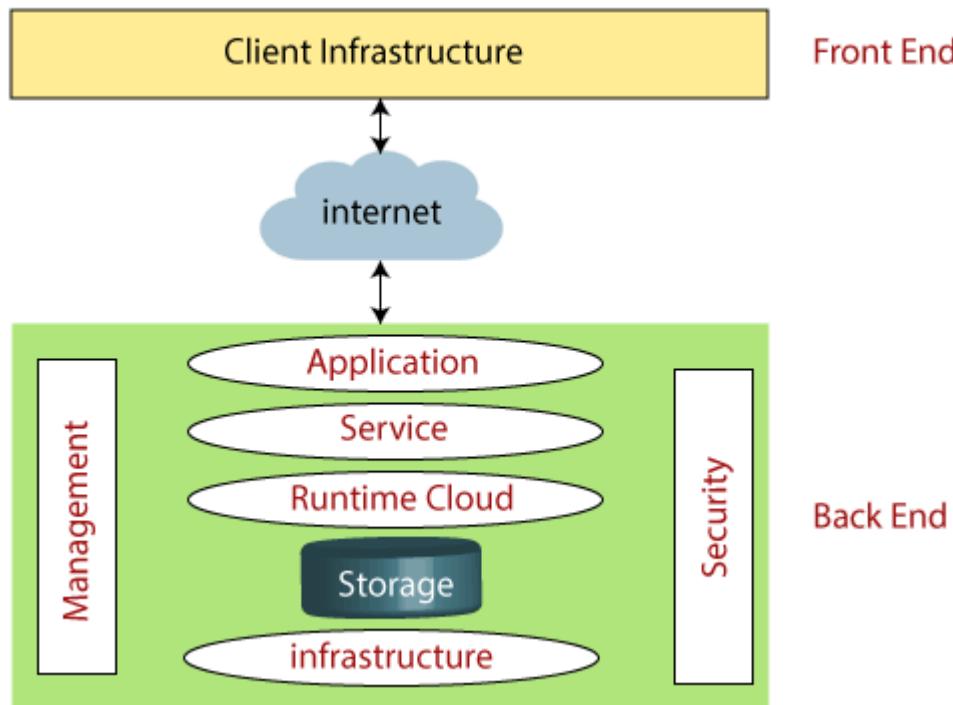
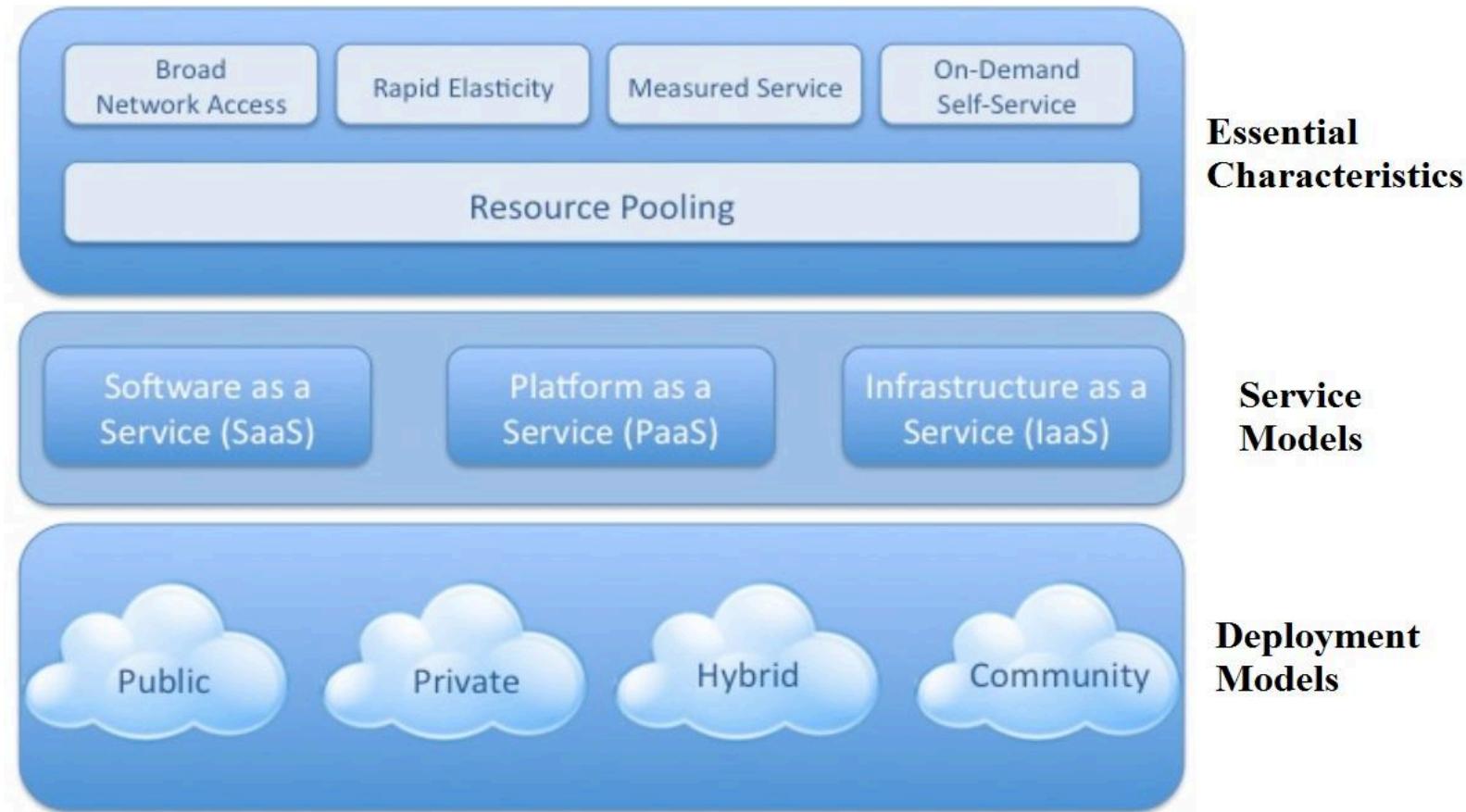


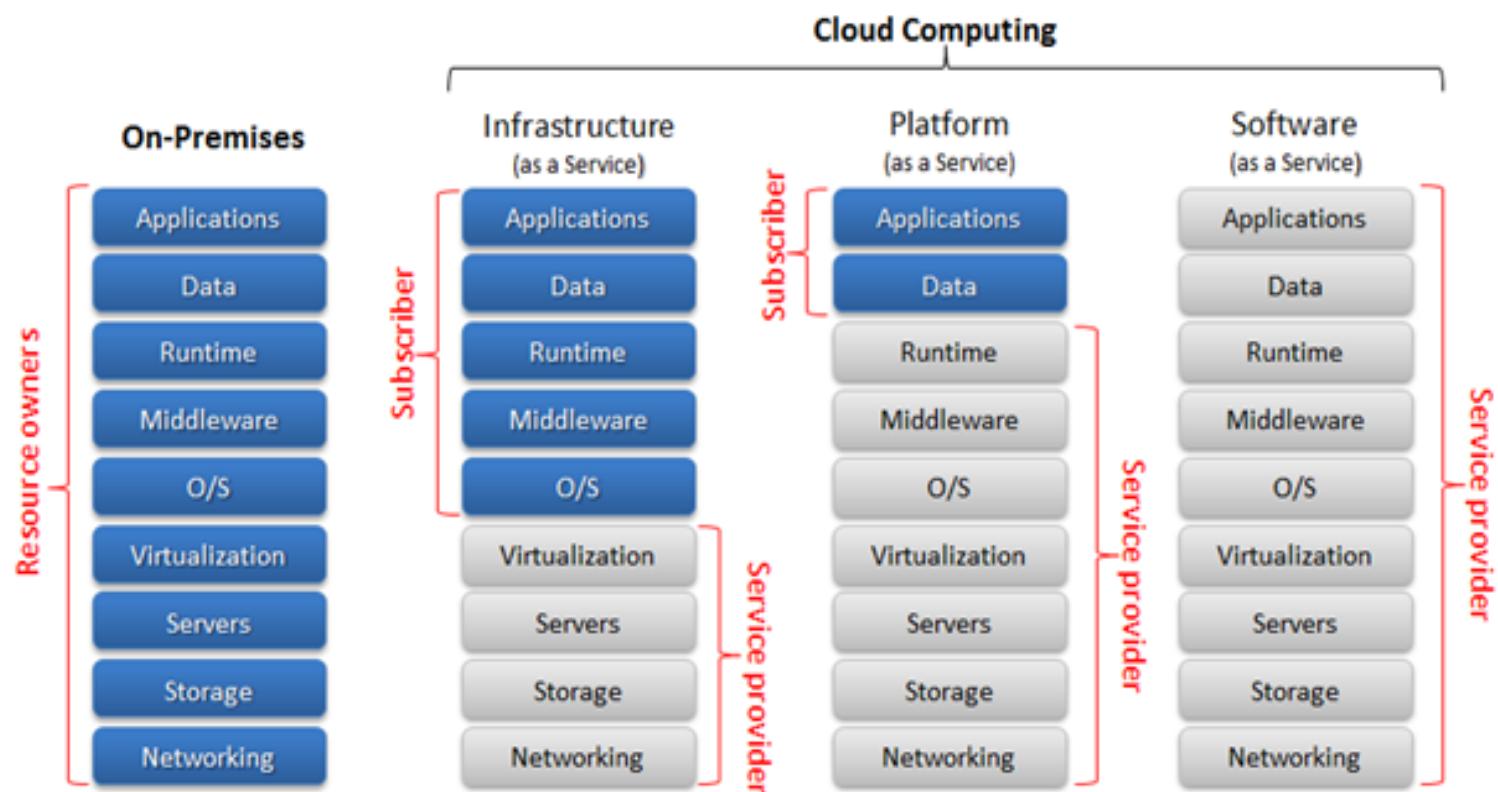
Architecture of Cloud Computing



Architecture Overview



Cloud Computing Services: IaaS, PaaS, SaaS



Cloud Computing Services: An Analogy

Pizza as a Service

Traditional
On-Premises
(On Prem)

Dining Table

Soda

Electric / Gas

Oven

Fire

Pizza Dough

Tomato Sauce

Toppings

Cheese

Made at
home

Infrastructure
as a Service
(IaaS)

Dining Table

Soda

Electric / Gas

Oven

Fire

Pizza Dough

Tomato Sauce

Toppings

Cheese

Take & Bake

Platform
as a Service
(PaaS)

Dining Table

Soda

Electric / Gas

Oven

Fire

Pizza Dough

Tomato Sauce

Toppings

Cheese

Pizza
Delivered

Software
as a Service
(SaaS)

Dining Table

Soda

Electric / Gas

Oven

Fire

Pizza Dough

Tomato Sauce

Toppings

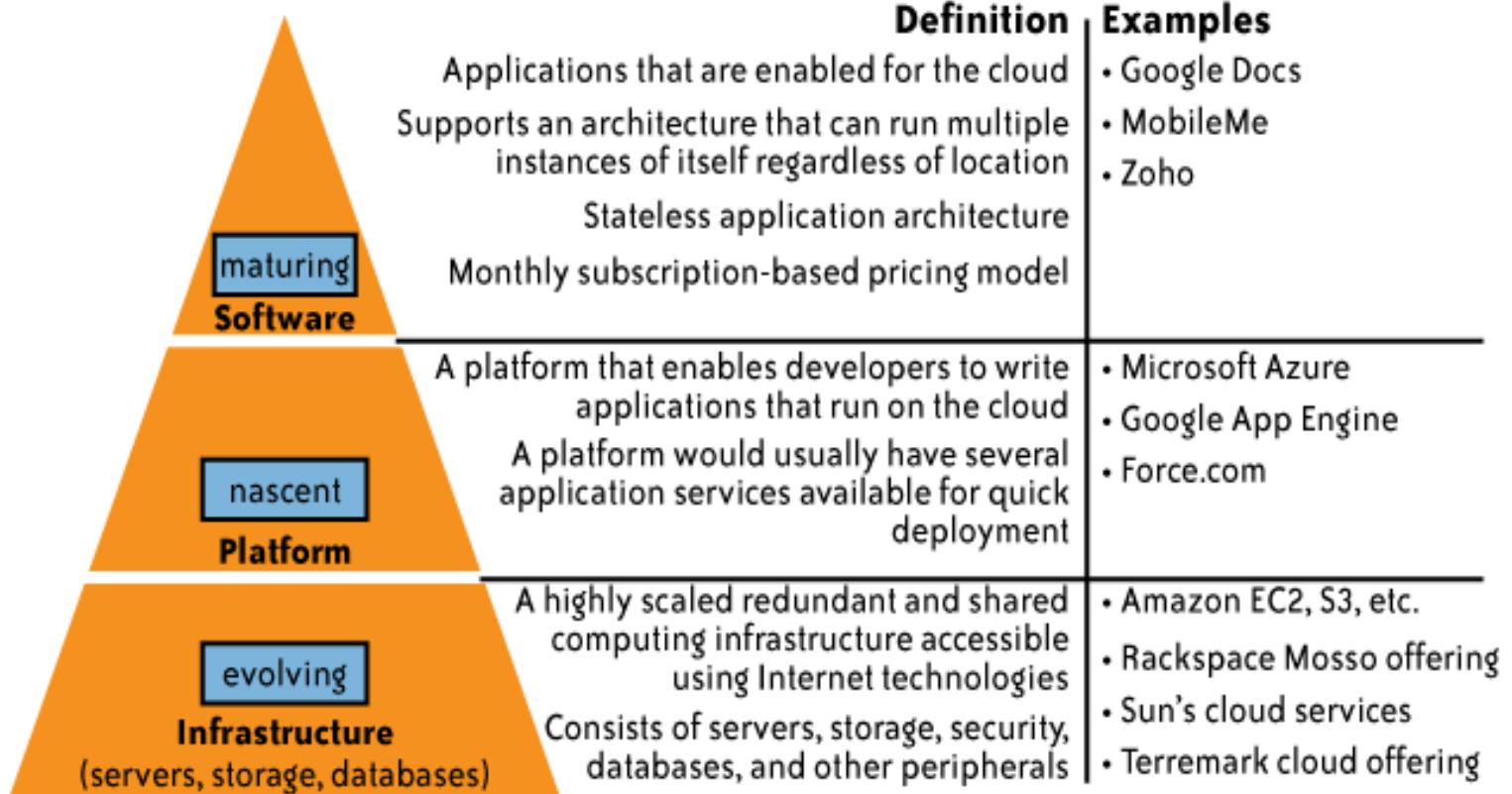
Cheese

Dined
Out

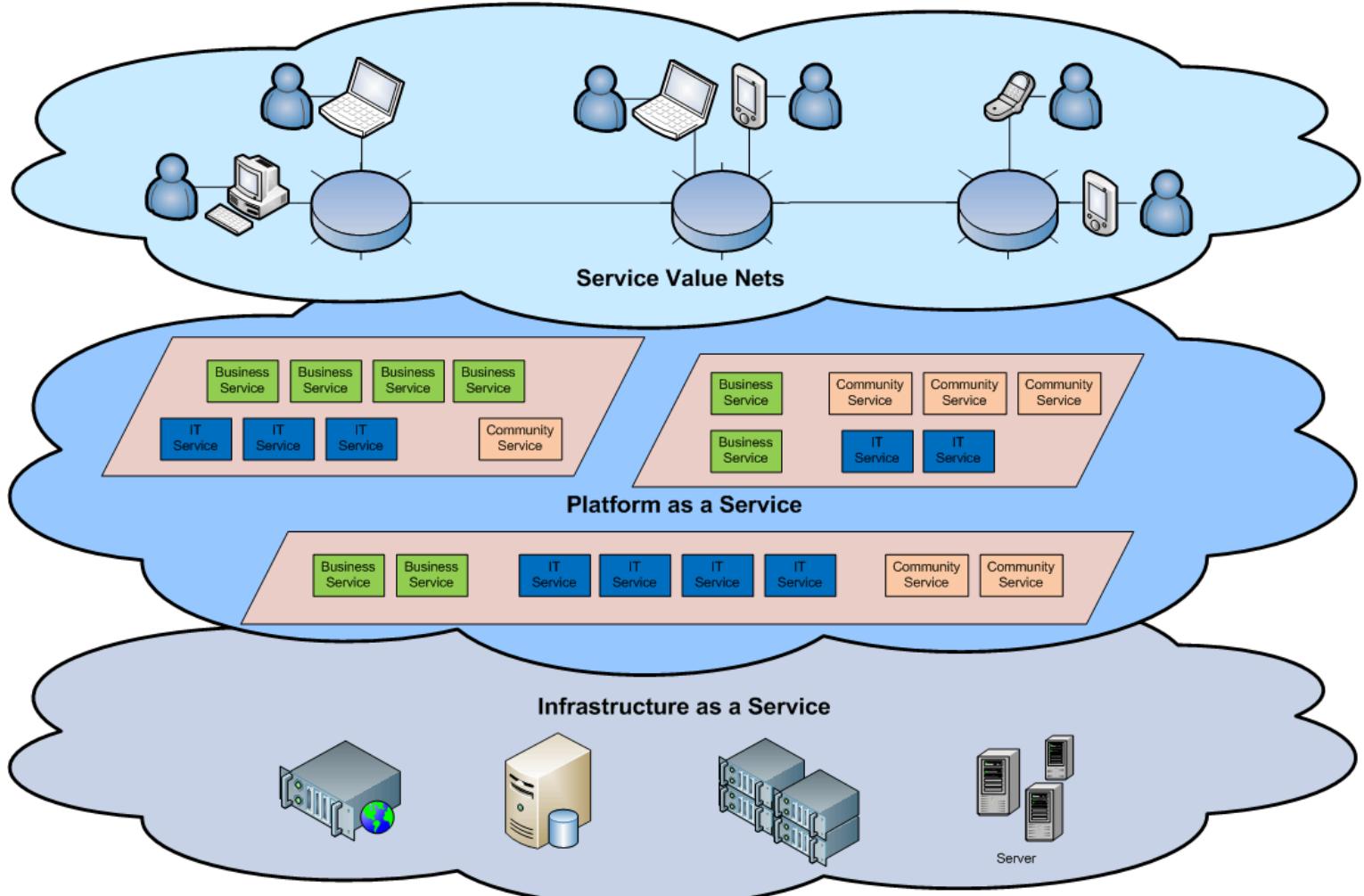
■ You Manage

■ Vendor Manages

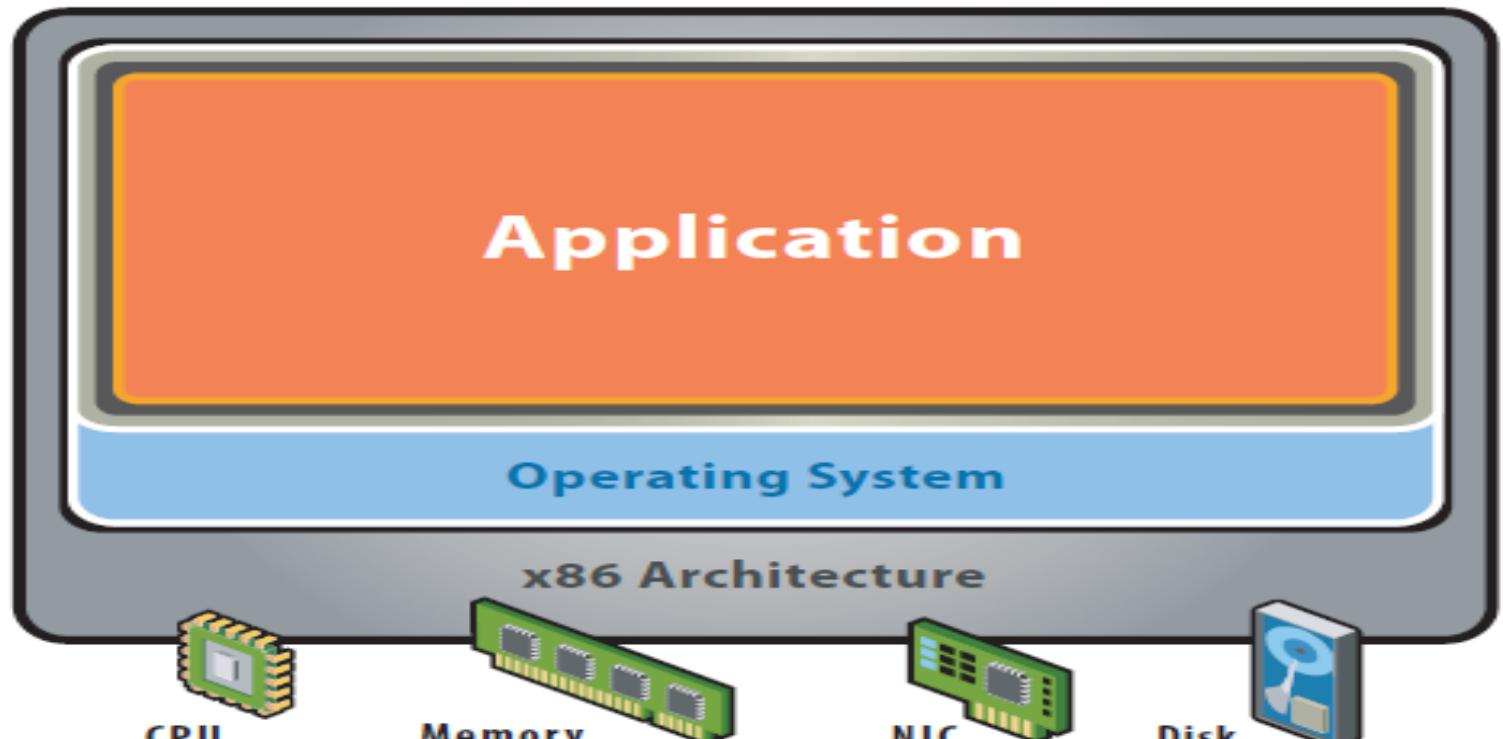
Delivery Models



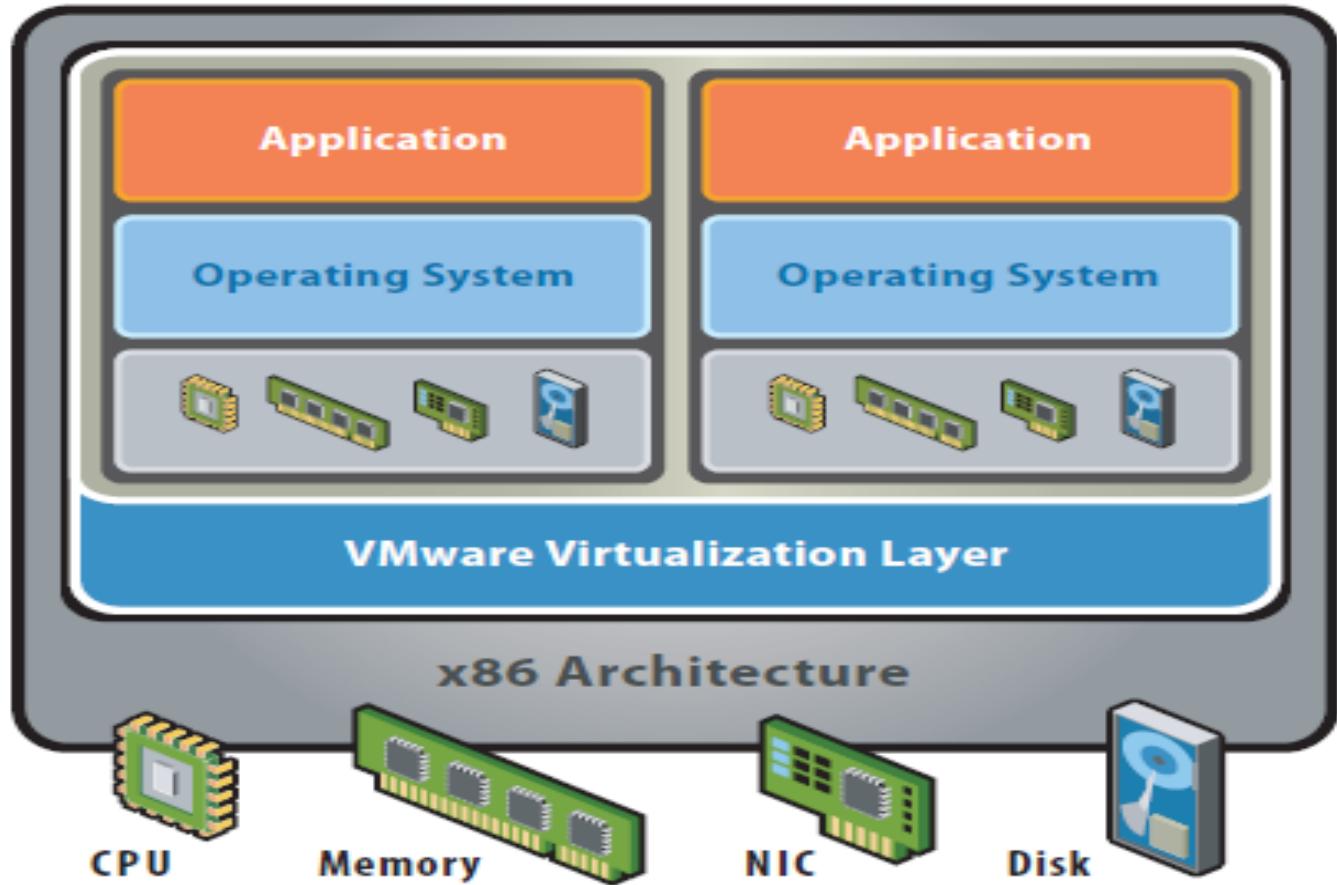
Cloud Architecture



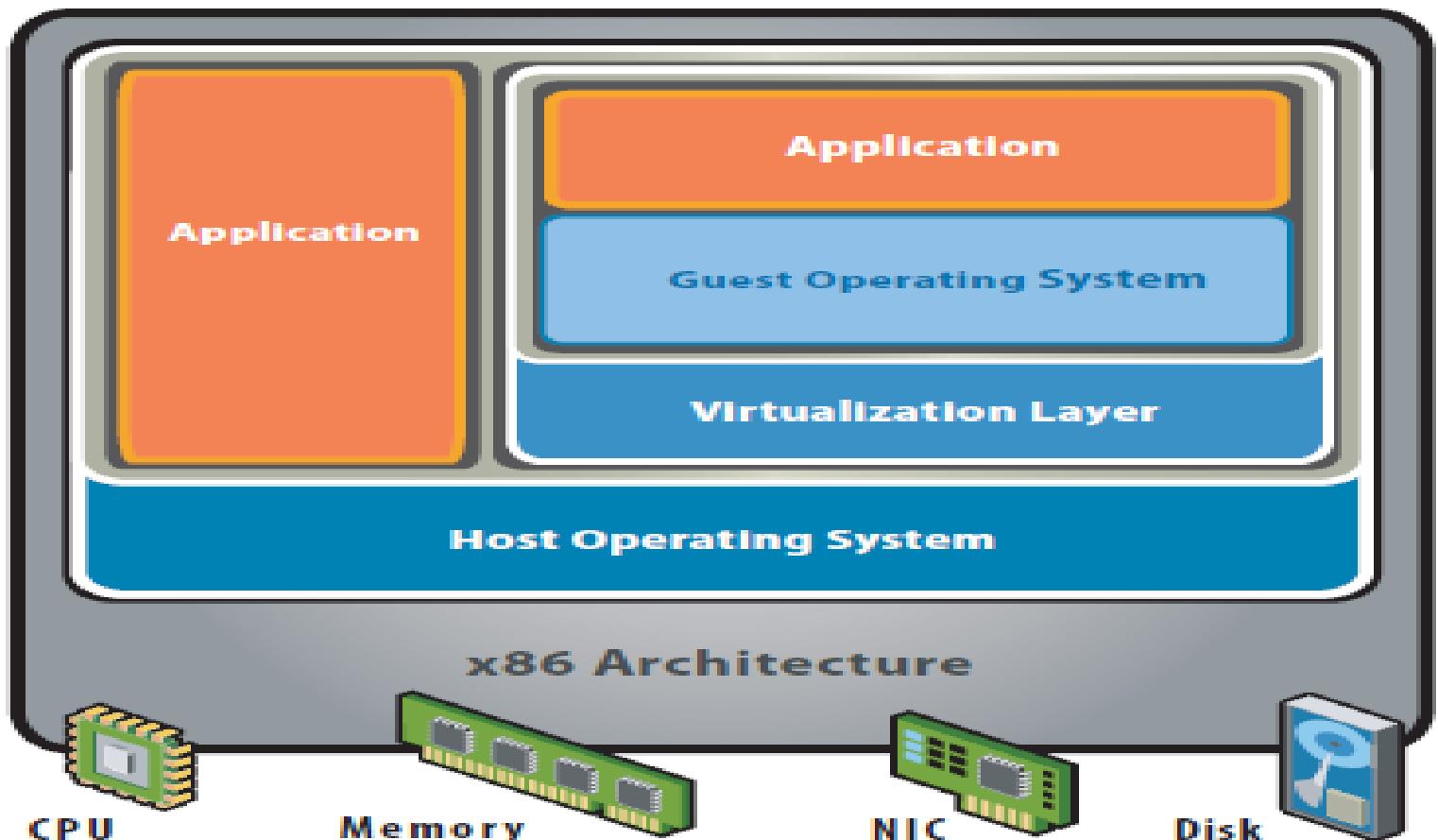
Before Virtualization



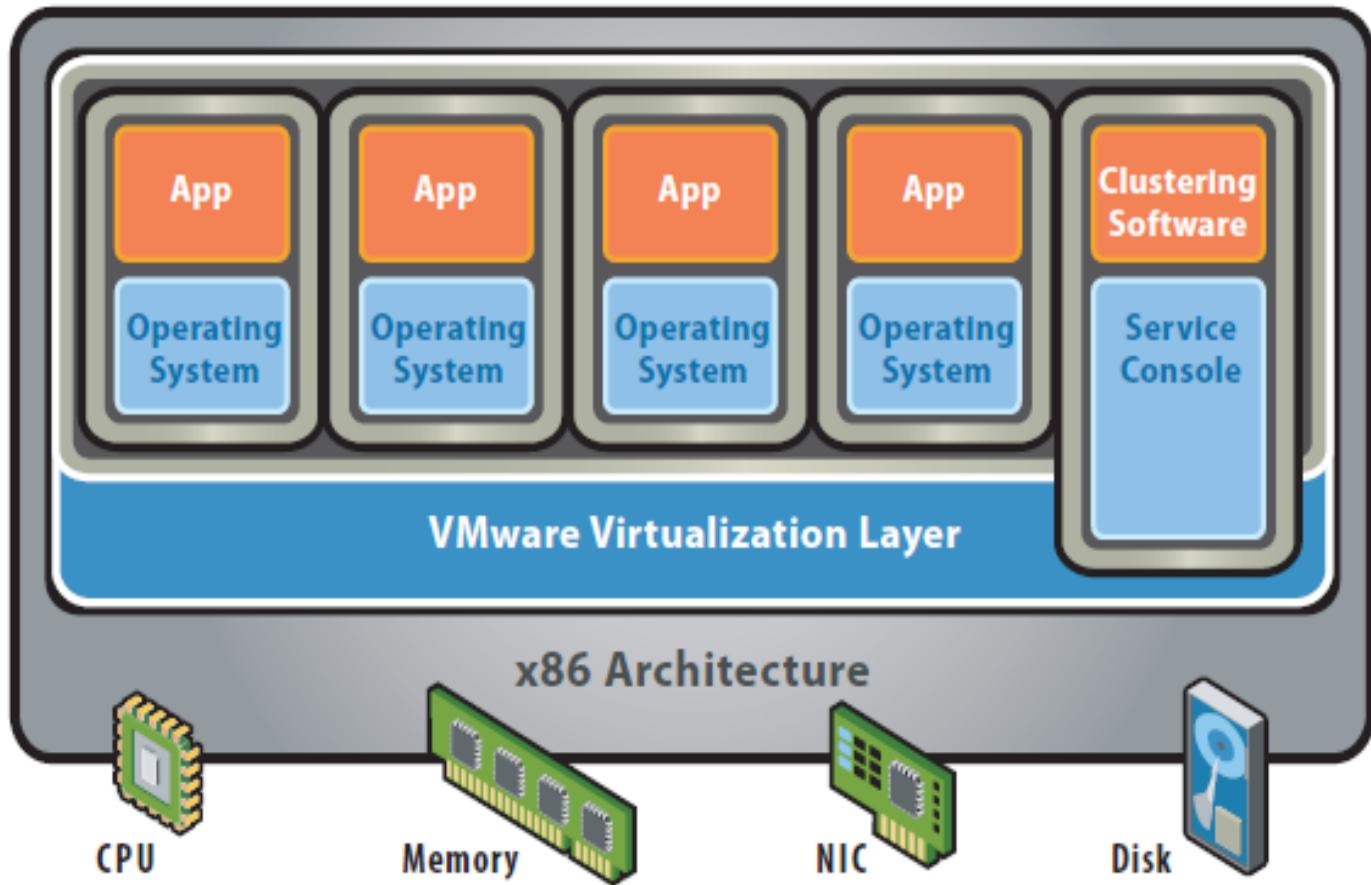
AFTER VIRTUALIZATION



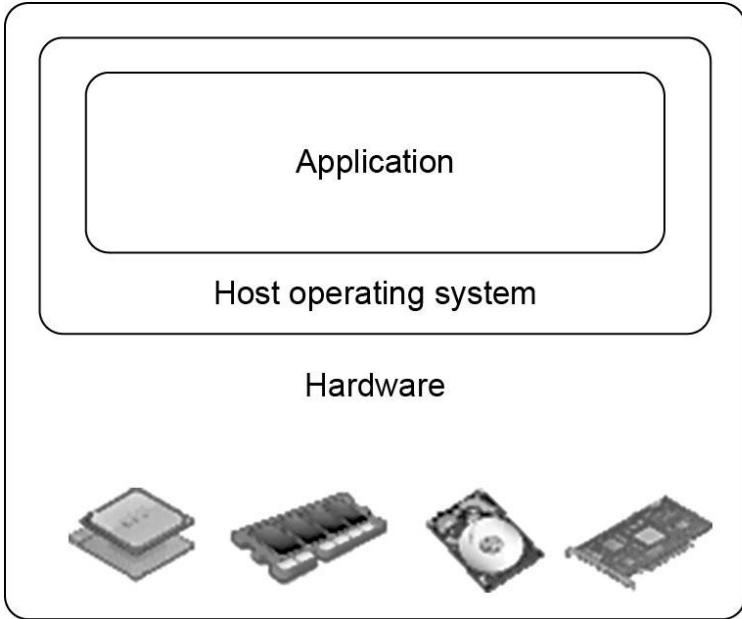
HOSTED ARCHITECTURE



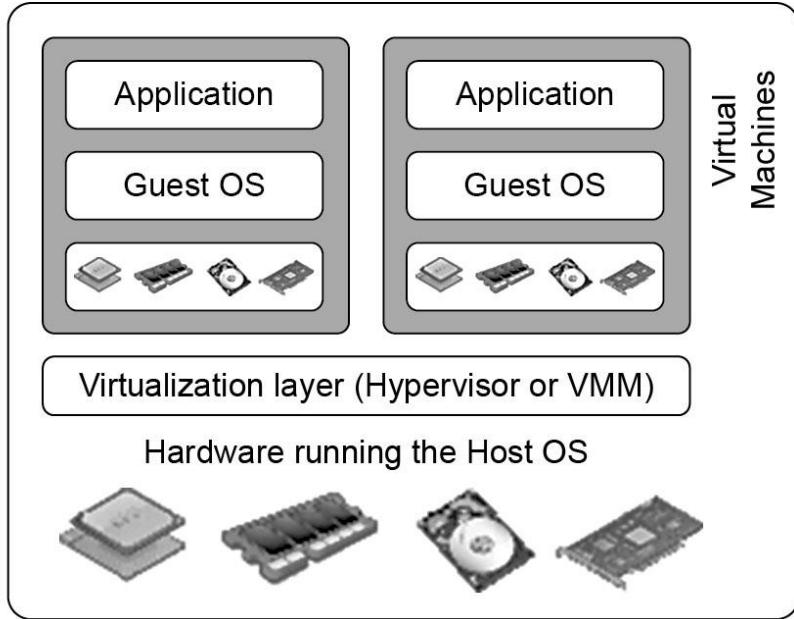
BARE-METAL (HYPERVISOR) ARCHITECTURE



Difference between Traditional Computer and Virtual machines



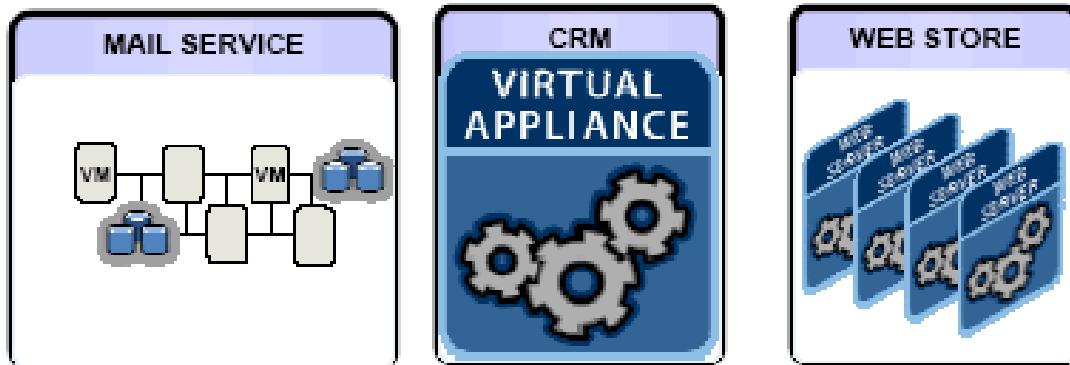
(a) Traditional computer



(b) After virtualization

User's view of virtualization

LOGICAL VIEW

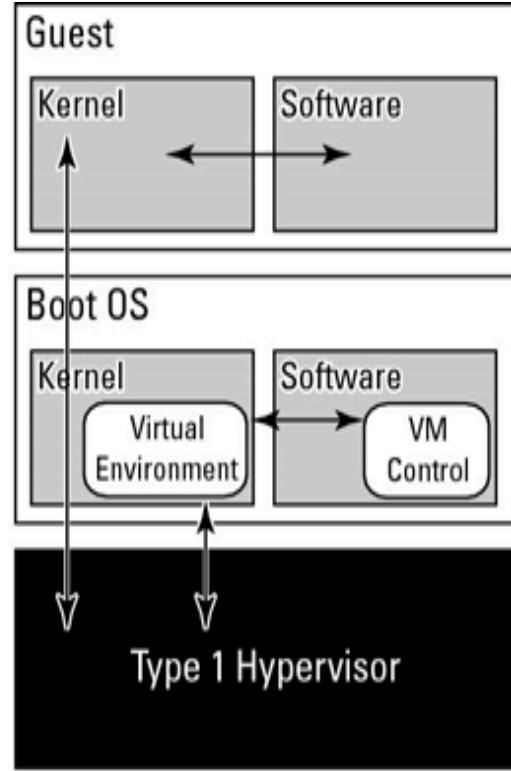
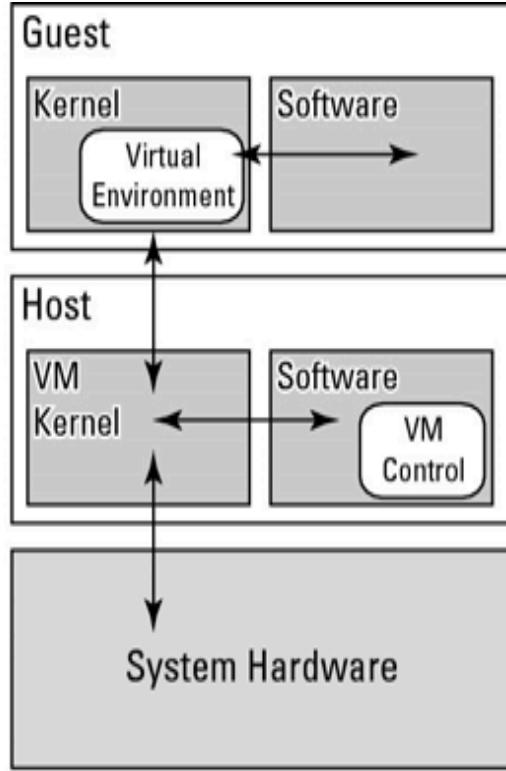
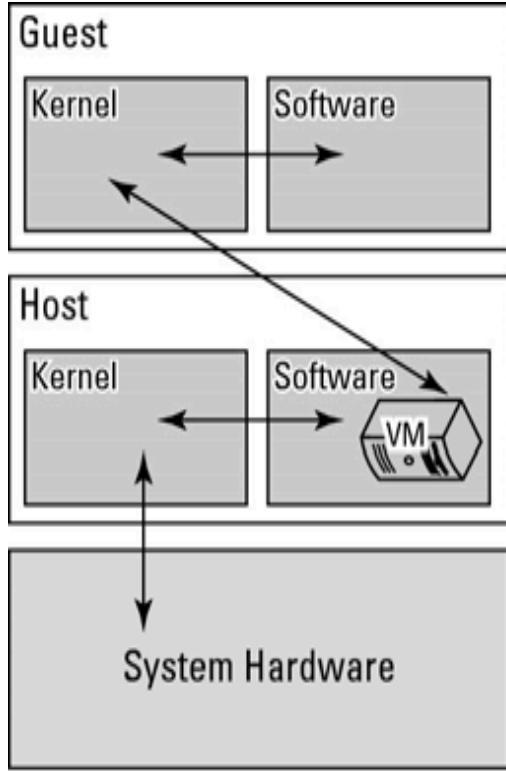


Virtualization Layer - Optimize HW utilization, power, etc.

PHYSICAL VIEW



Emulation, paravirtualization, and full virtualization



Emulation

Paravirtualization

Full Virtualization

Virtualization Ranging from Hardware to Applications in Five Abstraction Levels

Application level

JVM / .NET CLR / Panot

Library (user-level API) level

WINE/ WABI/ LxRun / Visual MainWin / vCUDA

Operating system level

Jail / Virtual Environment / Ensim's VPS / FVM

Hardware abstraction layer (HAL) level

VMware / Virtual PC / Denali / Xen / L4 /
Plex 86 / User mode Linux / Cooperative Linux

Instruction set architecture (ISA) level

Bochs / Crusoe / QEMU / BIRD / Dynamo

Virtualization at OS Level

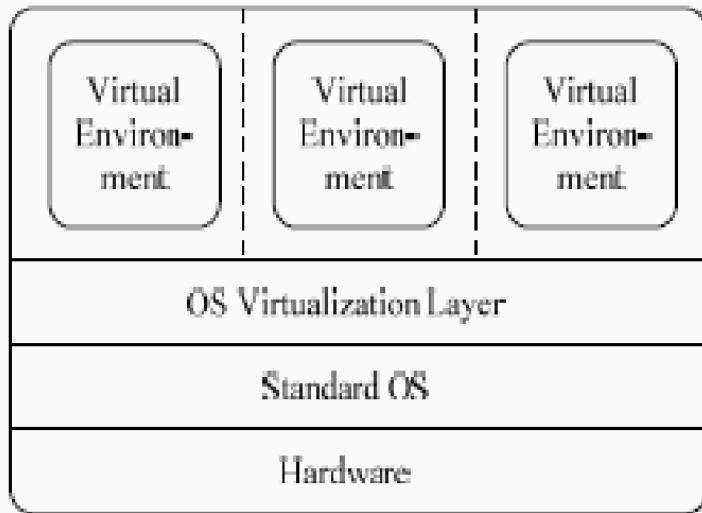
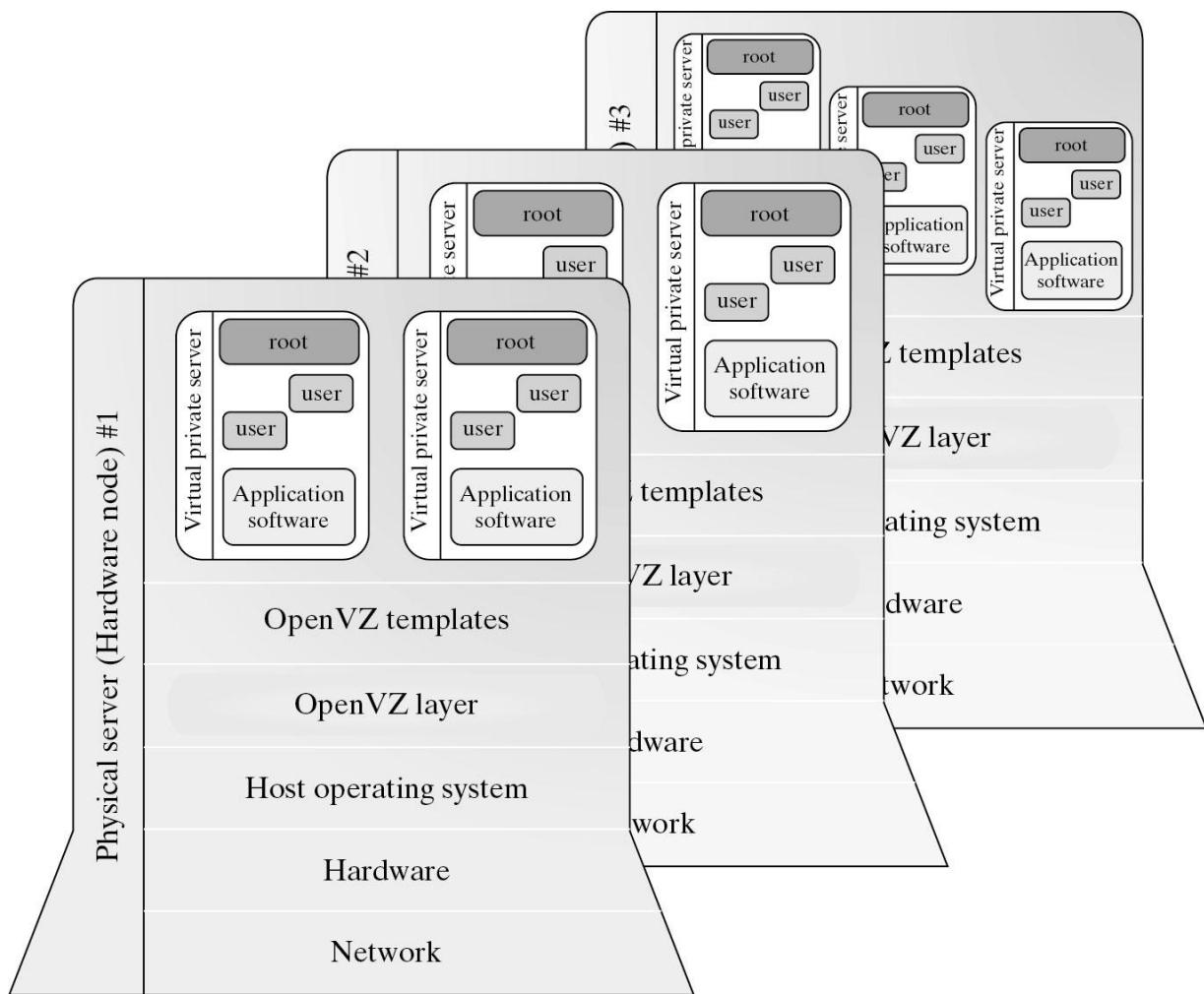


Figure 6.3 The virtualization layer is inserted inside an OS to partition the hardware resources for multiple VMs to run their applications in virtual environments

Virtualization for Linux and Windows NT Platforms



The vCUBE for Virtualization of GPGPU

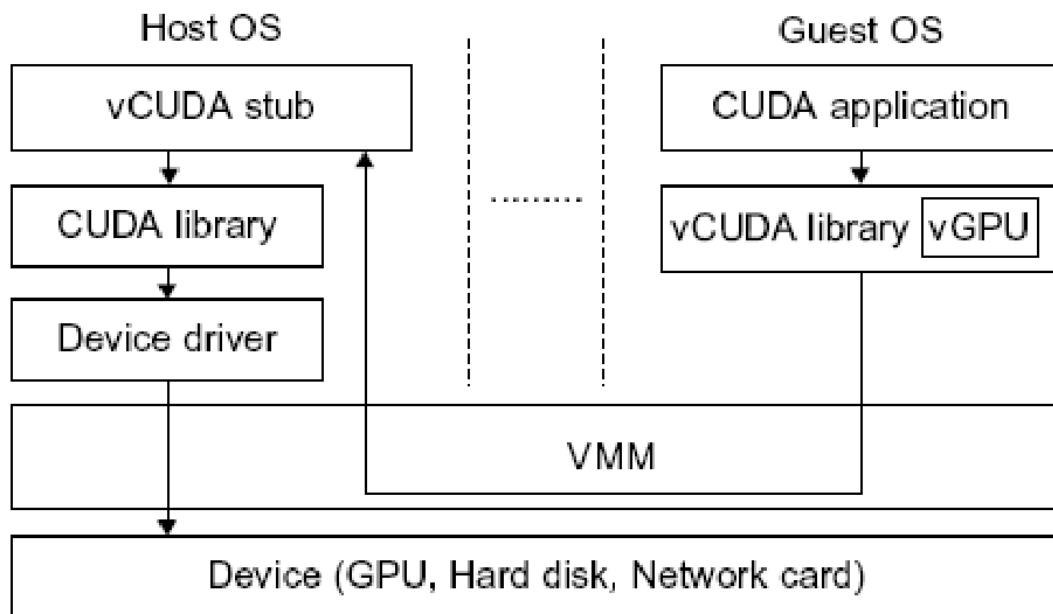


FIGURE 3.4

Basic concept of the vCUDA architecture.

(Courtesy of Lin Shi, et al. [57])

The XEN Architecture

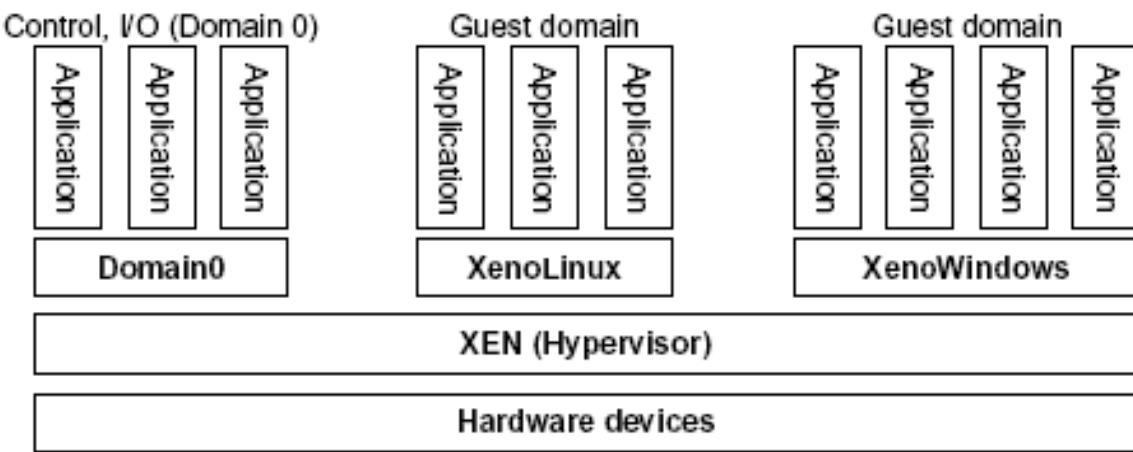


FIGURE 3.5

The Xen architecture's special domain 0 for control and I/O, and several guest domains for user applications.

Full Virtualization

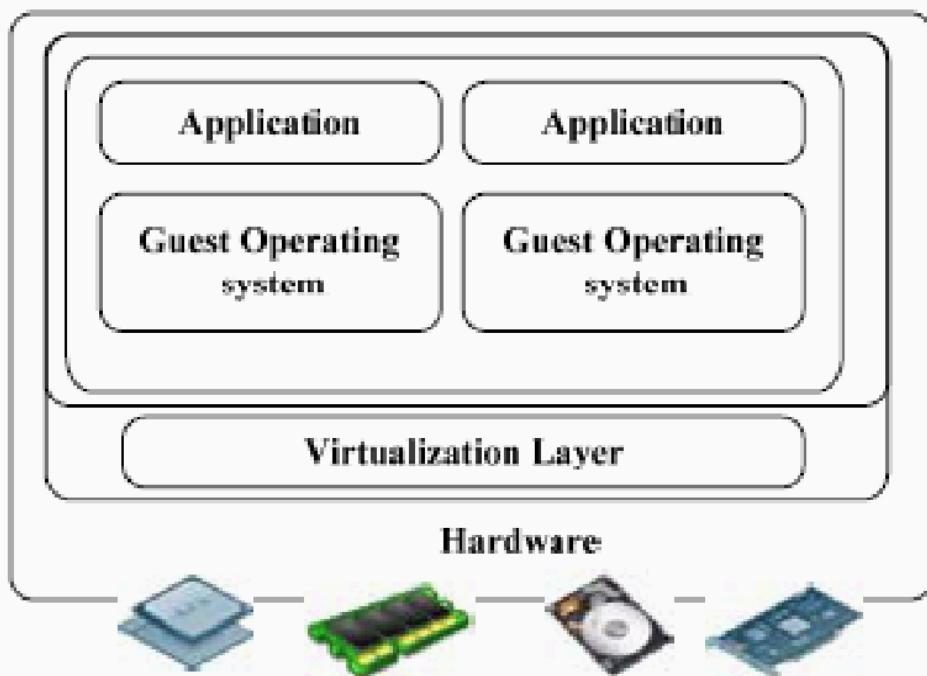
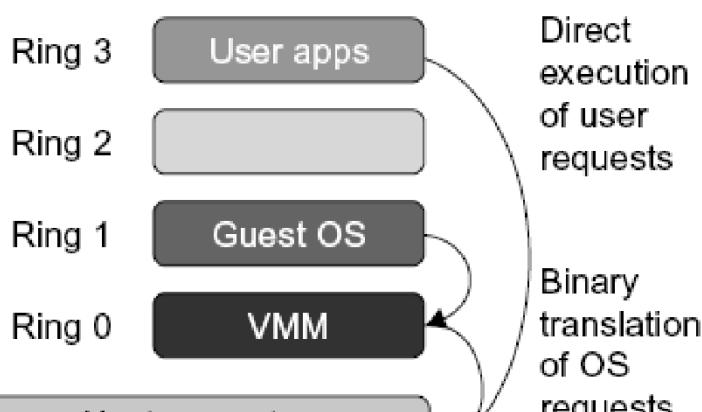


Figure 6.9 The concept of full virtualization using a hypervisor or a VMM directly sitting on top of the bare hardware devices. Note that no host OS is used here as in Figure 6.11.



Binary Translation of Guest OS Requests using a VMM:

Para- Virtualization with Compiler Support.

The KVM builds offers kernel-based VM on the Linux platform, based on para-virtualization

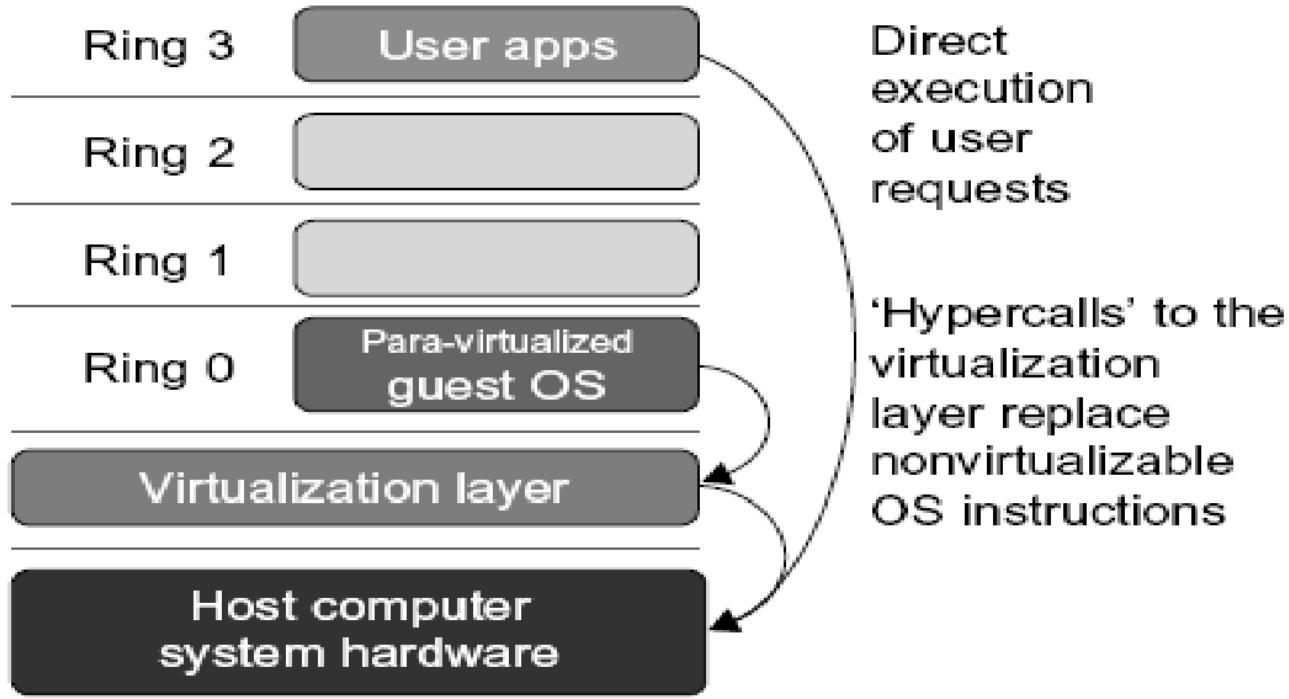
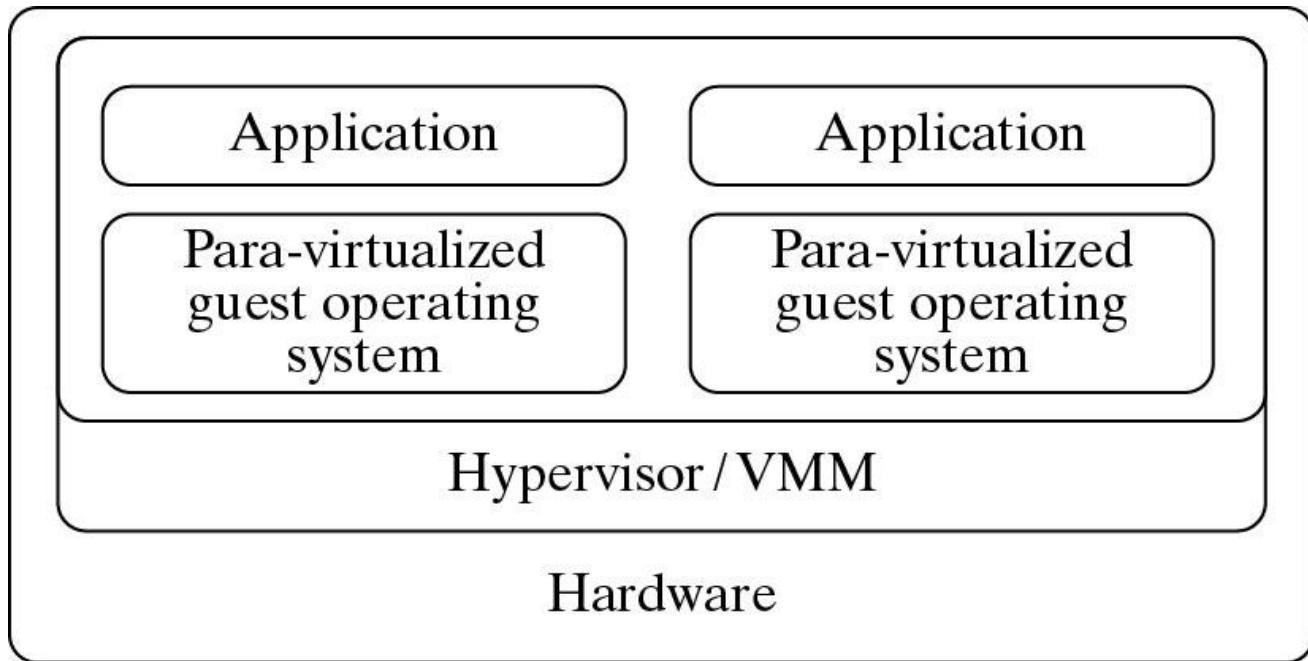
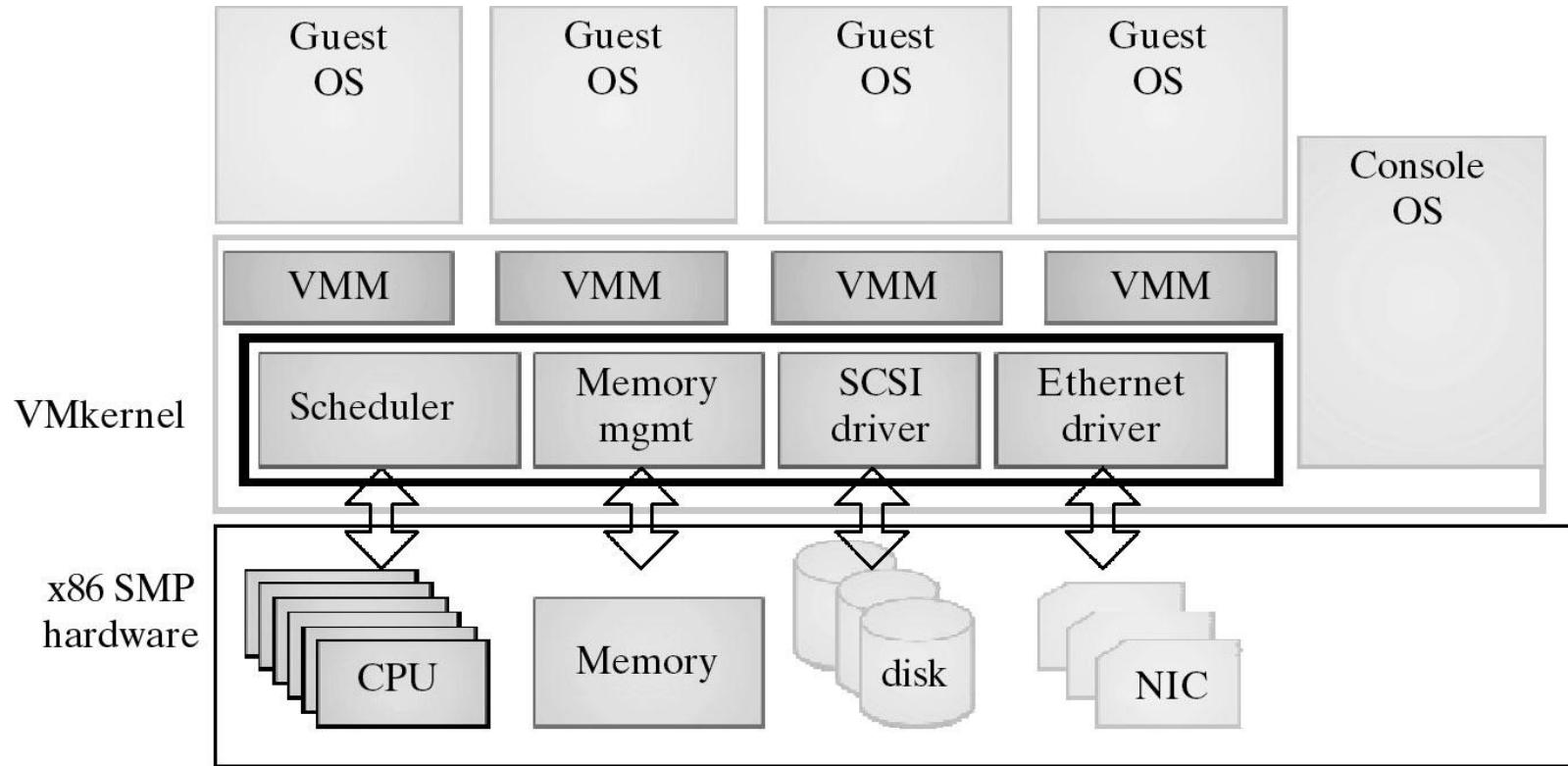


FIGURE 3.8

The Use of a para-virtualized guest OS assisted by an intelligent compiler to replace nonvirtualizable OS instructions by hypercalls.

VMWare ESX Server for Para-Virtualization



Memory Virtualization Challenges

Address Translation

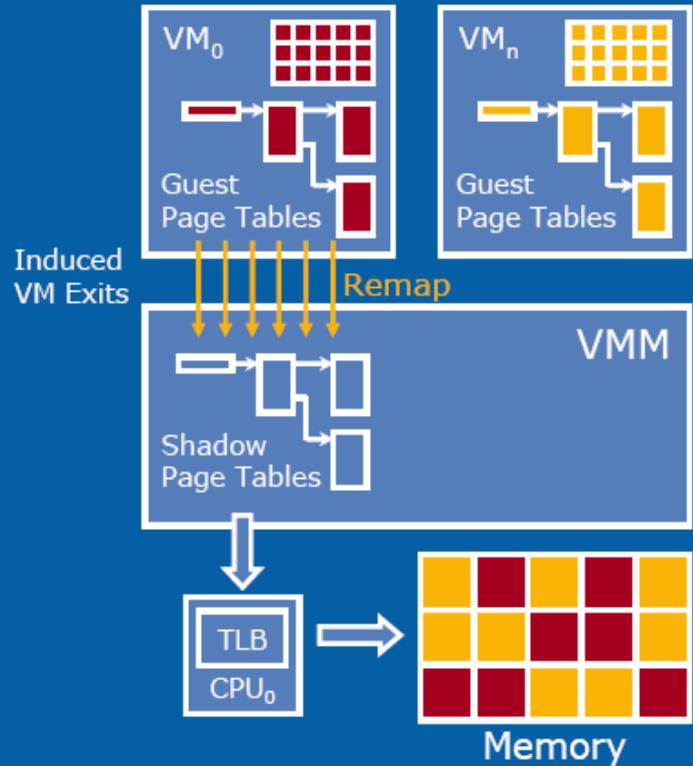
- Guest OS expects contiguous, zero-based physical memory
- VMM must preserve this illusion

Page-table Shadowing

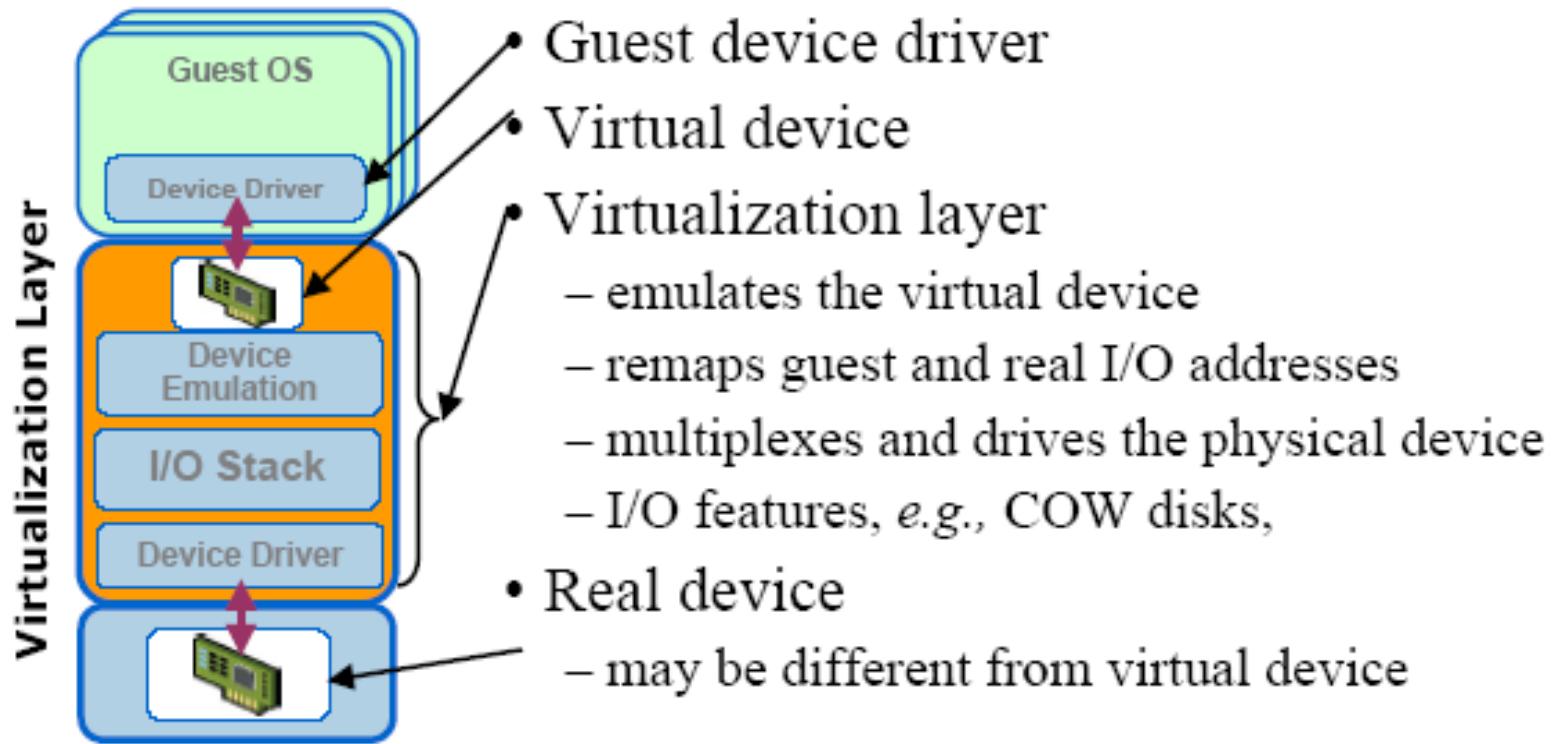
- VMM intercepts paging operations
- Constructs copy of page tables

Overheads

- VM exits add to execution time
- Shadow page tables consume significant host memory



Current virtual I/O devices



Multi-Core Virtualization:

VCPUs vs. traditional CPU

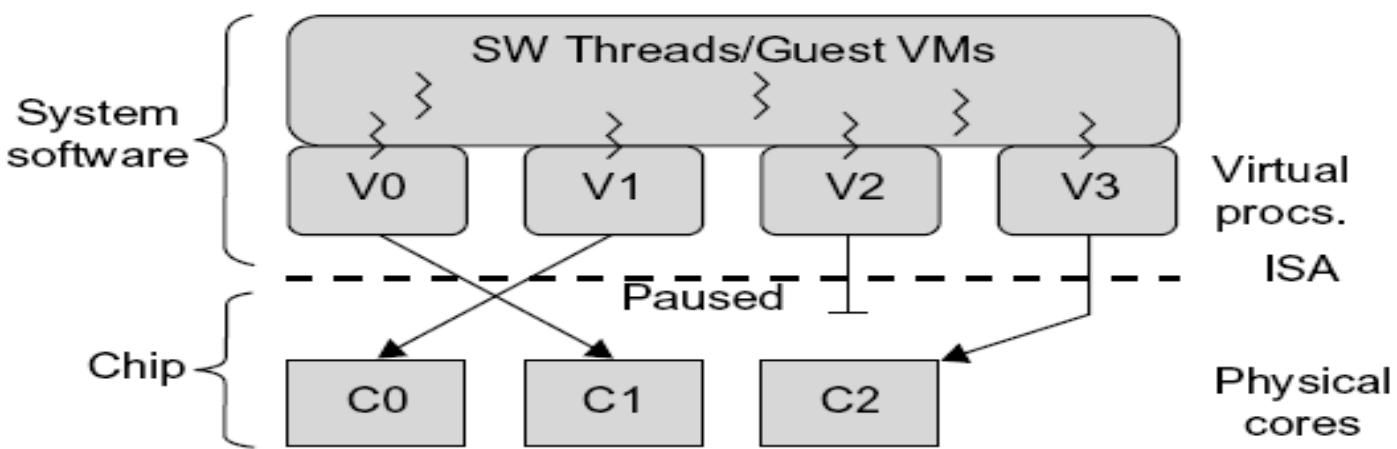
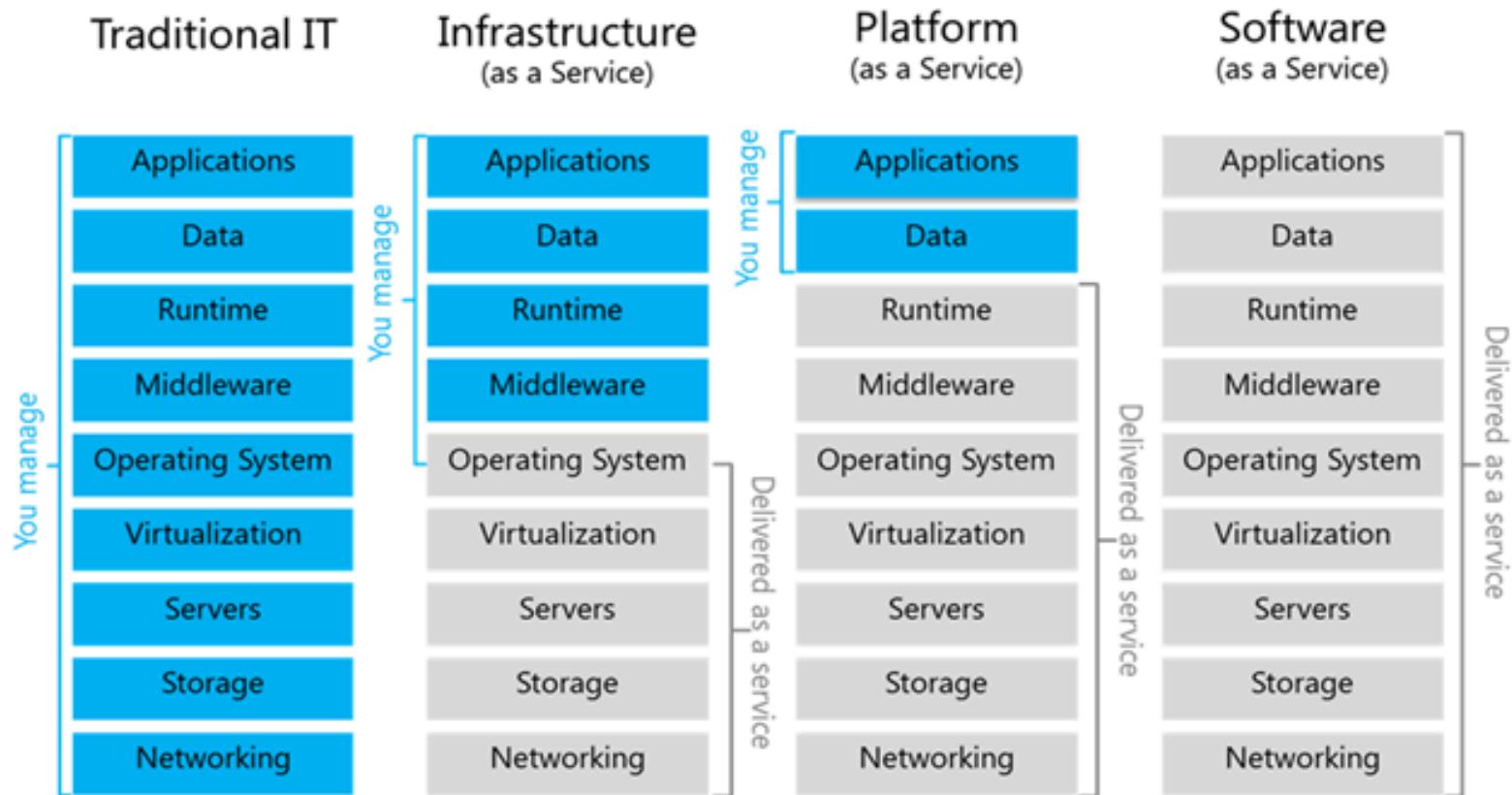


Figure 3.16 Four VCPUs are exposed to the software, only three cores are actually present. VCPUs V0, V1, and V3 have been transparently migrated, while VCPU V2 has been transparently suspended. (Courtesy of Wells, et al., "Dynamic Heterogeneity and the Need for Multicore Virtualization", ACM SIGOPS Operating Systems Review, ACM Press,

2009 [68])

SaaS, PaaS, IaaS





SAAS

Software
as a Service



PAAS

Platform
as a Service



IAAS

Infrastructure
as a Service

Email

CRM

Collaborative

ERP

Application Development

Decision Support

Web

Streaming

Caching

Legacy

File

Networking

Technical

Security

System Mgmt

CONSUME

BUILD ON IT

MIGRATE TO IT

Platform as a Service (PaaS) Providers



Google app engine



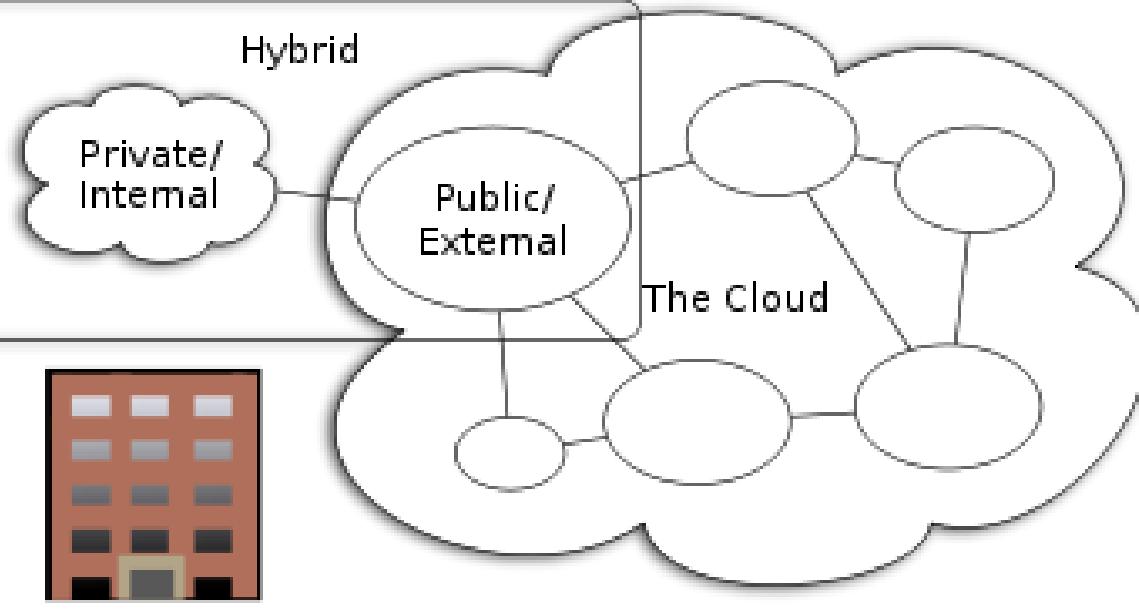
CLOUD FOUNDRY™
DEPLOY & SCALE YOUR APPLICATIONS IN SECONDS



Windows® Azure™



Cloud Deployment Model



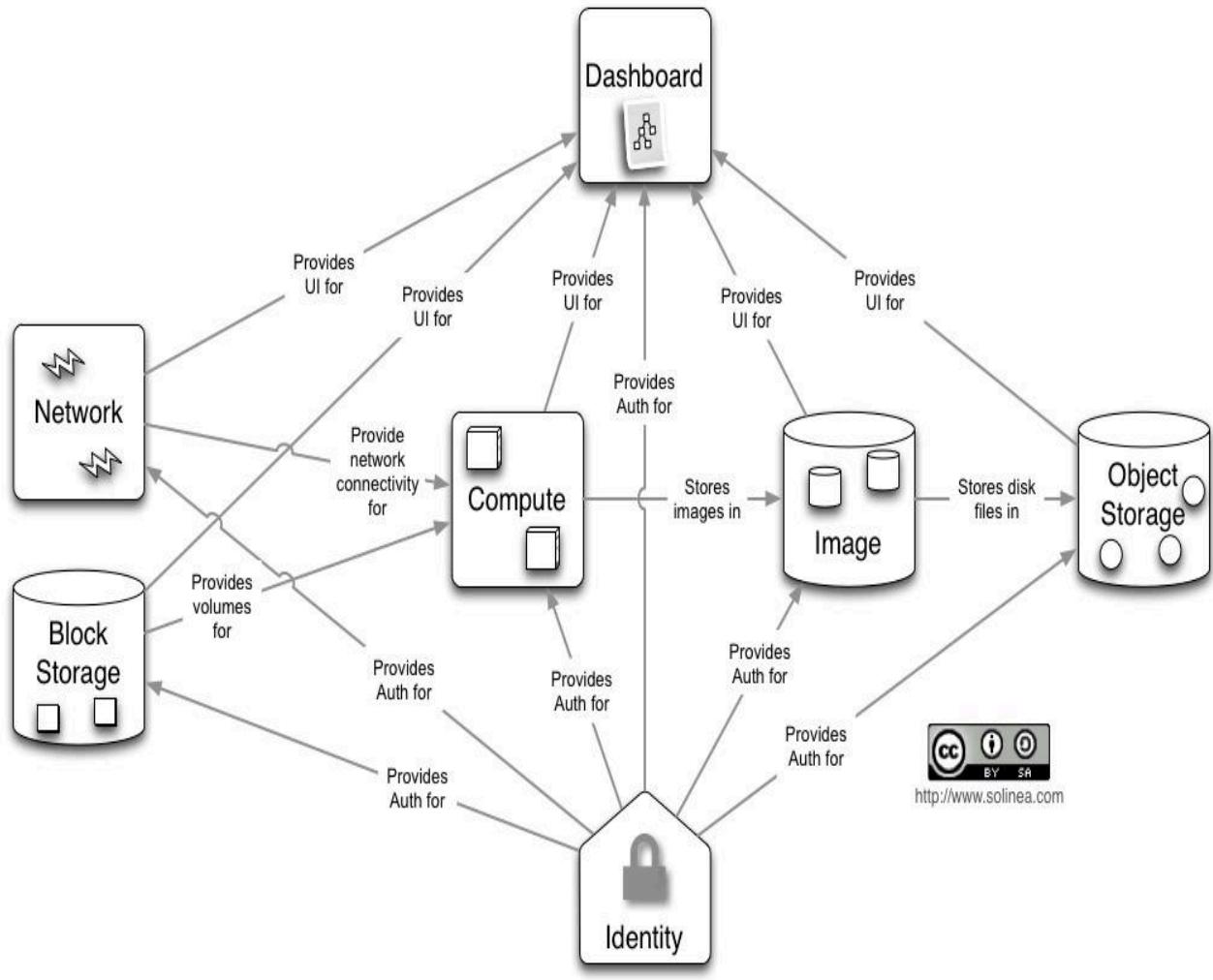
Cloud Computing Types

CC-BY-SA 3.0 by Sam Johnston

Community with Broad Commercial Support

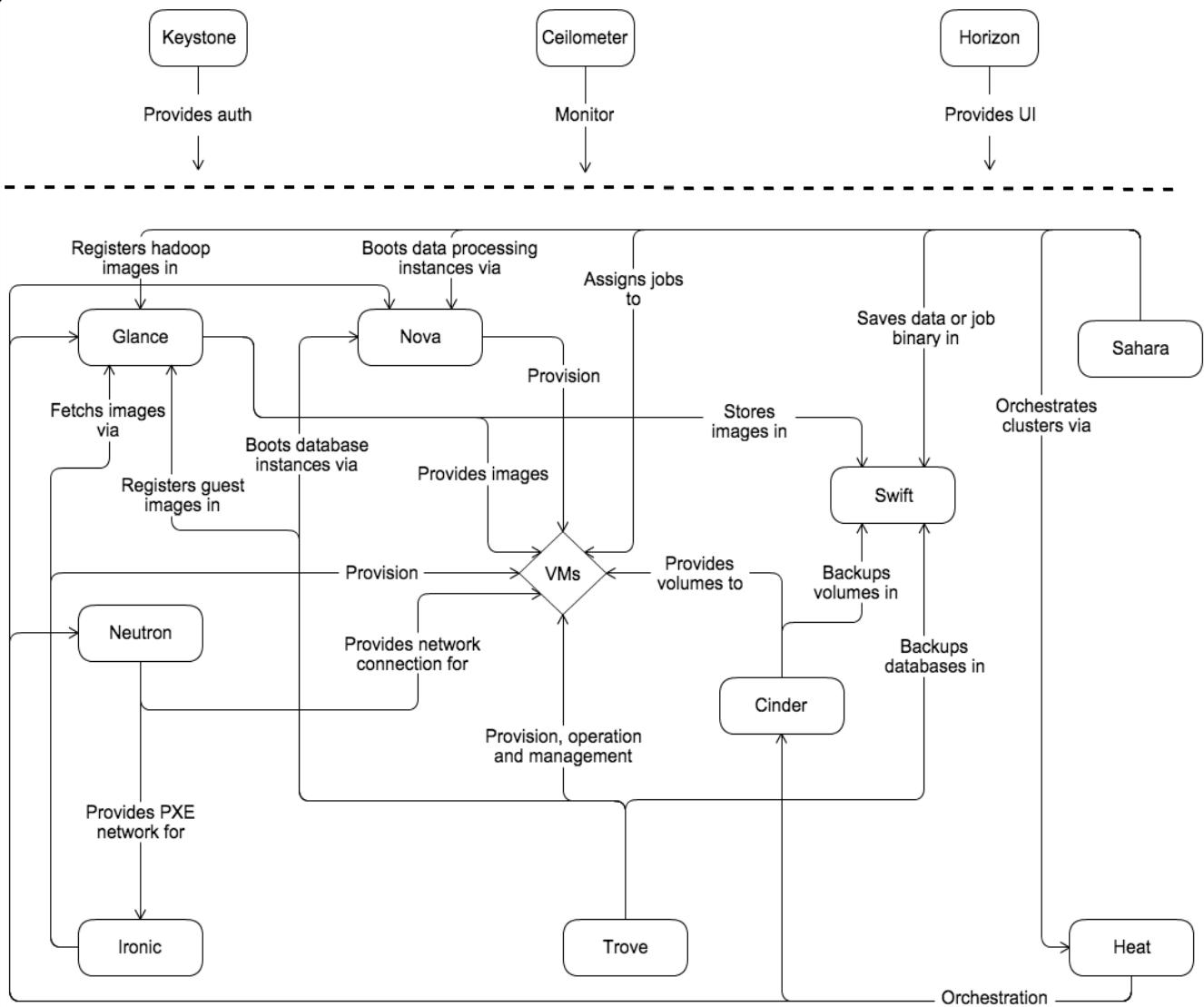


OpenStack component interaction ?



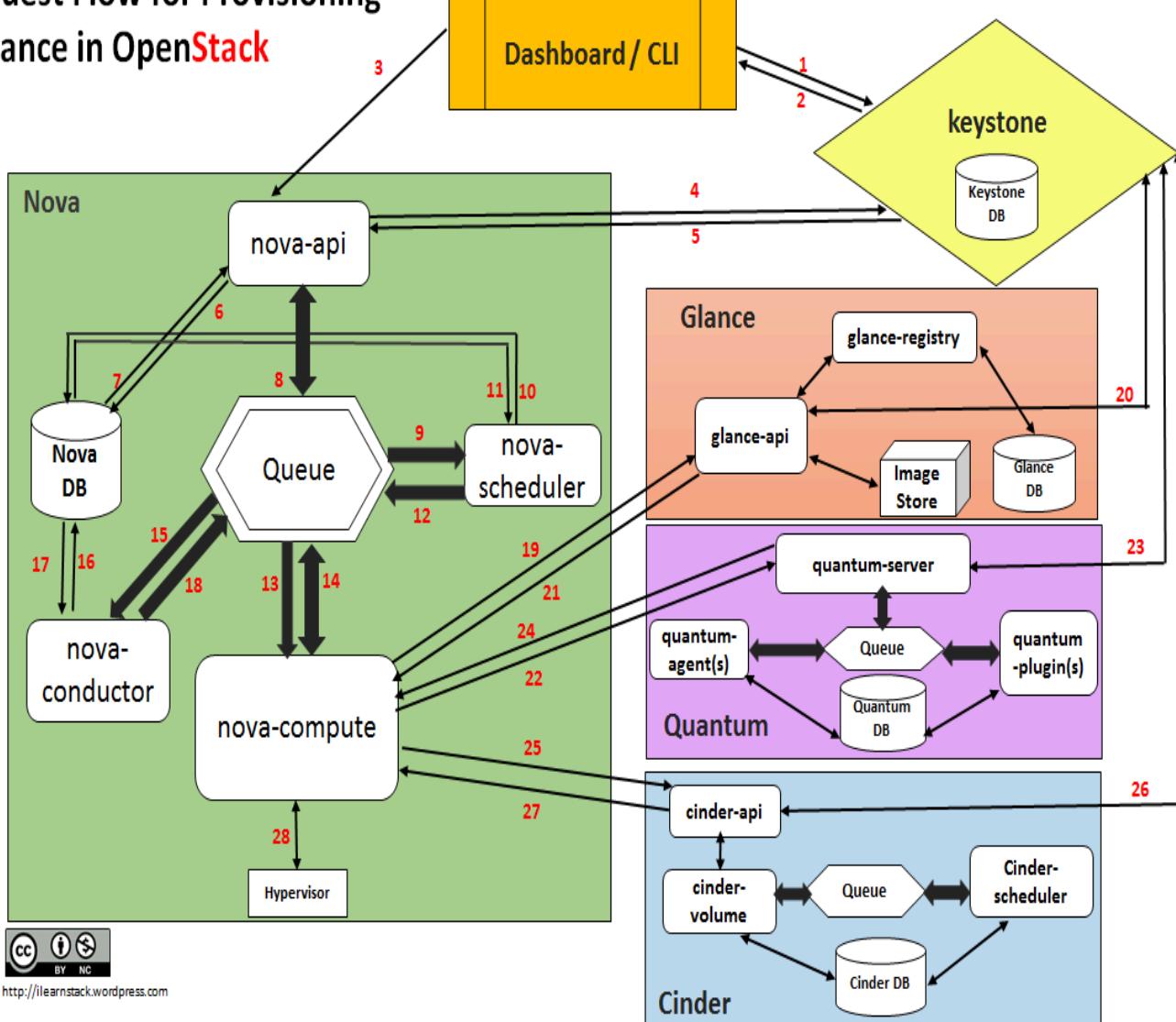
http://www.solinea.com

Architecture of Openstack



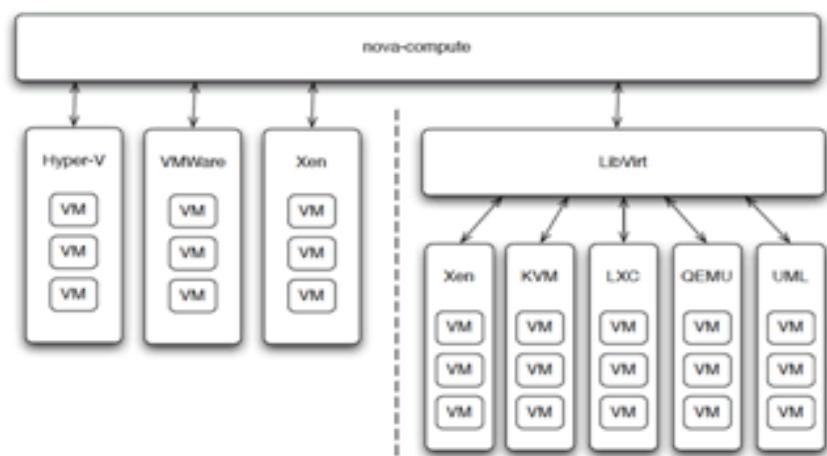
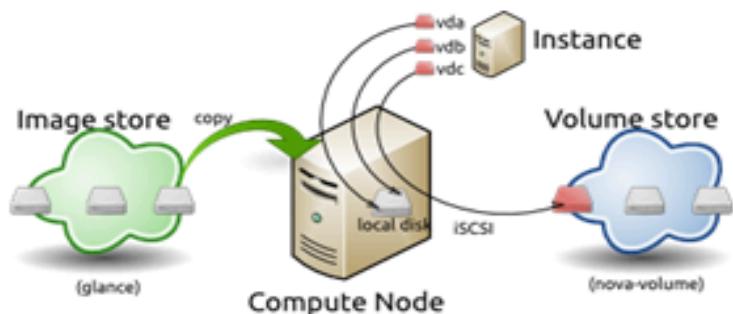
Request flow (VM Creation)

Request Flow for Provisioning Instance in OpenStack

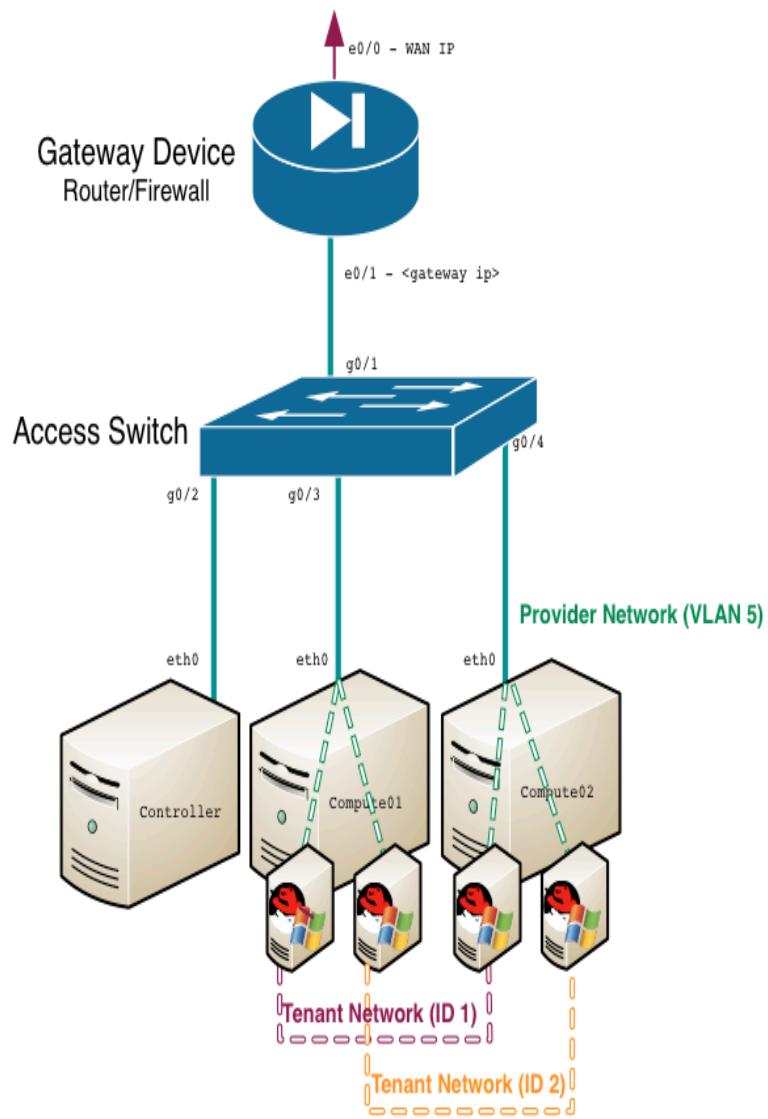


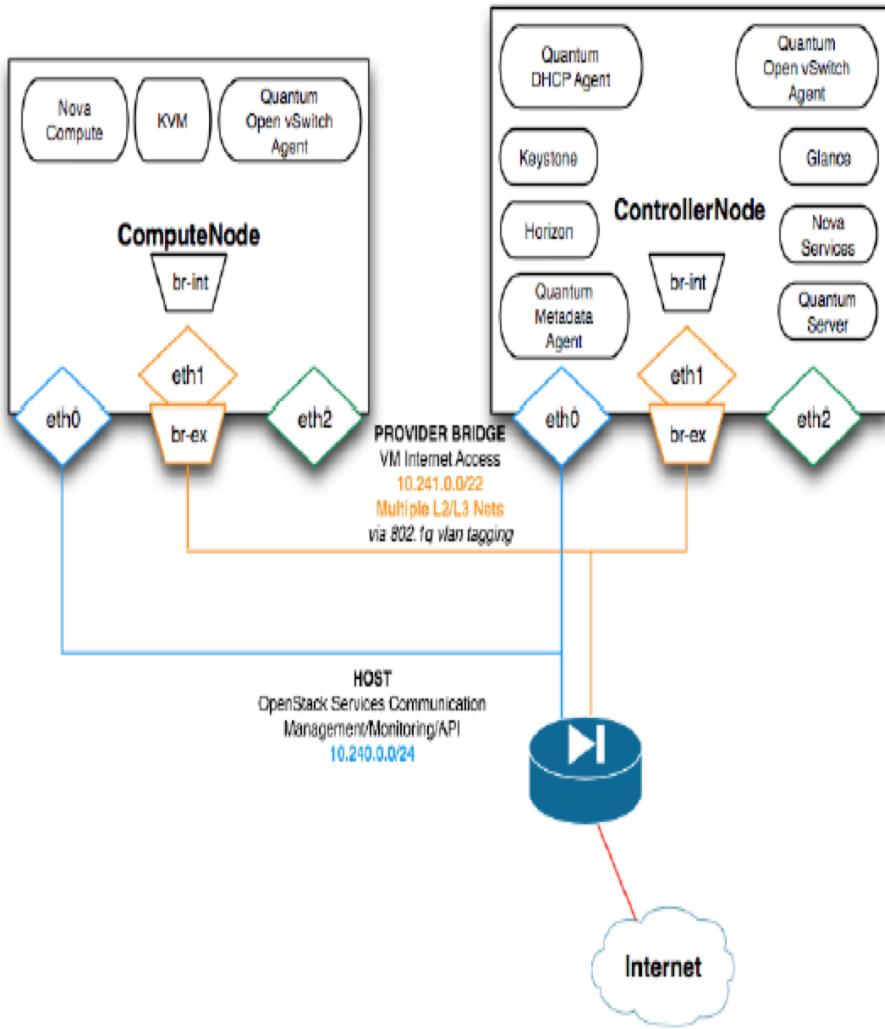
<http://ilearnstack.wordpress.com>

Nova Compute

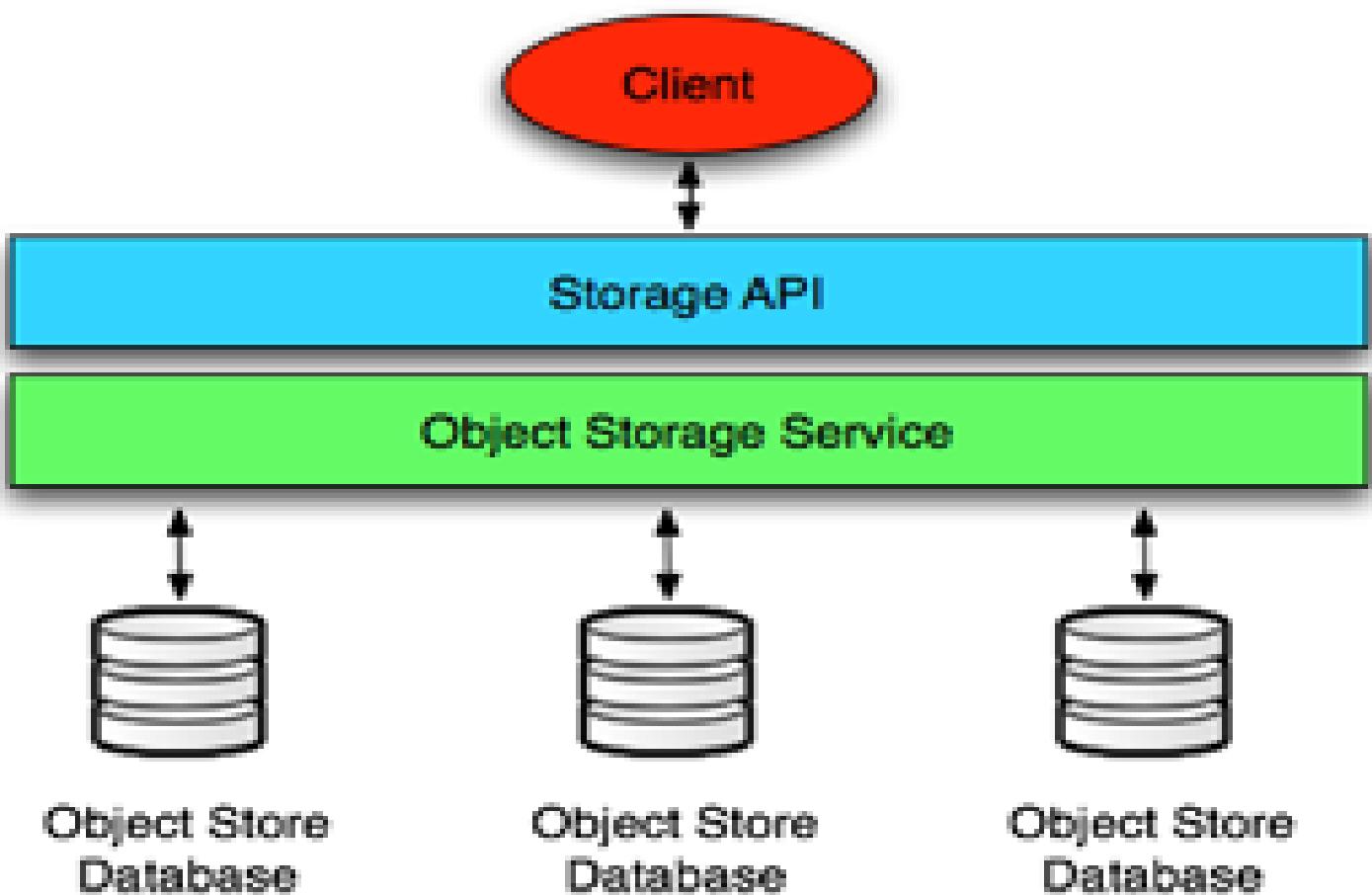


Neutron Networking

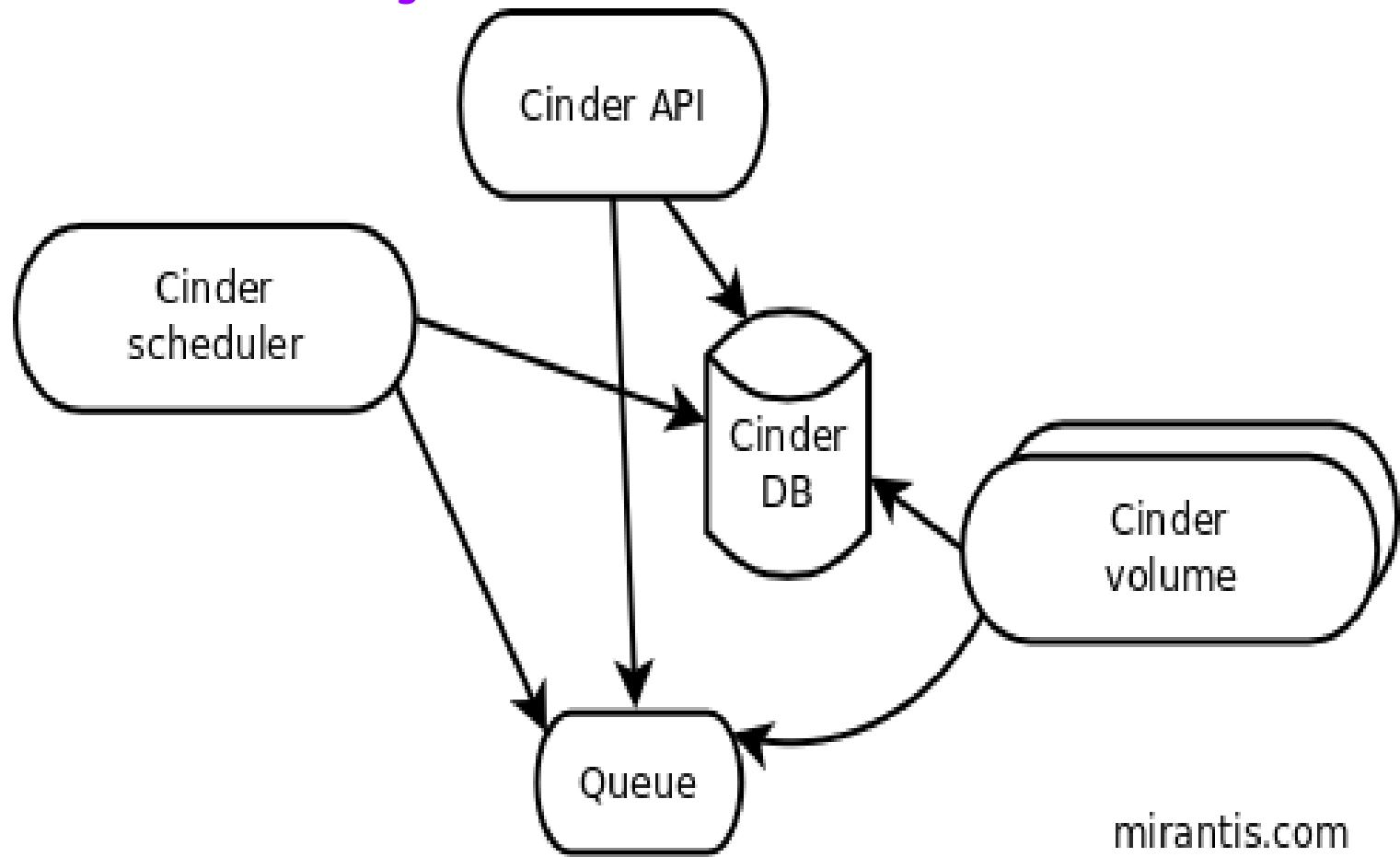


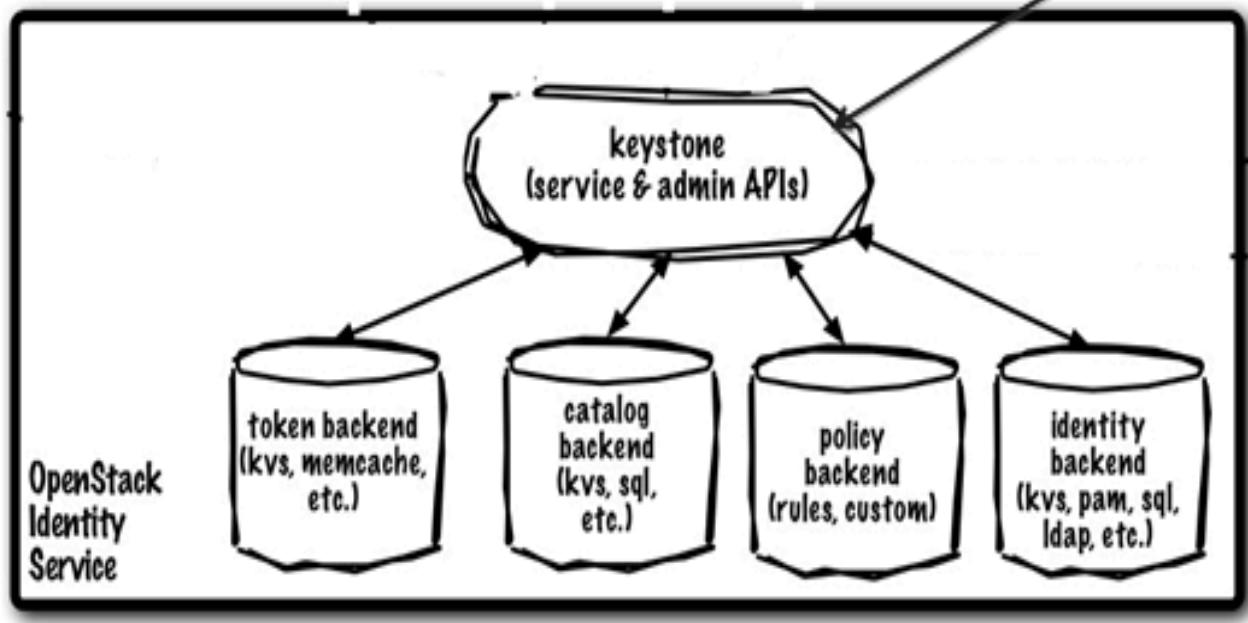


Swift Object Storage

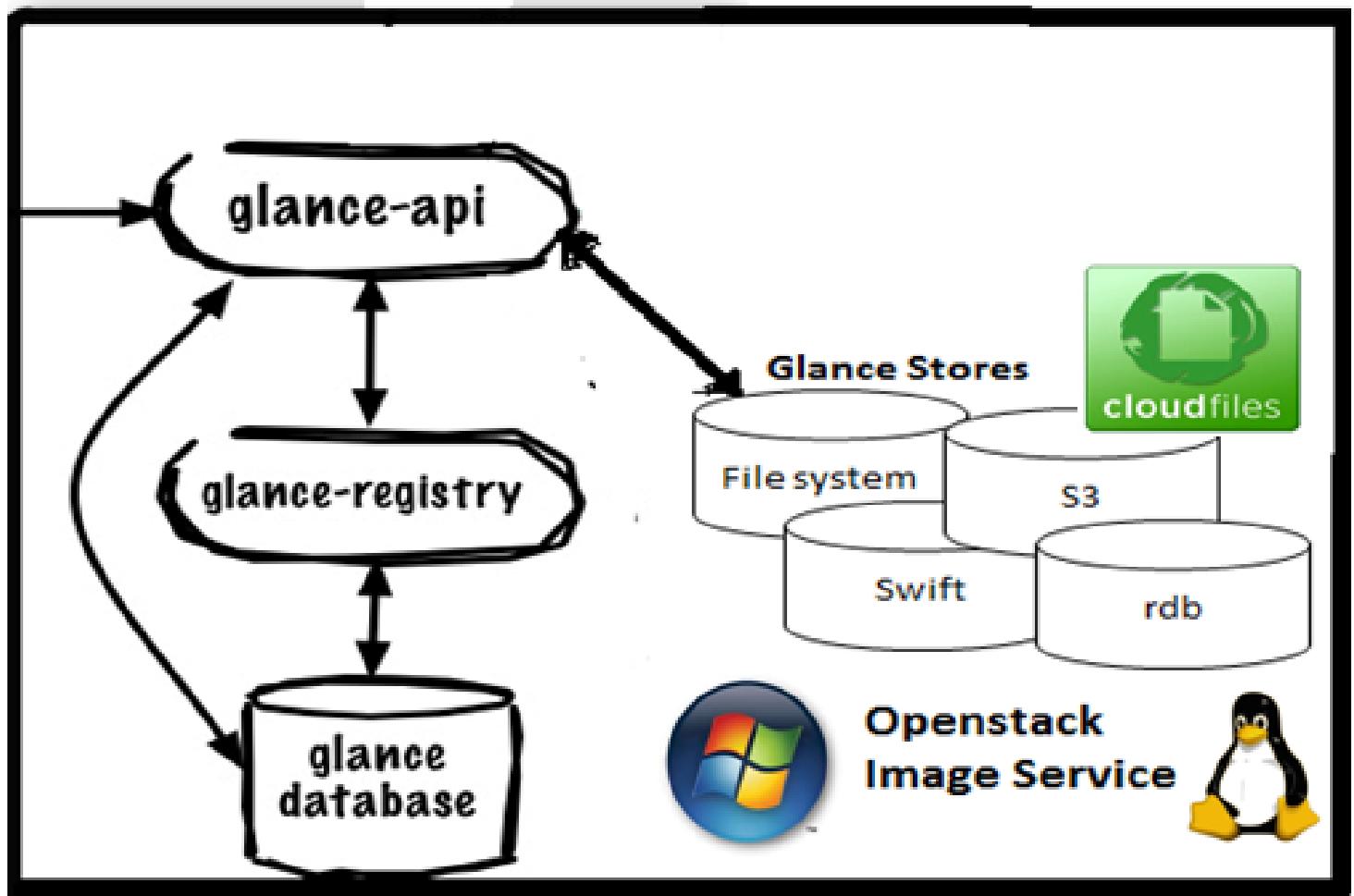


Cinder Block Storage

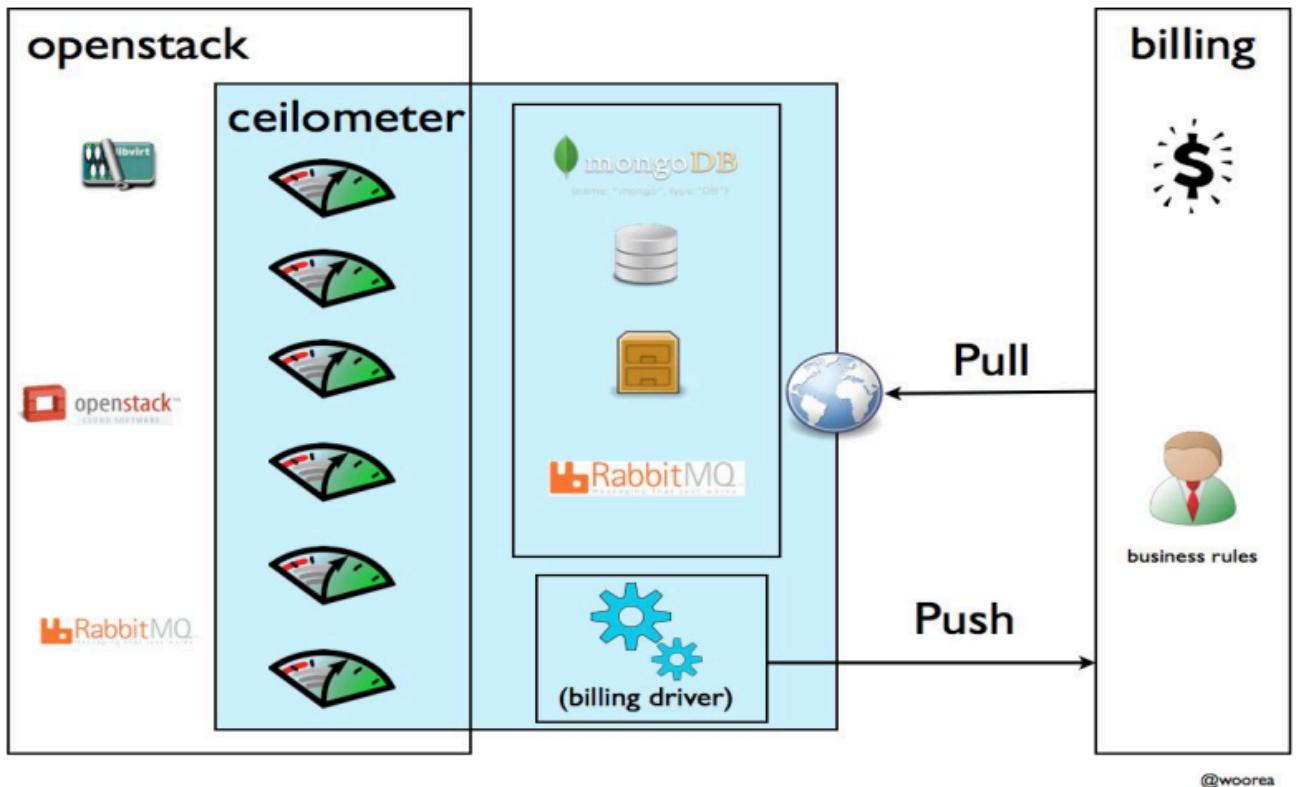




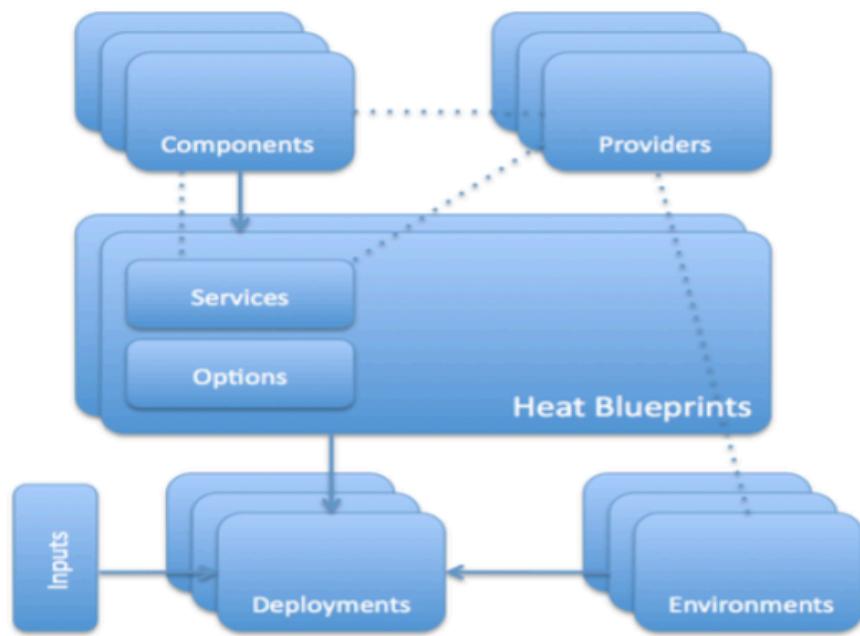
Glance Image Management



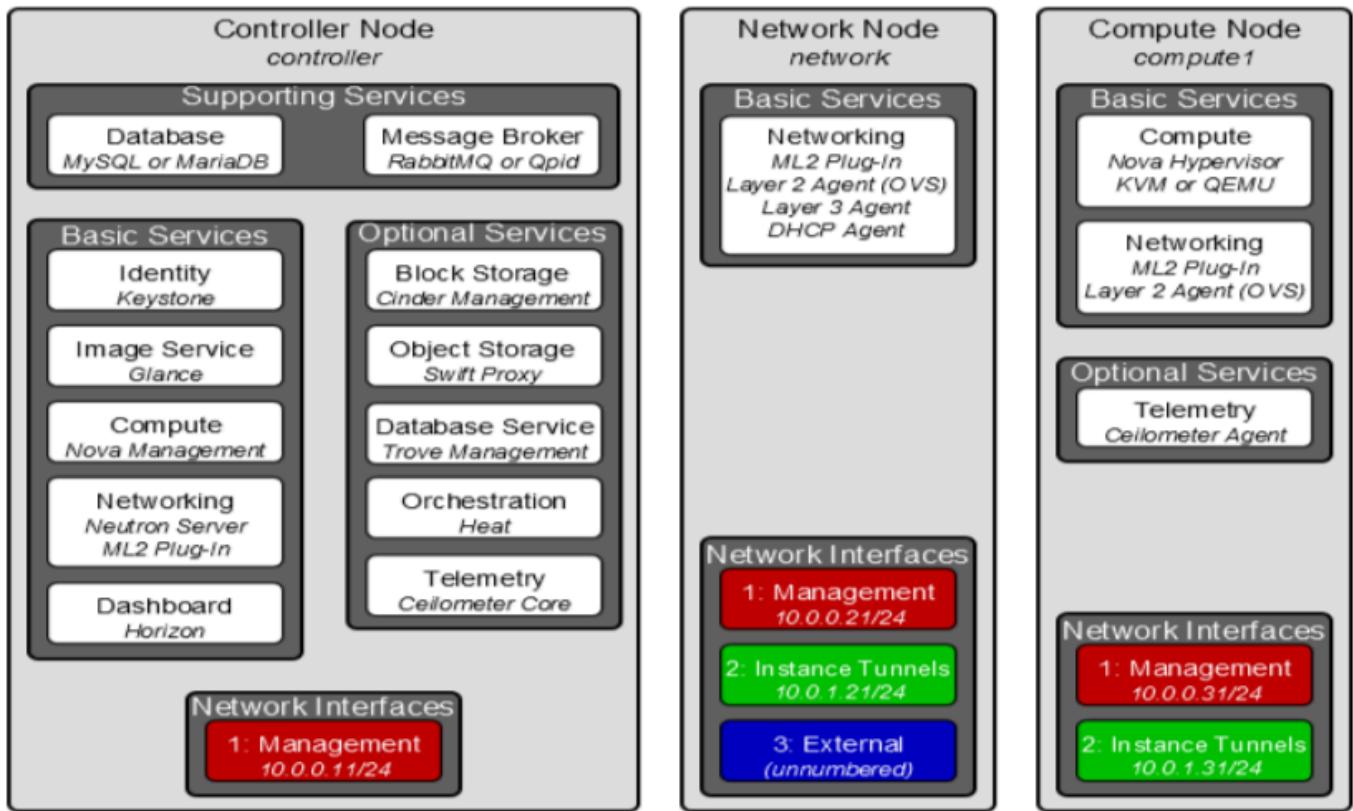
Ceilometer Metering and Monitoring



Heat Orchestration



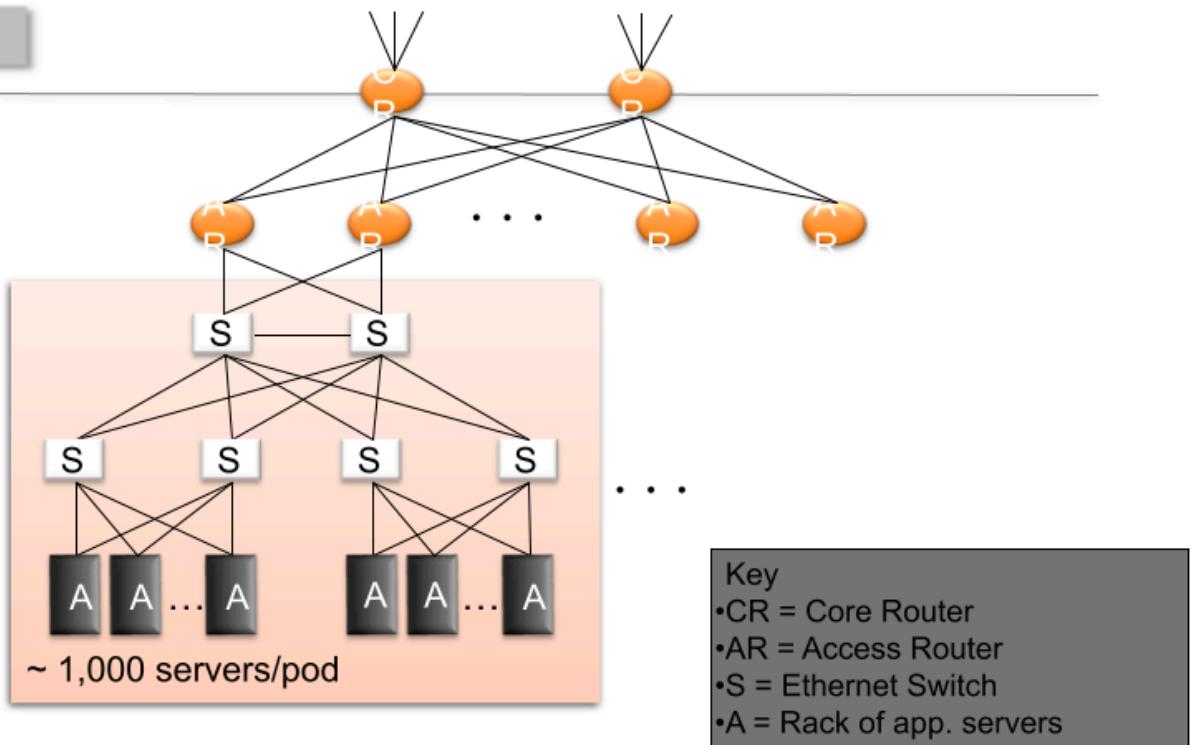
Sample Architecture



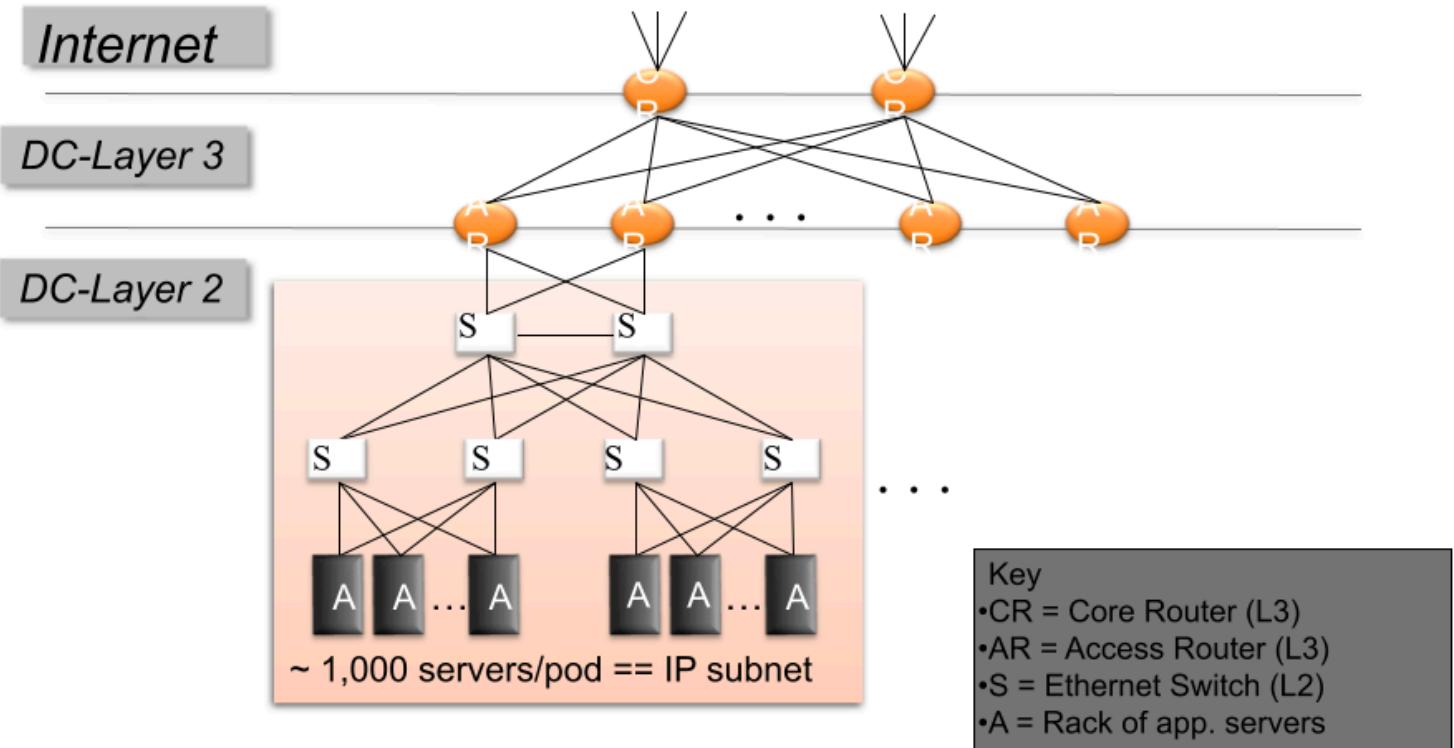
Three node-architecture with OpenStack Networking (Neutron)

Data Center Network Topology

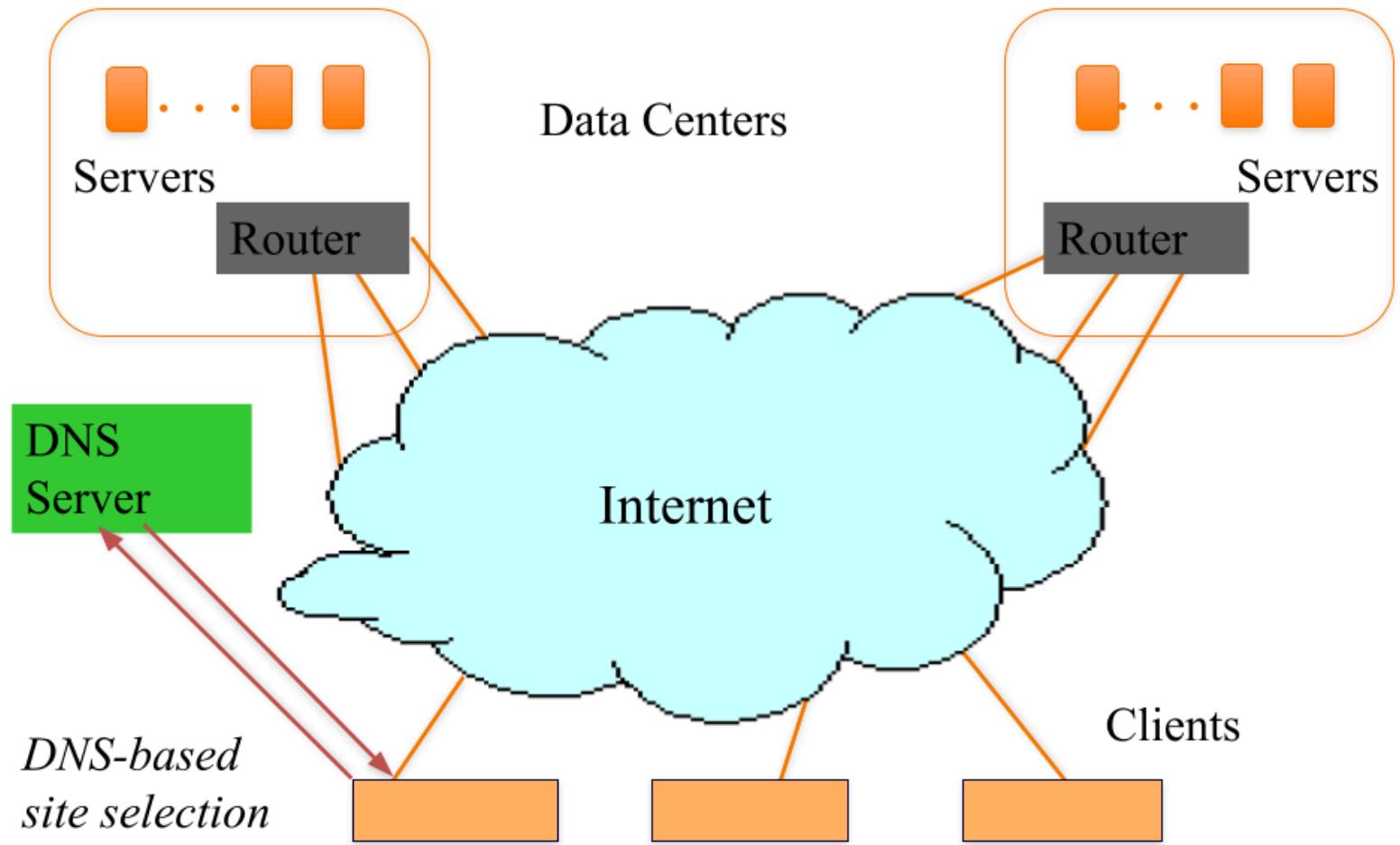
Internet



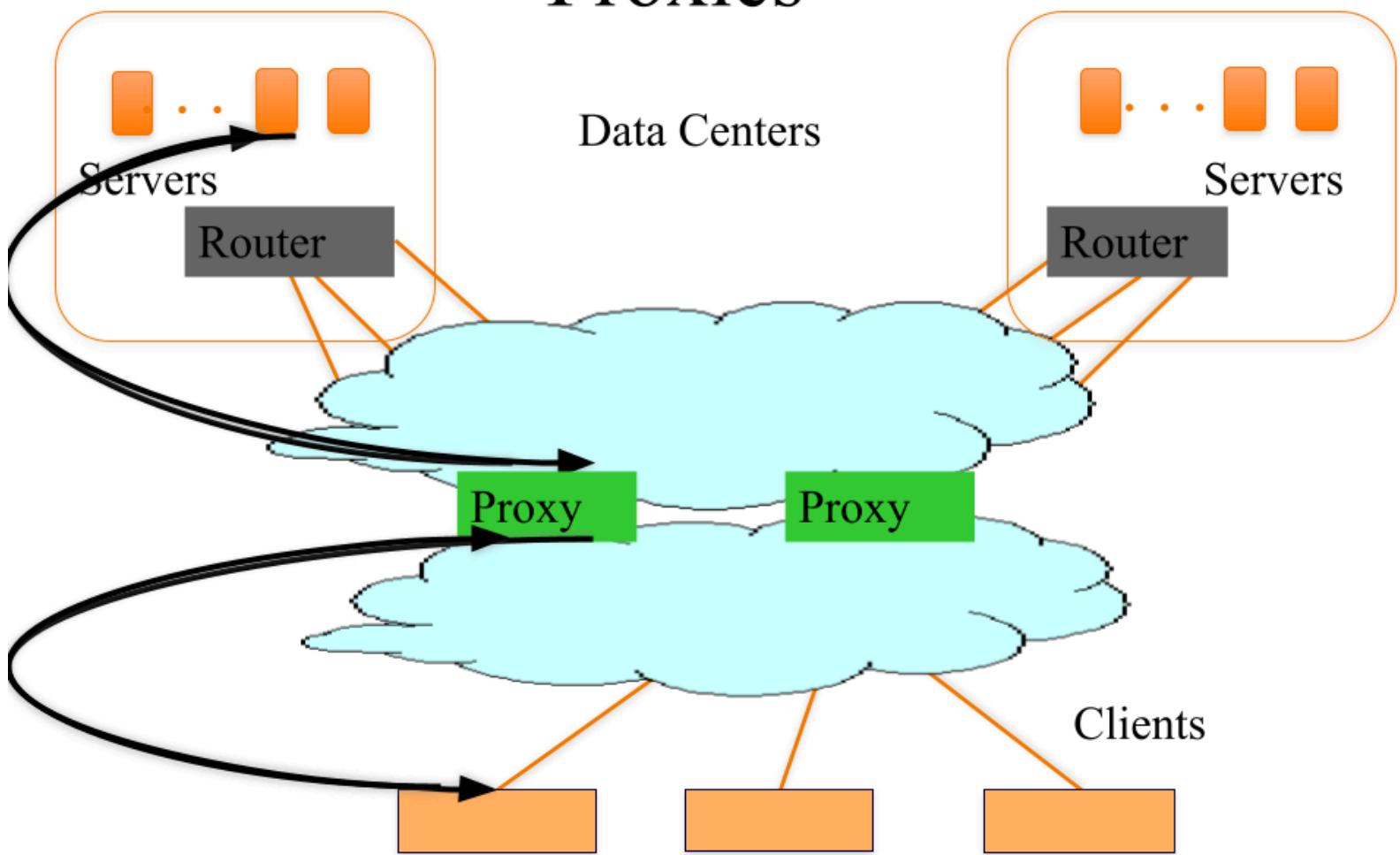
Data-Center Routing



Wide-Area Network



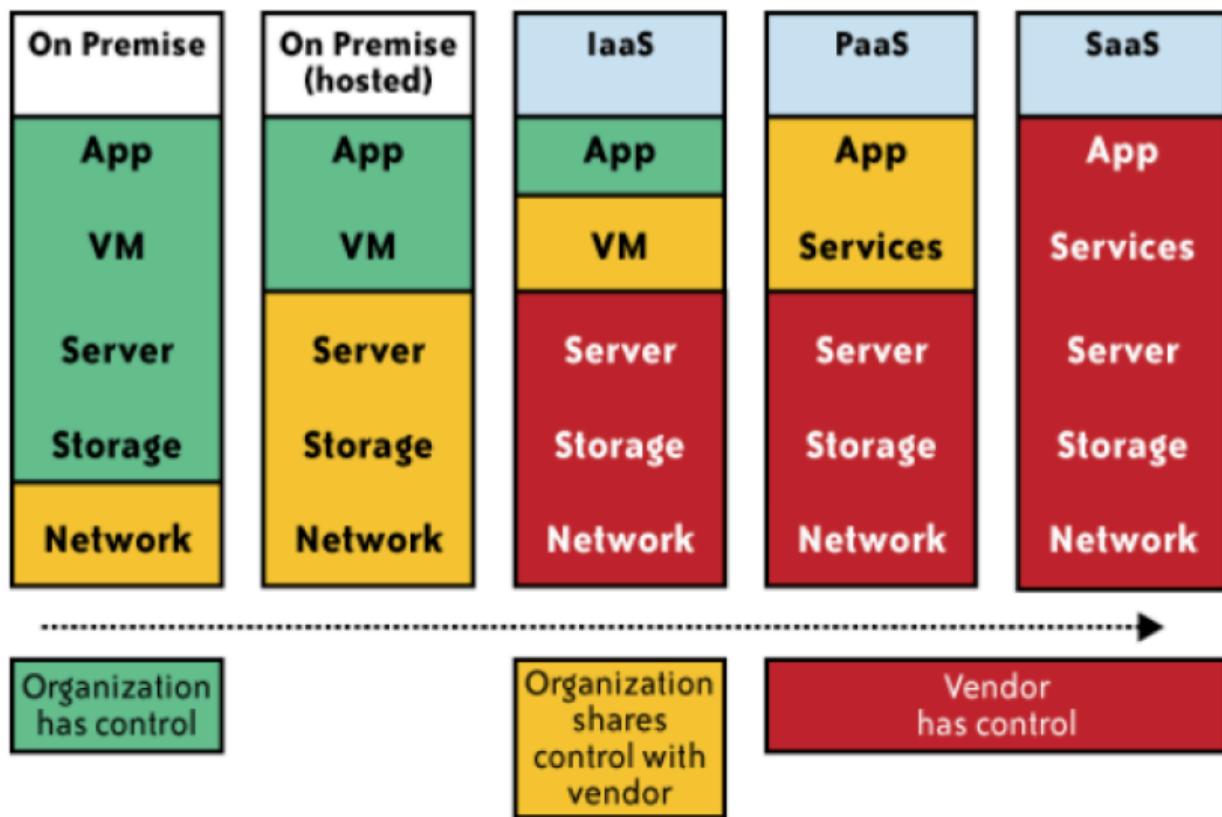
Wide-Area Network: Ingress Proxies



Objectives of Cloud service broker

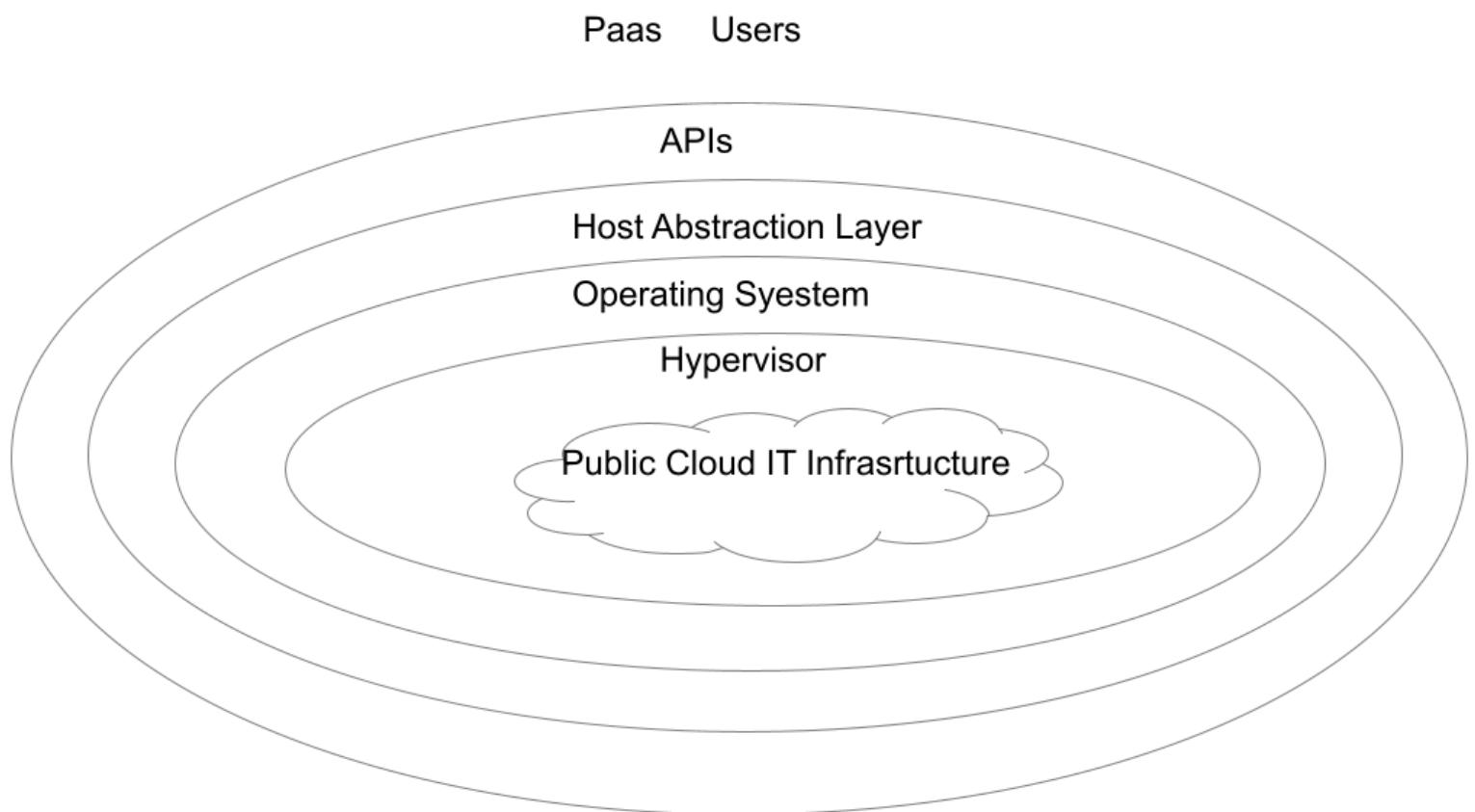


Impact of cloud computing on the governance structure of IT organizations

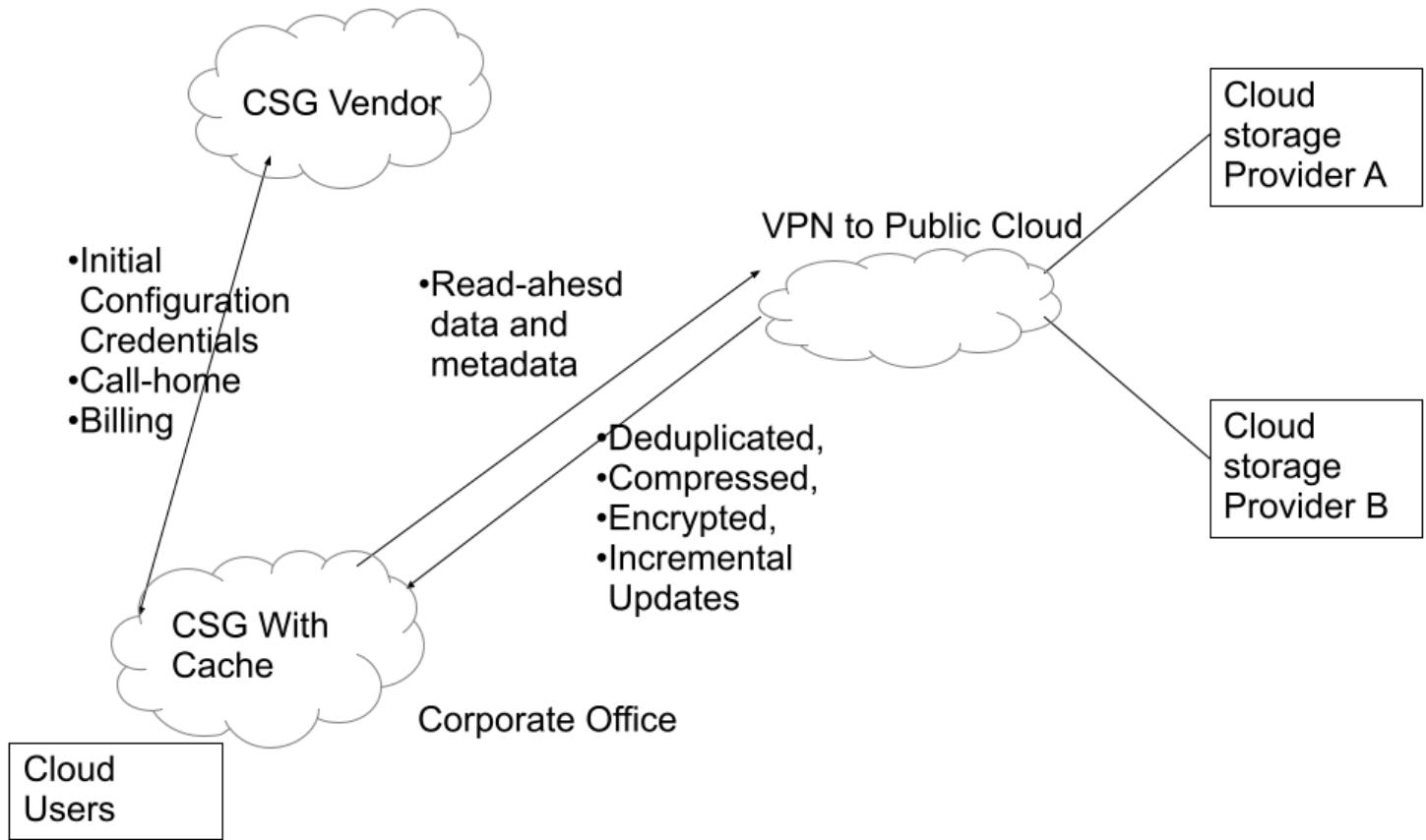


From [6] Cloud Security and Privacy by Mather and Kumaraswamy

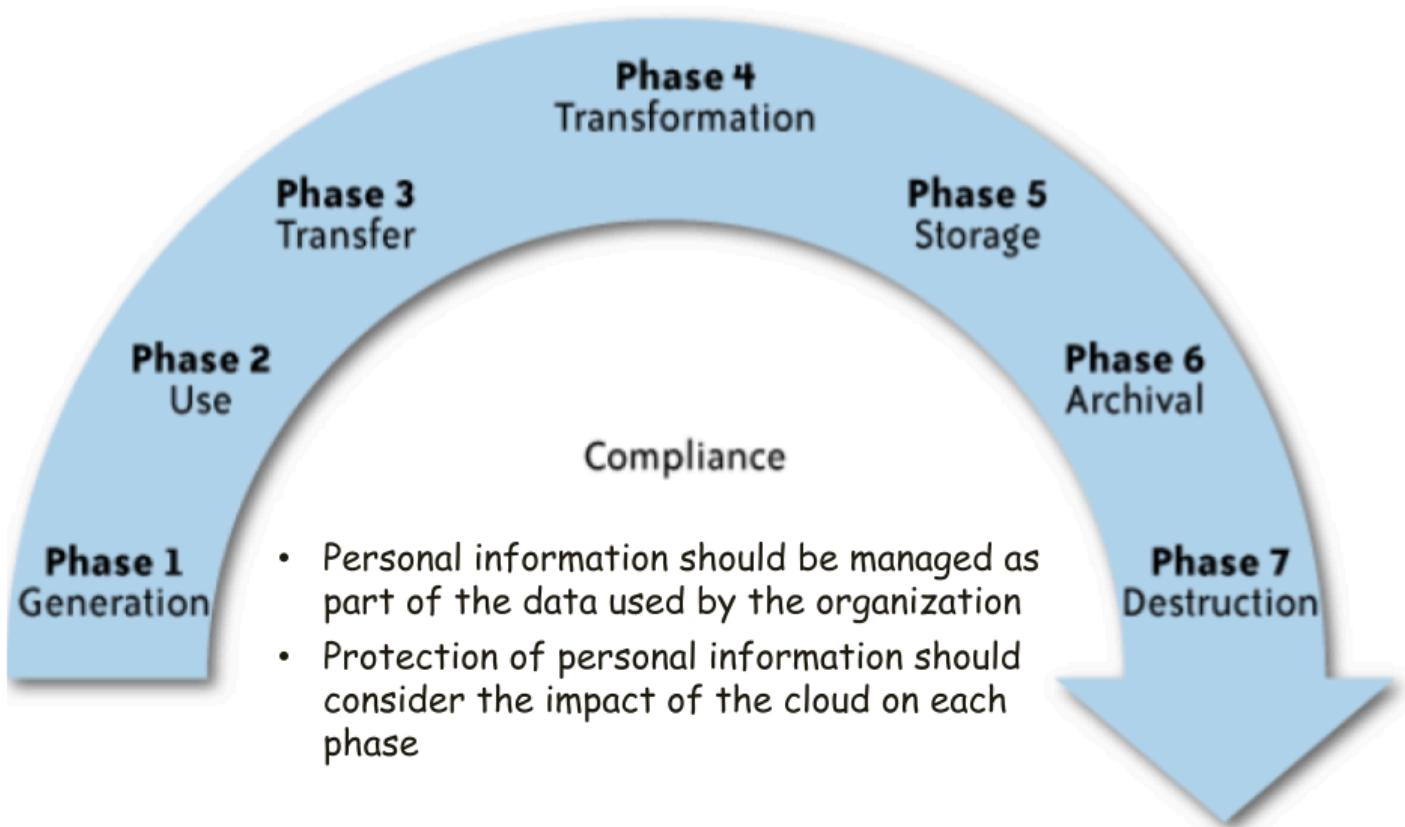
Utilization API to access the Host Abstraction Layer and OS



The CSG



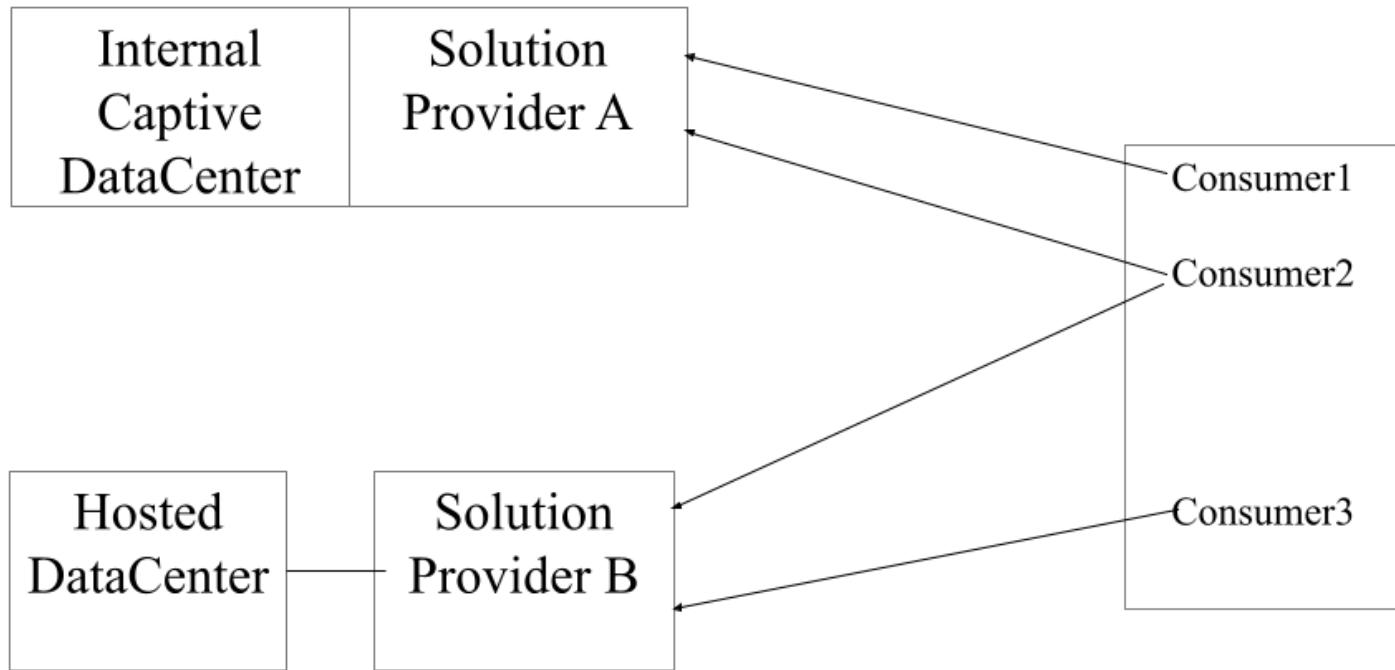
What is the data life cycle?



From [6] Cloud Security and Privacy by Mather and Kumaraswamy

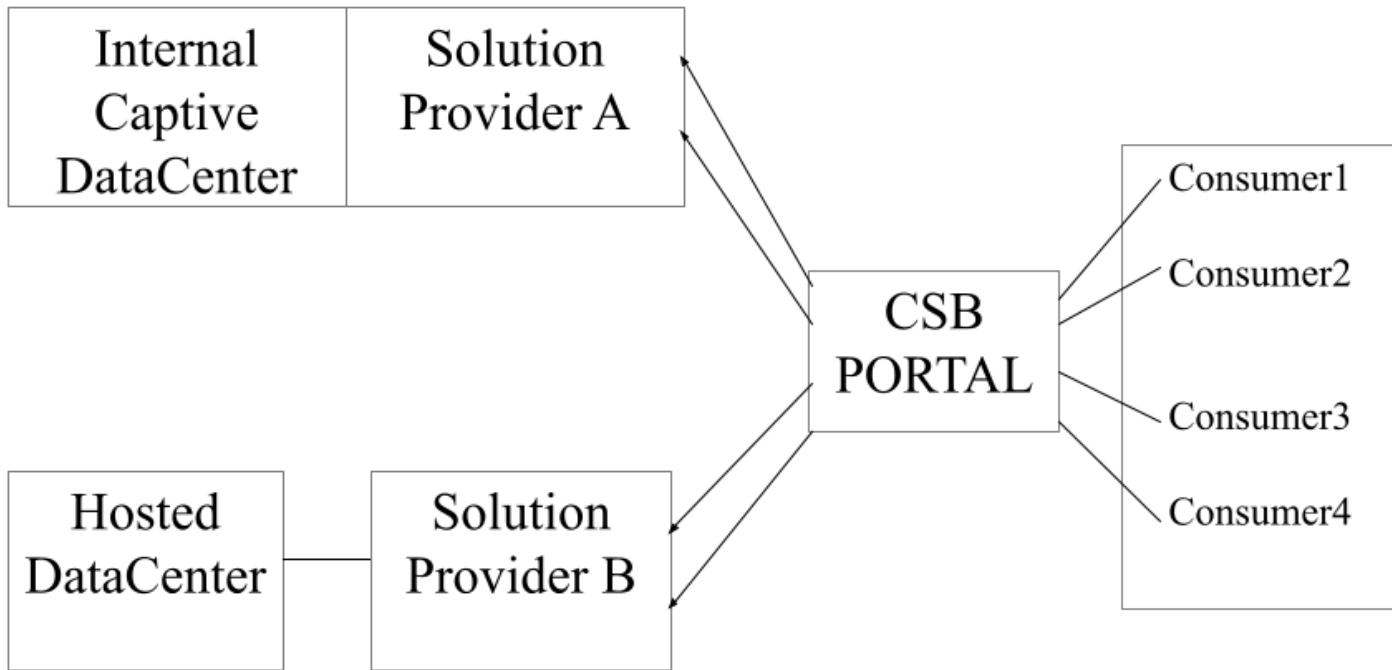
46

The Direct SaaS Model



Direct SAAS Model

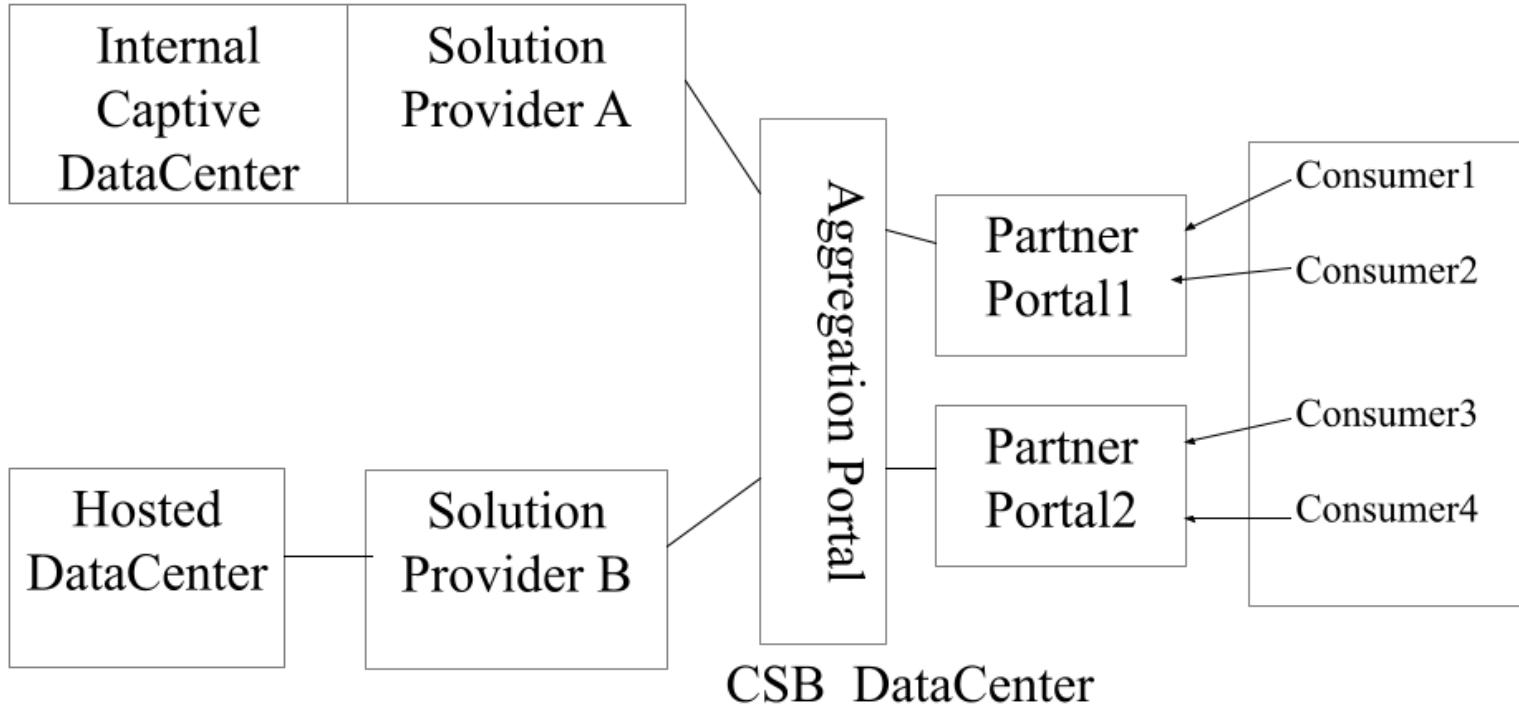
The Direct SaaS Model and the Role of CSB as an Intermediary



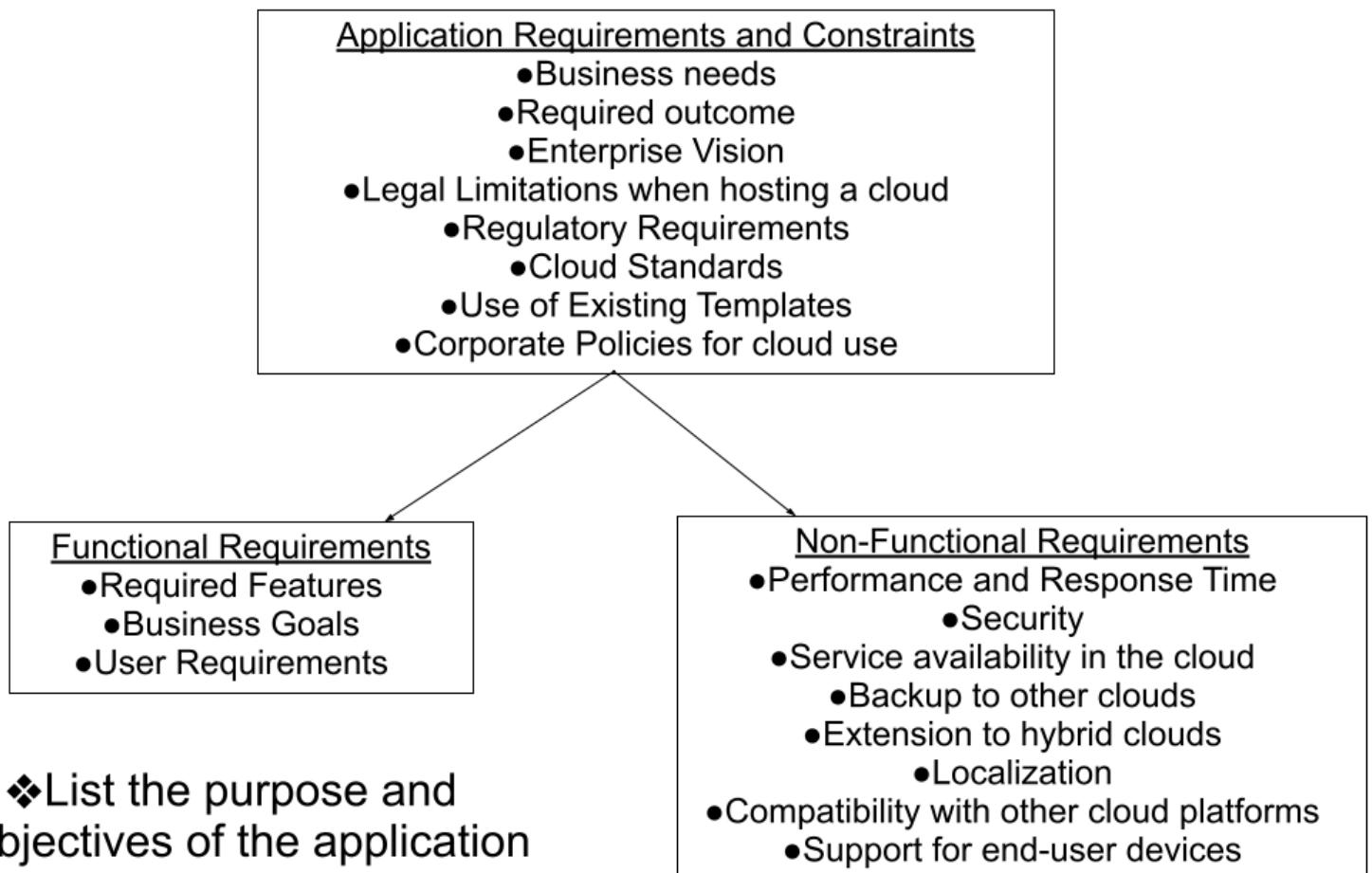
CSB Intermediary Role

CSB Services as an Aggregator for Public Cloud Services

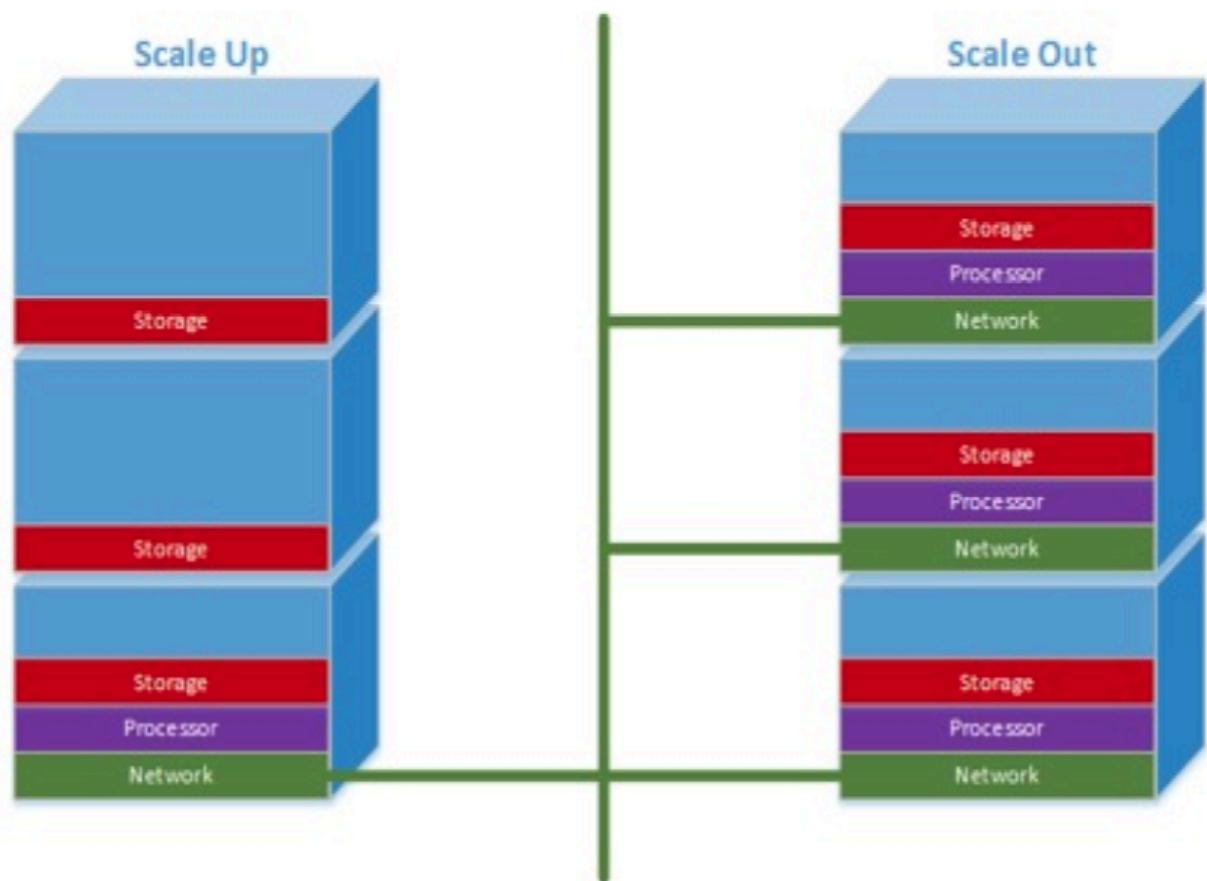
CSB Services For Public SAAS Cloud



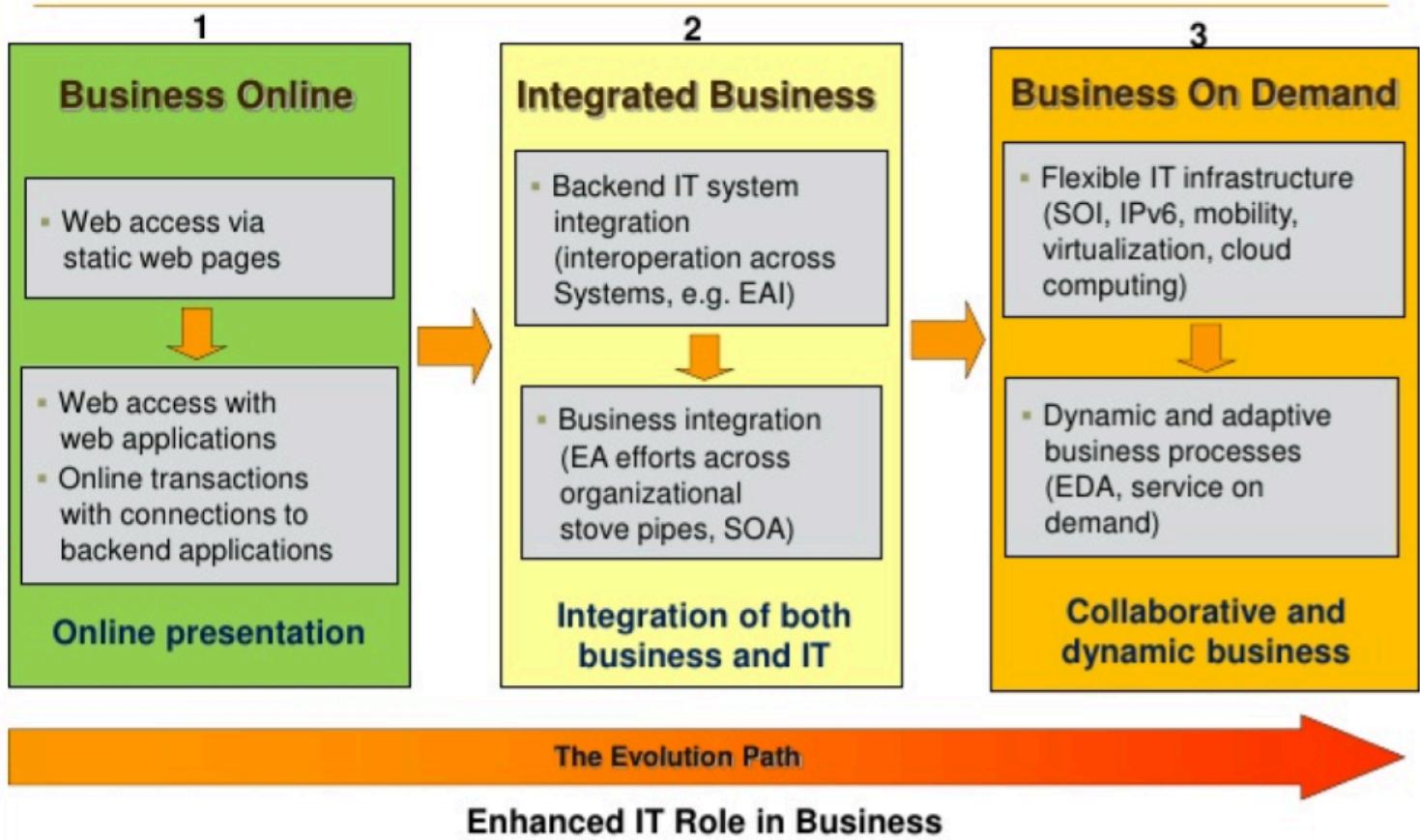
Cloud Application Requirements



❖List the purpose and objectives of the application



Business Evolution Associated with IT

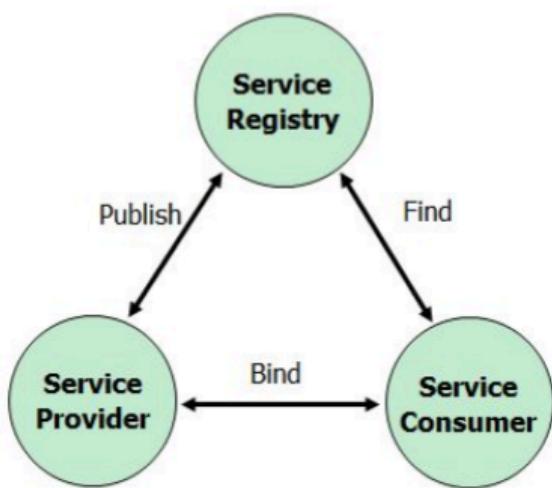


Yan Zhao, Ph.D, ArchiTech Consulting LLC

4

SOA Conceptual Model

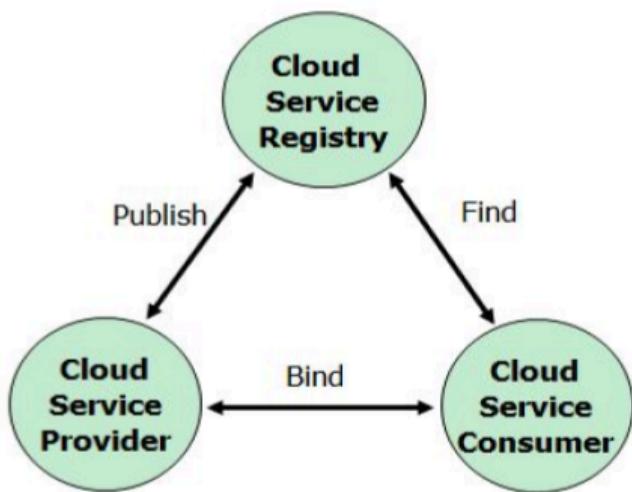
SOA Conceptual Model



- **Service Provider:** who publish services to Service Registry
- **Service Consumer:** who find services from Service Registry and use (or “bind” to) them
- **Service Registry:** where contains information for available services.
- **Publish:** providers announce service availability to consumers via Service Registry
- **Find:** consumers discover available services inside Registry
- **Bind:** a service provider and a service consumer reached agreement, and the consumer connected to the service to consume it.

Cloud Computing Model

Cloud Service Model



Yan Zhao, Ph.D, ArchiTech Consulting LLC®

- **Service Provider:** who publish services to Service Registry
- **Service Consumer:** who find services from Service Registry and use (or “bind” to) them
- **Service Registry:** where contains information for available services.
- **Publish:** providers announce service availability to consumers via Service Registry
- **Find:** consumers discover available services inside Registry
- **Bind:** a service provider and a service consumer reached agreement, and the consumer connected to the service to consume it.

Represented as a Stack of Service Offering Categories

Cloud Clients

Presentation Layer

Example: browsers, mobile devices

Cloud Applications

Software as a Service

Example: Google docs or calendar

Cloud Services

Components as a Service

Example: SOA via Web Service standards

Cloud Platform

Platform as a Service

Example: web server, app server

Cloud Storage

Storage as a Service

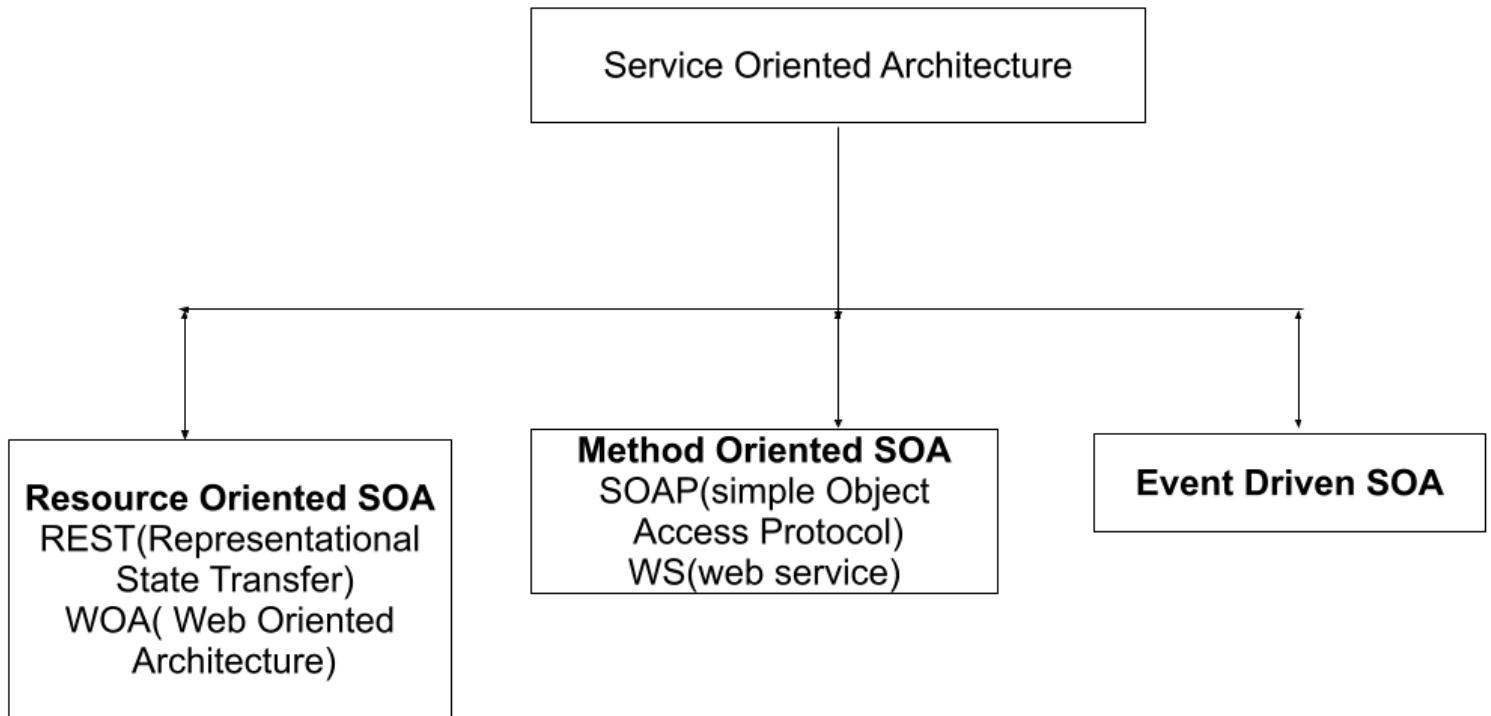
Note: formerly utility computing

Cloud Infrastructure

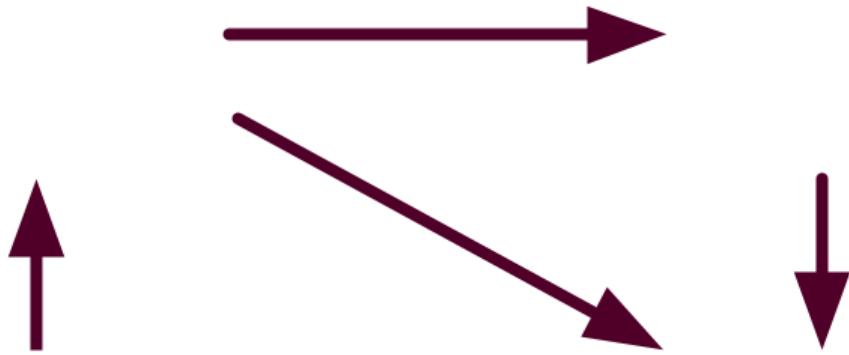
Distributed Multi-site Physical Infrastructure

Note: enabled by server virtualization

Common interaction pattern used in SOA

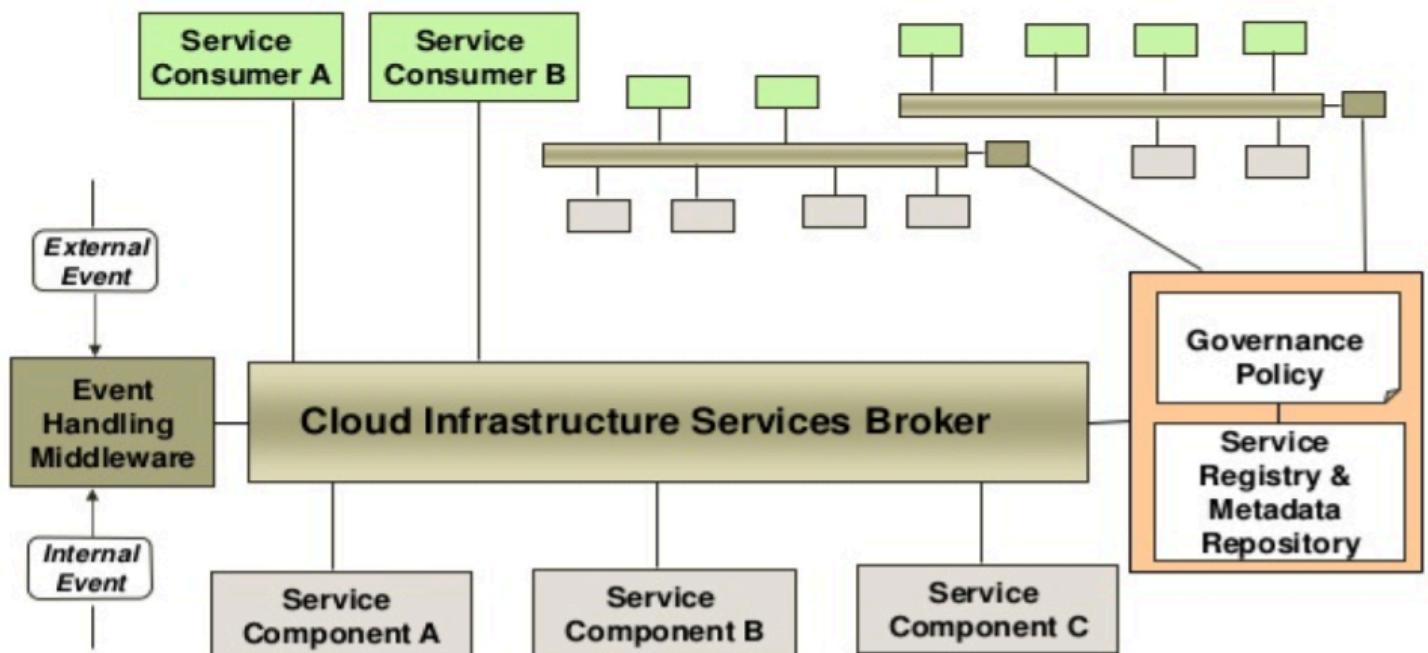


SOAP



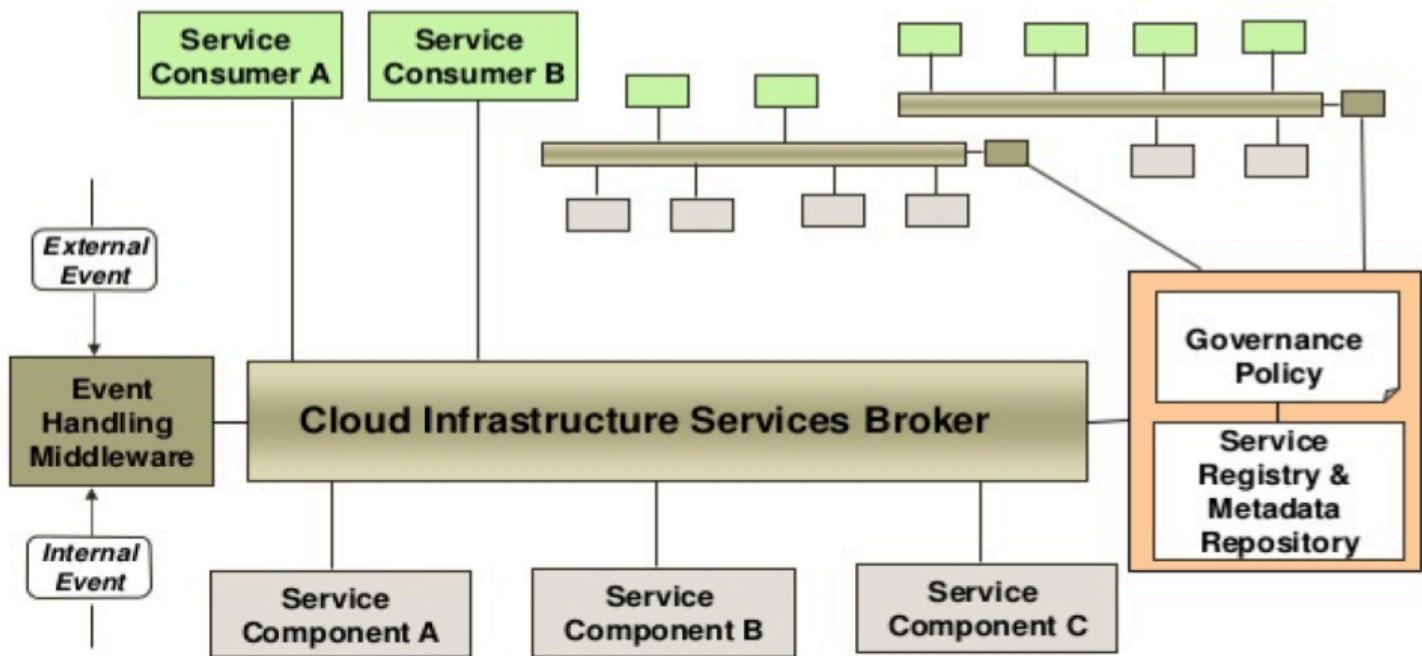
Web Service Description Language (WSDL).
Universal Description Discovery and Integration (UDDI)

Infrastructure Cloud Service (IaaS)



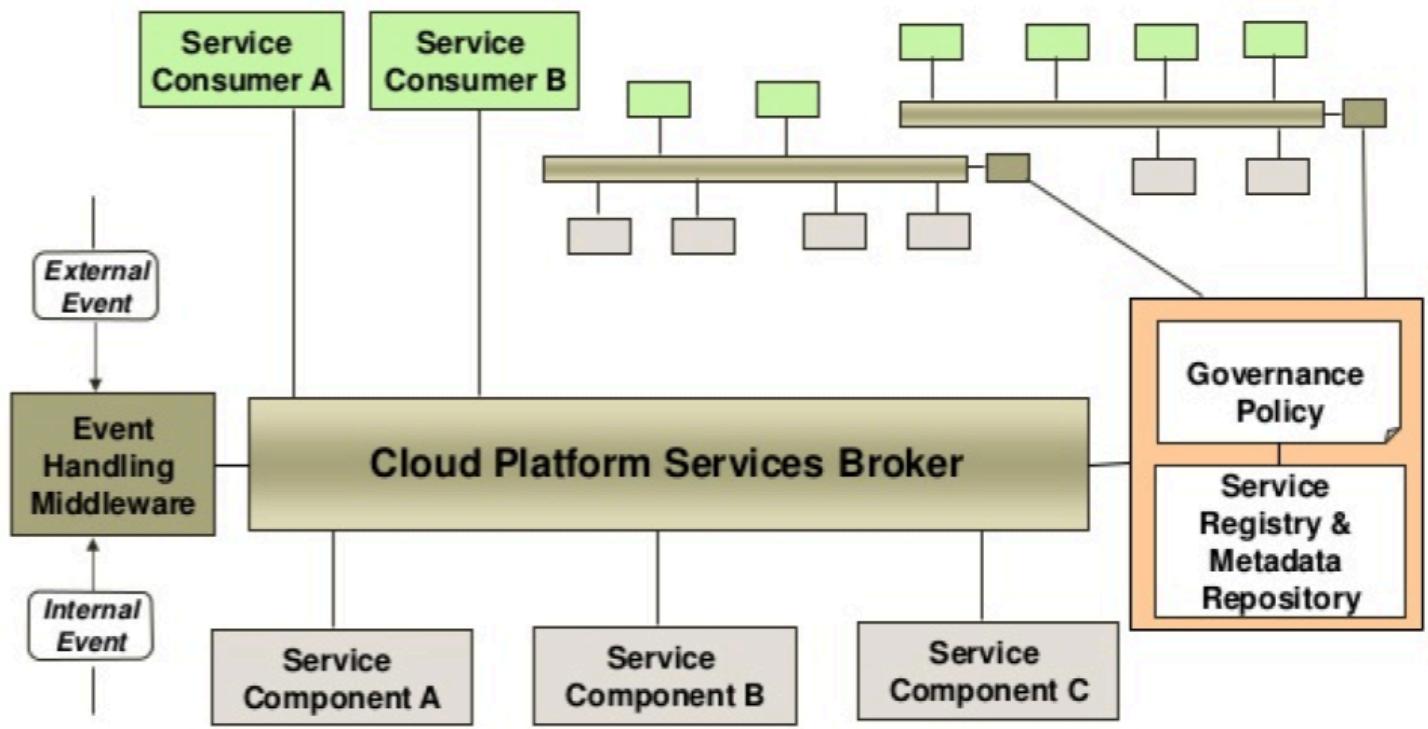
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Infrastructure Cloud Service (IaaS)



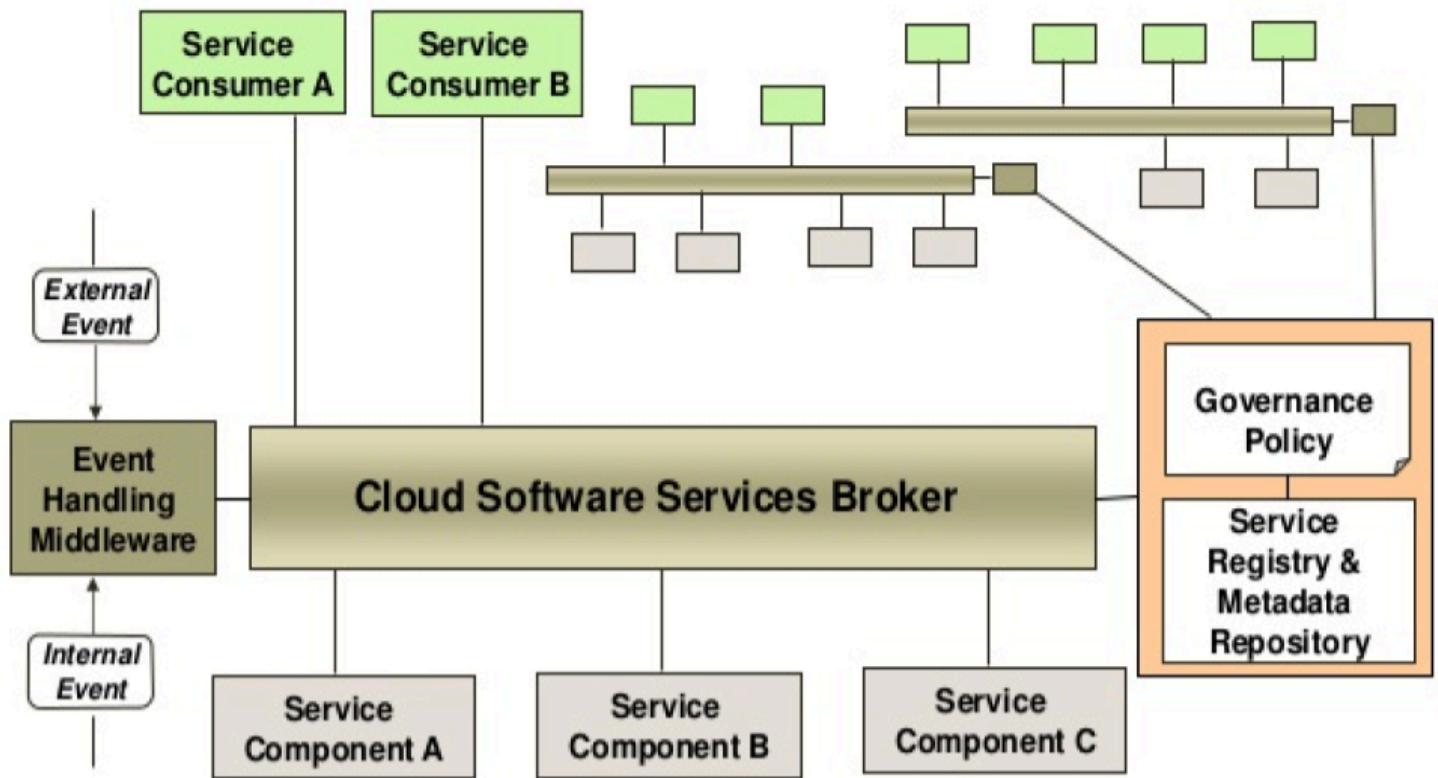
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Platform Cloud Service (PaaS)



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Software Cloud Service (SaaS)



Yan Zhao, Ph.D, ArchiTech Consulting LLC®

Enterprise IT Challenges

Meeting business growth

Data center limitations

Inflexible architecture

Disaster recovery & high availability

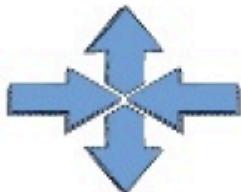
Finding/retaining talent



Fundamentals of the AWS Cloud



Complete Set
of Services



Flexibility



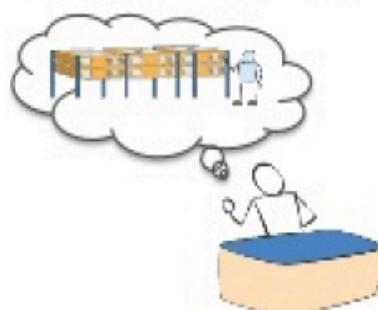
Global Presence



Instant Access
to Resources



Low Cost IT



Productive

What is Available from AWS?

What is Available from AWS

Deployment & Administration

Application Services

Compute

Storage

Database

Networking

AWS Global Infrastructure

What is Available from AWS?

