

Cloud Programming:

Lecture 1 – Cloud Computing Overview

*National Tsing-Hua University
2016, Spring Semester*

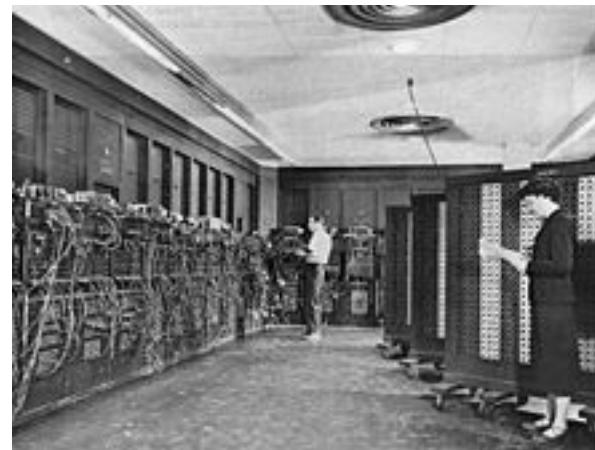


Outline

- History & Trend of Computing
- What is Cloud Computing ?
 - Properties and characteristics
 - Benefits from cloud computing
 - Obstacles of Cloud
- Service and Deployment models
 - Three service models
 - Four deployment models
- Cloud Enabling Technologies

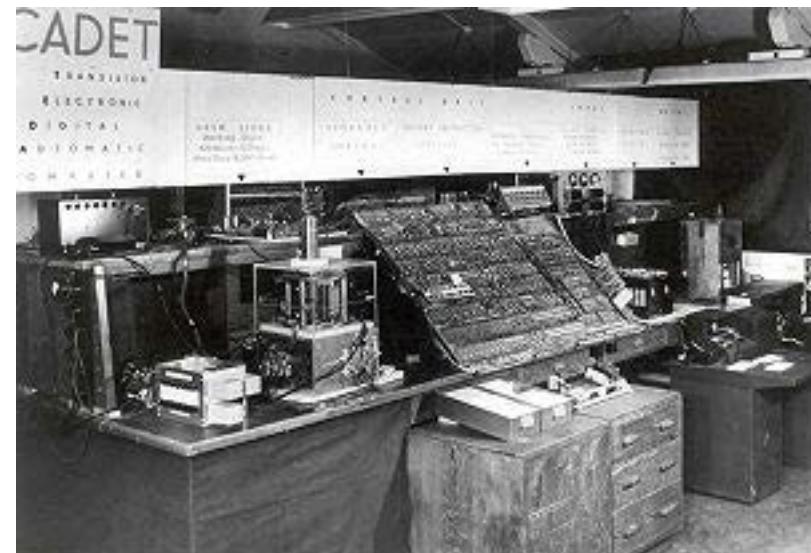
First-generation: Vacuum Tubes (1940-1956)

- 1946 ENIAC: first electronic general purpose computer
- In 1954, IBM 650
 - Main body 900 kg,
 - Power supply 1350 kg
 - Size: 1.5m*0.9m*1.8 m
 - Memory: 2,000 ten-digit word



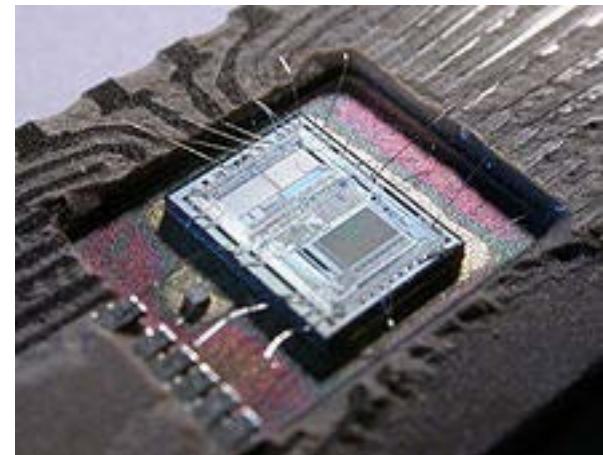
Second-generation: Transistors (1956-1963)

- 1955 Harwell CADET: first fully transistorised computer
 - 200 transistors and 1,300 solid-state diodes and had a power consumption of 150 watts.



Third-generation: Integrated Circuits (1964-1971)

- Making use of Jack St. Clair Kilby's and Robert Noyce's independent invention of the integrated circuit (or microchip).
- Transistors were miniaturized and placed on silicon chips, called semiconductors
- In 1966, Hewlett-Packard entered the general purpose computer business with its HP-2116



Intel 8742 eight-bit microcontroller IC

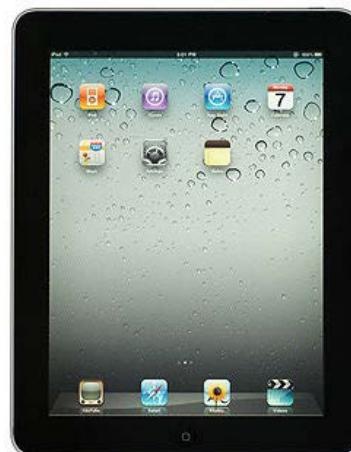
Fourth-generation: Microprocessors (1971-Present)

- Thousands of integrated circuits were built onto a single silicon chip
- In 1975, Apple I, first personal computer
- 1981, IBM-PC announced
- 1981, Osborne 1, the first laptop

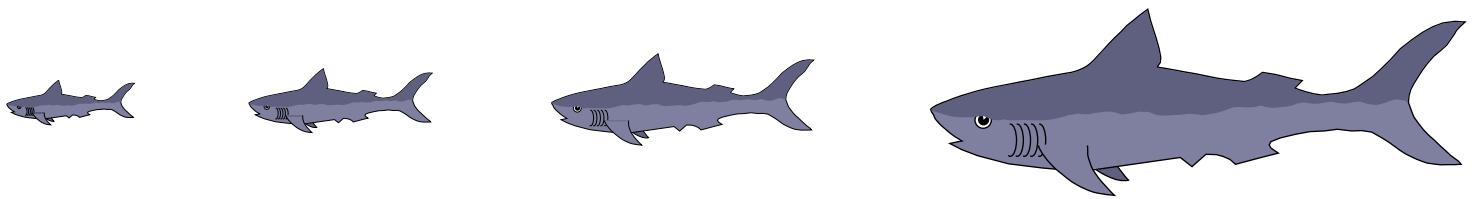


Past Decade

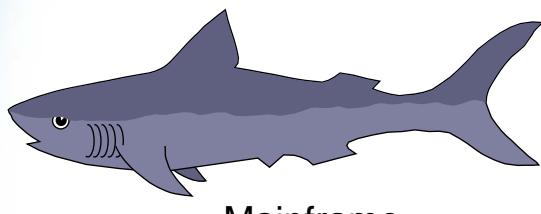
- 2003 IBM sold its PC department to Lenovo
- 2007: Apple released the first iPhone
- 2010: Apple released the first iPad,
 - Sold 3 million of the devices in 80 days.
- 2011 HP separated its PC department



Traditional Food Chain



Food Chain of Computer



Mainframe



Workstation



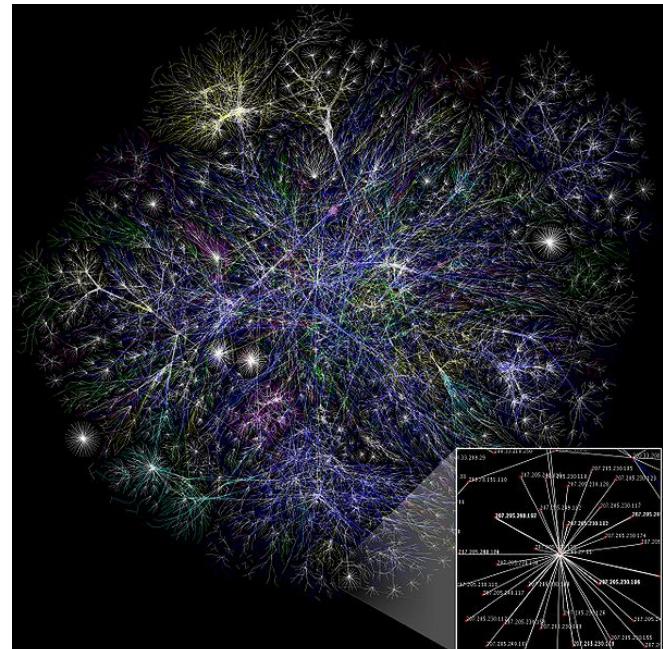
PC



Mobile devices

The Story of the Internet

- First message sent over Arpanet, 1969
- First email over Arpanet, 1971
- The name Internet, 1974
- World Wide Web, 1989
- Wireless App Protocol, 1997
- Google launched, 1998
- DotCom bubble bursts, 2000
- Wikipedia launched, 2001
- Facebook 2004



What's Next?

- Computing devices are smaller and smaller
- Ubiquitous networking, IoT

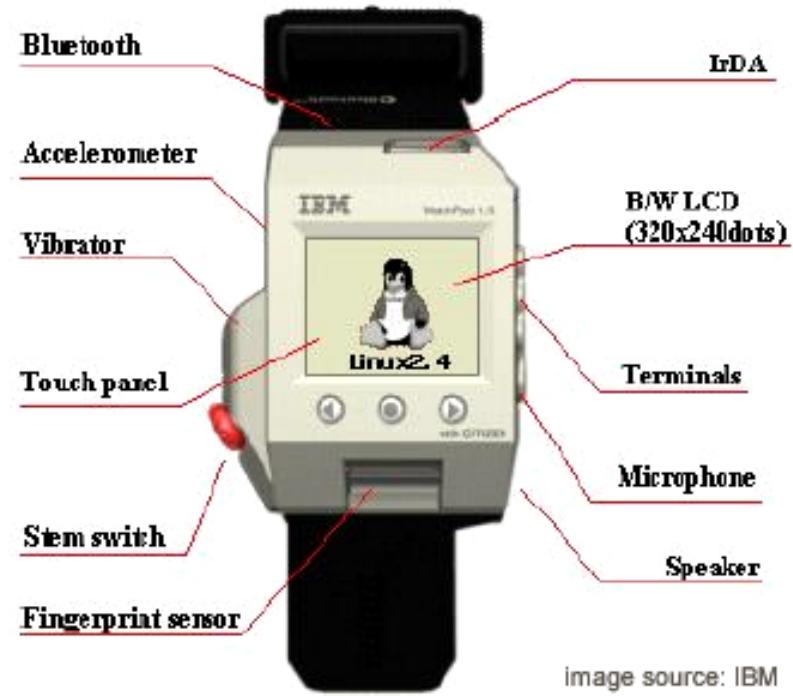
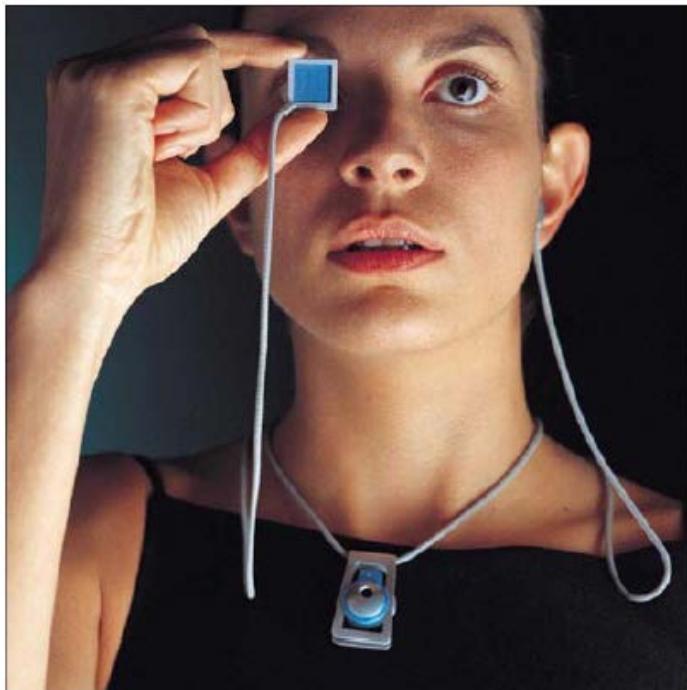
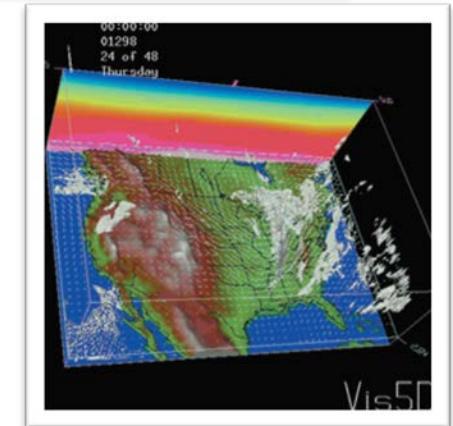
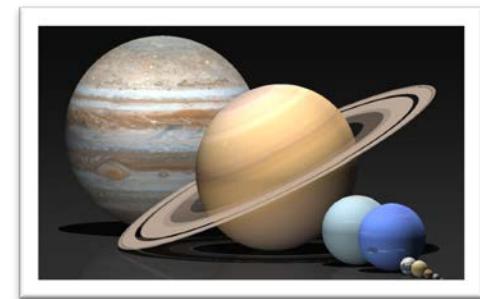
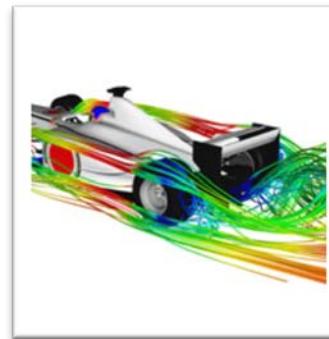


image source: IBM

But...

- The demands of computing power are increasing.
 - Scientific application
 - Computer animation
 - Computer games
 - Image processing
 - Data mining
 - ... etc
- ***Where & How*** to get the desired computing power?





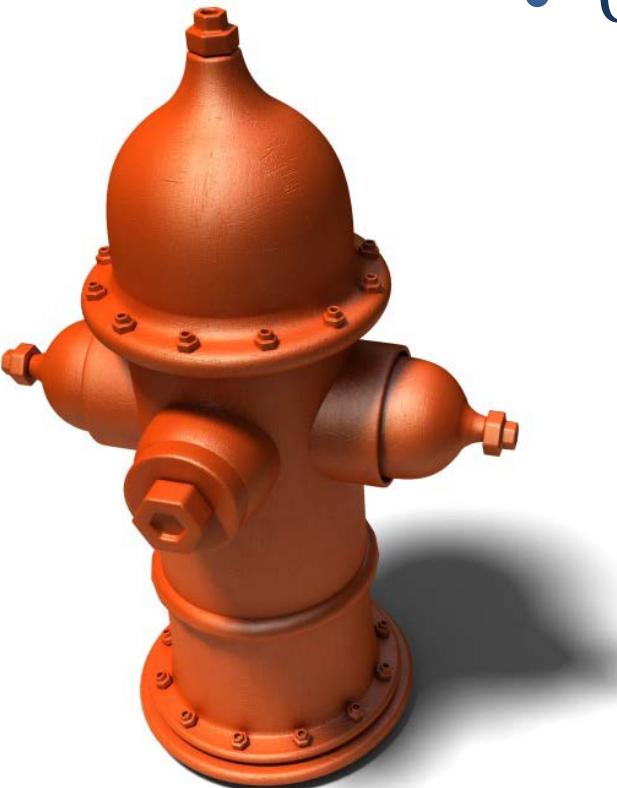
Computing will one day be...



The 5th Utility



Utility Computing



- One service provisioning model
 - Service provider makes **computing resources** and **infrastructure management** available to the customer as needed, and **charges them for specific usage** rather than a flat rate.
 - Like other types of on-demand computing , the utility model seeks to **maximize the efficient** use of resources and/or **minimize associated costs**.

- Perspective from user :
 - Don't care how it works, only **what they get**
 - Don't care what it takes, only the **quality of service**
 - Don't care who own it, only **pay as many as they used**
- Functionalities of service :
 - A service should be well-defined
 - A service should be self-contained
 - A service should not depend on the context or state of other services.



What Is Web Service?

- Definition :
 - Web service is **self-describing** and **stateless modules** that perform discrete units of work and are available over the network
 - Web service providers offer **APIs** that enable developers to exploit functionality **over the Internet**



Quality Of Service (QoS)

- Original definition
 - Quality of Service (QoS) is a set of technologies for managing **network** traffic in a cost effective manner to enhance user experiences for home and enterprise environments.
- Now becomes to a broad term:
 - Issues that have a direct impact on the experience of the customer



Service Level Agreement (SLA)

- Definition
 - A SLA is a **contract** between a service provider and a customer that specifies, usually in **measurable terms** (QoS), what services provider will furnish
- Common content in contract
 - Performance guarantee metrics
 - Up-time and down-time ratio
 - System throughput
 - Response time
 - Problem management detail
 - Penalties for non-performance
 - Documented security capabilities



Here Comes the “Cloud”

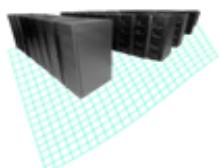
- Cloud is part of the computing evolution
- *Computing has transformed into a model consisting of services that are commoditized and delivered in a manner similar to traditional utilities*

2009

1990

Distributed Computing

- Solving large problems in parallel



Utility Computing

- Offering computing resources as a metered service



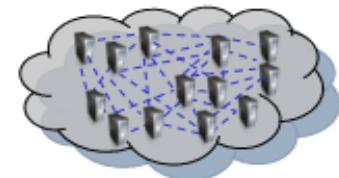
Software as a Service

- Network-based subscriptions to applications



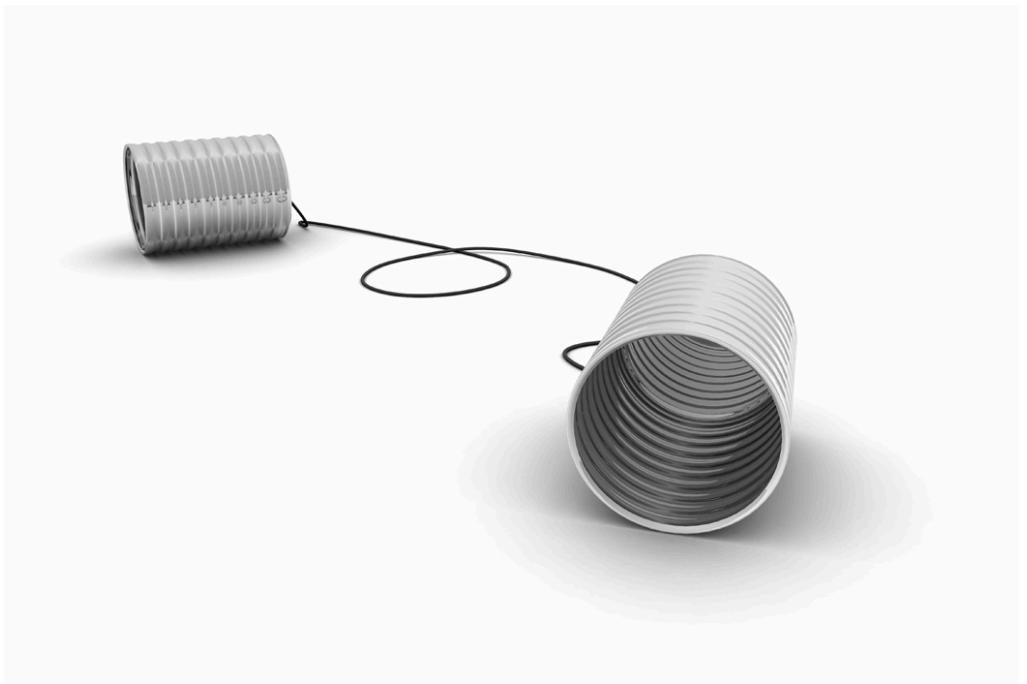
Cloud Computing

- Anytime, anywhere access to resources delivered on-demand as a service



Cloud Computing Players more and more...





What do they say ?

WHAT IS CLOUD COMPUTING ?

Cloud Disclaimers

- Oracle CEO *Larry Ellison*
 - We've redefined Cloud Computing to include everything that we already do. I don't understand what we would do differently other than change the wording of some of our ads.



Cloud Disclaimers

- ***Rich Stallman***

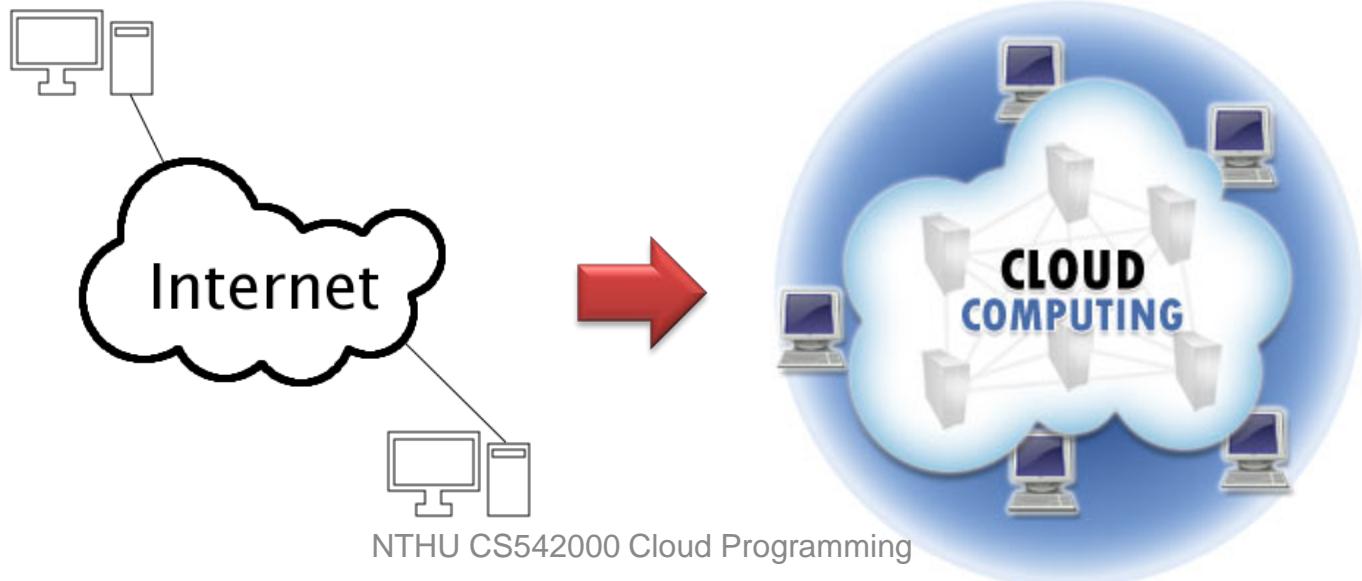
- Founder of Free Software Foundation
- It's stupidity. It's worse than stupidity: it's a marketing hype campaign. Somebody is saying this is inevitable – and whenever you hear somebody saying that, it's very likely to be a set of businesses campaigning to make it true.



What is Cloud?

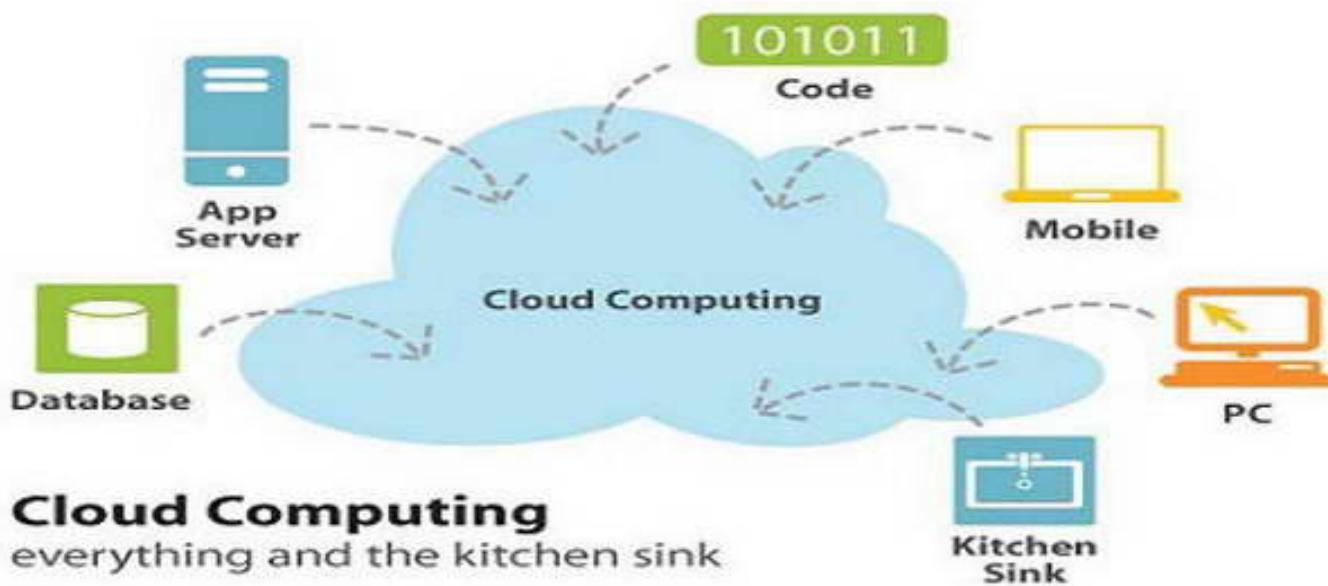
- Definition from ***Whatis.com***

- The name cloud computing was inspired by the cloud symbol that's often used to represent the Internet in flowcharts and diagrams. Cloud computing is a general term for anything that involves delivering hosted services over the ***Internet***.



What is Cloud?

- **Cloud computing** is a **distributed** technology which delivers hosted services over the **internet** to provide **easy access, scalable (and elastic) IT services**





Properties and characteristics

WHAT IS CLOUD COMPUTING ?

Definition from NIST

- Cloud computing is a **model** for enabling 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.
- Five characteristics
 - On-demand self-service.
 - Broad network access.
 - Resource pooling.
 - Rapid elasticity.
 - Measured Service.



National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

1. *On-demand Self-service*

- NIST Definition: A consumer can **unilaterally** provision computing capabilities, such as server time and network storage, as needed **automatically** without requiring human interaction with each service's provider.



Cloud Business Model

- Resource is made available is transparent and not a concern of a subscriber through an *online control panel*
- Computing *capacities can be adjusted dynamically* according to demands
- A business model in place to support “*pay according to how much you have consumed*”

2. *Broad Network Access*

- NIST Definition: Capabilities are available over the **network** and accessed through standard mechanisms that promote use by **heterogeneous** thin or **thick client platforms** (e.g., mobile phones, laptops, and PDAs).



Anyone !
Anytime !
Anywhere !

Web-Based Uniform Access

- Nowadays, **web browser** technique is one of the most widespread platform in almost any intelligent electronic devices.
- Cloud service delivery their services with ***web-based interface through the Internet.***



Thin Client

- What is thin client ?
 - Thin client is a computer or a computer program which depends heavily on some other computer to fulfill its traditional computational roles.
- Characteristics :
 - Cheap client hardware
 - Diversity of end devices
 - Client simplicity



3. Resource Pooling

- NIST Definition: The provider's computing resources are **pooled** to serve multiple consumers using a **multi-tenant** model, with different physical and virtual resources dynamically **assigned and reassigned according to consumer demand**.



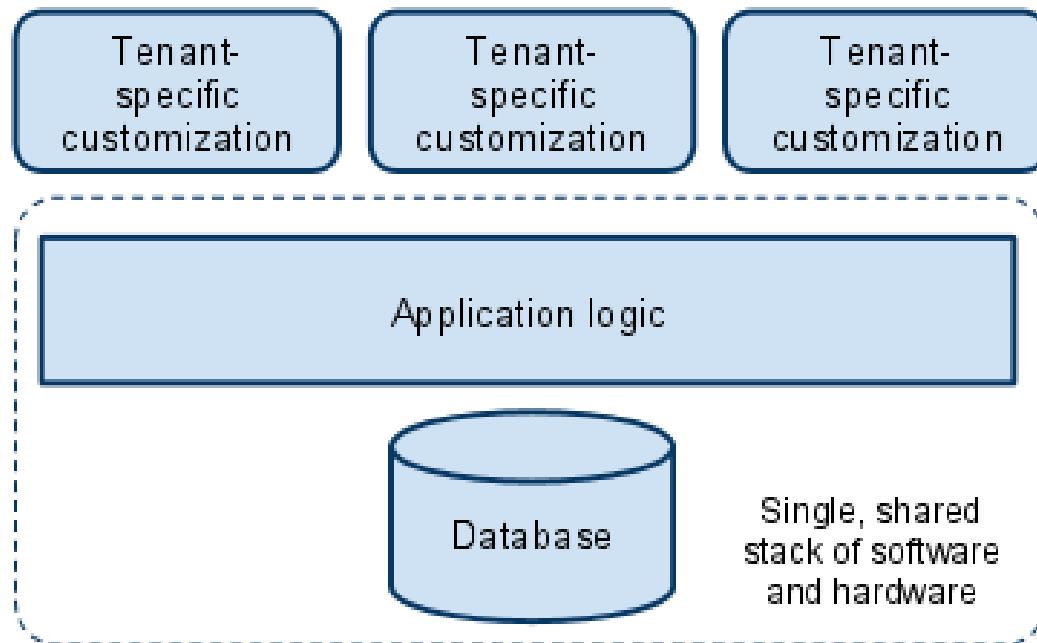
Data Center

- Google: (not formally disclose)
 - ~900,000 servers
 - 206,040 sqft (50 basketball courts)
 - 12 sites in US, 5 sites in EU
- Manage and maintain a pool of resources is a big problem
 - Container data center
 - Modular data center



Multi-tenancy

- In a multi-tenant environment a **single application** can be used and **customized** by different *organization* as if they each have a separate instance.



4. *Rapid Elasticity*

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



**Give me the world
without limitation!!**

Story That Happens Every Time

離譜 台鐵網路票 第1分鐘就塞爆

2010年 01月28日

【李姿慧／台北報導】台鐵昨早六時開賣春節東部車票，才一開放網路系統，台鐵訂票系統昨一開放就狂塞，不少民眾瘋狂到票，與往年平均有「一步重信」就坐上車。台鐵表

台鐵表示，初步調查發現昨清晨六時一開放訂票就發現網路系統異常，每秒瞬間流量達八萬八千多筆，比去年六萬筆多出近五成，且第一分鐘僅有一千四百二十八人成功訂票，遠低於去年第一分鐘有七千多人成功訂票，「最離奇的是，第一分鐘僅有百分之三點七約五十二人是用網路買到票，但正常比率應是八成，今年是網路凸槌最嚴重的一次，但中華電聲稱是流量太大導致。」

台鐵昨早六時開賣春節東部車票，才一開放網路系統，台鐵訂票系統昨一開放就狂塞，不少民眾瘋狂到票，與往年平均有「一步重信」就坐上車。台鐵表

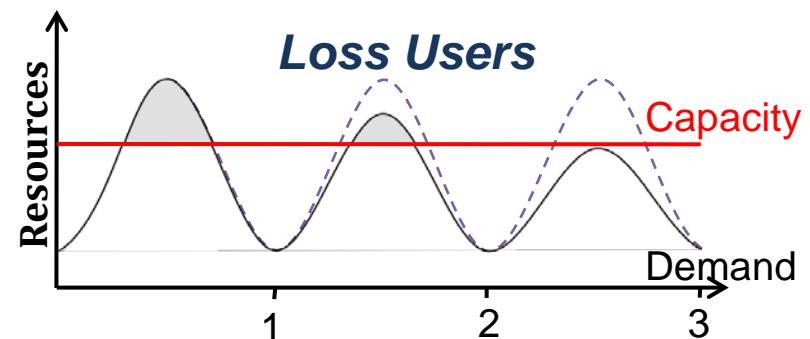
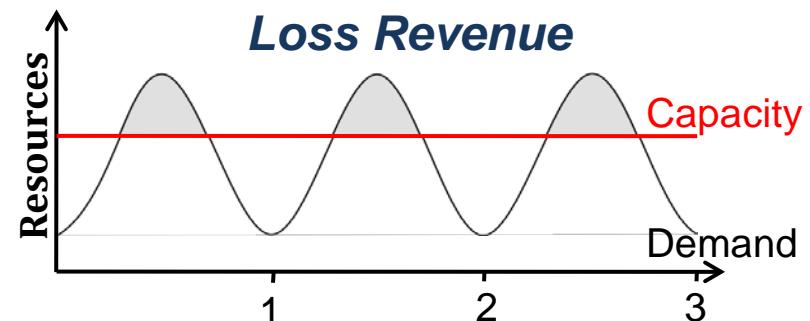
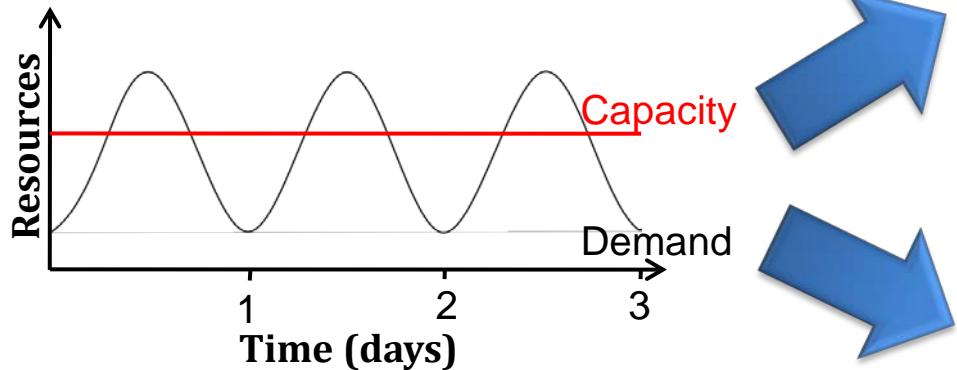
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一個半小時，民眾林先生不滿的去就是掛掉，每次網路當掉台鐵量大不是事先料想到的嗎？還以食！」

，想買花蓮到高雄的車票，試代道路都沒用，還不如想辦法民怨不斷，有網友說訂不到票毫無歉意的說：「現在都塞爆

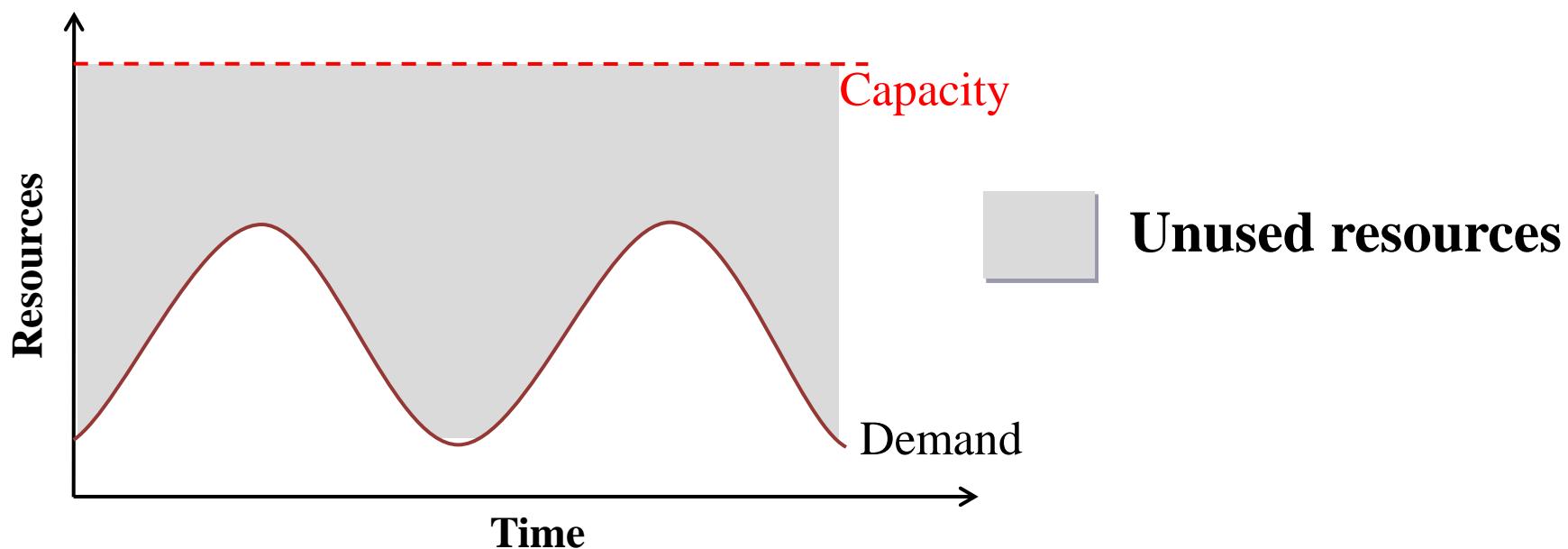
Dynamic Provisioning

- In traditional computing model, two common problems :
 - Underestimate system utilization which result in under provision



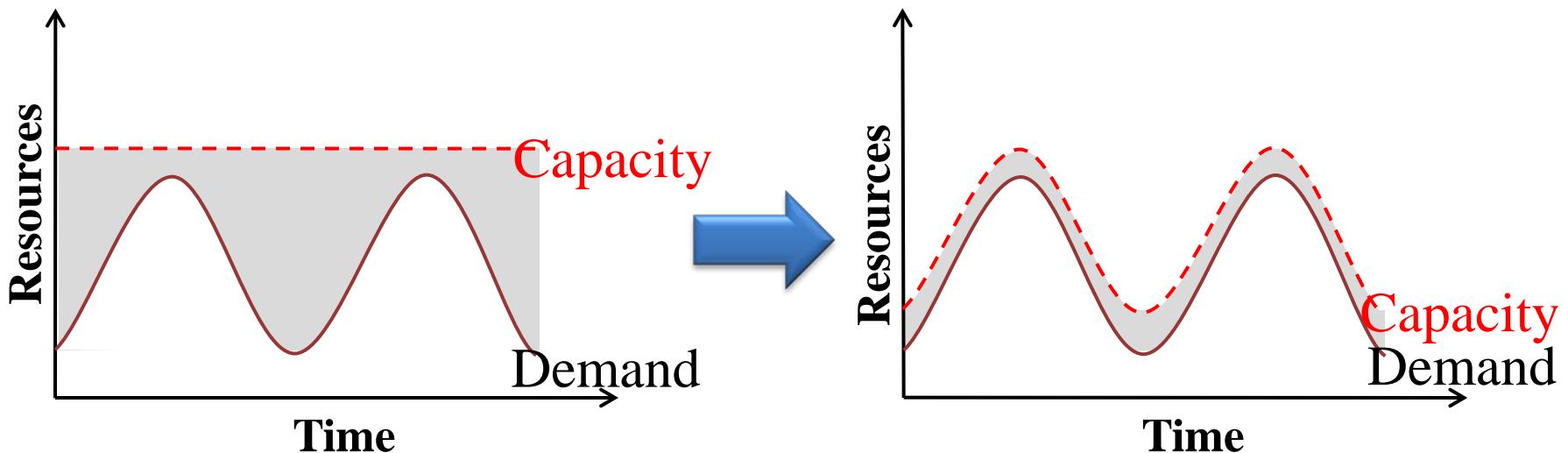
Dynamic Provisioning

- Overestimate system utilization which result in low utilization



Dynamic Provisioning

- Cloud resources are provisioned ***dynamically***
 - Meet seasonal demand variations
 - Meet demand between different industries
 - Meet burst demand for some extraordinary events



5. Measured Service

- NIST Definition: Cloud systems automatically control and optimize resource use by leveraging a **metering** capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts).
 - Typically through a **pay-per-use** business model
 - Resource usage can be **monitored, controlled, and reported**, providing transparency for both the provider and consumer of the utilized service.

Monitoring System

- What should be monitored in the Cloud ?
 - Physical and virtual hardware state
 - Resource performance metrics
 - Network access patterns
 - System logs
 - ... etc
- Anything more ?
 - Billing system



Billing System

- Billing System in Cloud
 - Users **pay as many as they used**
 - Must first **determine the list of service usage price**
 - Record the resource or service usage of each user, and then **charge users by these records**
- How can cloud provider know users' usage ?
 - Get those information by means of monitoring system.
 - Automatically calculate the billing amount of users
 - **Automatically request money from user's banking account**



Amazon EC2 Pricing

	Linux/UNIX Usage	Windows Usage
Standard On-Demand Instances		
Small (Default)	\$0.085 per Hour	\$0.115 per Hour
Medium	\$0.170 per Hour	\$0.230 per Hour
Large	\$0.340 per Hour	\$0.460 per Hour
Extra Large	\$0.680 per Hour	\$0.920 per Hour
Micro On-Demand Instances		
Micro	\$0.020 per Hour	\$0.020 per Hour
High-Memory On-Demand Instances		
Extra Large	\$0.506 per Hour	\$0.570 per Hour
Double Extra Large	\$1.012 per Hour	\$1.140 per Hour
Quadruple Extra Large	\$2.024 per Hour	\$2.280 per Hour
High-CPU On-Demand Instances		
Medium	\$0.186 per Hour	\$0.285 per Hour
Extra Large	\$0.744 per Hour	\$1.140 per Hour
Cluster Compute Instances		
Quadruple Extra Large	N/A*	N/A*
Cluster GPU Instances		
Quadruple Extra Large	N/A*	N/A*



What can we gain from cloud ?

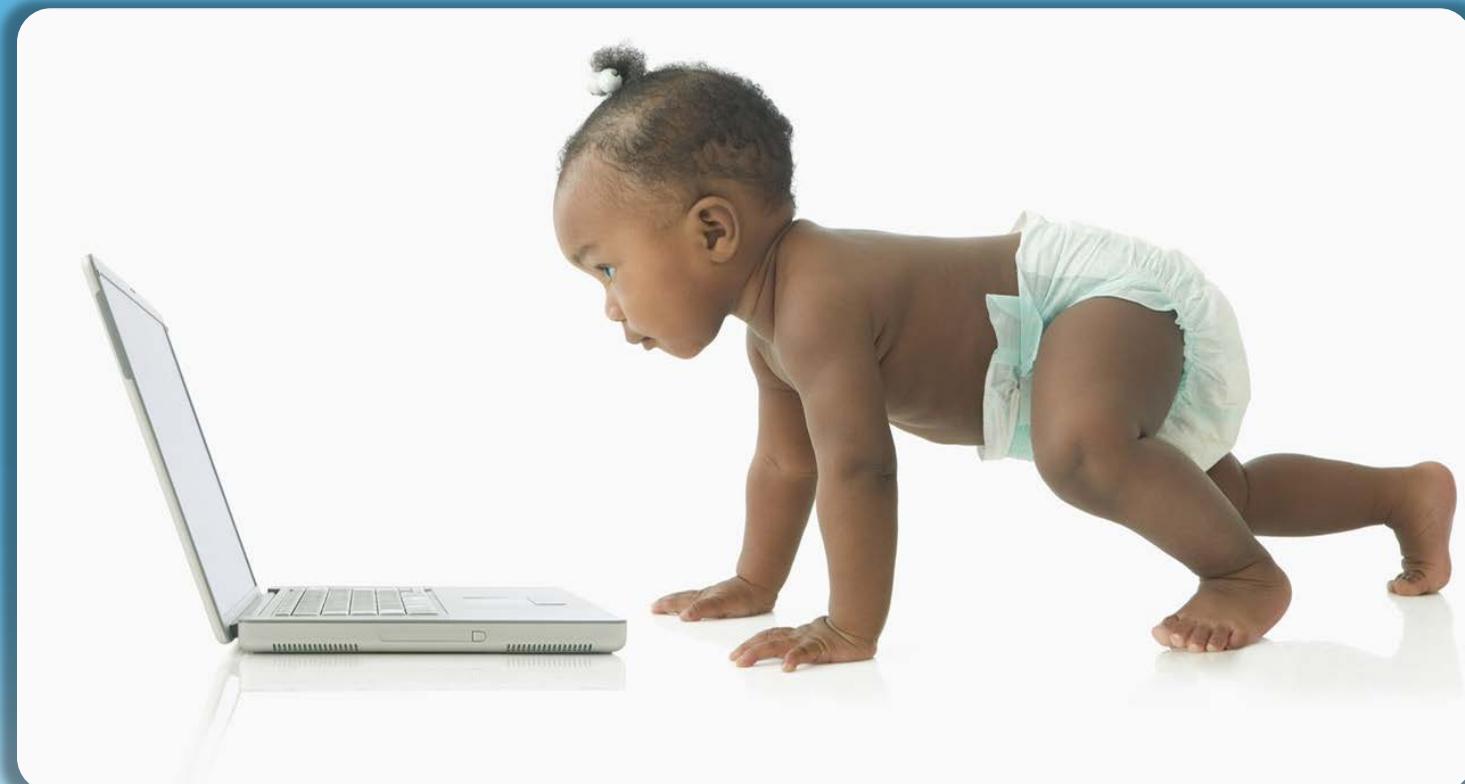
WHAT IS CLOUD COMPUTING ?

Benefits From Cloud

- Cloud computing brings many benefits :
 - For the end user and individuals
 - Lower computer costs
 - Improved performance
 - Instant update & free software
 - Device independence
 - For the market and enterprises
 - Reduce initial investment
 - Reduce capital expenditure
 - Improve industrial specialization
 - Improve resource utilization



For End User and Individual



Lower Computer Costs

- Without Cloud:
 - One needs to buy your own personal computer
 - Require more powerful processor, larger memory, bigger disk
 - High-end devices consume more power
- With Cloud:
 - Only need a cheap PC to access *Internet!!!*



Improved Performance

- Without Cloud:
 - Limited by the resource on your local device for storage, computation, etc.
 - Resource & performance optimized by professionals
- With Cloud:
 - Unlimited computation power
 - Unlimited storage capacity
 - Resource managed by user



VS.



Instant Update & Free Software

- Without Cloud:
 - Buy and install your own software
 - Face repeated cost for SW update and maintenance
- With Cloud:
 - Free SW provided by Cloud provider (e.g. Google Doc)
 - Latest version avail. and maintained by Cloud provider



Devices Independence

- Without Cloud:
 - PC is the only affordable device that could provide sufficient computation power and storage capacity
- With Cloud:
 - Access data & service from any device with any OS
 - Allow the variety use of end devices, including more ***portable and thin devices***



It is all about CONVENIENCE to user!!!

For Market and Enterprises



- What is IT:
 - a branch of engineering dealing with the use of **computers** and **telecommunications** equipment to store, retrieve, transmit and manipulate **data**
- Computers and information systems are essential parts of every business today



Information Technology (IT) Industry

- If you think maintaining a computer is a lot of work, think about people need to manage a bunch of computers.
 - Hardware/software upgrade, downgrade
 - Network facility and management
 - Heat problem, power consumption
 - Place to host the machines
 - User account management
 - Technician, technical support
 - Trouble shooting

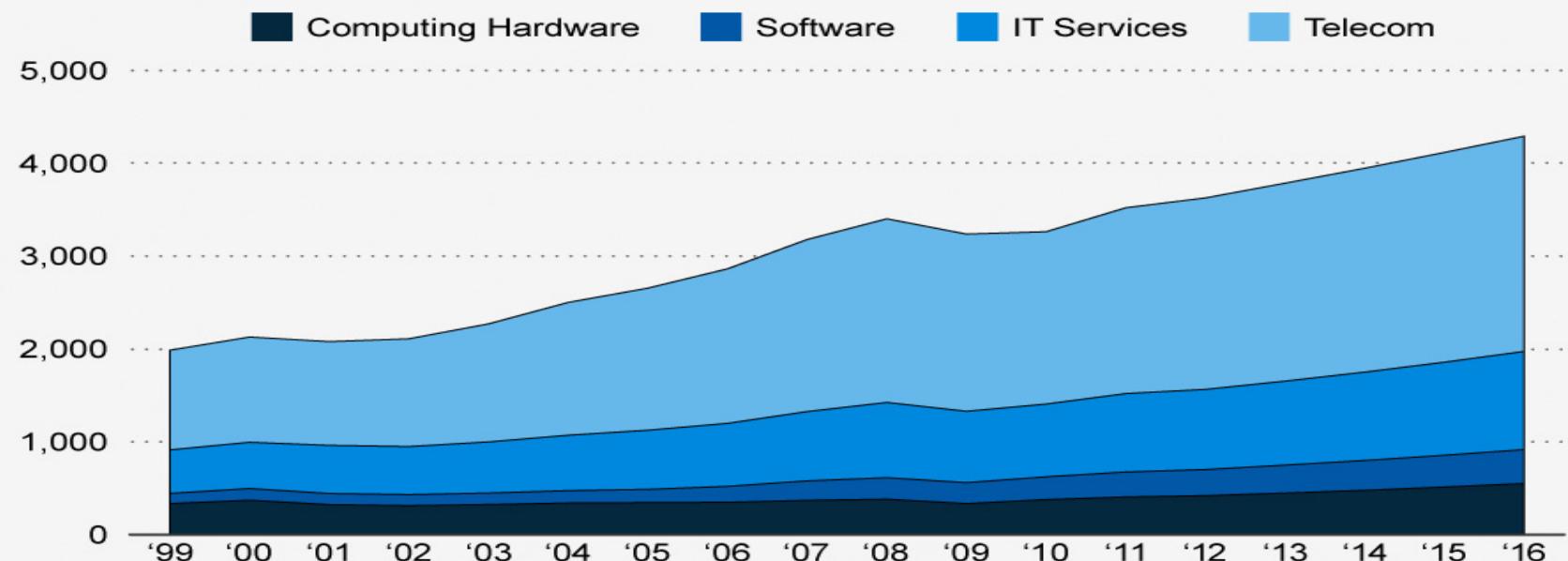


Information Technology (IT) Industry

- Relative less money spent on HW/SW...

Worldwide IT Spending to Pass \$ 3.6 Trillion in 2012

Worldwide IT Spending Forecast in billion U.S. dollars



Reduce Capital Expenditure

- Without Cloud provider
 - Each enterprise must establish its own IT Dept.
 - Enterprises pay for all IT investment and human resource
- With Cloud provider
 - Enterprise can almost dismiss its IT department
 - Enterprises only *rent* the service they need and care
 - Enterprise *pays* to cloud provider as many as the *service used*

Reduce Initial Investment

- Traditional process to initiate business :
 - Survey and analysis the industry and market
 - Estimate the quantity of supply and demand
 - Purchase and deploy IT infrastructure
 - Install and test the software system
 - Design and develop enterprise specific business service
 - Announce the business service to clients
- Some drawbacks :
 - The survey, analysis and *estimation may not 100% correct*
 - Infrastructure deployment is *time consuming*

Reduce Initial Investment

- Initiate business with Cloud services :
 - Survey and analysis the industry and market
 - Estimate the quantity of supply and demand
 - ~~Purchase and deploy IT infrastructure~~
 - ~~Install and test the software system~~
 - Chose one cloud provider for enterprise deployment
 - Design and develop enterprise specific business service
 - Announce the business service to clients
- Some benefits :
 - Enterprise can develop and *deploy business in short time*
 - Enterprise can *reduce the loss of wrong investment*

Improve Industrial Specialization

- Without Cloud providers:
 - IT resource is managed by enterprise themselves
 - Most enterprises are lacking of experience for managing IT
- Collaboration with Cloud providers :
 - Cloud providers employ experts for management and administration
 - Cloud providers focus on providing reliable IT services
- Some benefits :
 - IT service performance will be optimized
 - Enterprise business focus will be enhanced

Improve Resource Utilization

- Without Cloud provider:
 - Enterprise seldom optimizes their IT resource usage
 - IT resource usually over invested for ***peak demand***
- Collaboration with Cloud providers :
 - IT resources are centrally managed and optimized
- Some benefits :
 - IT infrastructure can be shared among enterprises
 - Large-scale integrated optimization can be applied across geographic locations & organizations

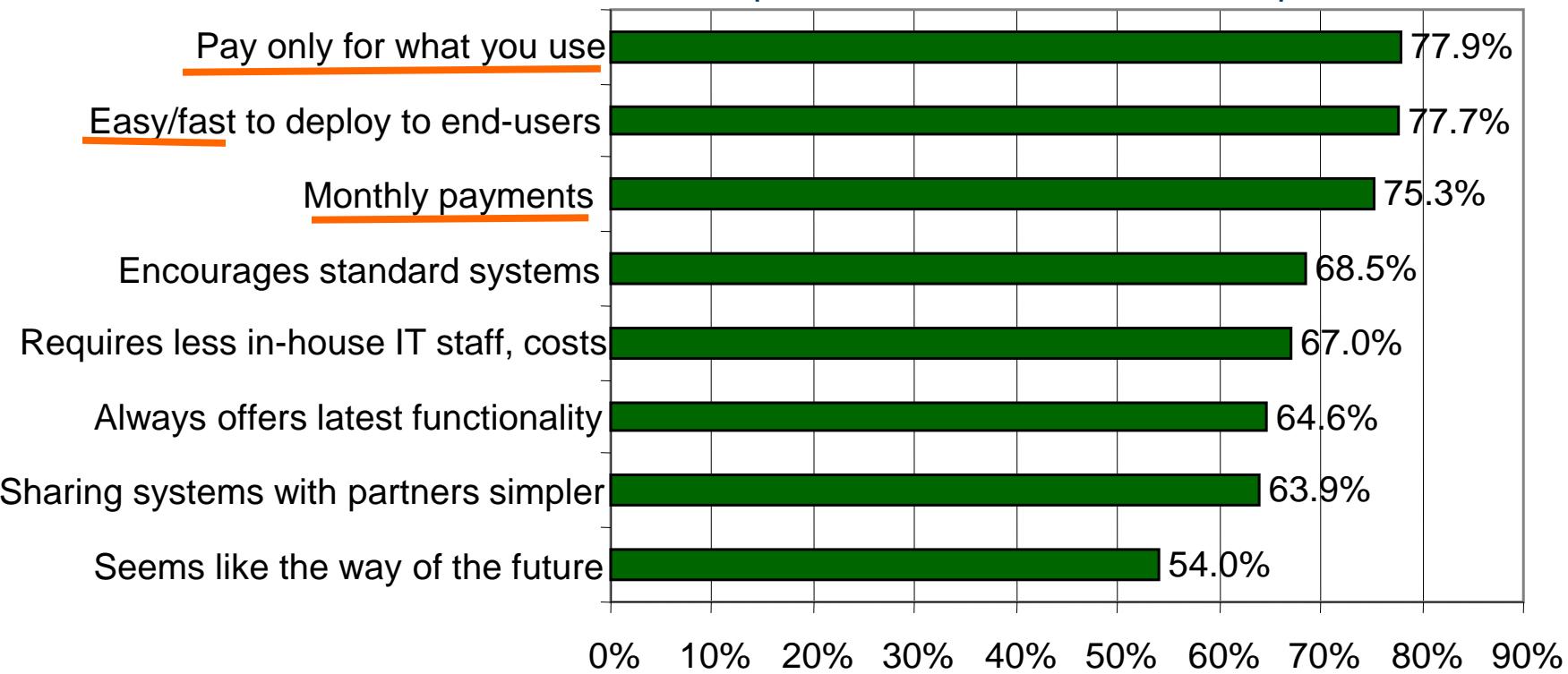
Enterprise Benefit Summary

	Traditional	With Cloud Computing
Infrastructure	<i>Enterprise owns the infrastructure</i>	<i>Cloud provider owns the infrastructure</i>
IT Capital	<i>Pay for all investment and human resource</i>	<i>Enterprise pays as the service used</i>
IT Management	<i>Enterprise works with poor manageability</i>	<i>Cloud provider applies professional control & service</i>
IT Resource Utilization	<i>IT resource under utilized most of time</i>	<i>Share to improve utilization of IT resource</i>
Business Focus	<i>Enterprise needs to take care everything</i>	<i>Enterprise focuses on its own business</i>

Benefits from Cloud Computing

Q: Rate the *benefits* commonly ascribed to the 'cloud'/on-demand model

Source: IDC Enterprise Panel, 3Q09, n = 263, September 2009



It is all about MONEY to industry!!!

Obstacles of cloud

WHAT IS CLOUD COMPUTING ?

10 Obstacles of Cloud

Obstacle	Opportunity
1 Availability/Business Continuity	Use Multiple Cloud Providers
2 Data Lock-In	Standardize APIs; Compatible SW to enable Surge or Hybrid Cloud Computing
3 Data Confidentiality and Auditability	Deploy Encryption, VLANs, Firewalls
4 Data Transfer Bottlenecks	FedExing Disks; Higher BW Switches
5 Performance Unpredictability	Improved VM Support; Flash Memory; Gang Schedule VMs
6 Scalable Storage	Invent Scalable Store
7 Bugs in Large Distributed Systems	Invent Debugger that relies on Distributed VMs
8 Scaling Quickly	Invent Auto-Scaler that relies on ML; Snapshots for Conservation
9 Reputation Fate Sharing	Offer reputation-guarding services like those for email
10 Software Licensing	Pay-for-use licenses

Source: "Above the Clouds: A Berkeley View of Cloud Computing." Published on February 10th, 2009

Availability/Business Continuity

- Reality:
 - No one is 100% reliable
 - DDoS attack
- Opportunity:
 - Use multiple cloud providers, no single source failure
 - Libcloud <https://libcloud.apache.org>
 - Rightscale Multi-Cloud platform
 - Nasuni <http://www.nasuni.com/>

Amazon outage takes down Reddit, Foursquare, others

By Dorrine Mendoza, CNN

October 23, 2012 -- Updated 1206 GMT (2006 HKT) | Filed under: Web

9 September 2011 Last updated at 12:19 GMT

Microsoft online services hit by major failure

Millions of Microsoft users were left unable to access some online services overnight because of a major service failure.



Temporary service interruption

Google Docs is temporarily unavailable -- please try outage notices. We apologize for any inconvenience

Outages in AWS, AppEngine, and Gmail

Service and Outage	Duration	Date
S3 outage: authentication service overload leading to unavailability [39]	2 hours	2/15/08
S3 outage: Single bit error leading to gossip protocol blowup. [41]	6-8 hours	7/20/08
AppEngine partial outage: programming error [43]	5 hours	6/17/08
Gmail: site unavailable due to outage in contacts system [29]	1.5 hours	8/11/08

Data Lock-In

- Reality:
 - No existing standard for Cloud API
 - Customers cannot easily extract their data and programs from one site to another
 - Users are vulnerable to price increases
 - What if providers going out of business
- Opportunity:
 - Standardize API (However, it will reduce provider's profit)
 - Multi-cloud service

Storage provider Linkup shut down on August 8, 2008 after losing access as much as 45% of customer data

Data Confidential & Auditability

- Reality:
 - Many data is sensitive
 - Countries have their own government laws for data privacy
- Opportunity:
 - Private cloud

EU data law changes offer opportunities for Asia's datacenter markets

Summary: Destinations such as Singapore, Malaysia or Hong Kong need to seize the opportunity of being deemed an acceptable data transfer partner with the European Union in order to get ahead of the competition.



Data Transfer Bottleneck

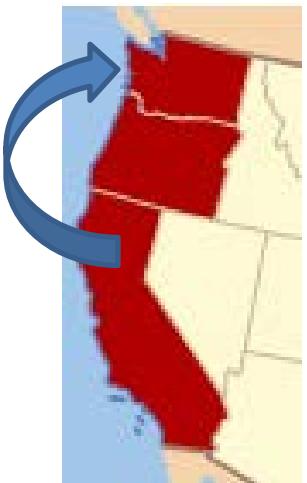
- Reality:

- The cheapest way to send a lot of data is to physically send disks or even whole computers via overnight delivery services
- E.g.: 10TB from San Francisco to Seattle
 - Through Internet: 45days, \$1000USD service charge
 - Through FedEx: 1night, \$400USD mail fee



- Opportunity:

- No charge and small latency within a cloud platform (E.g. between EC2 and S3 of Amazon Cloud Service)
- Provider better and more data service, such as data searching, backup, recover, etc.



Performance Unpredictability

- Reality:
 - Virtual Machines can share CPUs and main memory surprisingly well, but that I/O sharing is more problematic
- Opportunity:
 - Improve I/O virtualization techniques
 - Keep data in memory or flash
 - Dedicate VM for high performance computing (HPC)
 - 2011: Amazon EC2 announce new cluster computing instance for HPC

Outline

- History & Trend of Computing
- What is Cloud Computing ?
 - Properties and characteristics
 - Benefits from cloud computing
 - Obstacles of Cloud
- Service and Deployment models
 - Three service models
 - Four deployment models
- Cloud Enabling Technologies



Choose the service you need.

SERVICE MODELS

A Simple Analogy

Say, you just moved to a city and you are looking for a place to live...



What is your choice ?



Built a new house ?
Buy an empty house ?
Live in a hotel ?

Let's built a new house !!

You can fully control everything you like your new house to have. But that is a hard work ...



If you buy an empty house ?



You can customize some part of your house. But never change the original architecture.

How about live in a hotel ?

Live in a hotel will be a good idea if the only thing you care is enjoy your life!!
There is nothing you can do with the house except living in it.

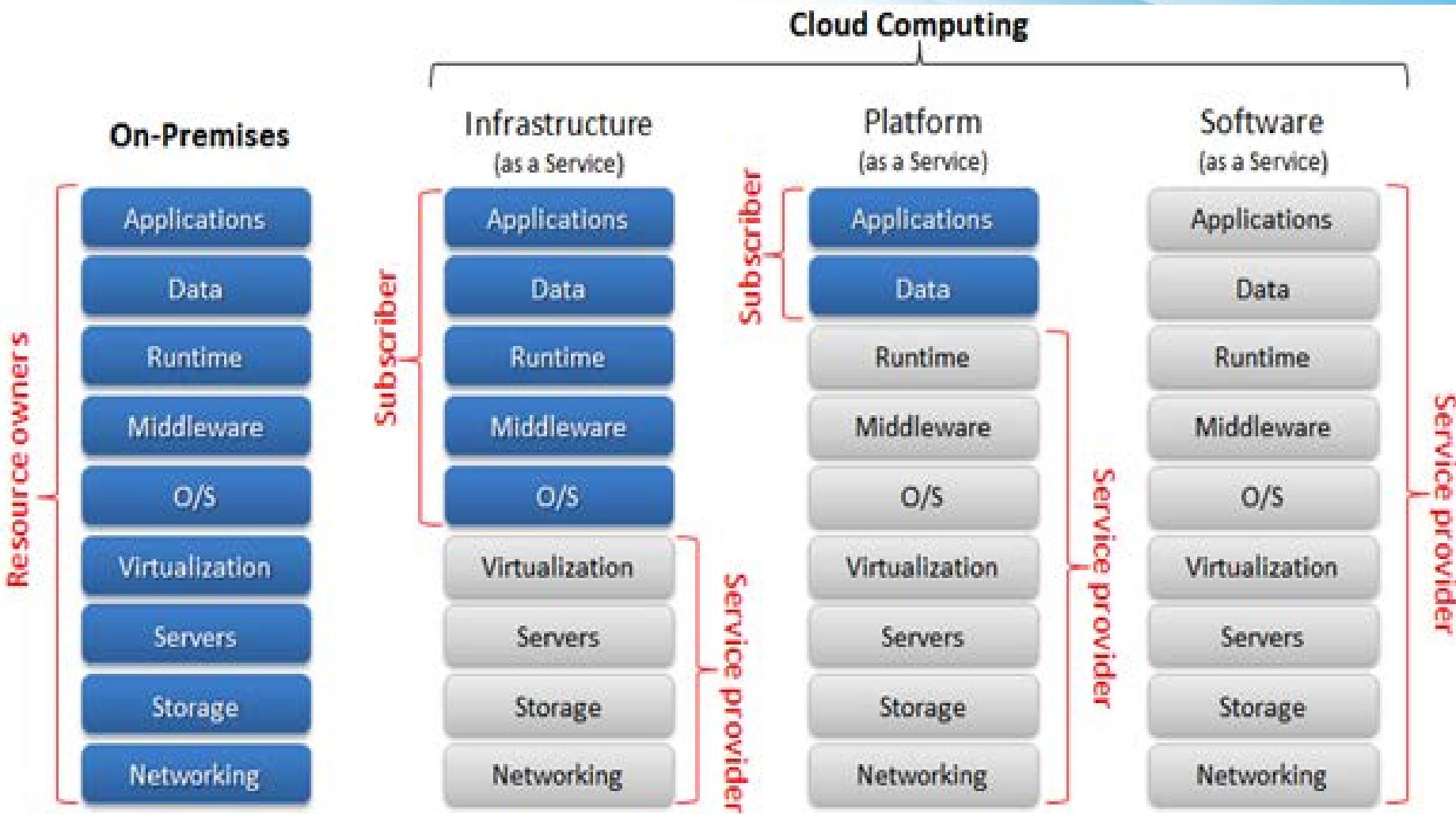


**Let's translate to
Cloud Computing !!**

Three Service Models

- What if you want to have an IT department ?
 - *Infrastructure as a Service* solution: *build a new house*
 - Rent some virtualized infrastructure/*resources* to build up your own fully controlled IT system
 - *Platform as a Service* solution: *buy an empty house*
 - Directly develop your IT system through one cloud platform, which provide lower level **resource management**
 - *Software as a Service (SaaS)* solution: *live in a hotel*
 - Directly use some existed IT **solutions** without knowing any detail technique about how these service was achieved

Separation of Responsibility

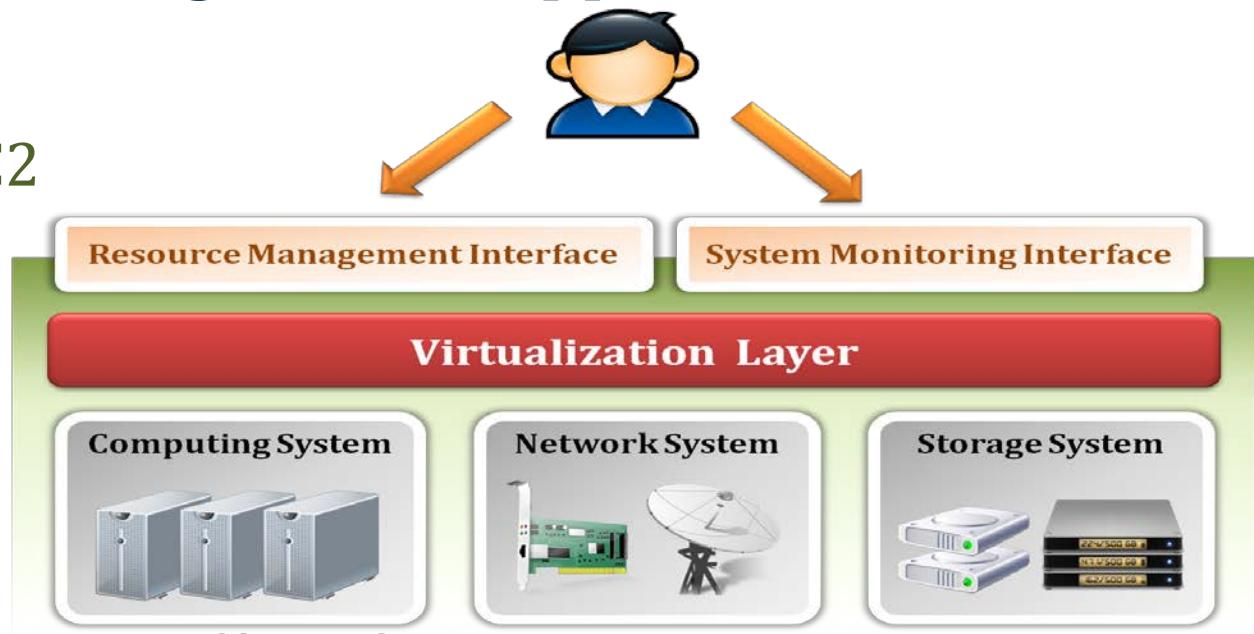


Infrastructure as a Service (IaaS)

- IaaS provides customer the capability to provision ***processing, storage, networks***, and other ***fundamental computing resources*** where the consumer is able to deploy and run arbitrary software, including OSs and applications.

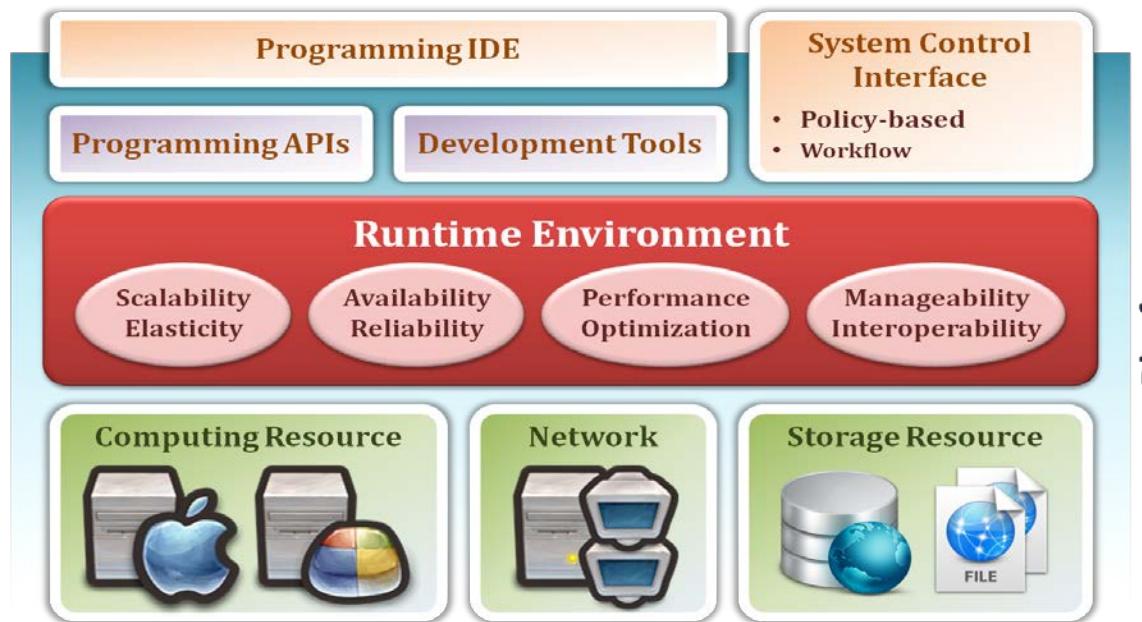
- Examples:

- Amazon EC2
- OpenStack
- etc...



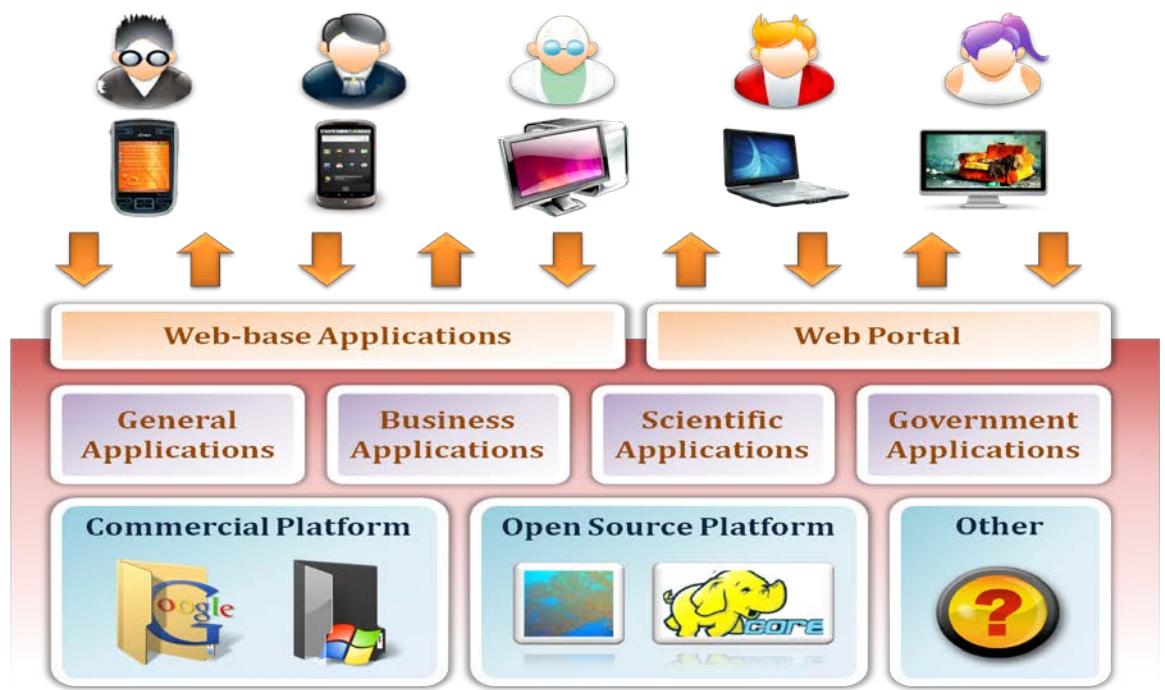
Platform as a Service (PaaS)

- An Application Platform (**runtime environment**) comprised of an operating system, middleware and other software that allows applications to run on the cloud with much of the management abstract away
- Example:
 - MapReduce
 - Azure
 - GAE

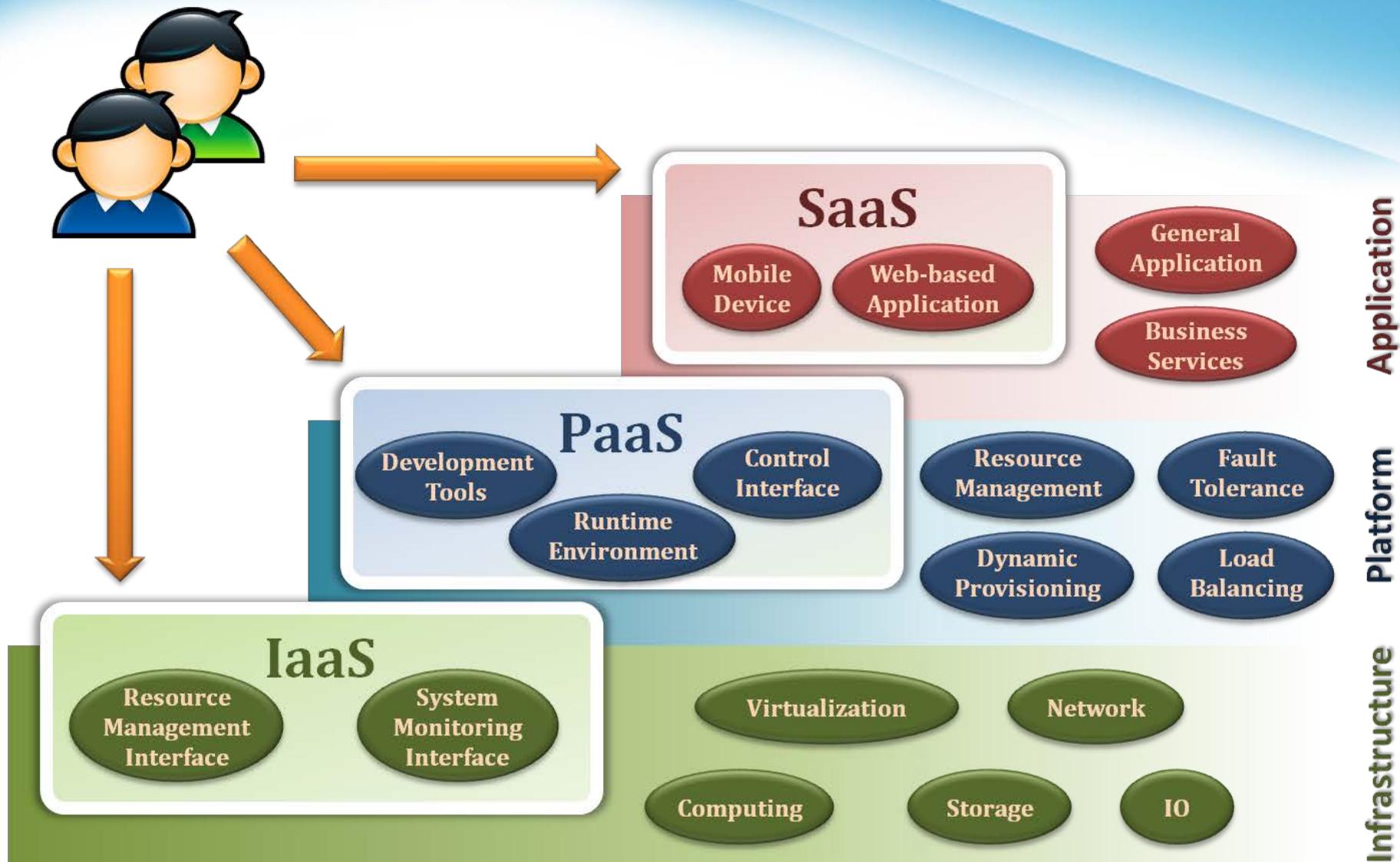


Software as a Service

- A software delivery model in which software and associated data are centrally hosted on the cloud.
- SaaS is typically accessed by users using a thin client via a web browser
- Examples:
 - Google Apps
 - Salesforce



Three Service Models



How to deploy a cloud system ?

DEPLOYMENT MODELS

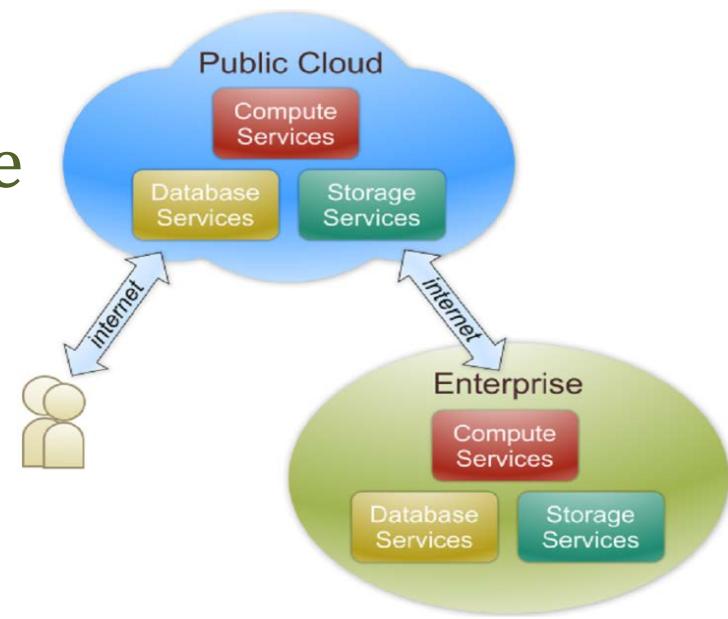


Deployment Model

- There are four primary cloud deployment models :
 - Public Cloud
 - Private Cloud
 - Community Cloud
 - Hybrid Cloud
- Each can exhibit the previously discussed characteristics; their differences lie primarily in the **scope and access of published cloud services**, as they are made available to service consumers.

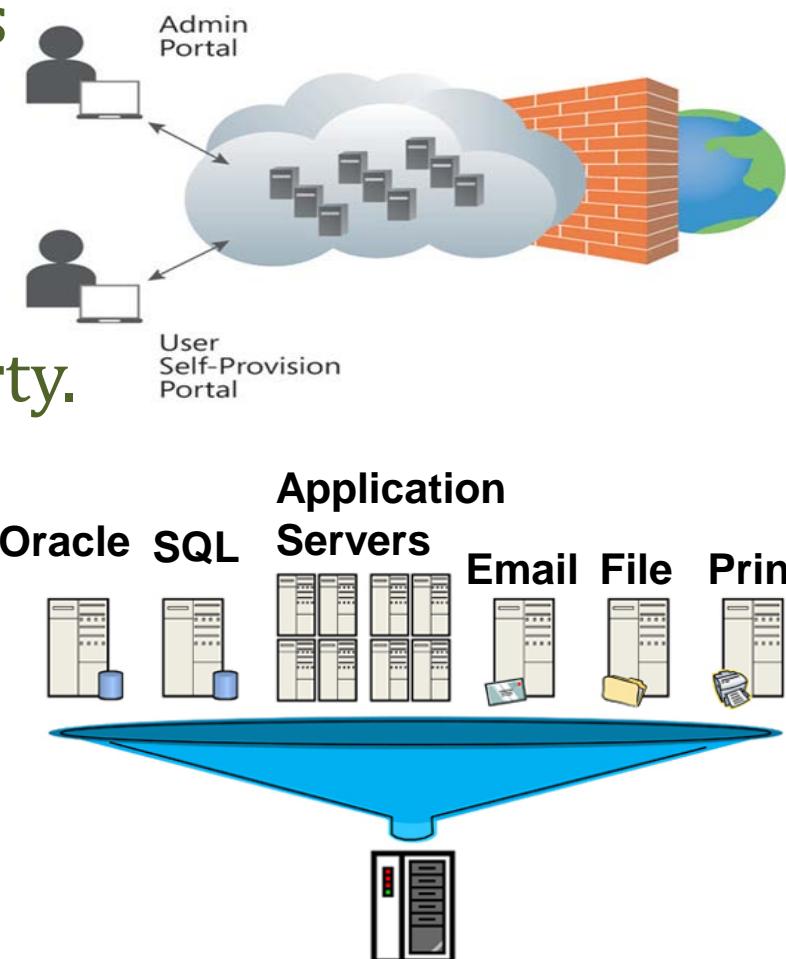
Public Cloud

- Definition
 - The cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services
- Characteristics :
 - Homogeneous infrastructure
 - Common policies
 - Shared resources
 - Rented infrastructure
 - Economies of scale



Private Cloud

- Definition
 - The cloud infrastructure is operated solely for an organization.
 - It may be managed by the organization or a third party.
- Characteristics :
 - Secure
 - Customized policies
 - Dedicated resources
 - In-house infrastructure
 - End-to-end control



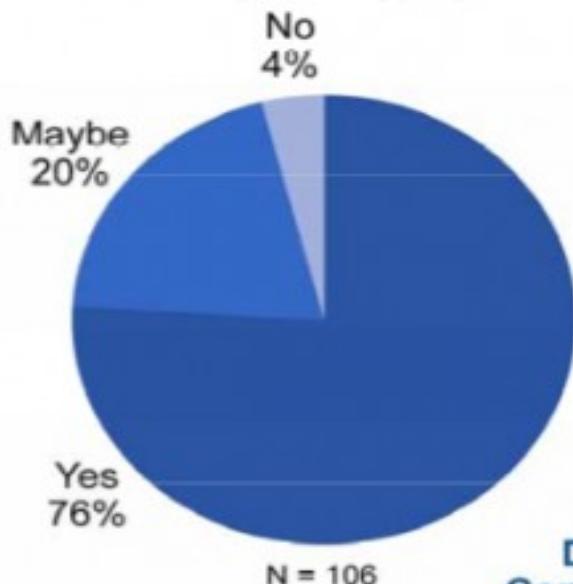
Public vs. Private

	Public Cloud	Private Cloud
Infrastructure	Homogeneous	Heterogeneous
Policy Model	Common defined	Customized & Tailored
Resource Model	Shared & Multi-tenant	Dedicated
Cost Model	Operational expenditure	Capital expenditure
Economy Model	Large economy of scale	End-to-end control

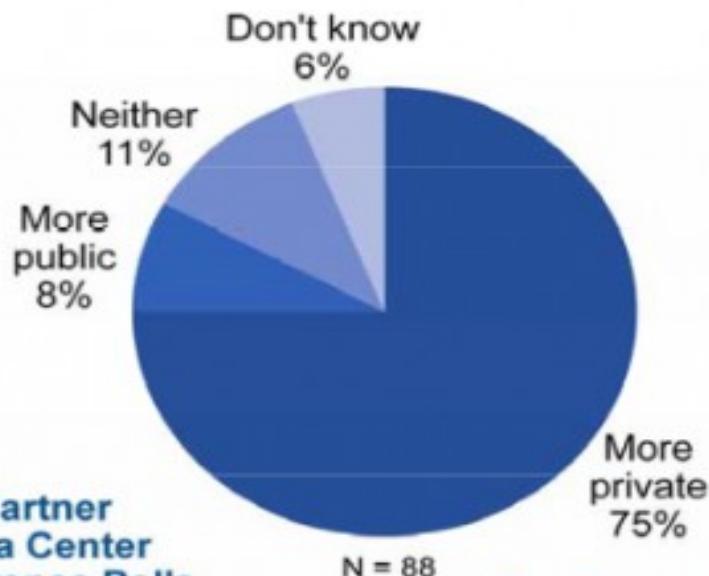
Public or Private?

Private and Public Cloud Plans

Will your enterprise be pursuing a private cloud computing strategy by 2012?



Through 2012, how will your IT organization invest in cloud computing?

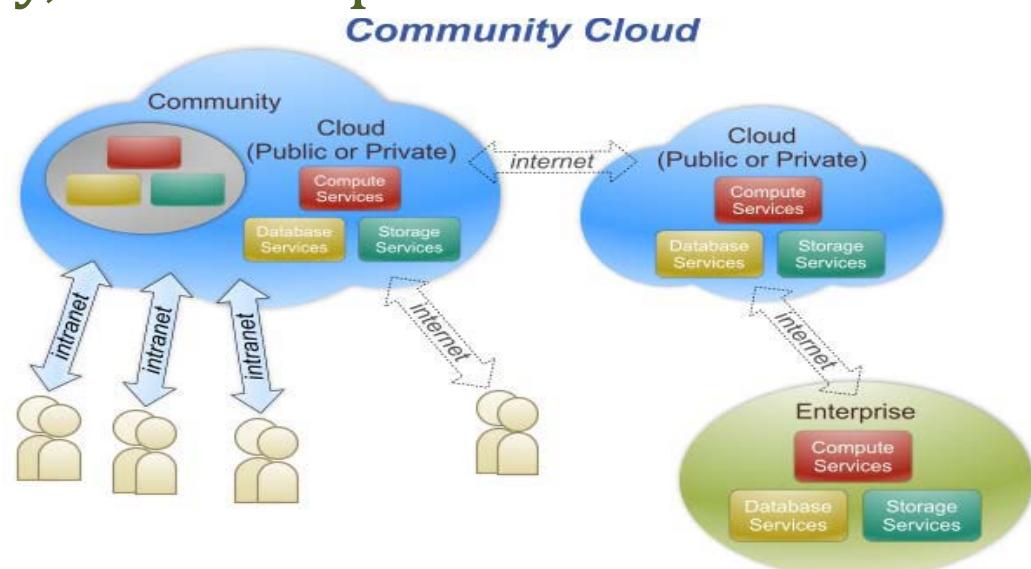


Gartner
Data Center
Conference Polls,
December 2009

Gartner

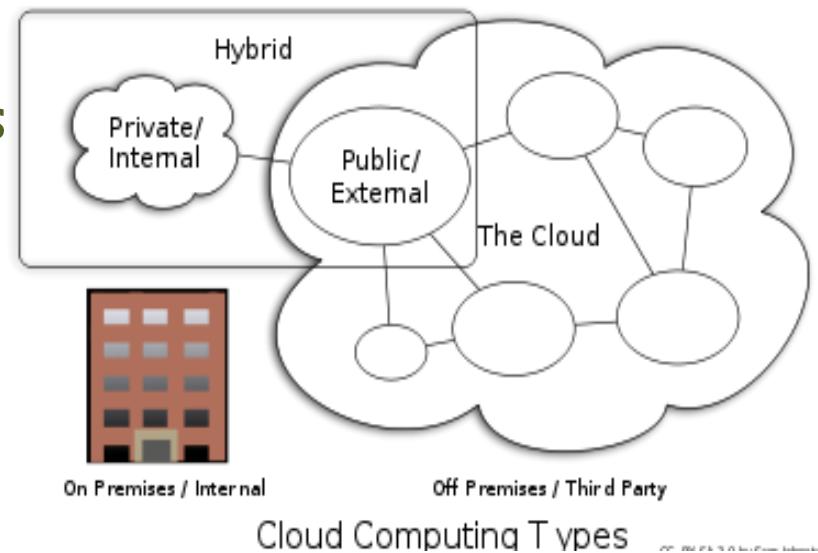
Community Cloud

- Definition
 - The cloud infrastructure is **shared by several organizations** and supports a specific community that has **shared concerns** (e.g., mission, security requirements, policy, and compliance considerations).
- Examples:
 - Academic Cloud
 - Government Cloud

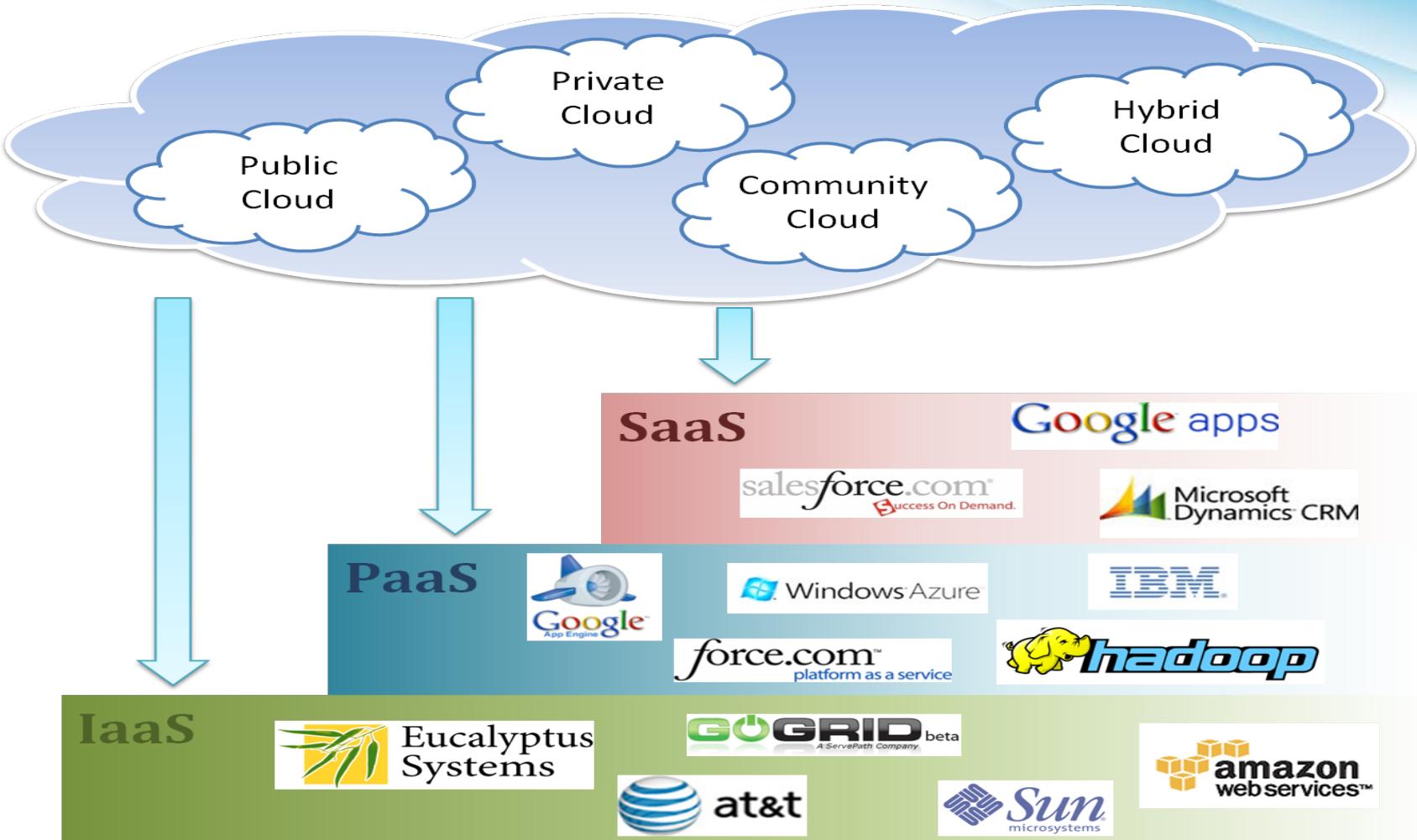


Hybrid Cloud

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



Cloud Ecosystem



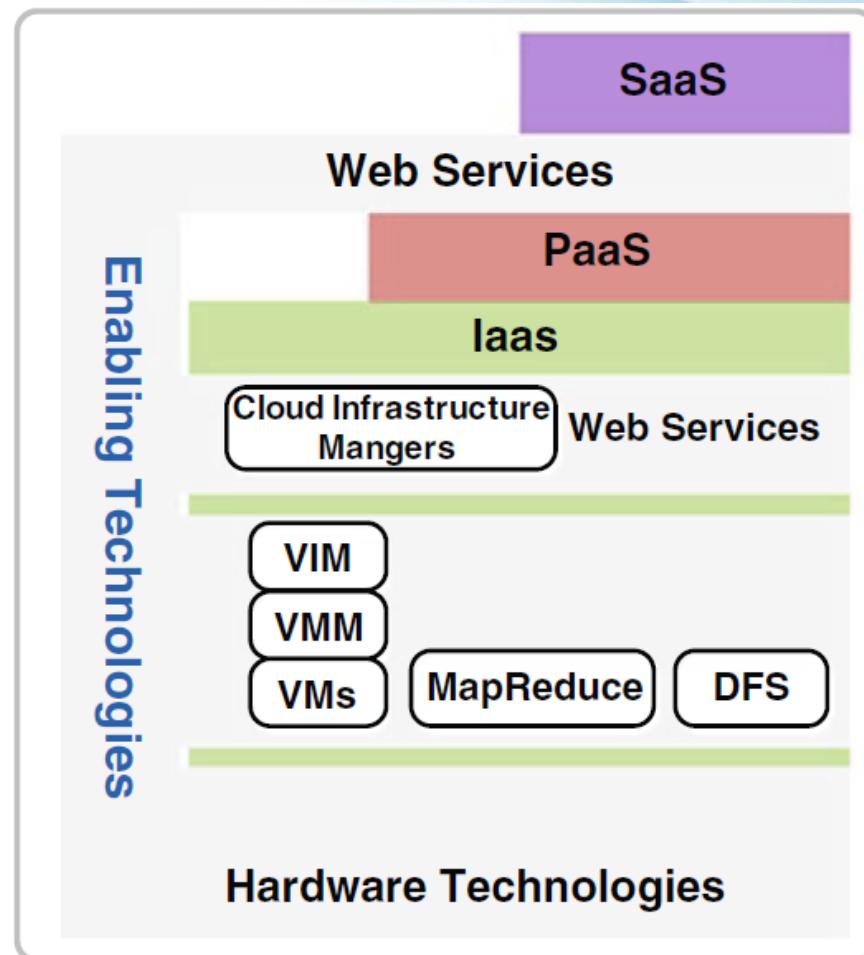


What it takes to build a Cloud

CLOUD ENABLING TECHNOLOGIES

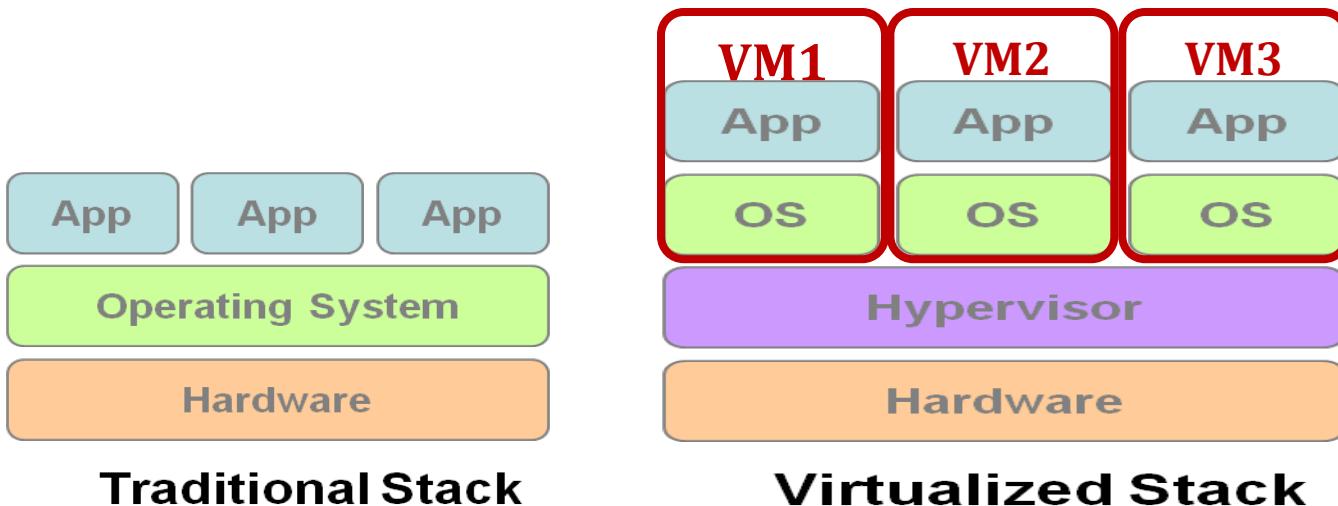
Cloud Enabling Technologies

- Web services
- Virtualization technology
- Distributed file systems
- MapReduce programming model
- NoSQL Cloud DataBase
- Many more



What is Virtualization?

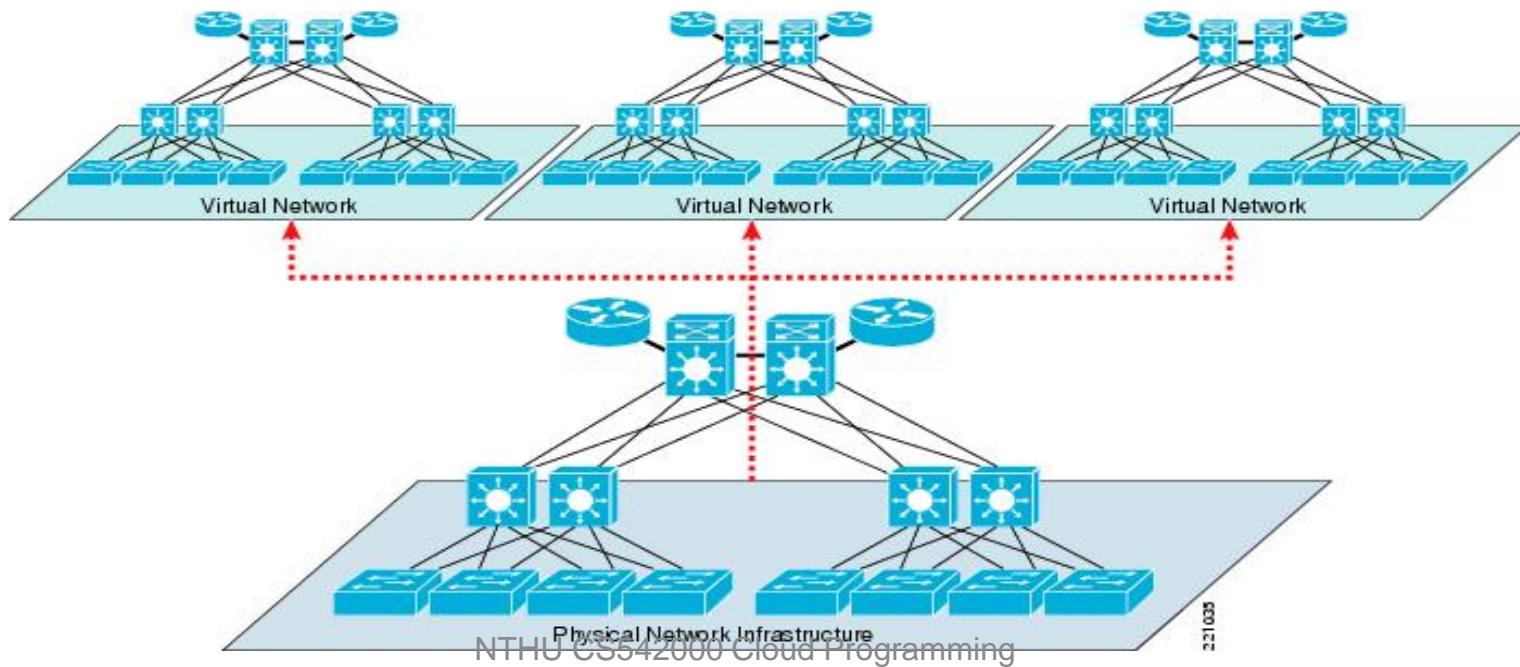
- Definition: the creation of a virtual (rather than actual) version of something
- Server virtualization:
 - **Virtual Machine**: Multiple OS share the physical hardware and provide different services.



What is Virtualization?

- Network virtualization:

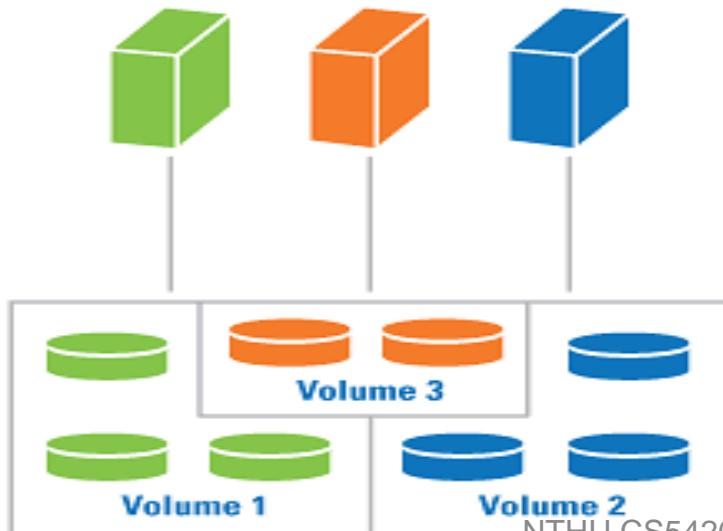
- splitting up the available bandwidth into channels, each of which is independent from the others, and each of which can be assigned (or reassigned) to a particular server or device in real time.



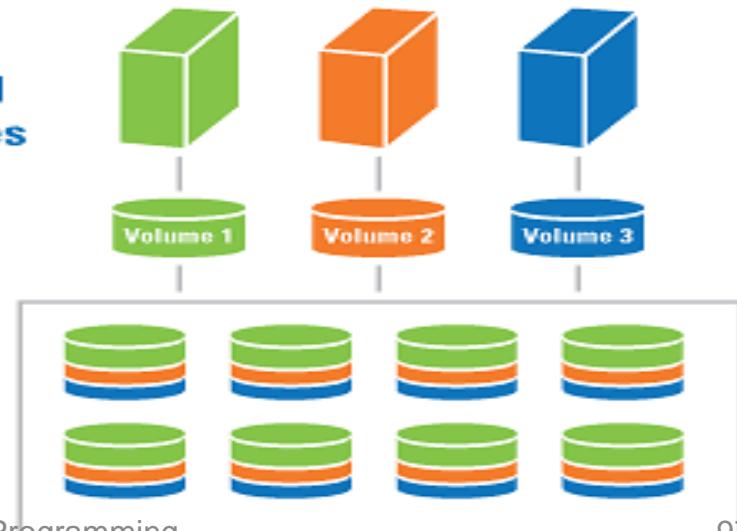
What is Virtualization?

- Storage virtualization
 - the pooling of physical storage from multiple network storage devices into what appears to be a single storage device that is managed from a central console.

Traditional Disk Mapping



Virtualized Storage Disk Mapping

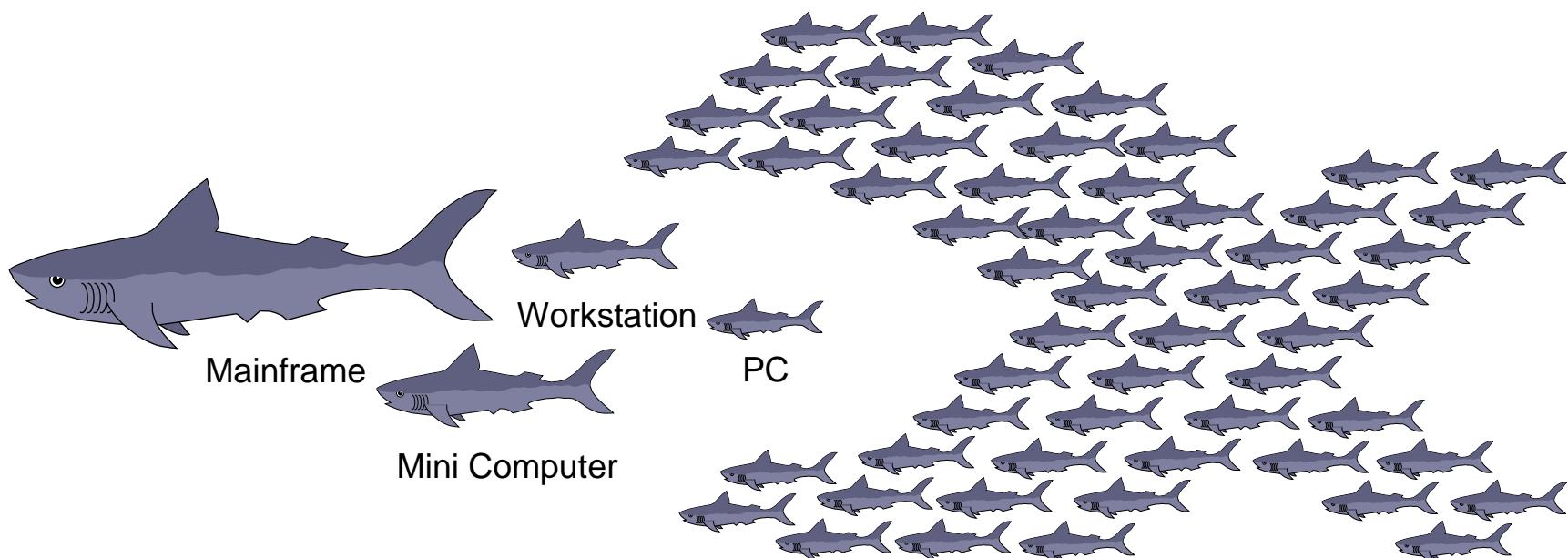


Why Virtualization?

- Higher resource utilization
 - Multiple server and application can be **consolidated/ran** on the same server
- Configurability:
 - Allows **dynamic configuration** - different applications require different resources
- Increased application availability:
 - Allow **quick failure recovery** from unplanned outages with no interruption in service.
- Improved responsiveness:
 - Resource provisioning, monitoring, and maintenance can be **automated**.

Distributed Computing

- A computer system in which several *interconnected computers* share the computing tasks assigned to the system



Distributed File Systems

- Any file system that allows access to files from multiple hosts sharing via a computer network
- Can offer support for replication and local caching
- Network file system (NFS 1984)
 - Network drives are *mounted* into local directory hierarchy
- Google file system (GFS 2003)
 - Design for redundant storage of **massive amounts of data** on **cheap and unreliable computers**

MapReduce Programming Models

- A parallel programming model
 - Developer specifies **what are the computations** need to be performed
 - Execution framework (“runtime”) handles **how to execute the computations**
- Google uses its MapReduce framework to process 20 petabytes of data per day
- Hadoop is a open source implementation

Cloud Database

- SQL (Structure Query Language) DB:
 - Designed for managing data in relational database management systems (RDBMS)
 - High throughput but **difficult to scale**
 - E.g.: Oracle Database, Microsoft SQL Server and MySQL
- NoSQL (Not only SQL) DB
 - Does not use SQL as its query language
 - Does not guarantee **ACID** (*atomicity, consistency, isolation, durability*)
 - Based on other Cloud technology, such as MapReduce, GFS
 - E.g.: Cassandra, CouchDB, MongoDB and HBase

Remark

- To me, Cloud is a dream to build “THE” perfect computer for EVERYONE to use at ANYTIME, ANYWHERE.
- Although it is a work in progress, we are getting closer with the advancing of computer technology.
 - Mobile device, Internet, e-commerce, SW, etc.
- What Do You THINK???

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- All resources of the materials and pictures were partially retrieved from the Internet.