



ITCS443 Parallel and Distributed Systems

Cloud Computing and

Virtualization

Sudsanguan Ngamsuriyaroj
Ekasit Kijsipongse
Putt Sakdhnagool

Semester 1/2019

Outline



- Evolution of Computing Platforms
- NIST Cloud Framework
- Cloud Service Models
- Cloud Deployment Models
- Scaling
- Multitenant Technology
- Roles in Cloud
- Cloud Adoption Model
- Virtualization Concepts



Evolution of Computing Platforms



**70's – 80's
Mainframe Era**



**90's-2000's
Client Server Era**



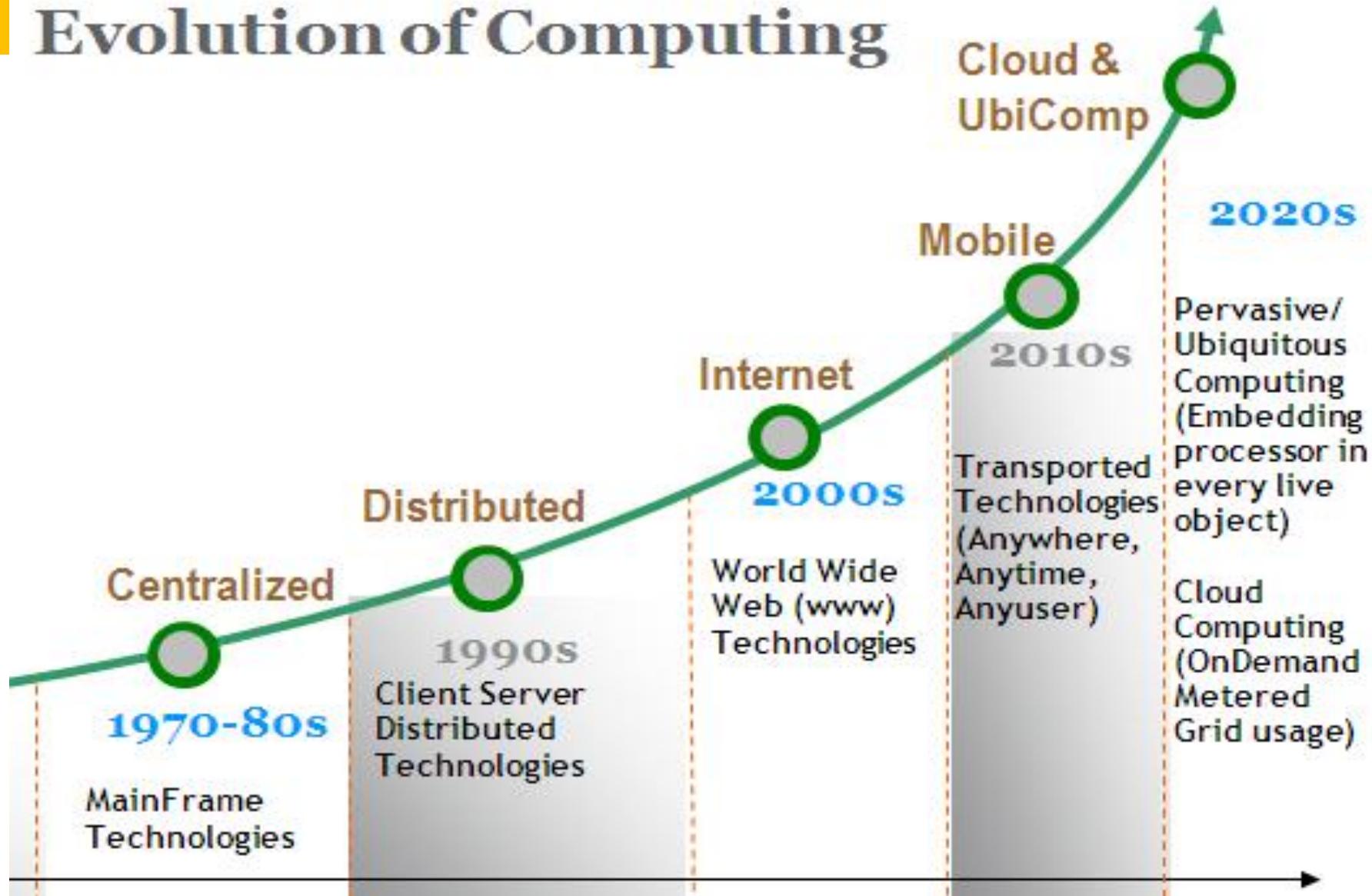
**2010-beyond
Cloud Era**



Evolution of Computing Platforms



Evolution of Computing



Latest Evolution



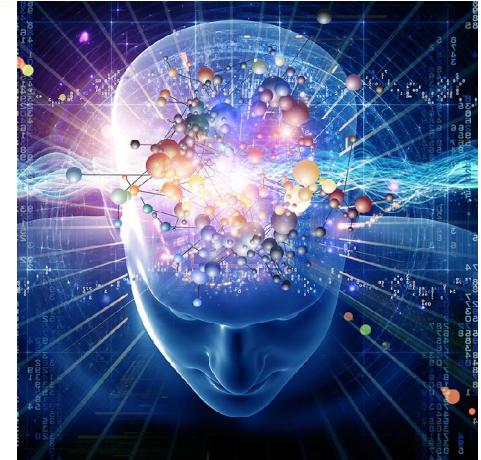
Cloud Computing



Big Data



Machine Intelligence



Internet of Things



Mobile Computing



Social Networks



Internet of Things

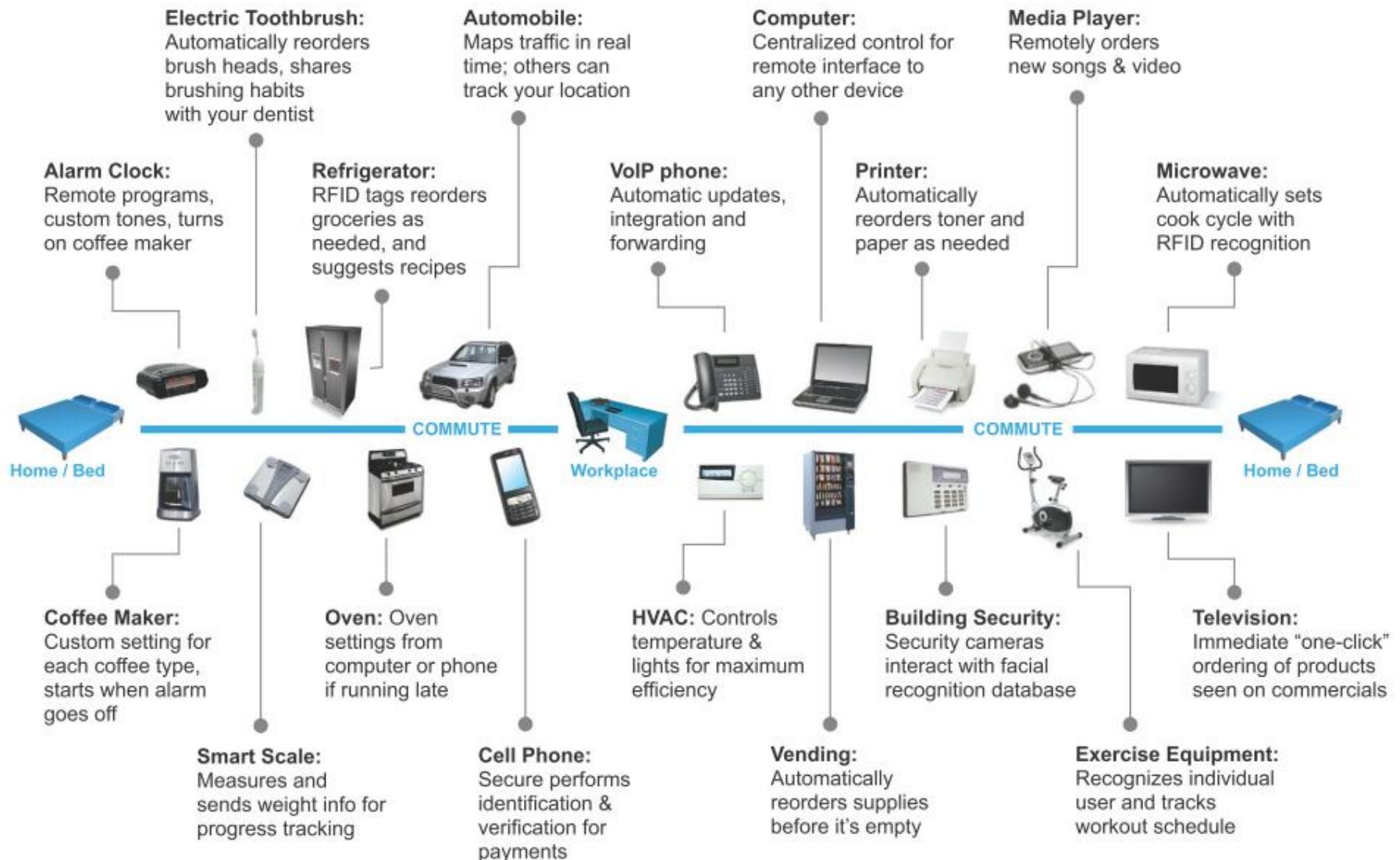


Figure 3. The Internet of Things

Big Data: From Biology to Astronomy



Data are
created
every
minute!

2019 *This Is What Happens In An Internet Minute*



Top 10 Technology Trends 2019



Intelligent



AI-Driven Development



Autonomous Things



Augmented Analytics

Digital



Digital
Twin



Empowered
Edge

have
factory
in
digital



Immersive
Experience

Mesh



Blockchain



Smart
Spaces



Privacy and Ethics



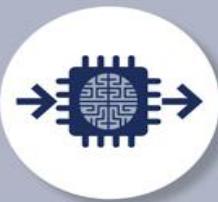
Quantum Computing

Gartner

Corum Top Ten Disruptive Technology Trends



2018



AI ENABLEMENT

Putting AI to work by means of big data and feedback



ONLINE EXCHANGES

Connecting creators & consumers

IOT SOFTWARE

Emerging platforms, standards & analytics



OMNI-CHANNEL SALES

Purchasing decisions anywhere, any platform



VISUAL INTELLIGENCE SYSTEMS

Intersection of AI, computer vision & analytics



CONNECTED HEALTH

Linking people to their health data & services

DIGITAL CURRENCY FLOW

Decreasing friction in payments & exchange



FOCUSED IT SERVICES

Differentiation drives new value in a sleepy sector



DATA SCIENCE MONETIZATION

Maximizing return with real-time analytics

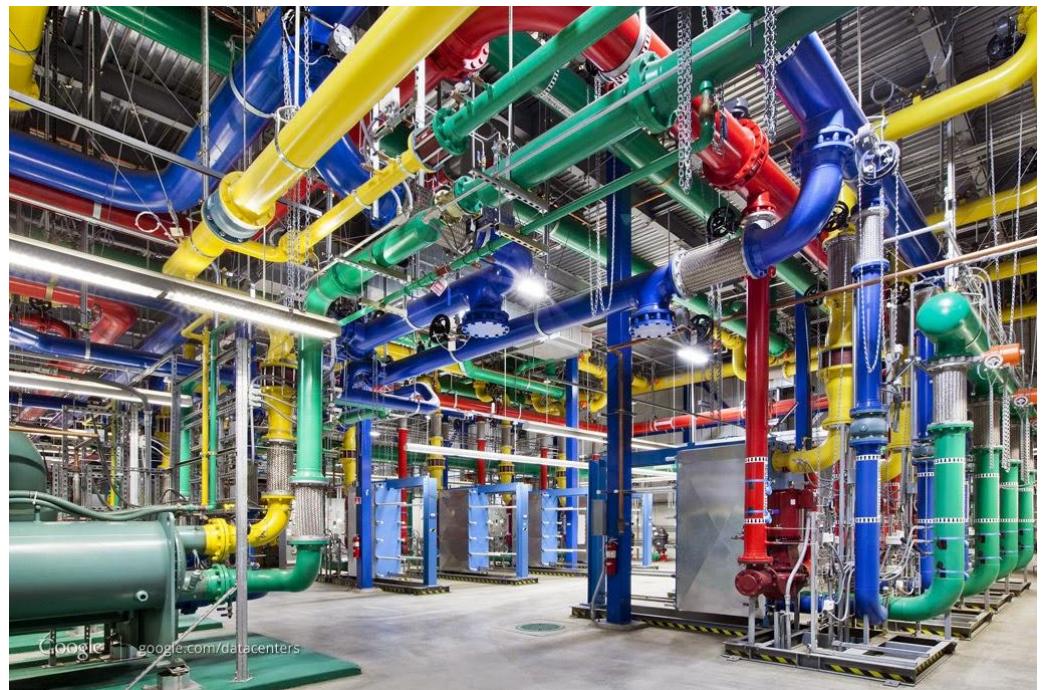


DATA SECURITY

Building barriers in an age of blurred lines

For more information
on these trends and how they drive M&A
visit www.CorumGroup.com/TechTrends

Data Centers



Building a Data Center



Sun's Modular Data Center: Project Blackbox

[HOW IT WORKS]

KEEPING COMPUTERS COOL

Inside Project Blackbox, racks of up to 38 servers apiece generate tremendous heat. A panel of fans in front of each rack forces warm exhaust air through a heat exchanger, which cools the air for the next rack (detail), and so on in a continuous loop.

DESIGN SPECS

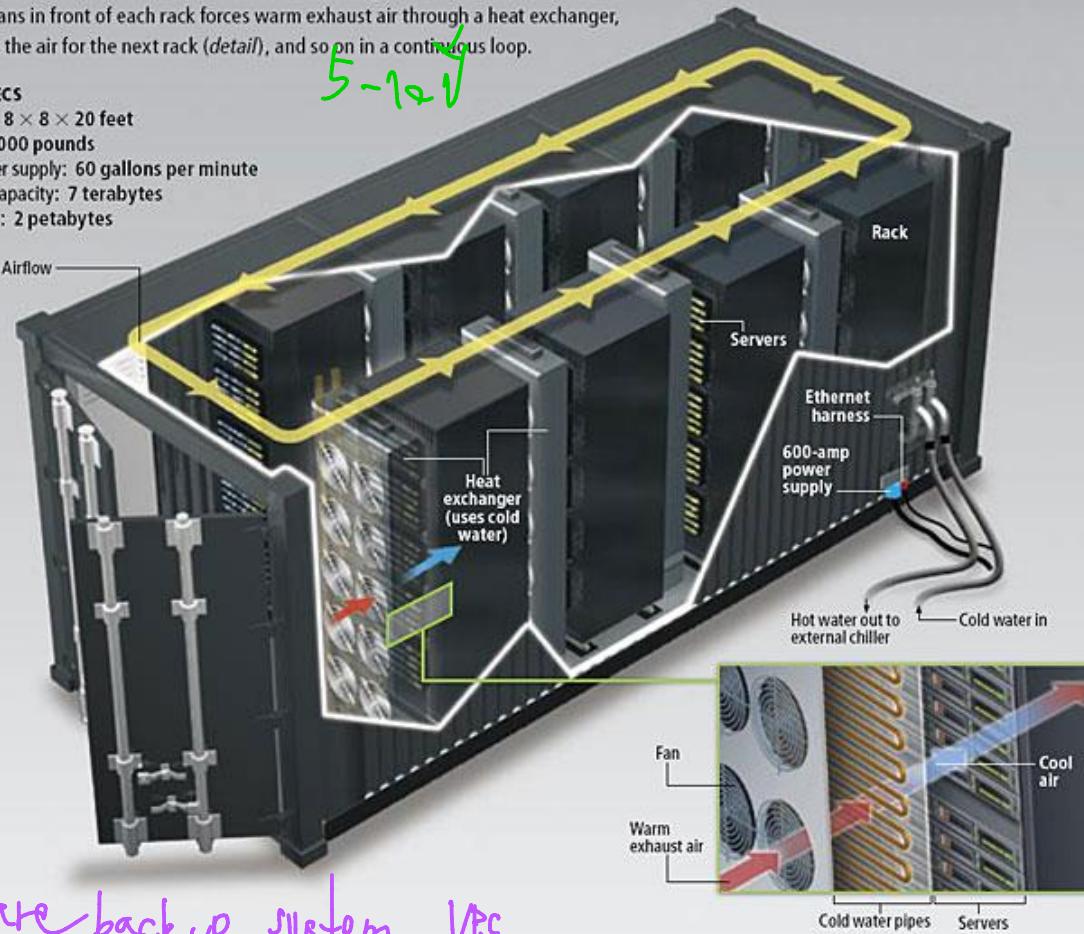
Dimensions: $8 \times 8 \times 20$ feet

Weight: 20,000 pounds

Cooling water supply: 60 gallons per minute

Computing capacity: 7 terabytes

Data storage: 2 petabytes



How Large of a Data Center?



Facts and Stats of World's largest data centers

- **Google** 16 data centers: 9 in U.S., 1 in South America, 4 in Europe and 2 in Asia with about 2.5 million servers
- **Facebook:**
 - 1.13 billion daily active users (as of September 2016)
 - 60,000 servers (2010)
 - Own about \$3.63 billion in “network equipment” (end of 2015)
- **Amazon:**
 - Amazon has 11 cloud regions
 - **1.5 million servers** in 7 locations
- **Microsoft:**
 - 1 billion users and 1,000,000 servers
 - Microsoft has 17 regions.
- **Rackspace Hosting** has 100,000 servers across 6 data centers.

Forces Driving Cloud Computing



Data-Intensive Applications:

- Explosion of applications and user-generated content:
- Exabyte in 2006
- Zettabyte in 2010



Datacenter Pressures:

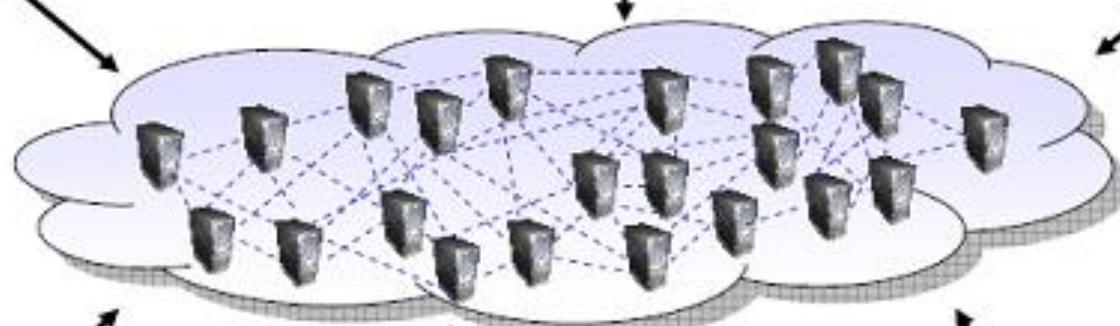
Growing operational complexity and cost from infrastructure and application sprawls



Increased network capacity and availability



Innovation and Collaboration



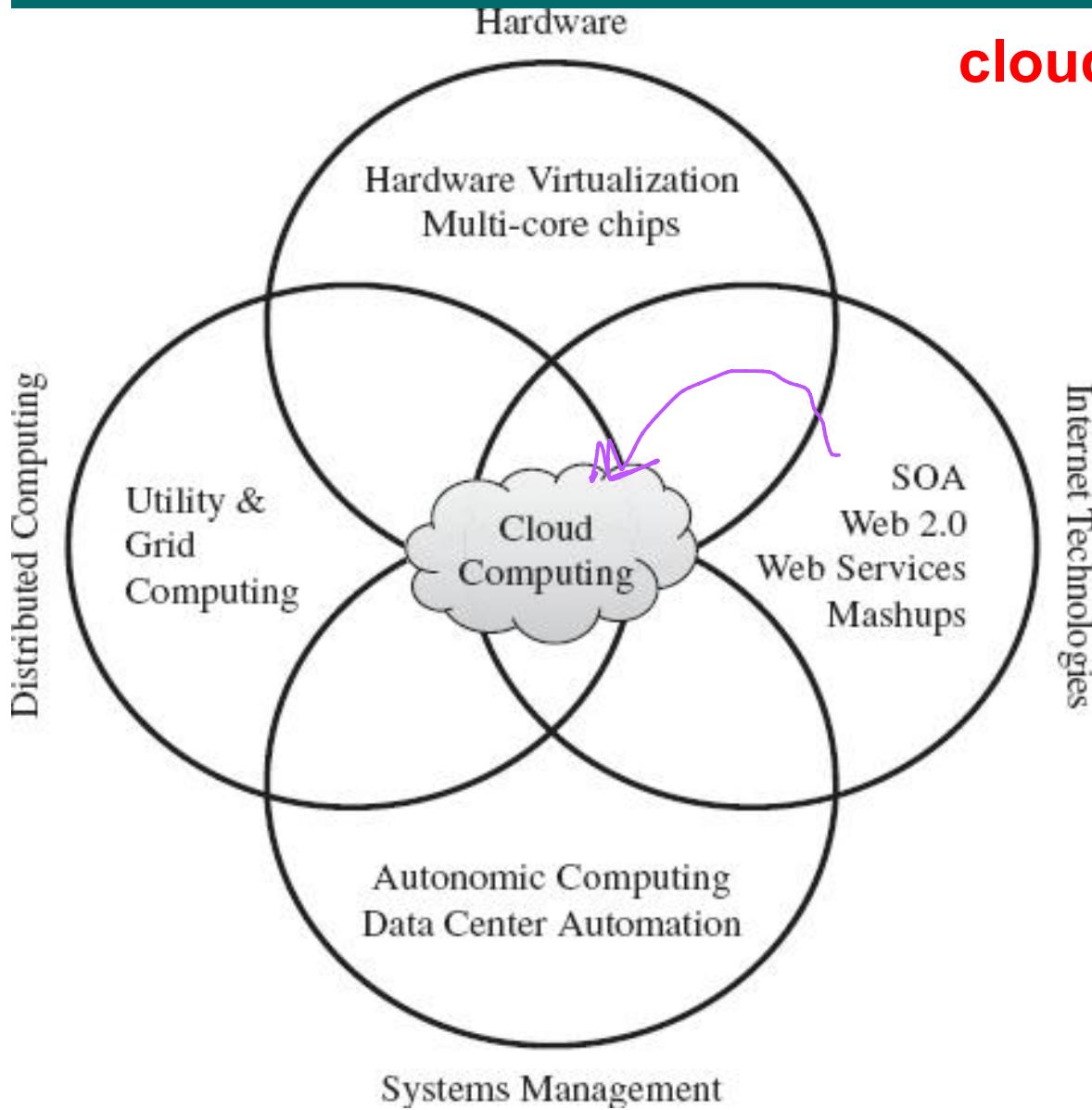
Rising Energy Cost & Green compliance



Shared Services Across Lines of Business



What Technologies Leads to Clouds



cloud-enabling technologies

- **Broadband Networks**
- **Internet Architecture**
- **Data Center Technology**
- **Virtualization Technology**
- **Web Technology**
- **Multitenant Technology**
- **Service Technology**



Cloud Computing Platform

Application Development SDK

Cloud Applications

Apps

Cloud Shared Services

Cloud Platform Services

resource that you have

Compute Resources

Storage Resources

Network Resources

Cloud Infrastructure Services

for all the

Hosting Platform

Management Services

Security Services

Cloud Services

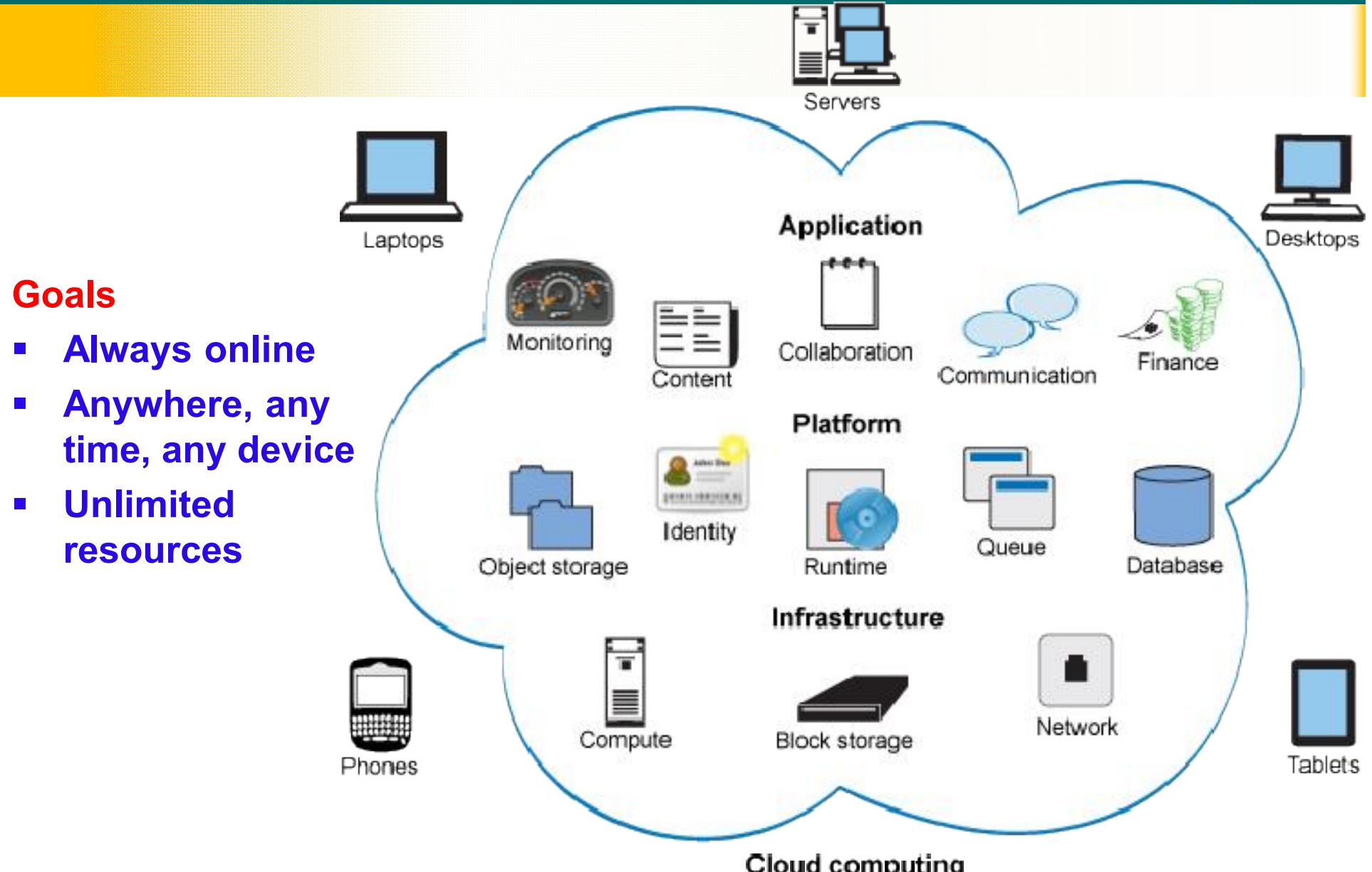


Service Catalogs



Self-service provisioning

A Big Picture of Cloud



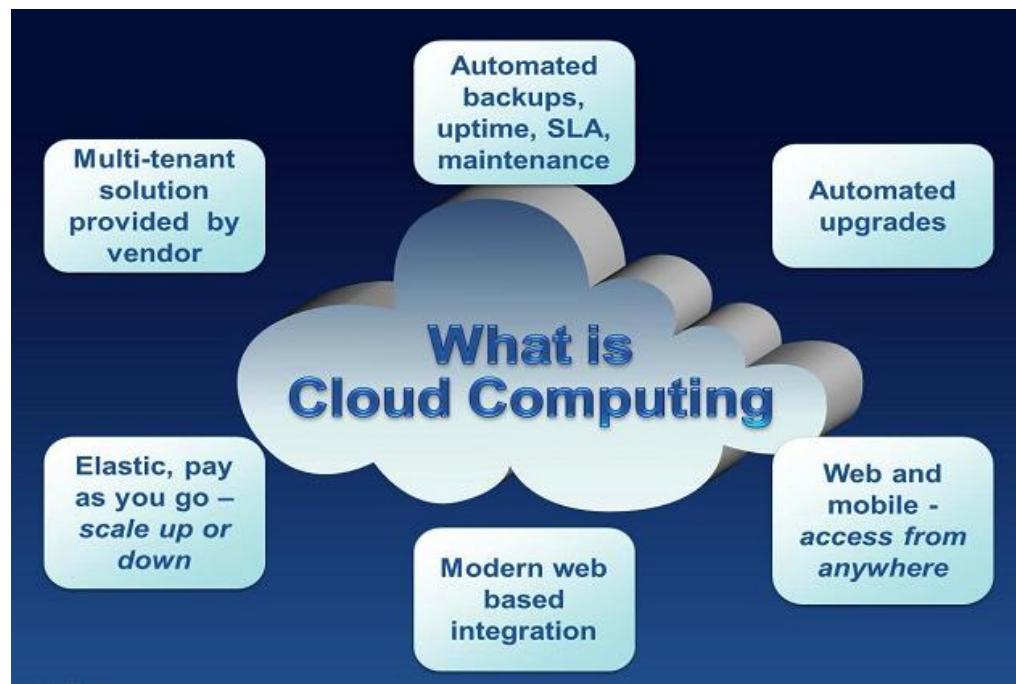
Goals

- **Always online**
- **Anywhere, any time, any device**
- **Unlimited resources**

NIST Cloud Definition



Cloud computing is a *pay-per-use* model for enabling *ubiquitous, convenient, on-demand access* to a shared pool of configurable computing resources that can be rapidly provisioned and released with *minimal management effort* or *service provider interaction*



คลาวด์คอมพิวติ้งเป็นรูปแบบการจ่ายต่อการใช้งานสำหรับการใช้งานทั่วไป

การเข้าถึงที่สอดคล้องและตามต้องการไปยังพูลที่แบ่งใช้ของการกำหนดทรัพยากรการคำนวณที่สามารถจัดสรรได้อย่างรวดเร็วและเปิดตัวด้วยความพยายามในการจัดการขั้นต่ำหรือผู้ให้บริการปฏิสัมพันธ์

5 essential characteristics

3 service models

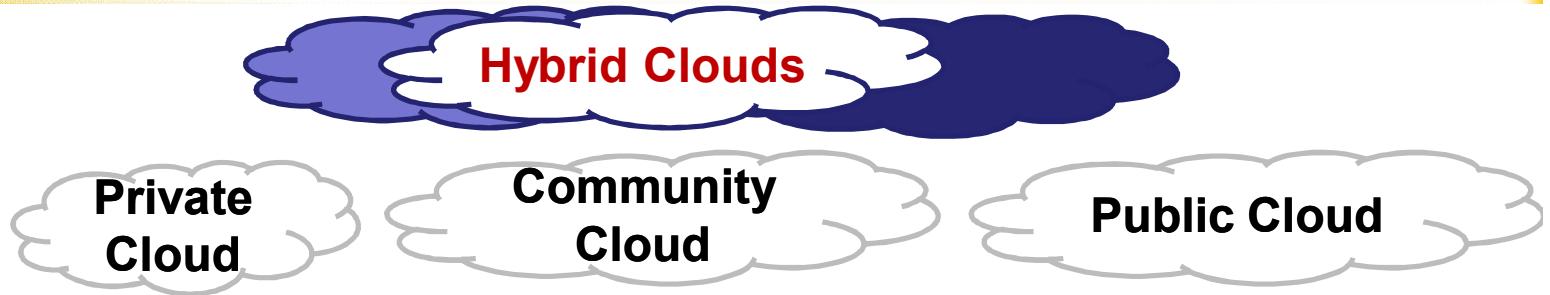
4 deployment models

National Institute of Standards and Technology (NIST)

NIST Cloud Framework



Deployment Models



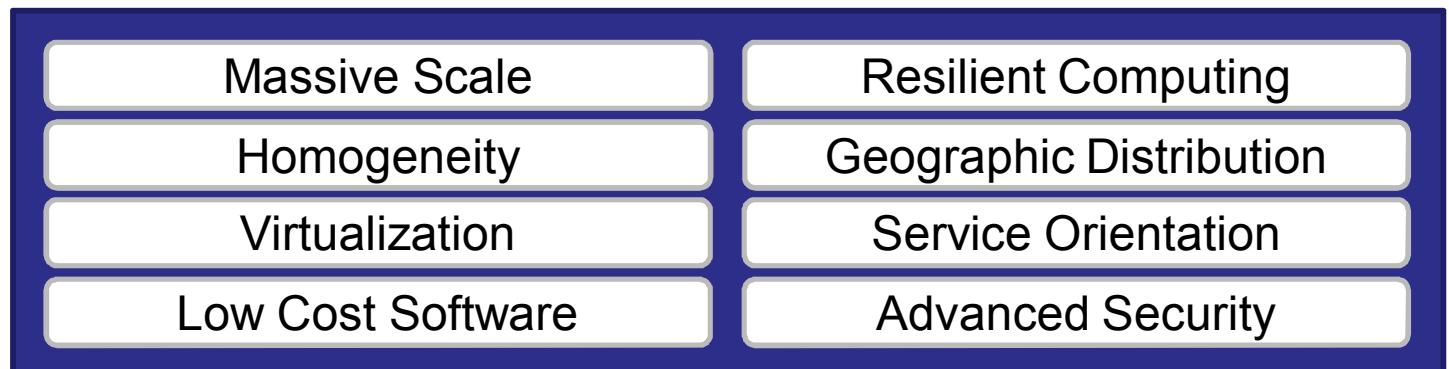
Service Models



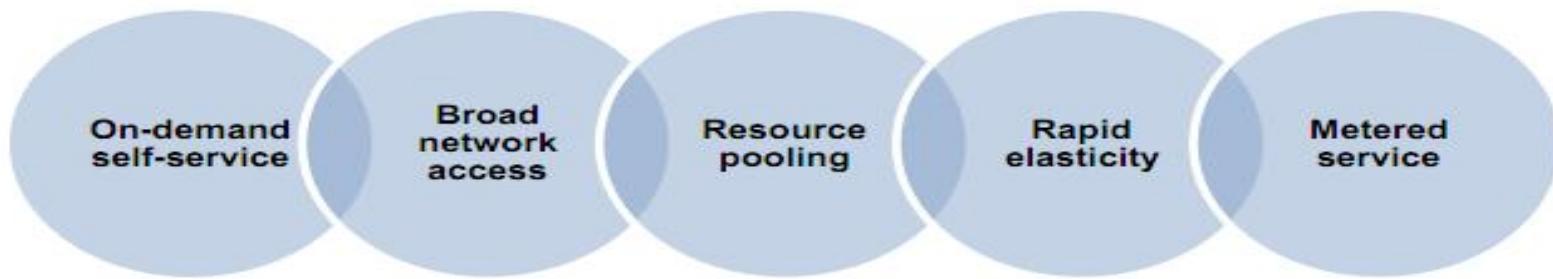
Essential Characteristics



Common Characteristics



NIST Cloud Framework



5 Essential Cloud Characteristics

On-demand self-services	Users can provision servers and networks with little human intervention <i>get the server</i> .
Broadband Network access	Any computing capabilities are available over the network, and can be accessed thru many different devices <i>Just say what they want</i>
Resource pooling	Multiple users can access clouds that serve other consumers according to demand. Location independence.
Elasticity	Automated ability of a cloud to transparently scale IT resources. Provisioning is rapid and scales out or based on needs
Metered services	Ability to keep track of the usage of its IT resources Just like utilities paid by hours or transactions <i>keep track of user, charge base on use!</i>



Additional Cloud Characteristics

Multi-tenancy

Mirrored from
server to ...

- Enable an instance of the program to serve different consumers (**tenants**) whereby each is isolated from the others
- Resource pooling allows cloud providers to pool large-scale IT resources to serve multiple cloud consumers

Resiliency

A form of failover that distributes redundant implementations of IT resources across physical locations

Clouds optimize resource usage and control it according to SLA (Service Level Agreement)

Vertical vs. Horizontal Scaling

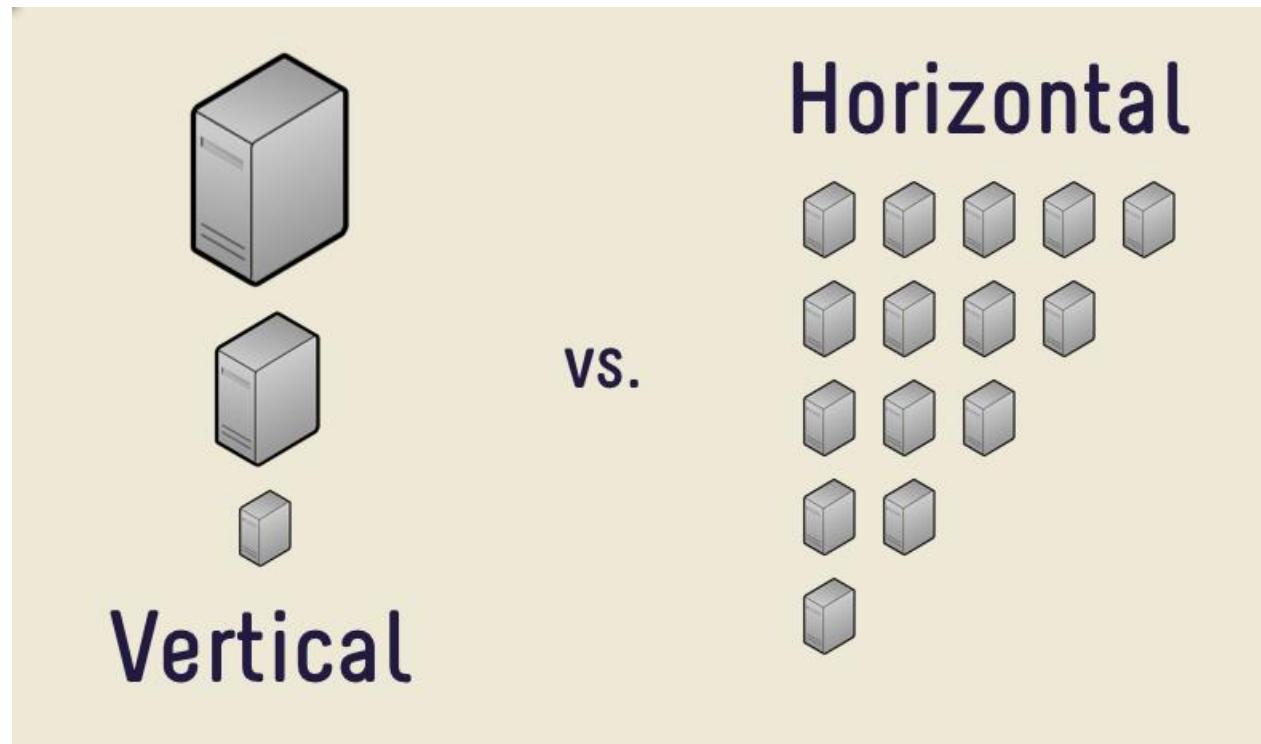


Scale up/down vs. Scale out/in

Ability of IT resources to handle increased / decreased demands

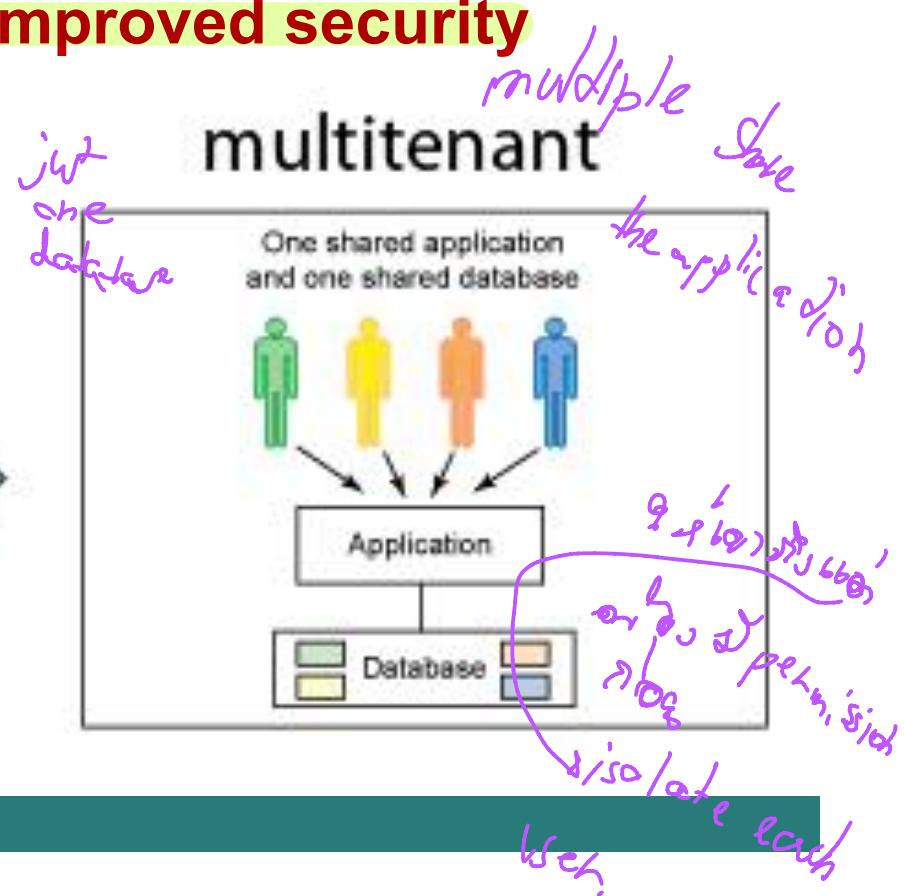
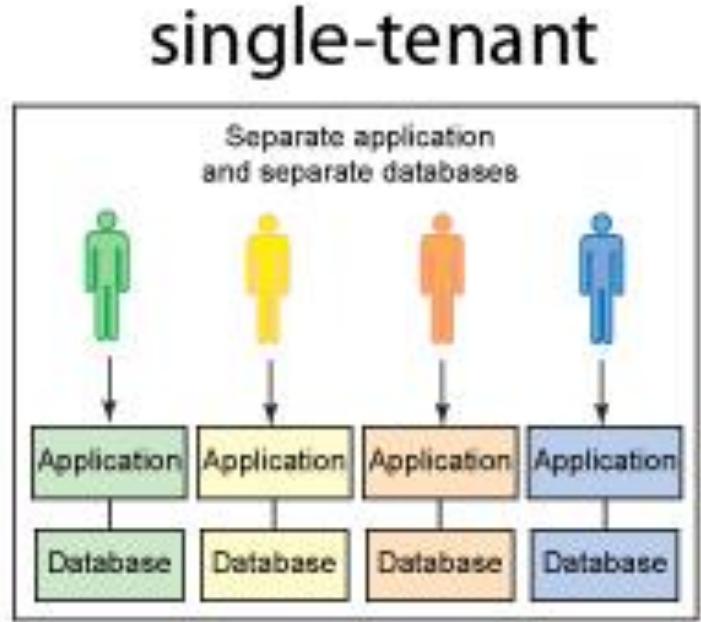
Horizontal Scaling: allocating or releasing IT resources of the same type

Vertical Scaling: replacing IT resources with higher or lower capacity



Multitenant Technology

- **Single-tenancy:** each customer has their own software instance
- **Multi-tenancy:** multiple customers (tenants) share the **same application**, running on the same OS, same hardware, with same data-storage mechanism
- **Benefits: isolation, cost saving, improved security**

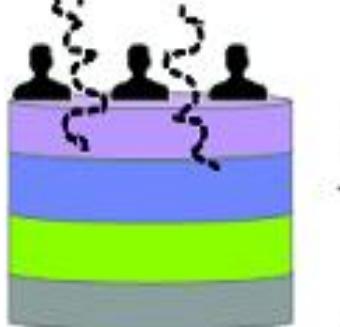




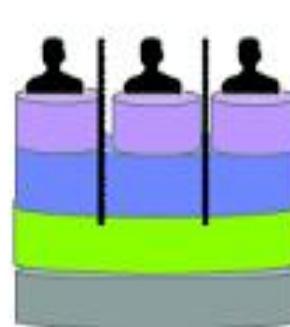
Multitenant Technology

Multi-tenancy at Different Levels

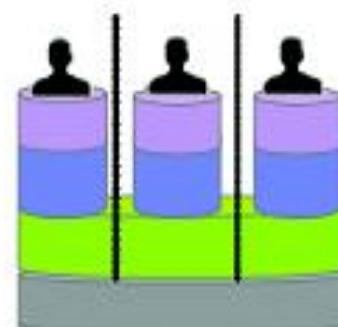
Application Level MT



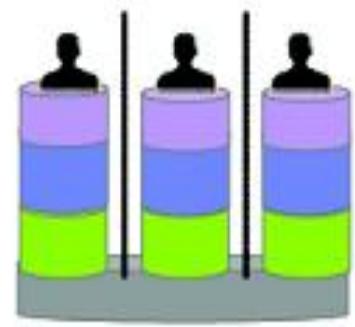
Middleware Level MT



OS Level MT

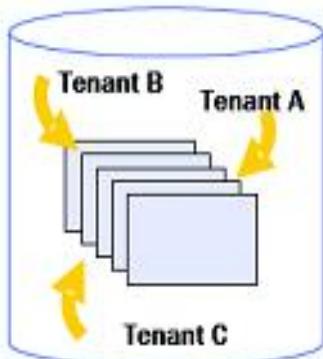


VM Level MT

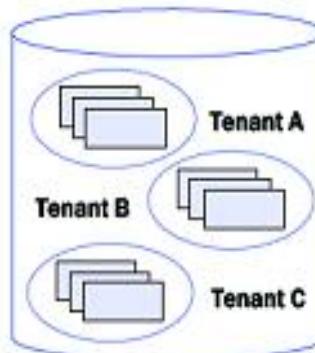


Example: Database Multi-tenancy

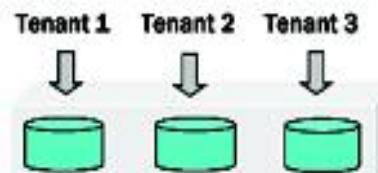
Same Table, hidden tenant ID field



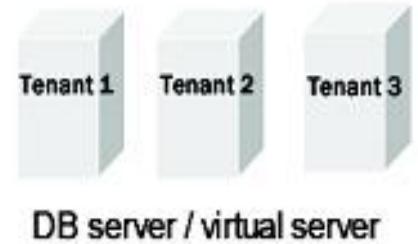
Same DB, separate tables or schemas



Same server, separate DB



Separate DB servers (instances)



Cloud Service Models

SaaS

Use provider's applications over a network

don't care
what program
to write.
PaaS

just p to arm base on model that they give

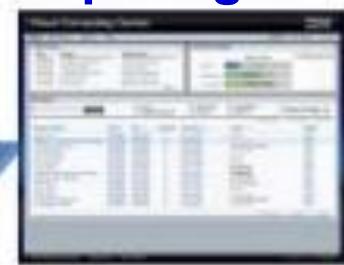
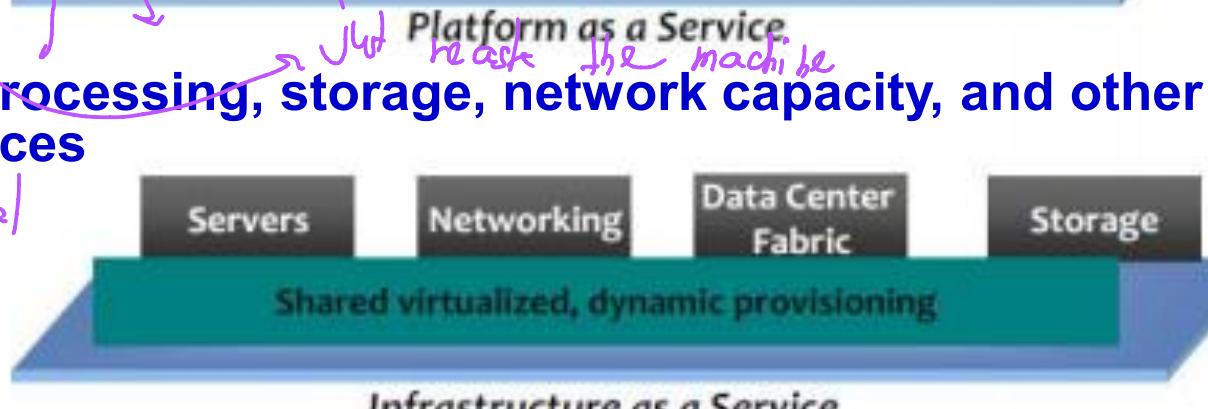
Deploy customer created applications to a cloud

provide platform
to host st.
write based API

IaaS

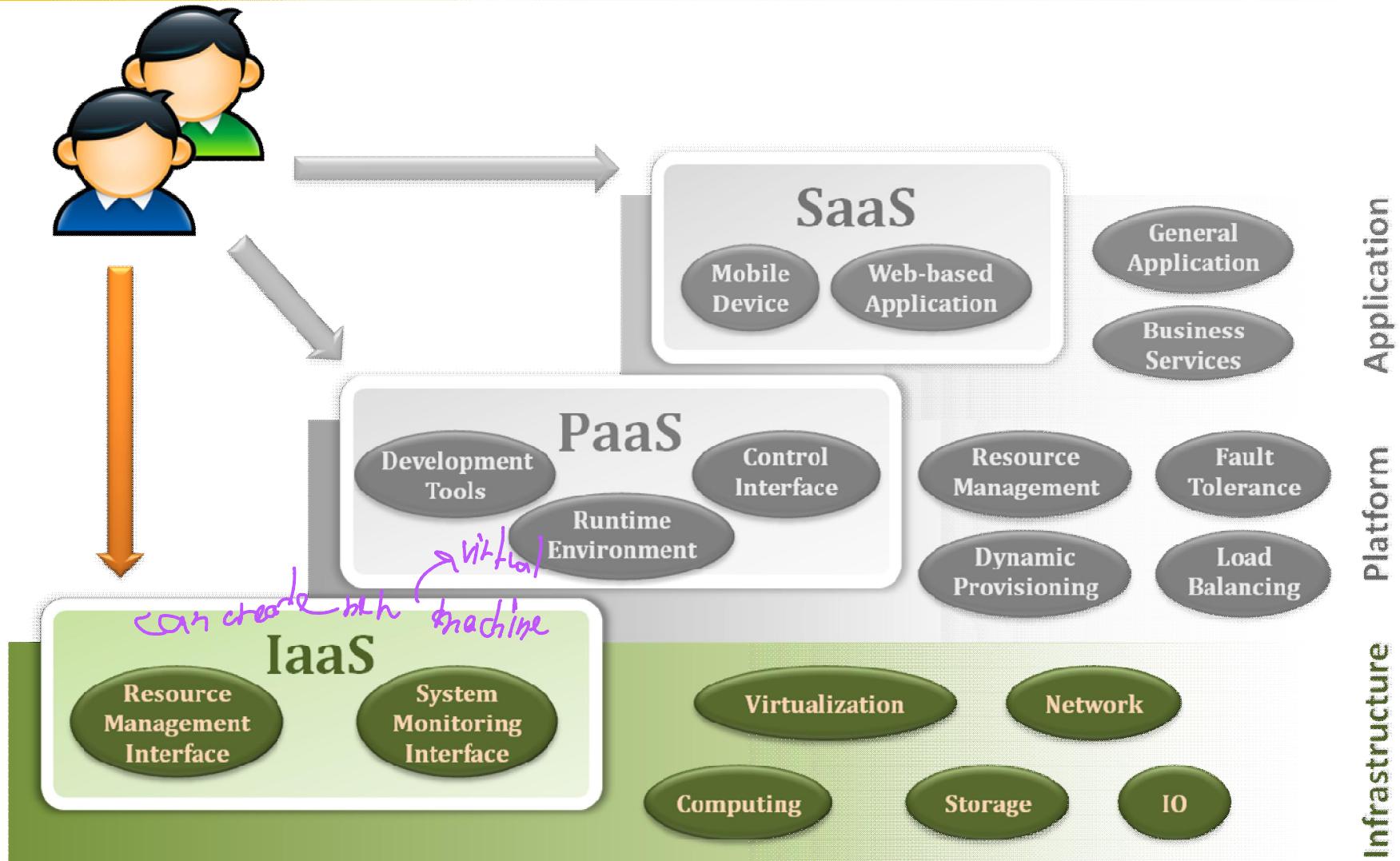
Rent processing, storage, network capacity, and other computing resources

provide actual
hard hardware



Cloud Service Models

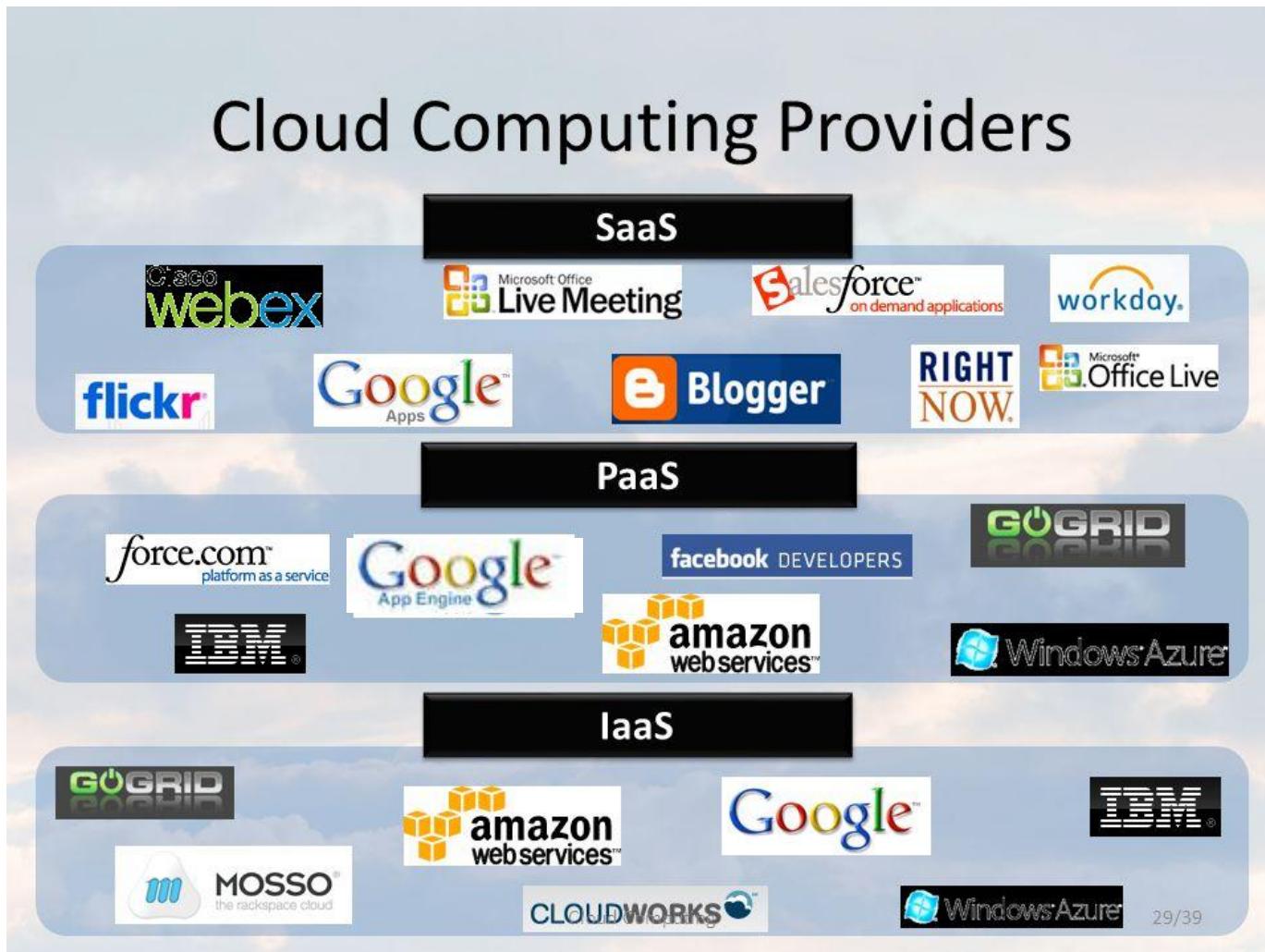
Service Features





Cloud Service Models

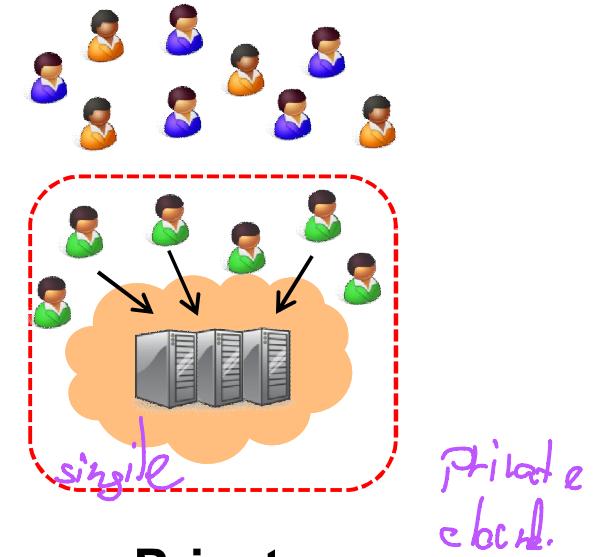
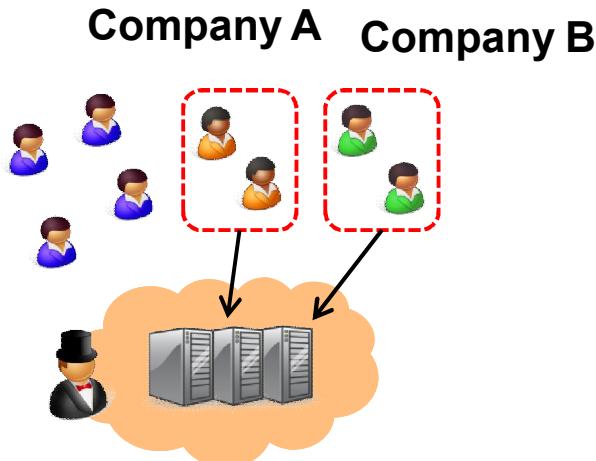
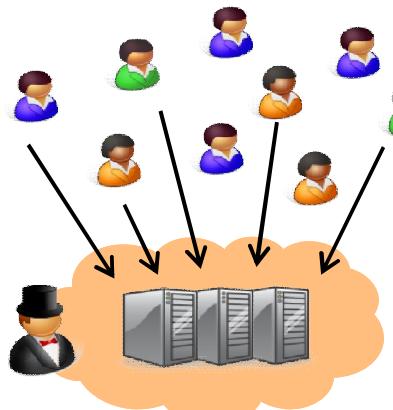
Who are at which service?



Cloud Deployment Models



Who is a customer of the cloud?

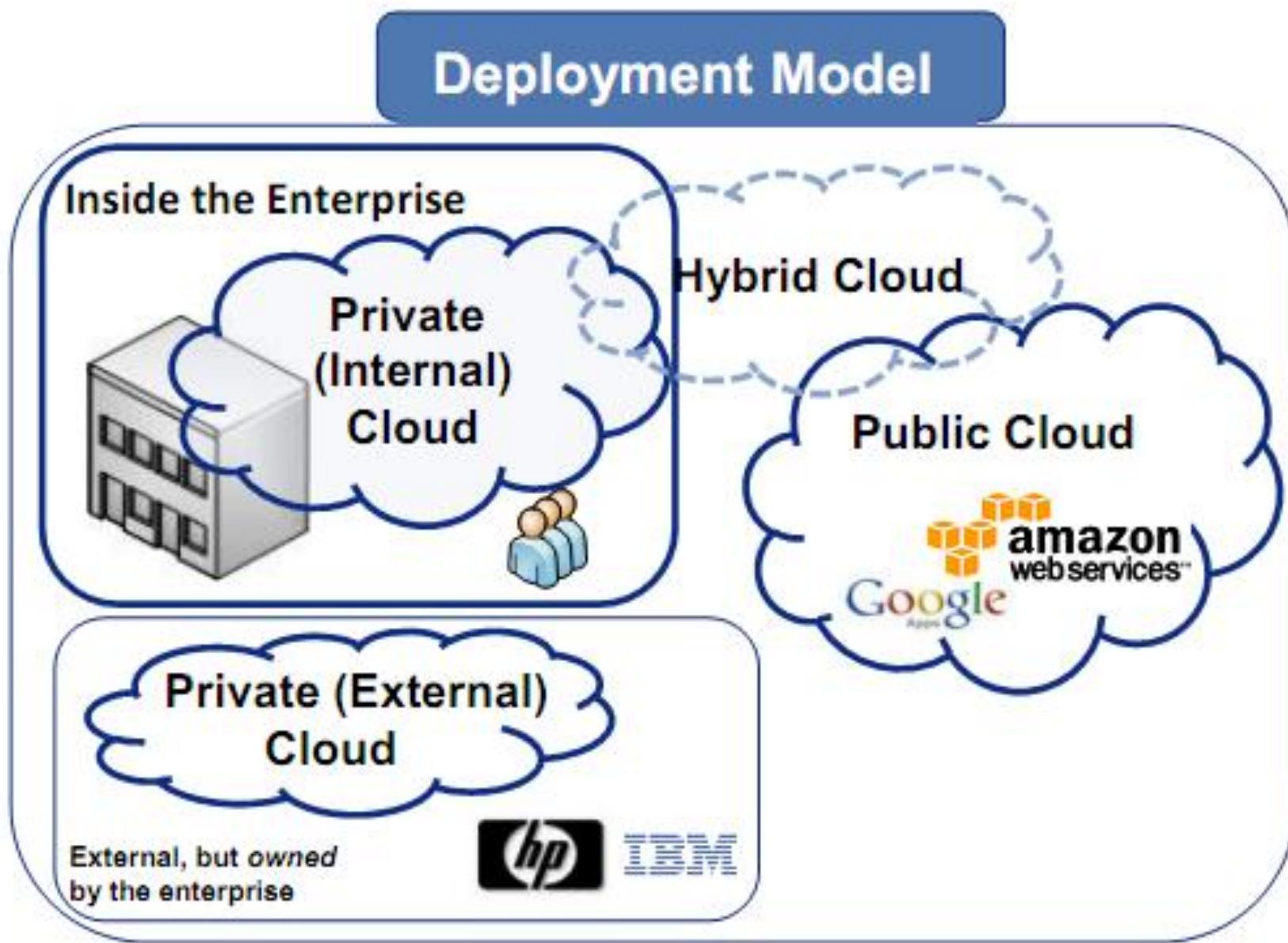


Public cloud: Amazon, Microsoft, Google, IBM

Community cloud: Shared by several similar organizations

Private cloud: Shared within a single organization

Cloud Deployment Models

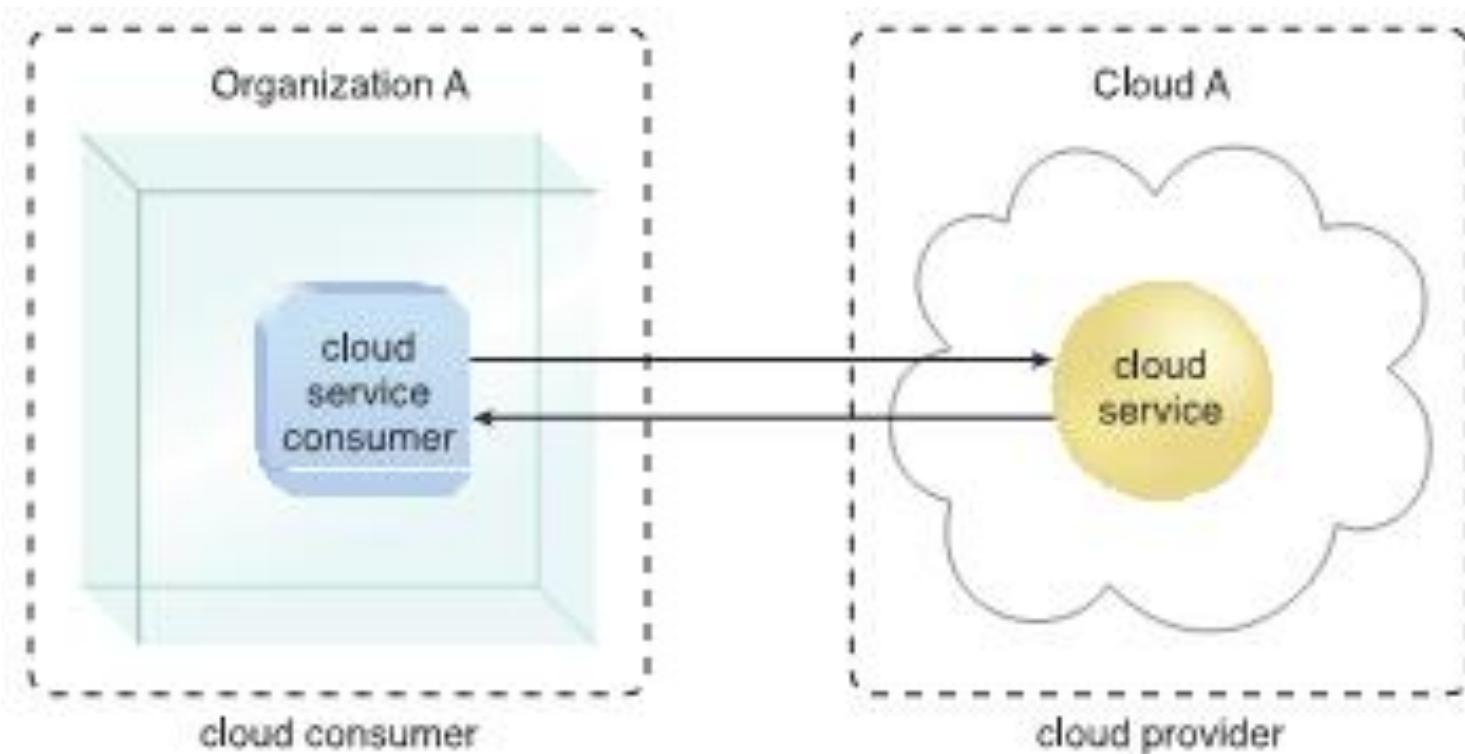


Roles in Cloud

Cloud Provider vs. Cloud Consumer

Cloud provider provides cloud-based IT resources

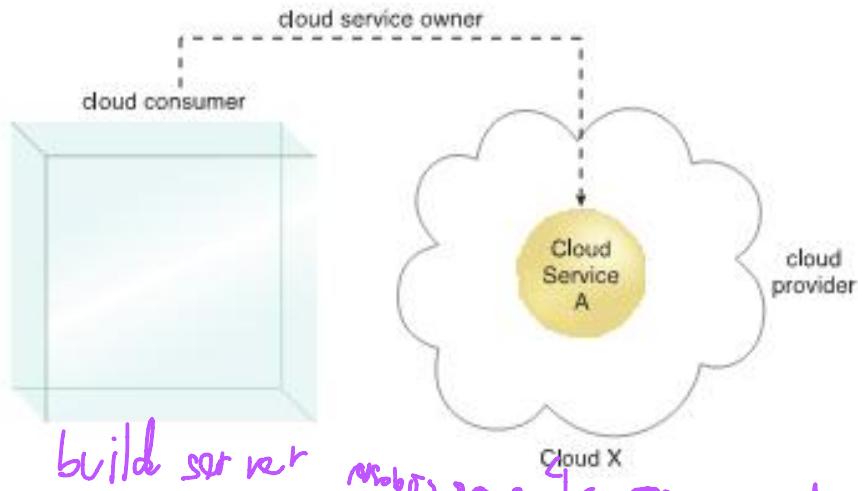
Cloud consumer uses IT resources made available by cloud providers



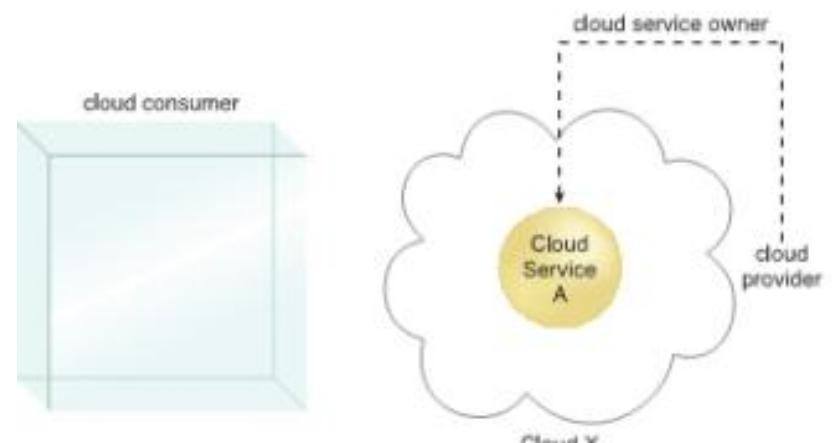
Roles in Cloud

Cloud Service Owner

A person/organization who **legally owns** a cloud service



A cloud consumer can be a cloud service owner when it deploys its own service in a cloud

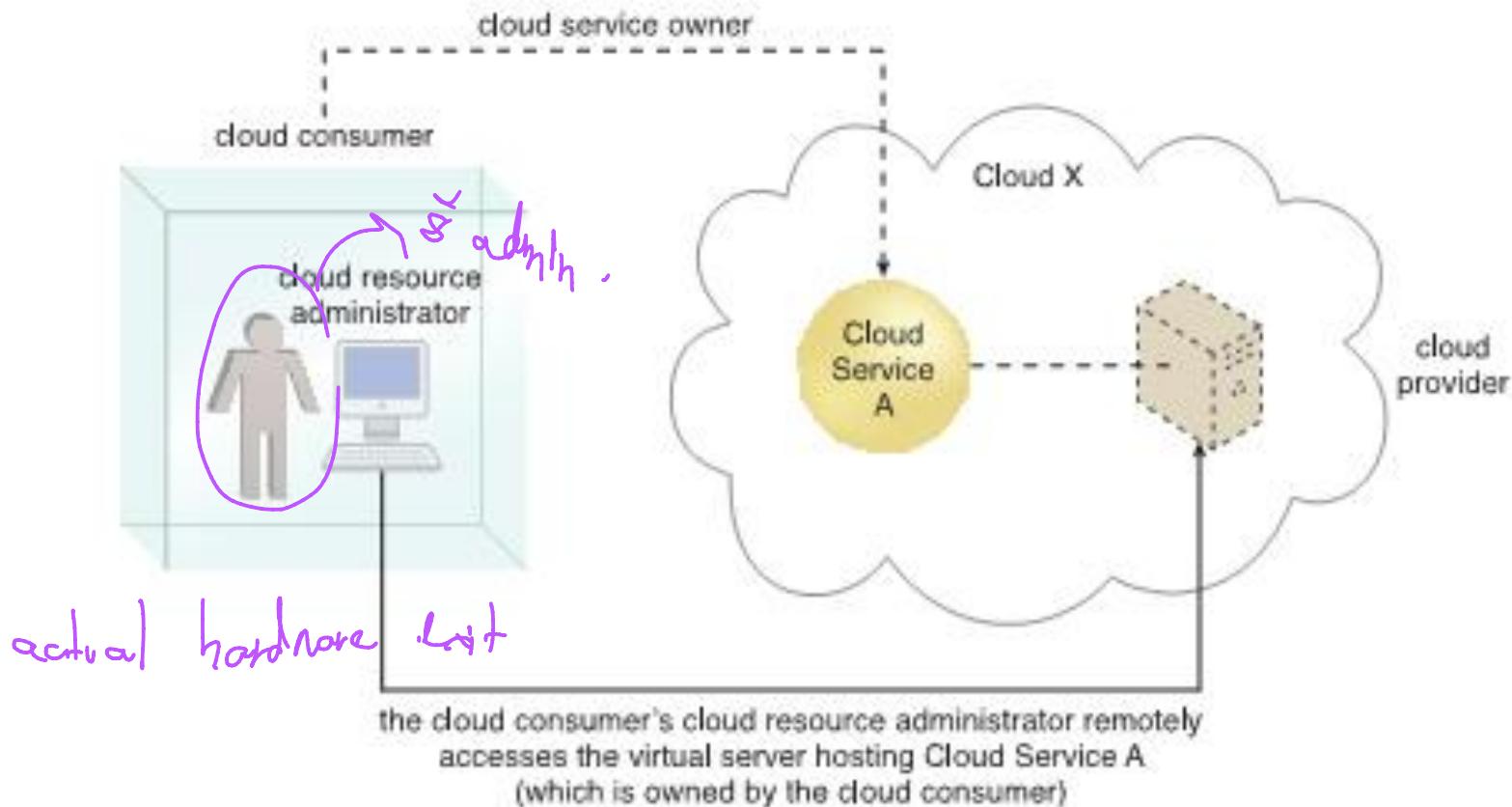


A cloud provider becomes a cloud service owner if it deploys its own cloud service, typically for other cloud consumers to use

Roles in Cloud

Cloud Resource Administrator

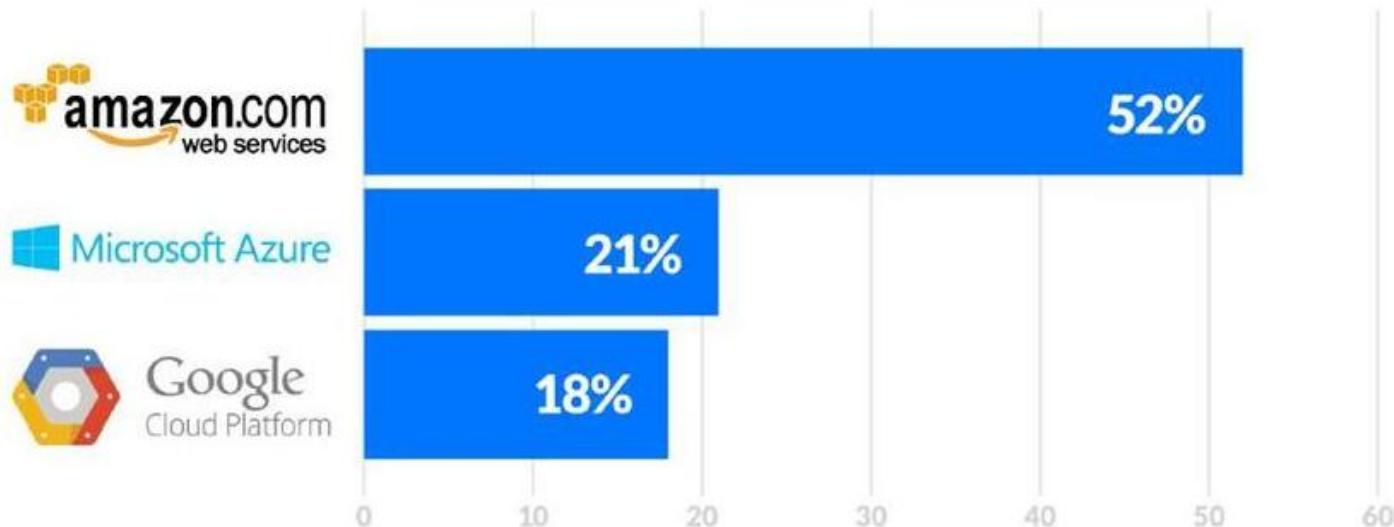
A person or organization responsible for administering a cloud-based IT resource (including cloud services)



Cloud Market Share



Predict the market share you expect AWS,
Microsoft and Google to hold in 2020.

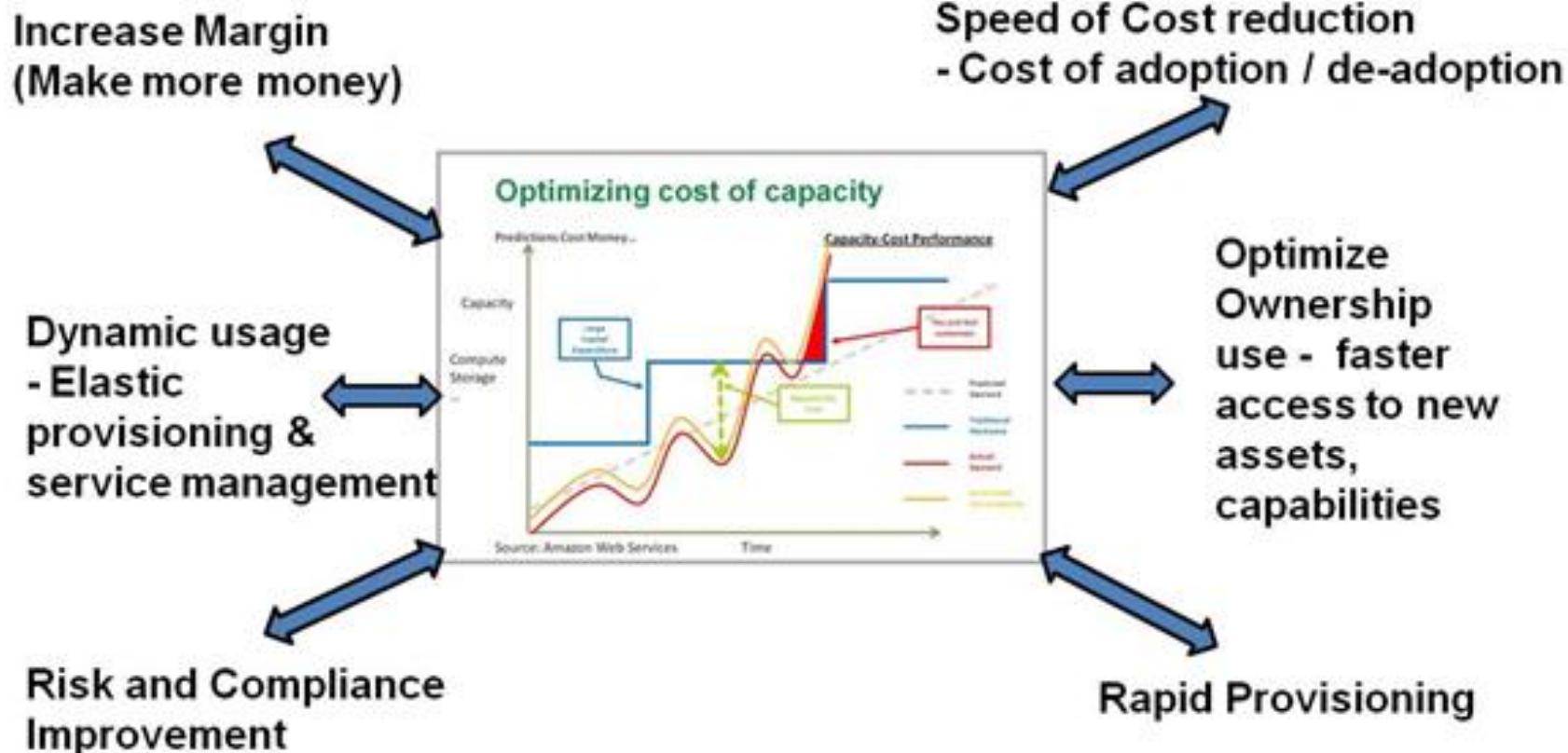


<https://www.forbes.com/sites/louis columbus/2018/01/07/83-of-enterprise-workloads-will-be-in-the-cloud-by-2020/>

Cloud Capacity and Utilization



Motivation





Top Cloud Applications

Which applications moved to Cloud

Top services or applications moving to the cloud:*

Small business

1. Storage (40%)
2. Conferencing & collaboration (37%)
3. Messaging (36%)



Medium business

1. Storage (35%)
2. Messaging (33%)
3. Office & productivity suites (32%)



Large business

1. Conferencing & collaboration (40%)
2. Storage/business process apps (35%)
3. Messaging/compute power (34%)



Federal govt.

1. Conferencing & collaboration (39%)
2. Messaging (37%)
3. Business process apps (31%)



State/local govt.

1. Storage (19%)
2. Conferencing & collaboration (17%)
3. Messaging/business process apps/compute power (15%)



Healthcare

1. Conferencing & collaboration (29%)
2. Compute power (26%)
3. Office & productivity suites (22%)



Higher education

1. Storage (31%)
2. Messaging/conferencing & collaboration (29%)
3. Compute power (25%)



K-12

1. Storage (40%)
2. Conferencing & collaboration (36%)
3. Office & productivity suites (33%)



*Those who are migrating or have migrated

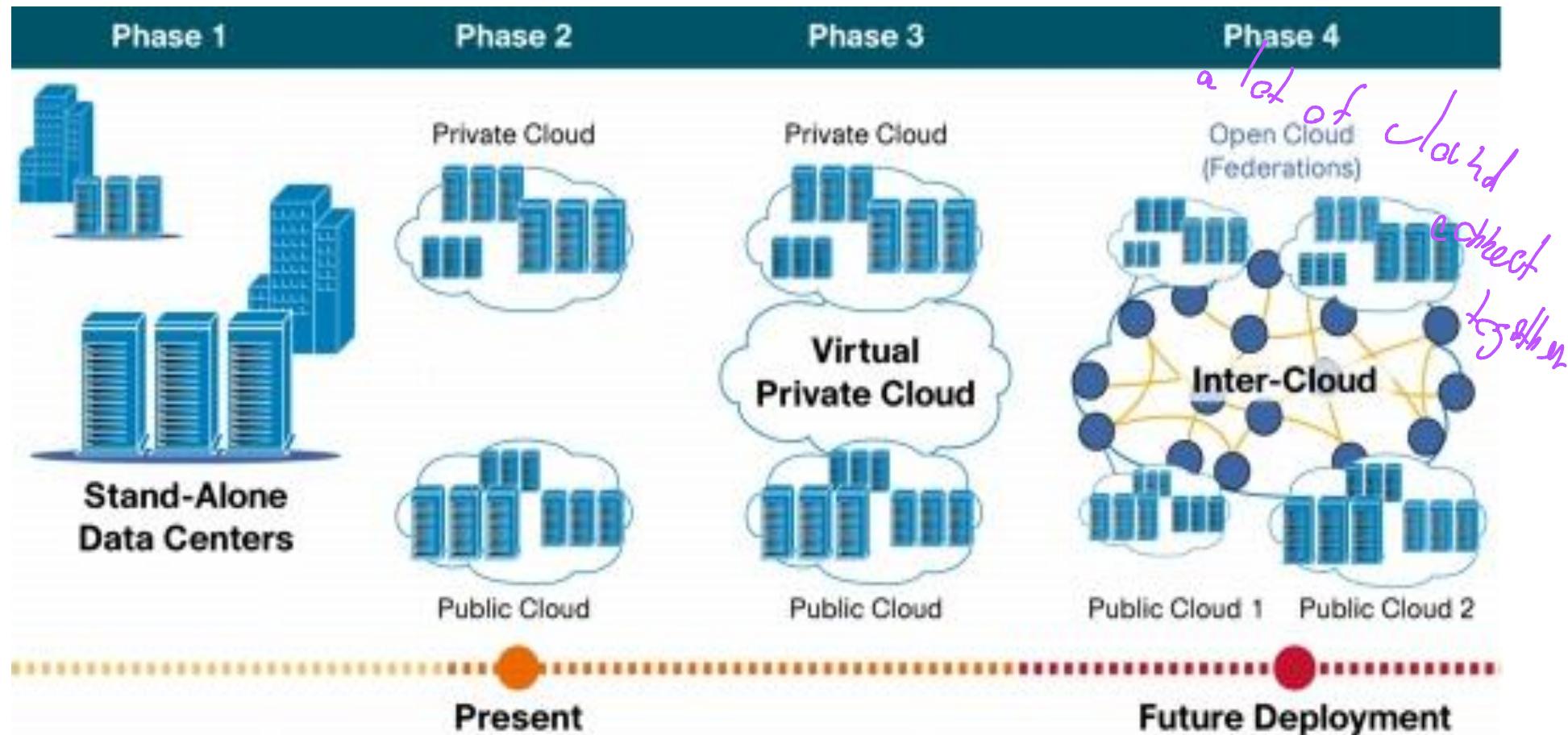
Most Used Enterprise Cloud Apps



MOST USED ENTERPRISE CLOUD APPS

	1	Facebook Social		6	Google Docs Productivity		11	Salesforce Customer relationship management/sales force automation
	2	Google Drive Cloud storage		7	YouTube Consumer		12	Cisco WebEx Collaboration
	3	Google Gmail Webmail		8	LinkedIn Social		13	Evernote Productivity
	4	Twitter Social		9	Dropbox Cloud storage		14	RingCentral Telecom
	5	iCloud Cloud storage		10	Microsoft OneDrive Cloud storage		15	Okta Security

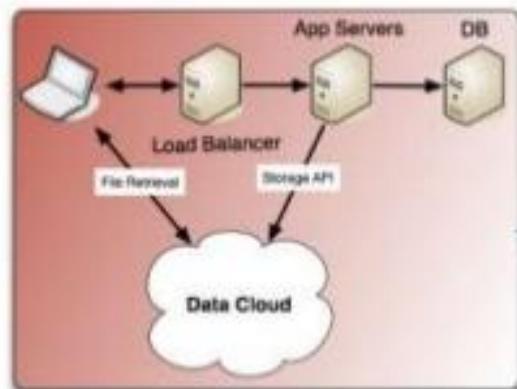
Cloud Adoption Model



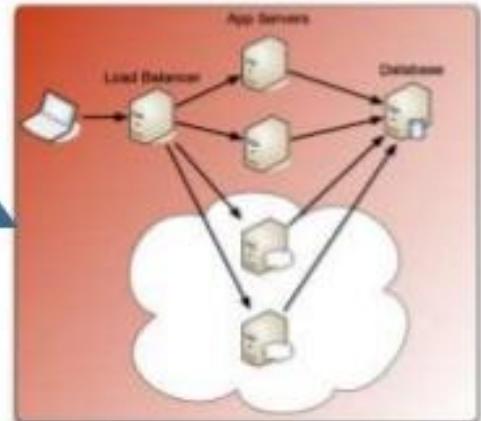
Cloud Adoption Model



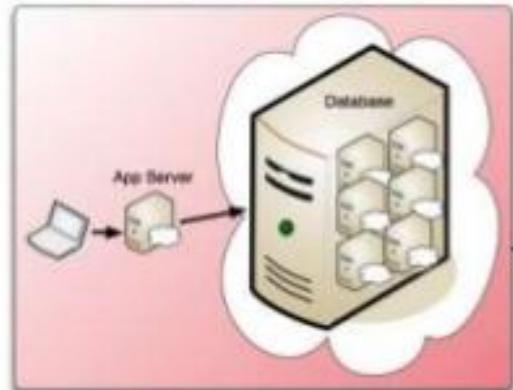
Starting with Common Use Cases



Augmentation
(Elastic scaling)

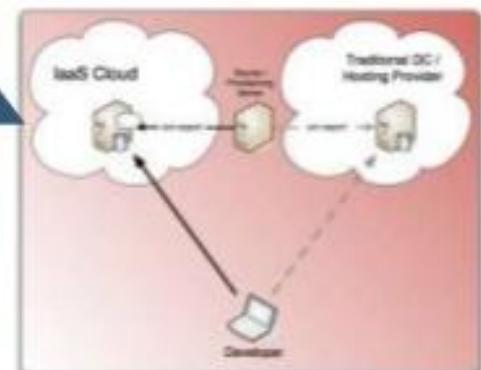


Shared Services



Development
and Test

Resource sharing
(consolidation)



Most enterprises are trying

- Shared development and test environments
- Hardware & Services consolidation

Cloud: Pros and Cons



X

Cloud Computing

Advantages

- Storage and Scalability
(can scale)
- Backup and Recovery
- Mobility
(more ^{one} _{one} service)
- Cost Efficiency
- IT Innovation

Disadvantages

- Control and Reliability
(can not control service)
- Security and Compliance
- Compatibility
- Unpredicted Costs
(usage charges)
- Contracts and Lock-Ins



Cloud Downtime

1
2
3
4
5
6
7
8
9
10

Microsoft's Windows Azure			
	October 30		
	>20hrs		
	A sub-component of the system failed worldwide		
Google			
	August 16		
	<5mins		
	Services went down, causing global Internet traffic volume to plunge by about 40%		
Amazon Web Services			
	September 13		
	<3hrs		
	Connectivity issues affected a single availability zone, disrupting a notable portion of Internet activity		
NASDAQ			
	August 22		
	3hrs		
	Software bug, and inadequate built-in redundancy capabilities, triggered a massive trading halt in the U.S.		
OTC Markets Group Inc			
	November 7		
	>Shrs		
	Network failure prompted a shutdown in over-the-counter stock trading in the U.S.		
HealthCare.gov			
	October 27-28		
	>16hrs		
	Downtime caused by a service outage at Verizon Terremark data center		
Amazon.com			
	January 31		
	49mins		
	1hr of interrupted service may have translated to \$5M in lost revenue		
Microsoft /Hotmail/Outlook.com			
	March 13		
	<16hrs		
	Firmware update caused servers to overheat. Hotmail and Outlook.com suffered a service loss		
Google Drive			
	March 18-20		
	17hrs		
	Slow download times caused by a network control software glitch, resulted in latency and recovery problems		
Google's Gmail			
	September 23		
	12hrs		
	Slow download times triggered by dual network failure affected 29% of users		

Top Ten Cloud Computing Outages in 2013

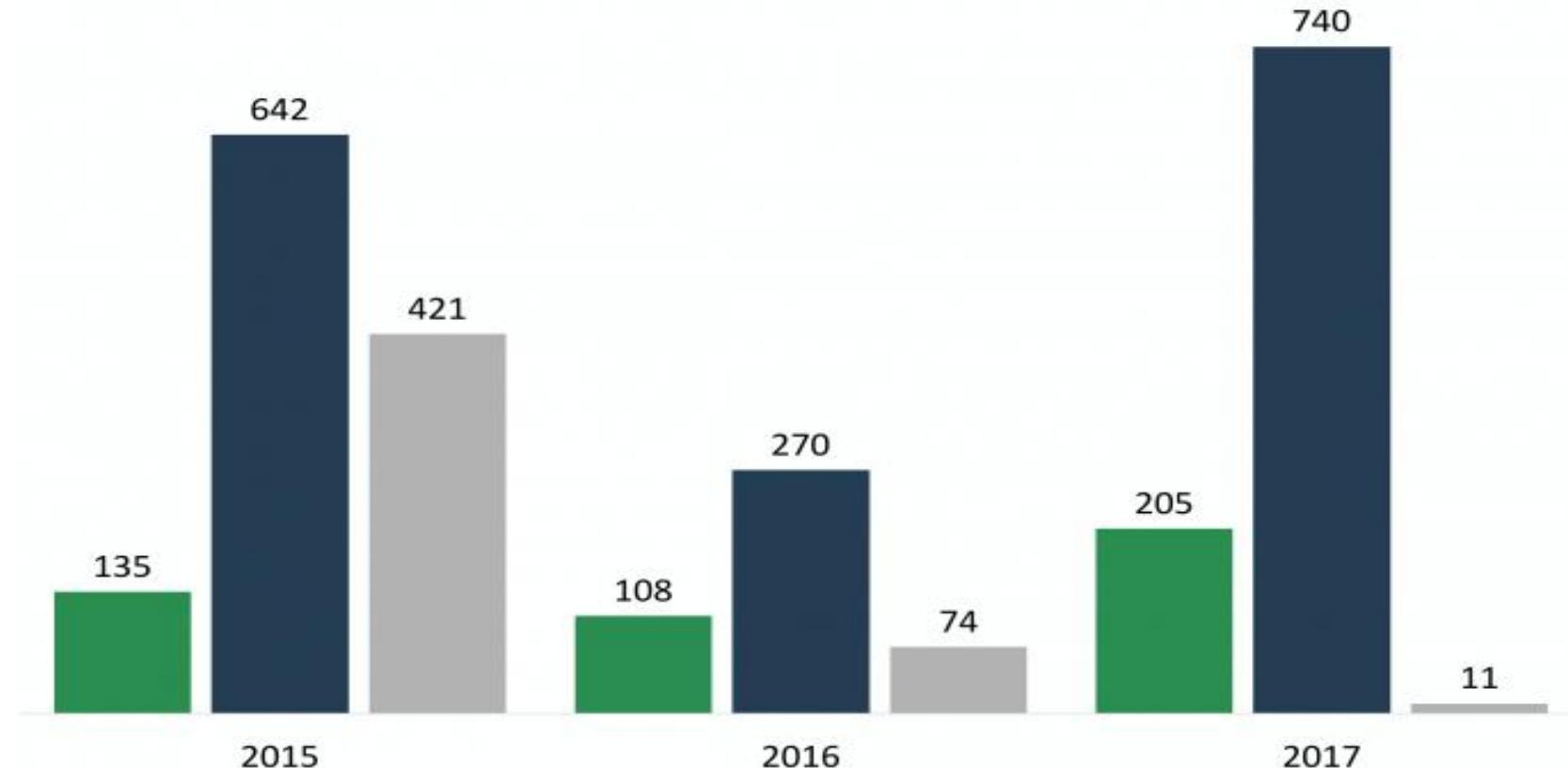
Cloud Downtime



Total Time Lost From Cloud Outages, By Vendor

Global, In minutes

■ Amazon ■ Microsoft ■ Google



Source: CloudHarmony

BI INTELLIGENCE



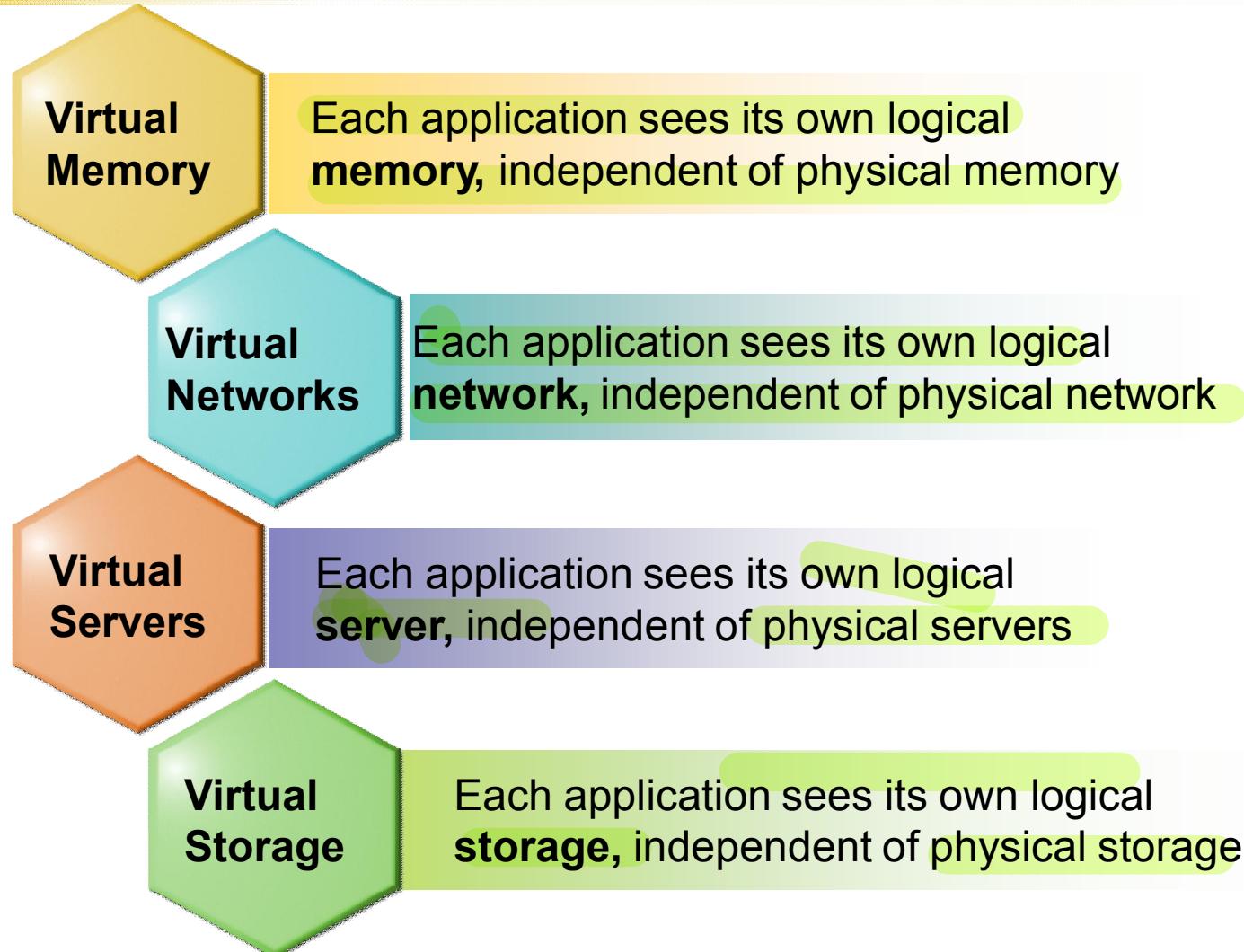
Sample SLAs

(greeting from Phoide (about promise of go))

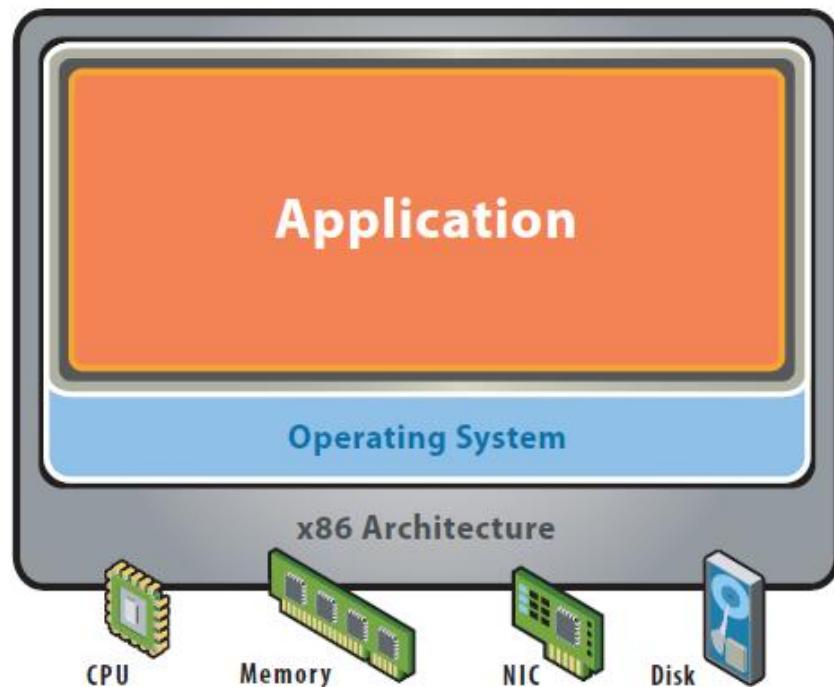
	Rackspace	Amazon
Uptime	100%	99.95%
Time-to-resolve	1 hour	Not specified
Timespan	Current period	"Service Year"
Credit back when failing to meet SLA	"Users receive 5% of the fees for each 30 minutes of network downtime, up to 100% of the fees"	"If the Annual Uptime Percentage for a customer drops below 99.95% for the <i>Service Year</i> , that customer is eligible to receive a Service Credit equal to 10% of their bill."



Virtualization Concepts



No Virtualized Server

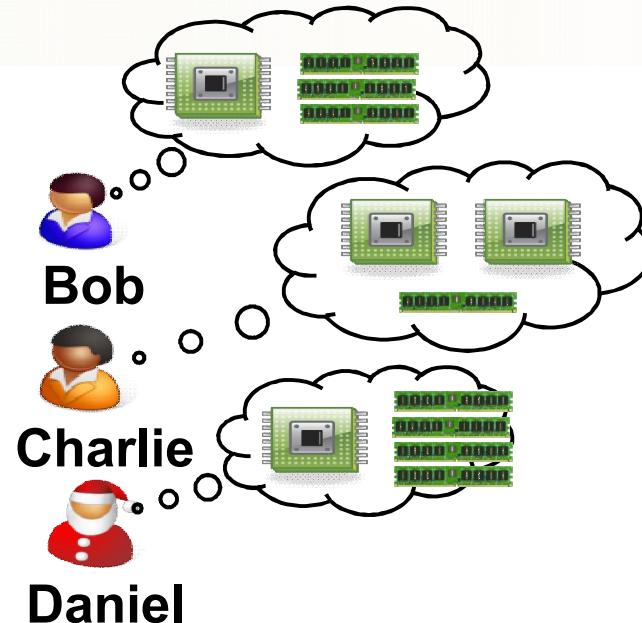
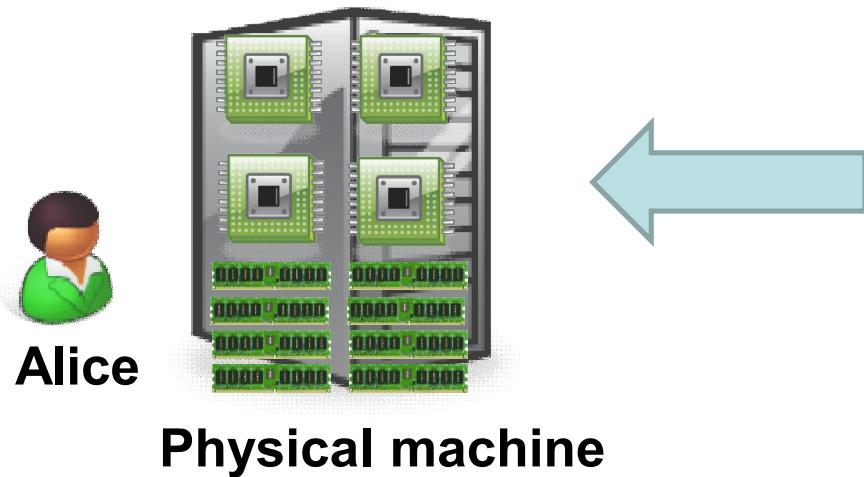


- Single OS per machine
- Software and hardware tightly coupled
- Running multiple applications on same machine often creates conflict
- Inflexible and costly infrastructure

Server Virtualization



Sample Scenario

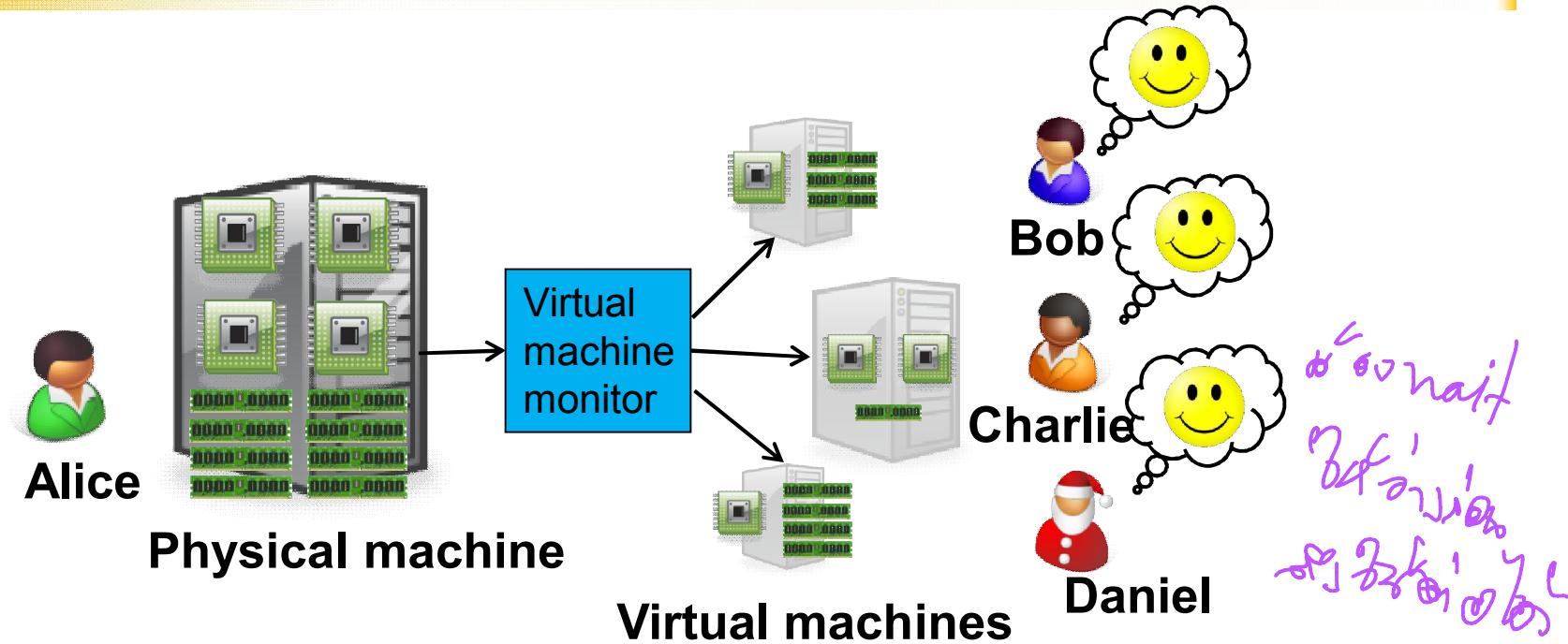


- Suppose Alice has a machine with **4 CPUs and 8 GB of memory**, and three customers:
 - Bob wants a machine with **1 CPU and 3GB of memory**
 - Charlie wants **2 CPUs and 1GB of memory**
 - Daniel wants **1 CPU and 4GB of memory**
- What should Alice do?

Server Virtualization



Sample Scenario



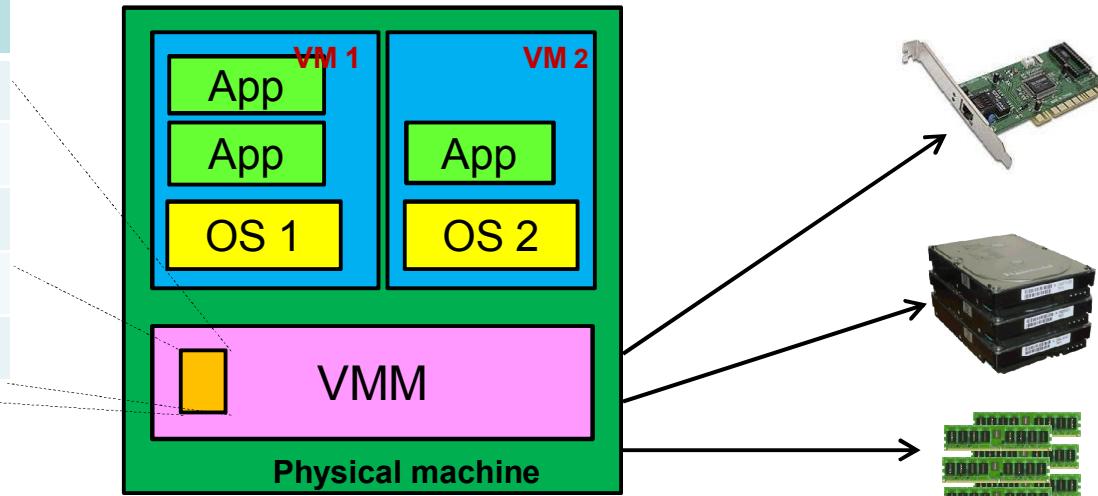
- Alice gives each customer a **virtual machine (VM)** with the requested resources
- From each customer's perspective, it appears **as if they had a physical machine all by themselves (isolation)**

Server Virtualization



Hypervisor (VMM)

VM	Virt	Phys
1	0-99	0-99
1	299-399	100-199
2	0-99	300-399
2	200-299	500-599
2	600-699	400-499



Translation table

split hardware to 2 parts

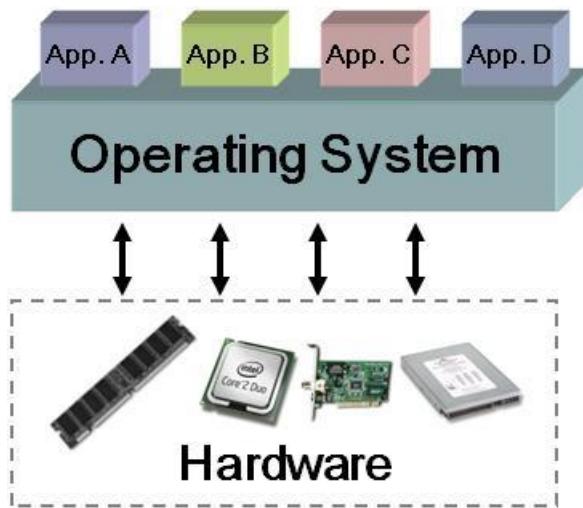
- Resources (CPU, memory, ...) are virtualized
- VMM ("Hypervisor") has translation table that maps each VM request for **virtual to physical resources**

help to map virtual and actual part.

Server Virtualization

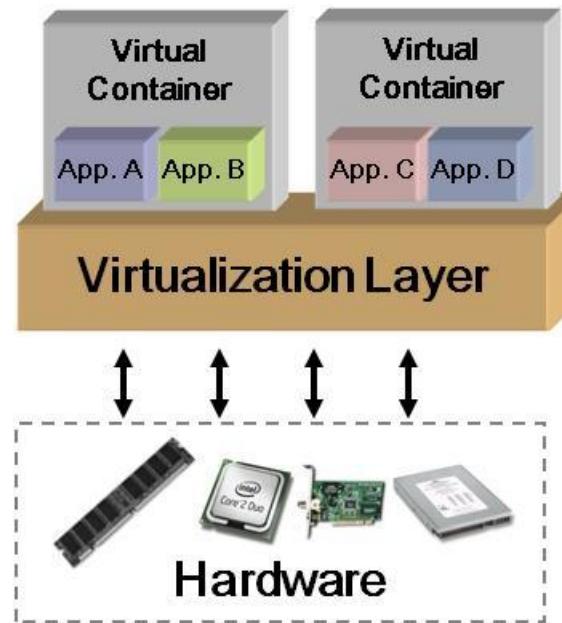
Non-Virtualized system

A single OS controls all hardware platform resources



Virtualized system

Multiple VMs on a single physical machine



Isolated VM

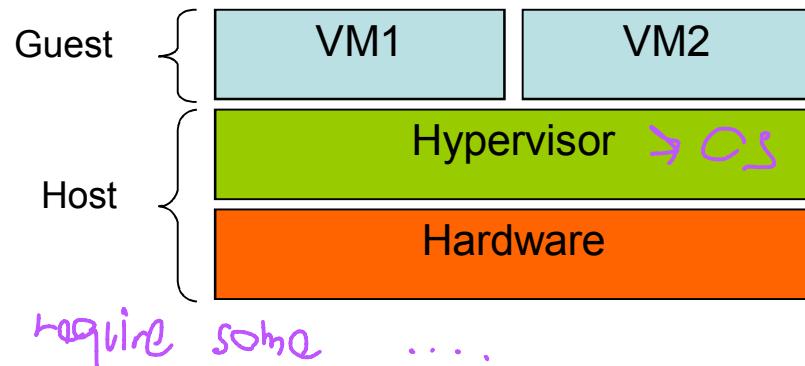
Hypervisor/ virtualization manager

to manage and monitor VMs

Server Virtualization

Two Hypervisor Types

bare-metal hypervisor

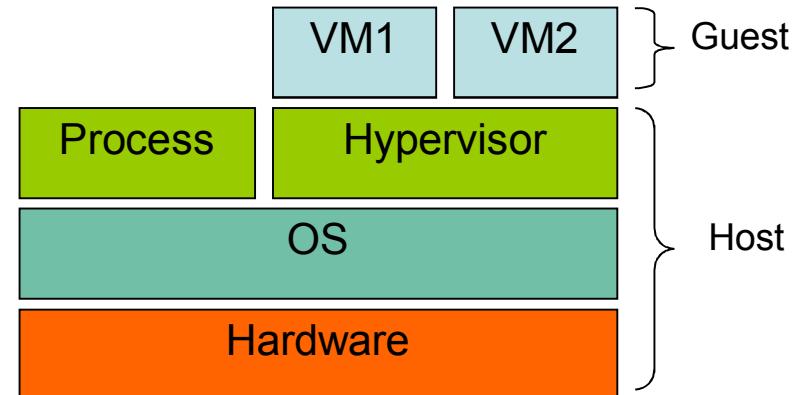


VMware ESX, Microsoft Hyper-V, Xen

Hypervisors run directly on the system hardware

- More efficient and more secure
 - Less hardware support
- less flexible.*

hosted hypervisor



VMware Workstation, Microsoft Virtual PC, Oracle VirtualBox, QEMU, KVM

Hypervisors run on a host OS that provides I/O and memory management

- Easy to install and manage
- more overhead, less secure

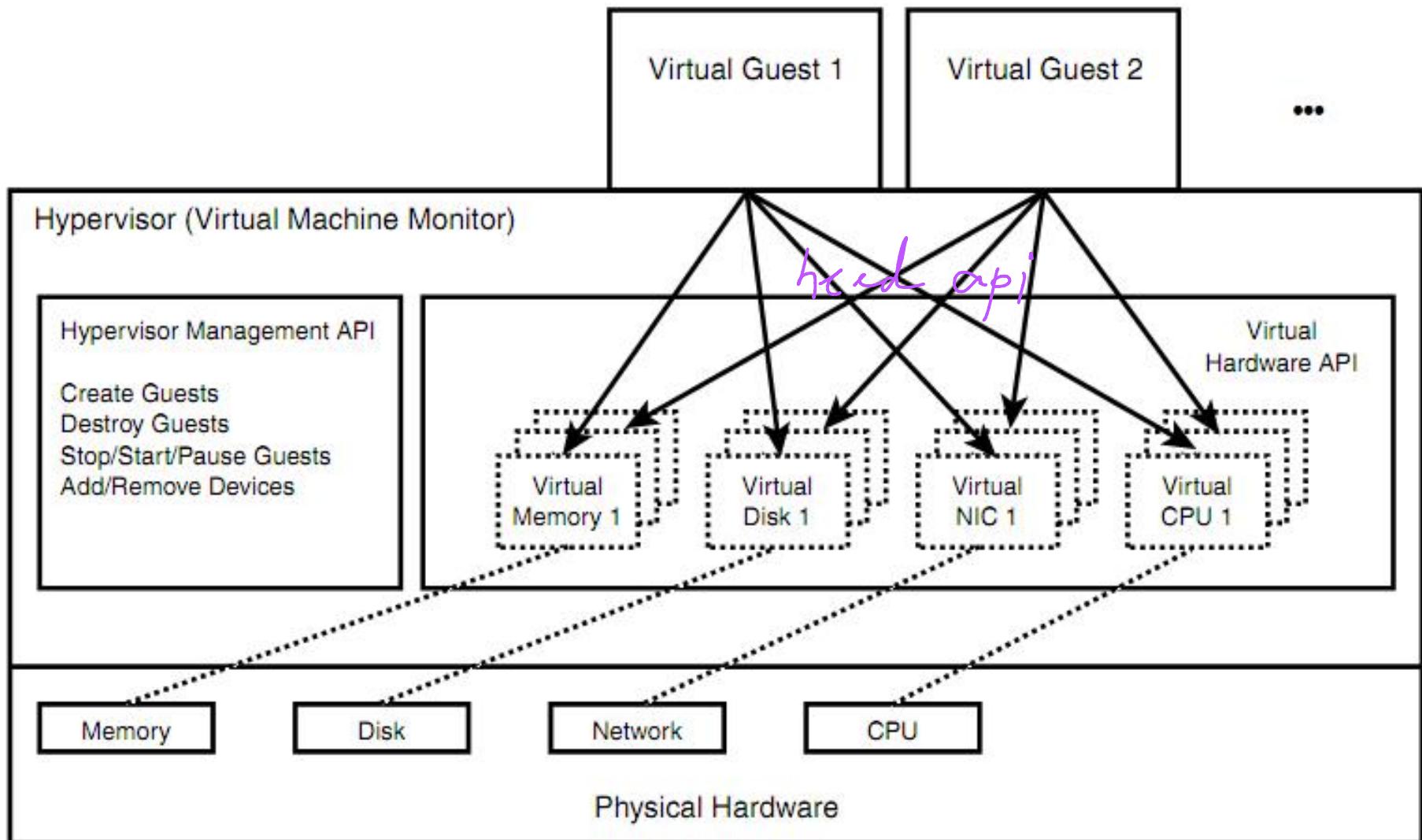
Server Virtualization Techniques



- *guest machine* is the virtual machine (VM)
- *Full virtualization* like **VMWare**
 - Unmodified guest OS
 - Privileged instructions are translated into safe codes on the fly
 - Execution may slow
- *Para-virtualization* like **Xen**
 - Modified guest OS and co-work with hypervisor
 - Any privileged instructions are replaced by hypervisor calls
- *Hardware-assisted virtualization (VT)* like **KVM**
 - Unmodified guest OS
 - Require Intel VT-x or AMD-v support *Can't run 32bit*
 - Simplify VMM and give better performance

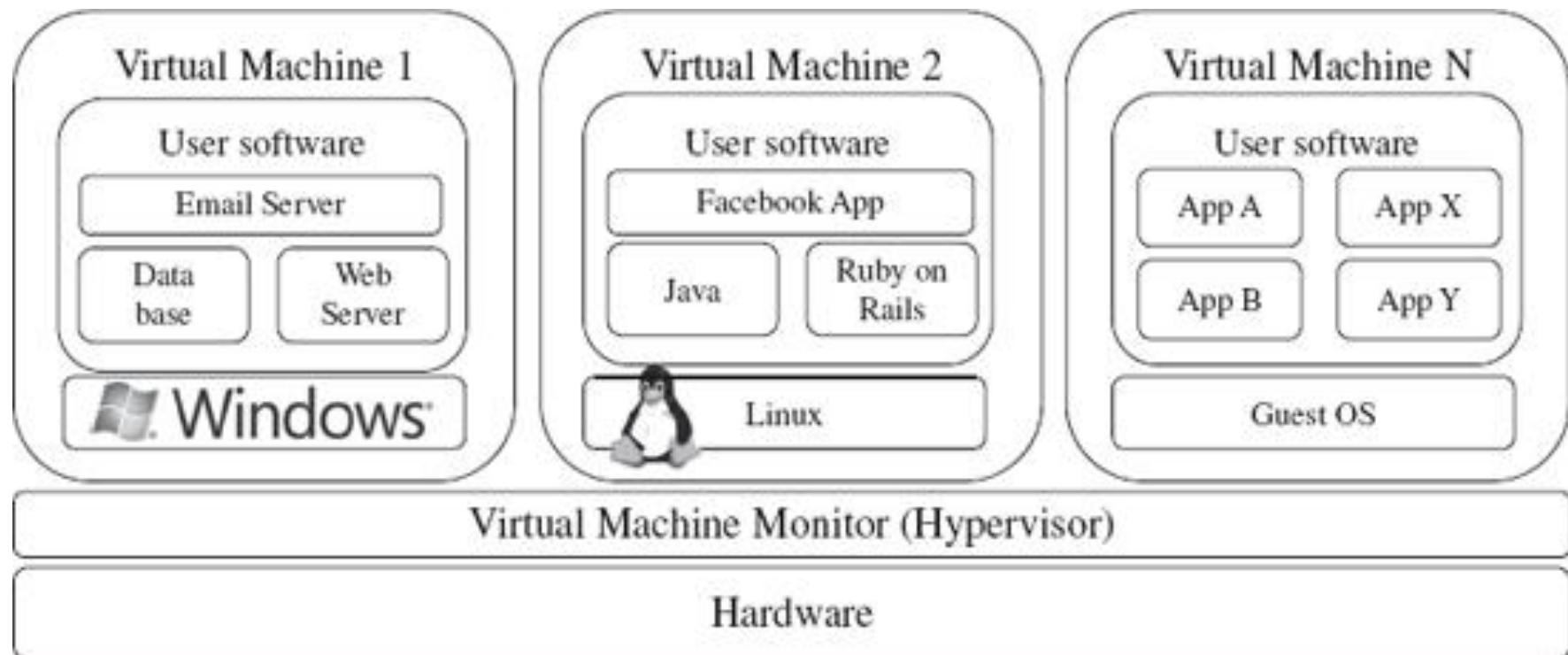
Server Virtualization

Hardware, Hypervisor and VM



Server Virtualization

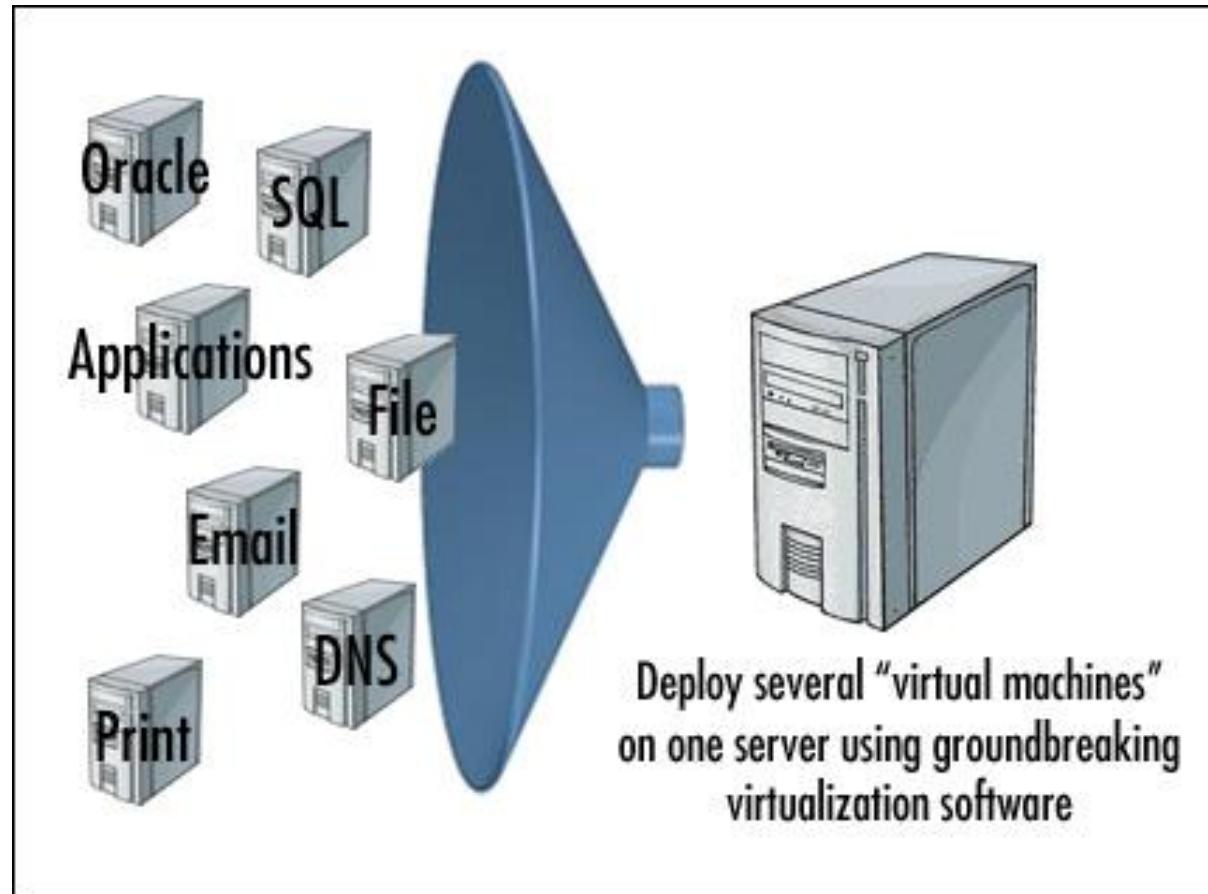
Guest Virtual Machines



Server Virtualization

Resource Consolidation

Run many logical (virtual) machines on the same physical machine and divide system resources between virtual machines



Server Virtualization

Higher Utilization ພາຍໃຕງານເປົ້າ ລູກຂຶ້ນ

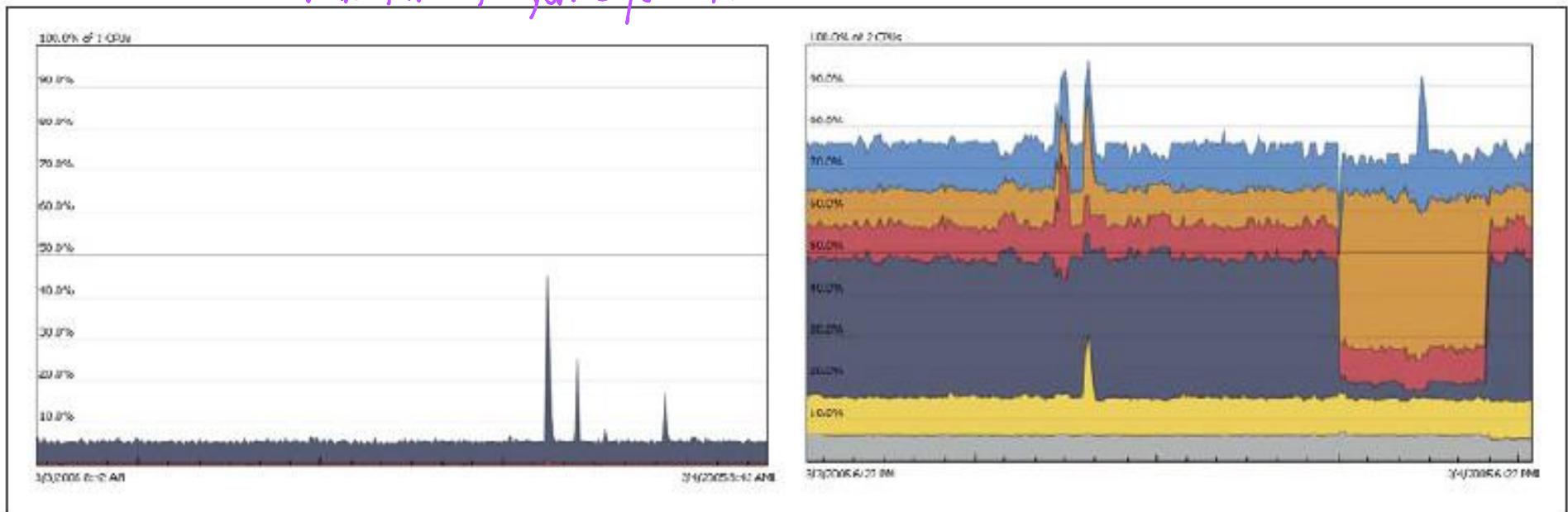
Consolidation of workloads from underutilized servers onto a single server to achieve higher utilization

การรวมเวิร์กໂລດຈາກເຊື່ອົວເວຼັອທີ່ໃຊ້ຈານໄຟໄຟໄມ່ຢັງ a
ເຊື່ອົວເວຼັອເຕີຍເພື່ອໃຫ້ເກີດການໃໝ່ປະໂຍບນທີ່ສູງຂຶ້ນ

Can have virtualization of workloads.

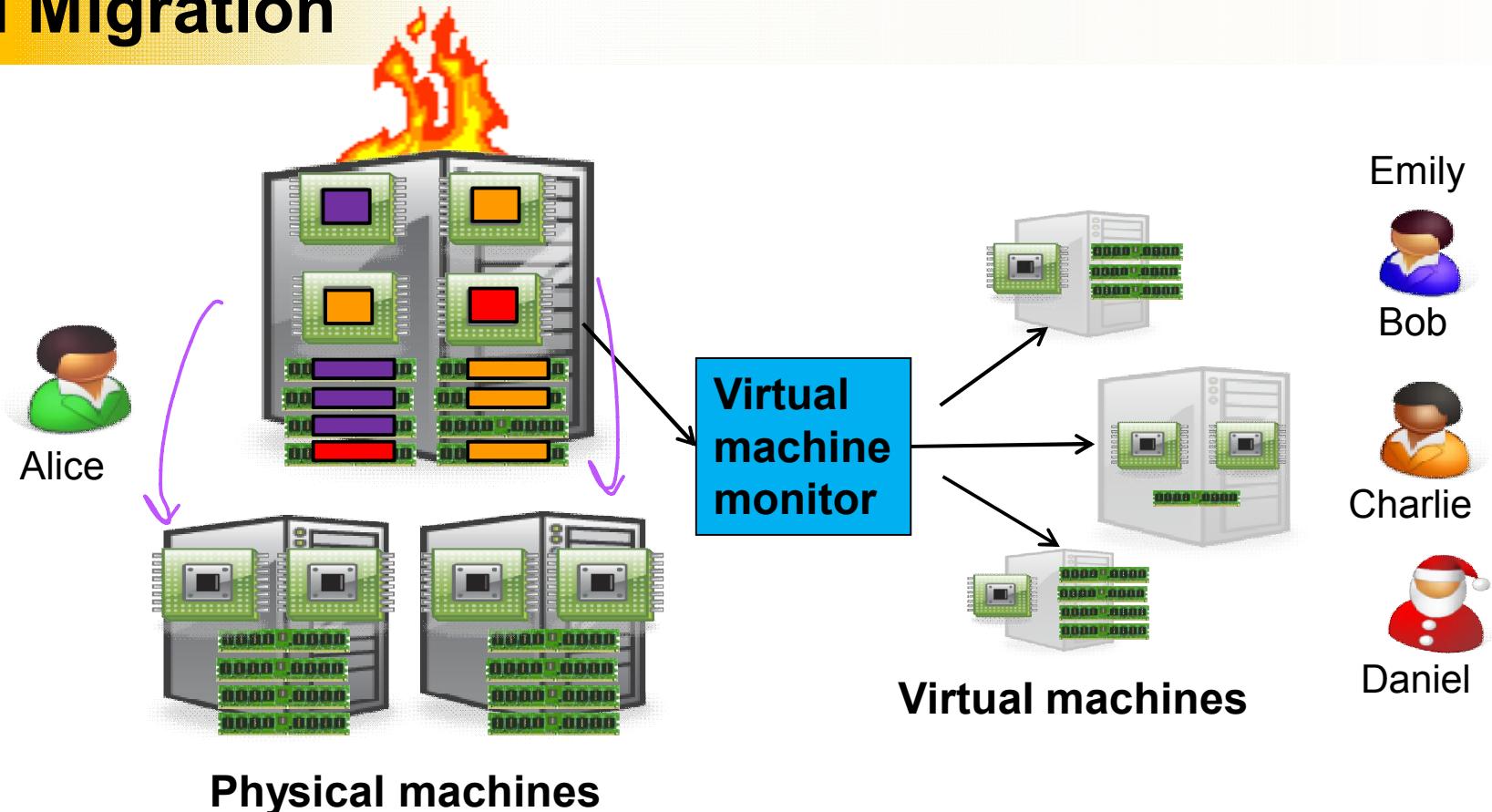
Dedicated Server

Virtualized Server



Server Virtualization

VM Migration

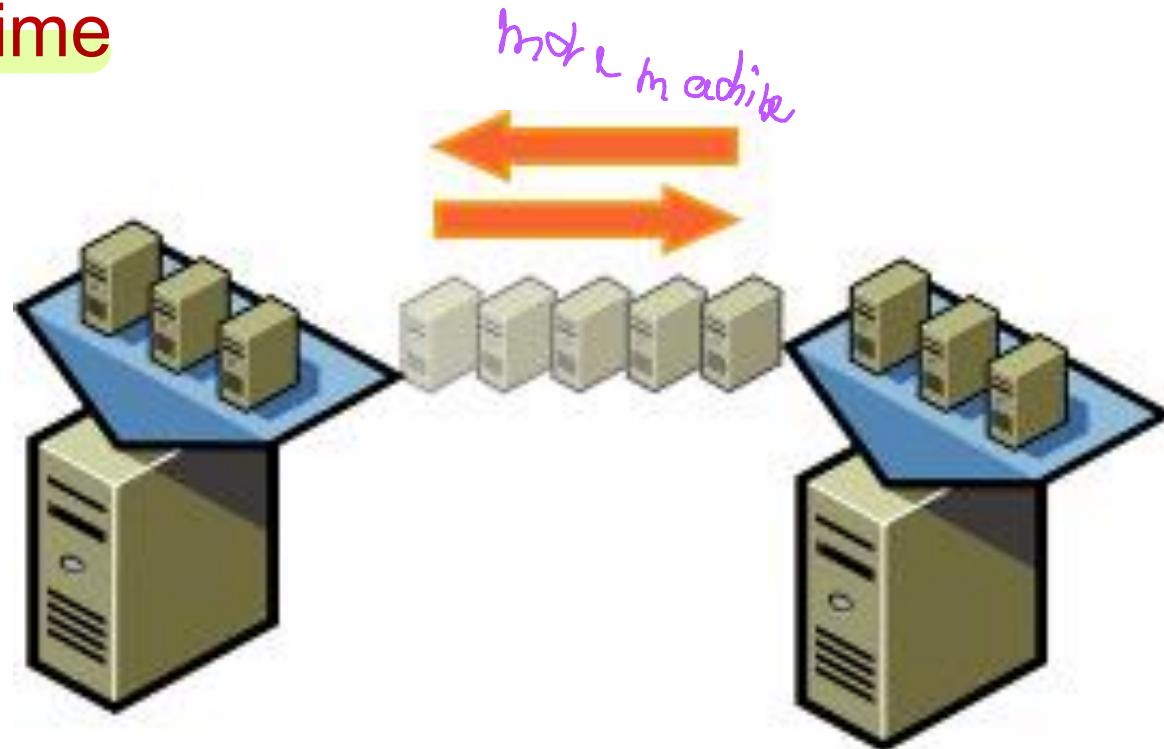


- What if the machine was **shut down**
- Alice can **migrate** a VM to another physical machine without any customer noticing

Server Virtualization

VM Migration

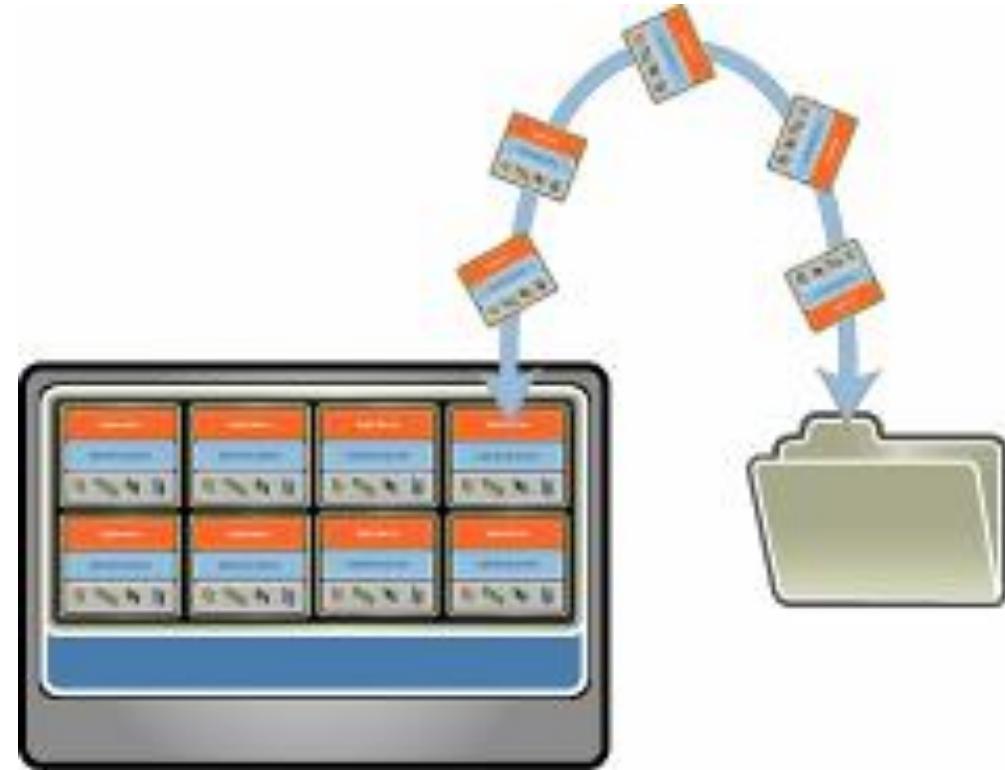
- Migrate a virtual machine to similar or different physical server
- Live migration of virtual machines with (almost) zero downtime



Server Virtualization

Snapshot as Backup

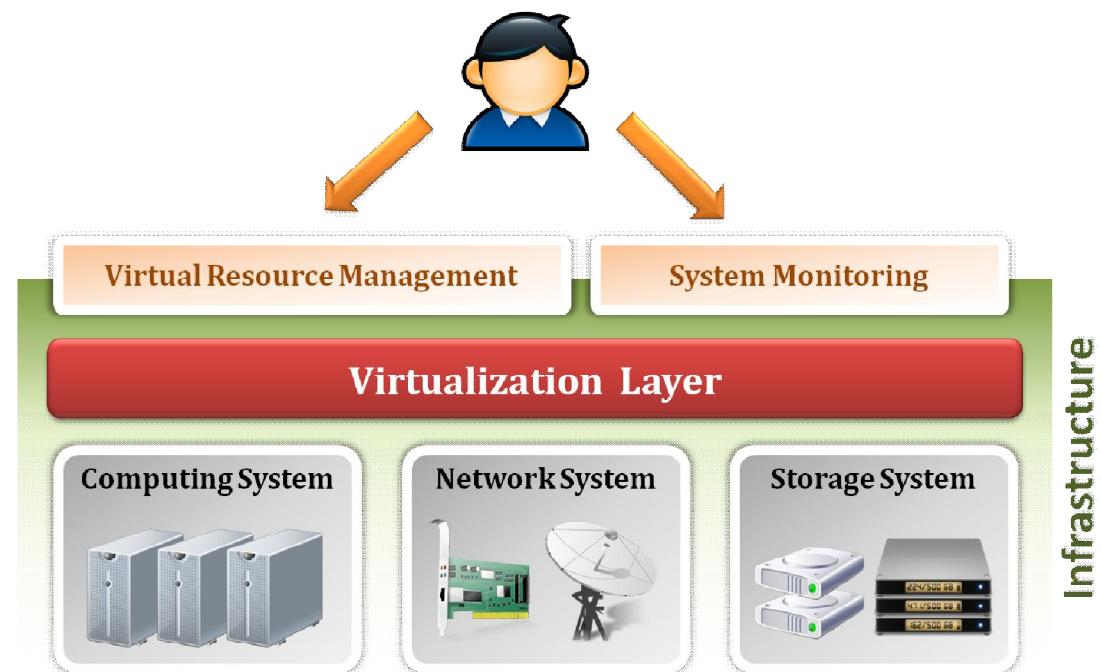
- Entire state of the virtual machine can be saved to files
- Move and copy virtual machines as easily as moving and copying files



Server Virtualization

Summary

- **Virtualization** is an **enabling technique** to provide **mapping of physical resources to multiple logical resources**
- Virtual instances of IT resources: **CPU, Memory, Network, Disk**
- **Isolate users from the underlying resources**
- **Isolate users from each other**
- **Isolate from fault and security**





Forms of Virtualization

Application Virtualization

- Application hosted in a datacenter and streamed to a desktop PC's

- Ex: Citrix XenApp, Microsoft App Virtualization
- **Hardware partitioning done on a server machines**
- Ex: VMware Server, VMware ESX, SUN xVM, Citrix Xen Server, etc

Desktop Virtualization

- Hardware partitioning performed on desktop machines
- Ex: VMware workstations, Microsoft Virtual PC

Hosted Desktop Virtualization

- Desktop environment hosted in Datacenter & streamed to a thin client / PC.
- Ex: VMware virtual Desktop Infrastructure (VDI), Microsoft Terminal Services

Operating System Virtualization

- The partitioning of system resources at **the operating system level**.
- Ex: Parallels Virtuozzo, SUN Solaris Containers

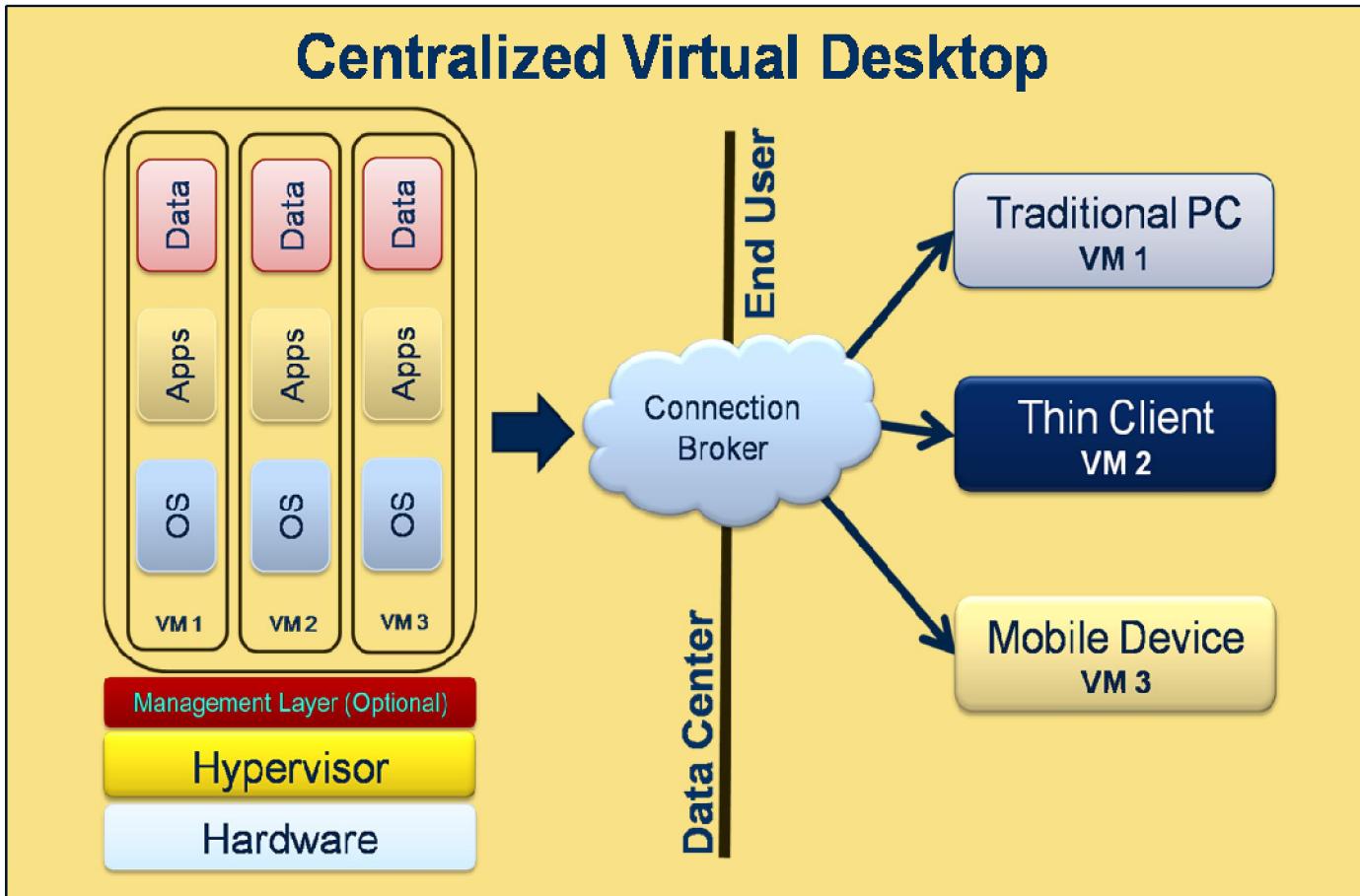
Network Virtualization

- The logical **segmentation of a physical network**
- Ex: VPN, VLAN

Storage Virtualization

- **The pooling of multiple physical storage devices, often different types into a single logical device.**
- Ex: NAS gateway

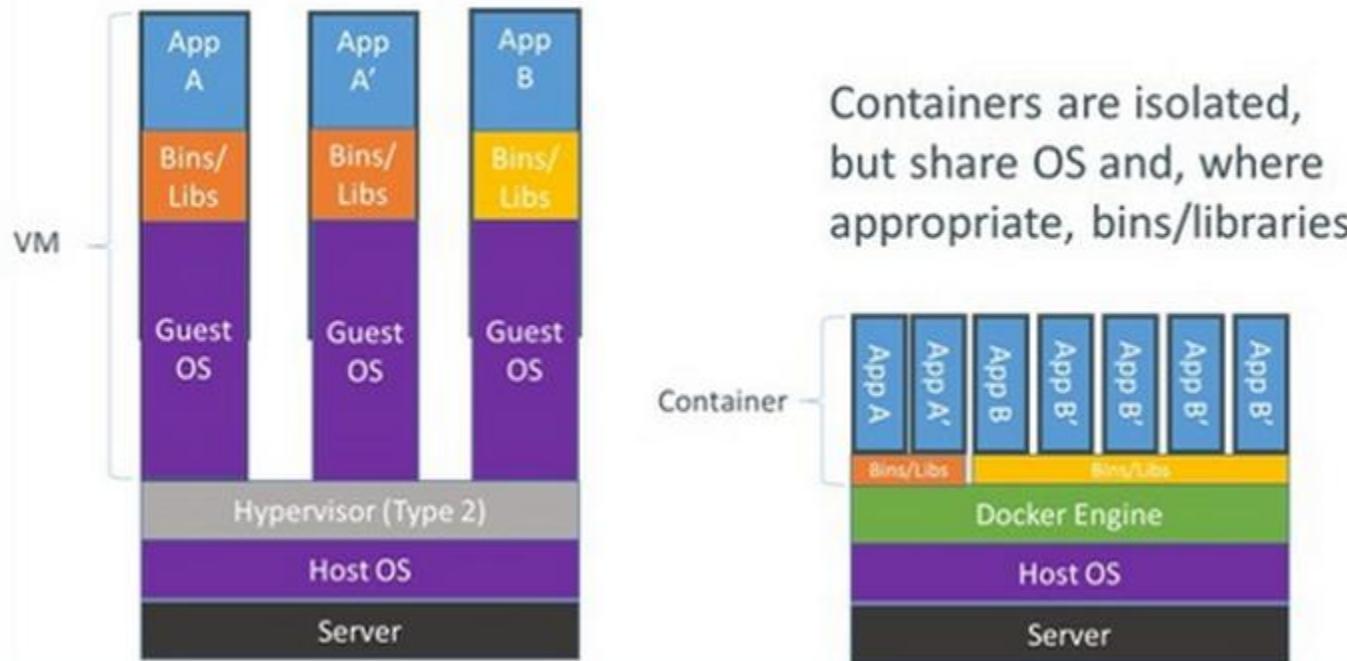
Desktop Virtualization



Container

- More light-weight than virtual machine
- Docker is popular

Containers vs. VMs

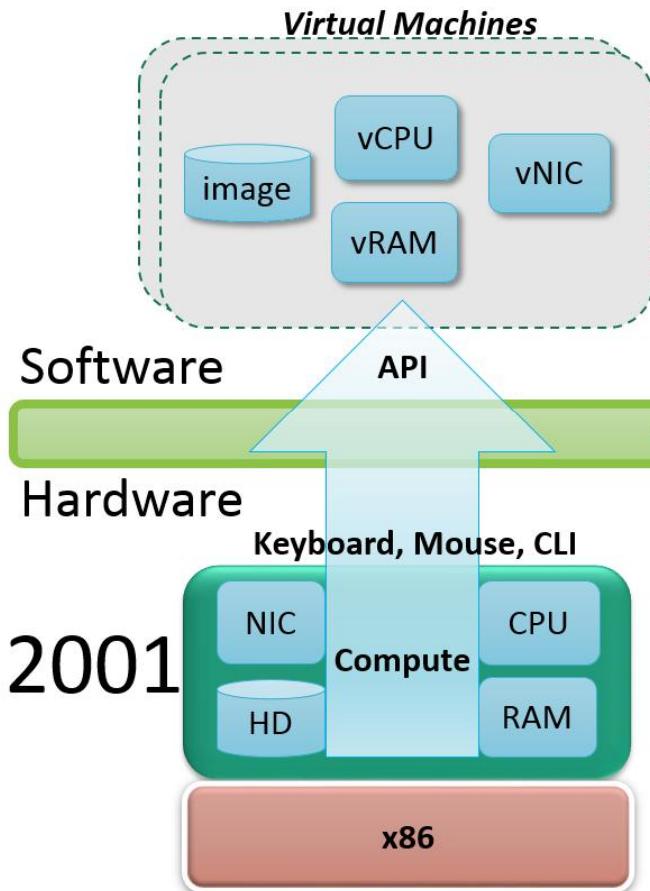


Network Virtualization

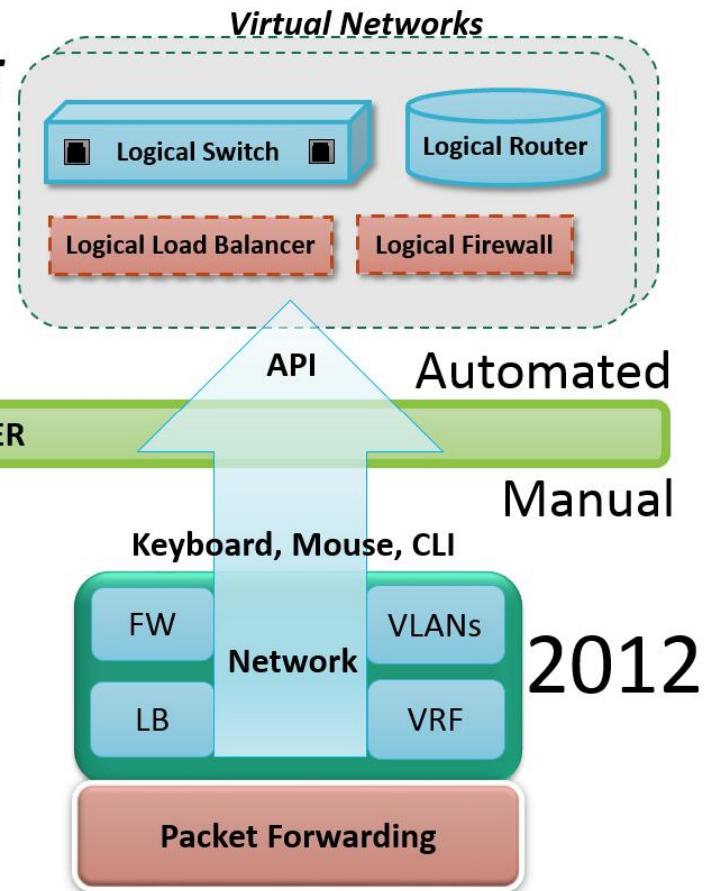


Virtual networks are placed on top of physical network elements

Server Virtualization

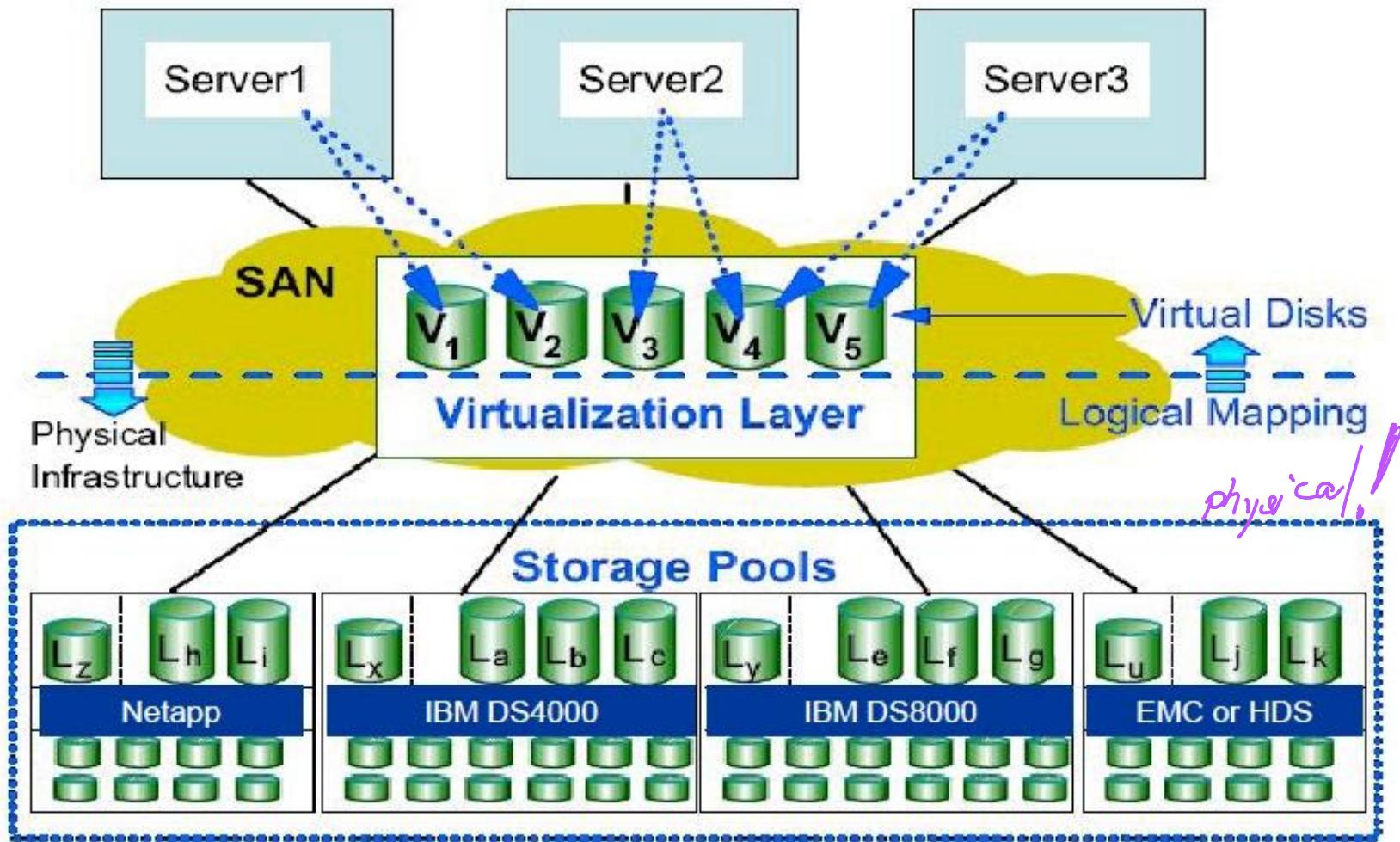


Network Virtualization



Storage Virtualization

Logical storage appears and behaves as physical storage directly connected to host, by combining multiple storage devices into a single storage pool



Virtualization in Cloud

