CLOUD COMPUTING

Networks and Communication Department

Lecture 4: Introductory lecture for cloud computing

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Outline

- Introduction to the cloud comupting
- Define the concept of cloud computing and cloud layers
    - Essential characteristics
    - Cloud service model
    - Cloud deployment model
- Introduce the actors in Cloud Computing
- Introduce the new technologies that enabled cloud computing
- Discuss cloud computing benefits
- Security in the cloud
- Discuss cloud computing challenges
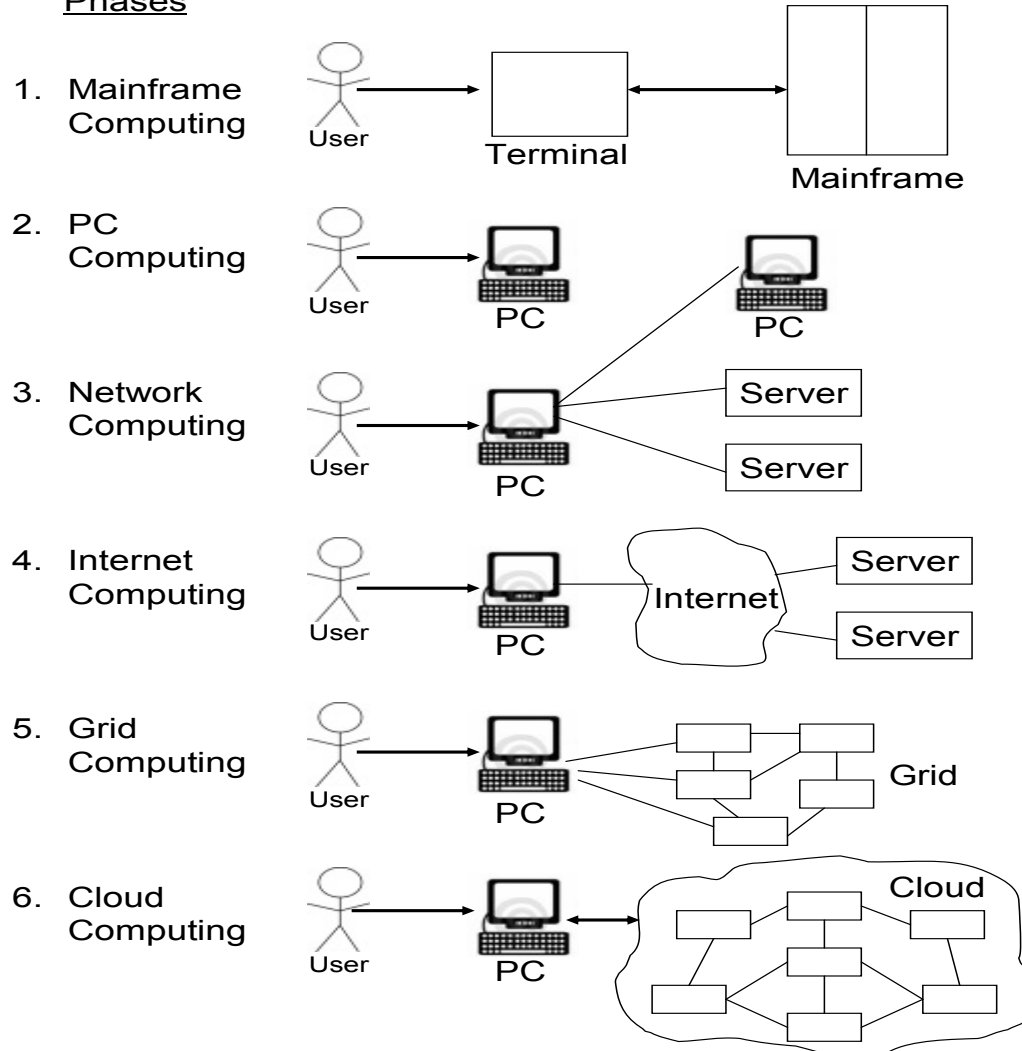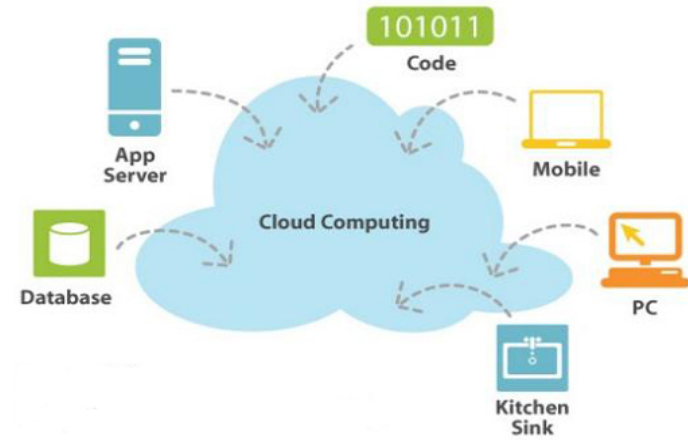- Present some real example

Introduction

- In last few years, Information Technology (IT) has embarked on a new paradigm – cloud computing

- Like every revolution, it contains components of the past from which it evolved

- The Figure below shows six computing paradigms from mainframe computing to Internet computing, to grid computing and cloud computing.

Phases

1. Mainframe Computing

    User → Terminal ↔ Mainframe

2. PC Computing

    User → PC ... PC

3. Network Computing

    User → PC — Server / Server

4. Internet Computing

    User → PC — Internet — Server / Server

5. Grid Computing

    User → PC — Grid

6. Cloud Computing

    User → PC ↔ Cloud

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Cloud computing

Introduction to cloud computing

- When you store your photos online instead of on your home computer, or use webmail or a social networking site, you are using a "cloud computing" service.

- If you are an organization, and you want to use, for example, an online invoicing service instead of updating the in-house one you have been using for many years, that online invoicing service is a "cloud computing" service.

Introduction to cloud computing (Cont.)

- The cloud makes it possible for you to access your information from anywhere at any time.

- Additionally, users use a variety of devices, including PCs, laptops, smartphones, and PDAs to access resources.

- While a traditional computer setup requires you to be in the same location as your data storage device. The cloud removes the need for you to be in the same physical location as the hardware that stores your data.

Introduction to cloud computing (Cont.)

- This is especially helpful for businesses that cannot afford the same amount of hardware and storage space as a bigger company.

- Small companies can store their information in the cloud, removing the cost of purchasing and storing memory devices.

- Remove the cost for hiring programmers and the time for building the application

Introduction to cloud computing (Cont.)

- Cloud computing turns traditionally soiled computing assets into a **shared pool of resources** that are based on an underlying Internet foundation.

- In another word, Cloud computing will reshape information technology (IT) processes and the IT marketplace.
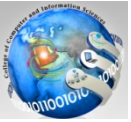
NIST Definition of Cloud Computing

July 5, 2011:

☐ The U.S. National Institute of Standards and Technology (NIST): Definition of Cloud Computing identified cloud computing as:

☐ 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.

NIST Definition of Cloud Computing (Cont.)

☐ NIST defines cloud computing by describing **five essential characteristics,** **three cloud service models (delivery models),** **and four cloud deployment models.** They are summarized in visual form in this figure and explained in detail below.
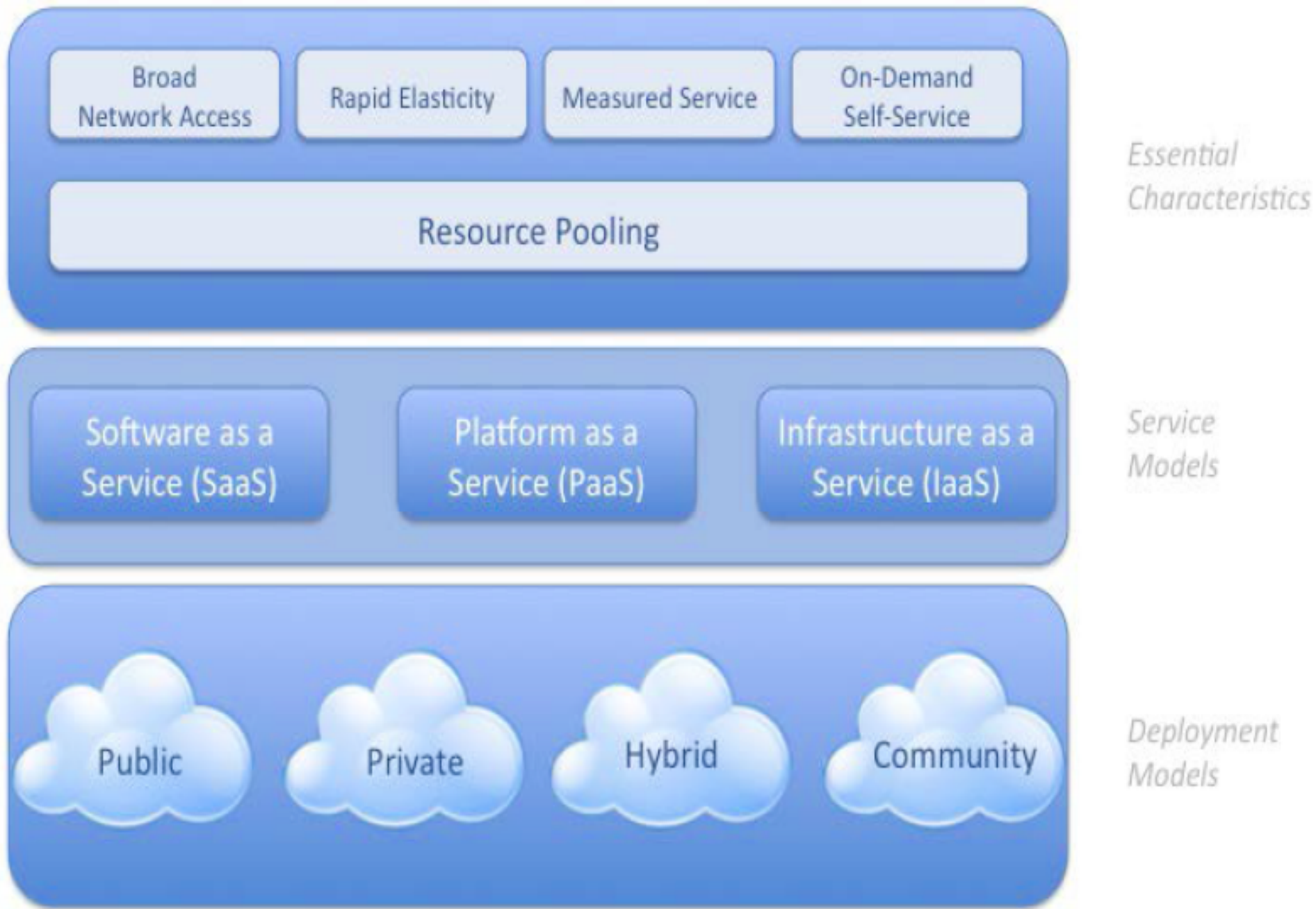
Figure 1—NIST Visual Model of Cloud Computing Definition[2]

Essential characteristics of cloud computing

- *On-demand self-service: A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider*

- *Broad network access: 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, tablets, laptops, and workstations).*

Essential characteristics of cloud computing (Cont.)

☐ *Resource pooling: 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.*

☐ *There is a sense of location independence in that the customer generally has no control or knowledge over the exact location of the provided resources but may be able to specify location at a higher level of abstraction (e.g., country, state, or datacenter).*

☐ *Examples of resources include storage, processing, memory, and network bandwidth.*

Multi-tenancy?

- Although **not an essential** characteristic of Cloud Computing we should mention
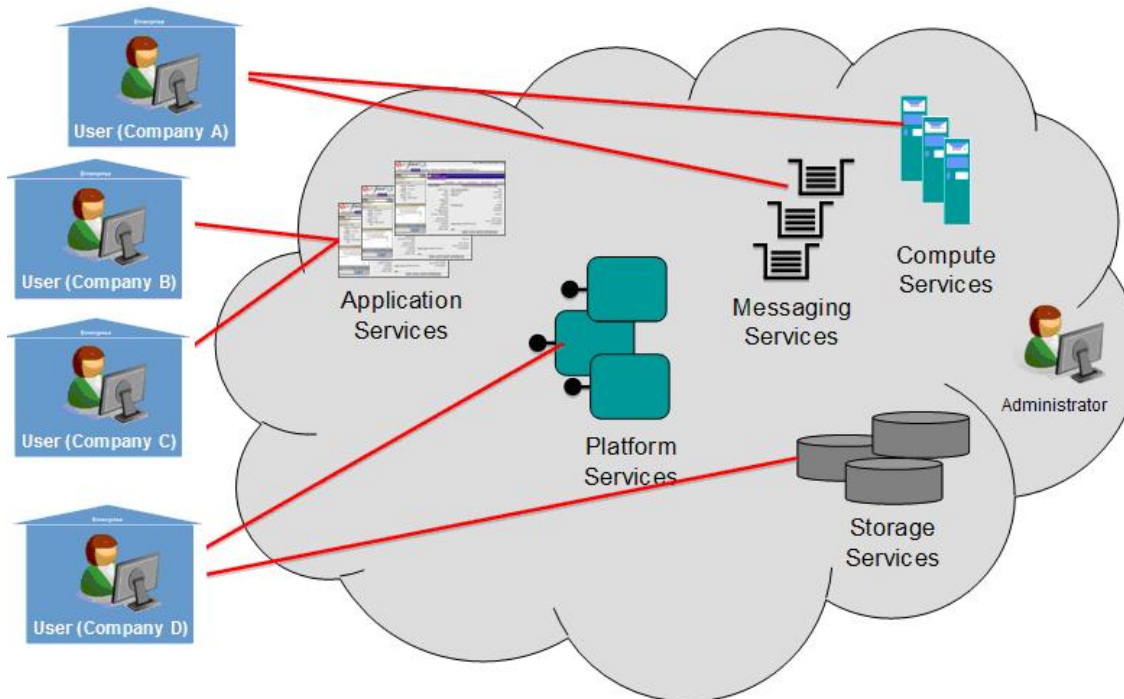
Multi-tenancy?

☐ Multi-tenancy is an architecture in which a single instance of a software application serves multiple customers.

☐ Each customer is called a tenant.

☐ Tenants may be given the ability to customize some parts of the application, such as color of the user interface (UI) or business rules, but they cannot customize the application's code

Essential characteristics of cloud computing (Cont.)

- *Rapid elasticity: Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward commensurate with demand.*

- *To the consumer, the capabilities available for provisioning often appear to be unlimited and can be appropriated in any quantity at any time.*
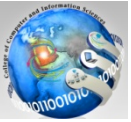
Essential characteristics of cloud computing (Cont.)

☐ *Measured service: Cloud systems automatically control and optimize resource (e.g., storage, processing, bandwidth, and active user accounts).*

☐ *Resource usage can be monitored, controlled, and reported*

Cloud services model

□ With the essential characteristics of Cloud Computing defined, it is critical to understand the types of services that are available in a Cloud Computing model.

□ The NIST definition of Cloud Computing defines three service models:

  ❑ Cloud Software as a Service (SaaS).

  ❑ Cloud Platform as a Service (PaaS).

  ❑ Cloud Infrastructure as a Service (IaaS).

Software as a Service (SaaS)

- The top layer is the application layer

- A complete application offered as a service on demand.

- A single instance of the software runs on the cloud and services multiple end users or client organizations.

- The applications are accessible from various client devices.

- The consumer does not manage or control the underlying cloud infrastructure, with the possible exception of limited user-specific application configuration settings.

- Used by end user

Software as a Service (SaaS) (Cont.)

□ Pros:

□ On the customer side, there is no need for software licenses.

□ For the provider, the costs are lowered, since only a single application needs to be hosted & maintained

□ Today Saas is offered by companies such as Google, Salesforce, Microsoft,etc.

Platform as a Service (Paas)

- The middle layer is the platform

- Development environment is encapsulated & offered as a service

- Consumers purchase access to the platforms, enabling them to deploy their own applications using programming languages, libraries, services, and tools supported by the provider (providers infrastructure)

Platform as a Service (Paas) (Cont.)

☐ The consumer does not manage or control the underlying cloud infrastructure, but has control over the deployed applications and possibly configuration settings for the application-hosting environment.

☐ Some of the Popular PaaS examples: Google's App Engine, force.com, etc

☐ Used by developers

Infrastructure as a Service (IaaS)

- The infrastructure layer is the foundation of the cloud

- The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources

- Where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications.

Infrastructure as a Service (IaaS) (Cont.)

- The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, and deployed applications; and possibly limited control of select networking components (e.g., host firewalls).

- Some common examples are Amazon, GoGrid, 3 Tera, etc.

- Used by network architecture

Types of service

SaaS	Highly scalable internet based applications are hosted on the cloud & offered as services to the end user. → Google Docs, acrobat.com, salesforce.com
PaaS	Here, the platforms used to design, develop, build & test applications are provided by the cloud infrastructure. → Azure Service Platform, force.com, Google App Engine.
IaaS	In this pay per use model, services like storage, database management & compute capabilities are offered on demand. → Amazon Web Services, GoGrid, 3 Tera

Figure 2: Cloud models

Four Cloud Deployment Models

☐ Regardless of the service model utilized (SaaS, PaaS, or IaaS) there are four deployment models for cloud services, with derivative variations that address specific requirements:

- ☐ Private cloud
- ☐ Community cloud
- ☐ Public cloud
- ☐ Hybrid cloud

Deployment Models (Cont.)

☐ Private Cloud:

☐ The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units).

☐ It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises.

Private Cloud

- Private Cloud:

- On-premise private cloud: also know as internal clouds. This model gives companies a high level of control over the use of cloud resources while bringing in the expertise needed to establish and operate the environment. Limited in size and scalability and increased cost

- Externally hosted private cloud:

  Hosted externally with a cloud provider

PRIVATE

ENTERPRISE
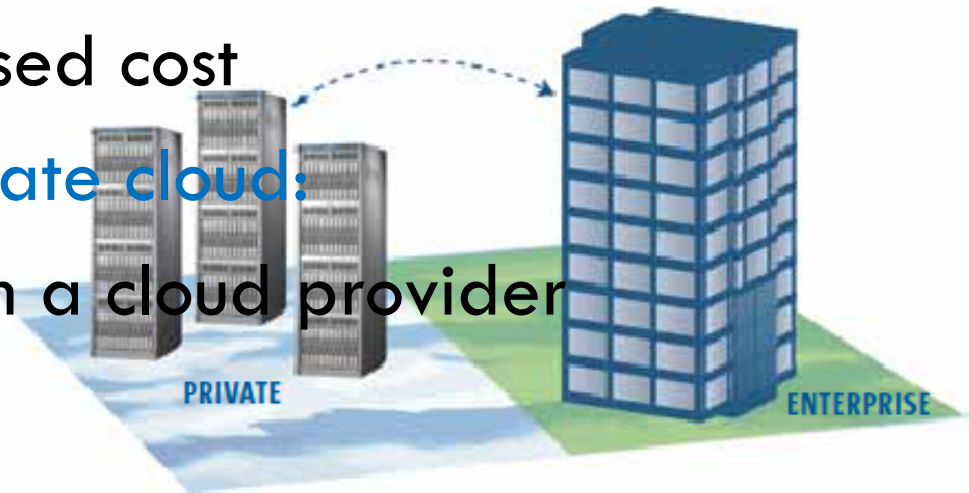
Community Cloud

☐ The cloud infrastructure is shared among a number of organizations with similar interests and requirements. (e.g., mission, security requirements, policy, etc).

☐ It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises.

Community Cloud (Cont.)

☐ This may help limit the capital expenditure costs for its establishment as the costs are shared among the organizations.

☐ For example all Government organizations within the state of California may share computing infrastructure on the cloud to manage data related to citizens residing in California
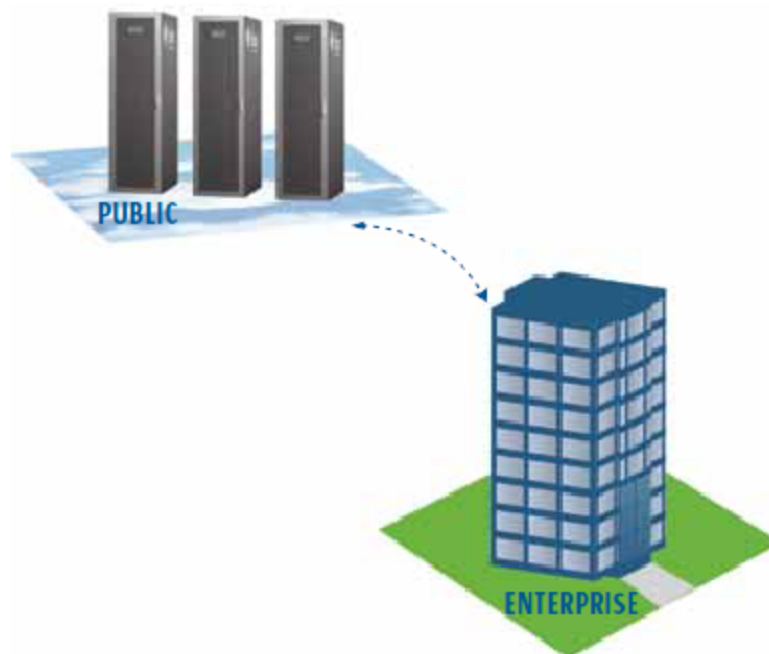
Public Cloud

- The cloud infrastructure is provisioned for open use by the general public.
- It owned and operated by third parties (Cloud providers)
- Low cost "Pay-as-you-go" model
- All customers share the same infrastructure pool
- Providing the ability to scale seamlessly ,on demand
- It exists on the premises of the cloud provider.

Figure shows *public cloud provides services to multiple customers*

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Hybrid Cloud

- The cloud infrastructure consists of a number of clouds of any type (private, community, or public)

- The clouds have the ability through their interfaces to allow data and/or applications to be moved from one cloud to another.

- Support the requirement to retain some data in an organization, and also the need to offer services in the cloud.

- Management responsibilities are divided between the public cloud provider and the business itself
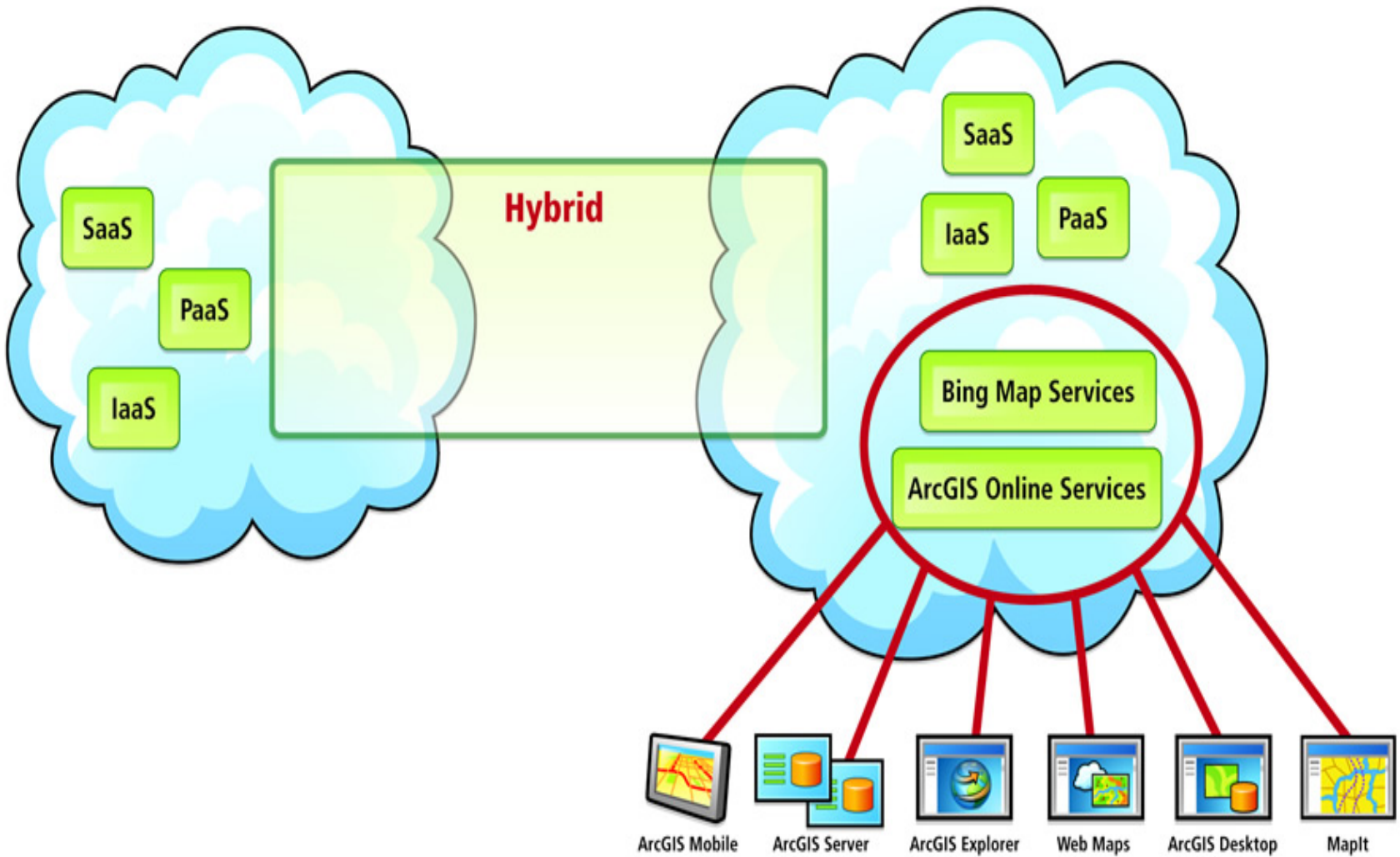
Figure shows public, private, and hybrid clouds
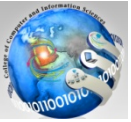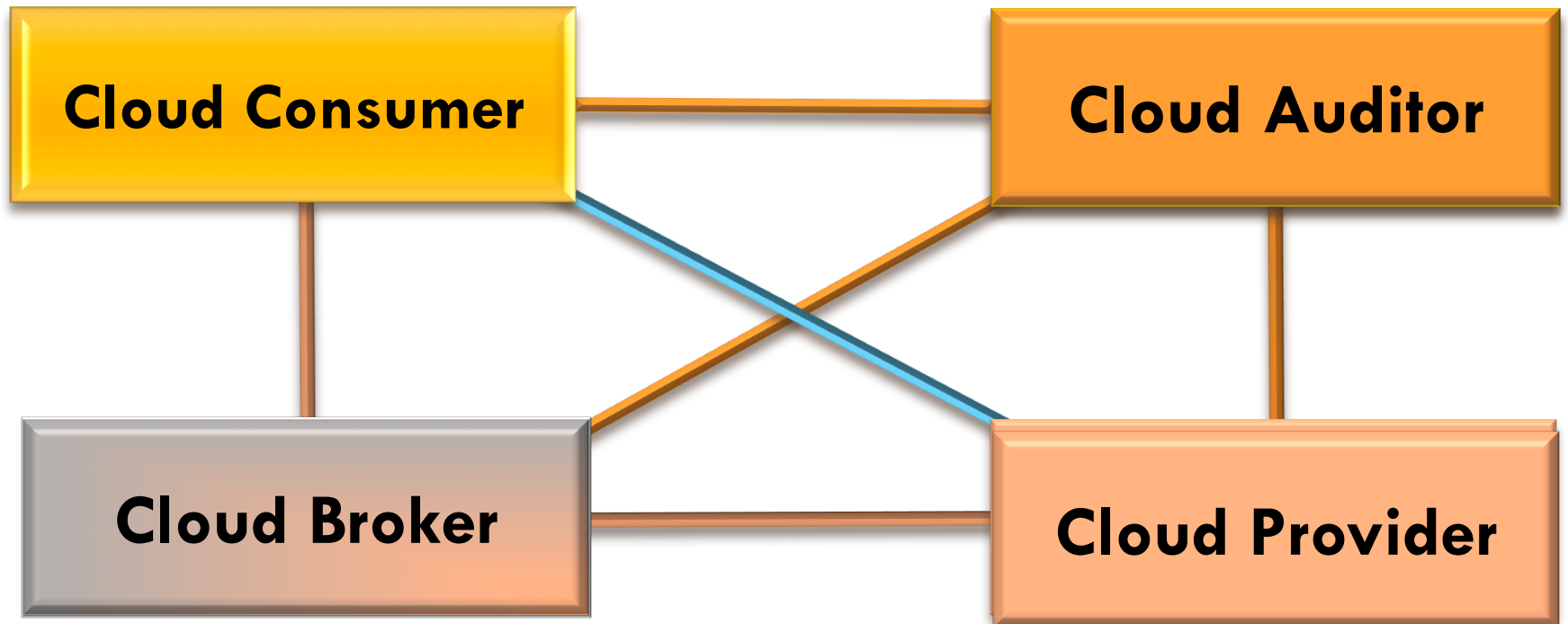
Actors in Cloud Computing (Cont.)

- **Cloud Consumer** Person or organization that maintains a business relationship with, and uses service from Cloud Providers.

- **Cloud Provider:** Person, organization, or entity responsible for making a service available to Cloud Consumers.

- **Cloud Auditor:** The goal of Cloud Audit is to provide cloud service providers with a way to make their performance and security data readily available for potential customers.

Actors in Cloud Computing (Cont.)

- **A cloud broker:** is a third-party individual or business that acts as an intermediary between the purchaser of a cloud computing service and the sellers of that service. In general, a broker is someone who acts as an intermediary between two or more parties during negotiations.

- **Cloud Carrier :** The intermediary that provides connectivity and transport of cloud services from Cloud Providers to Cloud Consumers

Related Technologies- Virtualization

☐ The virtualization is the infrastructure of cloud computing

☐ Is the ability to virtualize and share resources among different applications with the objective for better resources utilization

Why virtualization

- **Server computers:** machines that host files and applications on computer networks

- Problems :

  - Most servers use only a small fraction of their overall processing capabilities.

  - Another problem is that as a computer network gets larger and more complex, the servers begin to take up a lot of physical space
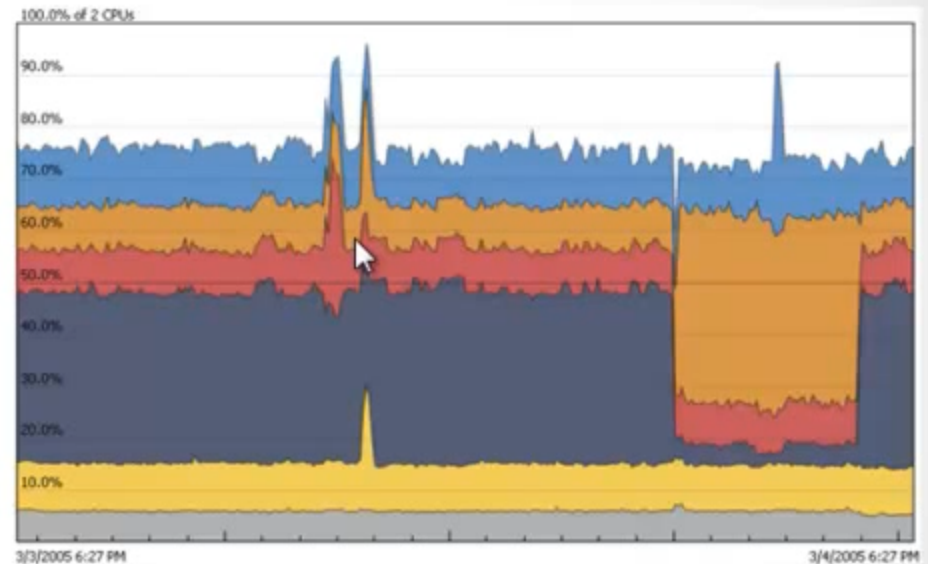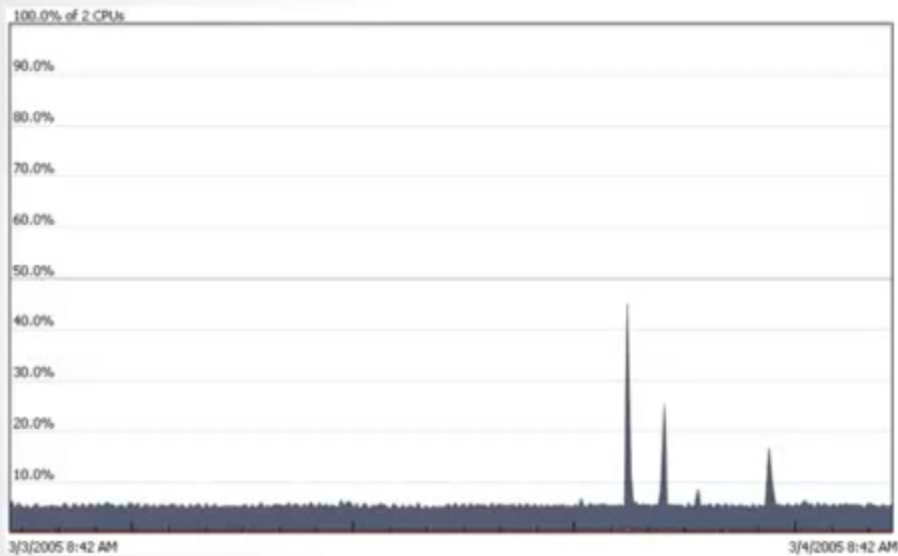
Hardware utilizations

**Virtualization Increases Hardware Utilization**

Before VMware

After VMware

Virtualization

- Figure below shows an example of virtualization:
- in non-cloud computing there is a need for three independent platforms (Servers) ;
- in the cloud computing, servers can be shared, or virtualized, for operating systems and applications resulting in fewer servers (two servers).
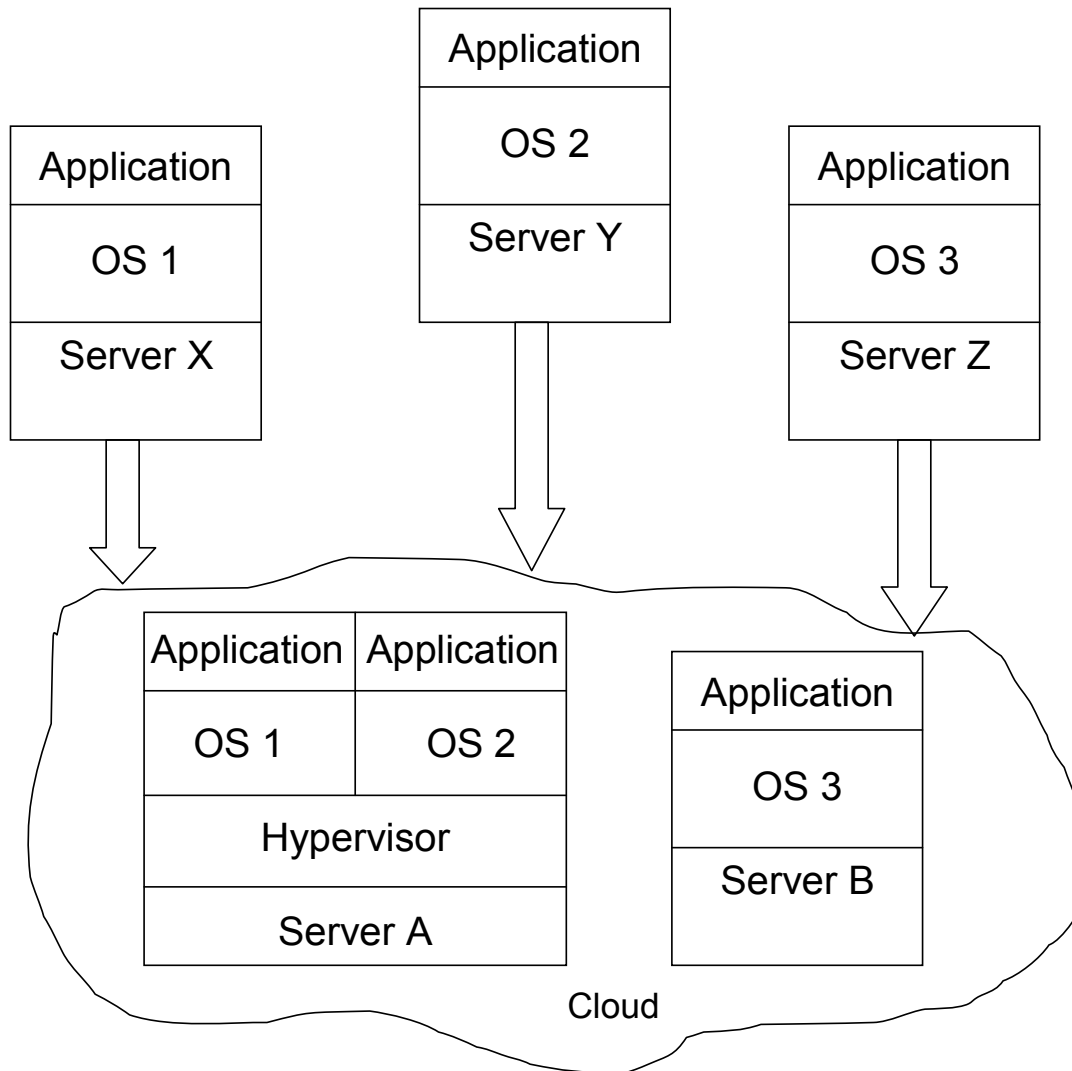
Virtualization (Cont.)

- Virtualization technologies include virtual machine techniques such as VMware and Xen, and virtual networks, such as VPN.

- Virtual machines provide virtualized IT-infrastructures on-demand, while virtual networks support users with a customized network environment to access cloud resources.

Cloud computing benefits

1. Cost Savings:

- The billing model is pay as per usage
- The infrastructure is not purchased thus lowering maintenance
- Initial expense and recurring expenses are much lower than traditional computing

2. Scalability/Flexibility:

- Companies can start with a small deployment and grow to a large deployment fairly rapidly, and then scale back if necessary.
- Enabling them to satisfy consumer demands.

Cloud computing benefits (Cont.)

3. Increase storage:

- with the massive infrastructure that is offered by cloud providers today, storage & maintenance of large volumes of data is a reality.

- Cloud can scale dynamically

4. Reliability: Services using multiple redundant sites can support business continuity and disaster recovery.

5. Mobile Accessible: Mobile workers have increased productivity due to systems accessible in an infrastructure available from anywhere.

Security in the cloud

- The information housed on the cloud is often seen as valuable to individuals with malicious intent.

- There is a lot of personal information and potentially secure data that people store on their computers, and this information is now being transferred to the cloud.

Security in the cloud (Cont.)

☐ The first thing you must look into is the security measures that your <u>cloud provider</u> already has in place.

    ❑ What encryption methods do the providers have in place?

    ❑ What methods of protection do they have in place for the actual hardware that your data will be stored on?

    ❑ Will they have backups of my data? Do they have firewalls set up?

    ❑ If you have a community cloud, what barriers are in place to keep your information separate from other companies?
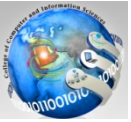
Cloud computing challenges

- Some of the notable challenges associated with cloud computing:

- **Security and Privacy:** Perhaps two of the more "hot button" issues surrounding cloud computing relate to storing and securing data, and monitoring the use of the cloud by the service providers.

- These issues are generally attributed to slowing the deployment of cloud services.

- Result in Hybrid cloud deployment with one cloud storing the data internal to the organization.

- **Lack of Standards** : Clouds have documented interfaces; however, no standards are associated with these, and thus it is unlikely that most clouds will be interoperable.

Cloud computing challenges (Cont.)

- **Continuously Evolving**:
  - the requirements for interfaces, networking, and storage.
  - This means that a "cloud," especially a public one, does not remain static and is also continuously evolving

- **Regulatory and Compliance Restrictions:**

- The Sarbanes-Oxley Act (SOX) in the US and Data Protection directives in the EU are just two among many compliance issues affecting cloud computing, based on the type of data and application for which the cloud is being used.

- Result in Hybrid cloud deployment with one cloud storing the data internal to the organization

Real examples

- Amazon EC2

- Google App Engine

- Microsoft Azure Service

Amazon EC2

- With Amazon Elastic Compute Cloud (EC2), you need to set up an Amazon Machine Image – a virtual machine running Windows (or Linux)

- Install applications, libraries, and data that you need.

- one processor, 1.7GB of RAM, 160GB of storage – is available for as little as £700 per year

- 4 processor 7.5 GB of RAM, 850GB storage – works out to £2800 per year

Google App Engine

- To build a Google App Engine website, you set up an account and get access to the App Engine

- Software Development Kit (SDK), which allows you to write App Engine-compatible software.

- Unfortunately the platform does not support Microsoft only Python or Java must be used.

- Charges
  - 500MB of storage
  - up to 5 million page views a month
  - 10 applications per developer account
  - pay for an extension
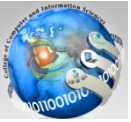
Windows Azure

- and as you'd expect it is slightly more focused on the use of .NET components (it natively supports ASP.NET). It is also set up to support SQL Server databases

- $1120, or around £700 per year

Any Questions ?

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