



**BITS** Pilani

# Cloud Computing

## SEWP ZG527

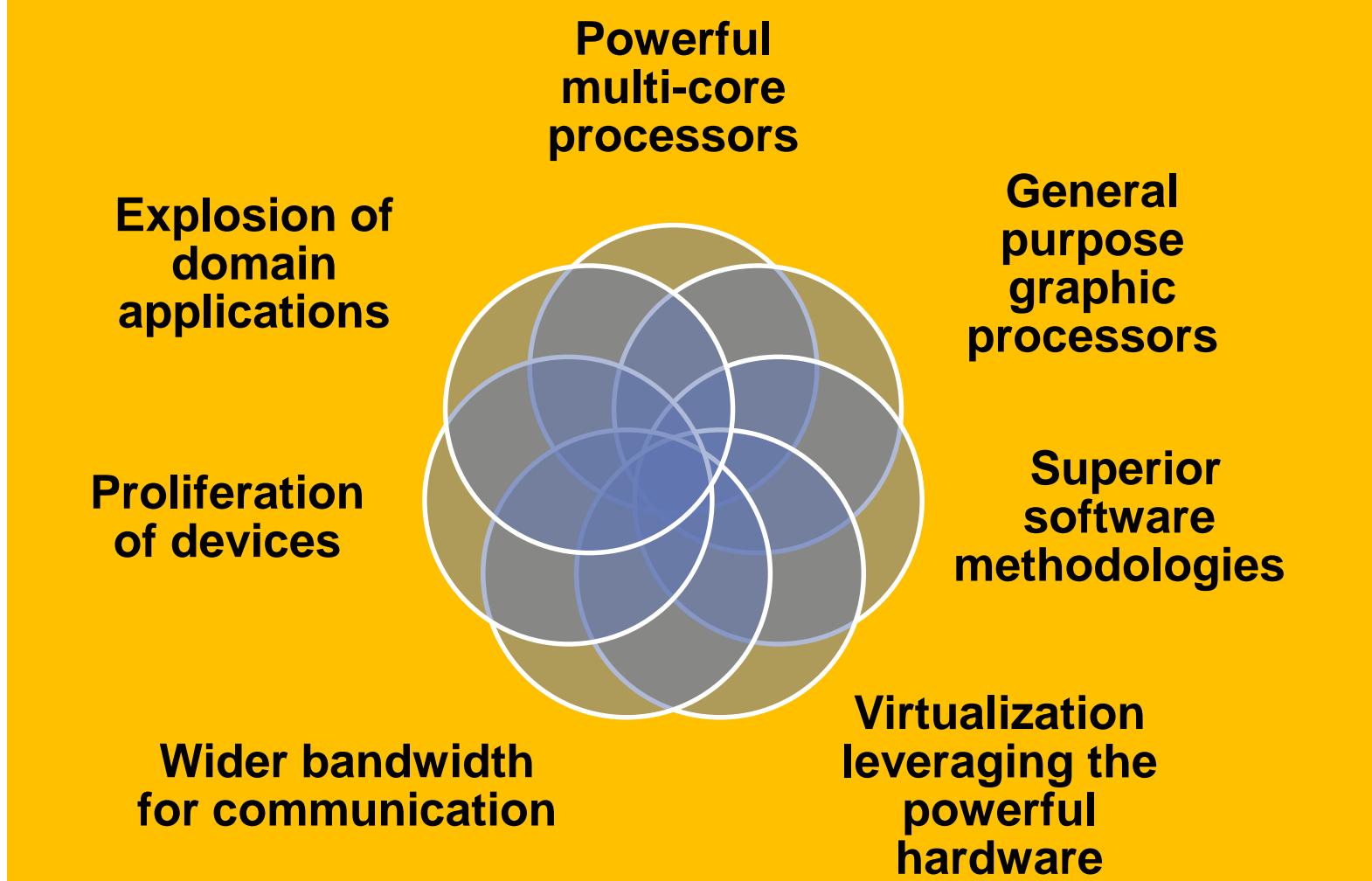


# **Introduction to Cloud Computing, services and deployment models**

---

- **Agenda**
  - 1. Introduction to Cloud Computing – Origins and Motivation**
  - 2. 3-4-5 rule of Cloud Computing**
  - 3. Types of Clouds and Services**
  - 4. Cloud Infrastructure and Deployment**

# Motivation



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

# Evolution of Web

---

Explosive growth in applications:

biomedical informatics, space exploration, business analytics,  
web 2.0 social networking: YouTube, Facebook

Extreme scale content generation: e-science and e-business data deluge

Extraordinary rate of digital content consumption: digital gluttony:

Apple iPhone, iPad, Amazon Kindle, Android, Windows Phone

Exponential growth in compute capabilities:

multi-core, storage, bandwidth, virtual machines (virtualization)

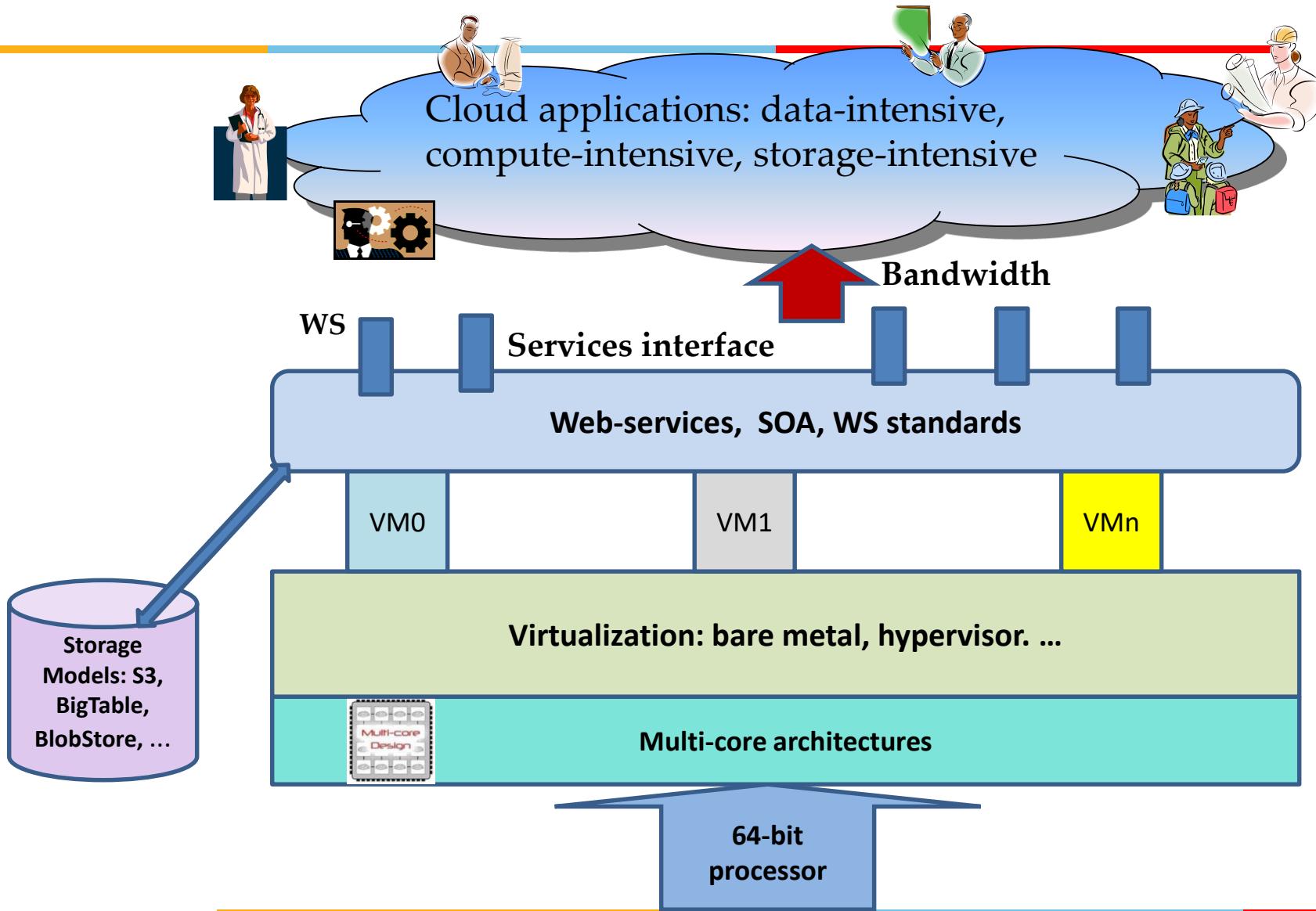
Very short cycle of obsolescence in technologies:

Windows 8, Ubuntu, Mac; Java versions; C → C#; Python

Newer architectures: web services, persistence models, distributed file systems/repositories (Google, Hadoop), multi-core, wireless and mobile

Diverse knowledge and skill levels of the workforce

# 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 up 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

## Generational Shift of Computing Platform

Technology	Economic	Business
	Centralized compute & storage, thin clients	Optimized for efficiency due to high cost
	PCs and servers for distributed compute, storage, etc.	Optimized for agility due to low cost
	Large DCs, commodity HW, scale-out, devices	Perpetual license for OS and application software
	Order of magnitude better efficiency and agility	Pay as you go, and only for what you use

<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

# Cloud Summary...

---

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.

Commodity model: 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!



**BITS** Pilani

# Cloud Computing

## SEWP ZG527



# **Introduction to Cloud Computing, services and deployment models**

---

- **Agenda**
  - 1. Introduction to Cloud Computing – Origins and Motivation**
  - 2. 3-4-5 rule of Cloud Computing**
  - 3. Types of Clouds and Services**
  - 4. Cloud Infrastructure and Deployment**

# 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

## 5 Essential Characteristics of Cloud Computing

Ref: The NIST Definition of Cloud Computing

<http://csrc.nist.gov/publications/nistpubs/800-145/SP800-145.pdf>



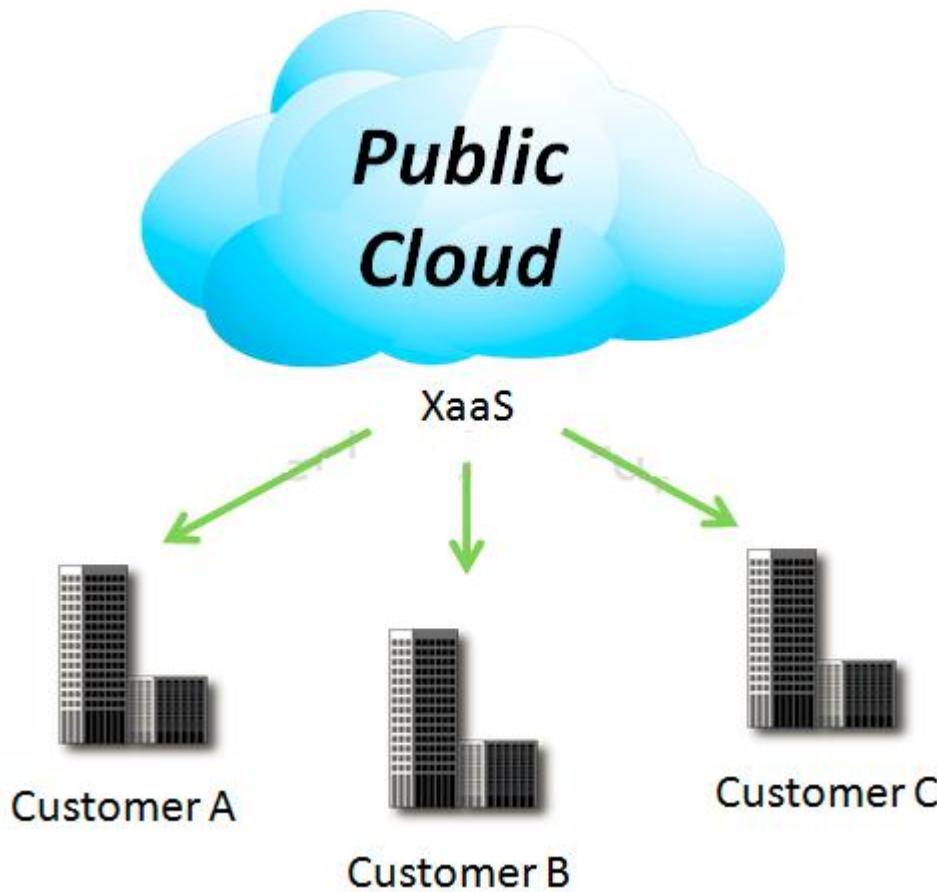
- On demand self-service
- Broad network access
- Resource pooling
- Rapid elasticity
- Measured service

Source: <http://aka.ms/532>

# 4 Deployment Models

---

## 1. Public Cloud

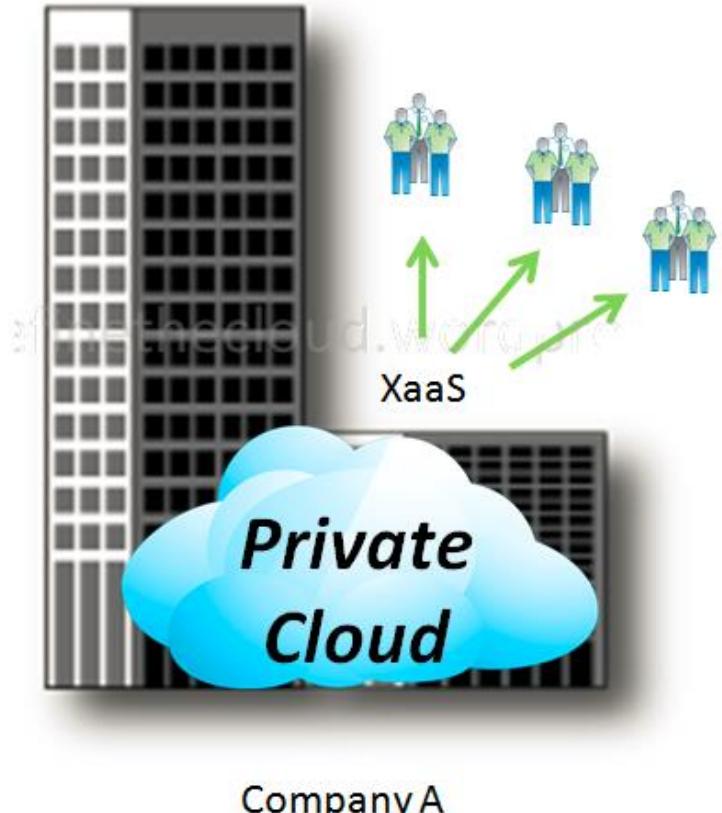


Mega-scale cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services.

# 4 Deployment Models

---

## 2. Private Cloud

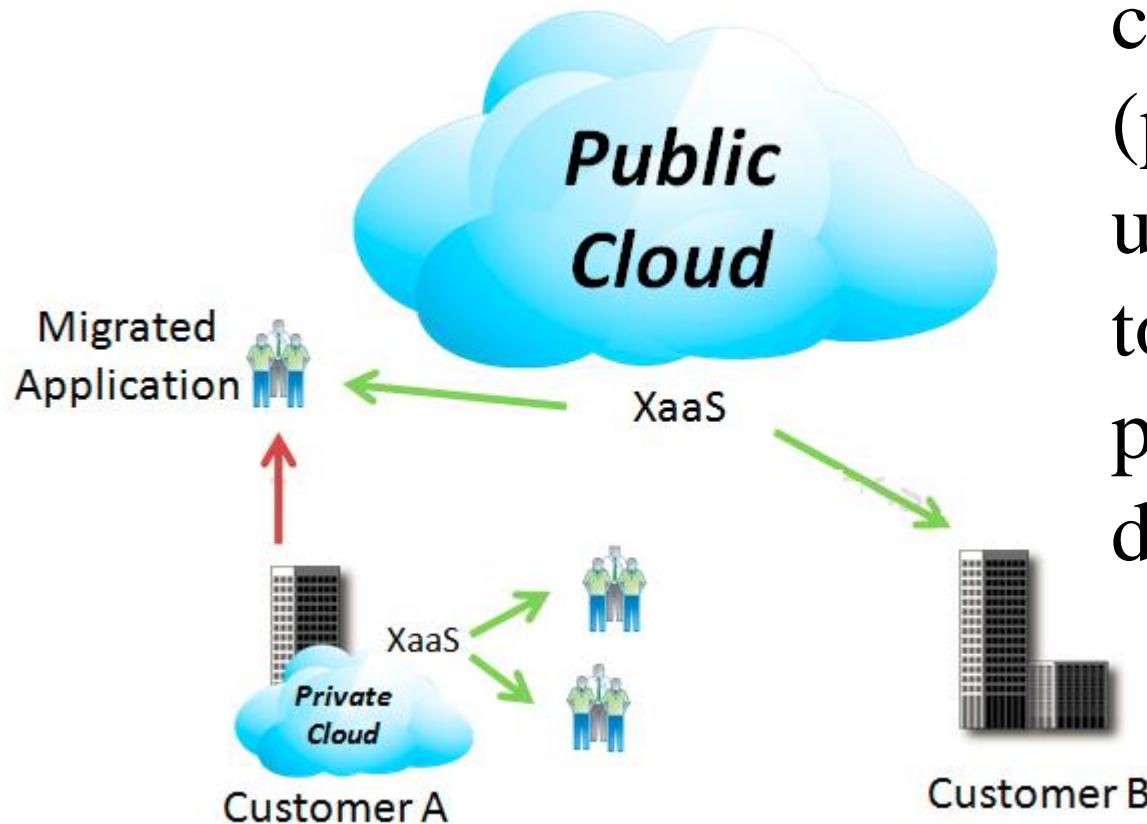


The cloud infrastructure is operated solely for an organization. It may be managed by the organization or a third party and may exist on premise or off premise.

# 4 Deployment Models

---

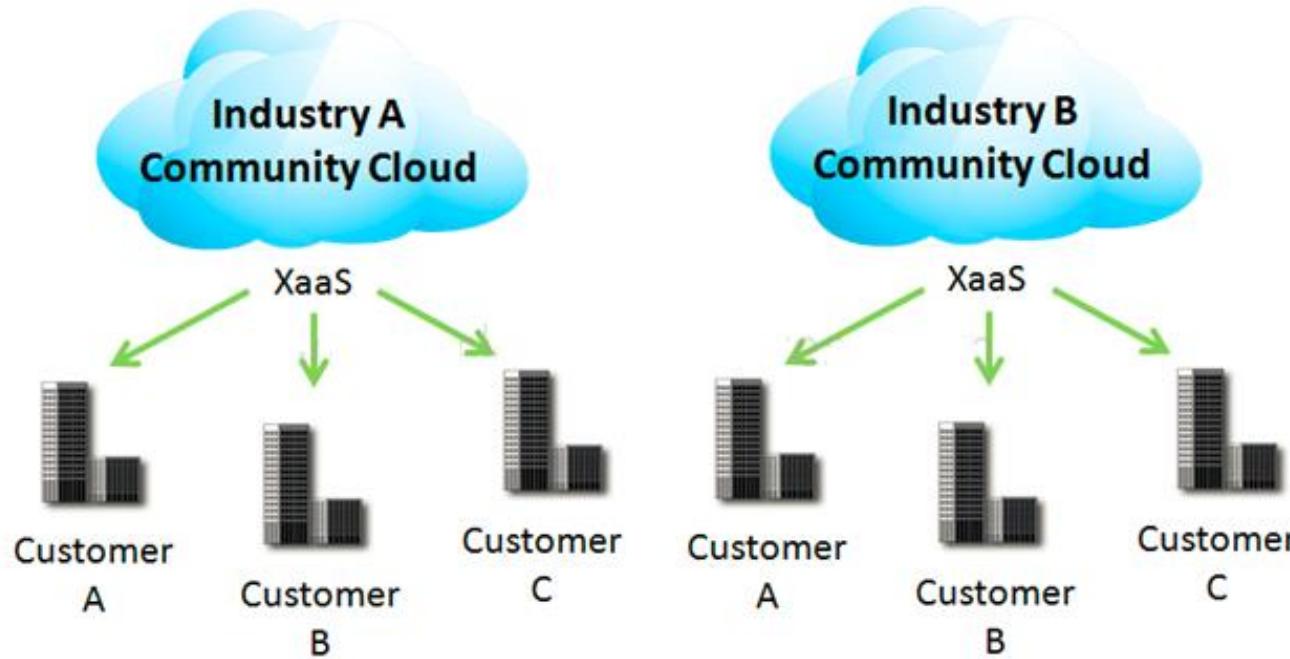
## 3. Hybrid Cloud



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



**BITS** Pilani

# Cloud Computing

## SEWP ZG527

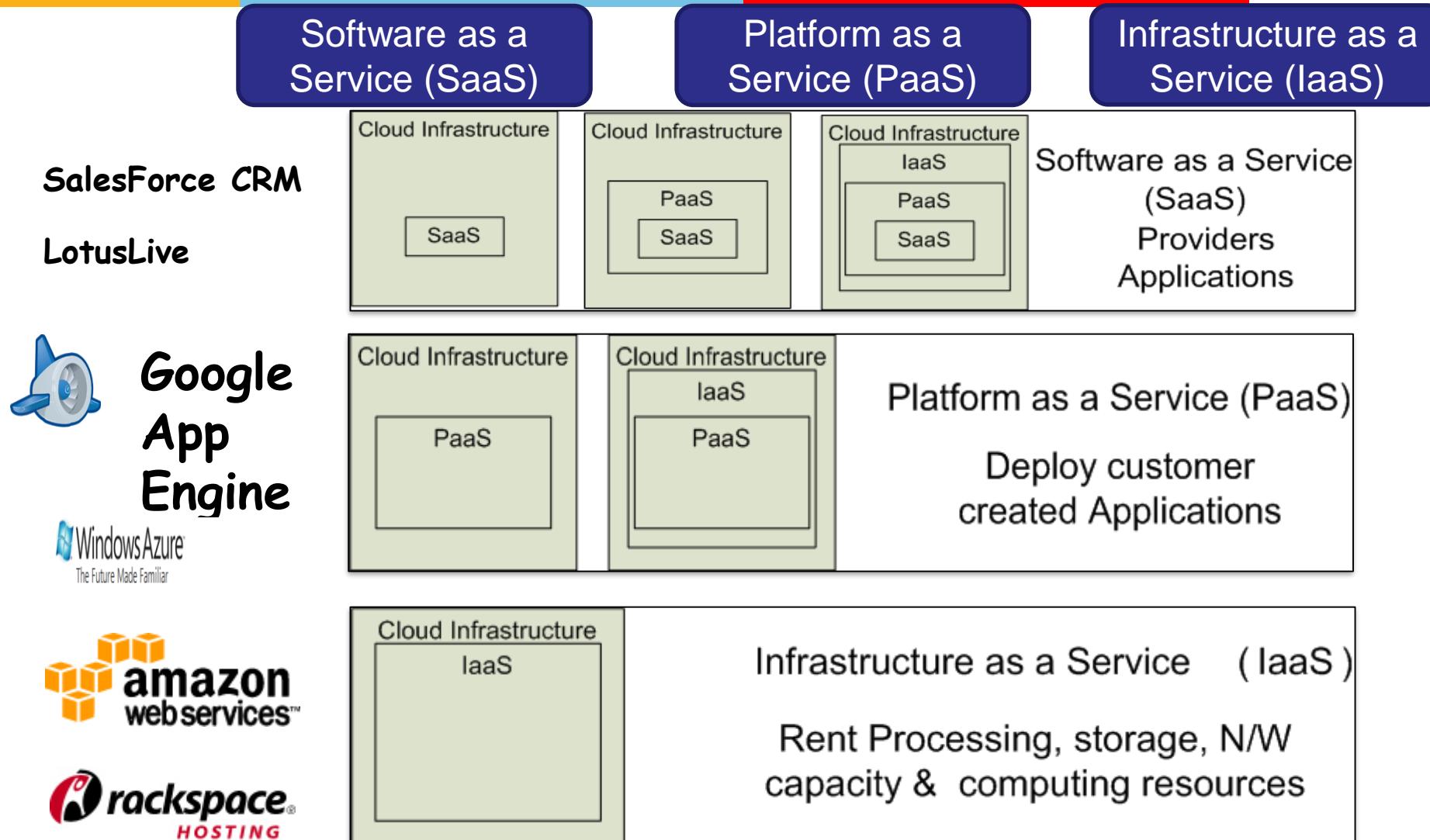


# **Introduction to Cloud Computing, services and deployment models**

---

- **Agenda**
  - 1. Introduction to Cloud Computing – Origins and Motivation**
  - 2. 3-4-5 rule of Cloud Computing**
  - 3. Types of Clouds and Services**
  - 4. Cloud Infrastructure and Deployment**

# 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.**

# Service Models Summary

---

## Cloud Software as a Service (SaaS)

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

## Cloud Platform as a Service (PaaS)

The **capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created applications using programming languages and tools supported by the provider** (e.g., Java, Python, .Net). The consumer does not manage or control the underlying cloud infrastructure, network, servers, operating systems, or storage, but the consumer has control over the deployed applications and possibly application hosting environment configurations.

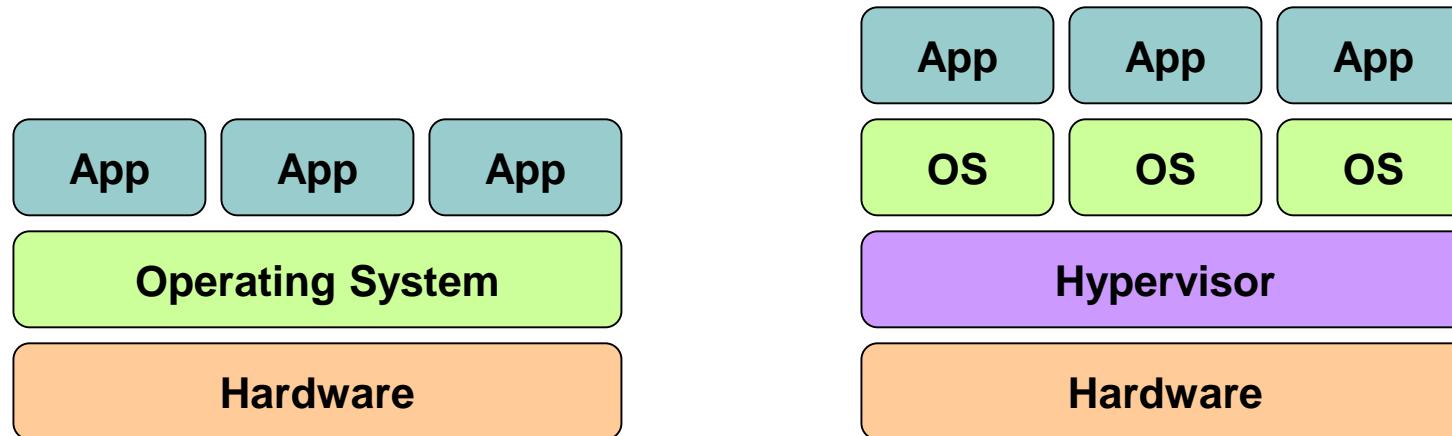
## Cloud Infrastructure as a Service (IaaS)

The **capability provided to the consumer is to rent processing, storage, networks, and other fundamental computing resources** where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, deployed applications, and possibly select networking components (e.g., firewalls, load balancers).

# 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**

# Cloud Infrastructure Anatomy

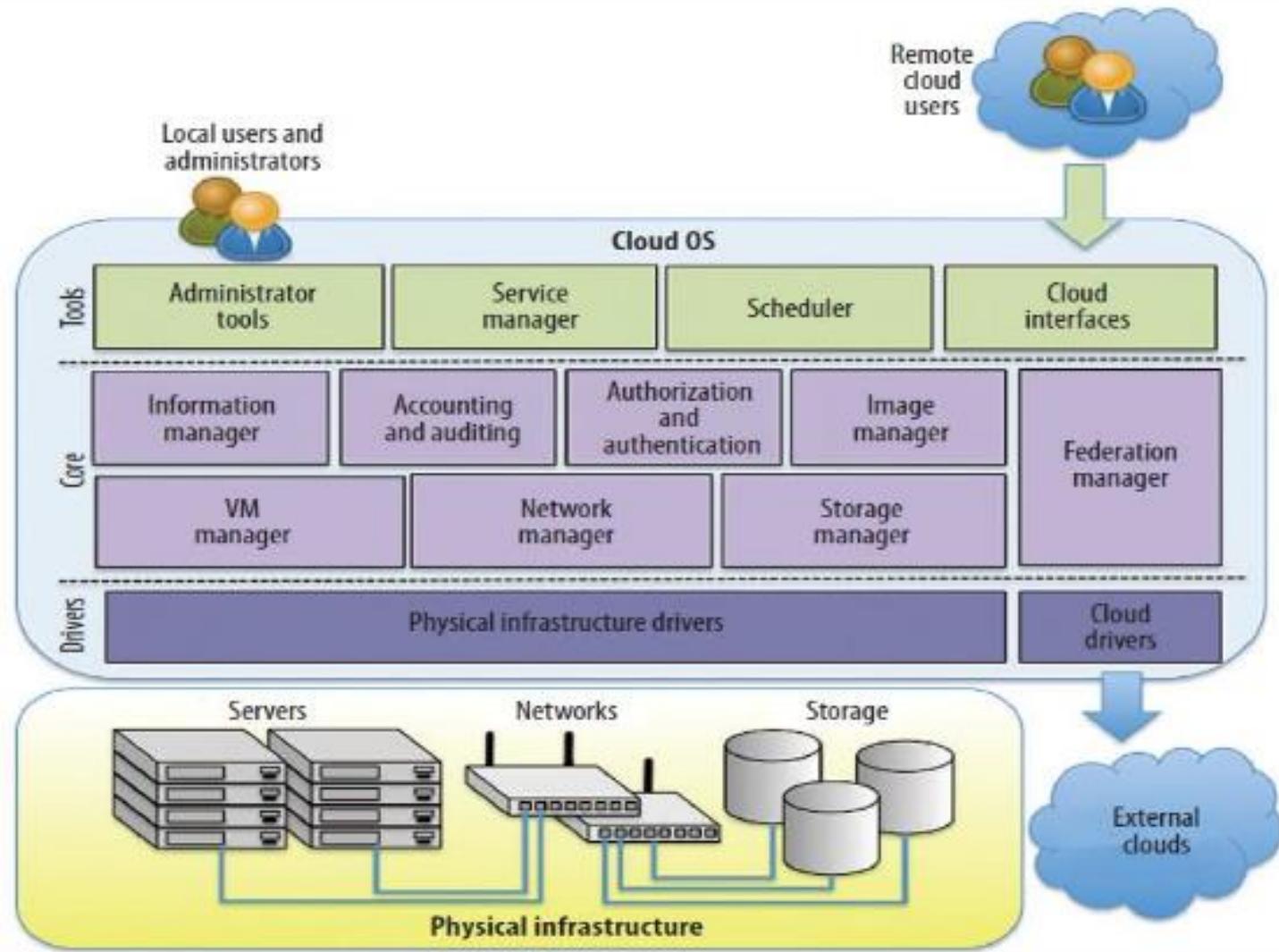
---

The key component of an IaaS cloud architecture is the **cloud OS**, which manages the physical and virtual infrastructures and controls the provisioning of virtual resources according to the needs of the user services

A **cloud OS**'s role is to efficiently manage datacenter resources to deliver a flexible, secure, and isolated multitenant execution environment for user services that abstracts the underlying physical infrastructure and offers different interfaces and APIs for interacting with the cloud

While local users and administrators can interact with the cloud using local interfaces and administrative tools that offer rich functionality for managing, controlling, and monitoring the virtual and physical infrastructure, remote cloud users employ public cloud interfaces that usually provide more limited functionality

# 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



**BITS** Pilani

# Cloud Computing

SEWP ZG527



# Agenda

---

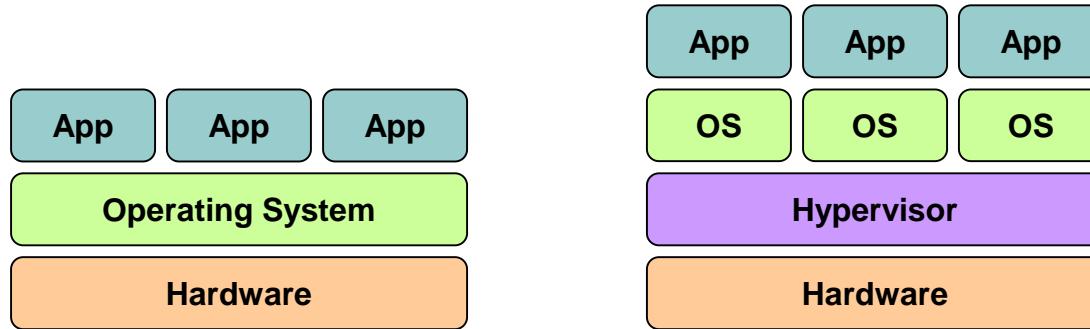
## Virtualization Techniques and Types

- ❑ Introduction to Virtualization
- ❑ Use & demerits of Virtualization
- ❑ Types of Virtualization
  - Examples
- ❑ x86 Hardware Virtualization

# Technology made cloud possible

---

## Key Technology is Virtualization



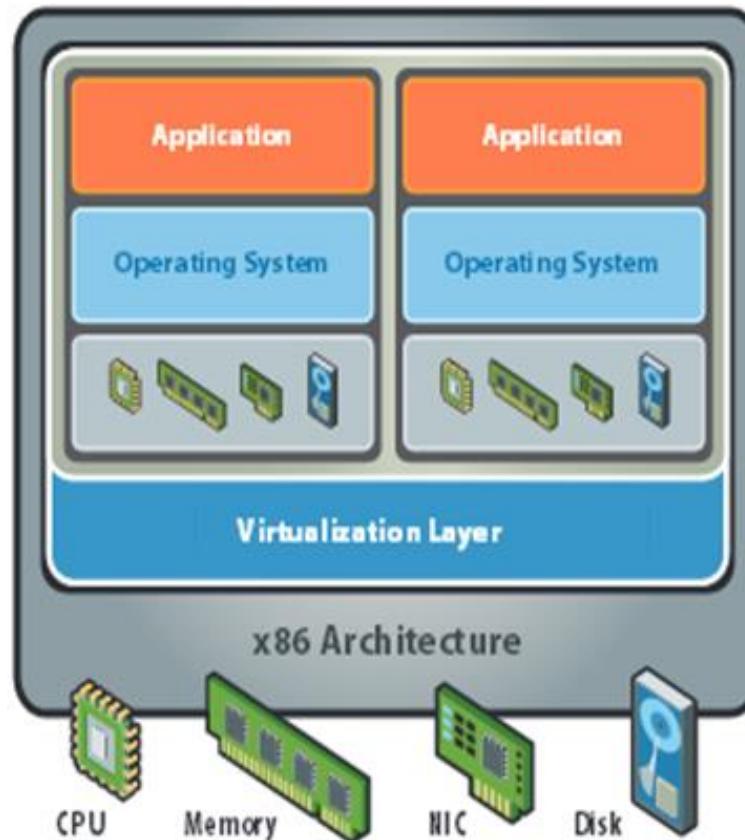
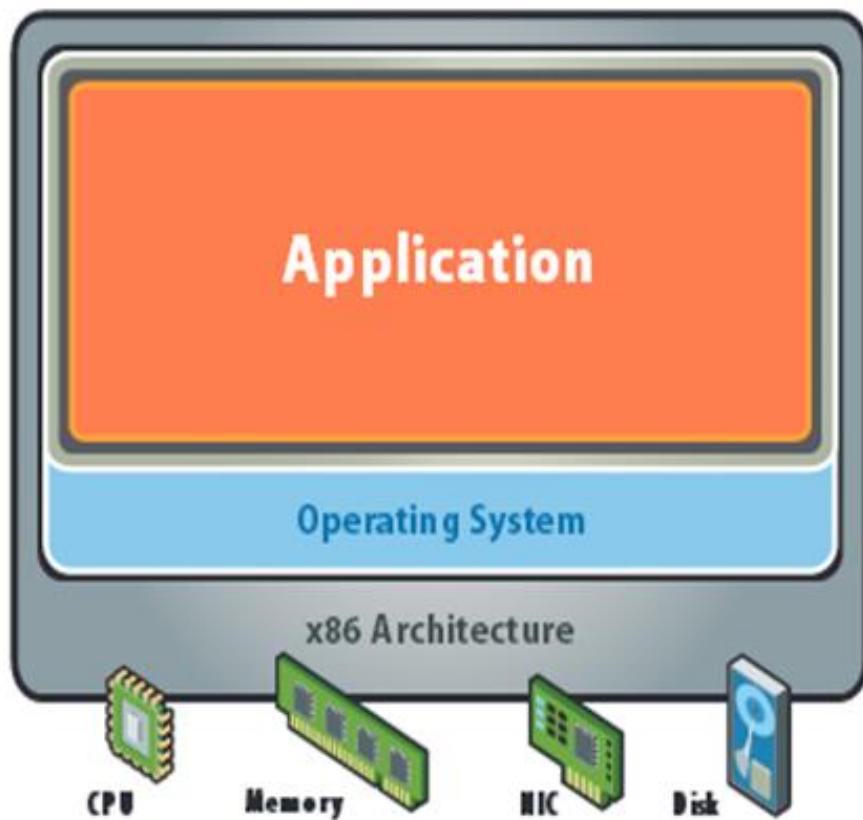
Virtualization plays an important role as an enabling technology for datacentre implementation by abstracting compute, network, and storage service platforms from the underlying physical hardware

# Importance of Virtualization in Cloud Computing

---

- Cloud can exist without Virtualization, although it will be difficult and inefficient.
- Cloud makes notion of “Pay for what you use”, “infinite availability- use as much you want”.
- These notions are practical only if we have
  - lot of flexibility
  - efficiency in the back-end.
- This efficiency is readily available in Virtualized Environments and Machines

# 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



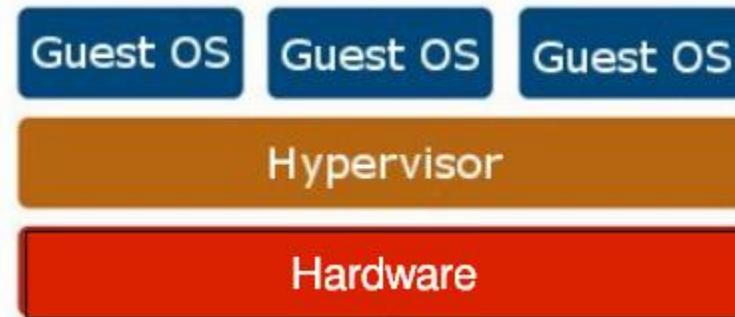
## After Virtualization

- 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





**BITS** Pilani

# Cloud Computing

SEWP ZG527



# Agenda

---

## Virtualization Techniques and Types

- Introduction to Virtualization
- Use & demerits of Virtualization
- Types of Virtualization
  - Examples
- x86 Hardware Virtualization

# 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.



# Terminologies to remember

Virtualization – System and Process

VMM or Hypervisor

Guest or Virtual machine – Application + OS

Multi-tenancy, Concurrency

# 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?

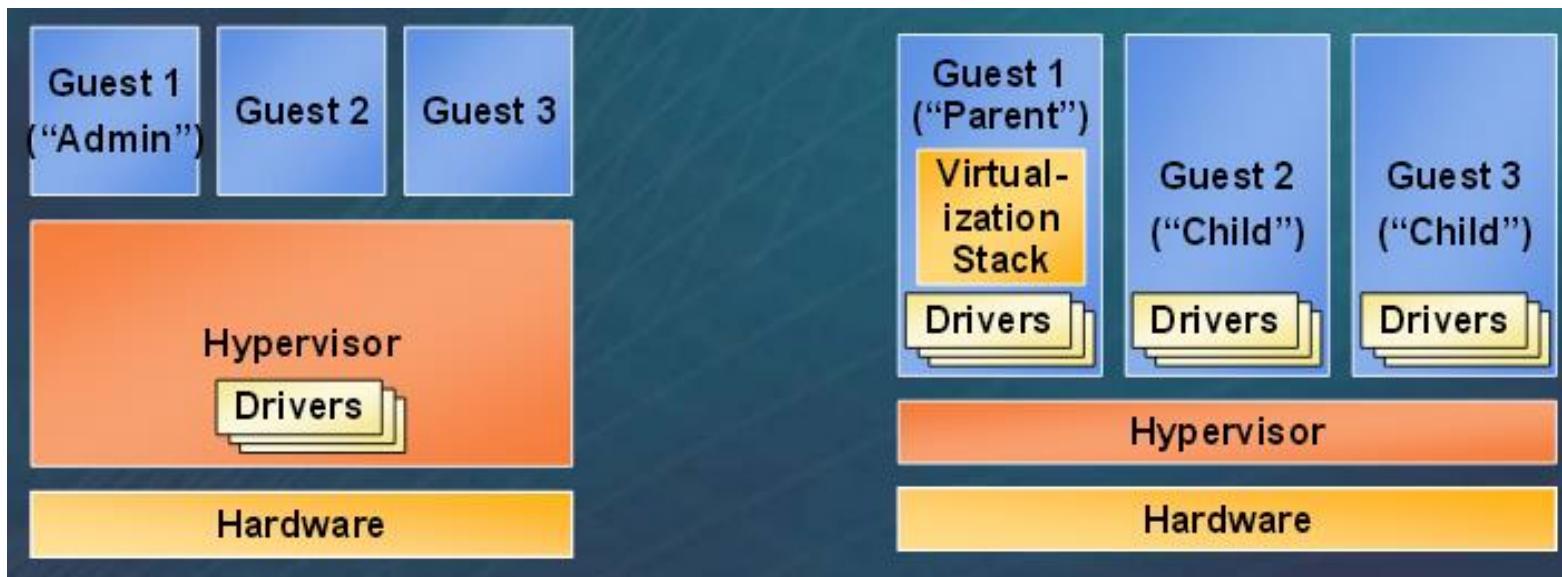


- Partitioning Kernel
  - “Partition” is isolation boundary
  - Few virtualization functions; relies on virtualization stack
- Very thin layer of software
  - Microkernel
  - Highly reliable
  - Basis for smaller Trusted Computing Base (TCB)
- No device drivers
  - Drivers run in a partition
- Well-defined 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



# Terminologies to remember

Types of Hypervisors – Bare metal or native – VMWare ESX

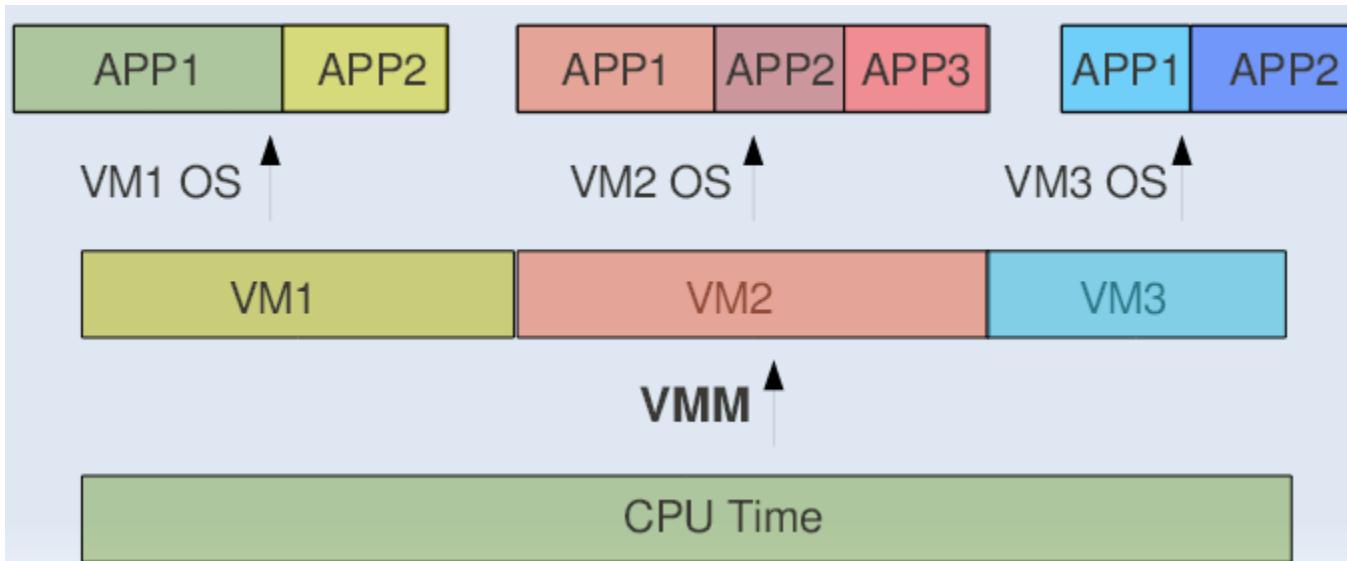
Hosted hypervisors – VMWare GSX

Hybrid hypervisors – MS Hyper-V, Xen

# CPU Sharing

---

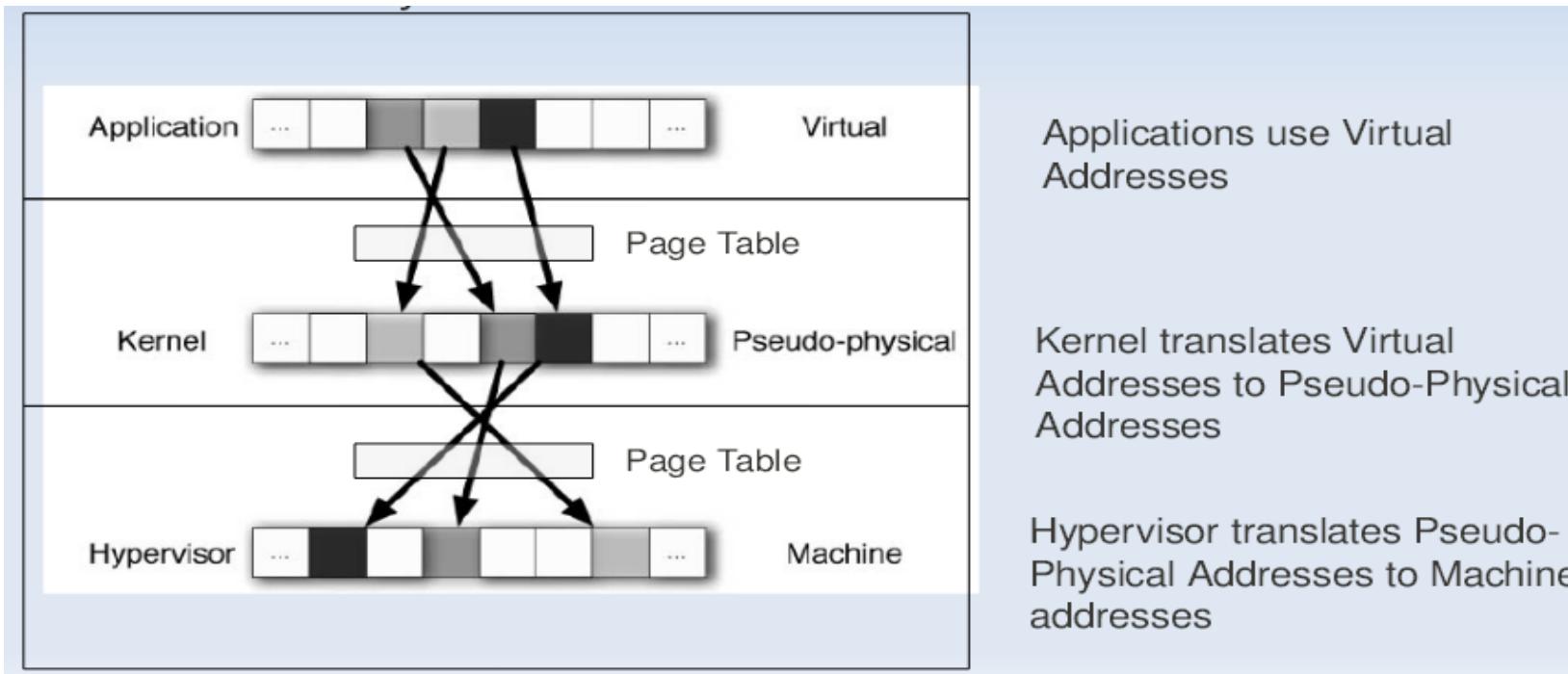
- VMM or Hypervisor provides a virtual view of CPU to VMs.
- In multi processing, CPU is allotted to the different processes in form of time slices by the OS.
- Similarly VMM or Hypervisor allots CPU to different VMs.



# 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



# 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?



**BITS** Pilani

# Cloud Computing

SEWP ZG527



# Agenda

---

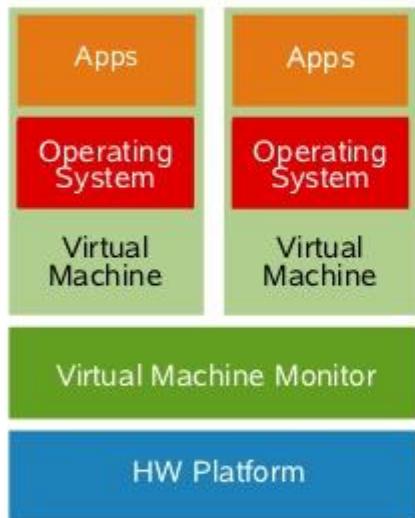
## Virtualization Techniques and Types

- Introduction to Virtualization
- Use & demerits of Virtualization
- Types of Virtualization
  - Examples
- x86 Hardware Virtualization

# Approaches for Virtualization

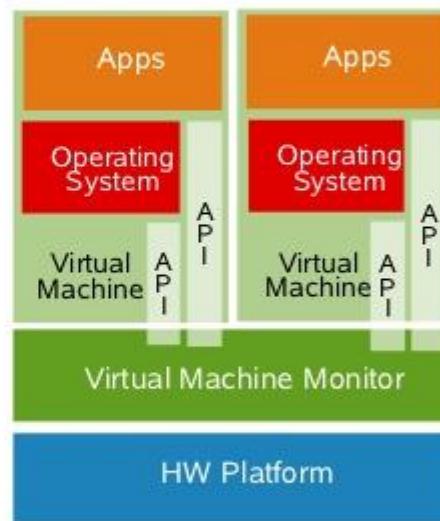
## Full & Paravirtualization Overview

Full Virtualization



Runtime modification of Guest OS:  
VMM manages the conflict, then  
returns to OS

Paravirtualization



Static modification of Guest OS prior to  
runtime: Privileged instruction calls are  
exchanged with API functions provided  
by the VMM  
– Almost no performance degradation  
– Significant scalability

# 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

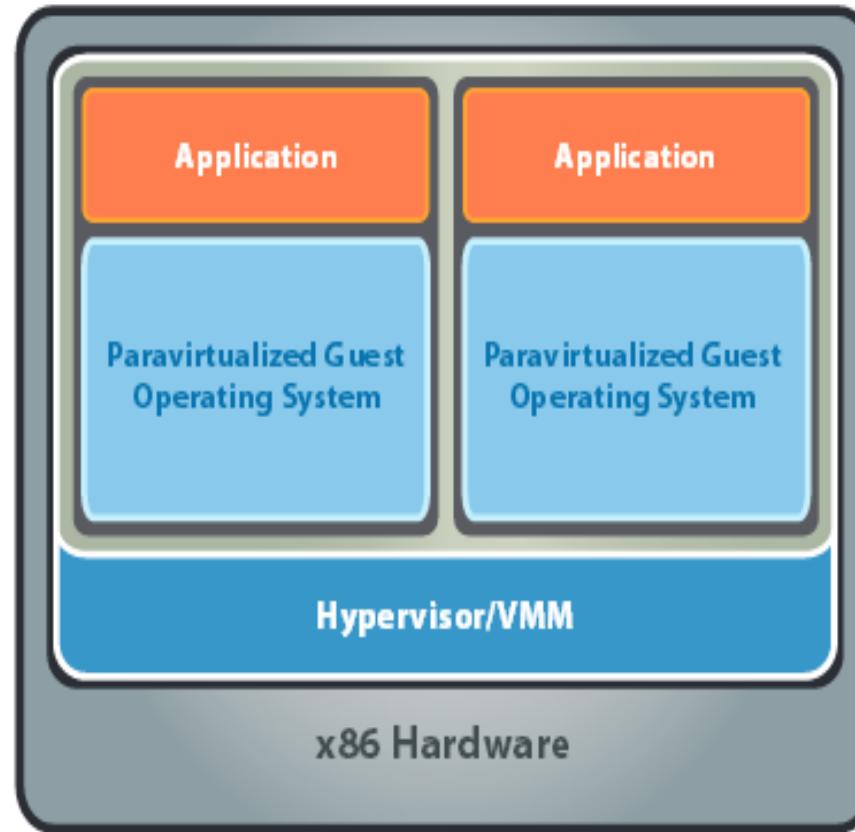
---

- 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

---

- The latest generation of x86-based systems feature processors with 64-bit extensions supporting very large memory capacities.
- This enhances their ability to host large, memory-intensive applications, as well as allowing many more virtual machines to be hosted by a physical server deployed within a virtual infrastructure.
- The continual decrease in memory costs will further accelerate this trend.

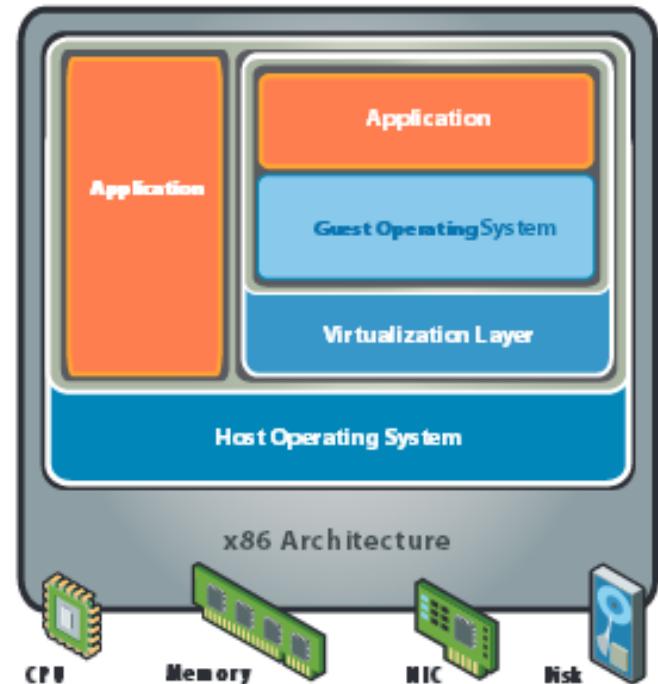


# x86 Hardware Virtualization

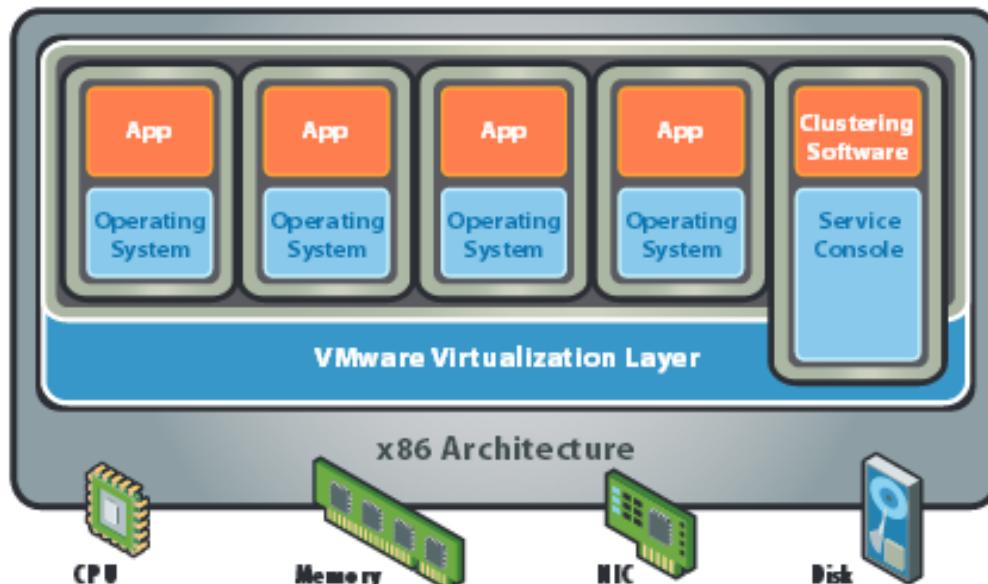
---

- 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

# Terminologies to remember

Basic technique of virtualization is – Trap and Emulate  
Virtualization

Privilege levels or protection ring

CPL – Current Privilege Level (Guest OS)

Instruction Types – Behavior sensitive, Control sensitive  
Control sensitive (privileged instructions)

Method of virtualization – Binary Translation

Para virtualization (Hypervisor dependent)

# 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

# Advantages of Virtualization

---

*Security:* by compartmentalizing environments with different security requirements in different virtual machines one can select the guest operating system and tools that are more appropriate for each environment. For example, we may want to run the Apache web server on top of a Linux guest operating system and a backend MS SQL server on top of a guest Windows XP operating system, all in the same physical platform. A security attack on one virtual machine does not compromise the others because of their isolation.

# Advantages of Virtualization

---

*Reliability and availability:* A software failure in a virtual machine does not affect other virtual machines.

*Cost:* It is possible to achieve cost reductions by consolidation smaller servers into more powerful servers. Cost reductions stem from hardware cost reductions (economies of scale seen in faster servers), operations cost reductions in terms of personnel, floor space, and software licenses. VMware cites overall cost reductions ranging from 29 to 64%

# Advantages of Virtualization

---

*Adaptability to Workload Variations:* Changes in workload intensity levels can be easily taken care of by shifting resources and priority allocations among virtual machines. Autonomic computing-based resource allocation techniques, such as the ones in can be used to dynamically move processors from one virtual machine to another.

*Load Balancing:* Since the software state of an entire virtual machine is completely encapsulated by the VMM, it is relatively easy to migrate virtual machines to other platforms in order to improve performance through better load balancing

# Advantages of Virtualization

---

*Legacy Applications:* Even if an organization decides to migrate to a different operating system, it is possible to continue to run legacy applications on the old OS running as a guest OS within a VM. This reduces the migration cost.

# 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.

# Applications of Virtualization

---

- Today, virtualization can apply to a range of system layers, including hardware-level virtualization, operating system-level virtualization, and high-level language virtual machines.
- **Maximize resources** — Virtualization can reduce the number of physical systems you need to acquire, and you can get more value out of the servers. Most traditionally built systems are underutilized. Virtualization allows maximum use of the hardware investment.
- **Multiple systems** — With virtualization, you can also run multiple types of applications and even run different OS for those applications on the same physical hardware.
- **IT budget integration** — When you use virtualization, management, administration and all the attendant requirements of managing your own infrastructure remain a direct cost of your IT operation.

# Technology Trends

---

- Virtualization is Key to Exploiting Trends
- Allows most efficient use of the compute resources
  - Few apps take advantage of 16+ CPUs and huge memory as well as virtualization
  - Virtualization layer worries about NUMA, not apps
- Maximize performance per watt across all servers
  - Run VMs on minimal # of servers, shutting off the others
  - Automated, live migration critical:
    - Provide performance guarantees for dynamic workloads
    - Balance load to minimize number of active servers
- Stateless, Run-anywhere Capabilities
  - Shared network and storage allows flexible mappings
  - Enables additional availability guarantees



Thanks!!!  
Queries?

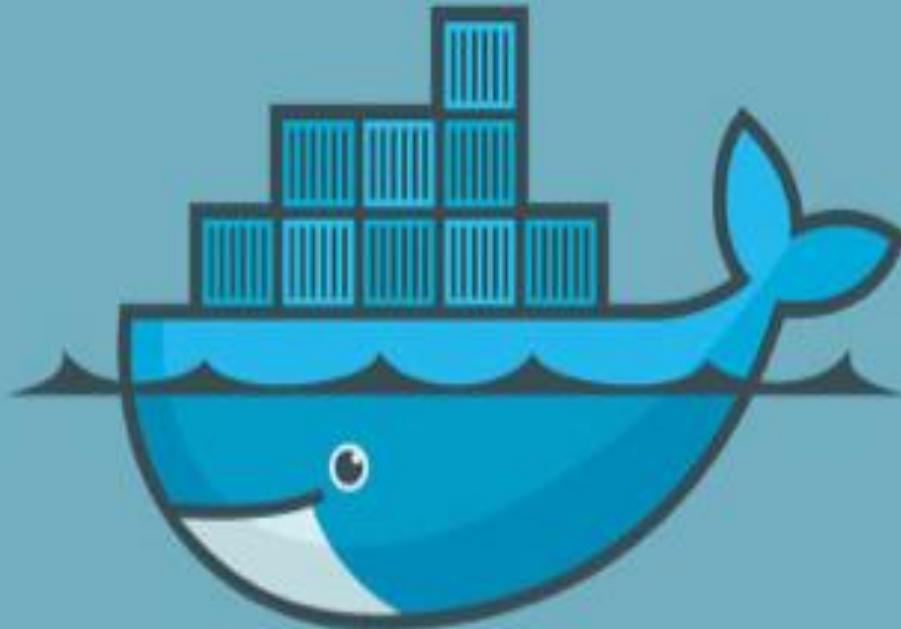


**BITS** Pilani

# Cloud Computing

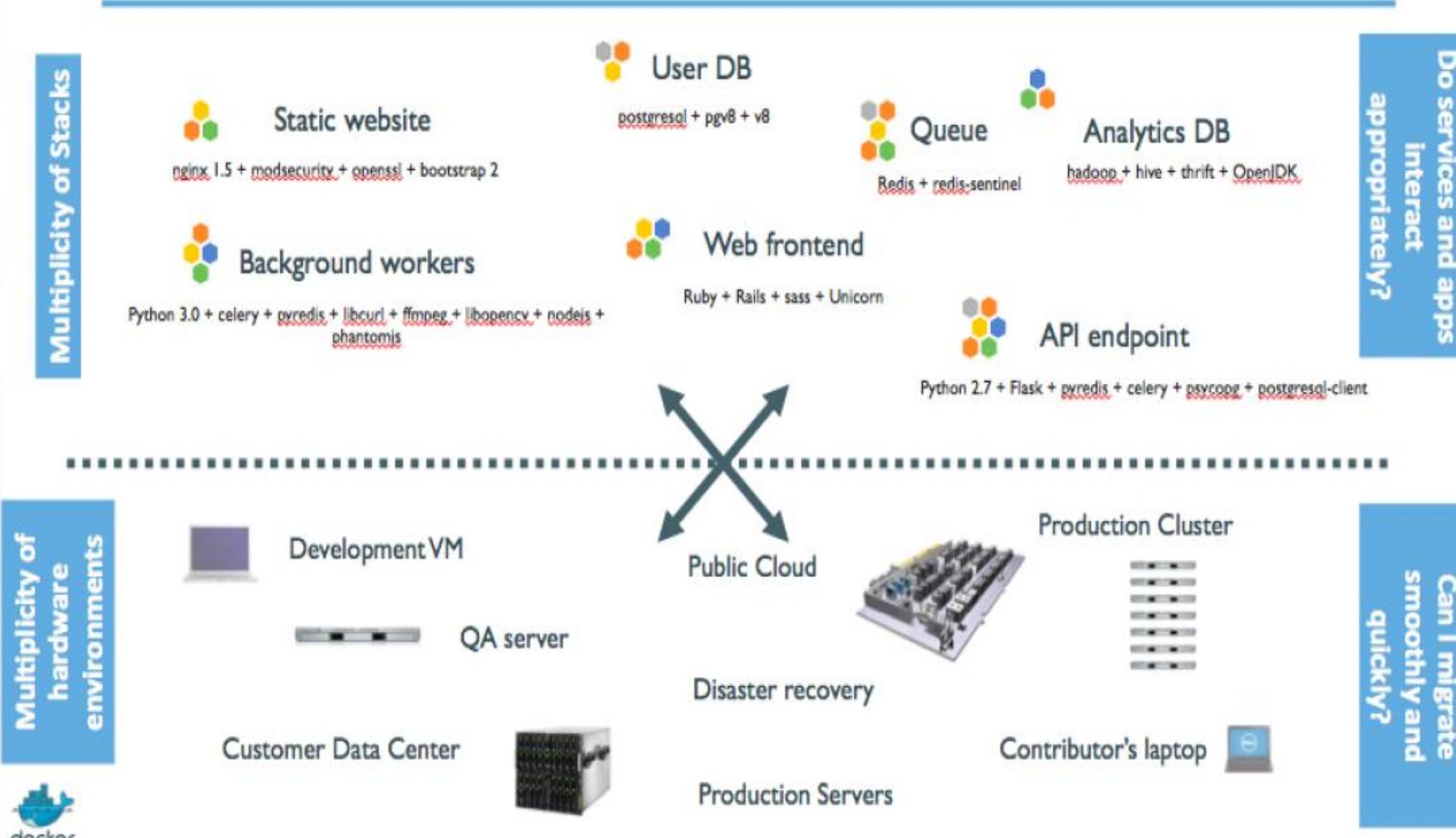
SEWP ZG527



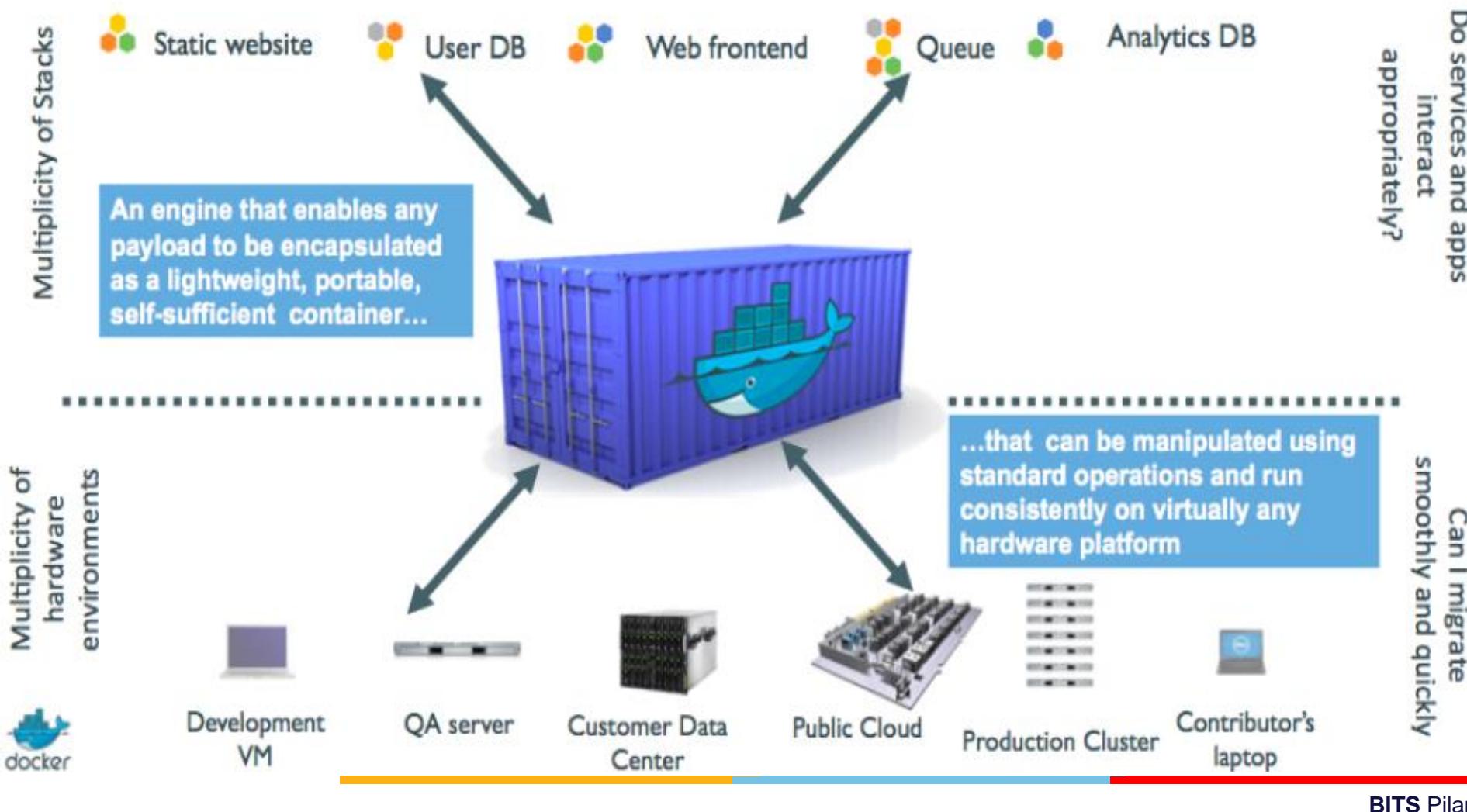


# docker

# Current Problem the Industry is facing



# A shipping container system for applications



# Dockers

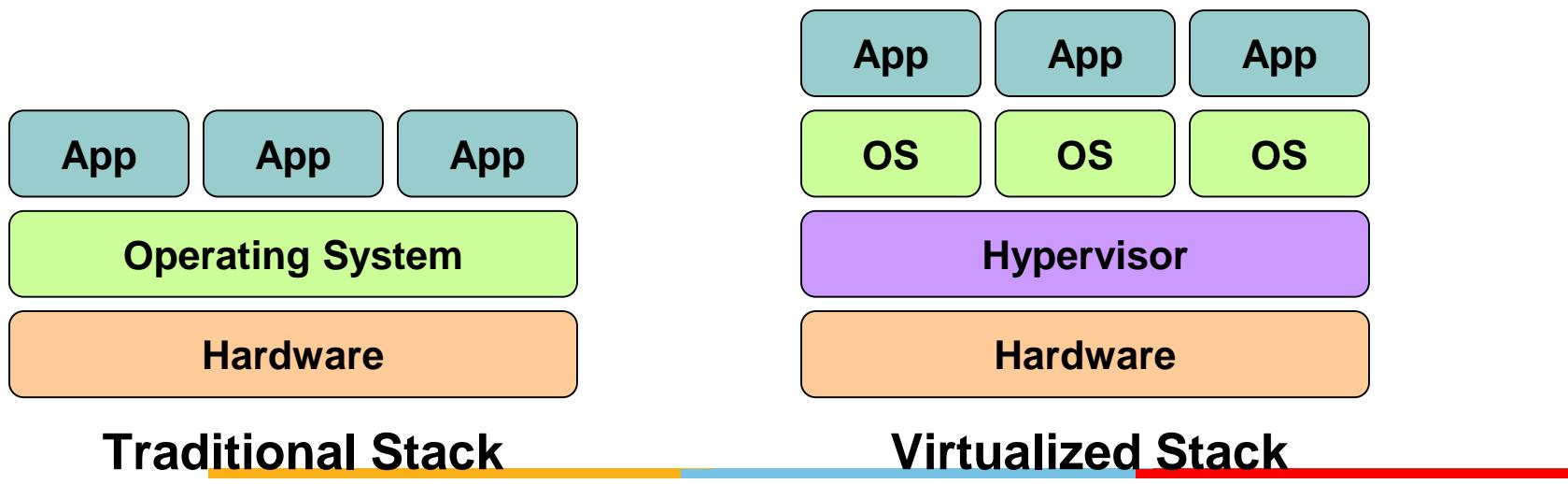
---

- 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?

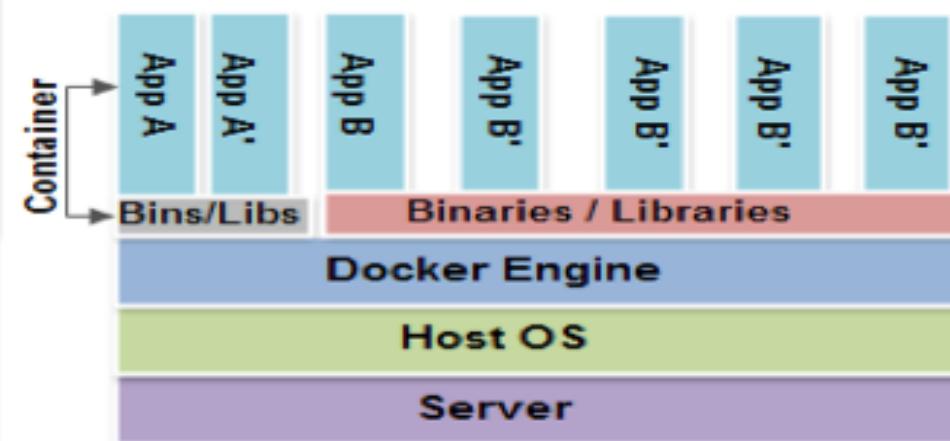
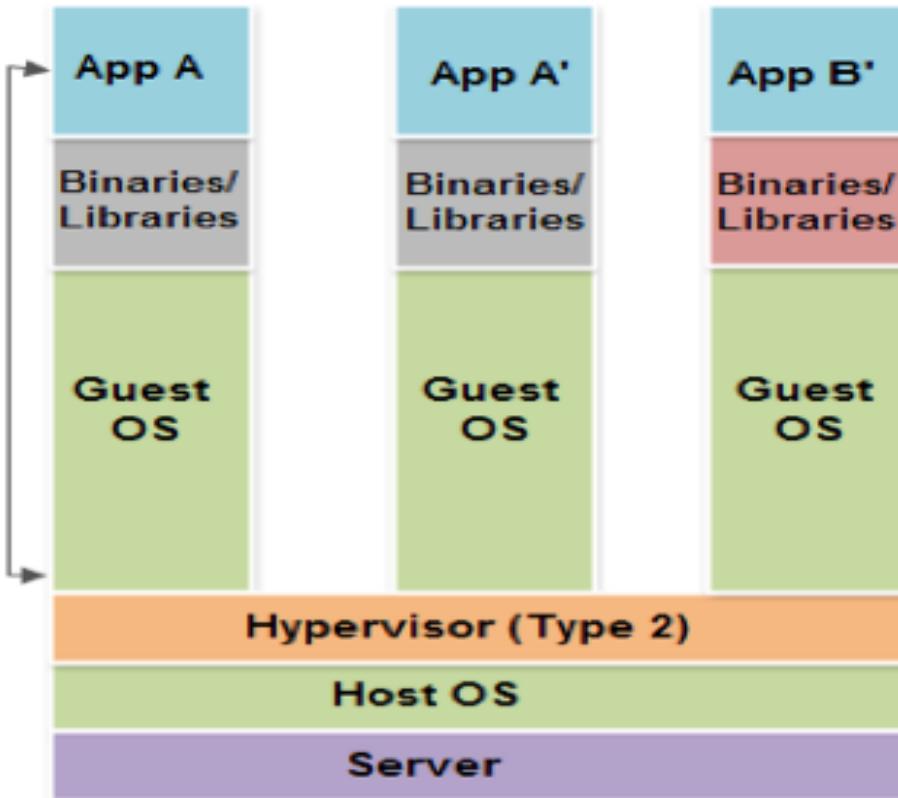
---

- 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.



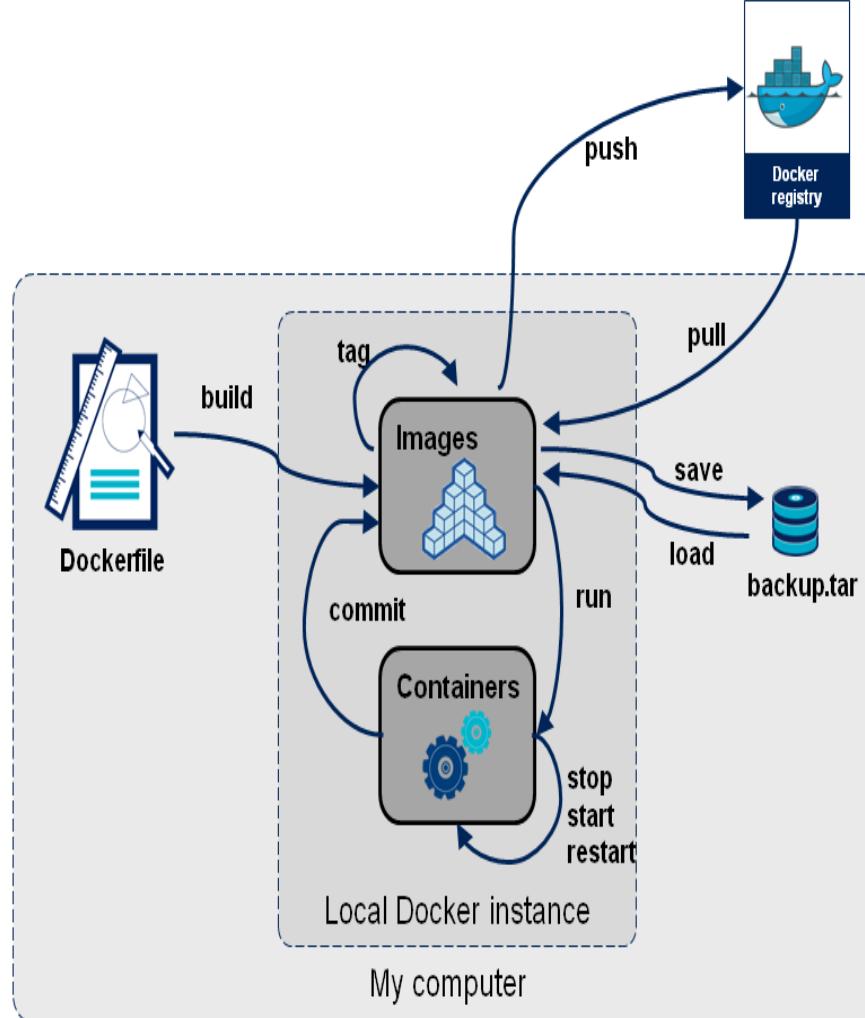
# How are Docker Containers different from a Virtual Machine?

## Containers vs Virtual Machines



# 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/bin/ubuntu-set-selections
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



**BITS** Pilani

# Cloud Computing

SEWP ZG527





# IaaS

*Really, what is iaas???*

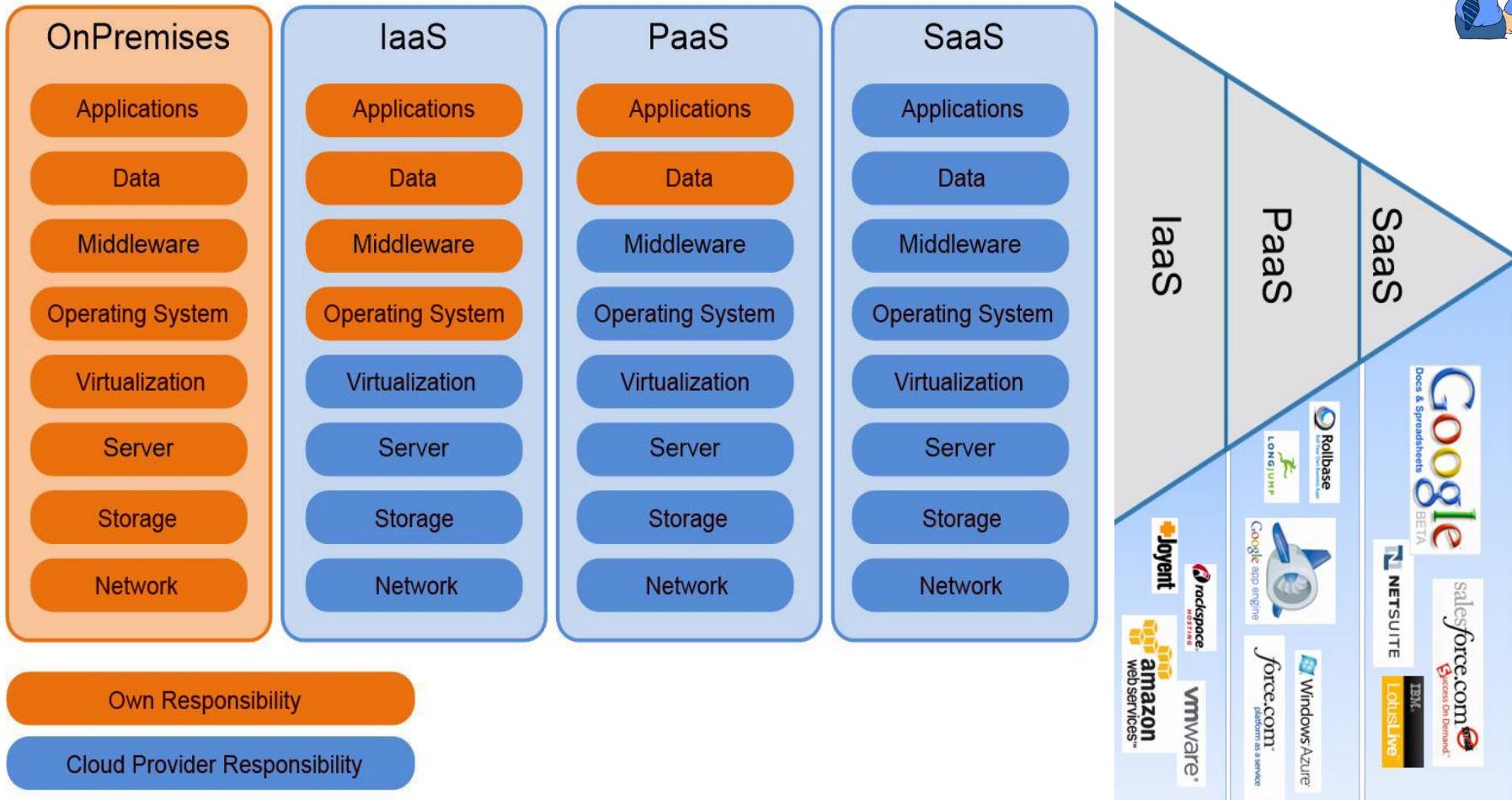




# heard of 3 models of Cloud Computing?



Yes, Yes, IaaS, PaaS and SaaS

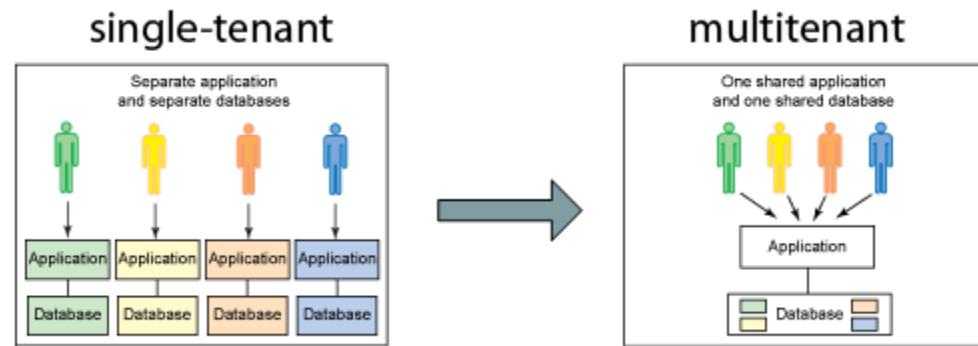


# Key concepts of IaaS

---

- 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

---

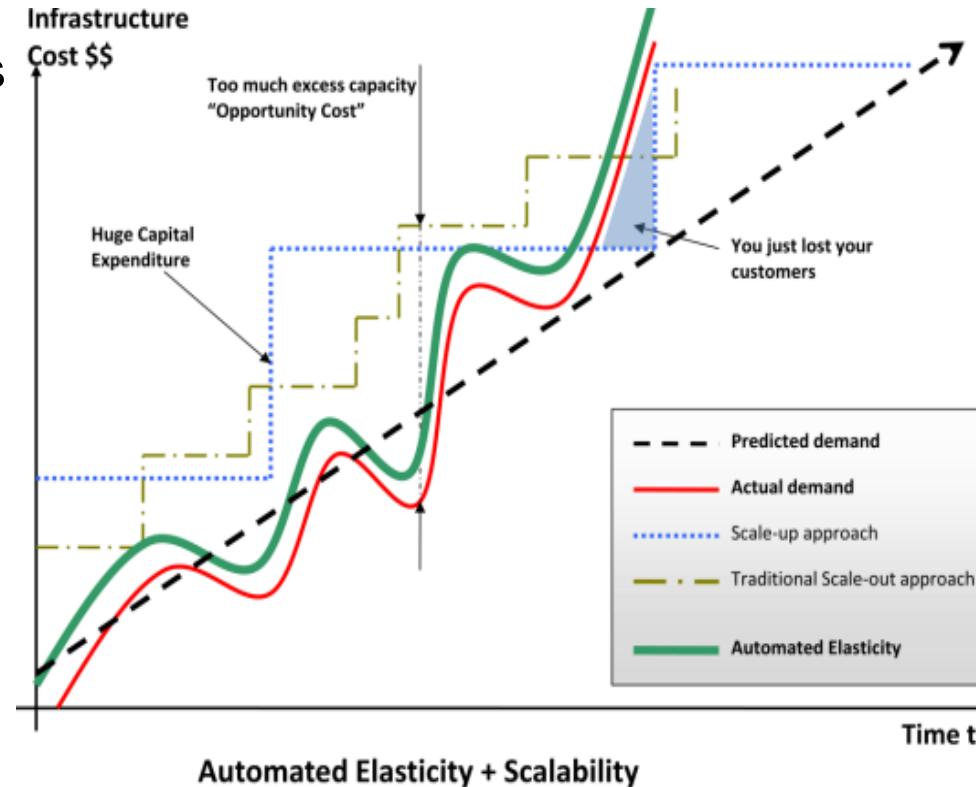
## Elasticity:

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



# The value of IaaS

---

For businesses, the greatest value of IaaS is through a concept known as *cloudbursting*—the process of off-loading tasks to the cloud during times when the most compute resources are needed.

To take advantage of IaaS in this capacity, IT departments must be able to build and implement the software that handles the ability to re-allocate processes to an IaaS cloud.

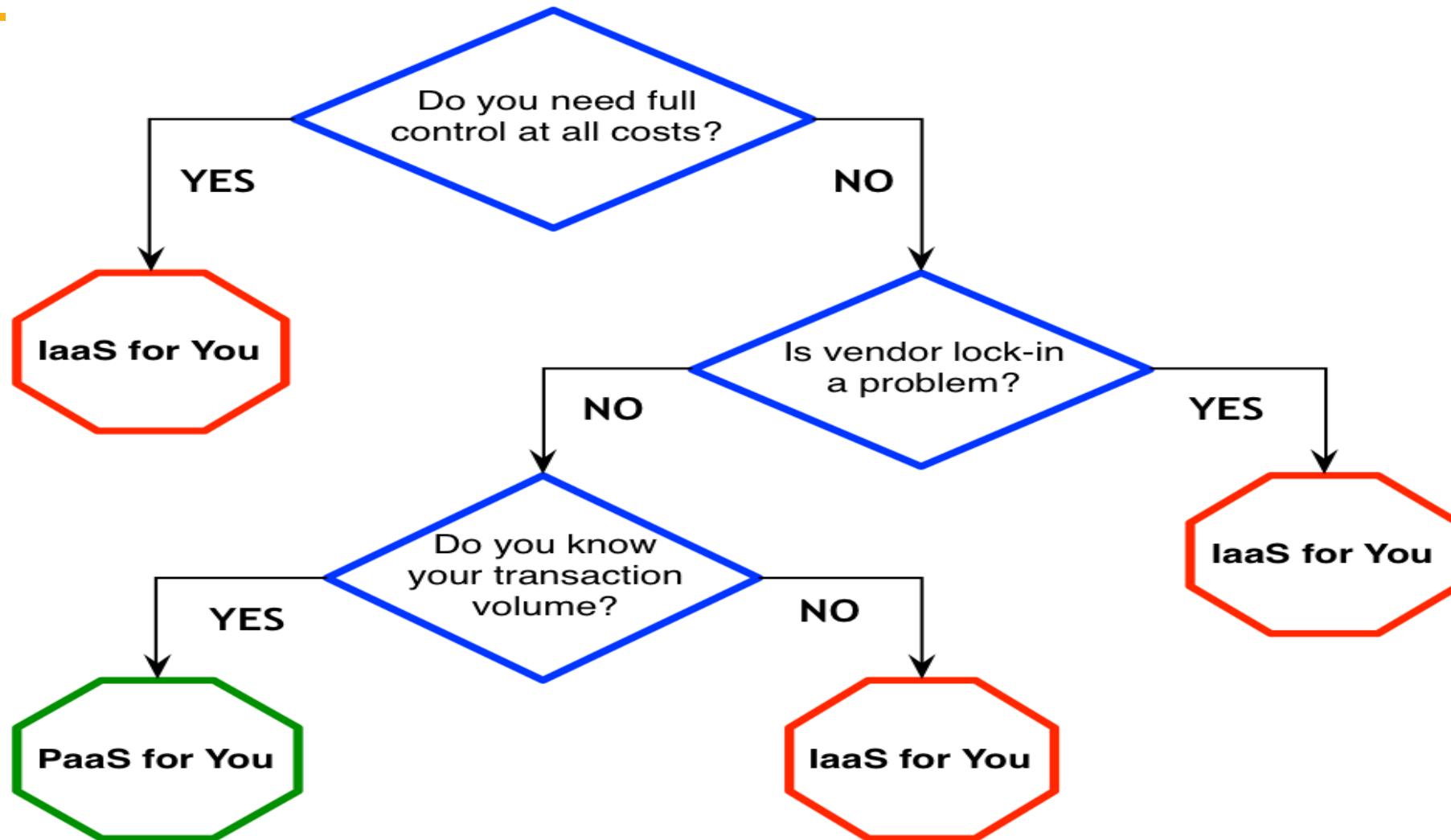
There are four important considerations to build and implement software that can manage such reallocation processes.

# 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/>

## IaaS or PaaS Decision Tree





# Cloud Computing

SEWP ZG527

**BITS** Pilani





# IaaS

*Really, what is iaas???*



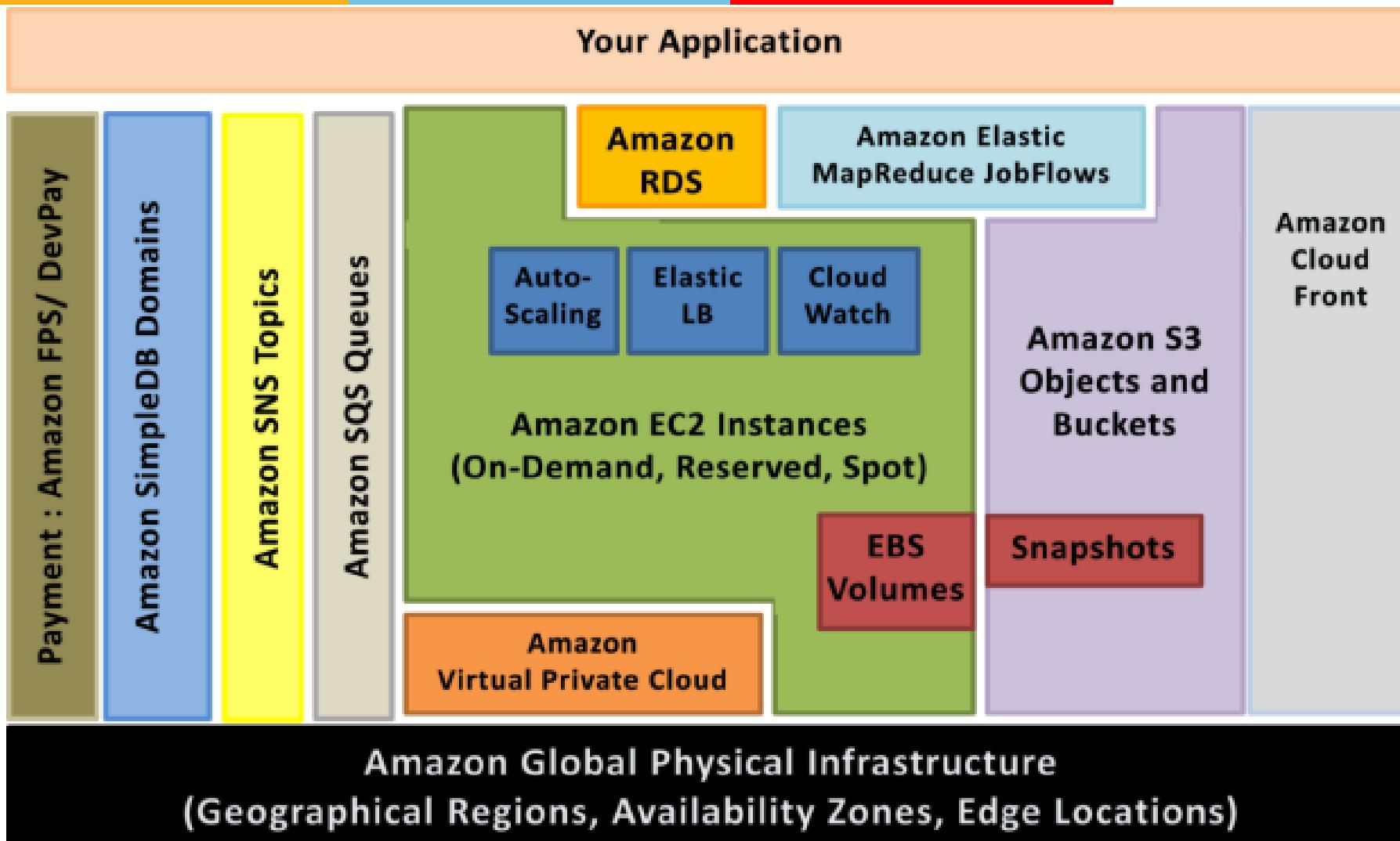
# Amazon Web Services

---

## 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



# Amazon Elastic Compute Cloud (Amazon EC2)

---

- Web service that provides resizable compute capacity in the cloud
- Can be bundled with OS, application software and associated configuration settings into an Amazon Machine Image (AMI).
- Use these AMIs to provision multiple virtualized instances
- Decommission them using simple web service calls to scale capacity up and down quickly, as capacity requirement changes.
- On-Demand Instances - pay for the instances by the hour
- Reserved Instances - pay a low, one-time payment and receive a lower usage rate to run the instance
- Spot Instances - bid for unused capacity and further reduce your cost.
- Instances can be launched in one or more geographical regions.
- Each region has multiple Availability Zones. Availability Zones are distinct locations that are engineered to be insulated from failures in other Availability Zones

# Infrastructure Services

---

- **Elastic IP addresses** - allocate a static IP address and assigned to an instance.
- **CloudWatch**: Enable monitoring Amazon EC2 instance - - visibility into resource utilization, operational performance, and overall demand patterns (including metrics such as CPU utilization, disk reads and writes, and network traffic).
- **Auto-scaling** - to automatically scale capacity on certain conditions based on metric that Amazon CloudWatch collects.
- **Elastic LB** – distribute incoming traffic by creating an elastic load balancer
- **Amazon Elastic Block Storage (EBS)** - volumes provide network-attached persistent storage to Amazon EC2 instances.

# Infrastructure Services

---

- **Amazon S3** is highly durable and distributed data store. With a simple web services interface, store and retrieve large amounts of data as objects in buckets (containers) at any time, using standard HTTP
- **Amazon SimpleDB** - Provides the core functionality of a database, real-time lookup and simple querying of structured data
- **Amazon Relational Database Service** - provides an easy way to setup, operate and scale a relational database in the cloud.
- **Amazon Elastic MapReduce** - provides a hosted Hadoop framework
- **AWS Identity and Access Management (IAM)** – enables multiple User creation with unique security credentials and manage the permissions for each of these Users

# Examples

---

AWS – EC2, EBS, S3, LB



# IaaS for you

*Thanks, I feel so “Clouded” now*





**BITS** Pilani

# Cloud Computing

SEWP ZG527



# IaaS

*Really, what is iaas???*

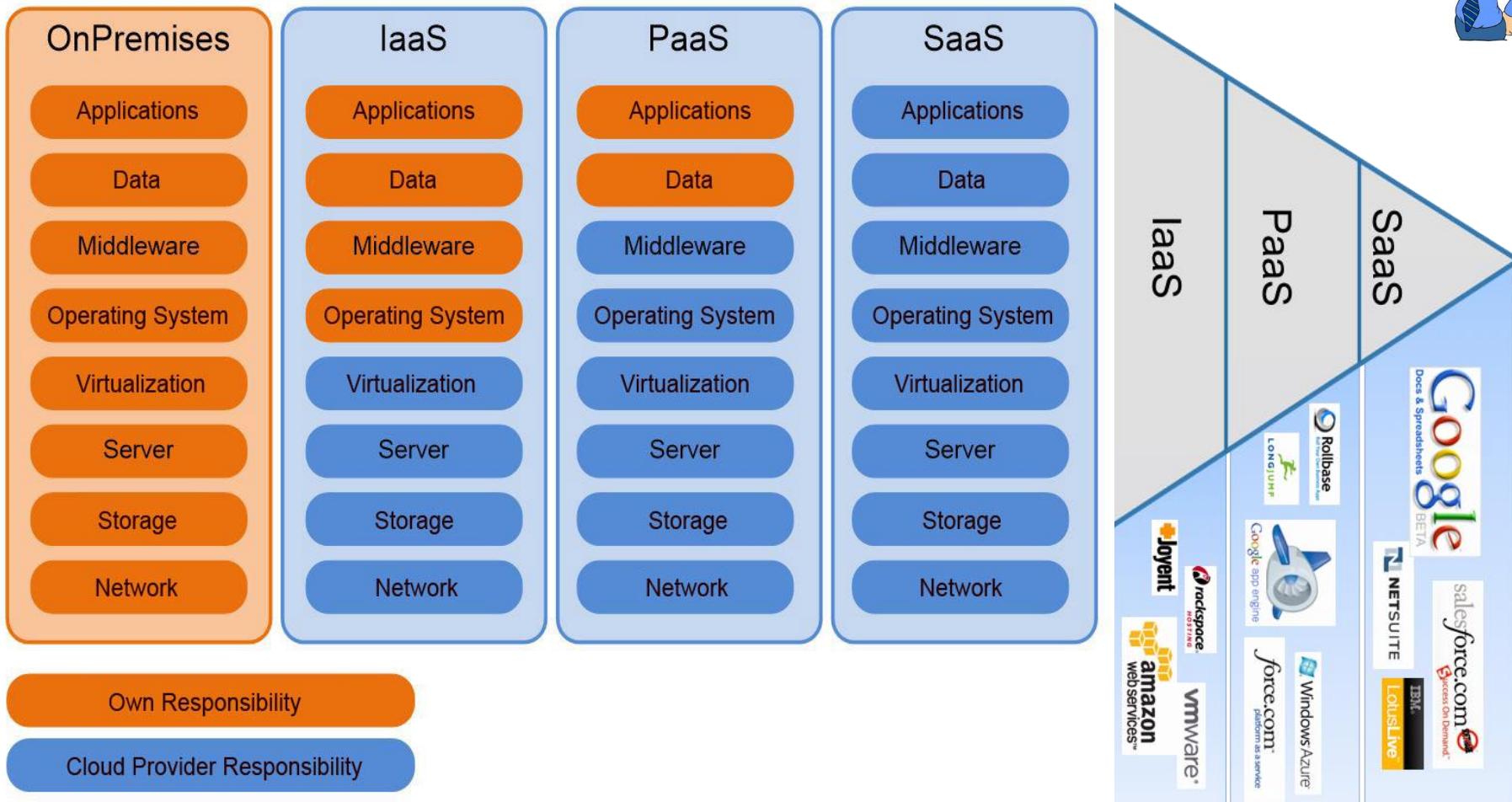




# heard of 3 models of Cloud Computing?



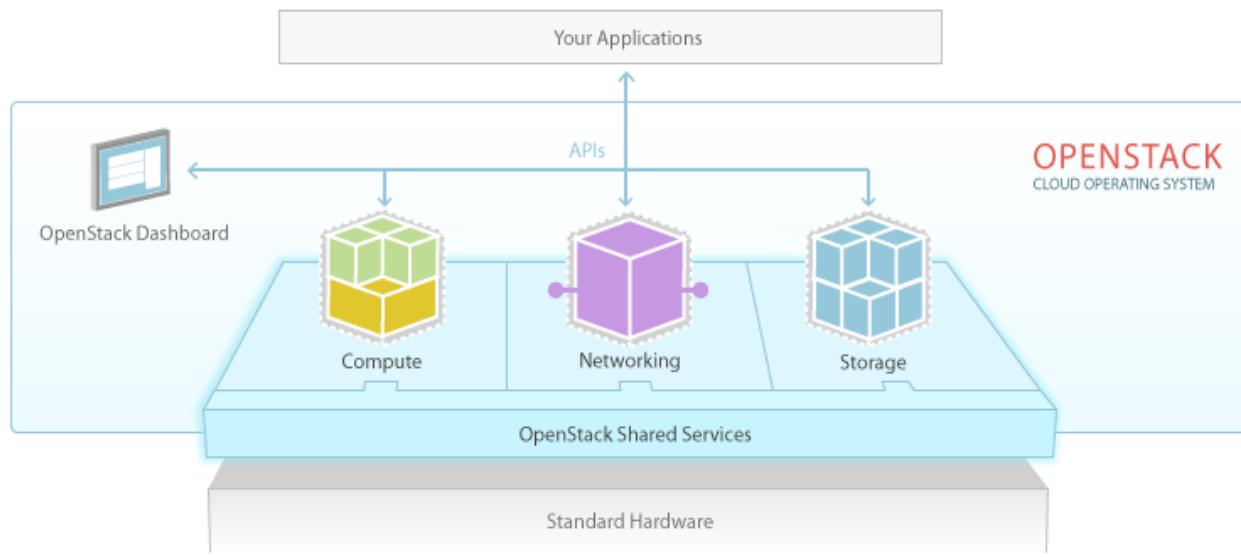
Yes, Yes, IaaS, PaaS and SaaS



# Openstack overview

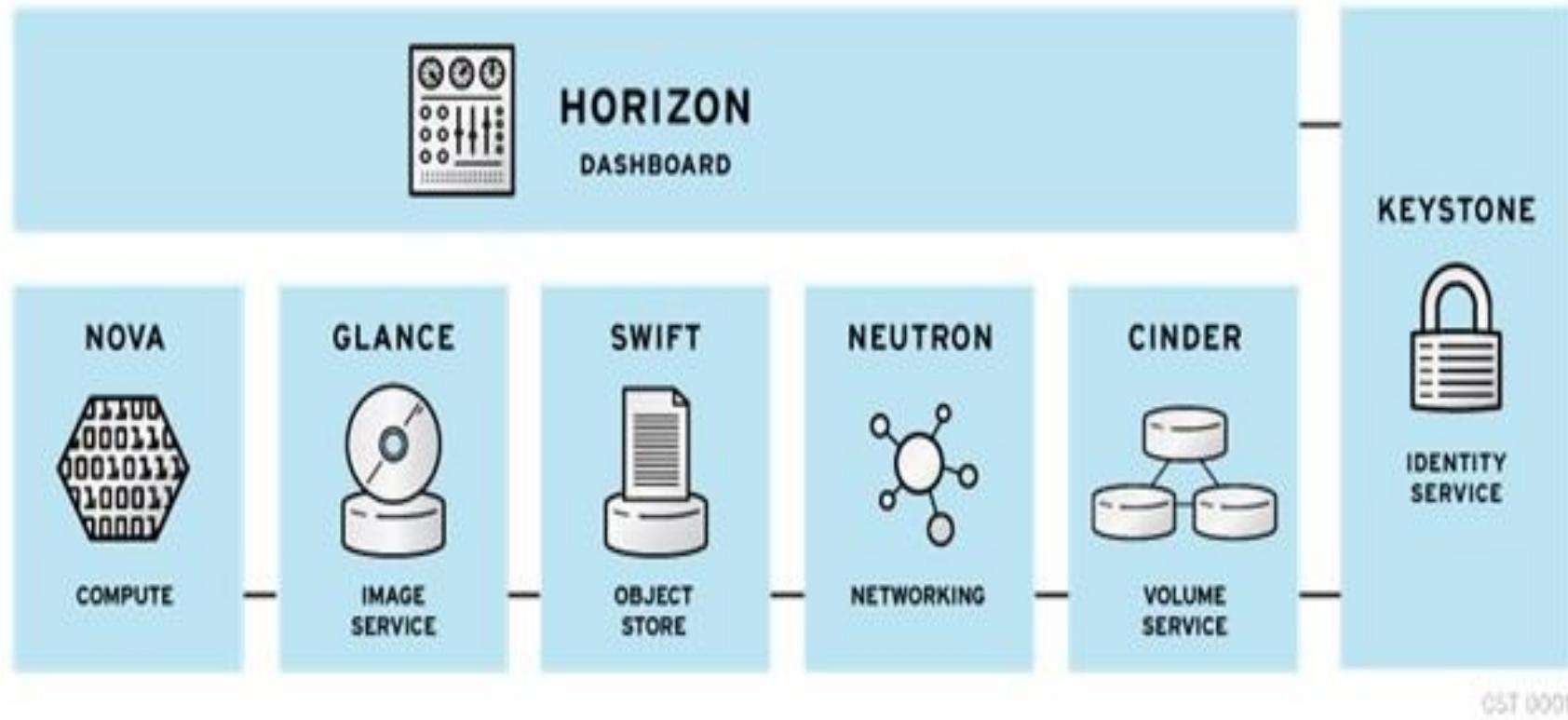
---

- ▶ 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.

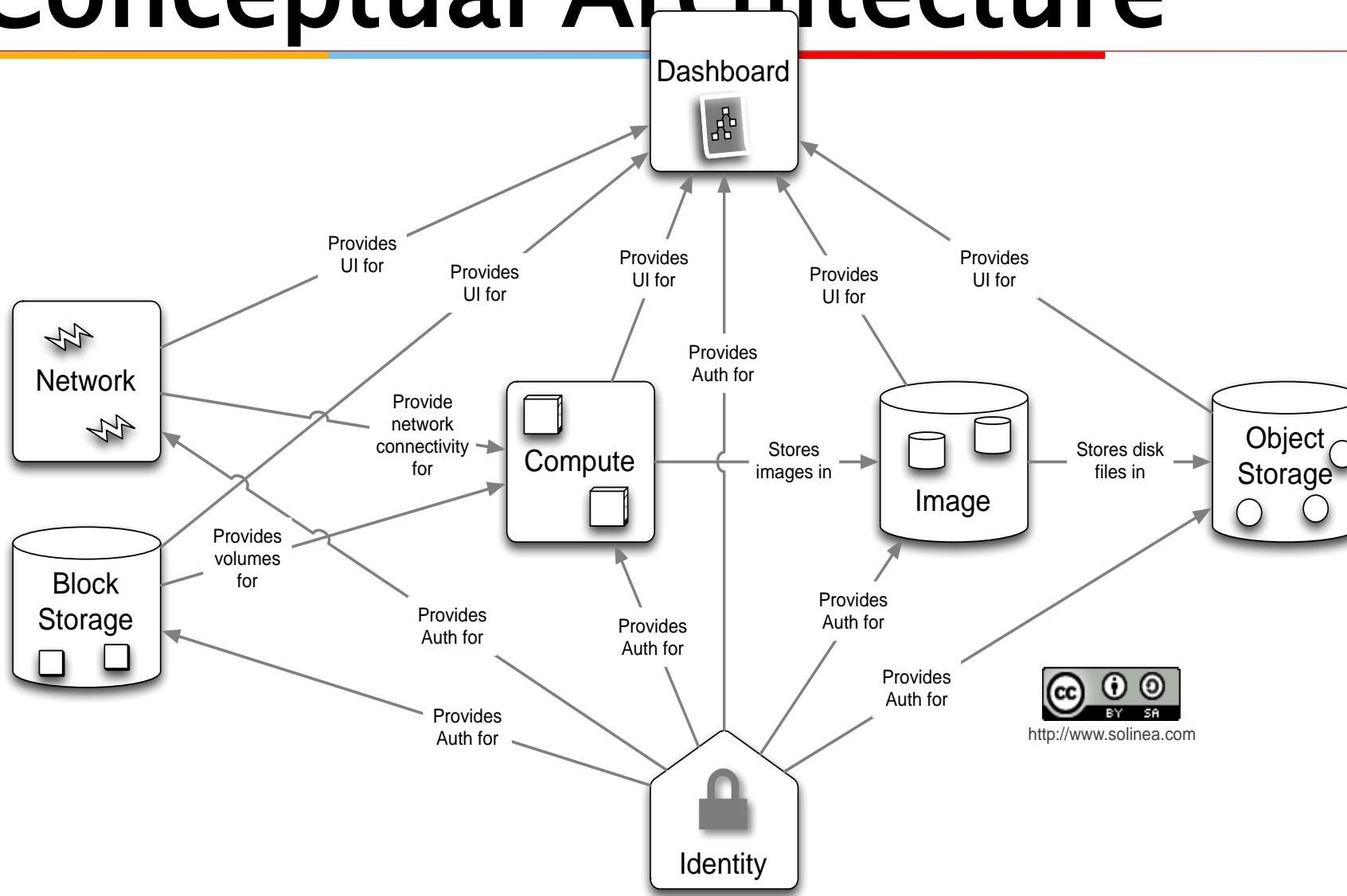


# Openstack Components

---



# Conceptual Architecture



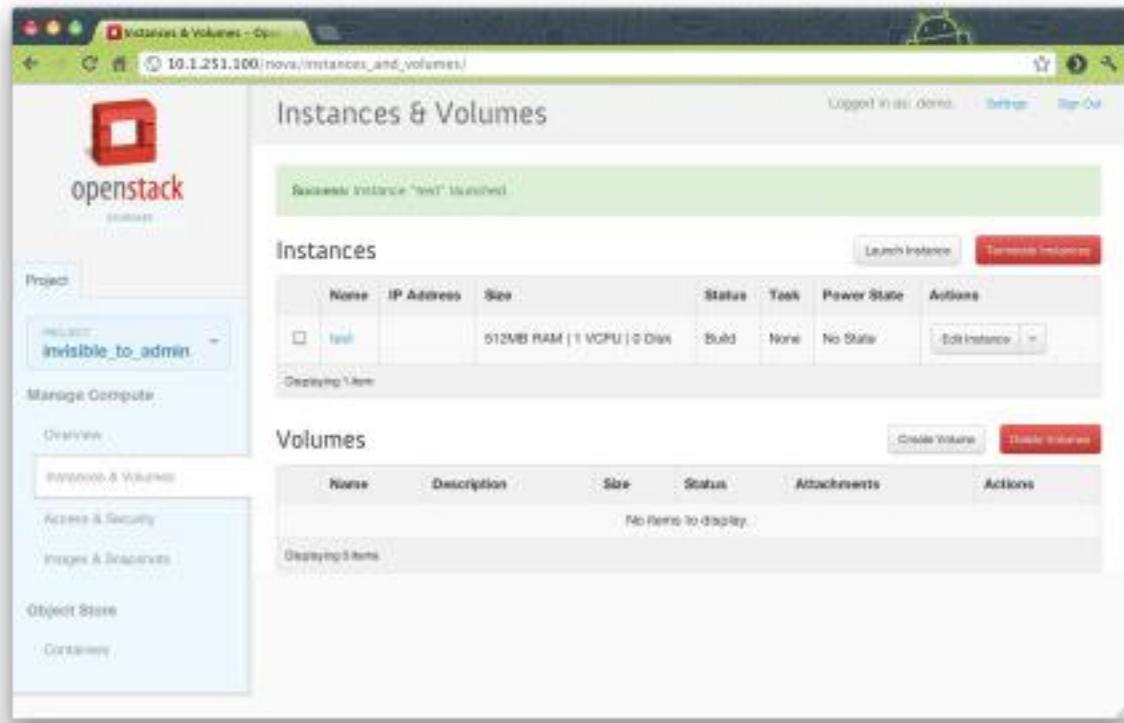
# Openstack Components. Cont.

---

## Horizon – Dashboard

It provides a modular web-based user interface for all the OpenStack services. With this web GUI, you can perform most operations on your cloud like launching an instance, assigning IP addresses and setting access controls.

# orizon – Dashboard

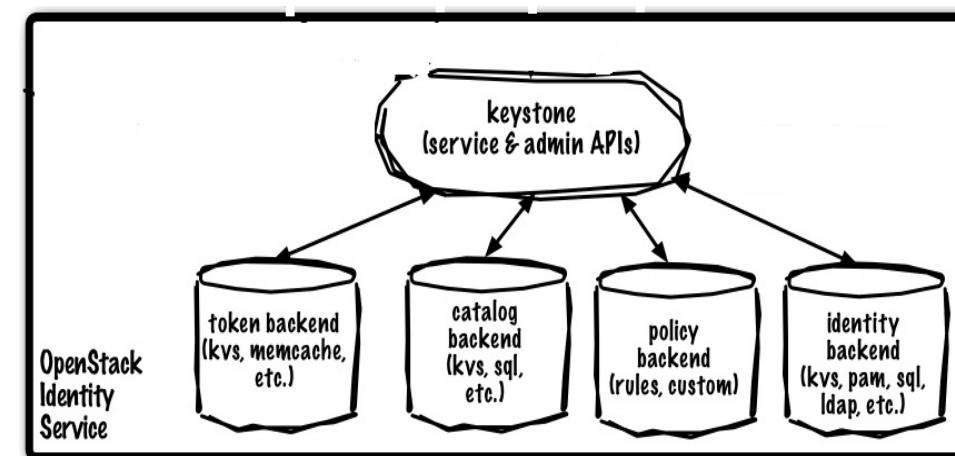


# Keystone – Identity

Keystone is a framework for authentication and authorization for all the OpenStack services.

Keystone handles API requests as well as providing configurable catalog, policy, token and identity services.

It provides the ability to add users to groups (also known as tenants) and to manage permissions between users and groups. Permissions include the ability to launch and terminate instances.



# Glance – Image Store

It provides discovery, registration and delivery services for disk and server images.

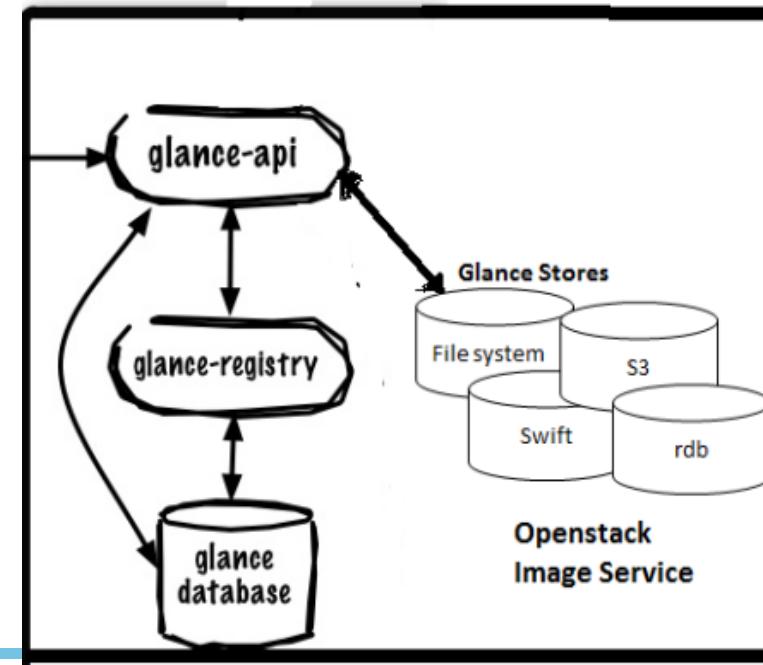
List of processes and their functions:

**glance-api** : It accepts Image API calls for image discovery, image retrieval and image storage.

**glance-registry** : it stores, processes and retrieves metadata about images (size, type, etc.).

**glance database** : A database to store the image metadata.

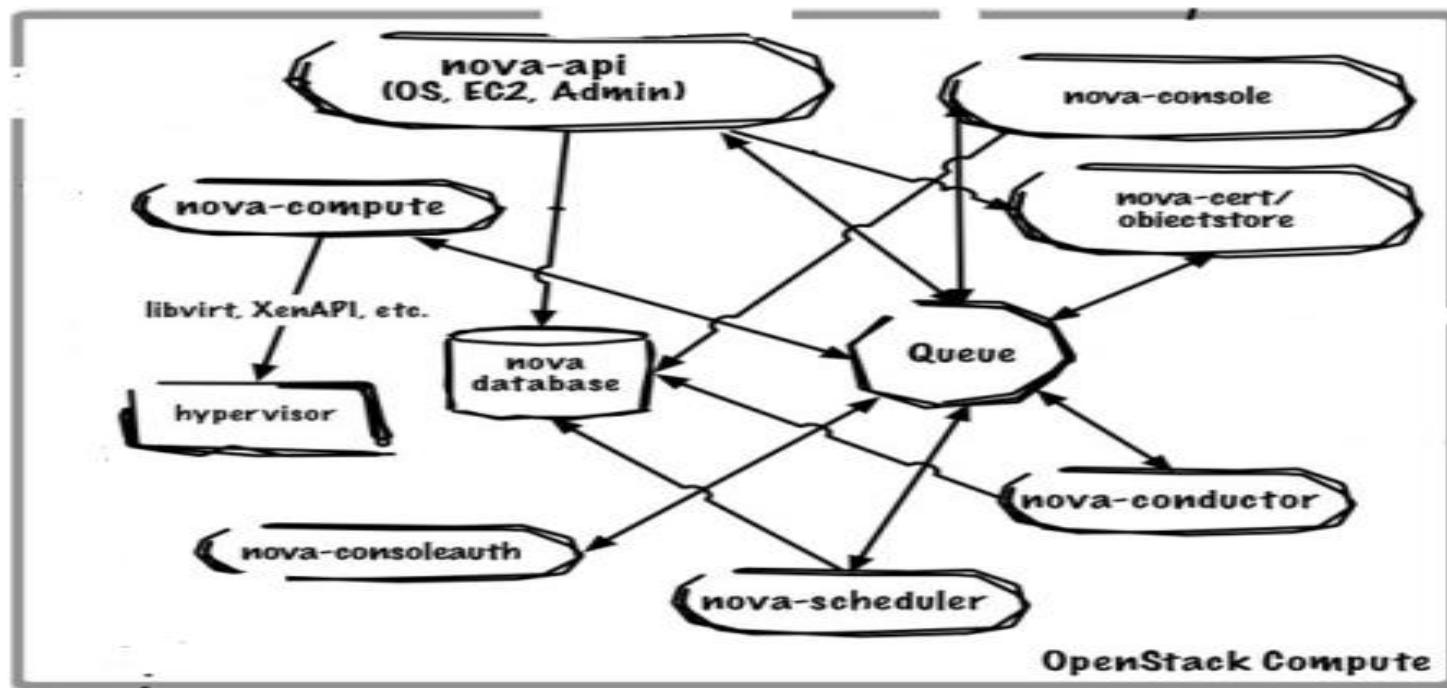
A **storage repository** for the actual image files. Glance supports normal file-systems, Amazon S3, and Swift.



# Nova – Compute

---

It provides virtual servers upon demand. Nova is the most complicated and distributed component of OpenStack. A large number of processes cooperate to turn end user API requests into running virtual machines.



# Nova – Compute

---

***nova-api*** : it's a RESTful API web service which accepts incoming commands to interact with the OpenStack cloud.

***nova-compute***: it's a worker daemon which creates and terminates virtual machine instances via Hypervisor's APIs .

***nova-scheduler***: it takes a request from the queue and determines which compute server host it should run on.

***nova-conductor***: It provides services for nova-compute, such as completing database updates and handling long-running tasks.

# Nova – Compute

---

***nova database:*** It stores most of the build-time and run-time state for a cloud infrastructure.

The ***queue*** provides a central hub for passing messages between daemons. This is usually implemented with RabbitMQ.

Nova also provides console services to allow end users to access their virtual instance's console through a proxy. This involves several daemons (***nova-console***, ***nova-novncproxy*** and ***nova-consoleauth***).

# Nova – Compute

---

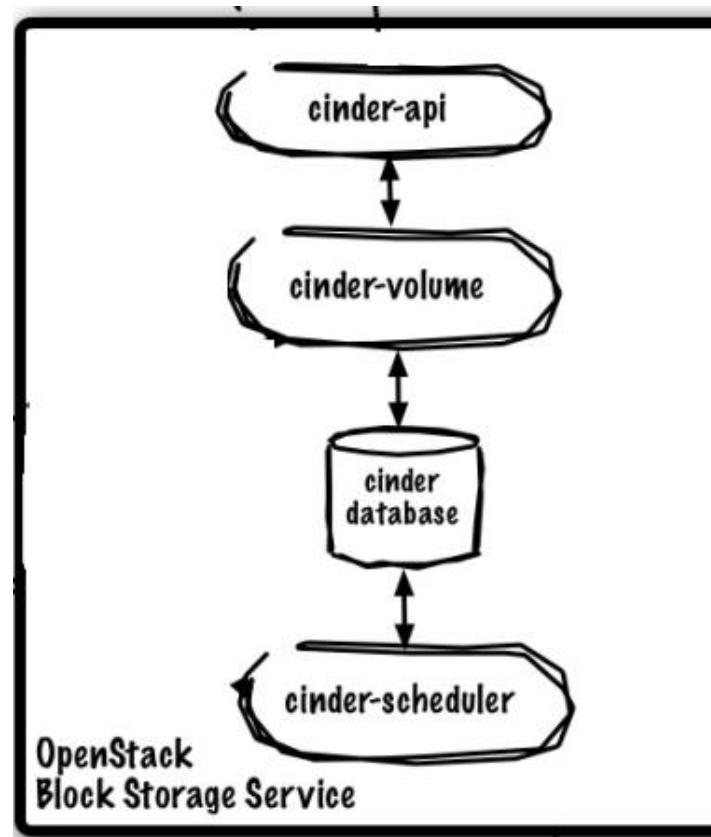
***nova-network*** : it's a worker daemon very similar to nova-compute. It accepts networking tasks from the queue and then performs tasks to manipulate the network (such as setting up bridging interfaces or changing iptables rules). This functionality is being migrated to **Quantum**, a separate OpenStack service.

***nova-volume*** : Manages creation, attaching and detaching of persistent volumes to compute instances. This functionality is being migrated to Cinder, a separate OpenStack service.

# Cinder – Block Storage

---

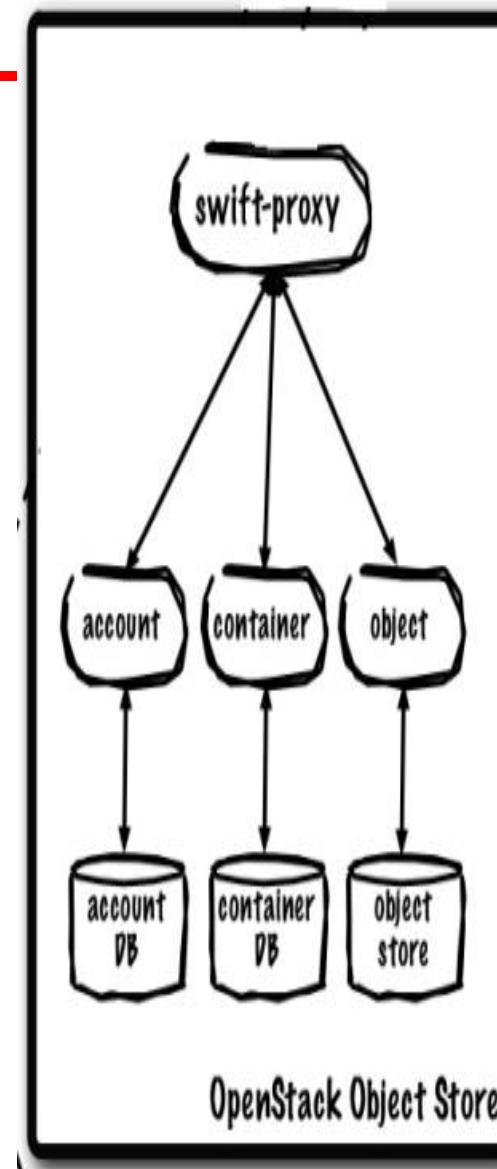
Cinder allows block devices to be exposed and connected to compute instances for expanded storage & better performance.



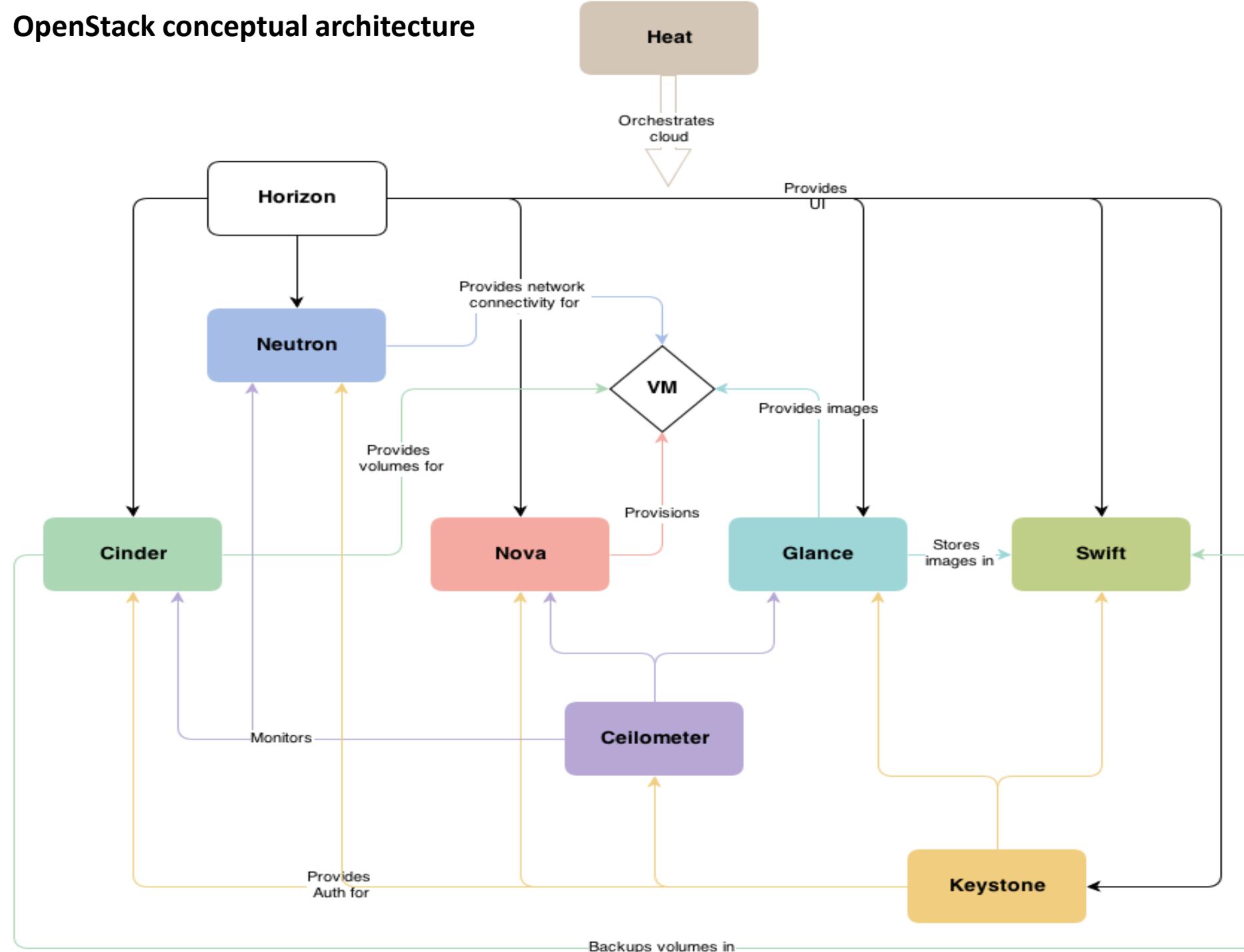
# Swift – Object Storage

Object store allows you to store or retrieve files. It provides a fully distributed, API-accessible storage platform that can be integrated directly into applications or used for backup, archiving and data retention.

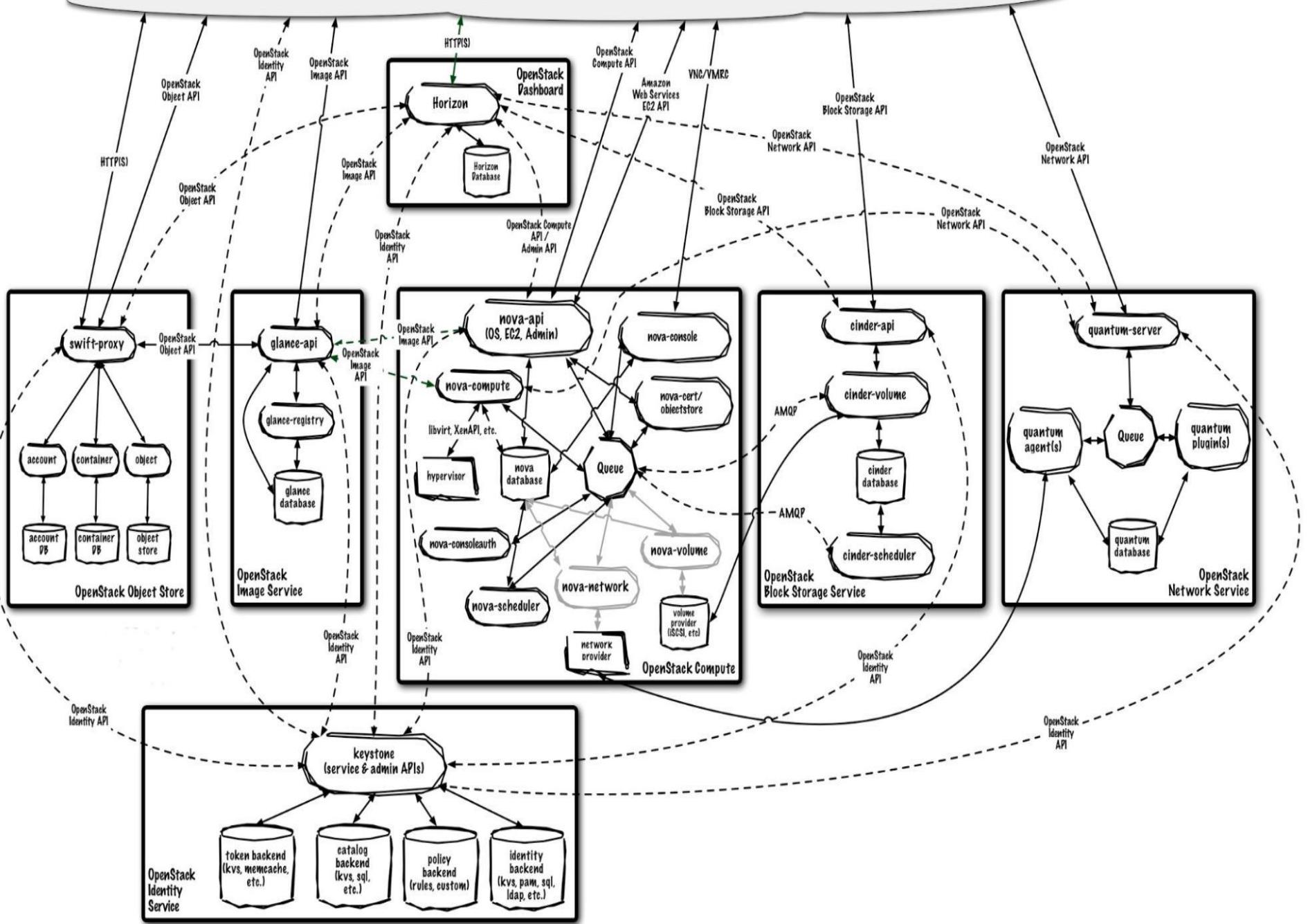
*Note :* Object Storage is not a traditional file system, but rather a distributed storage system for static data such as virtual machine images, photo storage, email storage, backups and archives.



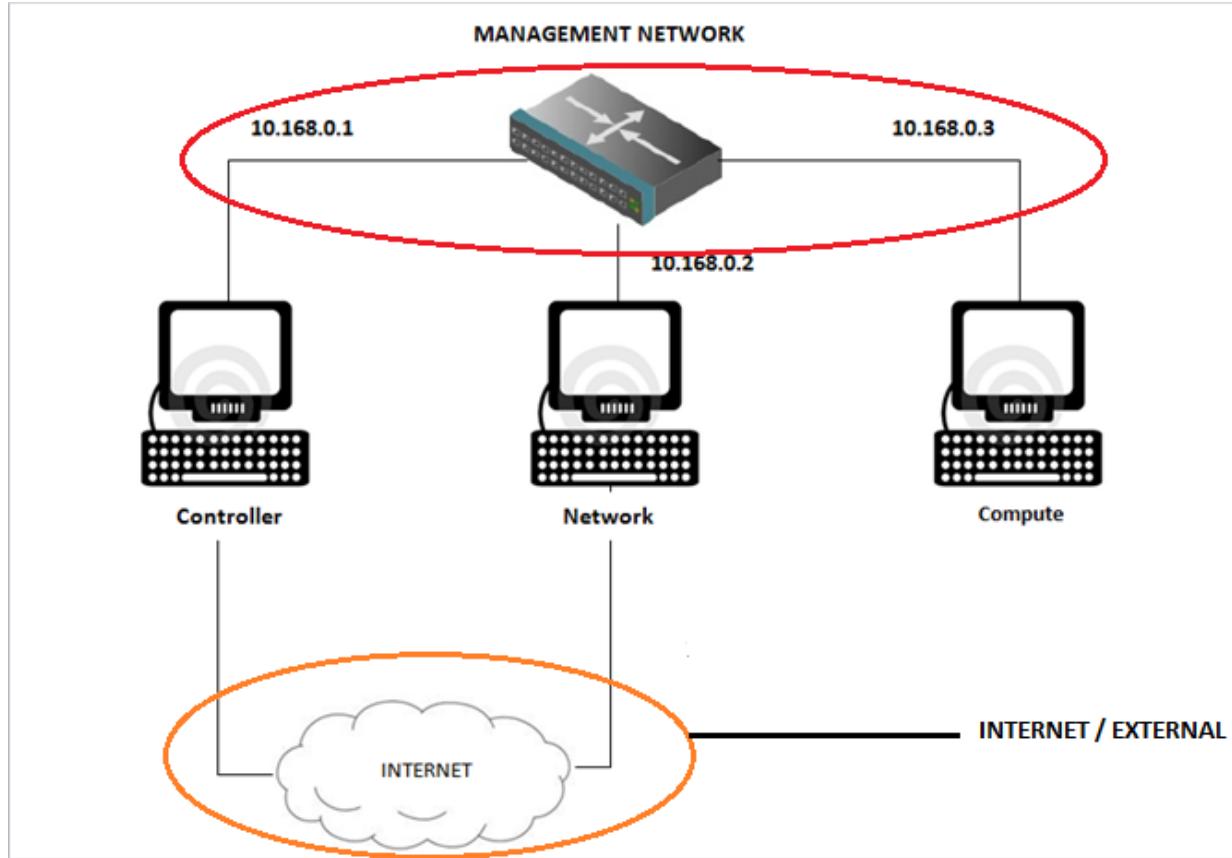
# OpenStack conceptual architecture



# OpenStack End Users



# Networking



There are two networks :

1. Internal or Management network
2. External or Internet network

---

## 1. INTERNAL / MANAGEMENT NETWORK:

- This network is present for internal connection between the machines.
- The IP addresses for the network must be reachable only by the admin.

## 2. INTERNET / EXTERNAL NETWORK :

- provides the VMs with internet access in some scenarios.
- The IP addresses are reachable by anyone on the internet.

- Note the IP addresses of the two networks. They are **different**.
- The networks **must** be different from each other.
- They are **isolated** from one another.

# REASONS FOR CHOOSING THIS ARCHITECTURE

---

1. Clarity
2. Clear demarcation of roles
3. Ease of debugging
4. Easy to understand

# CONTROLLER NODE

The controller is the central management system in a multinode cloud installation. Its main services include authentication and authorization ,and message queuing.

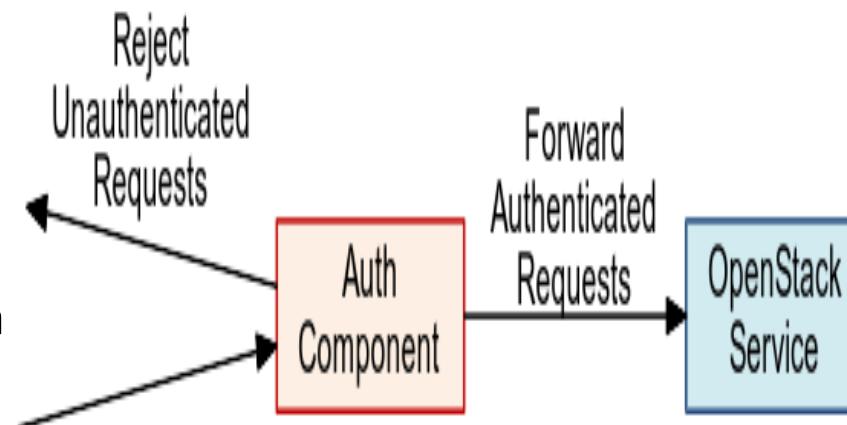
---

## **COMPONENTS OF CONTROLLER :**

- Databases(with MYSQL)
- Queues(with Rabbit MQ)
- Keystone
- Glance
- Nova(without nova-compute)
- Cinder
- Quantum Server(with OVS plugin)
- Dashboard(with horizon)

## Keystone (OpenStack Identity Service):

The OpenStack Identity Service provides the cloud environment with an authentication and authorization system. In this system, users are a part of one or more projects. In each of these projects, they hold a specific role. Users need to have identity and a particular level of access in the cloud. When a user logs into the cloud, Keystone authenticates that he is indeed a user and authorises his level of access within the cloud.





**BITS** Pilani

# Cloud Computing

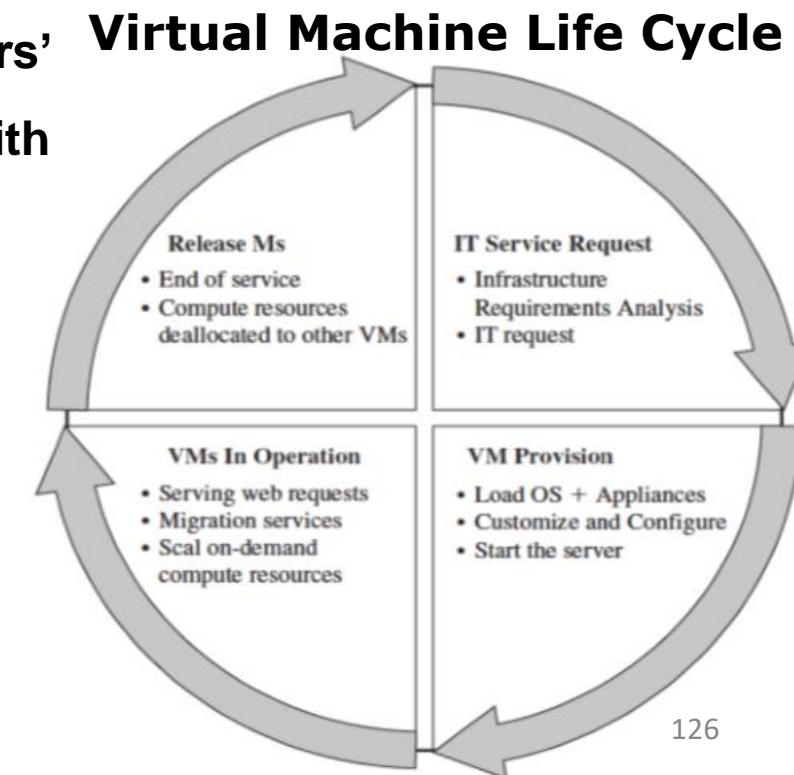
SEWP ZG527



# VM Provisioning and Migration

# **Virtual Machine Provisioning and Manageability Life Cycle**

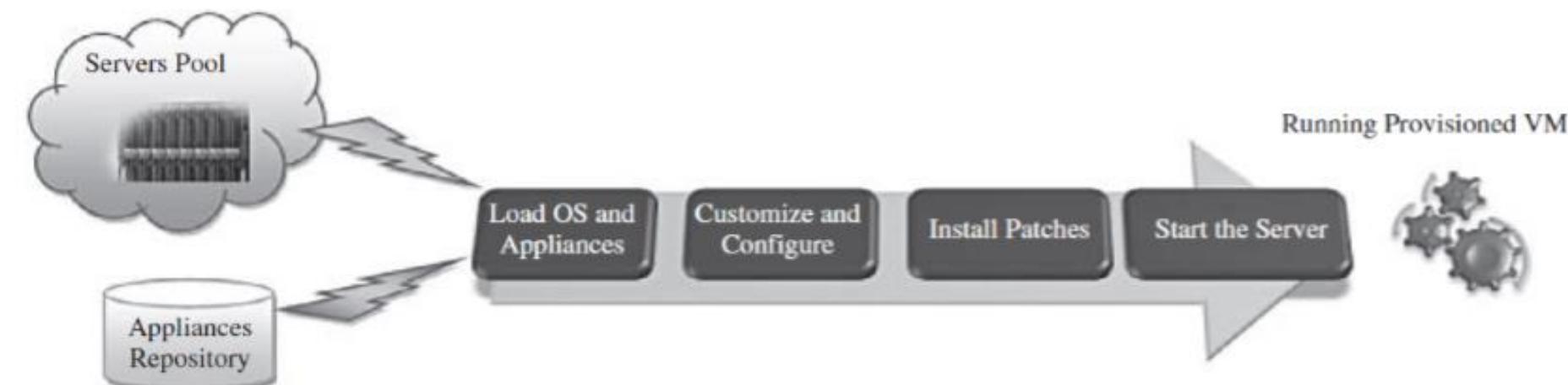
- The cycle starts by a request delivered to the IT department, stating the requirement for creating a new server for a particular service.
- This request is being processed by the IT administration to start seeing the servers' resource pool, matching these resources with requirements
- Starting the 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.



# 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.



**BITS** Pilani

# Cloud Computing

SEWP ZG527

# VM Migration

# 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:

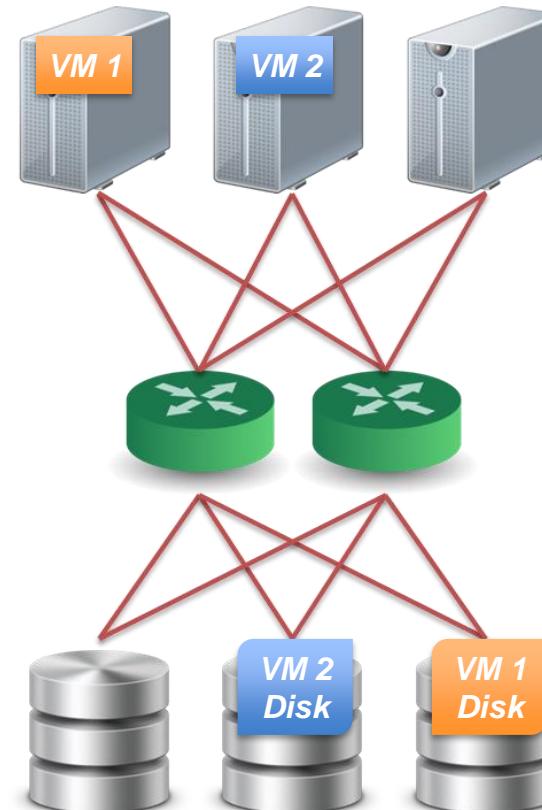
- If the option to move to a different datastore was chosen, the configuration files, including the NVRAM file (BIOS settings), and log files are moved from the source host to the destination host's associated storage area. If you chose to move the virtual machine's disks, these are also moved.
- The 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

---

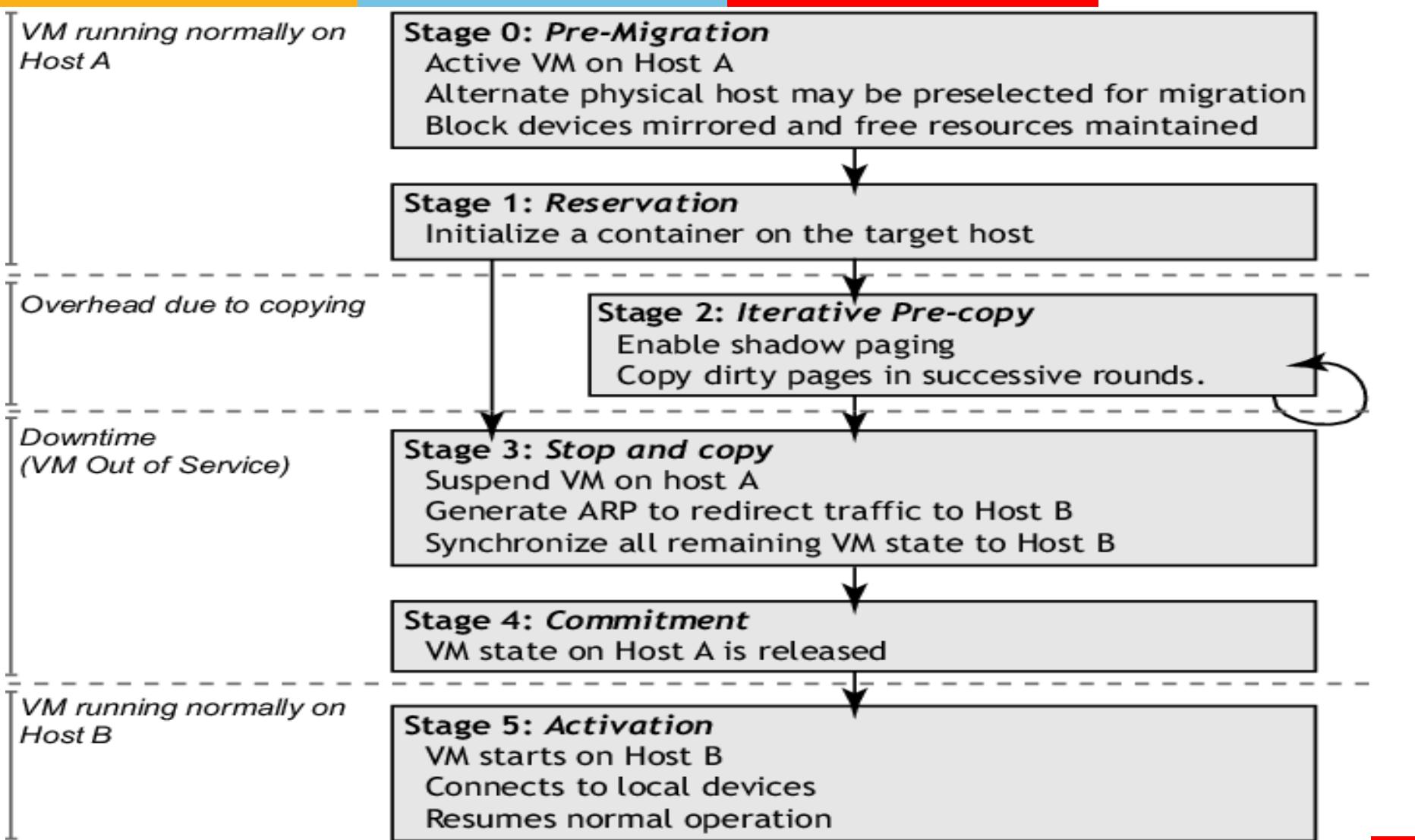
Challenges of live migration :

- 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 :

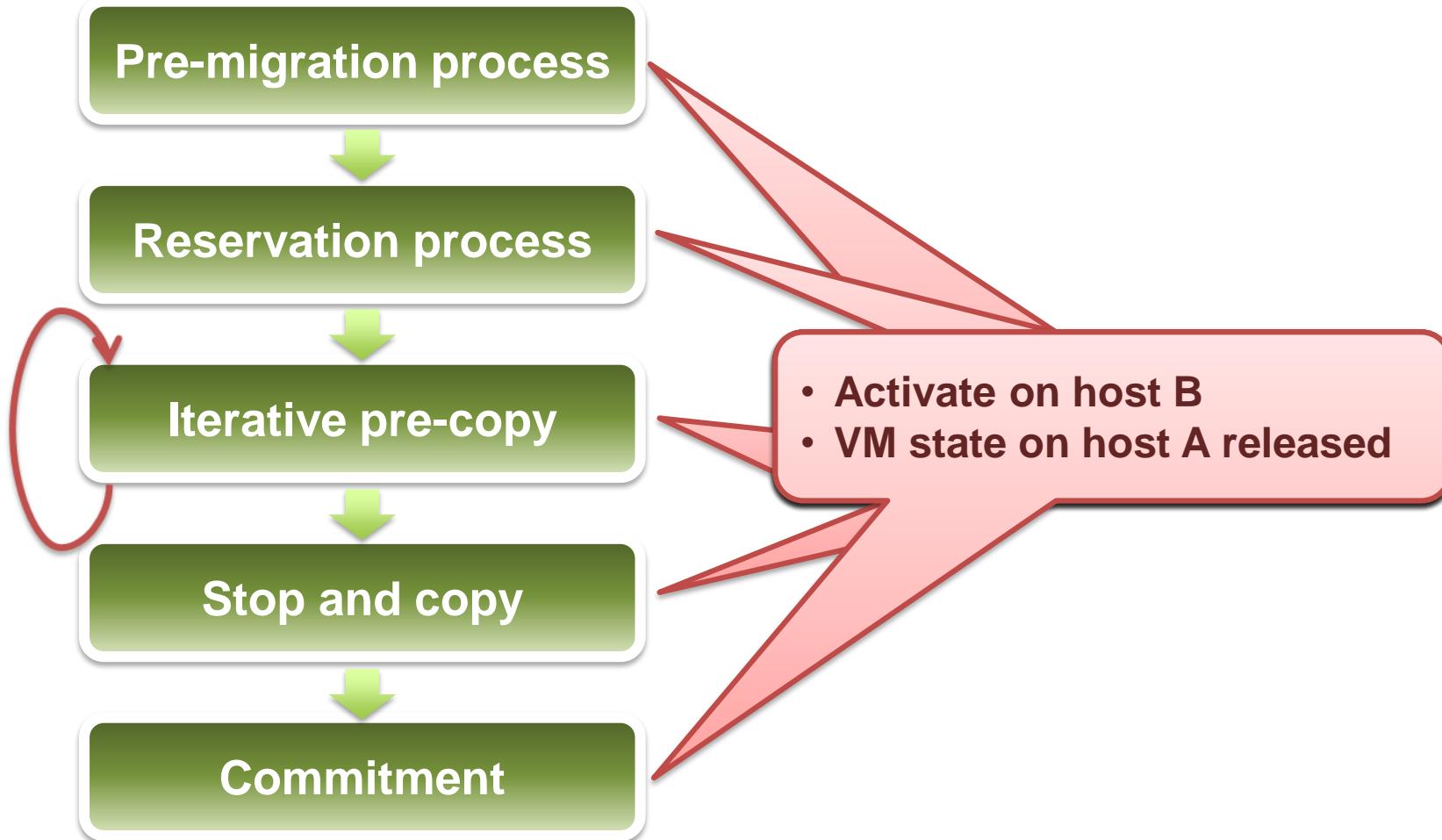
1. Pre-migration process
2. Reservation process
3. Iterative pre-copy
4. Stop and copy
5. Commitment

# Live Migration Technique



# Live Migration Technique

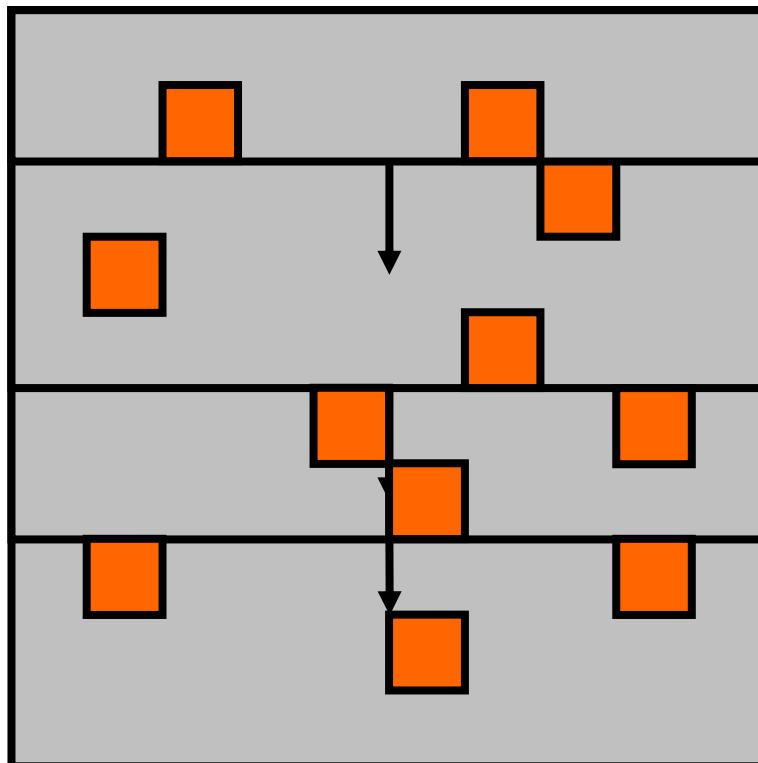
---



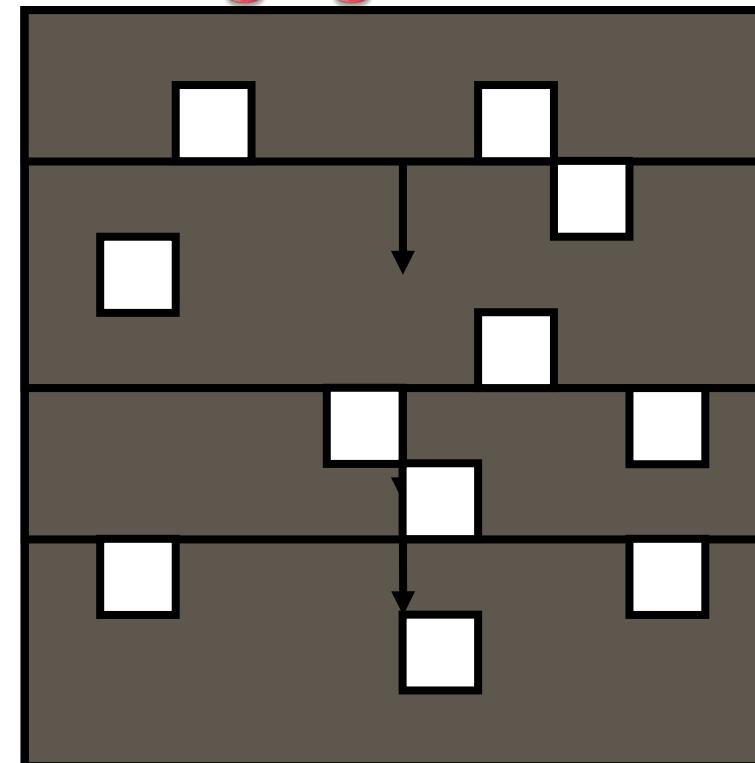
# Live Migration Technique

Live migration process :

**Pre-copy migration : Round 1,  
Enable Shadow Paging**



*Host A*



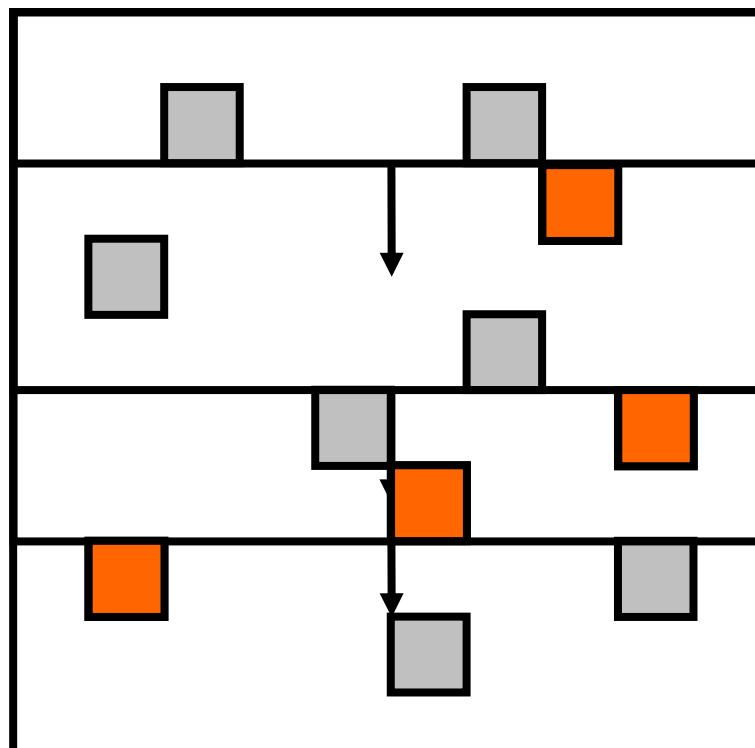
*Host B*

# Live Migration Technique

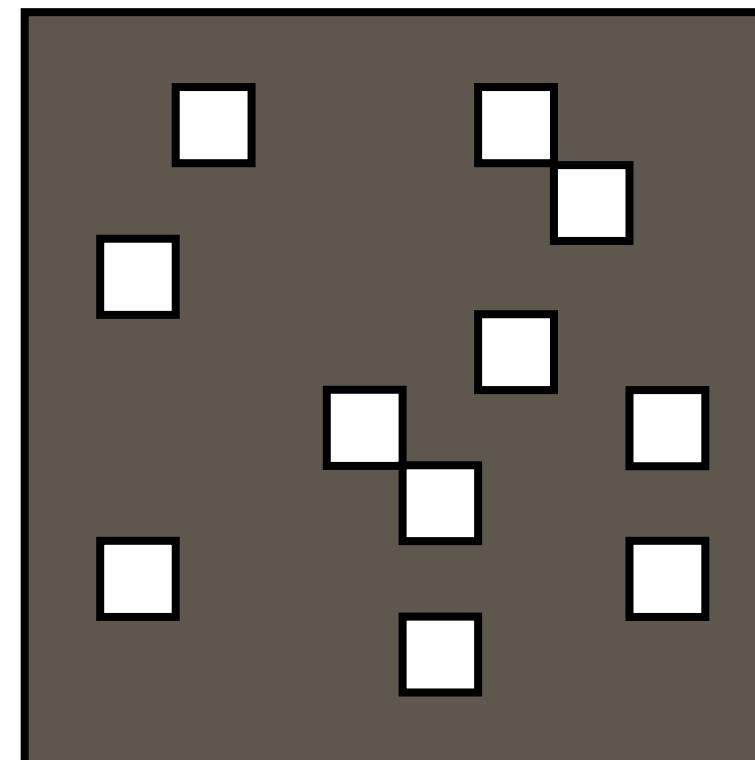
---

Live migration process :

**Pre-copy migration : Round 2**



*Host A*



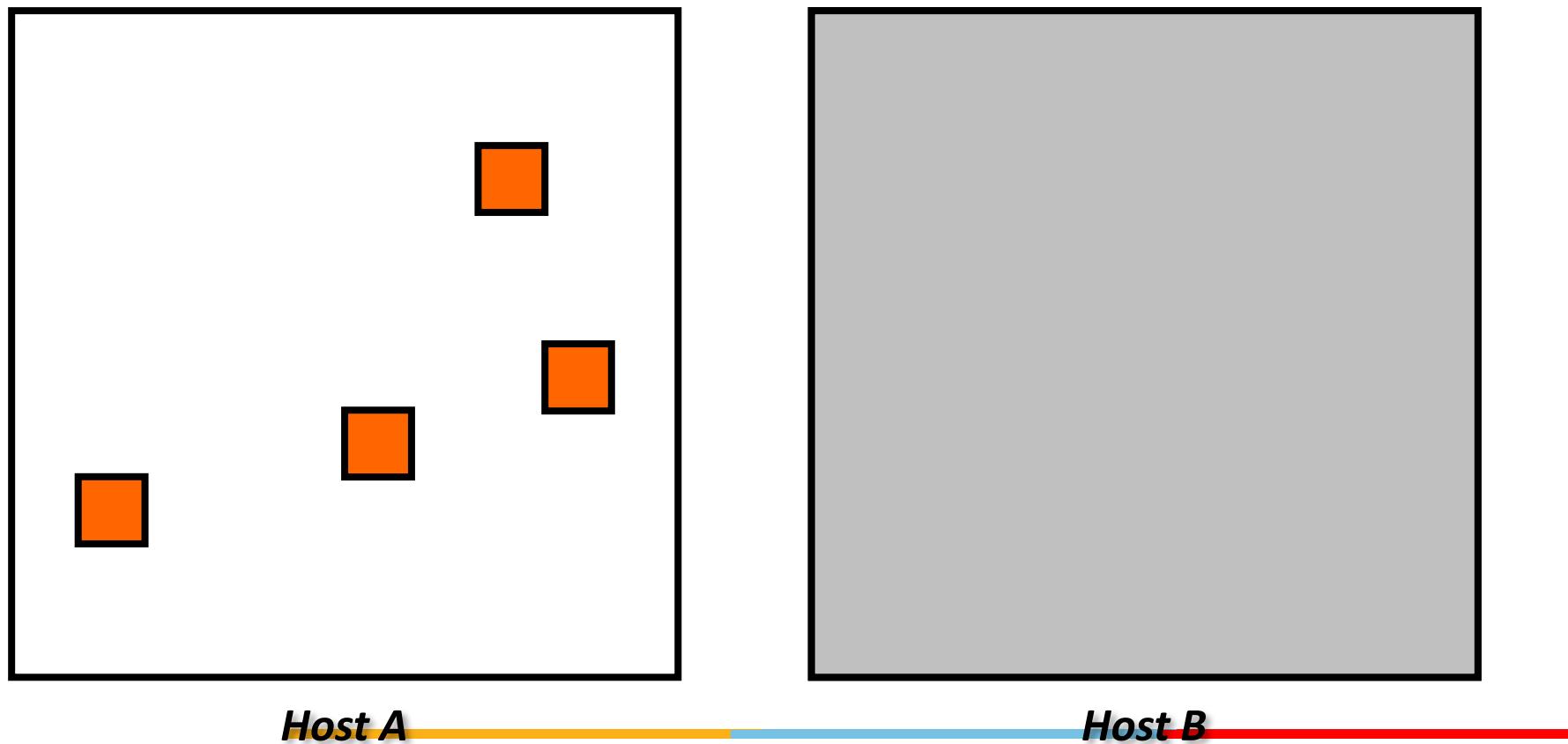
*Host B*

# Live Migration Technique

---

Live migration process :

**Stop and copy : Final Round**



# Live Migration Demo

---

- Using Proxmox deployment tool



# Cloud Computing

SEWP ZG527

**BITS** Pilani

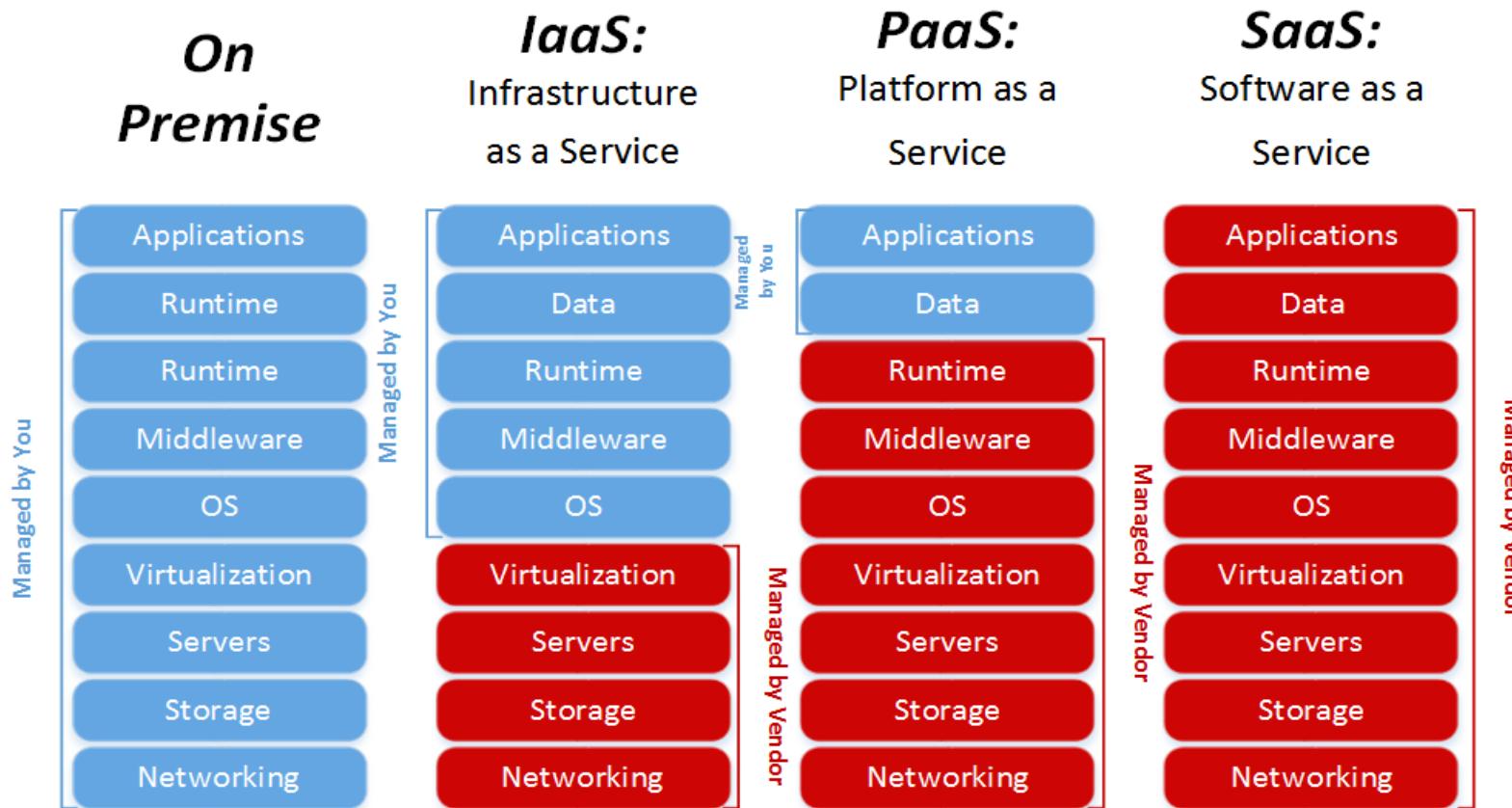


# Agenda

---

- o Introduction to PaaS
- o Building blocks of PaaS
- o Characteristics of PaaS
- o Advantages and Risks
- o PaaS Example – Windows Azure

# Dependency on IaaS and PaaS



# Introduction to PaaS

---

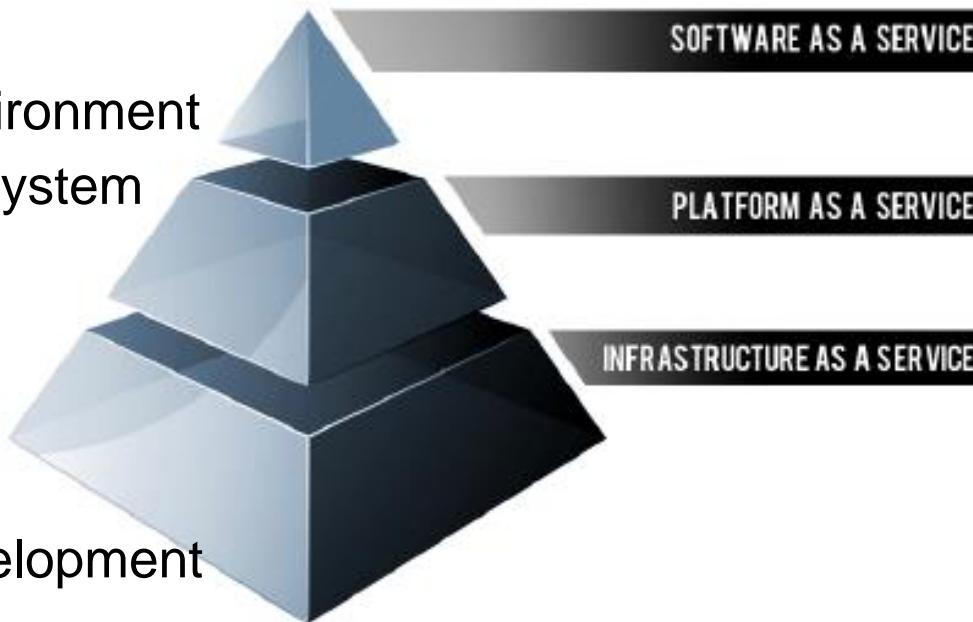
- Platform as a Service, referred to as PaaS, is a category of cloud computing that provides a platform and environment to allow developers to build applications and services over the internet.
- Platform as a Service allows users to create software applications using tools supplied by the provider.
- PaaS services are hosted in the cloud and accessed by users simply via their web browser.
- PaaS services can consist of preconfigured features that customers can subscribe to; they can choose to include the features that meet their requirements while discarding those that do not.

# Building blocks of PaaS

---

- PaaS providers can assist developers from the conception of their original ideas to the creation of applications, and through to testing and deployment.
- Below are some of the features that can be included with a PaaS offering:

- Operating system
- Server-side scripting environment
- Database management system
- Server Software
- Support
- Storage
- Network access
- Tools for design and development
- Hosting



# Characteristics of PaaS

---

- Services to develop, test, deploy, host and maintain applications in the same integrated development environment. All the varying services needed to fulfill 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

# Characteristics of PAAS

---

PaaS, which is similar in many ways to Infrastructure as a Service, is differentiated from IaaS by the addition of value added services and comes in two distinct flavours;

1. A collaborative platform for software development, focused on workflow management regardless of the data source being used for the application. An example of this approach would be Heroku, a PaaS that utilizes the Ruby on Rails development language.
2. A platform that allows for the creation of software utilizing proprietary data from an application. This sort of PaaS can be seen as a method to create applications with a common data form or type. An example of this sort of platform would be the Force.com PaaS from Salesforce.com which is used almost exclusively to develop applications that work with the Salesforce.com CRM

# Advantages and Risks

---

## Advantages

- Users don't have to invest in physical infrastructure
- PaaS allows developers to frequently change or upgrade operating system features. It also helps development teams collaborate on projects.
- Makes development possible for 'non-experts'
- Teams in various locations can work together
- Security is provided, including data security and backup and recovery.
- Adaptability; Features can be changed if circumstances dictate that they should.
- Flexibility; customers can have control over the tools that are installed within their platforms and can create a platform that suits their specific requirements. They can 'pick and choose' the features they feel are necessary.

# Advantages and Risks

---

## Risks

- Since users rely on a provider's infrastructure and software, vendor lock-in can be an issue in PaaS environments.
- Other risks associated with PaaS are provider downtime or a provider changing its development roadmap.
- If a provider stops supporting a certain programming language, users may be forced to change their programming language, or the provider itself. Both are difficult and disruptive steps.



# Cloud Computing

SEWP ZG527

**BITS** Pilani



# Agenda

---

- o Introduction to PaaS
- o Building blocks of PaaS
- o Characteristics of PaaS
- o Advantages and Risks
- o PaaS Example – Windows Azure

# PaaS Example

---

- PaaS does not typically replace a business' entire infrastructure. Instead, a business relies on PaaS providers for key services, such as Java development or application hosting.
- For example:  
Deploying a typical business tool locally might require an IT team to buy and install hardware, operating systems, middleware (such as databases, Web servers and so on) the actual application, define user access or security, and then add the application to existing systems management or application performance monitoring (APM) tools. IT teams must then maintain all of these resources over time.  
PaaS solution: A PaaS provider, however, supports all the underlying computing and software; users only need to log in and start using the platform – usually through a Web browser interface.

# PaaS Example: Windows Azure

---

- Windows Azure is Microsoft's operating system for cloud computing.
- Windows Azure is intended to simplify IT management and minimize up-front and ongoing expenses
- To this end, Azure was designed to facilitate the management of scalable Web applications over the Internet.
- Windows Azure can be used to create, distribute and upgrade Web applications without the need to maintain expensive, often underutilized resources onsite.
- New Web services and applications can be written and debugged with a minimum of overhead and personnel expense.

# PaaS Example: Windows Azure

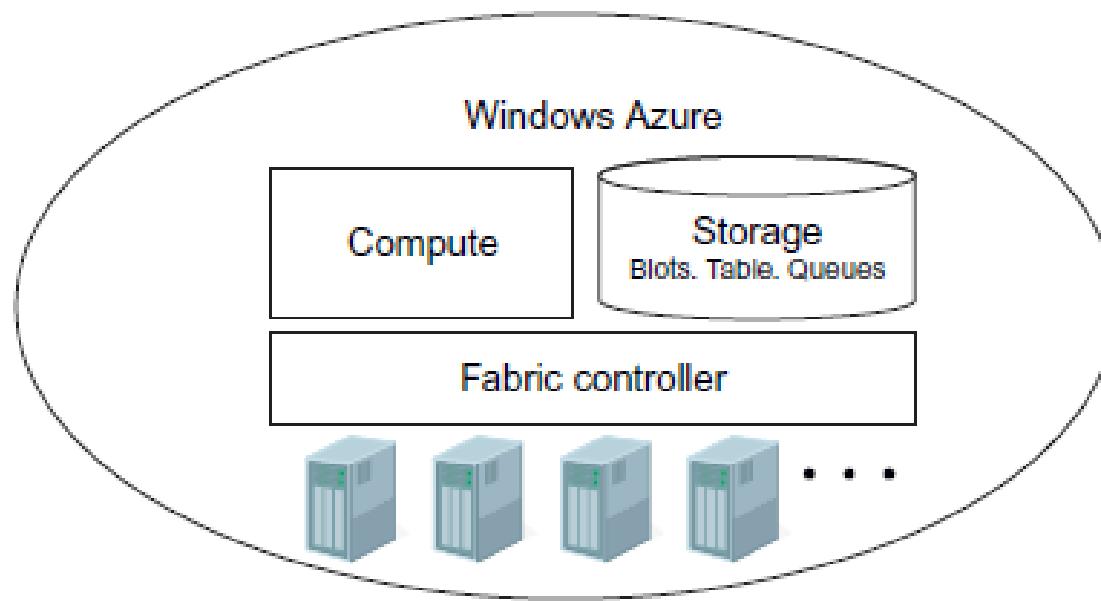
---

- The Azure operating system is the central component of the company's Azure Services Platform, which also includes separate application, security, storage and virtualization service layers and a desktop development environment.
- Windows Azure supports a wide variety of Microsoft and third-party standards, protocols, programming languages and platforms. Examples include XML (Extensible Markup Language), REST (representational state transfer), SOAP (Simple Object Access Protocol), Eclipse, Ruby, PHP and Python.
- Although it faces steep competition from Amazon Web Services (AWS), Microsoft Azure has managed to hold a strong second place among cloud hosting platform providers. <http://azure.microsoft.com/en-us/>

# Windows Azure Runtime Environment

---

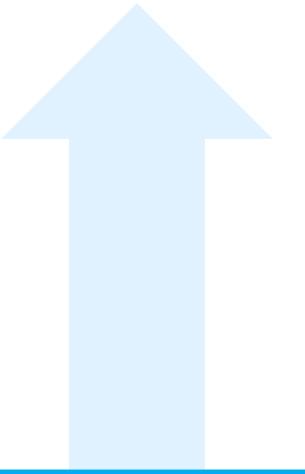
- The Windows Azure runtime environment provides a scalable compute and storage hosting environment along with management capabilities. It has three major components: Compute, Storage and the Fabric Controller



# Windows Azure Runtime Environment

---

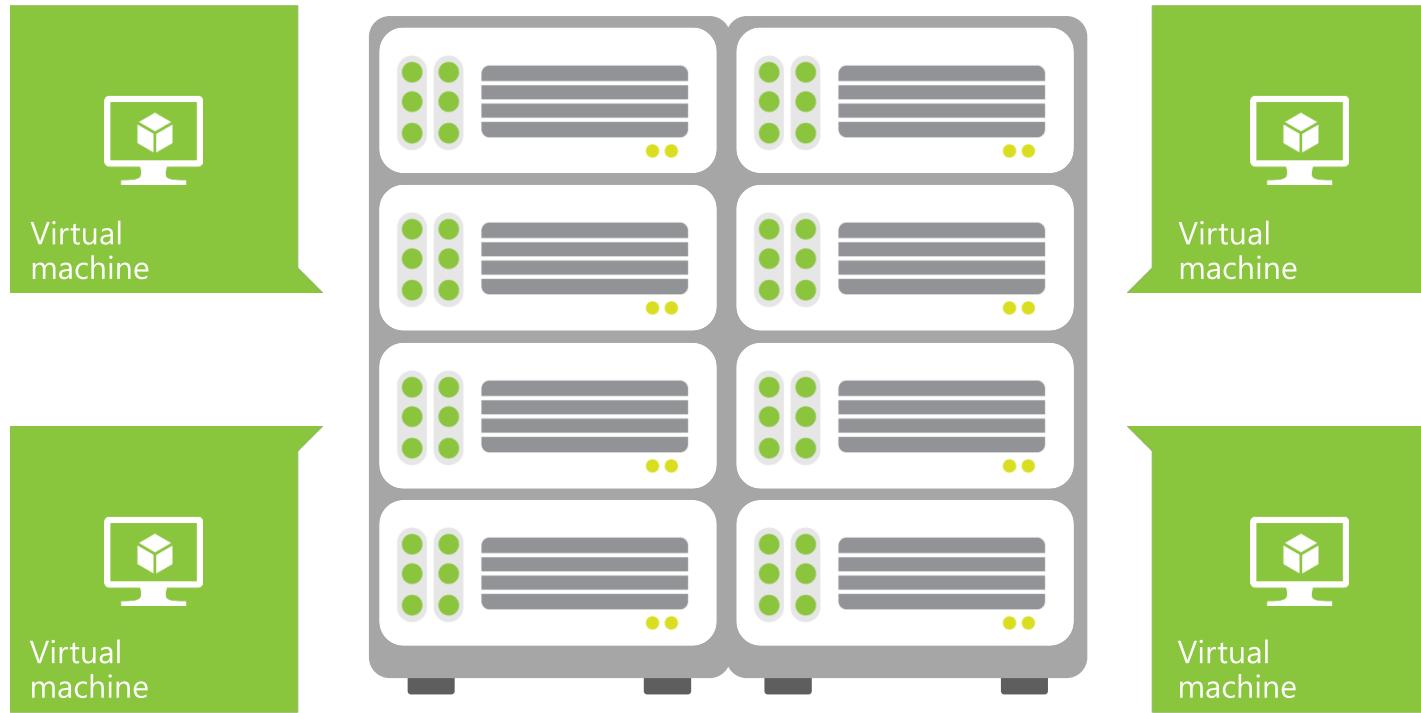
- The hosting environment of Azure is called the **Fabric Controller**. It has a pool of individual systems connected on a network and automatically manages resources by load balancing and geo-replication. It manages the application lifecycle without requiring the hosted apps to explicitly deal with the scalability and availability requirements. Each physical machine hosts an Azure agent that manages the machine.
- The **Azure Compute Service** provides a Windows-based environment to run applications written in the various languages and technologies supported on the Windows platform.
- The Windows **Azure storage service** provides scalable storage for applications running on the Windows Azure in multiple forms. It enables storage for binary and text data, messages and structured data through support for features called Blobs, Tables, Queues and Drives.



Provision Role Instances

Deploy App Code

Configure Network



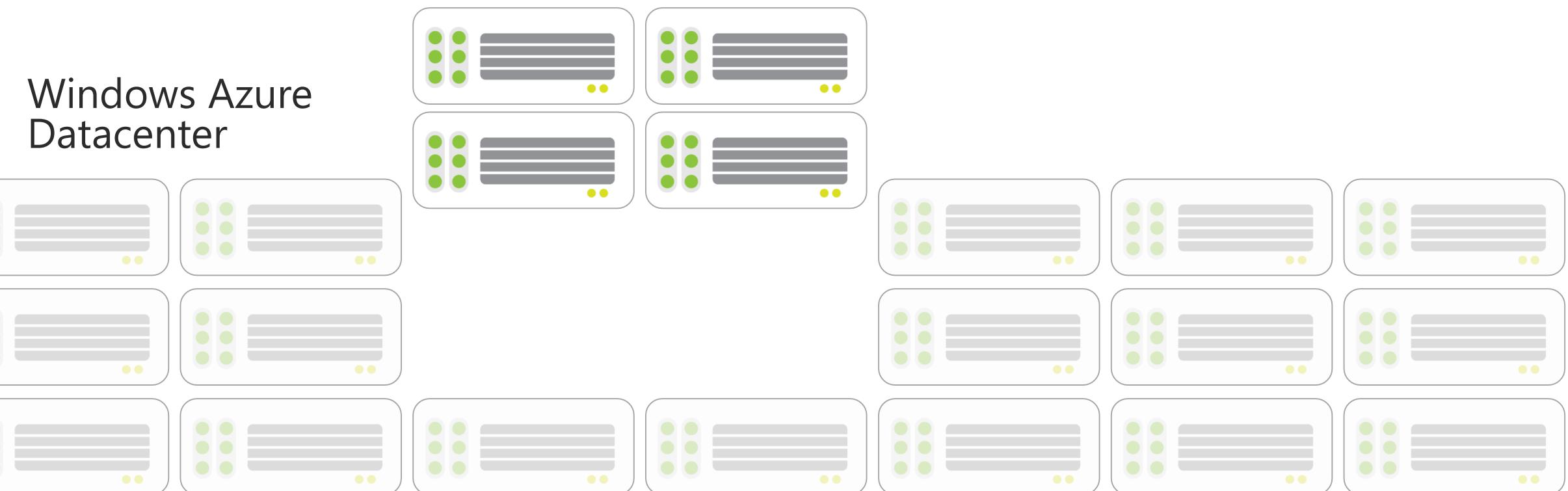
Provision Role Instances

Deploy App Code

Configure Network



Windows Azure  
Datacenter



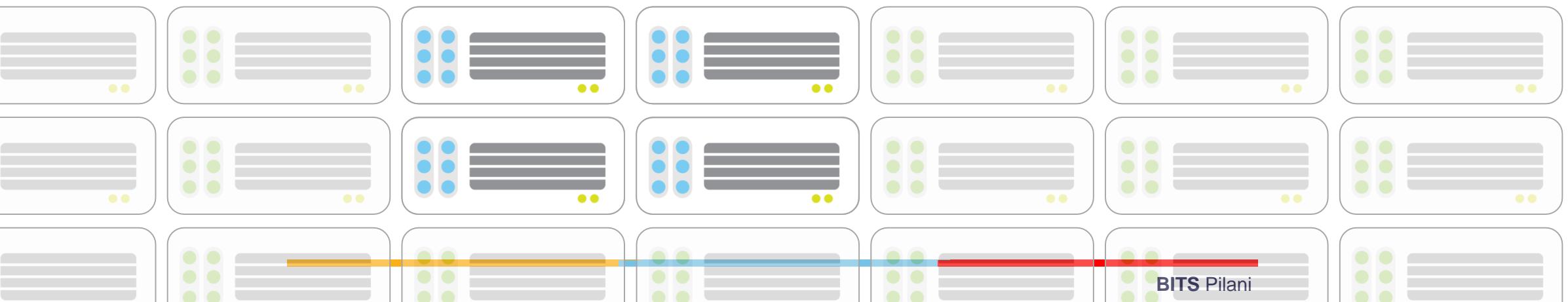
Provision Role Instances

Deploy App Code

Configure Network



Windows Azure  
Datacenter

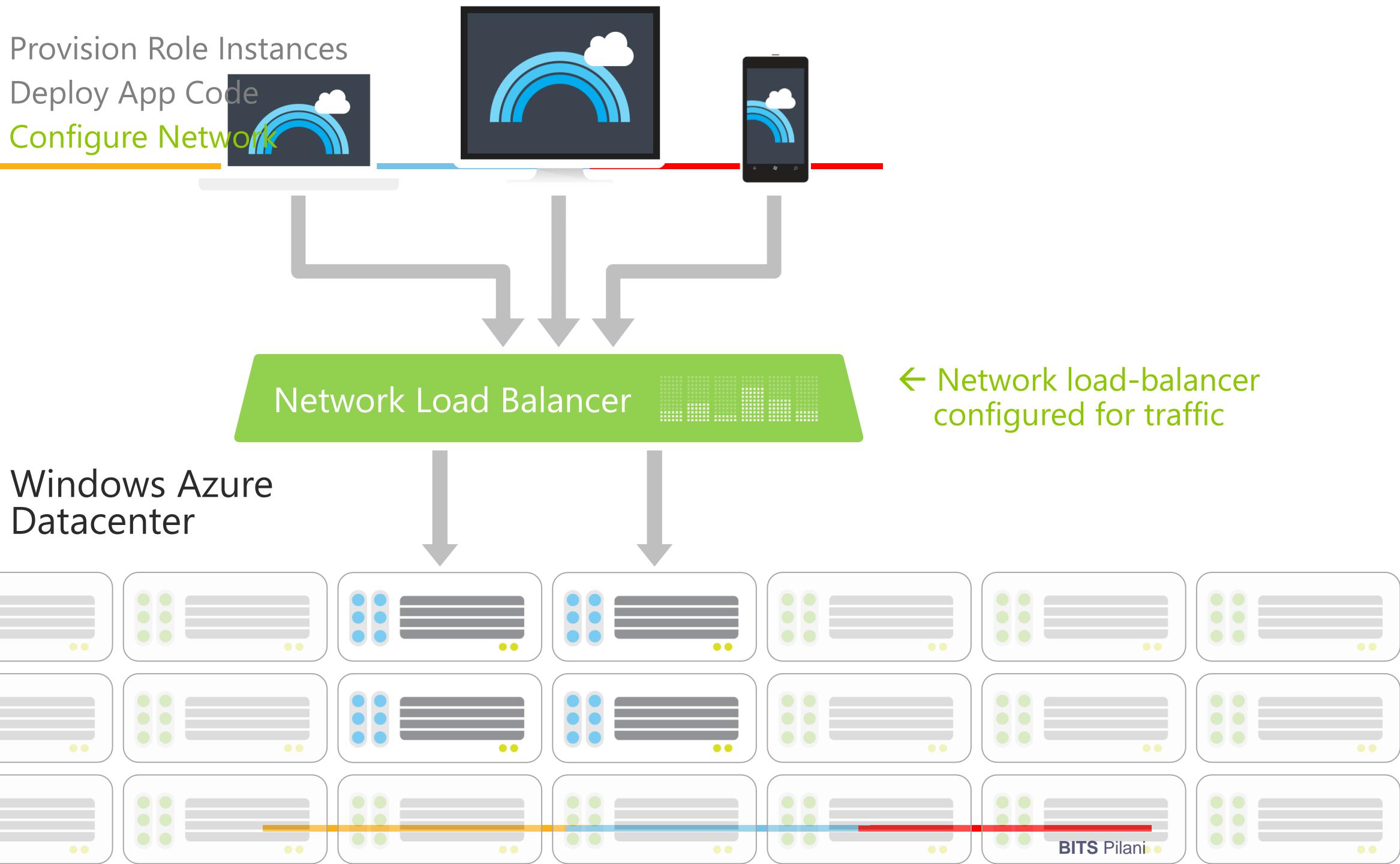


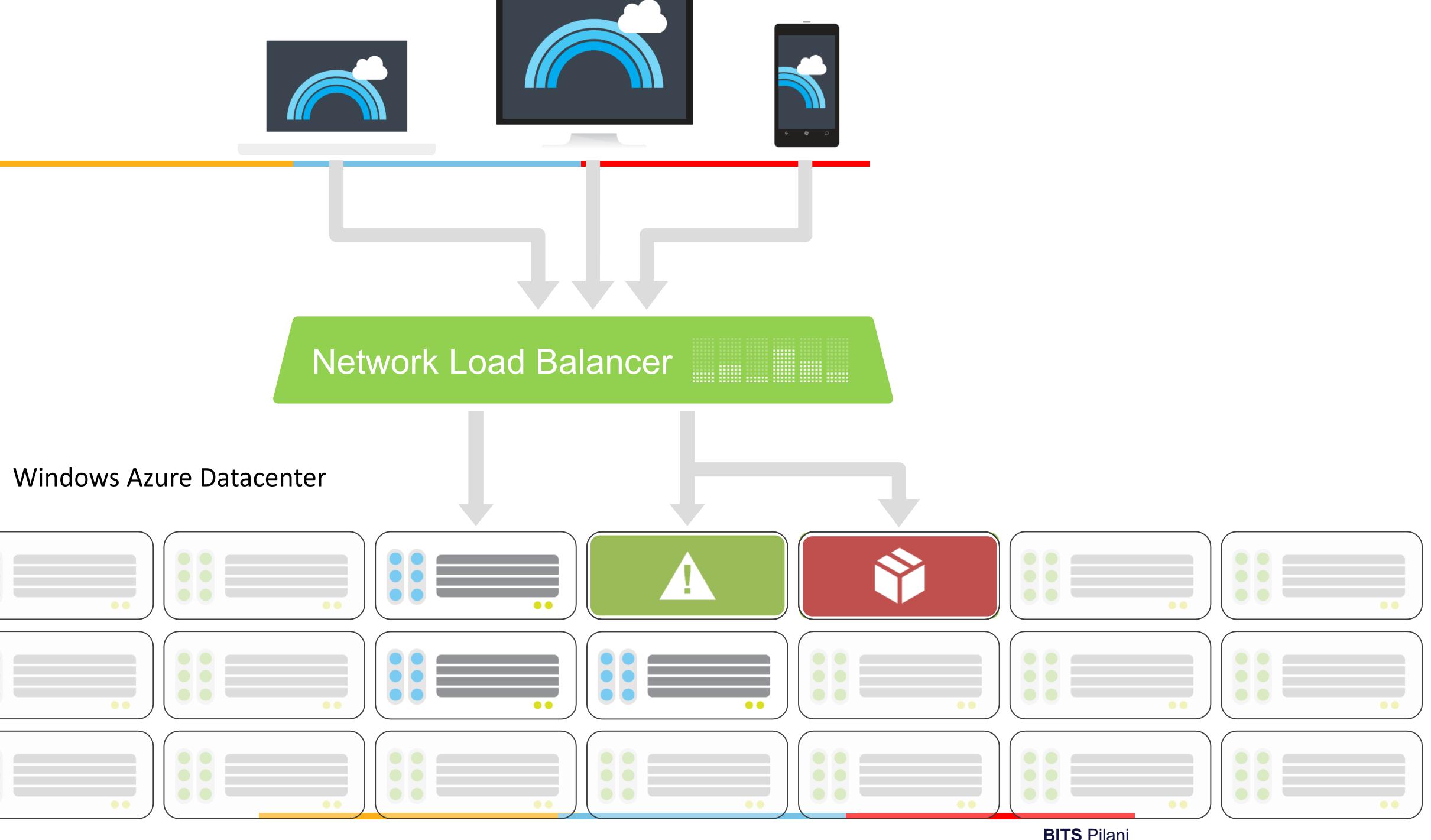
BITS Pilani

Provision Role Instances

Deploy App Code

Configure Network





# PaaS Vendors

---

- Common PaaS vendors include Salesforce.com's Force.com, which provides an enterprise customer relationship management (CRM) platform. PaaS platforms for software development and management include Appear IQ, Mendix, Amazon Web Services (AWS) Elastic Beanstalk, Google App Engine and Heroku.

# THANK YOU



**BITS** Pilani

# Cloud Computing

SEWP ZG527

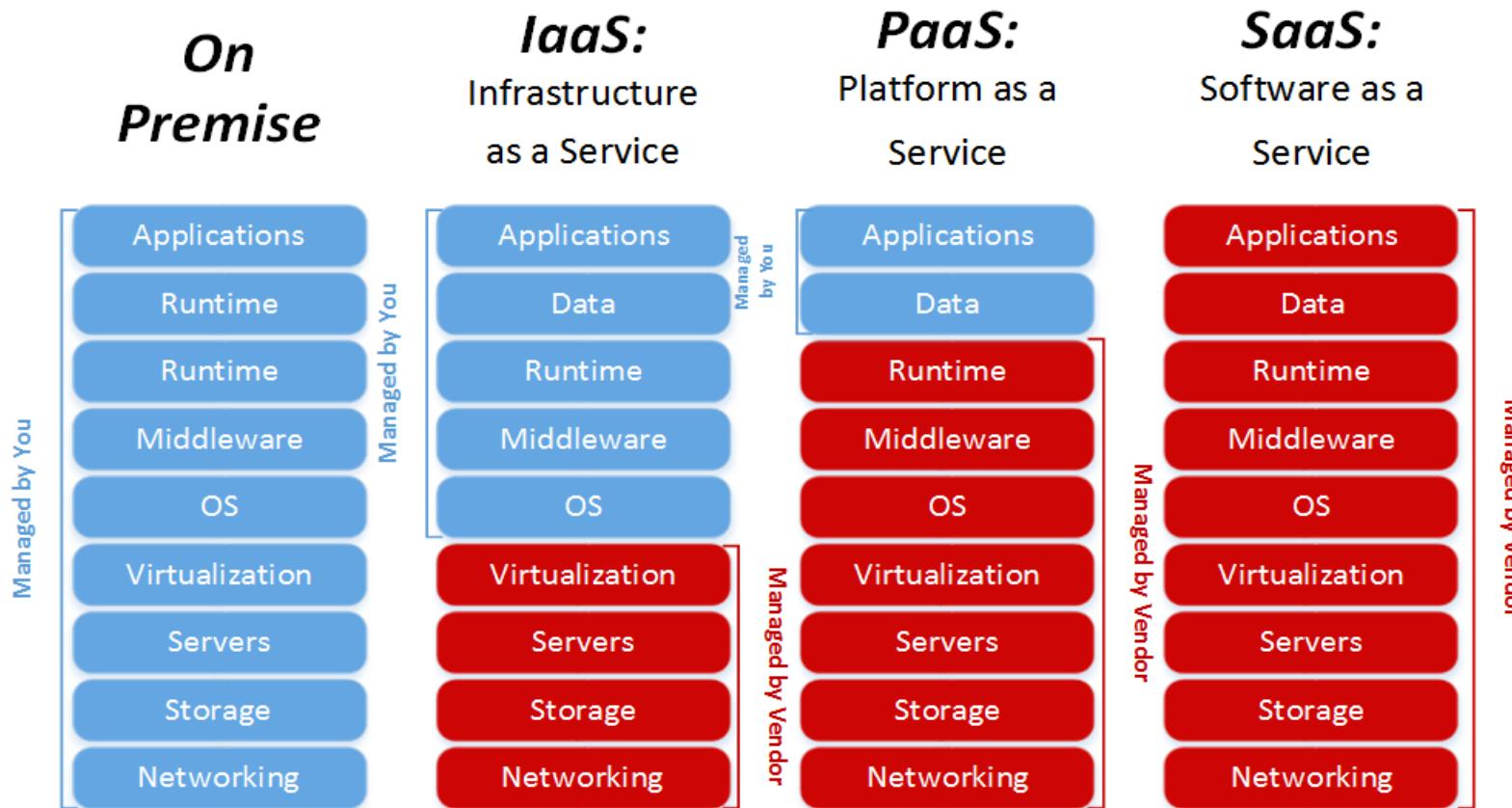


# SaaS – Agenda

---

- What is SaaS?
- Traditional Model
- How is it delivered?
- SaaS Architecture
- SaaS Models
- Advantages of SaaS
- User and Vendor benefits of SaaS

# Dependency on IaaS and PaaS



# What is SaaS?

---

- Software as a service is a software distribution model in which applications are hosted by a vendor or service provider and made available to customers over a network, typically the Internet.
- Shortly, in the SaaS model software is deployed as a hosted service and accessed over the Internet, as opposed to “On Premise.”
- Software delivered to home consumers, small business, medium and large business
  - The traditional model of software distribution, in which software is purchased for and installed on personal computers, is sometimes referred to as software as a product.

# Problems in traditional Model

---

- In the traditional model of software delivery, the customer acquires a perpetual license and assumes responsibility for managing the software.
- There is a high upfront cost associated with the purchase of the license, as well as the burden of implementation and ongoing maintenance.
- ROI is often delayed considerably, and, due to the rapid pace of technological change, expensive software solutions can quickly become obsolete.

# Problems in traditional Model

---

**Traditional Software**

**On-Demand Utility**



**Build Your Own**



**Plug In, Subscribe  
Pay-per-Use**

# SaaS – How is it delivered

---

- The web as a platform is the center point. The web as a platform is the center point
- Network-based access to, and management of, commercially available (i.e., not custom) software application delivery that typically is closer to a one-to-many model (single instance, multi-tenant architecture) than to a one-to-one model, including architecture, pricing, partnering, and management characteristics
- Software delivered to home consumers, small business, medium and large business
  - The traditional model of software distribution, in which software is purchased for and installed on personal computers, is sometimes referred to as software as a product.



Thanks!!!  
Queries?



**BITS** Pilani

# Cloud Computing

SEWP ZG527



# SaaS – Agenda

---

- What is SaaS?
- Traditional Model
- How is it delivered?
- SaaS Architecture
- SaaS Models
- Advantages of SaaS
- User and Vendor benefits of SaaS

# SaaS – Architecture

---

- Run by
  - Bandwidth technologies
  - The cost of a PC has been reduced significantly with more powerful computing but the cost of application software has not followed
  - Timely and expensive setup and maintenance costs
  - Licensing issues for business are contributing significantly to the use of illegal software and piracy.

# SaaS Application Architecture

---

- Scalable
- Multitenant efficient
- Configurable
- **Scaling the application** - maximizing concurrency, and using application resources more efficiently
- i.e. optimizing locking duration, statelessness, sharing pooled resources such as threads and network connections, caching reference data, and partitioning large databases.

# SaaS Application Architecture

---

- **Multi-tenancy** – important architectural shift from designing isolated, single-tenant applications
- One application instance must be able to accommodate users from multiple other companies at the same time
- All transparent to any of the users.
- This requires an architecture that maximizes the sharing of resources across tenants
- is still able to differentiate data belonging to different customers.

# SaaS Application Architecture

---

- **Configurable** - a single application instance on a single server has to accommodate users from several different companies at once
- To customize the application for one customer will change the application for other customers as well.
- Traditionally customizing an application would mean code changes
- Each customer uses metadata to configure the way the application appears and behaves for its users.
- Customers configuring applications must be simple and easy without incurring extra development or operation costs

# SaaS Introduction Cont.....

---

- SaaS is one of the fastest growing concepts: more than 30 million companies will be using SaaS in the next 5 - 10 years; more than 70% of all Fortune 500 companies are already using SaaS
- According to influential IT institutes, SaaS is the leading business model of choice
- Virtually all big software/service vendors (IBM, Microsoft, Oracle, Cisco) are investing heavily in SaaS
- With the continuously increasing bandwidth and reliability of the internet, using web services over the (public) internet has become a viable option

# SaaS Models

## Traditional Software

## Software as a Service

On Premise	→	In the Cloud
Centralized	→	Decentralized
Large Upfront Cost	→	Pay As You Go

## Software-as-a-Service Business Model

### Application Hosting

### Software-as-Services

Perpetual License	→	Subscription
One-to-Few	→	One-to-Many
Private Infrastructure	→	Public Infrastructure

# Business Model comparisons

Traditional packaged software

- Designed for customers to install, manage and maintain.
  
- Architect solutions to be run by an individual company in a dedicated instantiation of the software

Software as a service

- Designed from the outset up for delivery as Internet-based services
  
- Designed to run thousands of different customers on a single code

# Business Model comparisons

---

## Traditional packaged Software

- Infrequent, major upgrades every 18-24 months, sold individually to each installed base customer.
- Version control
- Upgrade fee
- Streamlined, repeatable functionality via Web services, open APIs and standard connectors

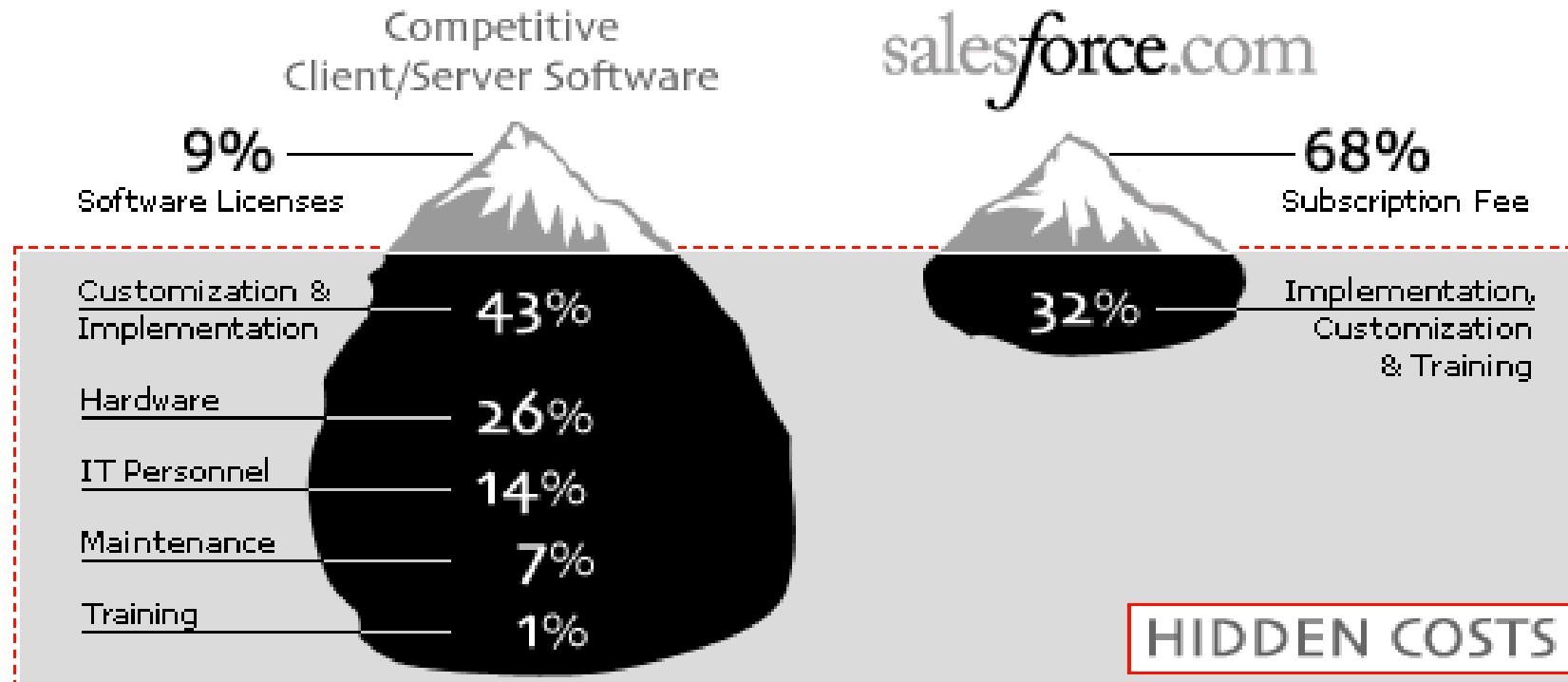
## Software as a service

- Frequent, "digestible" upgrades every 3-6 months to minimize customer disruption and enhance satisfaction.
- Fixing a problem for one customer fixes it for everyone
- May use open APIs and Web services to facilitate integration, but each customer must typically pay for one-off integration work.

# Business Model comparisons

## Hidden Cost

Avoid the hidden costs of traditional CRM software





Thanks!!!  
Queries?



**BITS** Pilani

# Cloud Computing

SEWP ZG527



# SaaS – Agenda

---

- What is SaaS?
- Traditional Model
- How is it delivered?
- SaaS Architecture
- SaaS Models
- Advantages of SaaS
- User and Vendor benefits of SaaS

# SaaS Advantages

Characteristics	Benefits
Network delivered access to commercially available software	<b>No local infrastructure or software to purchase or maintain</b> Applications & data are available anywhere with network connectivity
Application delivery is one-to-many model	Operating costs are reduced by managing infrastructure in central locations rather than at each customer's site
Built on optimized & robust platform	Improved availability and reliability
Customer pays for as much as they need when they need it	Lower TCO

Attributes	Software-as-a-Service (SaaS)	On-Premise
Alternate labels	On-Demand, Subscription Based, Hosted, Application Service Provider (ASP)	Installed, Hosted On-Premise
Purchase model	Lease, rent, subscription	Most commonly purchasing of licenses (ownership) with some lease and rent options
Maintenance and support	Typically included	For purchase option it would be based on the percentage of license fees
Security	Typically in a 3rd party highly secure data center	Responsibility of the costumer
Upgrades	Typically included Shared (multi-tenant) or dedicated (single) instance depending on the vendor	Included with maintenance
Data model	Shared (multi-tenant) or dedicated (single) instance depending on the vendor	Dedicated (single) instance on the customer's servers
Access	Typically all major web browsers	Typically all major web browsers
Initial investment	Low upfront cost since no hardware or infrastructure investment	Higher cost since typically purchasing licenses and hardware
3-5 year investment	Reoccurring fee Hosted by 3rd party and lack of ownership. This needs to be clearly defined in a SLA	One-time fee Less of an issue with the purchase option where costumer claims ownership
Legal implications	Typically shorter since all is hosted by the vendor	Can be lengthier since it is installed and integrated with the existing infrastructure
Implementation	Can be limited due to Web standards and protocols	Tends to be more flexible since it resides behind your firewall on your servers

# SaaS User Benefits

---

- **Lower Cost of Ownership**
  - The software is paid when it is consumed, no large upfront cost for a software license Salesforce.com has a best-of-breed CRM system for \$59.00 per user per month, with no upfront
  - Since no hardware infrastructure, installation, maintenance, and administration, budgeting is easy
  - The software is available immediately upon purchasing
- **Focus on Core Competency**
  - The IT saving on capital and effort allows the customer to remain focused on their core competency and utilize resources in more strategic areas.

# SaaS User Benefits

---

- **Access Anywhere**
  - Users can use their applications and access their data anywhere they have an Internet connection and a computing device
  - This enhances the customer experience of the software and makes it easier for users to get work done fast
- **Freedom to Choose (or Better Software)**
  - The pay-as-you-go (PAYG) nature of SaaS enables users to select applications they wish to use and to stop using those that no longer meet their needs. Ultimately, this freedom leads to better software applications because vendors must be receptive to customer needs and wants.

# SaaS User Benefits

---

- **New Application Types**
  - Since the barrier to use the software for the first time is low, it is now feasible to develop applications that may have an occasional use model. This would be impossible in the perpetual license model. If a high upfront cost were required the number of participants would be much smaller.
- **Faster Product Cycles**
  - Product releases are much more frequent, but contain fewer new features than the typical releases in the perpetual license model because the developer know the environment the software needs to run
  - This new process gets bug fixes out faster and allows users to digest new features in smaller bites, which ultimately makes the users more productive than they were under the previous model.

# SaaS Vendor Benefits

---

- **Increased Total Available Market**
  - Lower upfront costs and reduced infrastructure capital translate into a much larger available market for the software vendor, because users that previously could not afford the software license or lacked the skill to support the necessary infrastructure are potential customers.
  - A related benefit is that the decision maker for the purchase of a SaaS application will be at a department level rather than the enterprise level that is typical for the perpetual license model. This results in shorter sales cycles.

# SaaS Vendor Benefits

---

- **Enhanced Competitive Differentiation**
  - The ability to deliver applications via the SaaS model enhances a software company's competitive differentiation. It also creates opportunities for new companies to compete effectively with larger vendors.
  - On the other hand, software companies will face ever-increasing pressure from their competitors to move to the SaaS model.
  - Those who lag behind will find it difficult to catch up as the software industry continues to rapidly evolve.

# SaaS Vendor Benefits

---

## Lower Development Costs & Quicker Time-to-Market

- The main saving is at testing (35%).
  - Small and frequent releases – less to test
  - Application is developed to be deployed on a specific hardware infrastructure, far less number of possible environment – less to test.
  - This, in turn, provides the software developer with overall lower development costs and quicker time-to-market.

## Effective Low Cost Marketing

- Between 1995 and today, buyers' habits shifted from an outbound world driven by field sales and print advertising to an inbound world driven by Internet search.

# SaaS Vendor Benefits

---

- **Predictable MRR Revenue**
    - Traditionally, software companies rely on one major release every 12-18 months to fuel a revenue stream from the sale of upgrades (long tail theory).
    - In the SaaS model the revenue is typically in the form of Monthly Recurring Revenue (MRR)
  - **Improved Customer Relationships**
    - SaaS contributes to improved relationships between vendors and customers.
  - **Protecting of IP**
    - Difficult to obtain illegal copies
    - Price is low, making getting an illegal copies totally unnecessary
-

# Applicability – Scenario 1

---

## Single-User software application

- Organize personal information
- Run on users' own local computer
- Serve only one user at a time
- Inapplicable to SaaS model
  - Data security issue
  - Network performance issue
- Example: Microsoft office suite

# Applicability – Scenario 2

---

## Infrastructure software

- Serve as the foundation for most other enterprise software application
- Inapplicable to SaaS model
  - Installation locally is required
  - Form the basis to run other application
- Example: Window XP, Oracle database

# Applicability – Scenario 3

---

## Embedded Software

- Software component for embedded system
- Support the functionality of the hardware device
- Inapplicable to SaaS model
  - Embedded software and hardware is combined together and is inseparable
- Example: software embedded in ATM machines, cell phones, routers, medical equipment, etc

# Applicability – Scenario 4

---

## Enterprise Software Application

- Perform business functions
- Organize internal and external information
- Share data among internal and external users
- The most standard type of software applicable to SaaS model
- Example: Salesforce.com CRM application, Siebel On-demand application



Thanks!!!  
Queries?