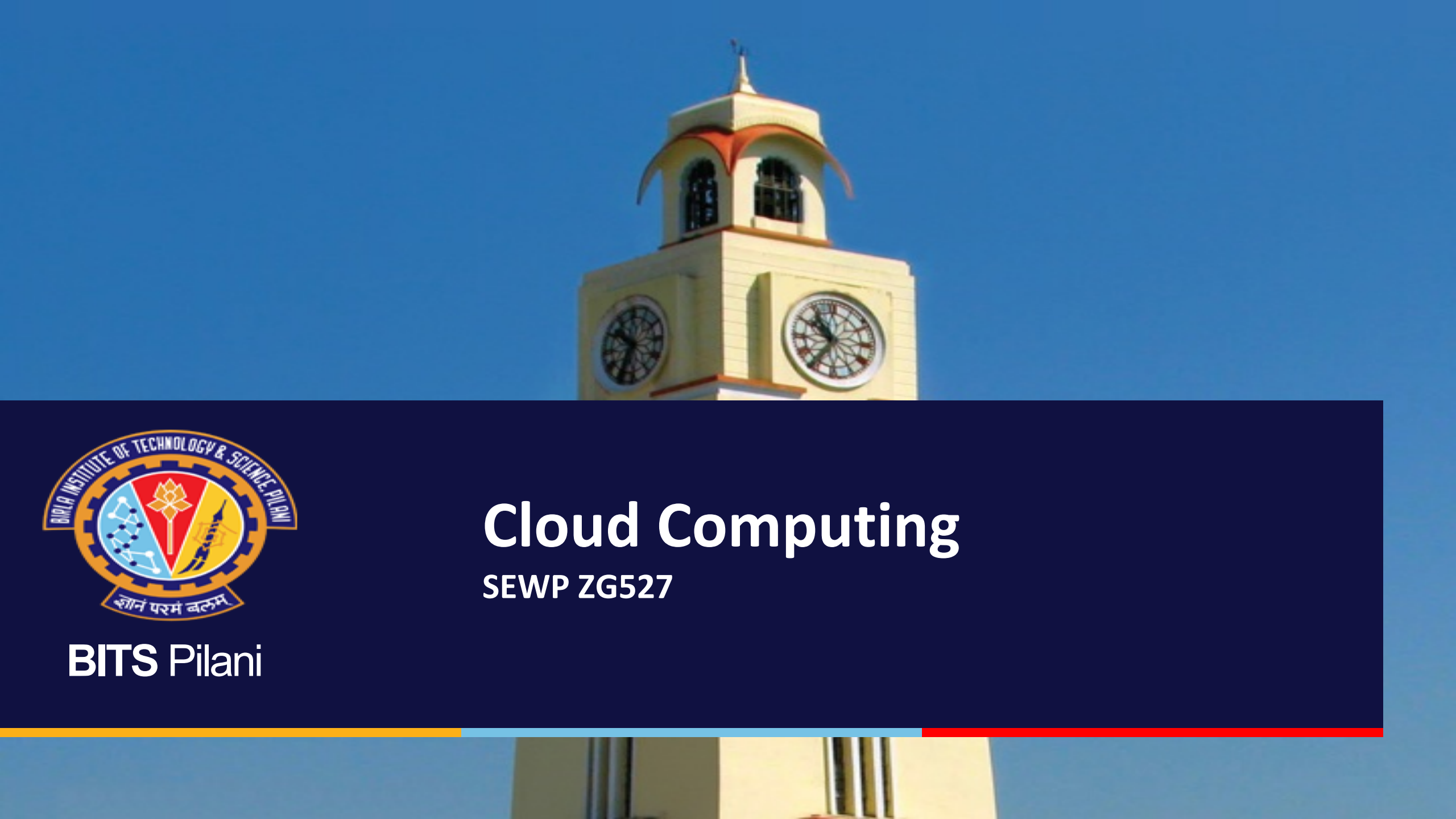

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Cloud Computing

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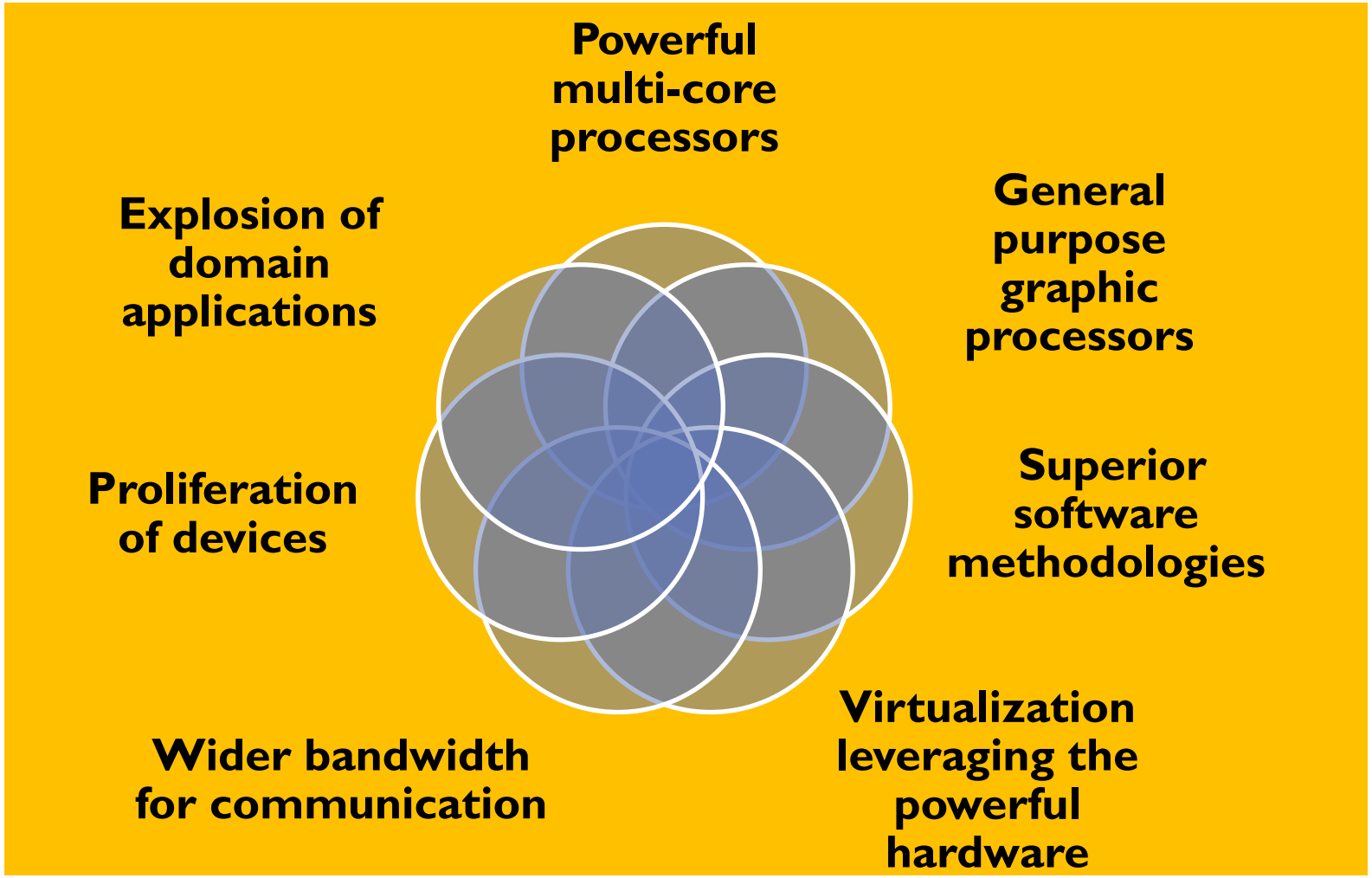
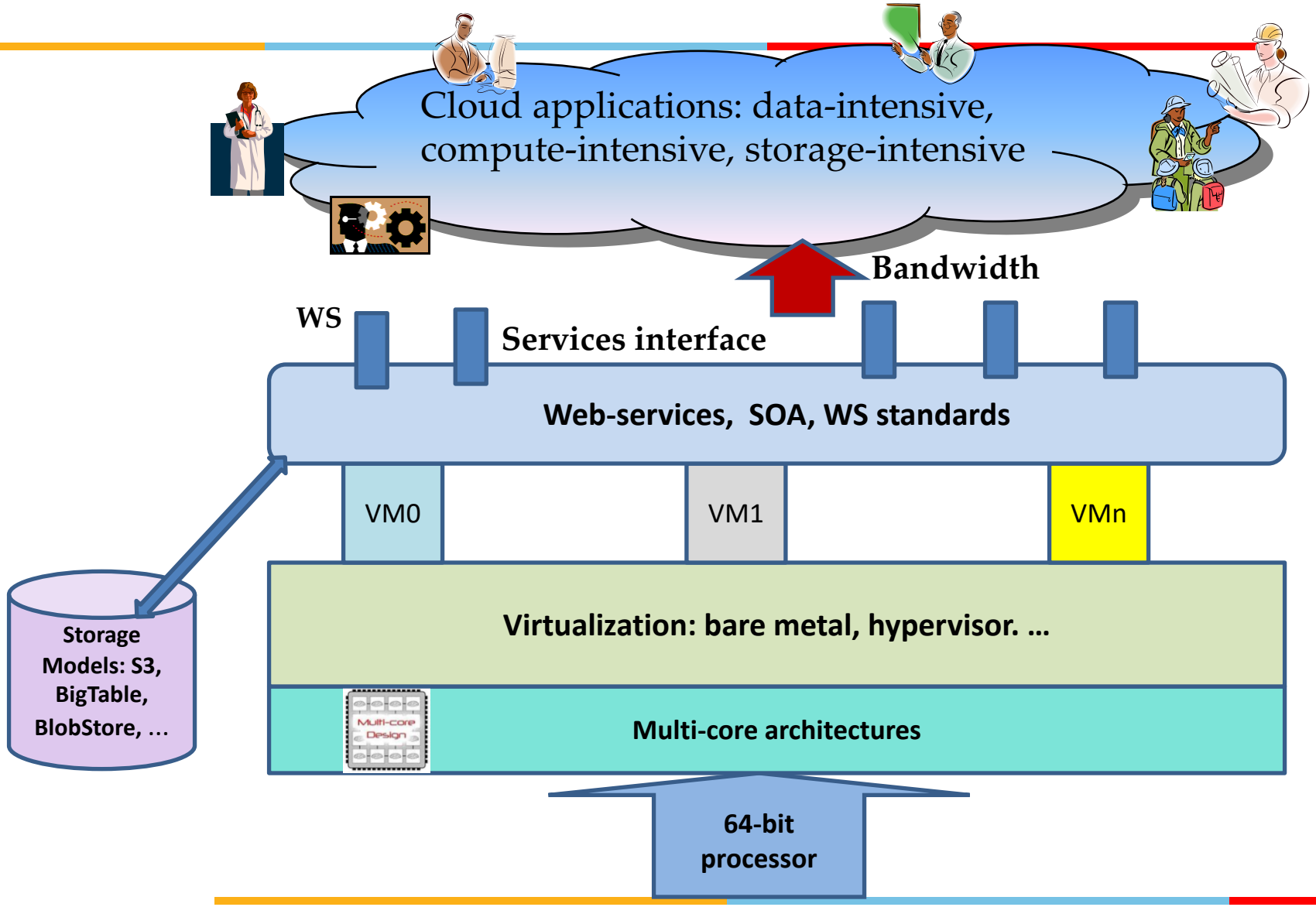
Motivation



1. Web Scale Problems
2. Web 2.0 and Social Networking
3. Information Explosion
4. Mobile Web

Technology Advances



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 cont.…

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

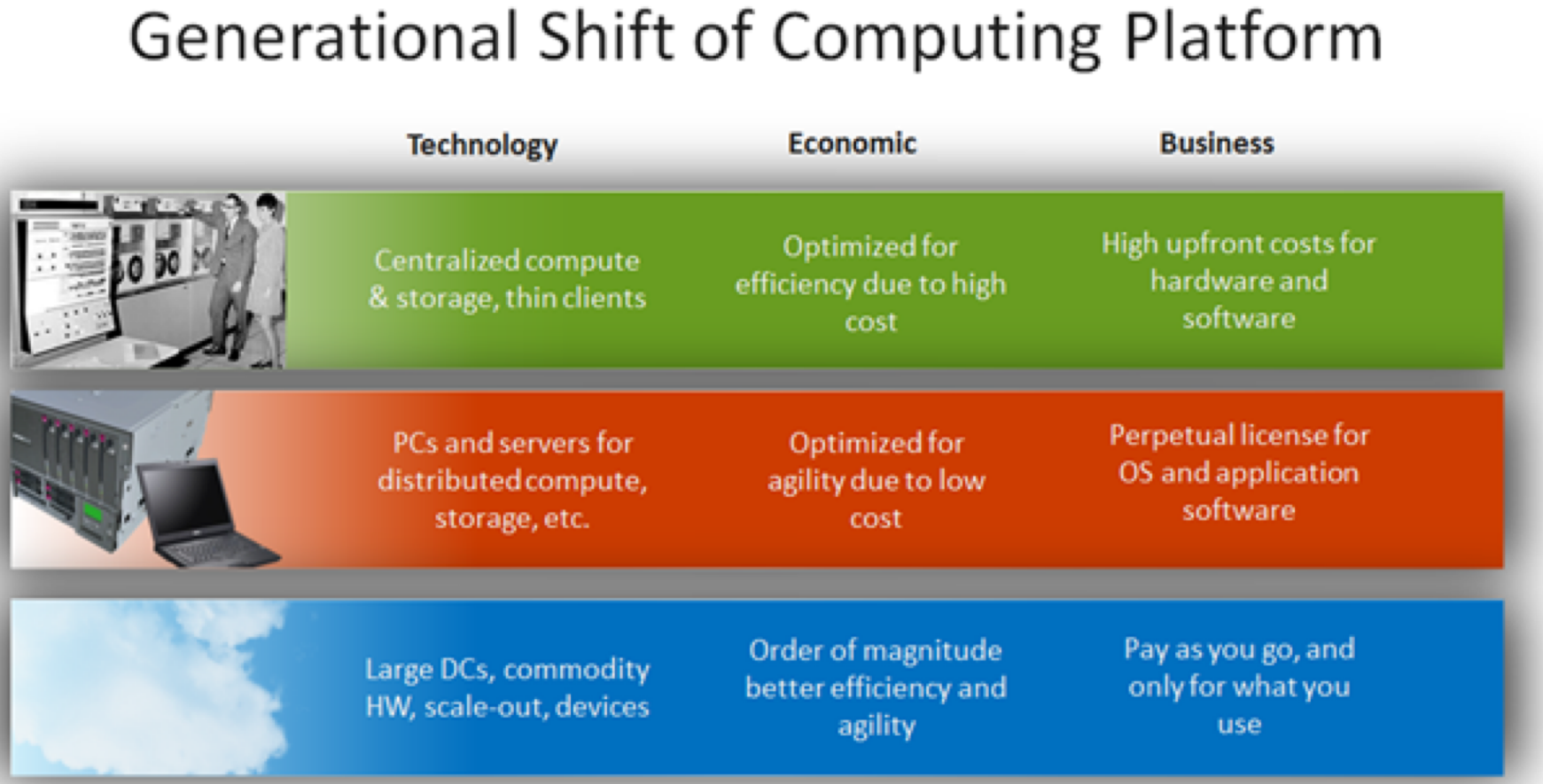
Pay for use and as needed, elastic

- scale up and down in capacity and functionalities

The hardware and software services are available to

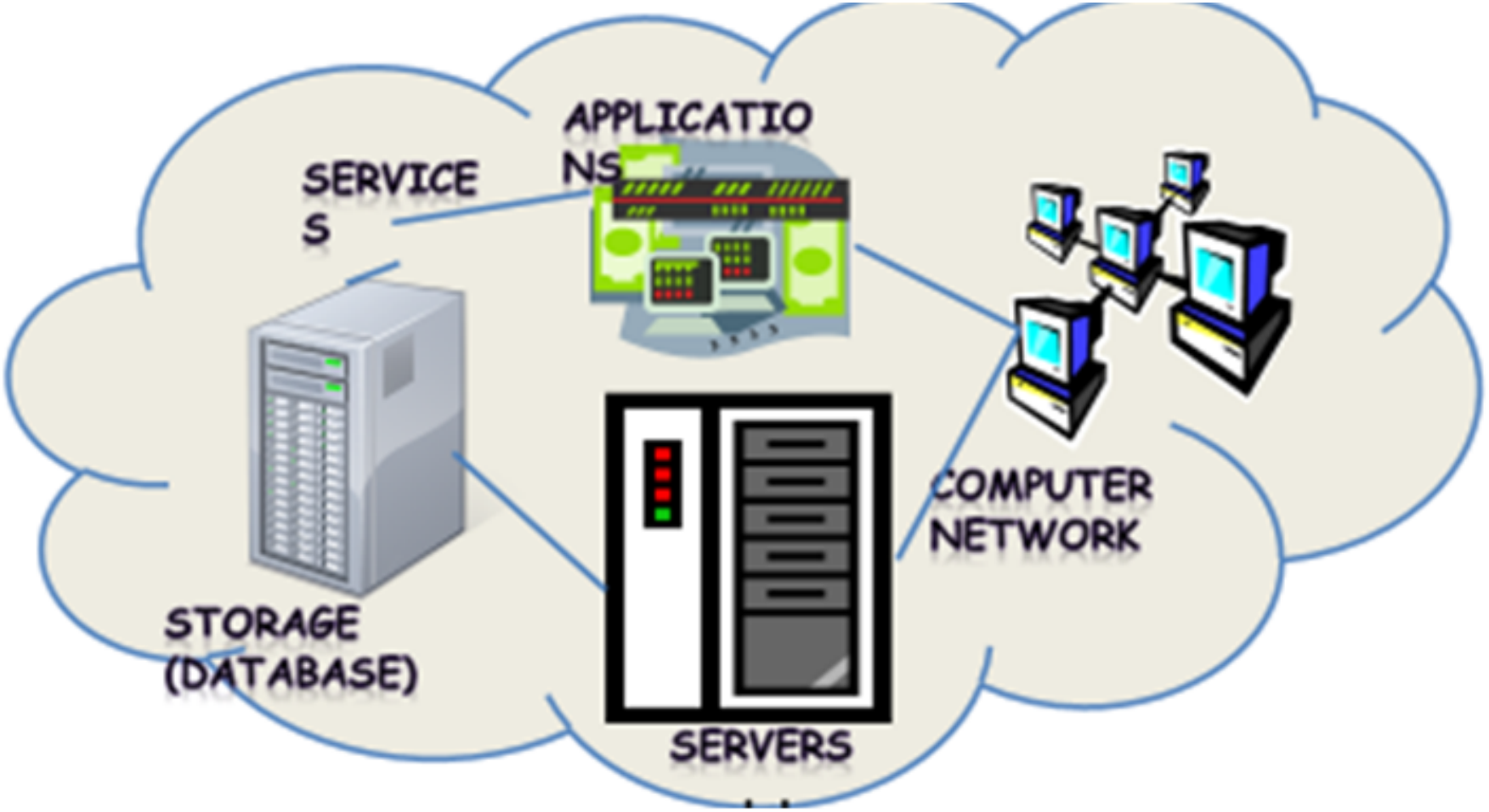
- general public, enterprises, corporations and businesses markets

Drivers for the new Platform

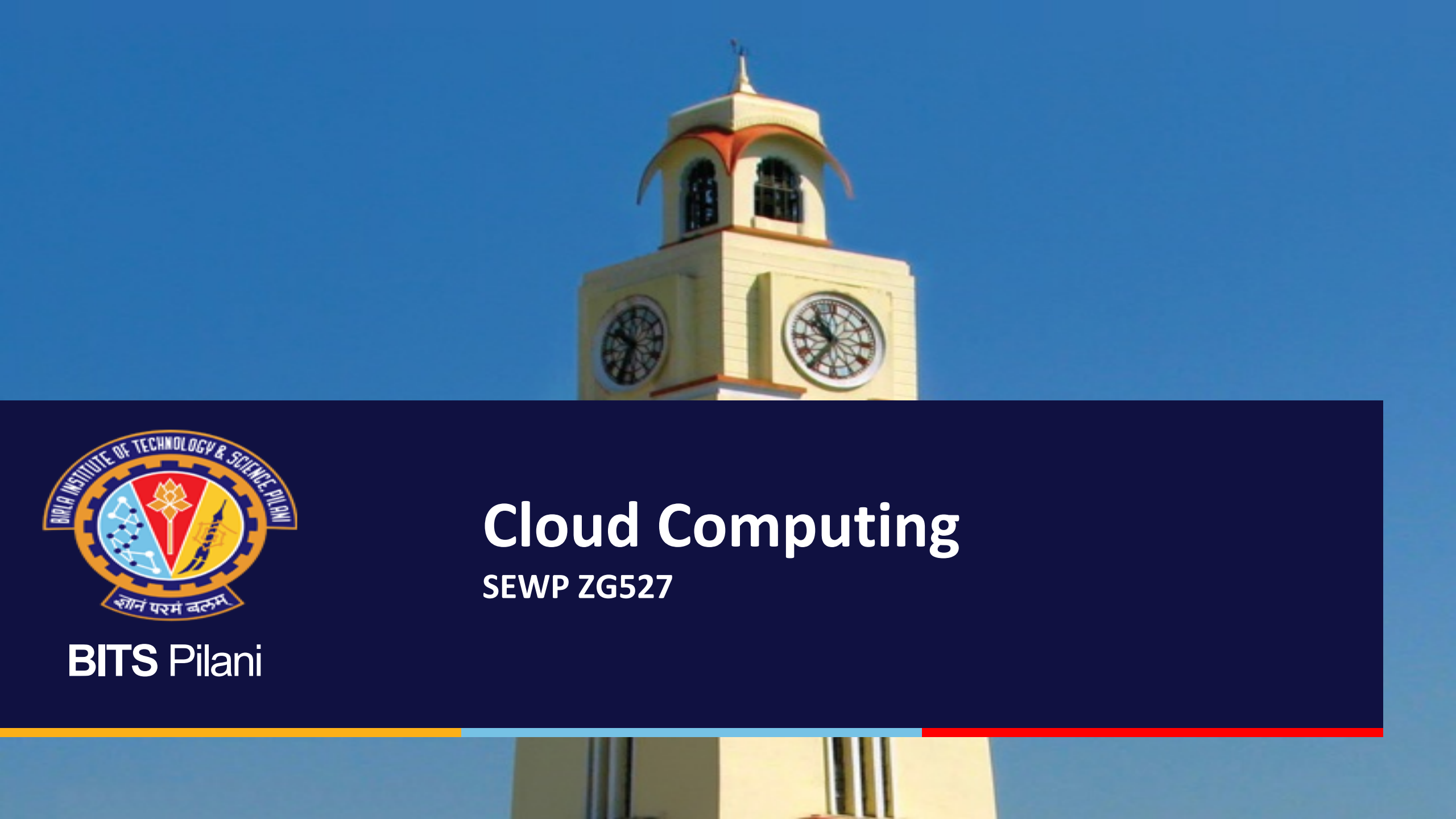


http://blogs.technet.com/b/yungchou/archive/2011/03/03/chou-s-theories-of-cloud-computing-the-5-3-2-principle.aspx

Cloud Summary



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



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Cloud Computing: Definition

The US National Institute of Standards (NIST) defines cloud computing as follows:

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.

3-4-5 rule of Cloud Computing

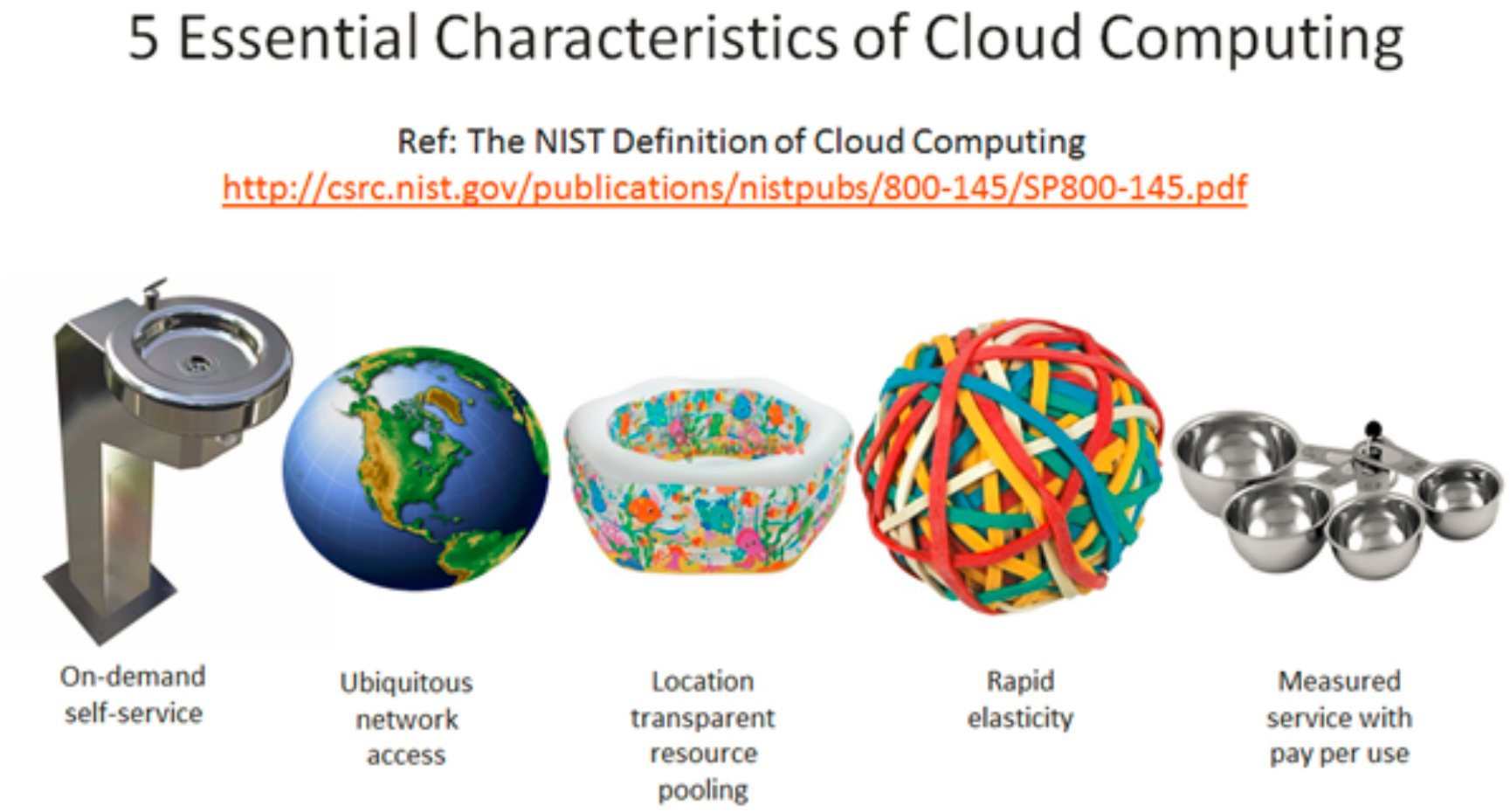
NIST specifies 3-4-5 rule of Cloud Computing

3 cloud service models or service types for any cloud platform

4 deployment models

5 essential characteristics of cloud computing infrastructure

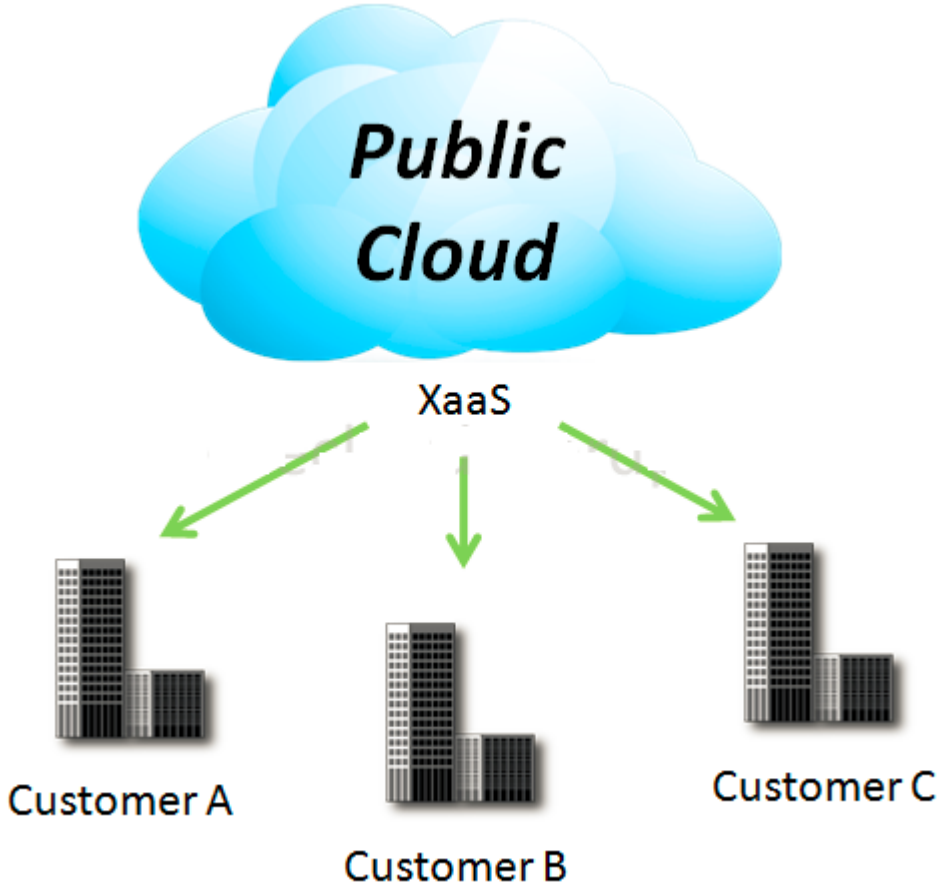
Characteristics of Cloud Computing



- On demand self-service
- Broad network access
- Resource pooling
- Rapid elasticity
- Measured service

4 Deployment Models

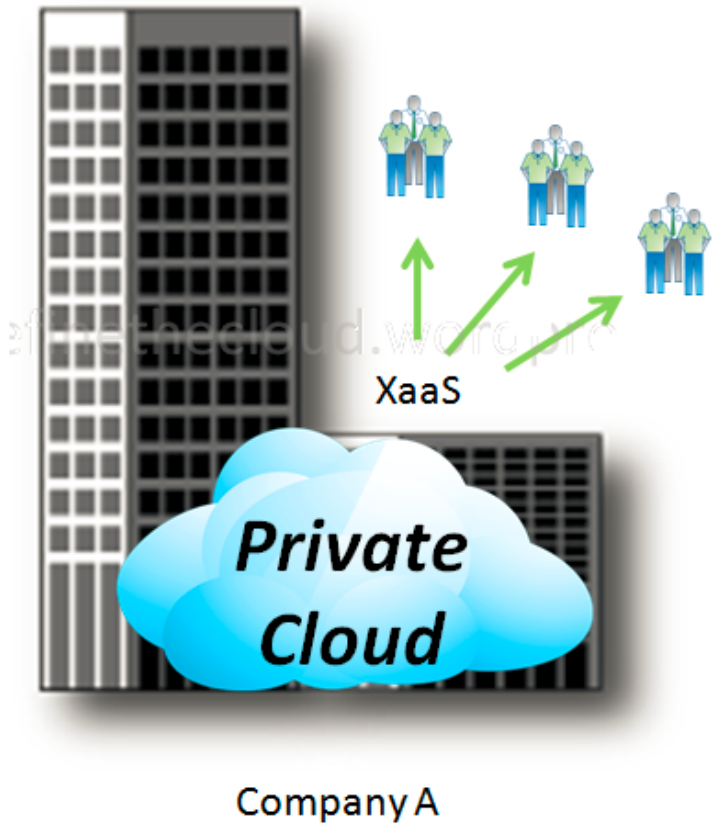
1. Public Cloud



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

4 Deployment Models

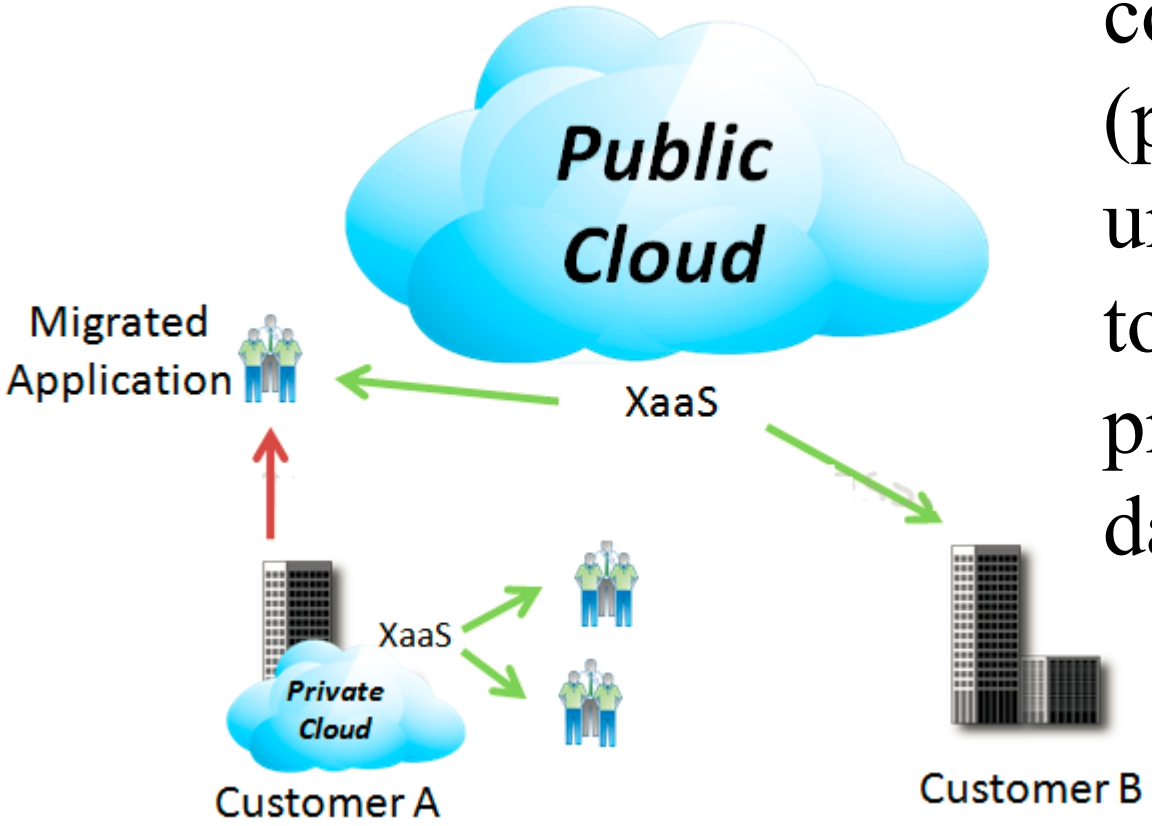
2. Private Cloud



The cloud infrastructure is operated solely for an organization. It may be managed by the organization or a third party and may exist on premise or off premise.

4 Deployment Models

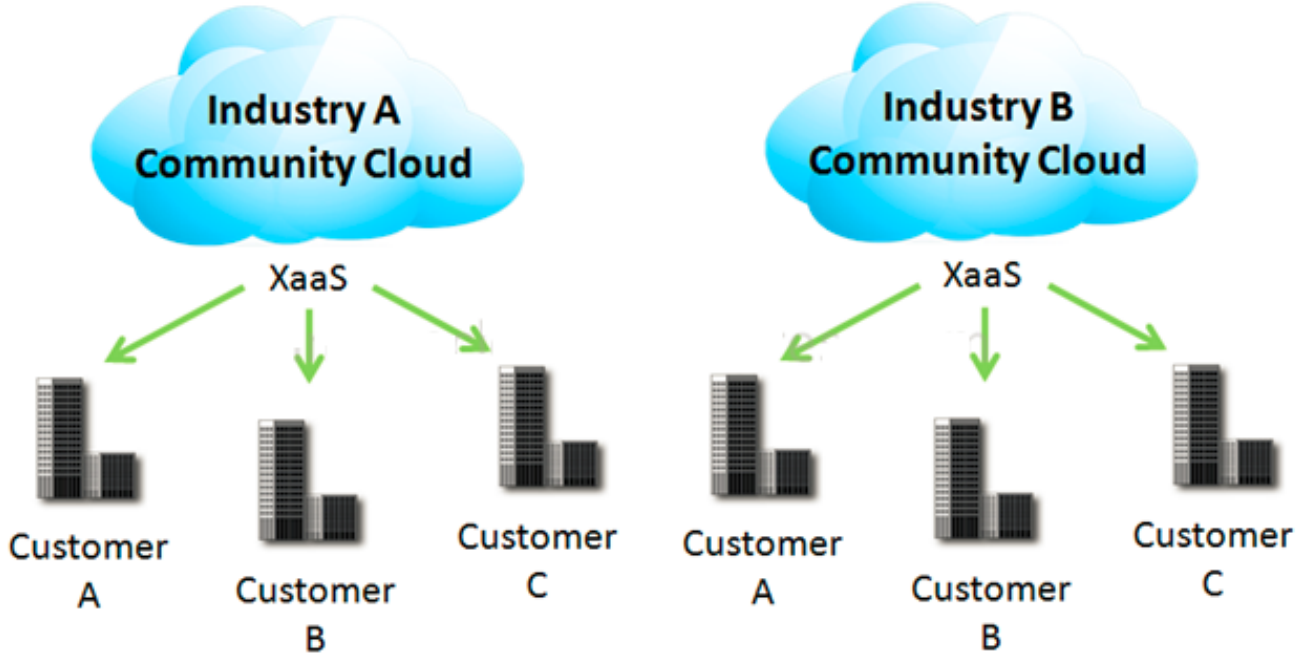
3. Hybrid Cloud



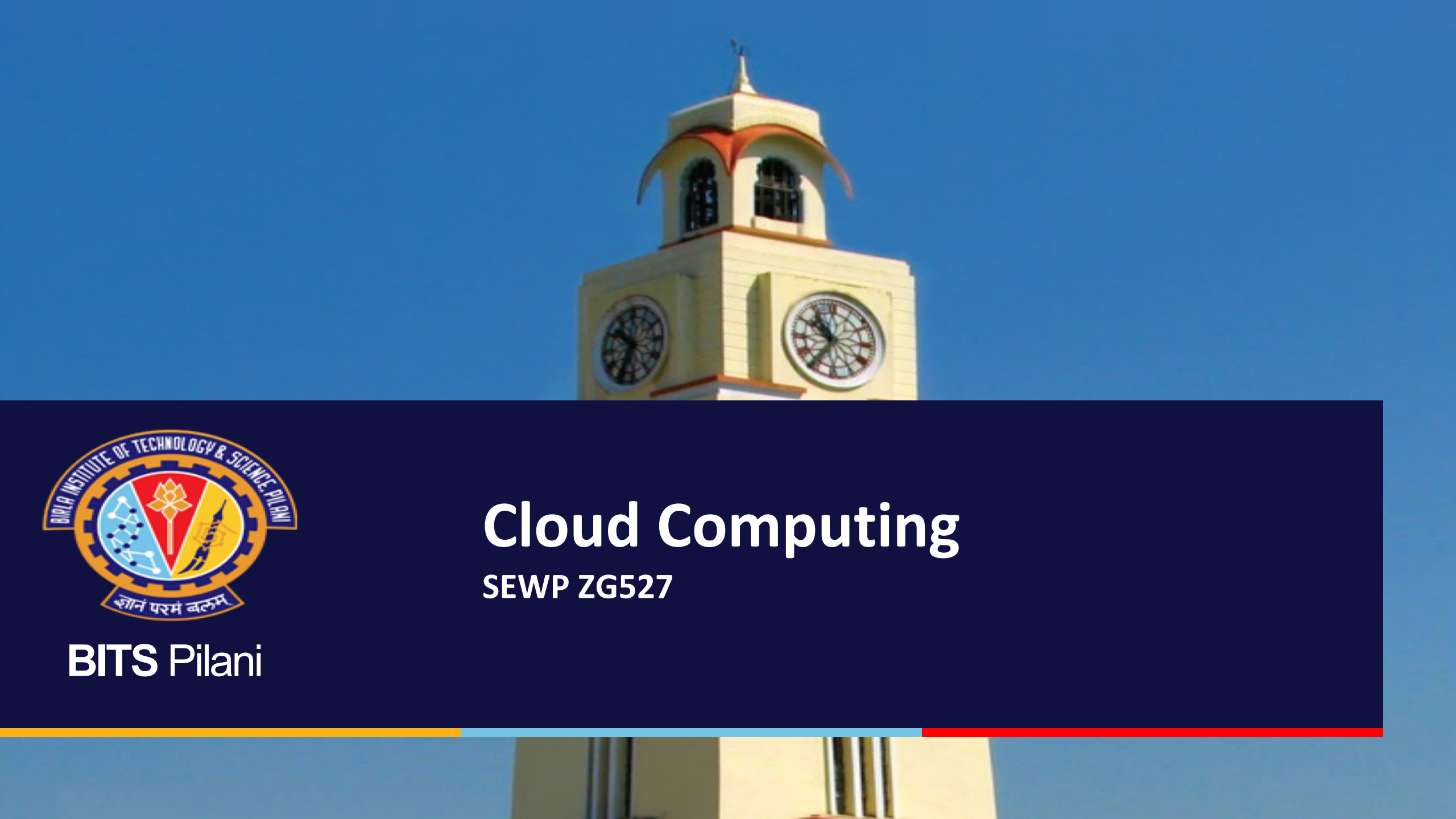
The cloud infrastructure is a composition of two or more clouds (private or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability

4 Deployment Models

4. Community Cloud



Community Clouds are when an 'infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be managed by the organizations or a third party and may exist on premise or off premise' according to NIST.
A community cloud is a cloud service shared between multiple organizations with a common tie/goal/objective.
E.g. OpenCirrus



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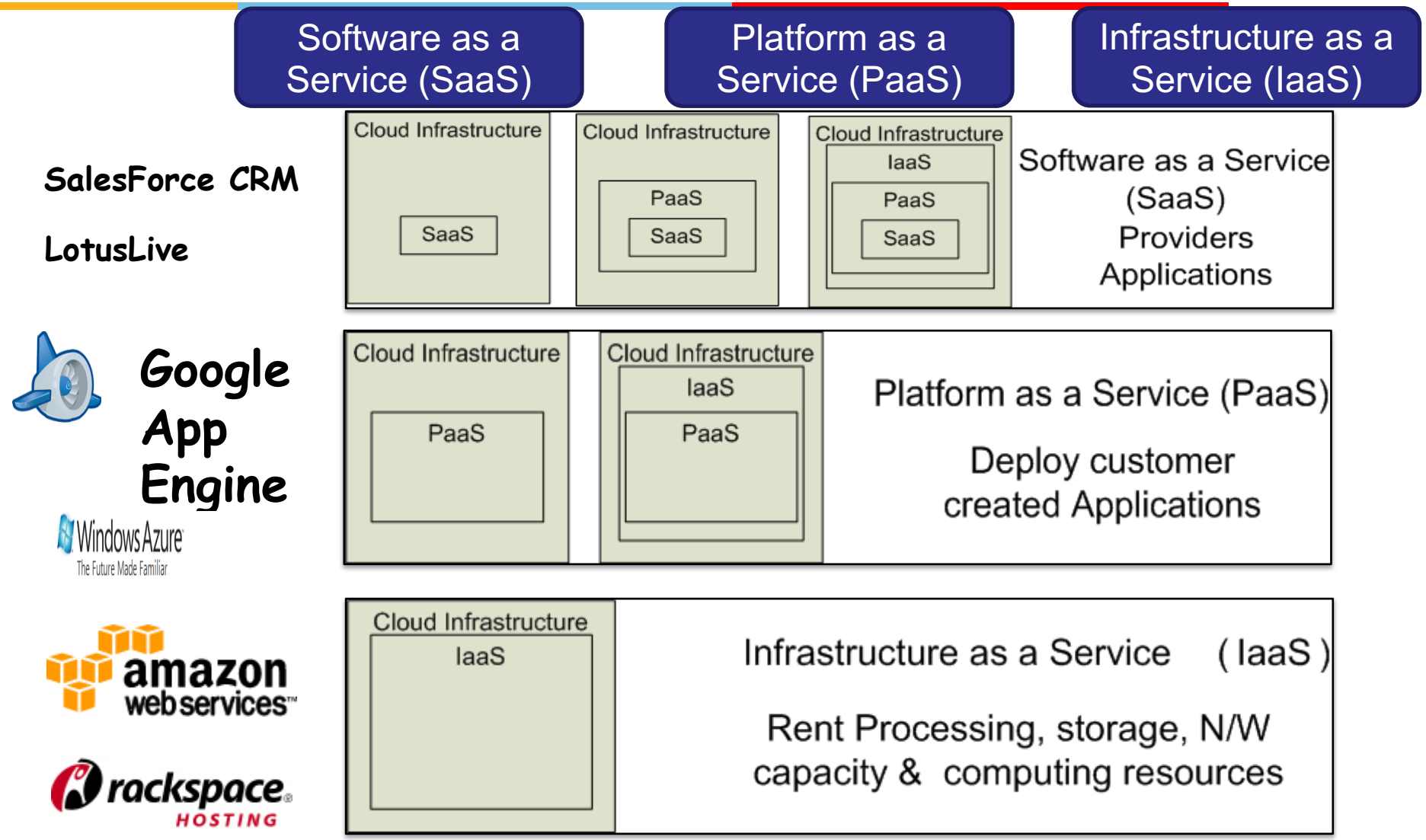
3 Cloud Service Models



Software as a Service (SaaS)

Software as a service features a complete application
offered as a service on demand.
A single instance of the software runs on the cloud and services multiple end users or client organizations.
E.g. salesforce.com , Google Apps

Platform as a Service

Platform as a service encapsulates a layer of software and provides it as a service that can be used to build higher-level services.

2 Perspectives for PaaS :-

1. Producer:- Someone producing PaaS might produce a platform by integrating an OS, middleware, application software, and even a development environment that is then provided to a customer as a service.

2. Consumer:-Someone using PaaS would see an encapsulated service that is presented to them through an API. The customer interacts with the platform through the API, and the platform does what is necessary to manage and scale itself to provide a given level of service.

Virtual appliances can be classified as instances of PaaS.

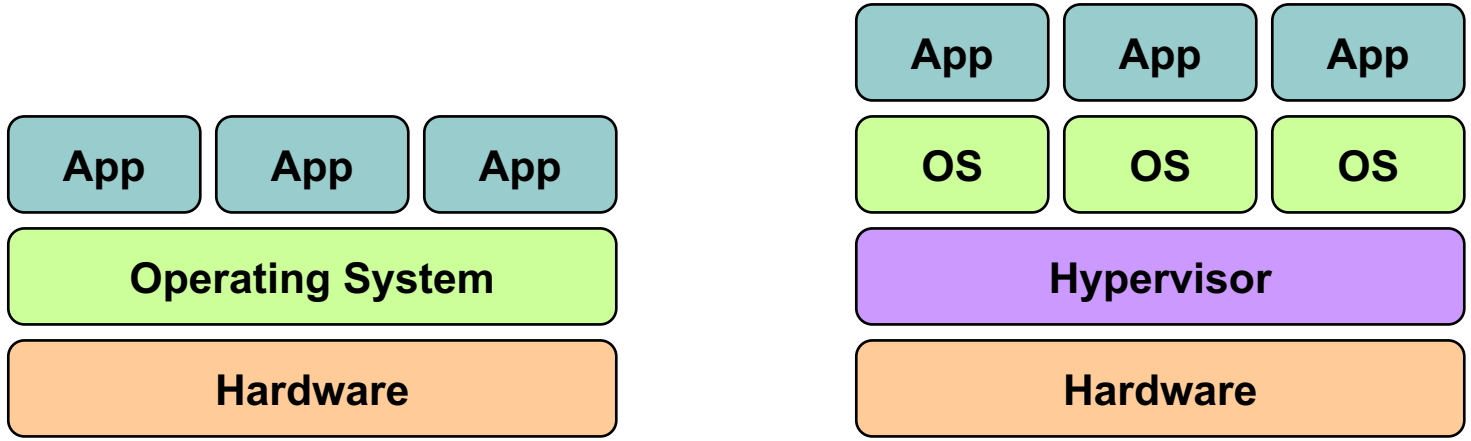
Infrastructure as a Service

Infrastructure as a service delivers basic storage and computing capabilities as standardized services over the network.

Servers, storage systems, switches, routers , and other systems are pooled and made available to handle workloads that range from application components to high-performance computing applications.

Cloud Infrastructures

Key Technology is Virtualization



Virtualization plays an important role as an enabling technology for datacentre implementation by abstracting compute, network, and storage service platforms from the underlying physical hardware

Cloud Providers Characteristics

- Provide on-demand provisioning of computational resources
- Use virtualization technologies to lease these resources
- Provide public and simple remote interfaces to manage those resources
- Use a pay-as-you-go cost model, typically charging by the hour
- Operate data centers large enough to provide a seemingly unlimited amount of resources to their clients

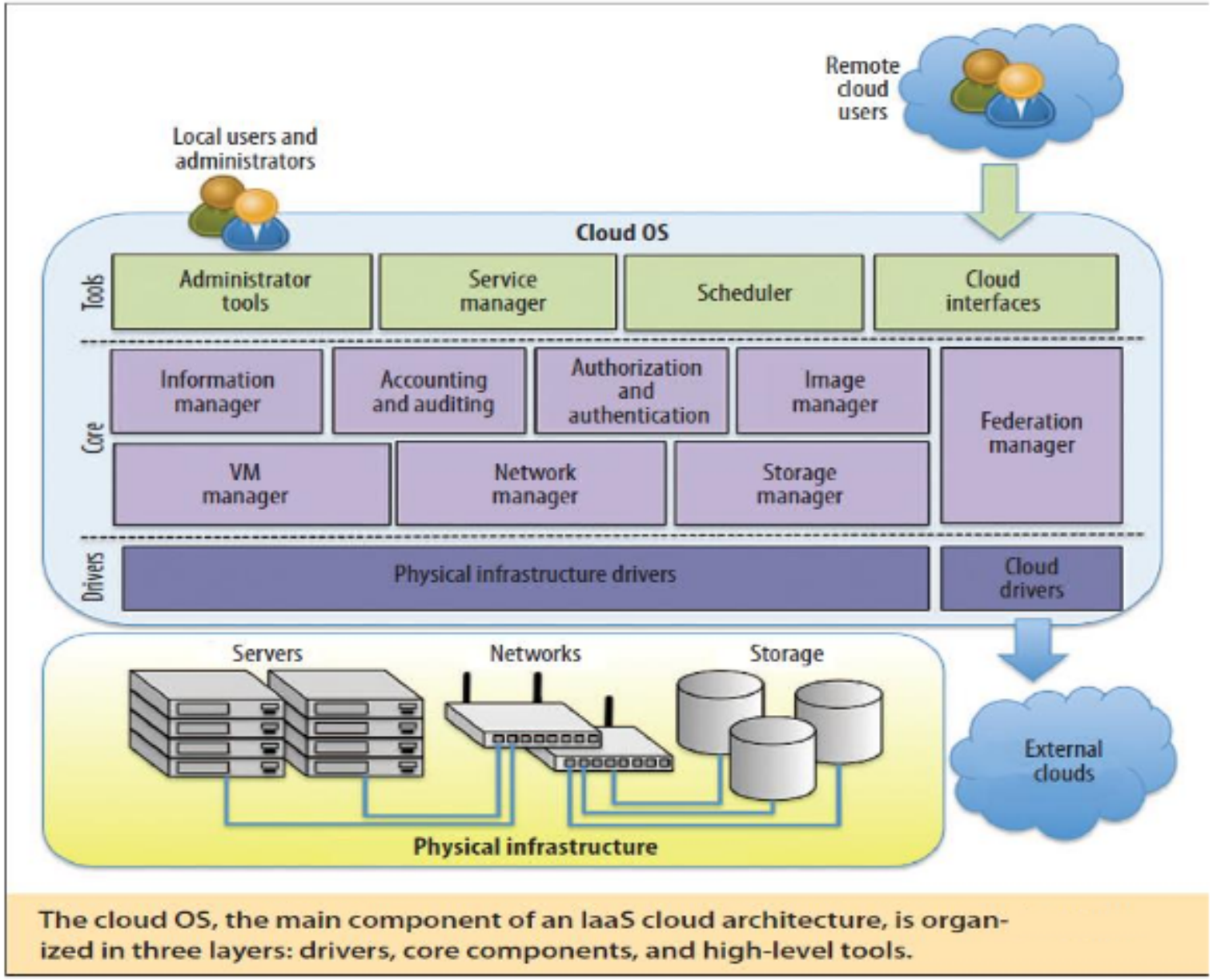
Management of Virtualized Resources

Distributed Management of Virtual Machines

Reservation-Based Provisioning of Virtualized Resources

Provisioning to Meet SLA Commitments

The Cloud OS



The cloud OS, the main component of an IaaS cloud architecture, is organized in three layers: drivers, core components, and high-level tools.

The cloud operating system is responsible for:

1. managing the physical and virtual infrastructure,
2. orchestrating and commanding service provisioning and deployment
3. providing federation capabilities for accessing and deploying virtual resources in remote cloud infrastructures

Cloud Computing

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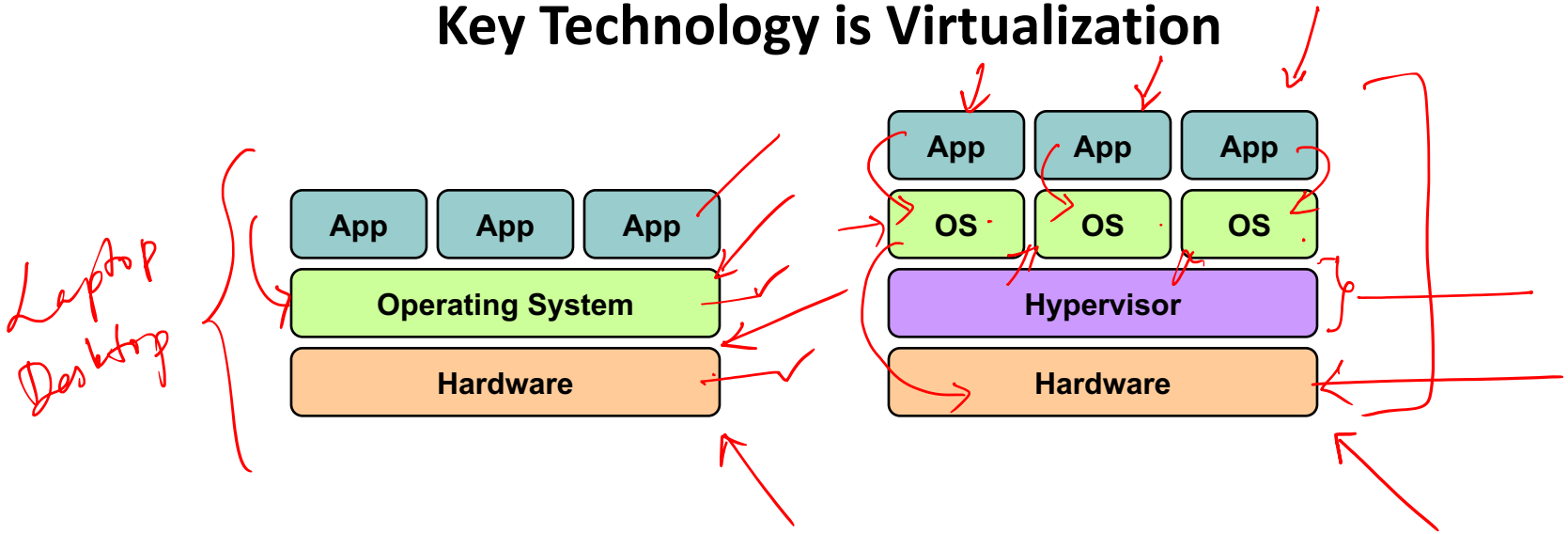
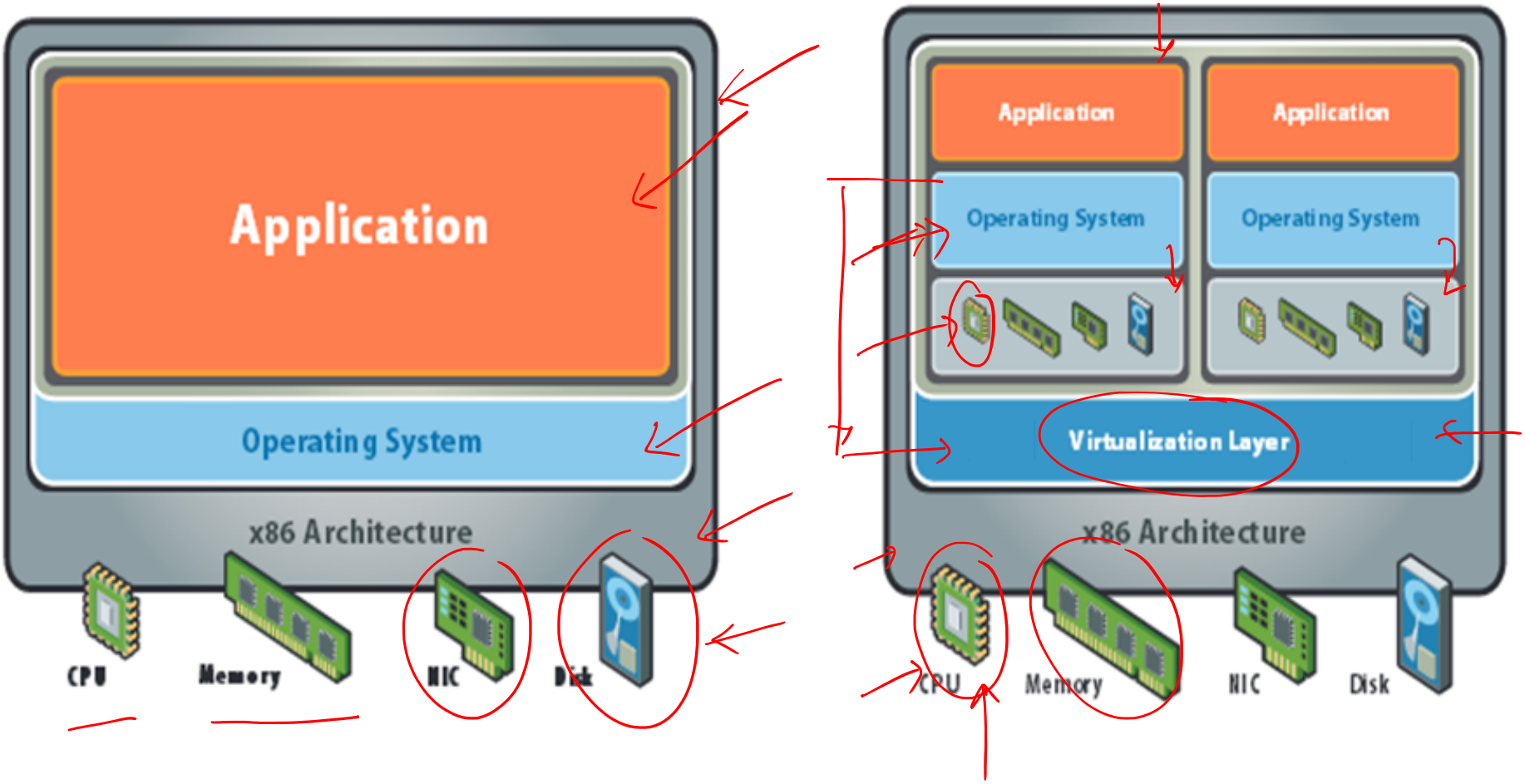
Technology made cloud possible

Key Technology is Virtualization



Virtualization plays an important role as an enabling technology for datacentre implementation by abstracting compute, network, and storage service platforms from the underlying physical hardware

What is Virtualization



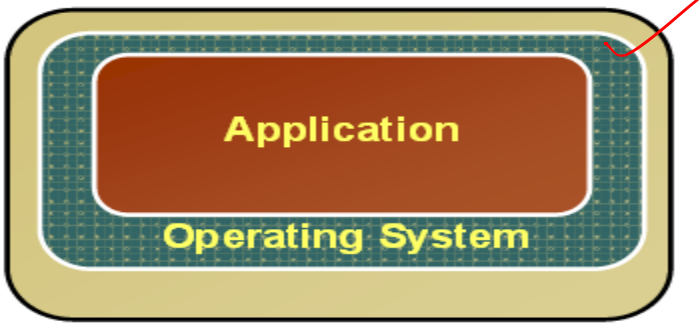
What does Virtualization do?

- Virtualization allows multiple operating system instances to run concurrently on a single computer
- It is a means of separating hardware from a single operating system.
- Each “guest” OS is managed by a Virtual Machine Monitor (VMM), also known as a hypervisor.
- Because the virtualization system sits between the guest and the hardware, it can control the guests’ use of CPU, memory, and storage, even allowing a guest OS to migrate from one machine to another.
- Instead of purchasing and maintaining an entire computer for one application, each application can be given its own operating system, and all those operating systems can reside on a single piece of hardware.
- Virtualization allows an operator to control a guest operating system’s use of CPU, memory, storage, and other resources, so each guest receives only the resources that it needs.

Changes after Virtualization

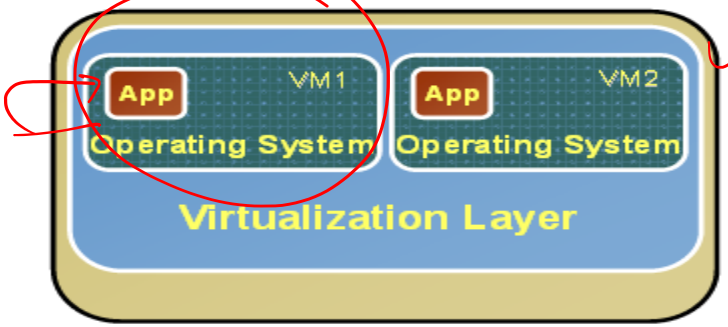
Before Virtualization

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



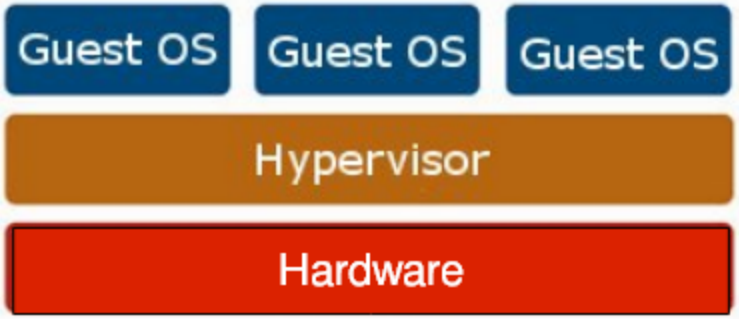
After Virtualization

- Hardware-independence of operating system and applications
- Virtual machines can be provisioned to any system
- Can manage OS and application as a single unit by encapsulating them into virtual machines



Virtualization Architecture

- OS assumes complete control of the underlying hardware.
- Virtualization architecture provides this illusion through a hypervisor/VMM.
- Hypervisor/VMM is a software layer which:
  - Allows multiple Guest OS (Virtual Machines) to run simultaneously on a single physical host
  - Provides hardware abstraction to the running Guest OSs and efficiently multiplexes underlying hardware resources



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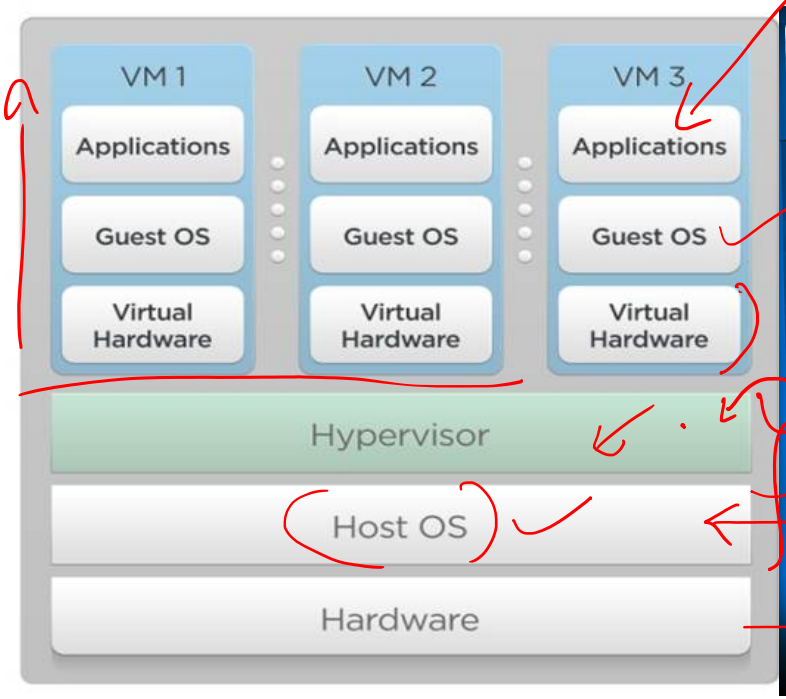
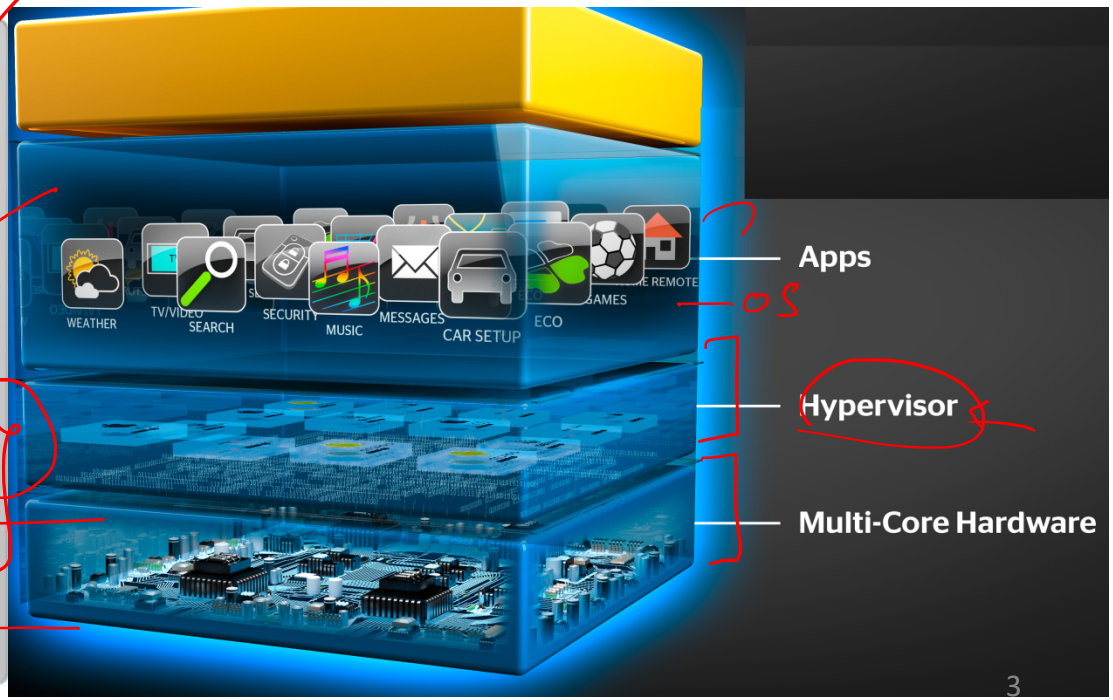
Hypervisor

A thin layer of software that generally provides virtual partitioning capabilities which runs directly on hardware, but underneath higher-level virtualization services. Sometimes referred to as a “bare metal” approach.





Hypervisor Design Goals

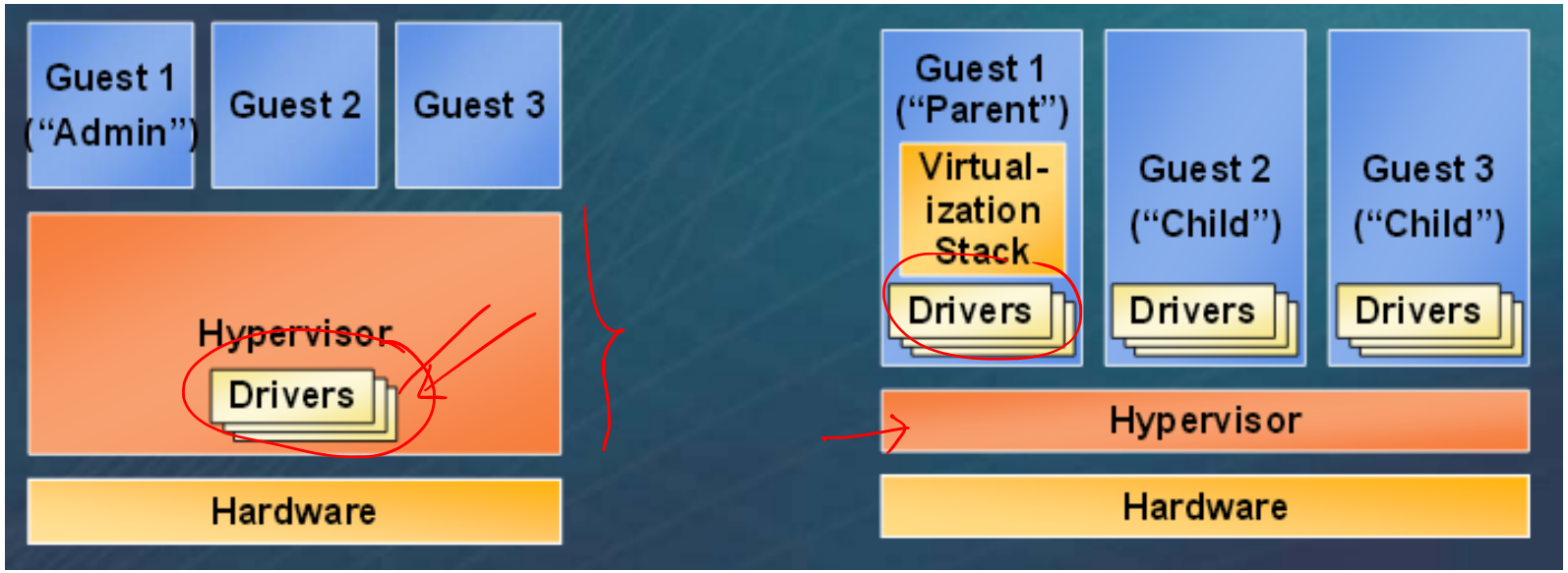
- Isolation
  - Security isolation
  - Fault isolation
  - Resource isolation
- Reliability
  - Minimal code base
  - Strictly layered design
  - Not extensible
- Scalability
  - Scale to large number of cores
  - Large memory systems

How Hypervisor goals are achieved?

- Partitioning Kernel
  - "Partition" is isolation boundary
  - Few virtualization functions; relies on virtualization stack
- Very thin layer of software
  - Microkernel
  - Highly reliable
  - Basis for smaller Trusted Computing Base (TCB)
- No device drivers
  - Drivers run in a partition
- Well-defined interface
  - Allow others to create support for their OSes as guests

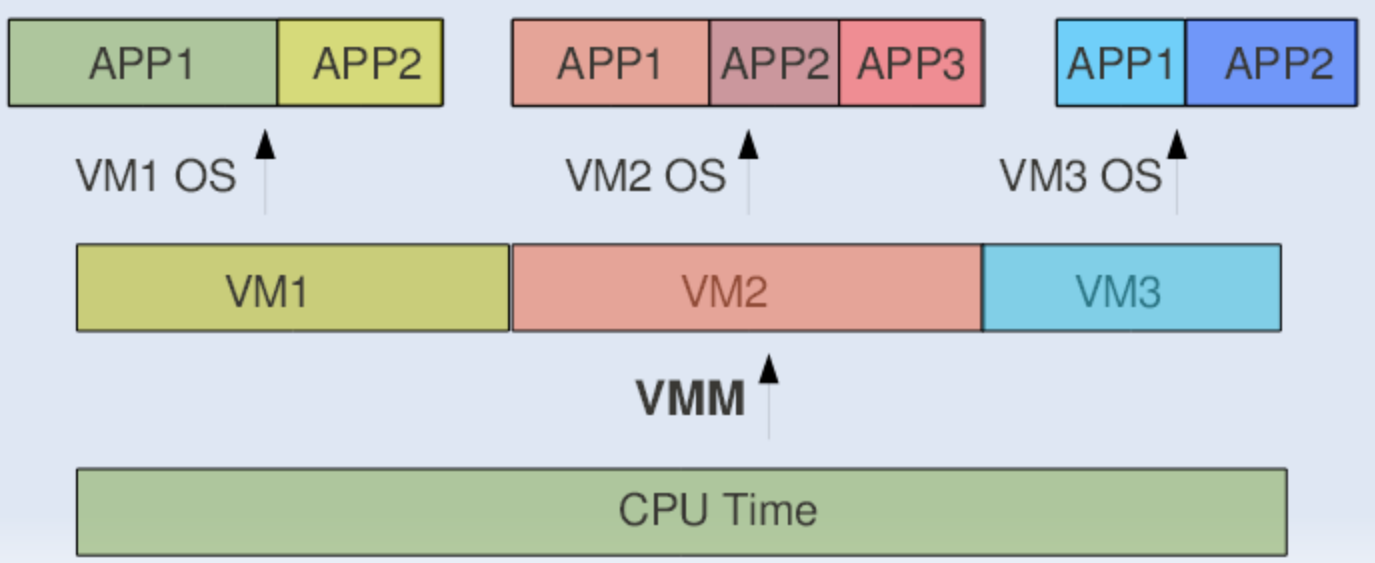
Hypervisor
Monolithic versus Microkernelized

- Monolithic hypervisor
  - Simpler than a modern kernel, but still complex
  - Contains its own drivers model
- Microkernelized hypervisor
  - Simple partitioning functionality
  - Increase reliability and minimize lowest level of the TCB
  - No third-party code
  - Drivers run within guests



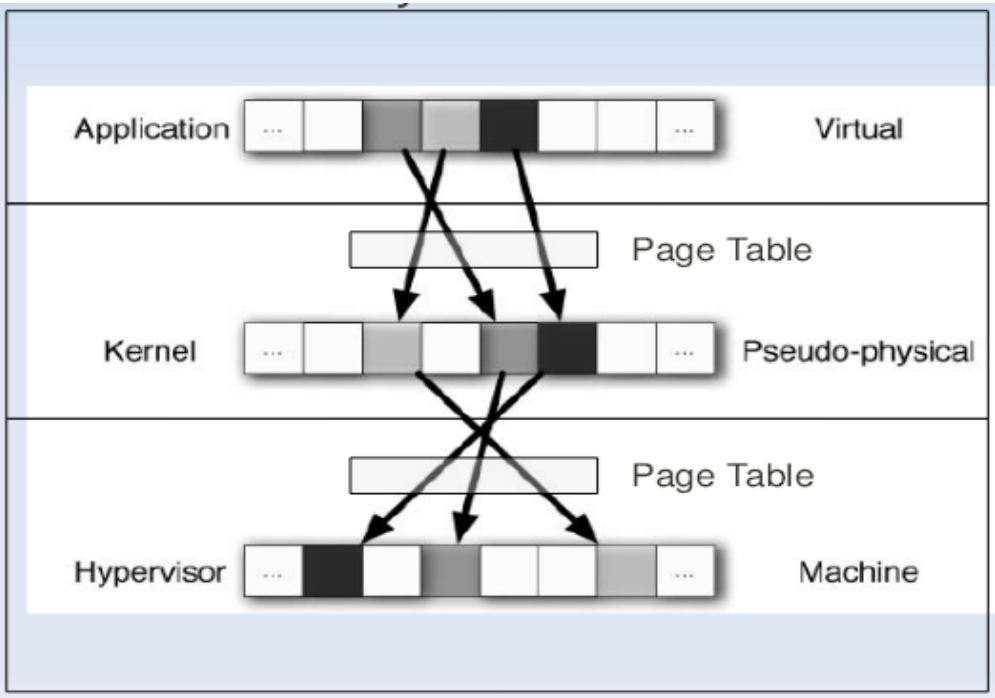
CPU Sharing

- VMM or Hypervisor provides a virtual view of CPU to VMs.
- In multi processing, CPU is alloted to the different processes in form of time slices by the OS.
- Similarly VMM or Hypervisor allots CPU to different VMs.



Memory Sharing

- In Multiprogramming there is a single level of indirection maintained by Kernel.
- In case of Virtual Machines there is one more level of indirection maintained by VMM



Applications use Virtual Addresses

Kernel translates Virtual Addresses to Pseudo-Physical Addresses

Hypervisor translates Pseudo-Physical Addresses to Machine addresses

IO Sharing

- Device needs to use Physical Memory location.
- In a virtualized environment, the kernel is running in a hypervisor-provided virtual address space
- Allowing the guest kernel to convey an arbitrary location to device for writing is a serious security hole
- Each device defines its own protocol for talking to drivers

Thanks!!!

Queries?

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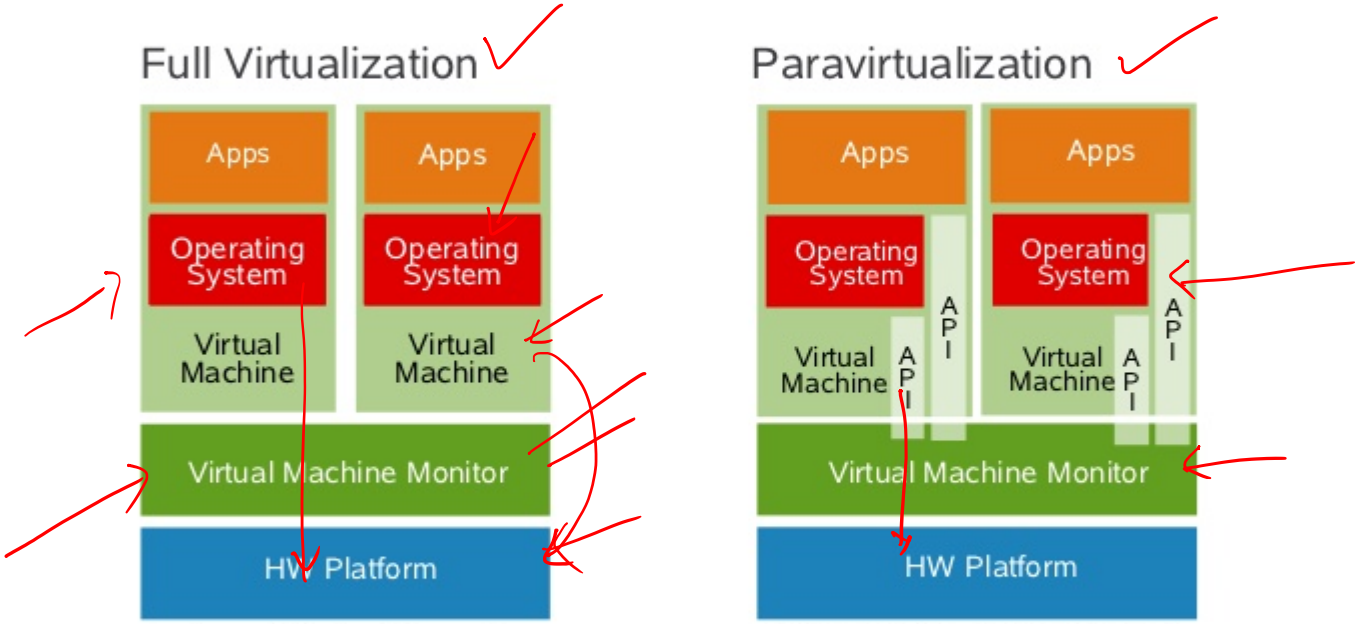
Approaches for Virtualization

Full & Paravirtualization Overview



Full Virtualization

- Full virtualization
- In its basic form known as “full virtualization” the hypervisor provides a fully emulated machine in which an operating system can run. VMWare is a good example.
- The biggest advantage to this approach is its flexibility: one could run a RISC-based OS as a guest on an Intel-based host.
- While this is an obvious approach, there are significant performance problems in trying to emulate a complete set of hardware in software.

ParaVirtualization

- Paravirtualization

- "Paravirtualization," found in the XenSource, open source Xen product, attempts to reconcile these two approaches. Instead of emulating hardware, paravirtualization uses slightly altered versions of the operating system which allows access to the hardware resources directly as managed by the hypervisor.
- This is known as hardware-assisted virtualization, and improves performance significantly.
- In order to retain flexibility, the guest OS is not tied to its host OS. Drastically different operating systems can be running in a hypervisor at the same time, just as they can under full virtualization.
- In this way, paravirtualization can be thought of as a low-overhead full virtualization

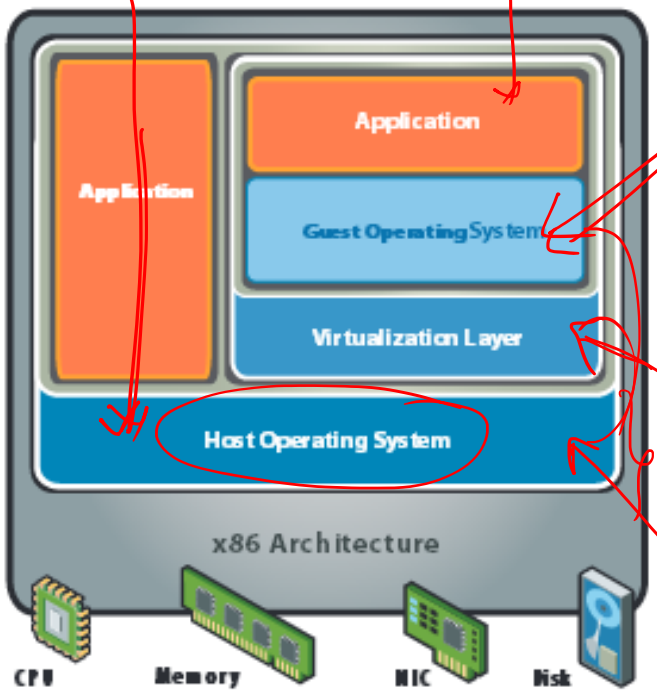
SKI Virtualization

- Single Kernel Image (SKI),
- Single Kernel Image (SKI), in which the host OS spawns additional copies of itself. This kind of virtualization can be found in Swsoft Virtuozzo and Sun Solaris, Zones. SKI can be thought of as “lightweight” virtualization.
- While this approach avoids the performance problems with pure emulation, it does so at the expense of flexibility.
- It is not possible, for instance, to run different versions or even different patch levels of a particular operating system on the same machine.
- Whatever versions exist in the host, that same software will be provided in the guest. SKI also sacrifices the security and reliability provided by other virtualization methods.

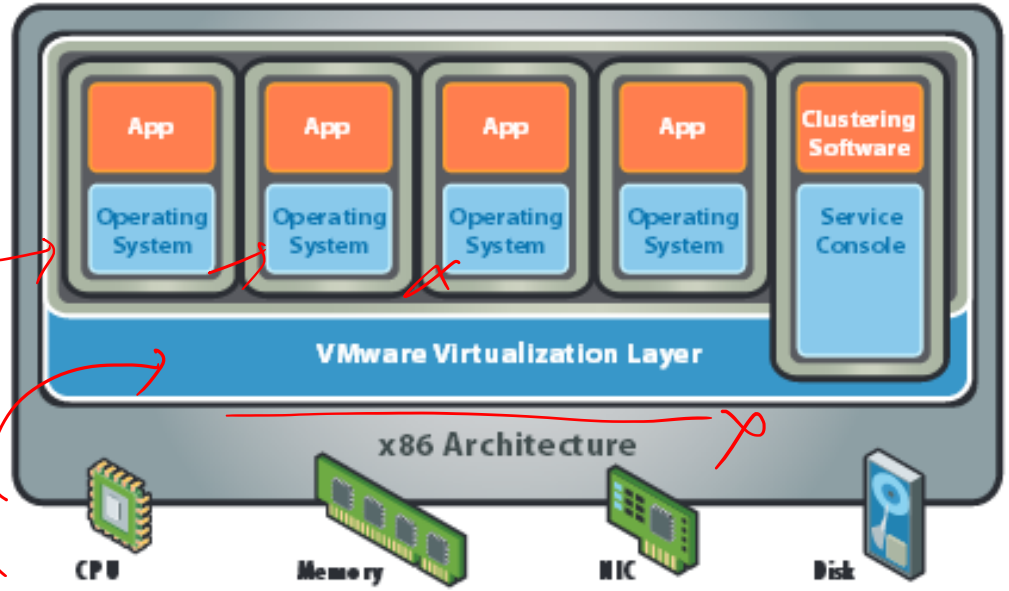
x86 Hardware Virtualization

- For Industry-standard x86 systems, the two approaches typically used with software-based partitioning are
  - hosted and
  - hypervisor architectures
- A hosted approach provides partitioning services on top of a standard operating system and supports the broadest range of hardware configurations.
- In contrast, a hypervisor architecture is the layer of software installed on a clean x86-based system (hence it is often referred to as a “bare metal” approach). Since it has direct access to the hardware resources, a hypervisor is more efficient than hosted architectures, enabling greater scalability, robustness and performance

x86 Hardware Virtualization



Hosted Architecture



Bare-Metal (Hypervisor) Architecture

Advantages of Virtualization

- Instant provisioning - fast scalability
- Live Migration is possible
- Load balancing and consolidation in a Data Center is possible.
- Low downtime for maintenance
- Virtual hardware supports legacy operating systems efficiently
- Security and fault isolation

Issues to be aware of

- **Software licensing**

  One of the most significant virtualization-related issues to be aware of is software licensing. Virtualization makes it easy to create new servers, but each VM requires its own separate software license. Organizations using expensive licensed applications could end up paying large amounts in license fees if they do not control their server sprawl.

- **IT training**

  IT staff used to dealing with physical systems will need a certain amount of training in virtualization. Such training is essential to enable the staff to debug and troubleshoot issues in the virtual environment, to secure and manage VMs, and to effectively plan for capacity.

- **Hardware investment**

  Server virtualization is most effective when powerful physical machines are used to host several VMs. This means that organizations that have existing not-so-powerful hardware might still need to make upfront investments in acquiring new physical servers to harvest the benefits of virtualization

Issues to be aware of

- Performance can be a concern, especially for in-band deployments, where the virtualization controller or appliance can become a bandwidth bottleneck.
- Interoperability among vendor products is still evolving.
- Failure of the virtualization device, leading to loss of the mapping table.

Thanks!!!

Queries?

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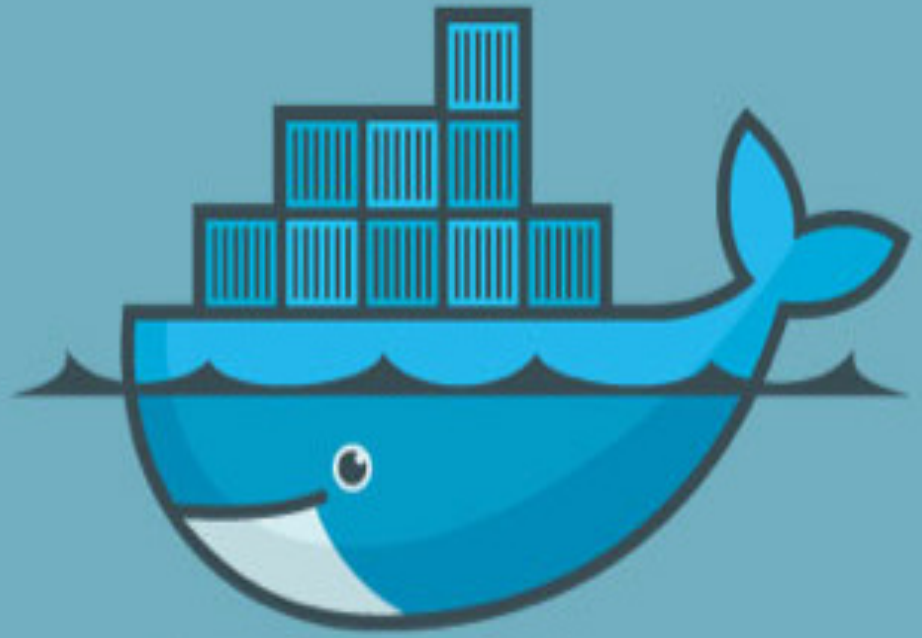
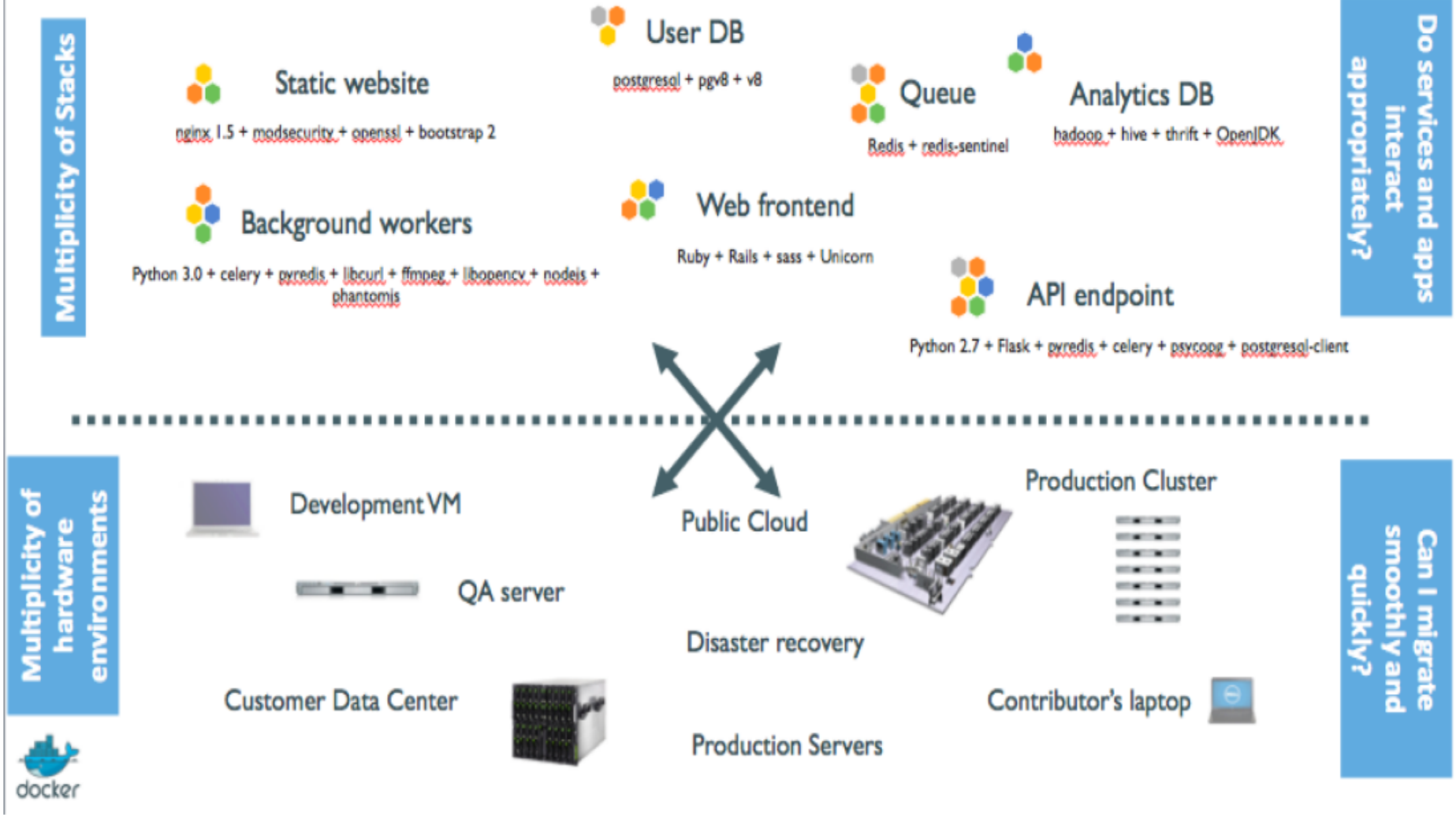
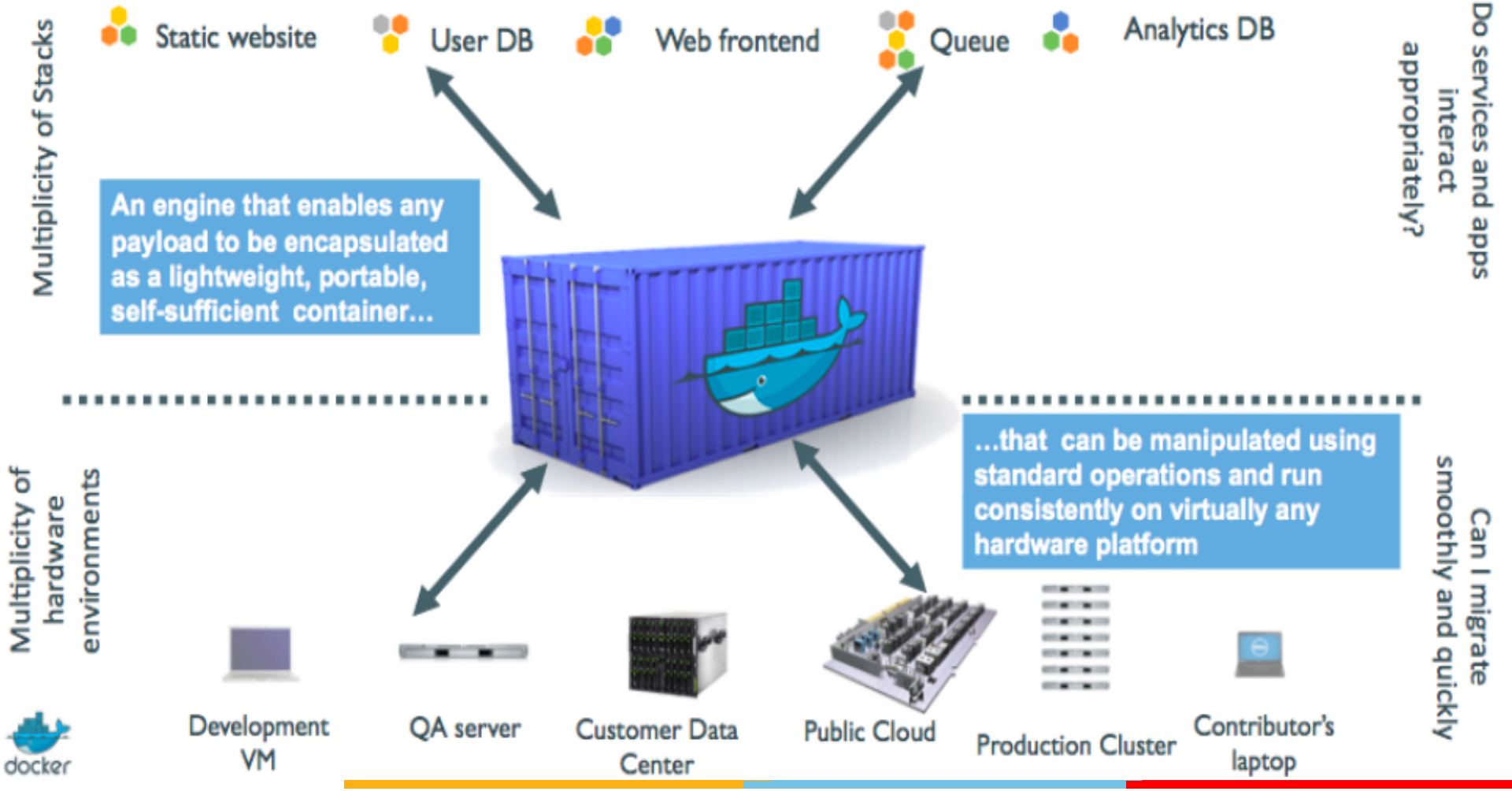


docker

Current Problem the Industry is facing



A shipping container system for applications

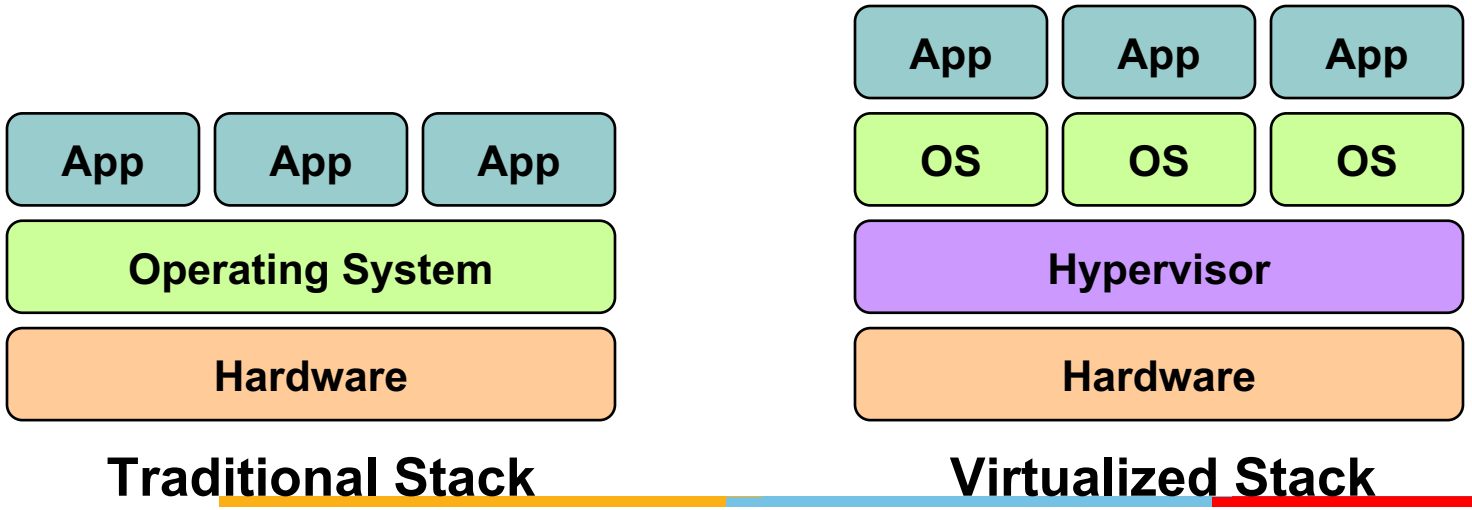


Dockers

- All applications have their own dependencies, which include both software and hardware resources.
- Docker is a mechanism that helps in isolating the dependencies per each application by packing them into containers.
- In terms of technology, it provides cloud portability by running the same applications in different virtual environments.
- Containers are scalable and safer to use and deploy as compared to regular approaches.

Virtual Machines

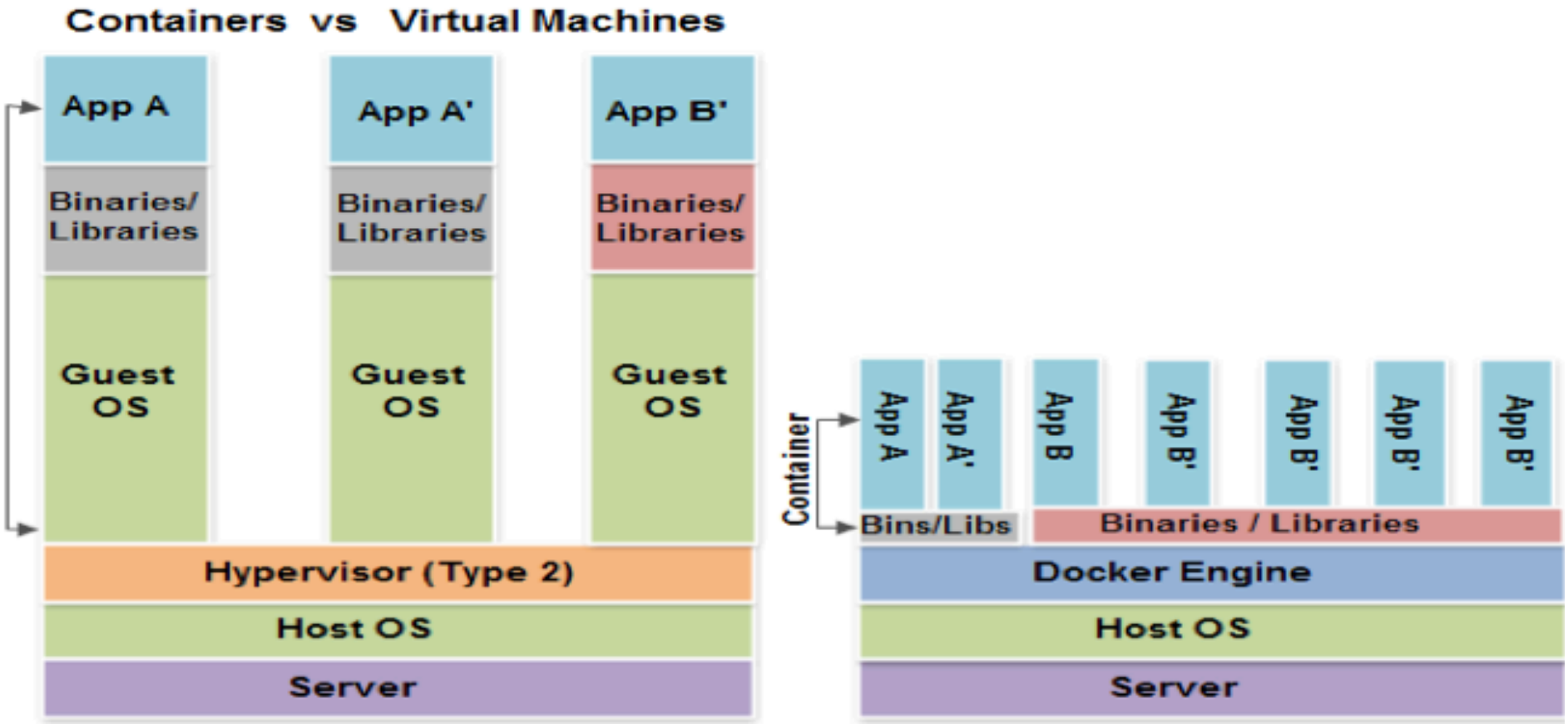
- Virtual machines are used extensively in cloud computing.
- Isolation and resource control have continually been achieved through the use of virtual machines.
- Virtual machine loads a full OS with its own memory management and enable applications to be more efficient and secure while ensuring their high availability.



How are Docker Containers different from a Virtual Machine?

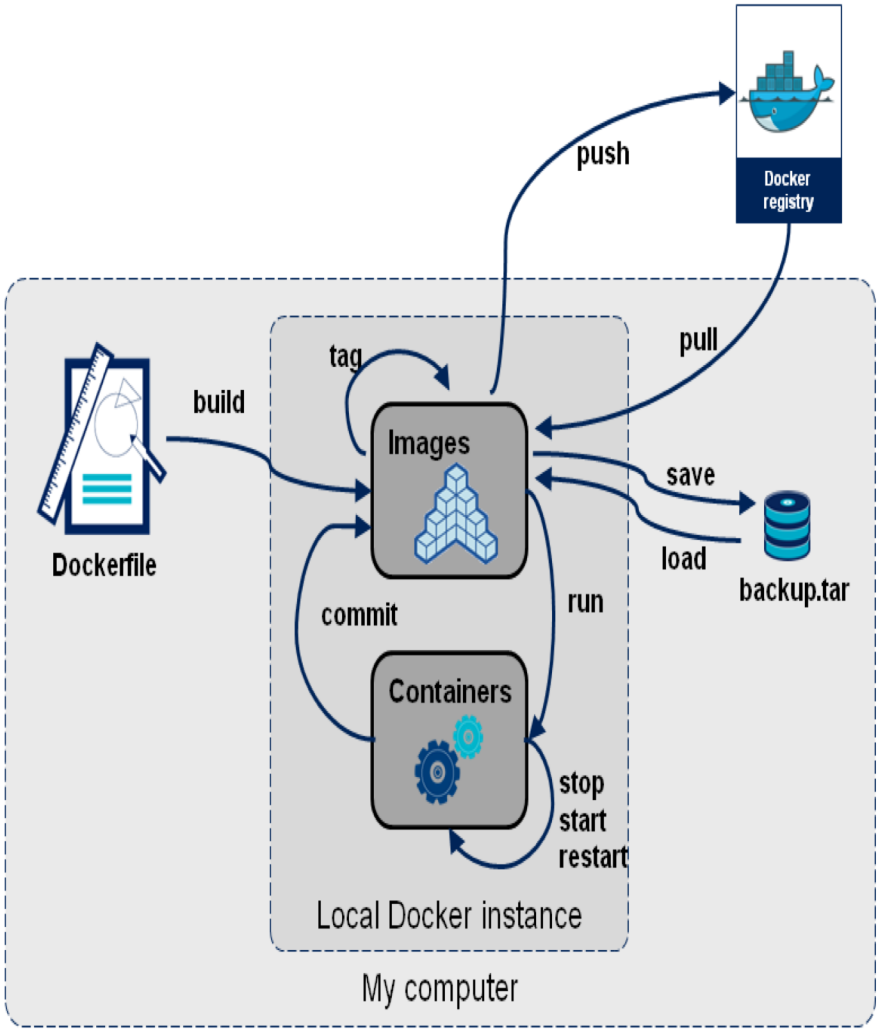
- Virtual machines have a full OS with its own memory management installed with the associated overhead of virtual device drivers.
- Docker containers are executed with the Docker engine rather than the hypervisor.
- Containers are therefore smaller than Virtual Machines and enable faster start up with better performance, less isolation and greater compatibility possible due to sharing of the host's kernel.

How are Docker Containers different from a Virtual Machine?



Docker Container Lifecycle ……

- The Life of a Container
  - Conception
    - **BUILD** an Image from a Dockerfile
  - Birth
    - **RUN** (create+start) a container
  - Reproduction
    - **COMMIT** (persist) a container to a new image
    - **RUN** a new container from an image
  - Sleep
    - **KILL** a running container
  - Wake
    - **START** a stopped container
  - Death
    - **RM** (delete) a stopped container
- Extinction
  - **RMI** a container image (delete image)



Dockerfile ……

- Like a Makefile (shell script with keywords)
- Extends from a Base Image
- Results in a new Docker Image
- Imperative, not Declarative
- A Docker file lists the steps needed to build an images
- docker build is used to run a Docker file

file | 15 lines (11 sloc) | 0.475 kb | Open | Edit | Raw | Blame | History | Delete

```
1  FROM ubuntu:12.04
2
3  RUN apt-get update
4
5  # Make it easy to install PPA sources
6  RUN apt-get install -y python-software-properties
7
8  # Install Oracle's Java (Recommended for Hadoop)
9  # Auto-accept the license
10 RUN add-apt-repository -y ppa:webupd8team/java
11 RUN apt-get update
12 RUN echo oracle-java7-installer shared/accepted-oracle-license-v1-1 select true | sudo /usr/bi
13 RUN apt-get -y install oracle-java7-installer
14 ENV JAVA_HOME /usr/lib/jvm/java-7-oracle
```

https://docs.docker.com/engine/installation/windows/

Thank you

Cloud Computing

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IaaS

Really, what is iaas???

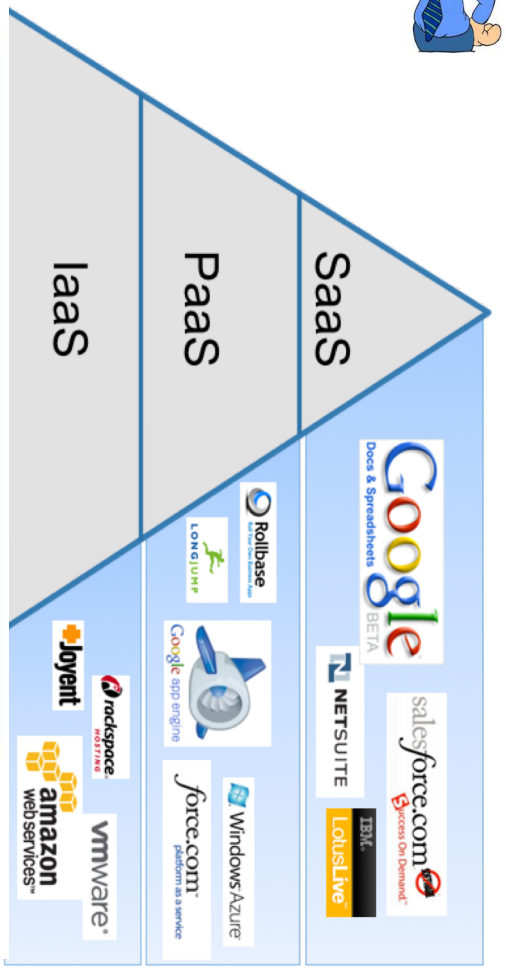
heard of 3 models of Cloud Computing?

Yes, Yes, IaaS, PaaS and SaaS

OnPremises	IaaS	PaaS	SaaS
Applications	Applications	Applications	Applications
Data	Data	Data	Data
Middleware	Middleware	Middleware	Middleware
Operating System	Operating System	Operating System	Operating System
Virtualization	Virtualization	Virtualization	Virtualization
Server	Server	Server	Server
Storage	Storage	Storage	Storage
Network	Network	Network	Network

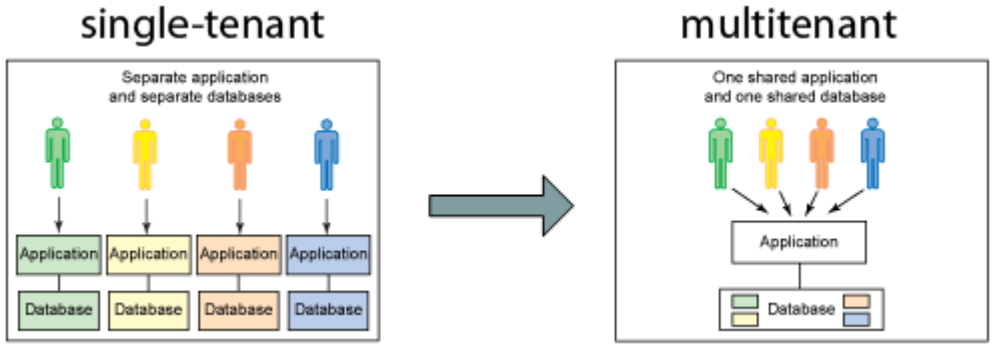
Own Responsibility

Cloud Provider Responsibility



Key concepts of IaaS

- Cloudbursting: The process of off-loading tasks to the cloud during times when the most compute resources are needed
- Multi-tenant computing



- Resource pooling: **Pooling** is a resource management term that refers to the grouping together of resources (compute(cpu), network(bandwidth), storage) for the purposes of ***maximizing advantage*** and/or ***minimizing risk*** to the users
- Hypervisor

Two primary facets that make IaaS special

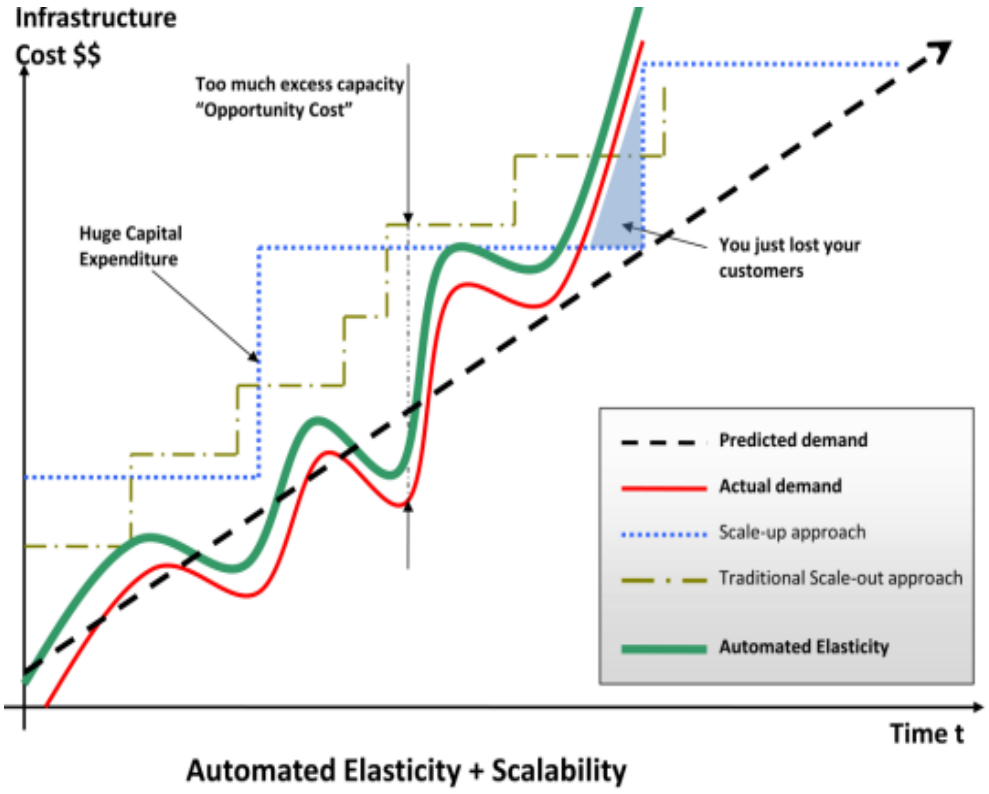
Elasticity:

Wikipedia: “In **cloud** computing, **elasticity** is defined as the degree to which a system (or a particular **cloud** layer) autonomously adapts its capacity to workload over time”

OR simply put “Ability of a system to **expand** or **contract** its dedicated resources to meet the demand”

&

Virtualization



4 considerations:

- Developing for a specific vendor's proprietary IaaS could prove to be a costly mistake
- The complexity of well-written resource allocation software is significant and do not come cheap
- What will you be sending off to be processed in the cloud? Sending data such as personal identities, financial information, and health care data put an organization's compliance at risk
- Understand the dangers of shipping off processes that are critical to the day-to-day operation of the business.

- http://www.ibm.com/developerworks/cloud/library/cl-cloudservices1iaas/

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IaaS

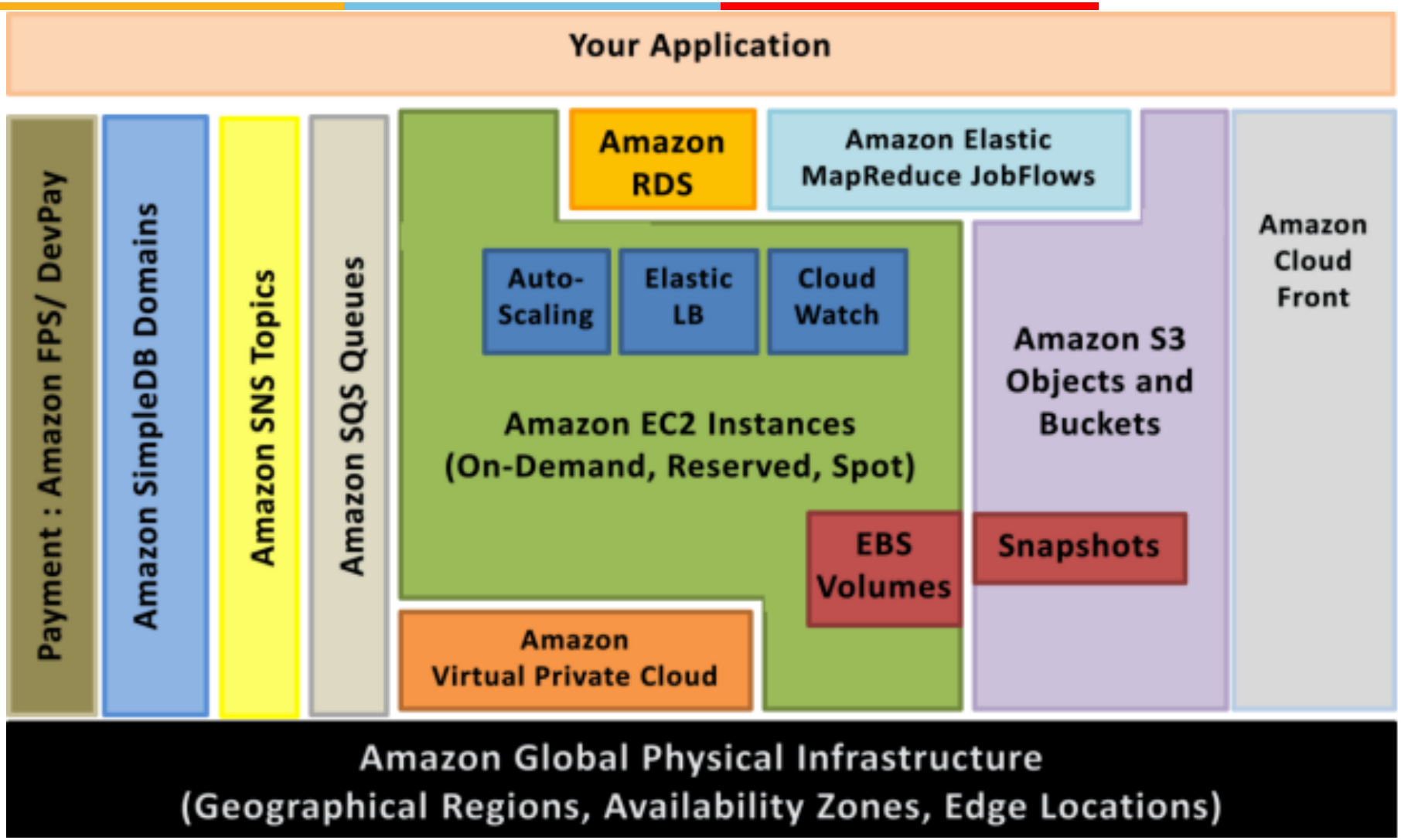
Really, what is iaas???

Amazon Web Services

Amazon Web Services Cloud

- Provides highly reliable and scalable infrastructure for deploying web-scale solutions
- With minimal support and administration costs
- More flexibility than own infrastructure, either on-premise or at a datacenter facility

AWS infrastructure services



Examples

AWS – EC2, EBS, S3, LB

IaaS for you

*Thanks, I feel so "**Clouded**" now*

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heard of 3 models of Cloud Computing?

Yes, Yes, IaaS, PaaS and SaaS

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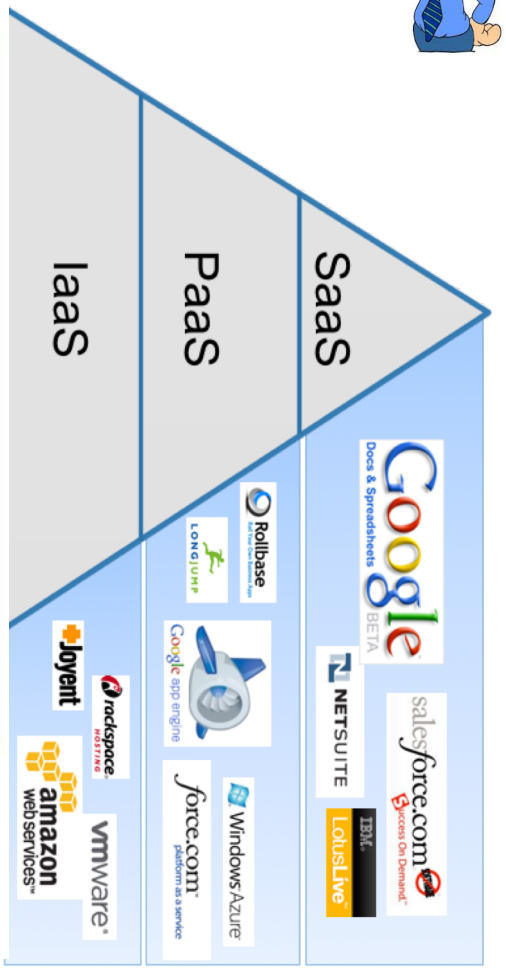
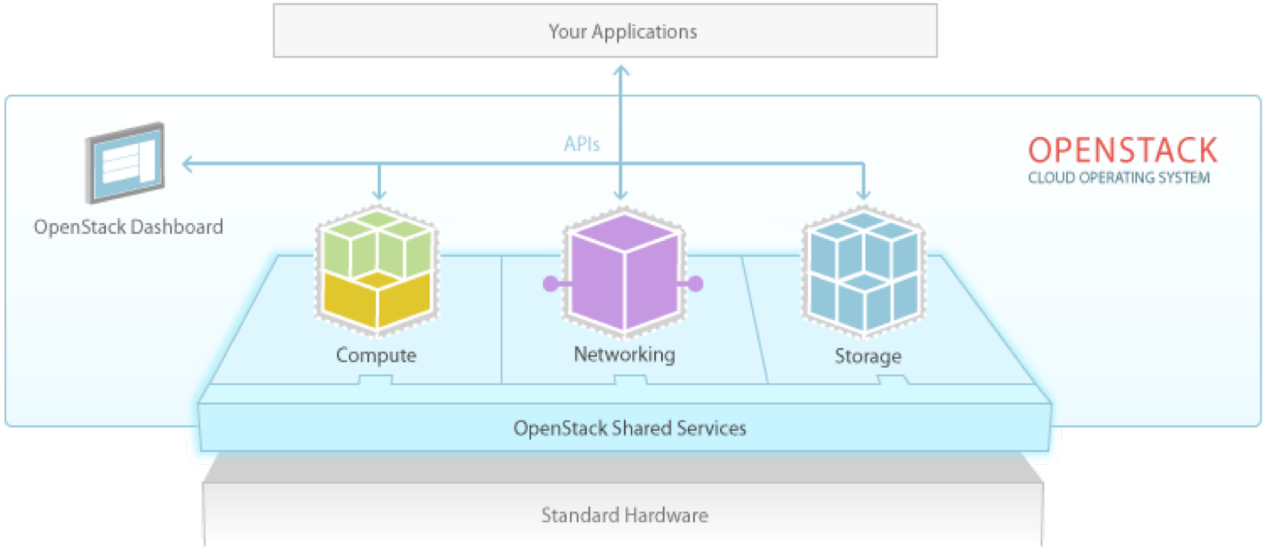
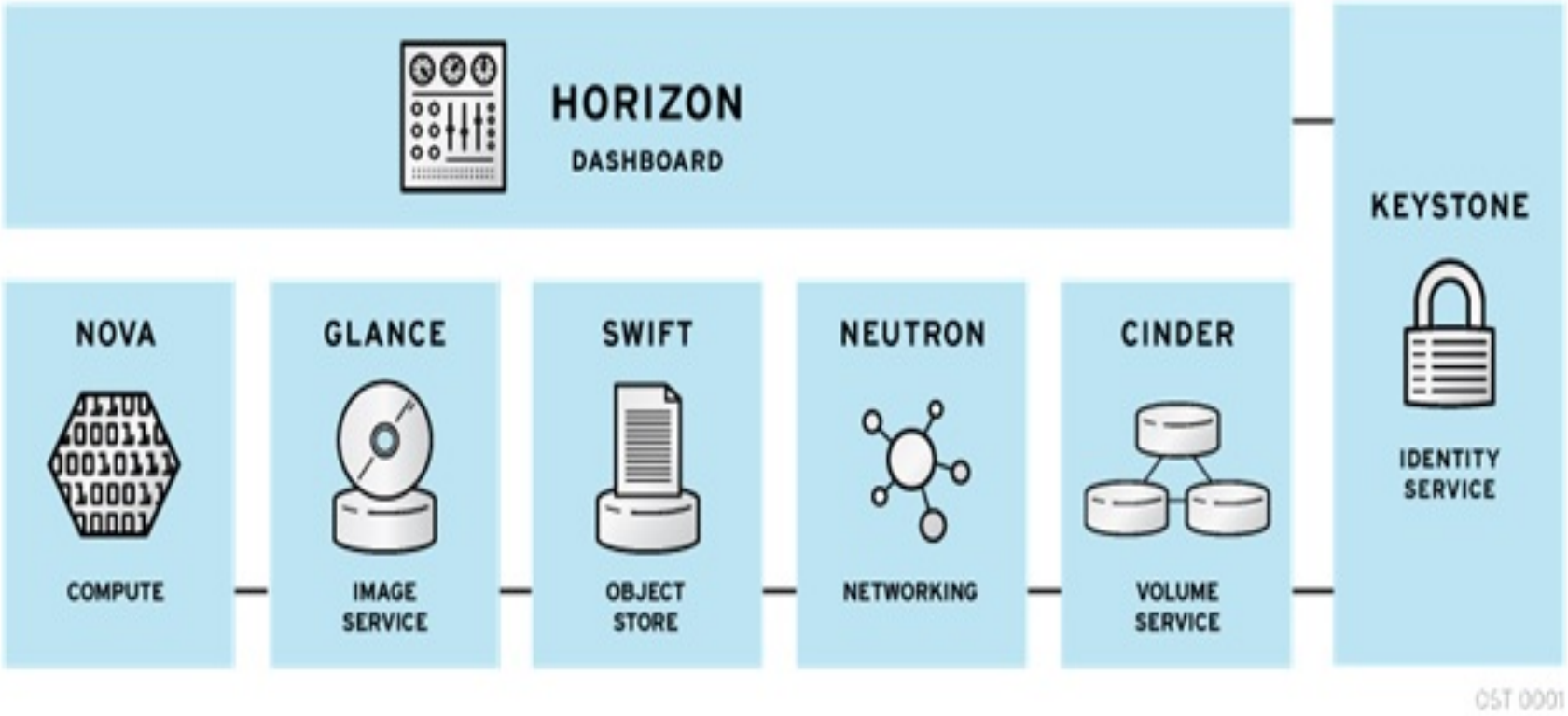


Openstack overview

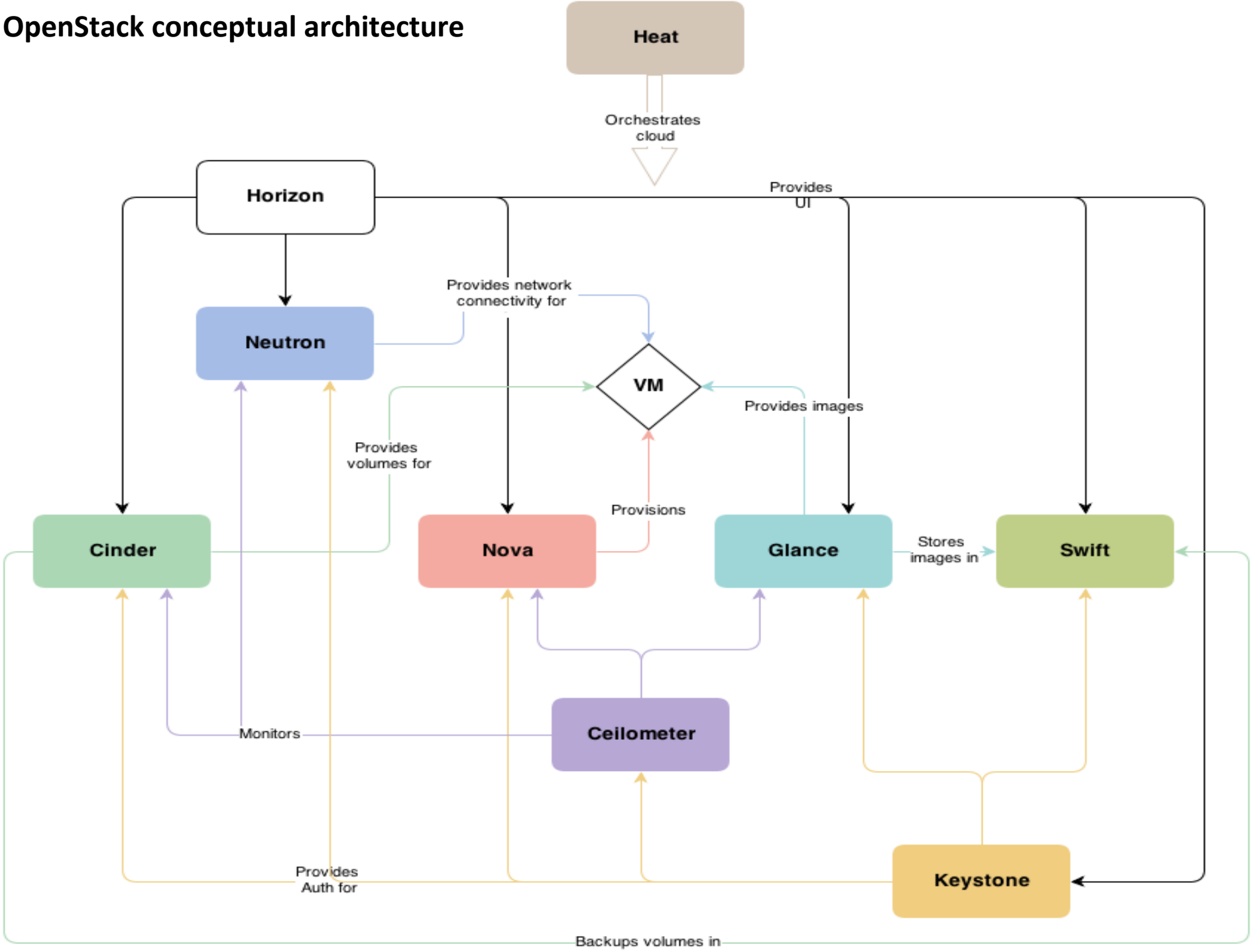
- OpenStack is a collection of open source technologies delivering a massively scalable cloud operating system.
- OpenStack cloud operating system controls large pools of compute, storage, and networking resources throughout a datacenter, all managed through a dashboard that gives administrators control while empowering their users to provision resources through a web interface.



Openstack Components



OpenStack conceptual architecture



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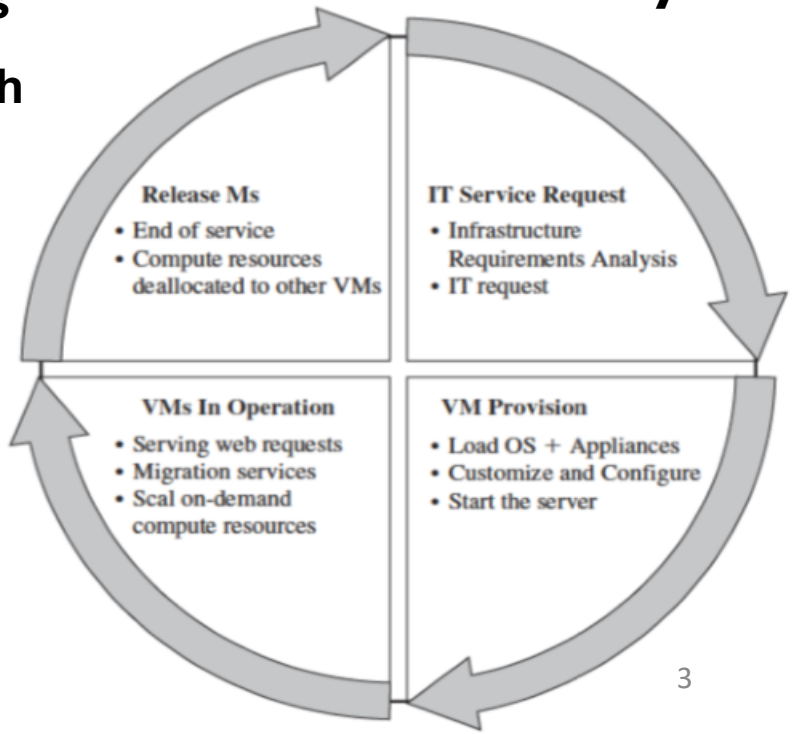
Virtual Machine Provisioning and Manageability Life Cycle

- The cycle starts by a request delivered to the IT department, stating the requirement for creating a new server for a particular service.
- This request is being processed by the IT administration to start seeing the servers' resource pool, matching these resources with requirements
- Starting the provision of the needed virtual machine.
- Once it provisioned and started, it is ready to provide the required service according to an SLA(Service Level agreement).
- Virtual is being released; and free resources.

Virtual Machine Life Cycle



VM Provisioning Process

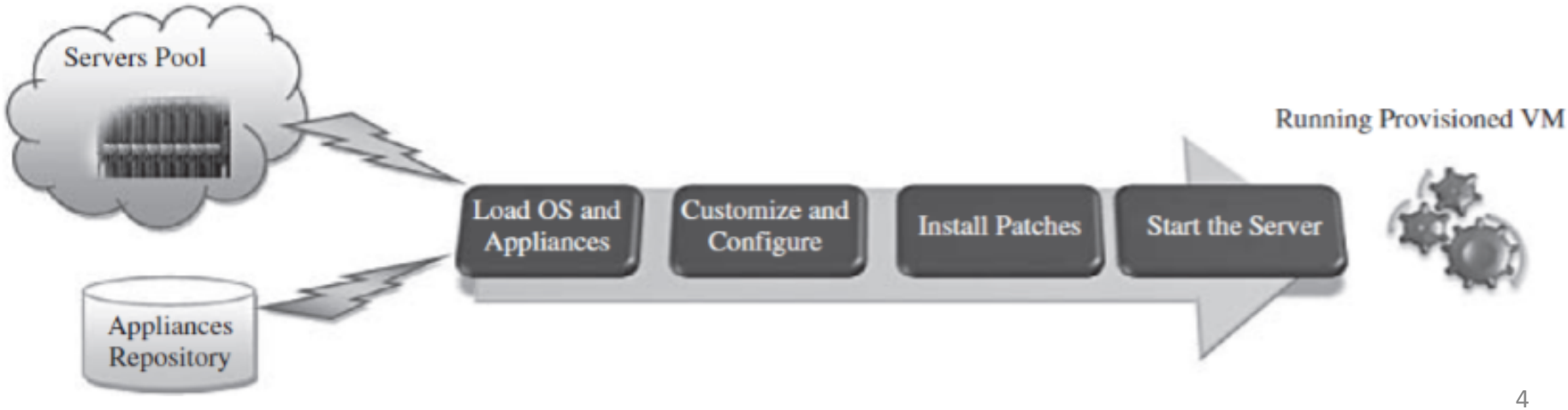
Steps to Provision VM -

• Select a server from a pool of available servers along with the appropriate OS template you need to provision the virtual machine.

• Load the appropriate software.

• Customize and configure the machine (e.g., IP address, Gateway) to an associated network and storage resources.

• Finally, the virtual server is ready to start with its newly loaded S/W.



VM Provisioning

• Server provisioning is defining server's configuration based on the organization requirements, a H/W, and S/W component (processor, RAM, storage, networking, operating system, applications, etc.).

VMs can be provisioned by

- Manually installing an OS,
- Using a preconfigured VM template,
- Cloning an existing VM, or importing a physical server or a
- Server from another hosting platform.
- Physical servers can also be virtualized and provisioned using P2V (Physical to Virtual)

VM Provisioning using templates

- Provisioning from a template reduces the time required to create a new virtual machine.
- Administrators can create different templates for different purposes.

  For example –

- Vagrant provision tool using VagrantFile (template file) (demo)
- Heat – Orchestration Tool of openstack (Heat template in YAML format) (demo – Instance creation in cloud, Load balancer in cloud)

This enables the administrator to quickly provision a correctly configured virtual server on demand.

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Virtual Machine Migration Services

Migration service –

The process of moving a virtual machine from one host server or storage location to another;

There are different techniques of VM migration-

- Hot/live migration,
- Cold/regular migration, and
- Live storage migration of a virtual machine.

In this process, all key machines' components, such as CPU, storage disks, networking, and memory, are completely virtualized, thereby facilitating the entire state of a virtual machine to be captured by a set of easily moved data files.

Cold/regular migration

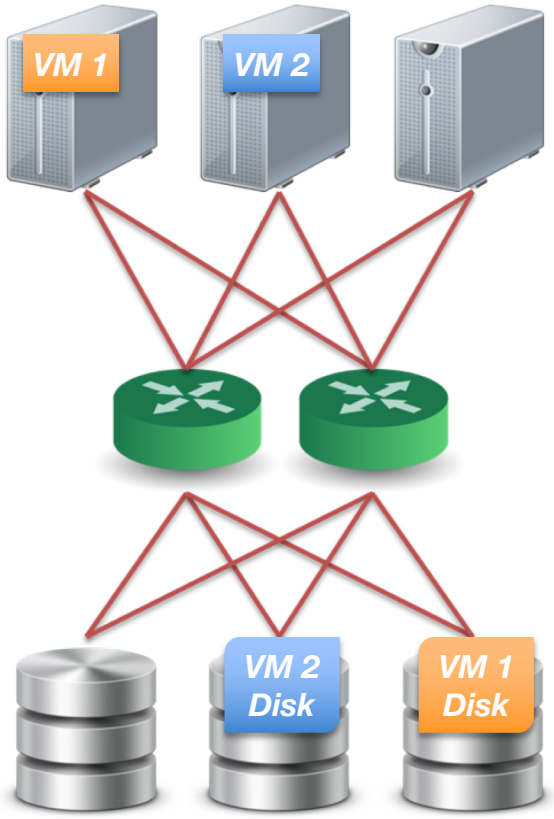
Cold migration is the migration of a powered-off virtual machine and is done in the following tasks:

- If the option to move to a different datastore was chosen, the configuration files, including the NVRAM file (BIOS settings), and log files are moved from the source host to the destination host's associated storage area. If you chose to move the virtual machine's disks, these are also moved.
- The virtual machine is registered with the new host.
- After the migration is completed, the old version of the virtual machine is deleted from the source host if the option to move to a different datastore was chosen.

Live Migration Technique

Pre-assumption :

- We assume that all storage resources are separated from computing resources.
- Storage devices of VMs are attached from network :
  - ***NAS***: NFS, CIFS
  - ***SAN***: Fibre Channel
  - ***iSCSI***, network block device
  - ***drdb*** network RAID
- Require high quality network connection
  - Common L2 network (LAN)
  - L3 re-routing



Live Migration Technique

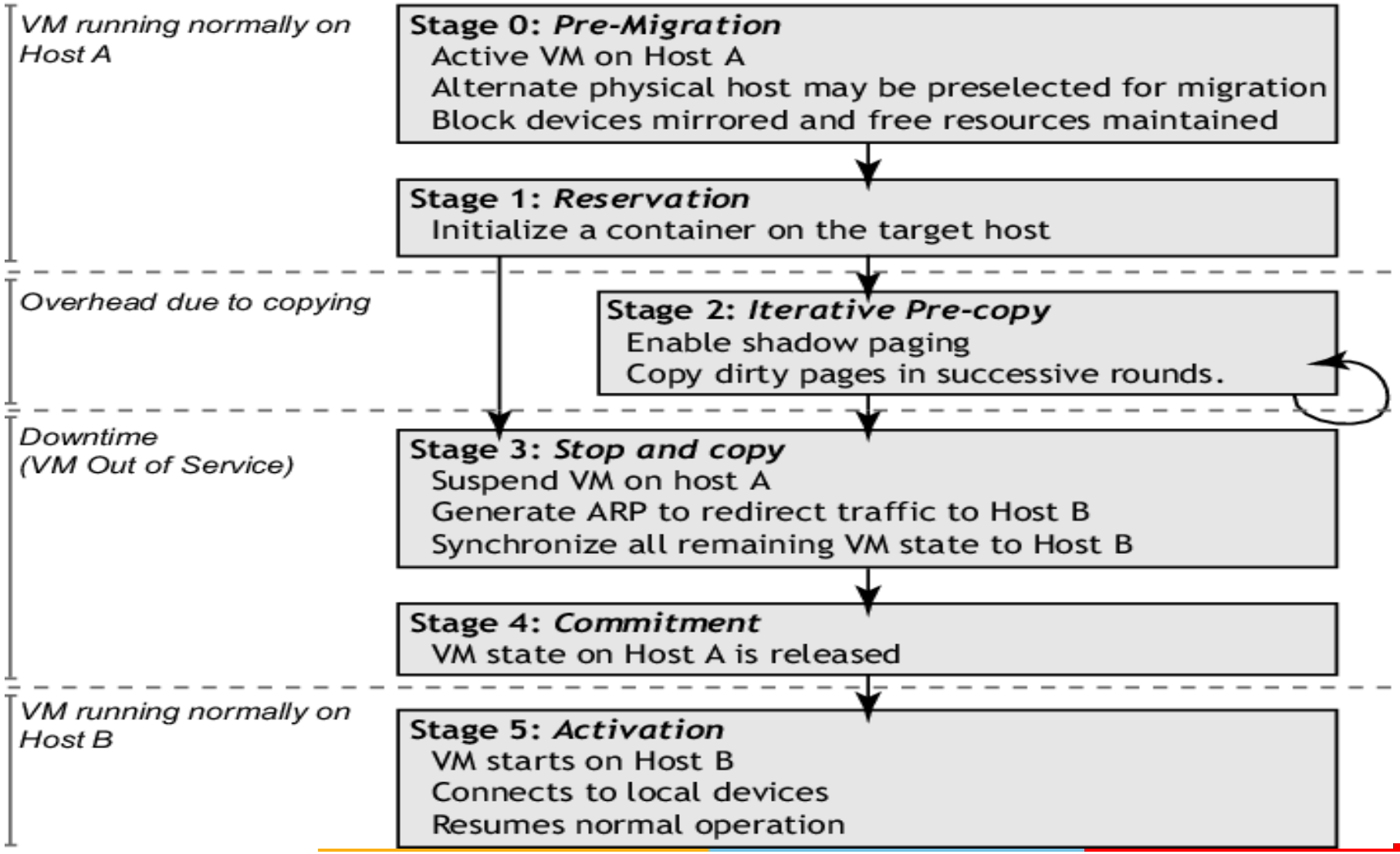
Challenges of live migration :

- VMs have lots of state in memory
- Some VMs have soft real-time requirements :
  - For examples, web servers, databases and game servers, ...etc.
  - Need to minimize down-time

Relocation strategy :

1. Pre-migration process
2. Reservation process
3. Iterative pre-copy
4. Stop and copy
5. Commitment

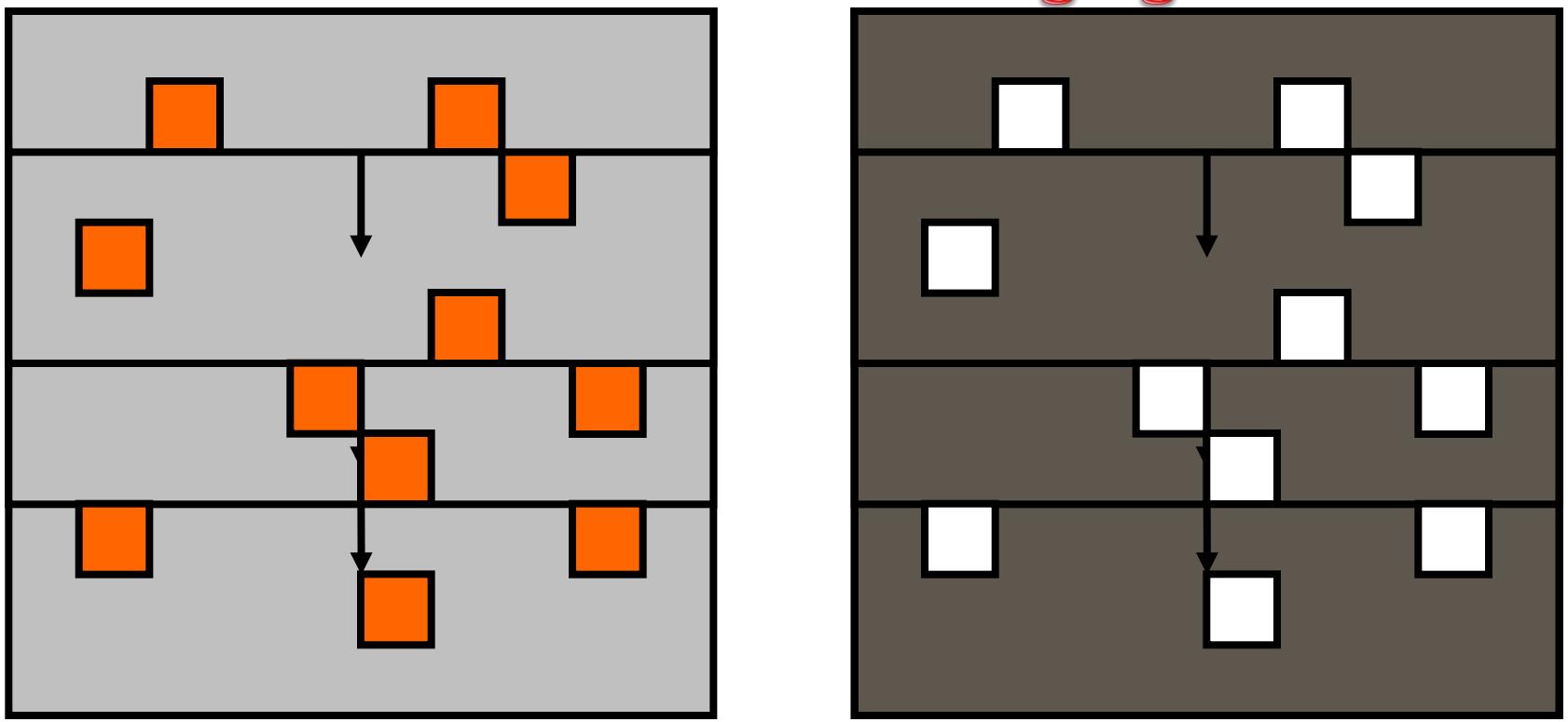
Live Migration Technique



Live Migration Technique

Live migration process :

Pre-copy migration : Round 1, Enable Shadow Paging

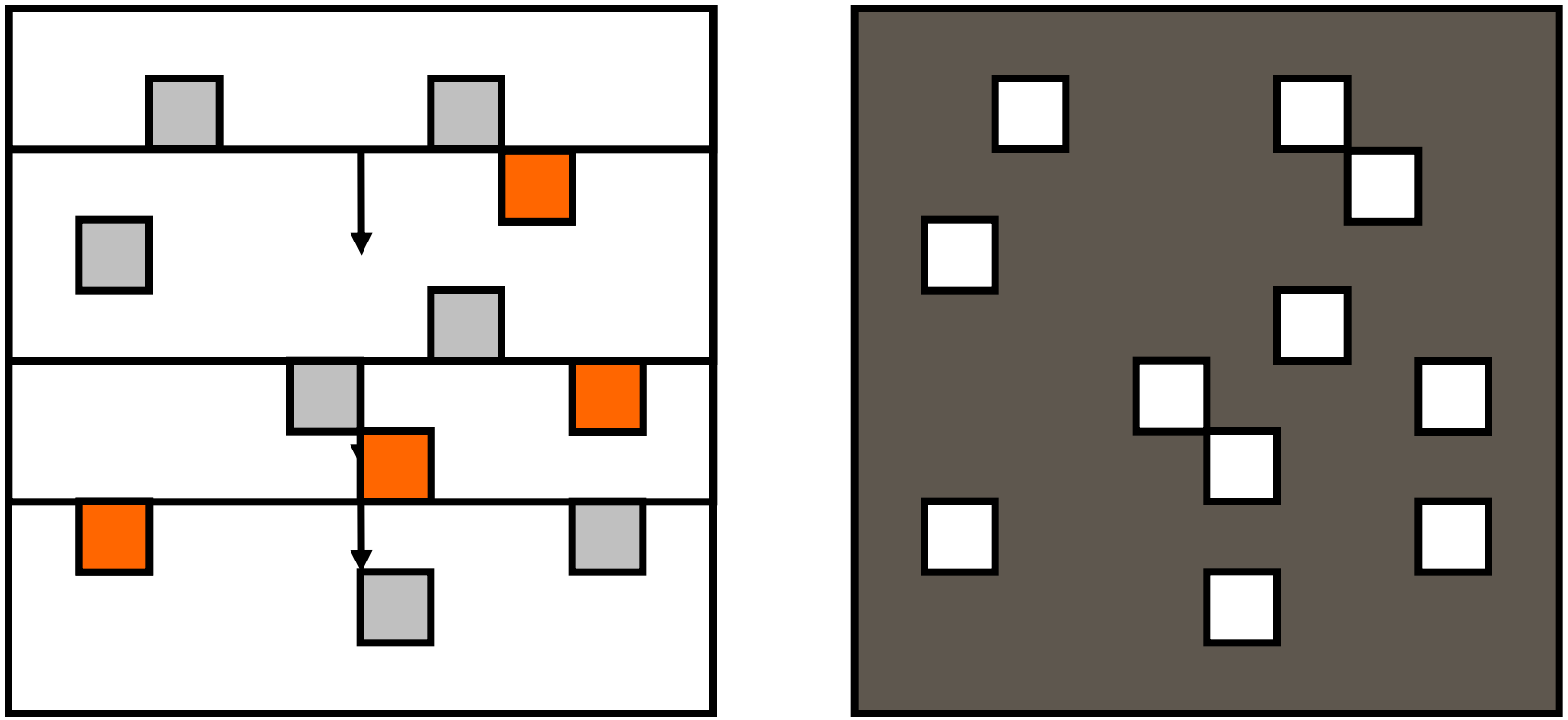


Host A ***Host B***

Live Migration Technique

Live migration process :

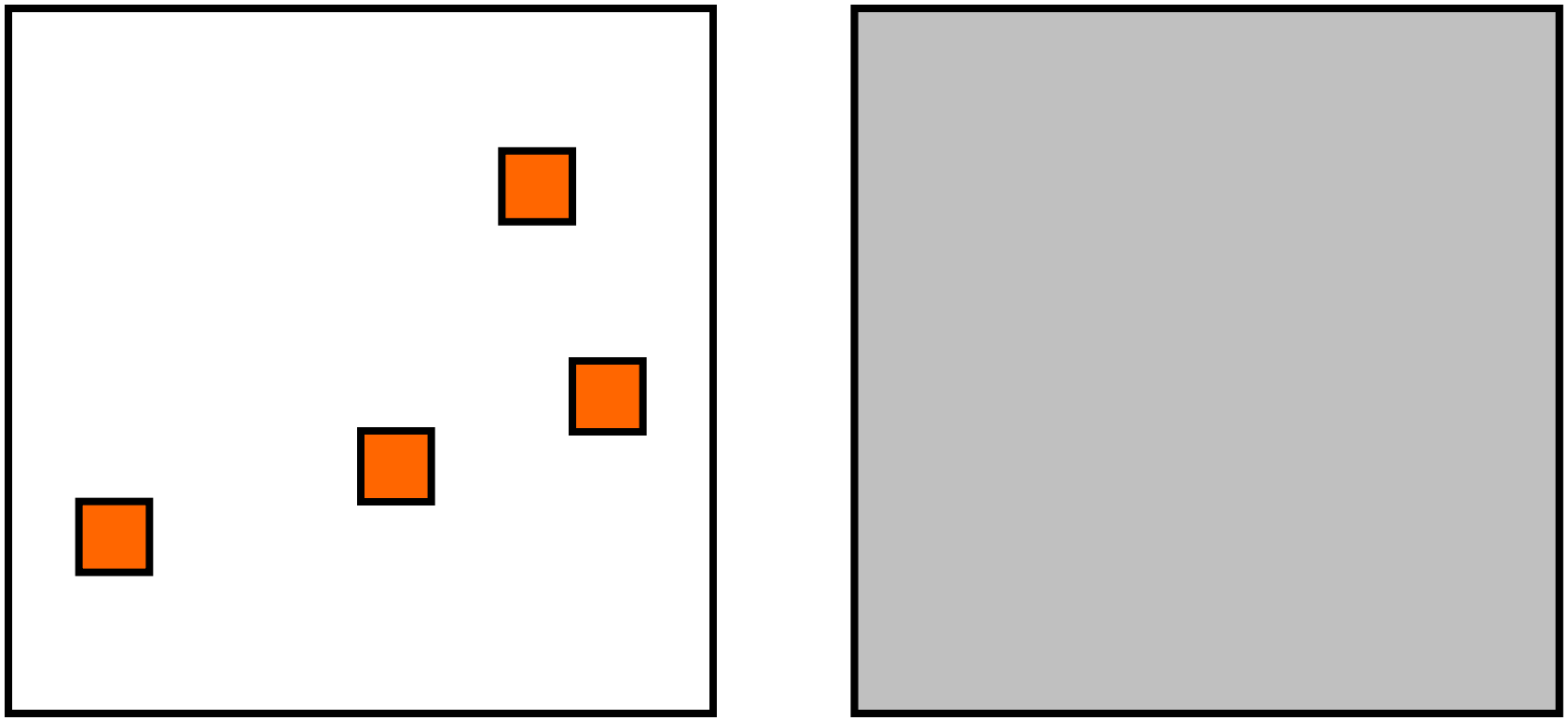
Pre-copy migration : Round 2



Live Migration Technique

Live migration process :

Stop and copy : Final Round



Live Migration Demo

- Using Proxmox deployment tool