1. **Full Virtualization:** Full Virtualization was introduced by IBM.
   - It is the first software solution of server virtualization and uses binary translation and direct approach technique.
   - In full virtualization, guest OS is completely isolated by the virtual machine from the virtualization layer and hardware.
   - Microsoft and Parallels systems are examples of full virtualization.



Full Virtualization

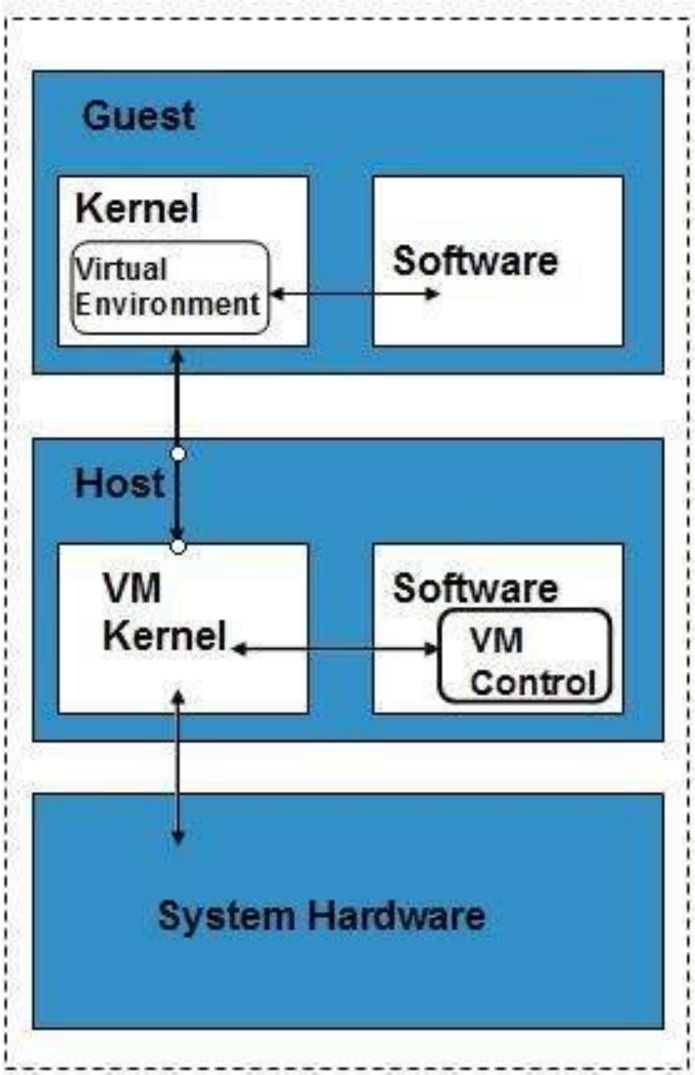
Virtualization Types:

2. Emulation Virtualization: In Emulation**,** the virtual machine simulates the hardware and hence becomes independent of it. In this, the guest operating system does not require modification.



Virtualization Types:

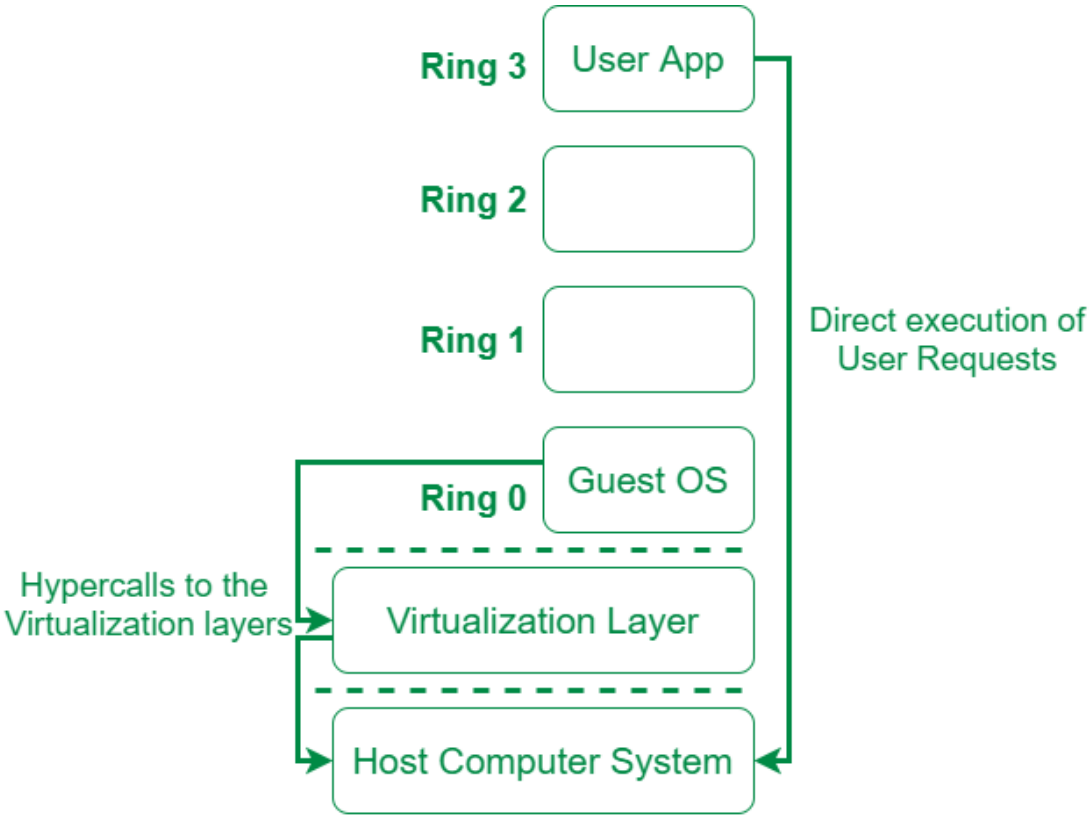
3. Paravirtualization: In **Paravirtualization,** the hardware is not simulated. The guest software run their own isolated domains.



Virtualization Types:

3. Paravirtualization: Paravirtualization is the category of CPU virtualization which uses hypercalls for operations to handle instructions at compile time.

- Here guest OS is not completely isolated but it is partially isolated by the virtual machine from the virtualization layer and hardware.
- VMware and Xen are some examples of paravirtualization.



Paravirtualization

Virtualization Types:

S.No.	Full Virtualization	Paravirtualization
1.	In Full virtualization, virtual machine permit the execution of the instructions with running of unmodified OS in an entire isolated way.	In paravirtualization, virtual machine does not implement full isolation of OS but rather provides a different API which is utilized when OS is subjected to alteration.
2.	Full Virtualization is less secure.	While the Paravirtualization is more secure than the Full Virtualization.
3.	Full Virtualization uses binary translation and direct approach as a technique for operations.	While Paravirtualization uses hypercalls at compile time for operations.

Virtualization Types:

S.No.	Full Virtualization	Paravirtualization
4.	Full Virtualization is slow than paravirtualization in operation.	Paravirtualization is faster in operation as compared to full virtualization.
5.	Full Virtualization is more portable and compatible.	Paravirtualization is less portable and compatible.
6.	Examples of full virtualization are Microsoft and Parallels systems.	Examples of paravirtualization are VMware and Xen.

Virtualization Types:

1. **Network Virtualization**
2. **Server Virtualization**
3. **Server Clustering**
4. **Storage Virtualization**
5. **Application Virtualization**

Virtualization Types:

1. **Network Virtualization:** Giving multiple group access to the physical network capabilities while keeping them logically separate to a degree that they have no visibility into other groups. It is achieved by combining the available resources in a network.

2. **Server Virtualization:** Method of partitioning a physical server into multiple servers so that each has a appearance and capabilities of running on its own dedicated machine. Base hardware is virtualized allowing multiple guests operating environments to run directly on top of the hardware.

Virtualization Types:

3. **Server Clustering:** Clustering is a method that allows multiple servers to be treated as a single server. Server clustering is a form of virtualization that makes several locally attached physical systems appear to the application and end users as a single processing resource.

4. **Storage Virtualization:** Method that pools physical storage from multiple network storage devices into what appears to be a common storage pool and isolating servers from physical storage. It allows adding a storage device without server/network reconfiguration, removing and/or changing storage volume definitions and assignments from one storage device to another.

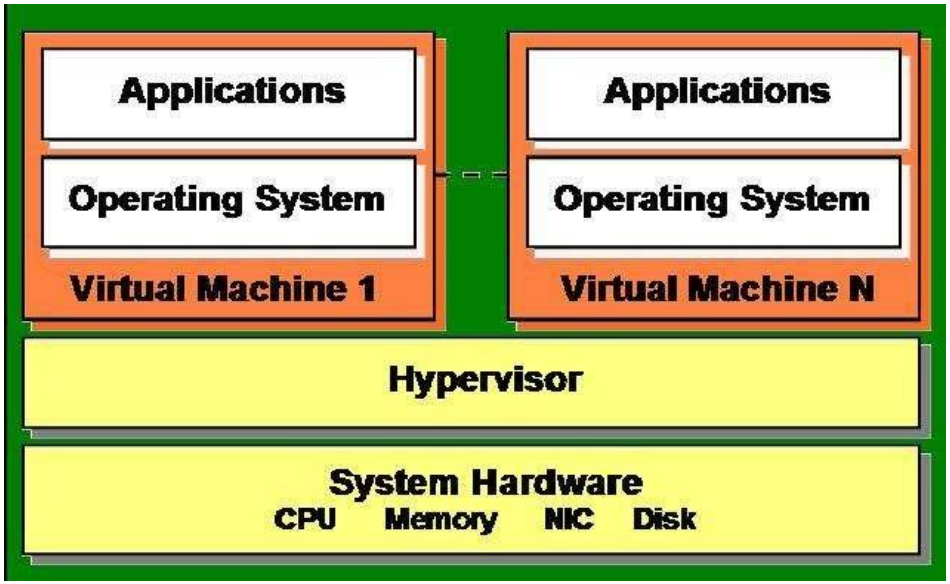
Virtualization Types:

5. **Application Virtualization:** Separate the use of software application from where the application is housed and maintained, enabling the user to enjoy full application functionality without having the application on their computing device. The application is deceived at run time to believing that it is interfacing directly with the original operating system and computing resources.

Virtualization

- Hypervisor plays an important role in the virtualization scenario by virtualization of hardware.

  It provides support for running multiple operating systems concurrently in virtual servers created within a physical server.

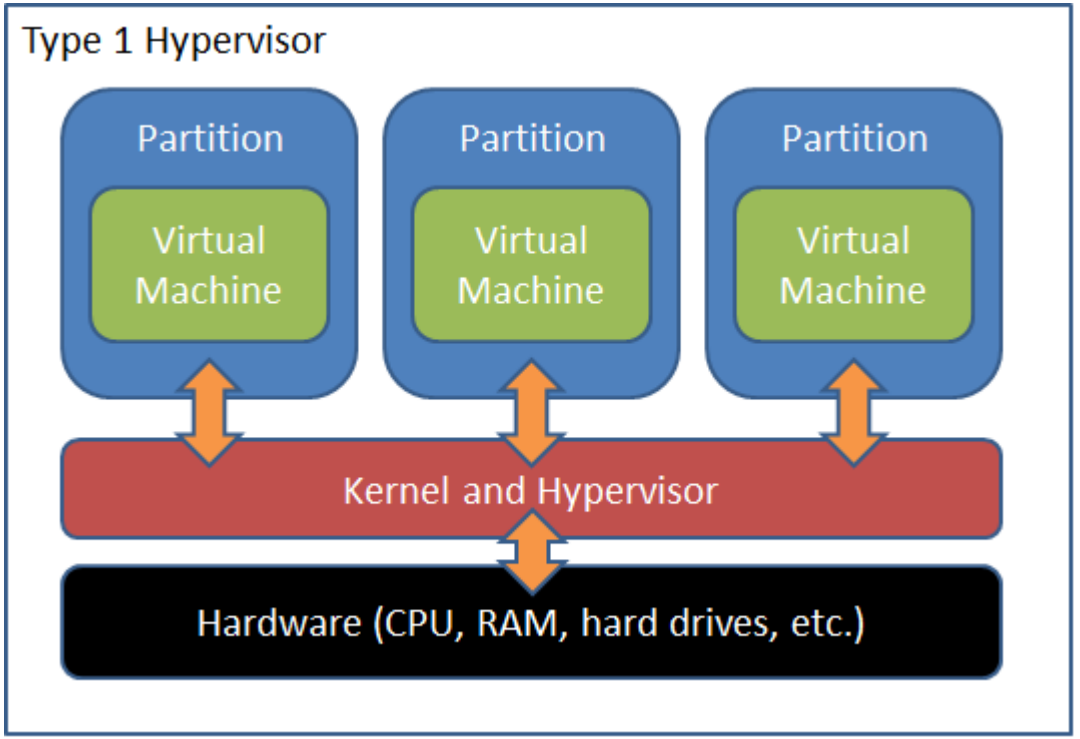


- The virtualization layer is the software responsible for hosting and managing all VMs.
- The virtualization layer is a hypervisor running directly on the hardware.

Example: VMWare, Xen, KVM.

Hypervisor Types:

- **Type I Hypervisor:**
  - A type I hypervisor operates directly on the host's hardware to monitor hardware and guest virtual machines, and it's referred to as the bare metal.
  - Usually, they don't require the installation of software ahead of time. Instead, you can install right onto the hardware.
  - Examples: Xen, Oracle VM Server for SPARC, Oracle VM Server for x86

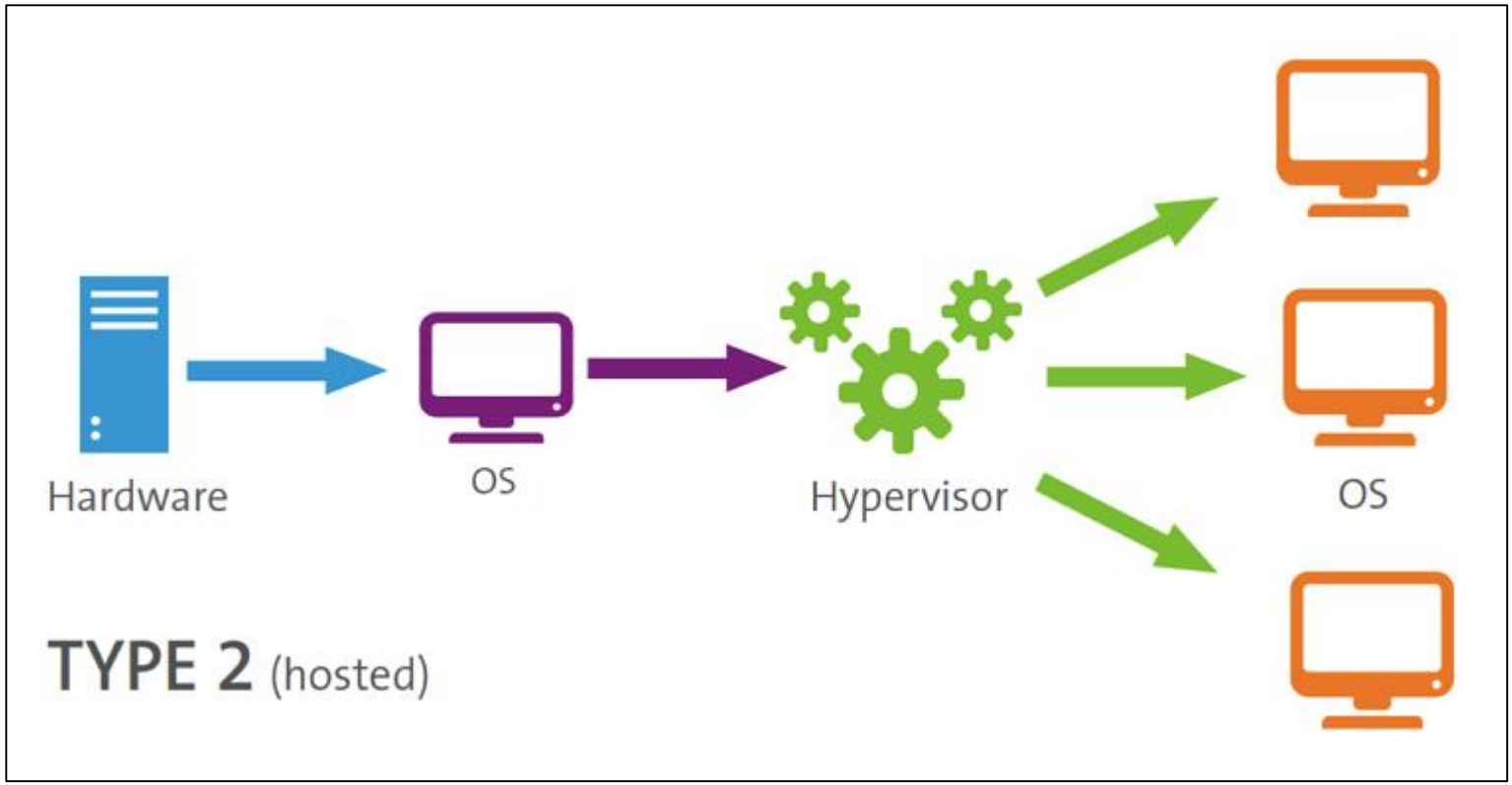


Hypervisor Types:

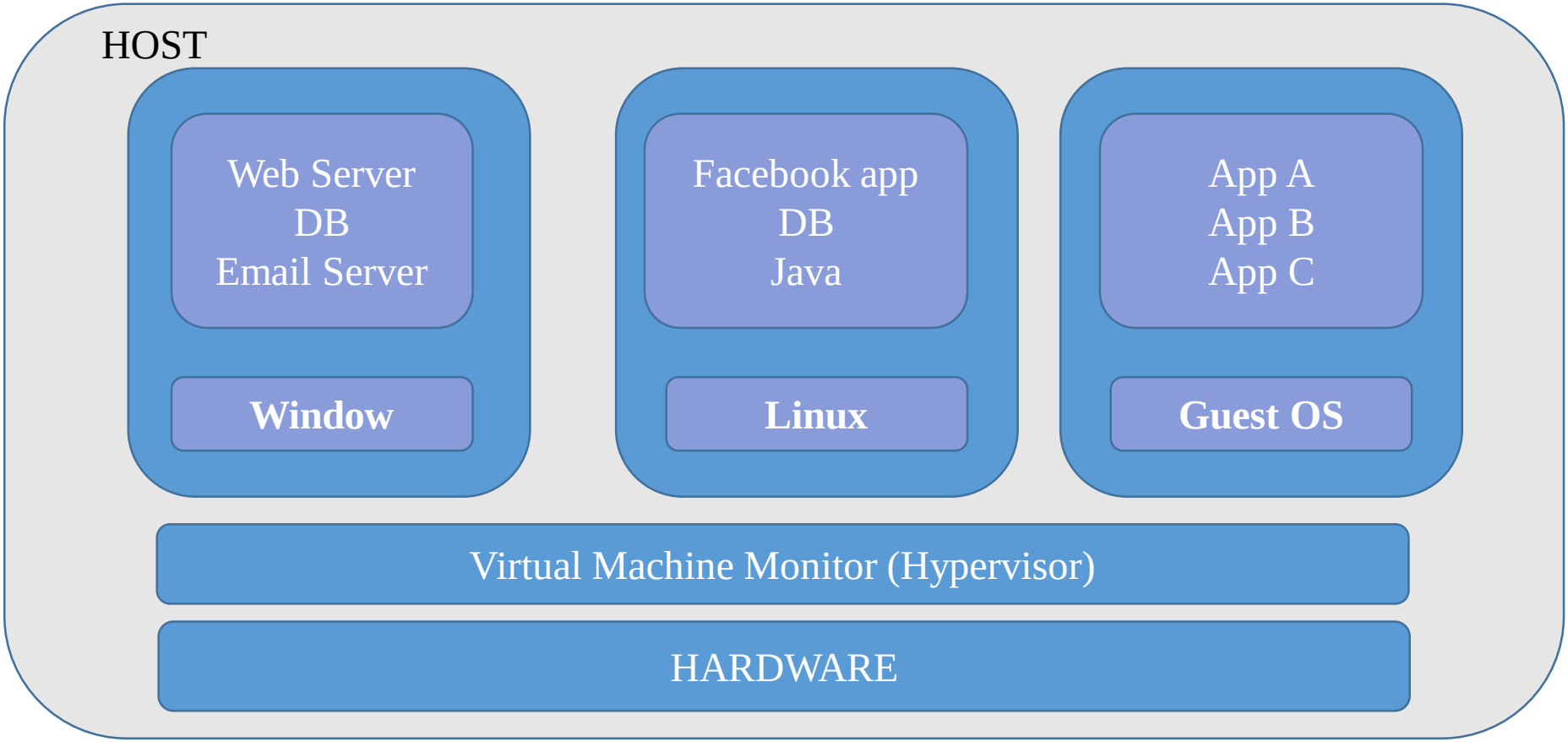
- **Type II Hypervisor:**
  - It's also called a hosted hypervisor because it is usually installed onto an existing operating system.
  - They are not much capable to run more complex virtual tasks. People use it for basic development, testing, and emulation.
  - If there is any security flaw found inside the host OS, it can potentially compromise all of virtual machines running.
  - This is why type II hypervisors cannot be used for data centre computing.
  - Examples are Virtual box, VMware workstation, fusion.

Hypervisor Types:

- **Type II Hypervisor:**



System Virtualization and Management



System Virtualization and Management

- Core capability of system virtualization is the ability to execute multiple operating system instances on shared hardware.
- To address the complexity of a system virtualization environment are based on the DMFT i.e. **Distributed Management Task Force** which defines a consistent way of managing any virtualized environment.
- A virtualization layer manages the lifecycle of virtual computer system, which is composed of resources allocated or assigned from the host computer system.
- Allows multiple operating system instances to run concurrently within virtual machine on a single computer, dynamically partitioning and sharing the available physical resources such as CPU, storage, memory and I/O devices.

System Virtualization and Management

- Virtualization approach uses either hosted or hypervisor architecture
  - ***A hosted architecture*** installs and run the virtualization layer as a applications on top of an operating system and supports the broadest range of hardware configuration.

  - ***A hypervisor architecture*** installs the virtualization layer directly on a clean system.
    - Since it has direct access to the hardware resources rather than going through an operating system, a hypervisor is more efficient than a hosted architecture and delivers greater scalability, robustness and performance.

Understanding the Hypervisors:

The following factors should be examined before choosing a suitable hypervisor:

1. **Understand your needs:** The company and its applications are the reason for the data centre.

Needs for a virtualization hypervisor are:

a. Flexibility
b. Scalability
c. Usability
d. Availability
e. Reliability
f. Efficiency
g. Reliable support

2. The cost of a hypervisor: For many buyers, the toughest part of choosing a hypervisor is striking the right balance between cost and functionality.

- While a number of entry-level solutions are free, or practically free, the prices at the opposite end of the market can be staggering.
- Licensing frameworks also vary, so it's important to be aware of exactly what you're getting for your money.

Understanding the Hypervisors:

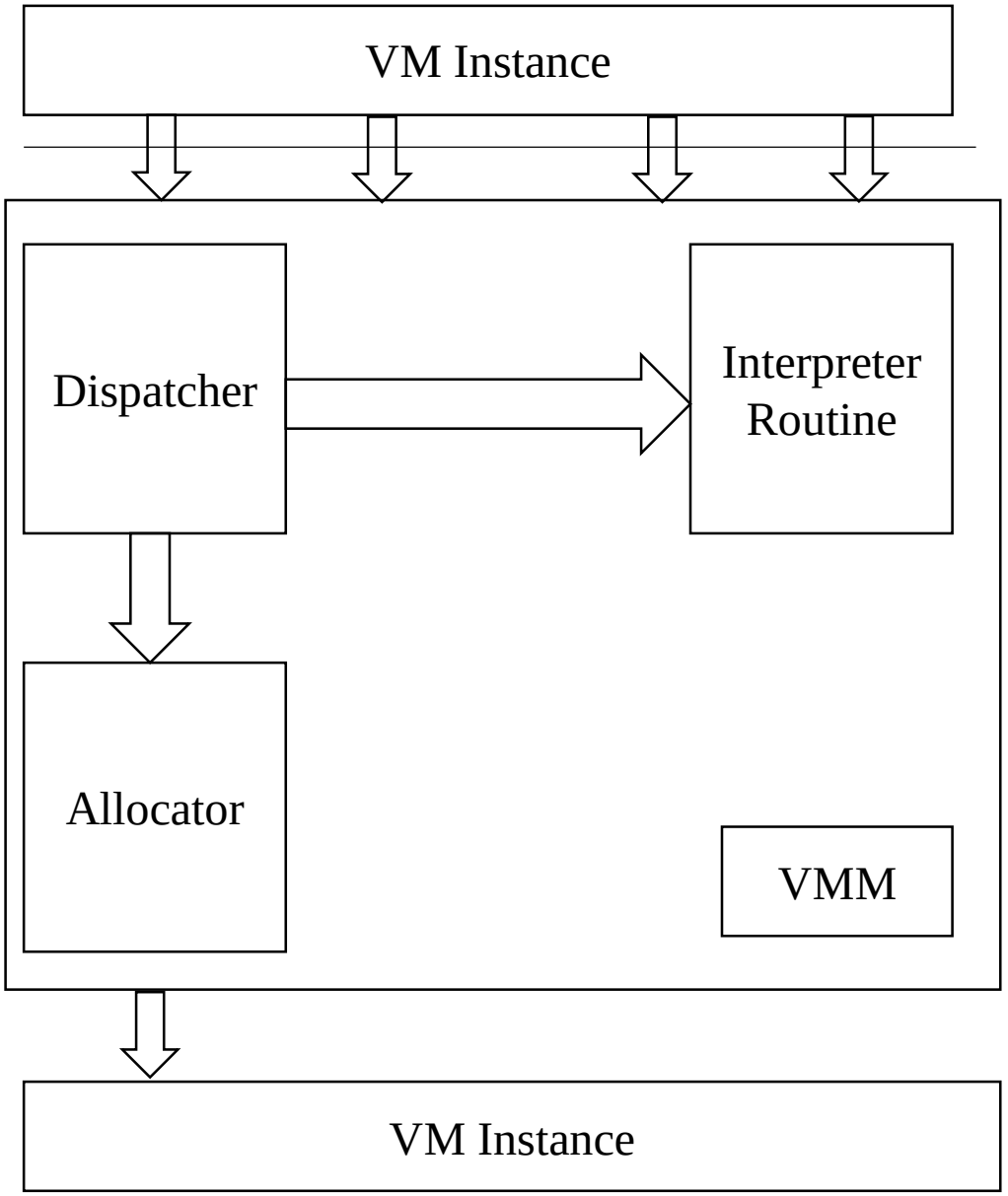
The following factors should be examined before choosing a suitable hypervisor:

3. Virtual machine performance: Virtual systems should meet or exceed the performance of their physical counterparts, at least in relation to the applications within each server. Everything beyond meeting this benchmark is profit.

4. Ecosystem: It's tempting to overlook the role of a hypervisor's ecosystem – that is, the availability of documentation, support, training, third-party developers and consultancies, and so on – in determining whether or not a solution is cost-effective in the long term.

5. Test for yourself: You can gain basic experience from your existing desktop or laptop. You can run both VMware vSphere and Microsoft Hyper-V in either VMware Workstation or VMware Fusion to create a nice virtual learning and testing environment.

Hypervisor reference Model:



Hypervisor reference Model:

There are 3 main modules coordinate in order to emulate the underlying hardware:

1. Dispatcher
2. Allocator
3. Interpreter

DISPATCHER:

The dispatcher behaves like the entry point of the monitor and reroutes the instructions of the virtual machine instance to one of the other two modules.

ALLOCATOR:

The allocator is responsible for deciding the system resources to be provided to the virtual machine instance. It means whenever virtual machine tries to execute an instruction that results in changing the machine resources associated with the virtual machine, the allocator is invoked by the dispatcher.

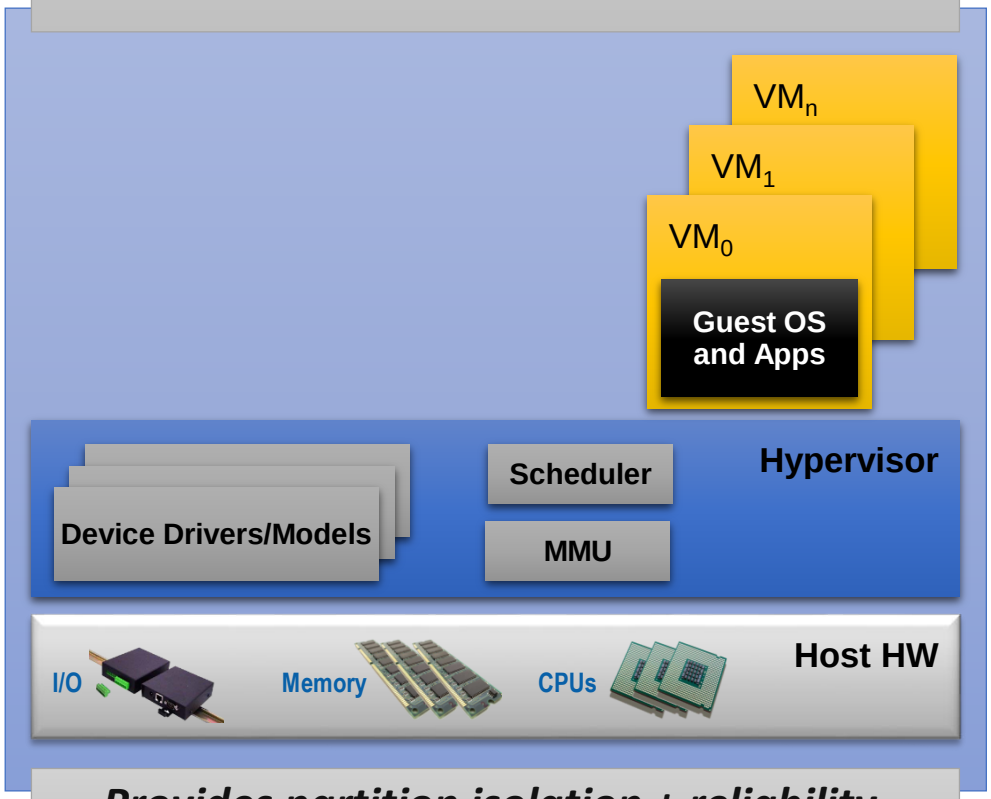
INTERPRETER:

The interpreter module consists of interpreter routines. These are executed, whenever virtual machine executes a privileged instruction.

Hypervisor Architectures

Type 1: Bare metal Hypervisor

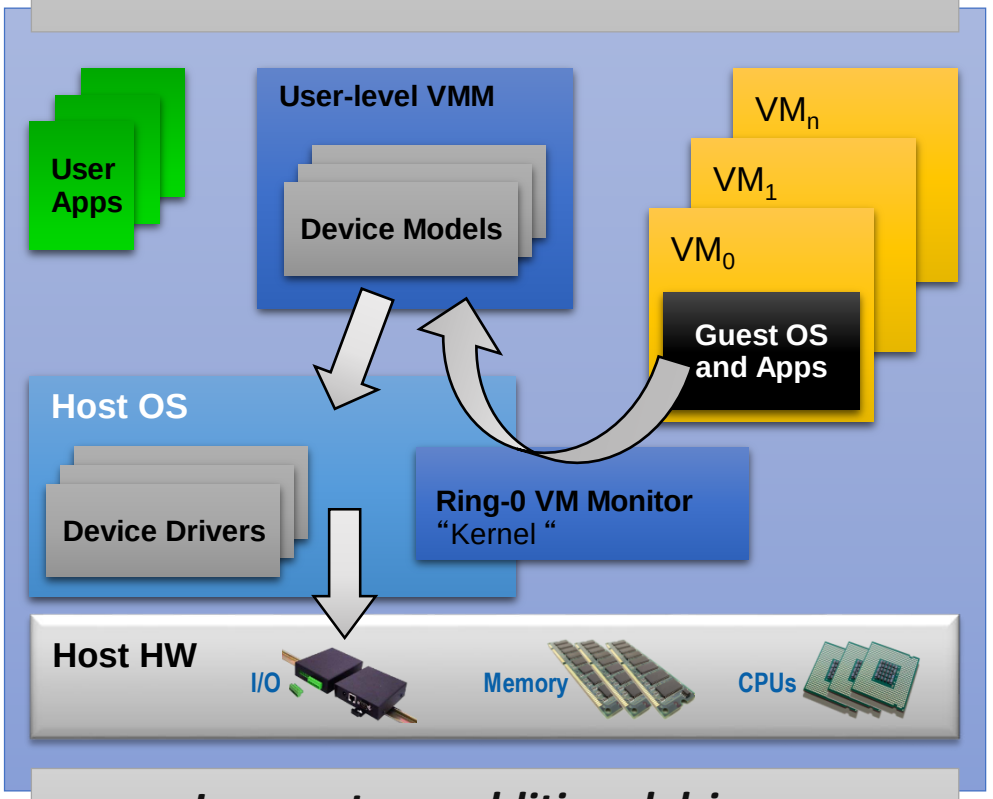
A pure Hypervisor that runs directly on the hardware and hosts Guest OS's.



Provides partition isolation + reliability, higher security

Type 2: OS 'Hosted'

A Hypervisor that runs within a Host OS and hosts Guest OS's inside of it, using the host OS services to provide the virtual environment.



Low cost, no additional drivers Ease of use & installation

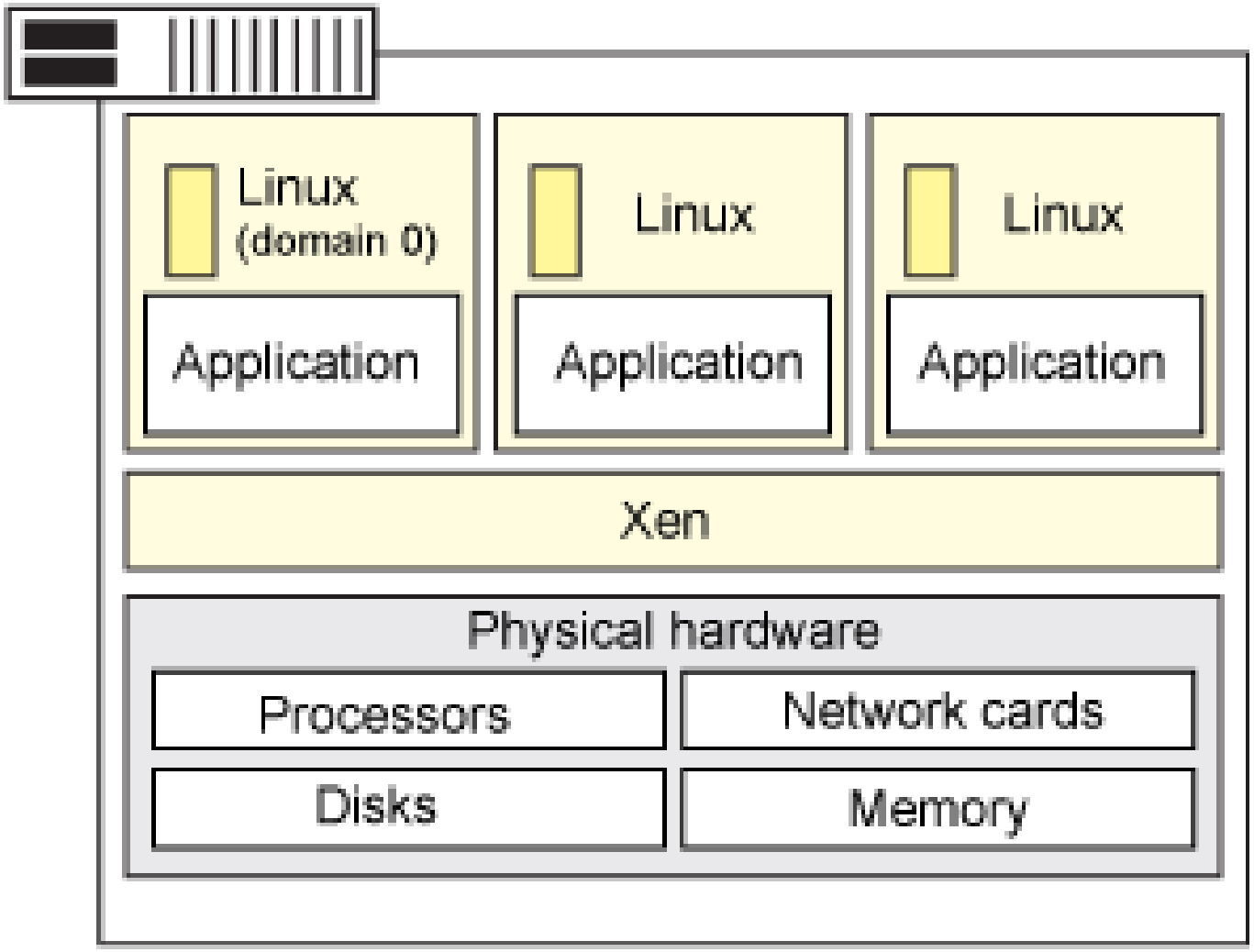
Hypervisor Architectures Xen

- Xen is a hypervisor that runs directly on the system hardware.

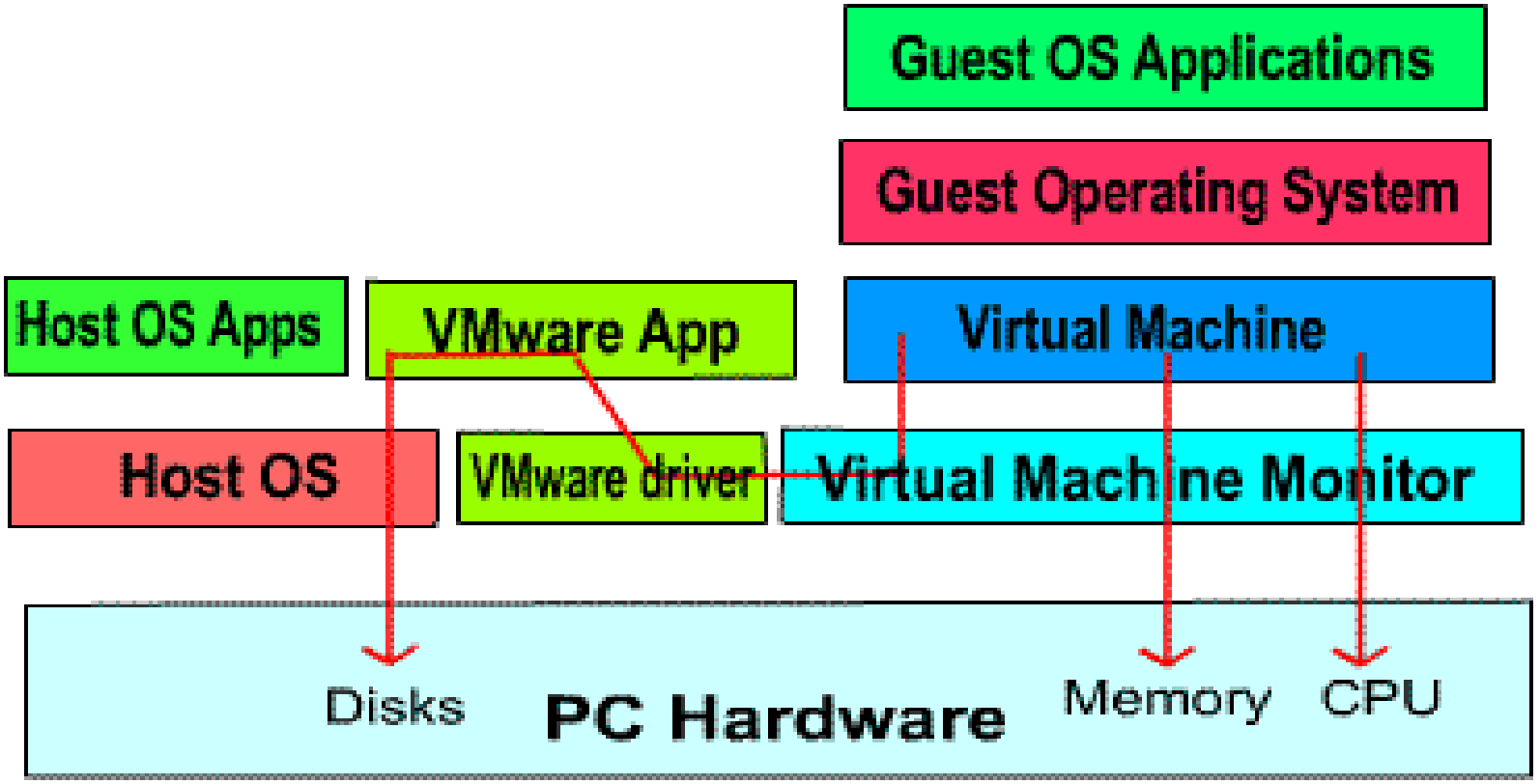
- Xen inserts a virtualization layer between the system hardware and the virtual machines, turning the system hardware into a pool of logical computing resources that Xen can dynamically allocate to any guest operating system.

- The operating systems running in virtual machines interact with the virtual resources as if they were physical resources.

Hypervisor Architectures Xen

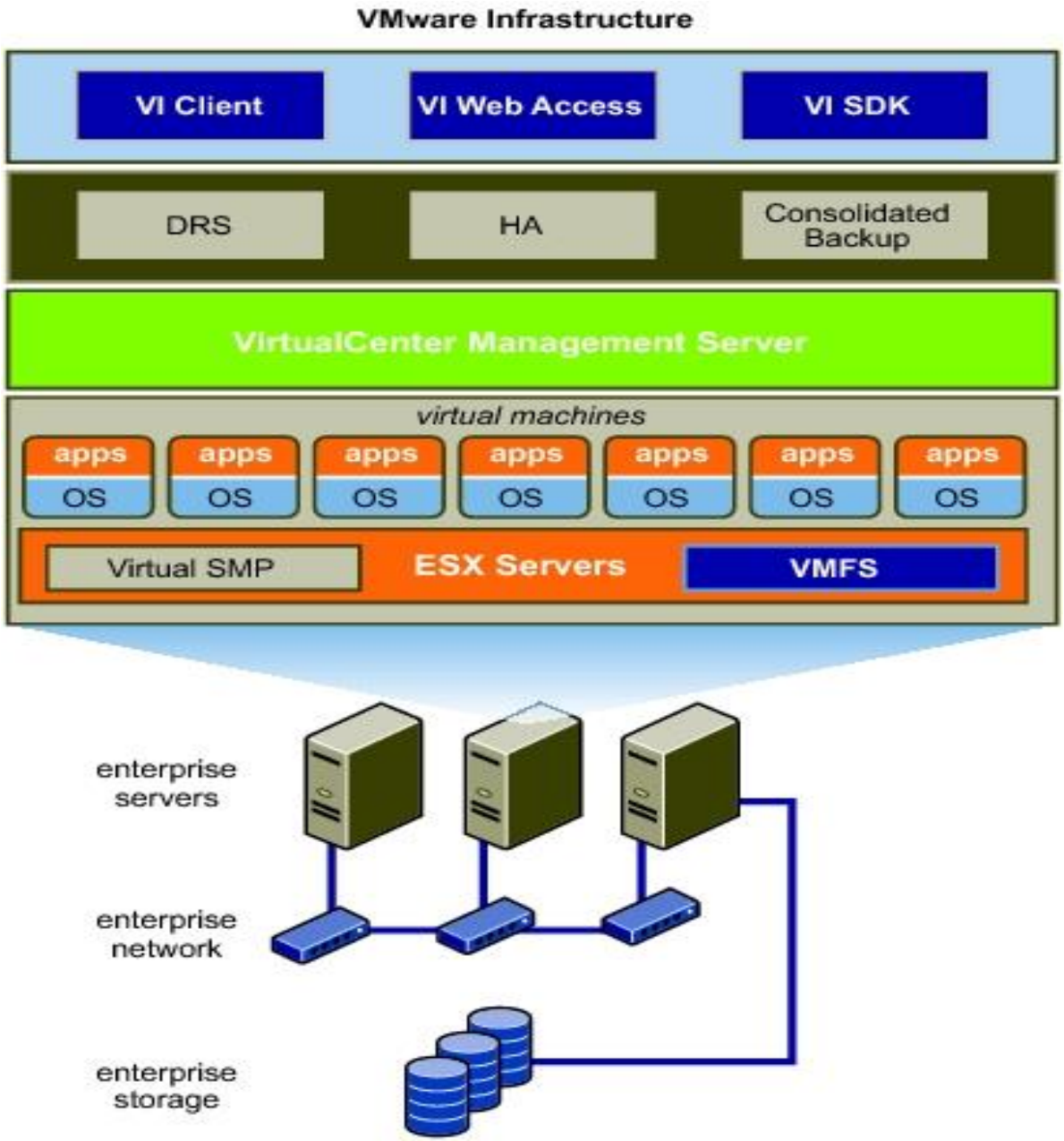


Hypervisor Architectures Vmware



VMware Workstation Architecture

Hypervisor Architectures Vmware



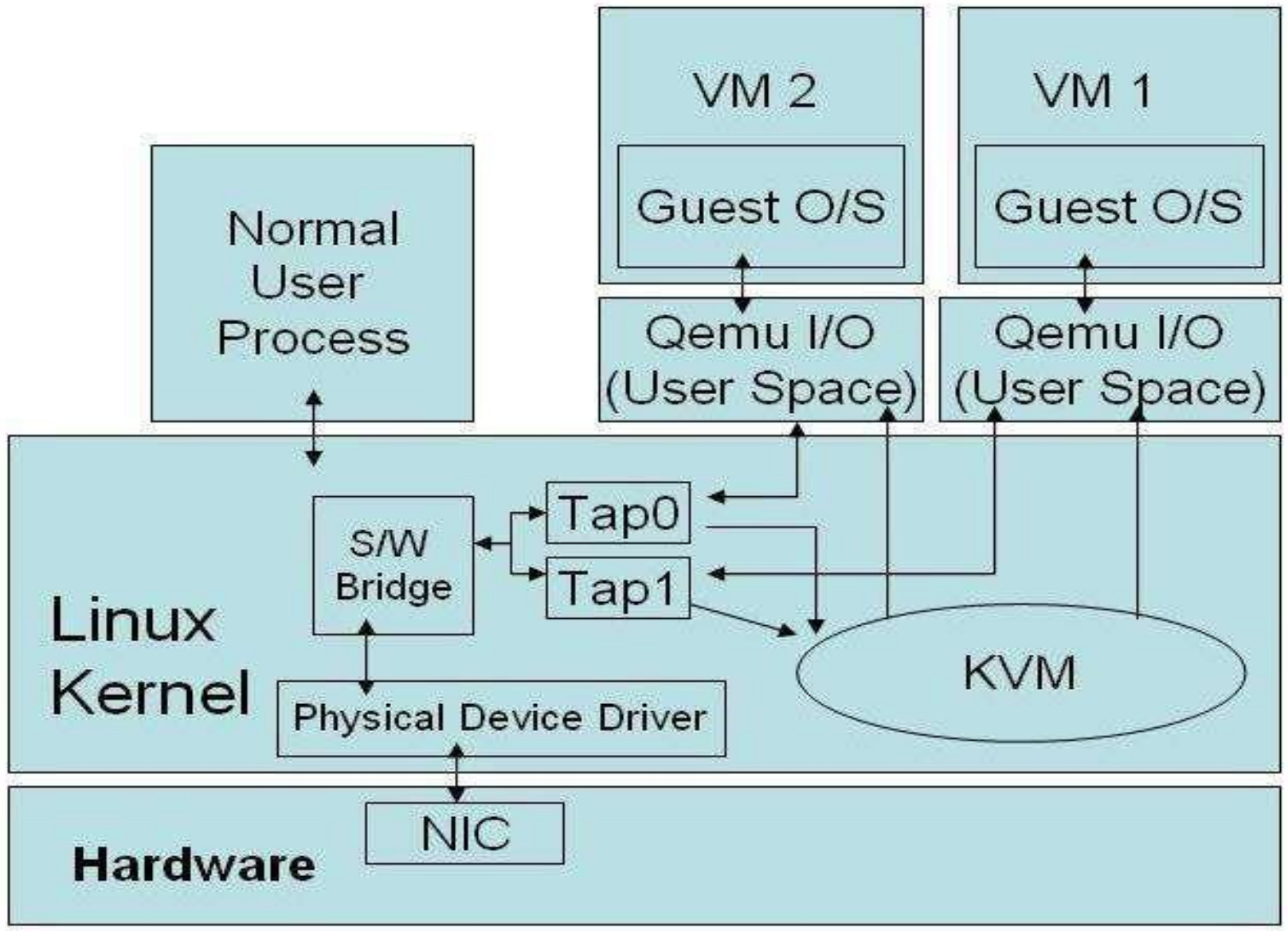
Hypervisor Architectures Vmware

- VMware Infrastructure is a virtualization suite for infrastructure that provides complete overview of :
  - application availability
  - Virtualization
  - resource optimization
  - management and operational automation.

- VMware Infrastructure integrates and virtualizes the hardware resources among two or more systems.

- In the virtual environment, it provides virtual resource pools to the datacentre.

Hypervisor Architectures KVM



Hypervisor Architectures KVM

- Each virtual CPU appears as a regular Linux process
- Emulation is handle by a modified version of QEMU (QuickEmulator)
- Linux as a VMM
- Resource management
- The KVM control interface
- Emulation of hardware
- It is free.
- It is a part of Linux
- Powerful CPU virtualization on Intel and AMD platforms, leverages hardware virtualization and Linux kernel, memory management, I/O capabilities
- Real time scheduling
- Powerful GUI
- Powerful command line scripting tools for better
- productivity
- Leverages security, kernel capabilities and memory management of Linux

Multi-Tenancy

- It is the capability to service multiple organization / client from a shared, common hosting environment by sharing the same physical instance and version of the cloud application.

- Multi tenancy in cloud computing is typically done by multiplexing the execution of virtual machine from potentially different users on the same physical server.

- This feature allows one tenant to customize an application’s interface and business logic without affecting the functionality or availability of the application for all other tenants.

- An application should be easily upgraded without breaking other specific customization.

Approaches to Multi-Tenancy

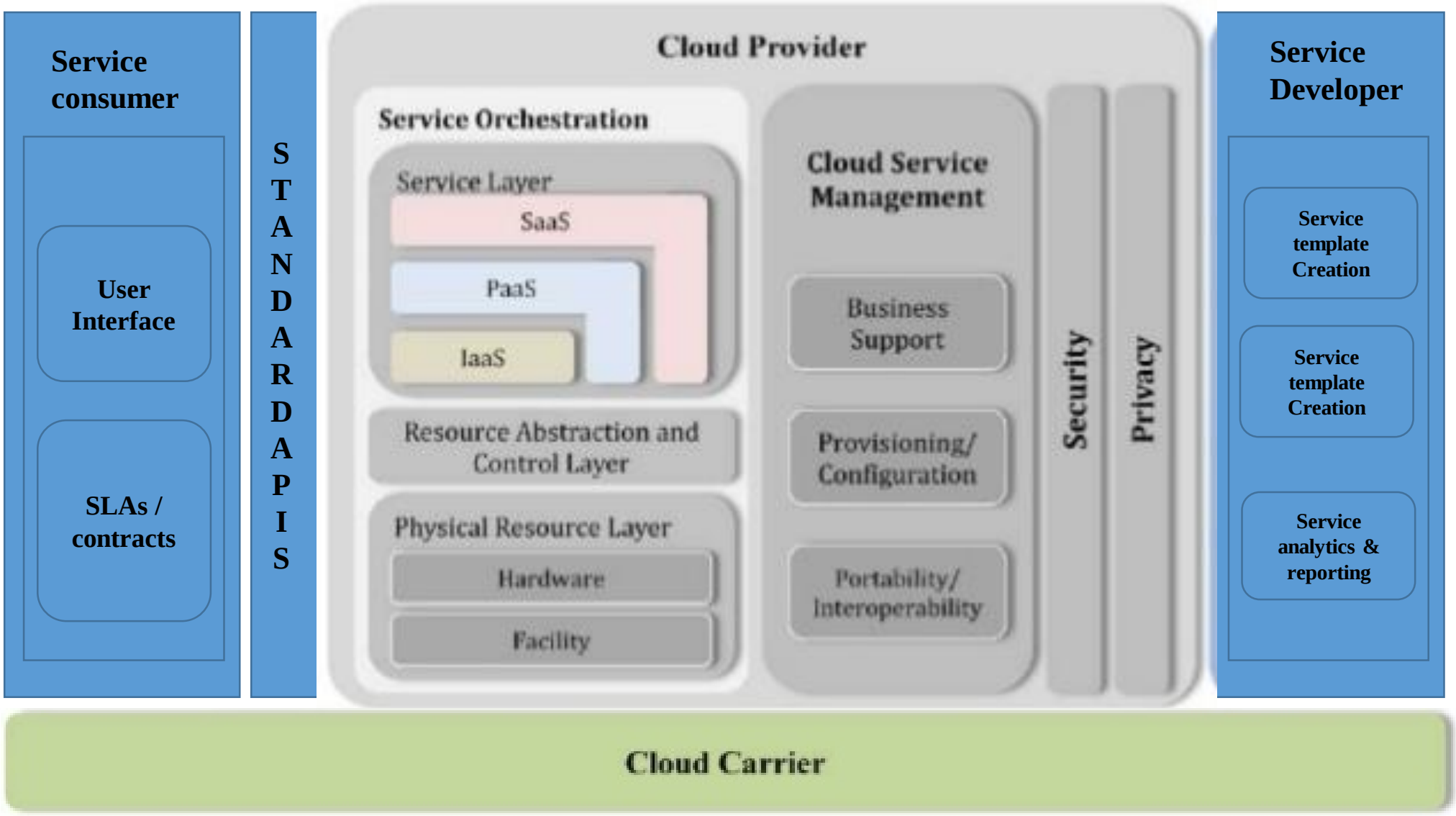
- Shared middleware approach with single application instance
- Shared middleware approach with multiple application instances sharing a common address space
- Shared middleware with multiple application instances each in a separate address space
- Virtualized approached used to run multiple virtualized tenants running on single instance of the middleware, operating system and servers

Architecture model for Cloud Computing

- A cloud computing architecture model is divided into functional component, building blocks, and other key elements such as actors, interfaces, templates, data sources and systems with all indication of interrelationship among these elements.

- Service consumers use the services provided through the cloud, service providers manage the cloud infrastructure and service developers develop the cloud service applications themselves.

Architecture model for Cloud Computing



Architecture model for Cloud Computing

- **Cloud Service Provider:** It is responsible for creation and maintenance of the hardware infrastructure that supports cloud computing applications.
- It makes services available to cloud service consumer (clients) at agreed service levels and costs.
- The services may be of any type or complexity.
- The provider manages the technical infrastructure required for providing the services and provides billing and other reports to the consumer.

Architecture model for Cloud Computing

- **The Cloud Service Consumer:** It represents an organization or individuals who contract for services with cloud service providers to use their services.
- The cloud service consumer could be another cloud that in turn is a provider to other consumers.
- The consumer is responsible for selecting the appropriate services, arranging payments for the services and performing the administration necessary to use those services such as managing user identities.

- **Cloud Service Developers:** Designs and implements the components of a service.
- The developers describes the services in a service template.
- The developer interacts with the cloud service provider to deploy the service components, based on the description in the templates, which the provider may customize before making them available as a service offerings to service consumer.

Reference Links:

- https://www.javatpoint.com/advantages-and-disadvantages-of-cloud-computing
- https://www.ijcaonline.org/archives/volume179/number32/etawi-2018-ijca-916732.pdf
- https://www.focaloid.com/blog/hypervisor-and-its-types-in-cloud-computing
- https://www.geeksforgeeks.org/hypervisor/?ref=lbp