

Chapter 1

# Cloud Computing Fundamentals

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# Definition of Cloud Computing

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- Cloud computing can be defined as a new style of computing in which dynamically scalable and often virtualized resources are provided as a services over the Internet
- Cloud computing has become a significant technology trend, and many experts expect that cloud computing will reshape information technology (IT) processes and the IT marketplace

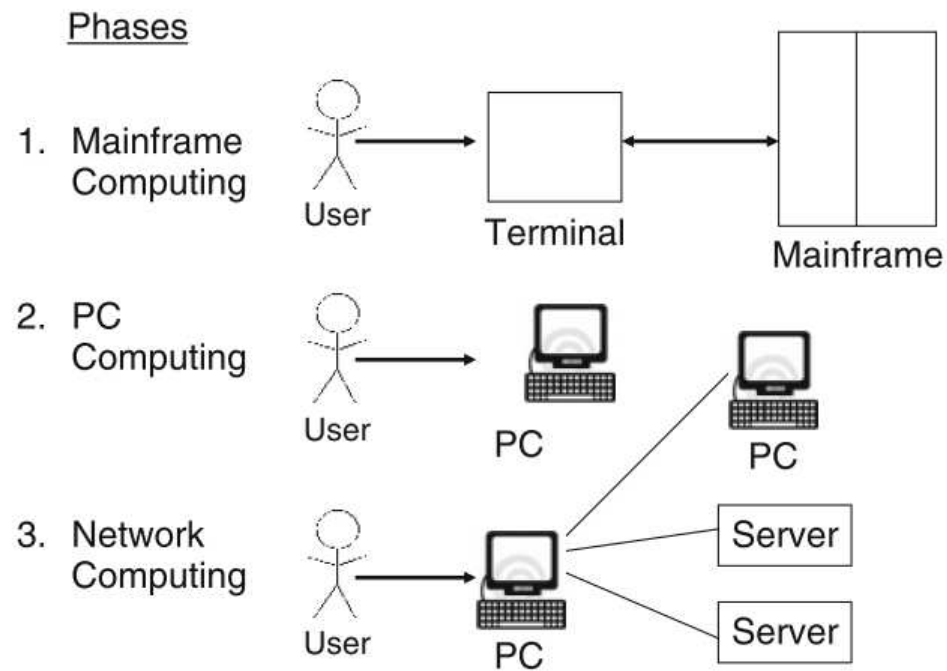
# Definition of Cloud Computing

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- With the cloud computing technology, users use a variety of devices, including PCs, laptops, smartphones, and PDAs to access programs, storage, and application-development platforms over the Internet, via services offered by cloud computing providers
- Advantages of the cloud computing technology include cost savings, high availability, and easy scalability

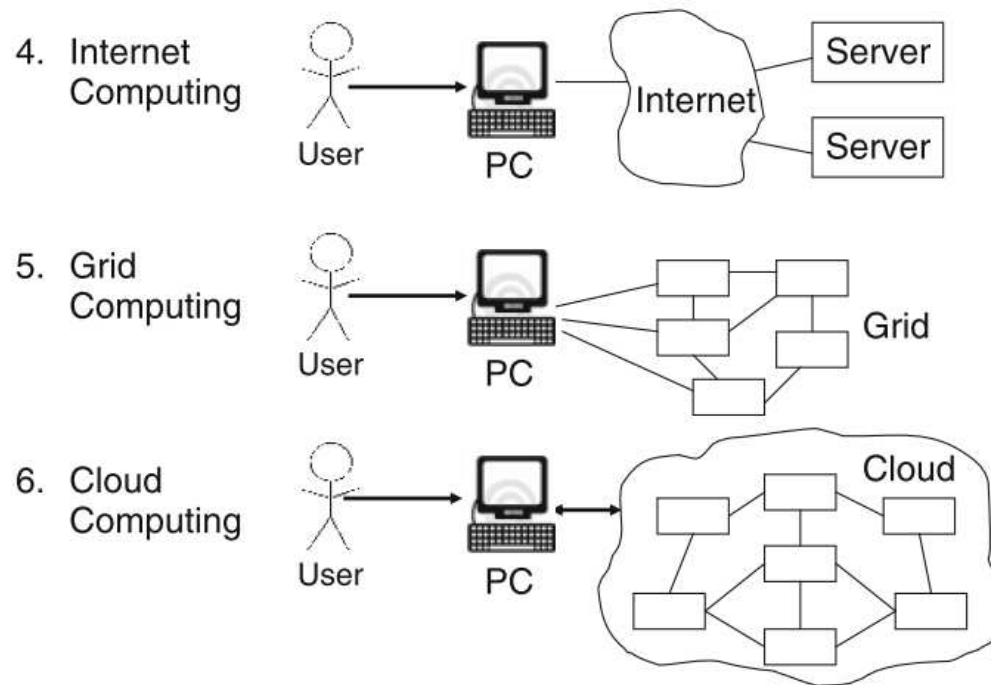
# six phases of computing paradigms

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# six phases of computing paradigms (cont.)

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# six phases of computing paradigms (cont.)

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- In phase 1, many users shared powerful mainframes using dummy terminals
- In phase 2, stand-alone PCs became powerful enough to meet the majority of users' need
- In phase 3, PCs, laptops, and servers were connected together through local networks to share resources and increase performance

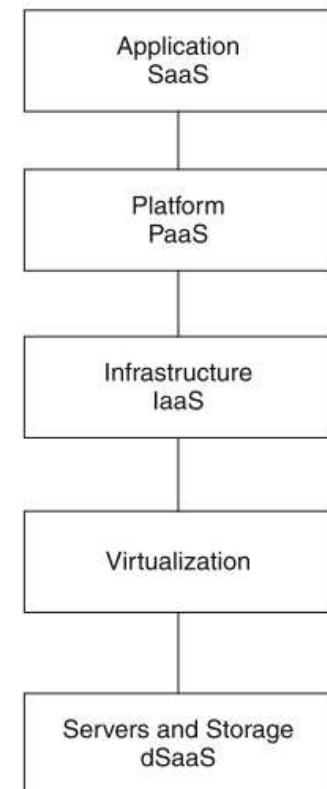
# six phases of computing paradigms (cont.)

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- In phase 4, local networks were connected to other local networks forming a global network such as the Internet to utilize remote applications and resources
- In phase 5, grid computing provided shared computing power and storage through a distributed computing system
- In phase 6, cloud computing further provides shared resources on the Internet in a scalable and simple way

# Layers of Cloud Computing

- Cloud computing can be viewed as a collection of services, which can be presented as a layered cloud computing architecture
- services offered through cloud computing usually include IT services referred as to SaaS (Software-as-a-Service), which is shown on top of the stack
- SaaS allows users to run applications remotely from the cloud



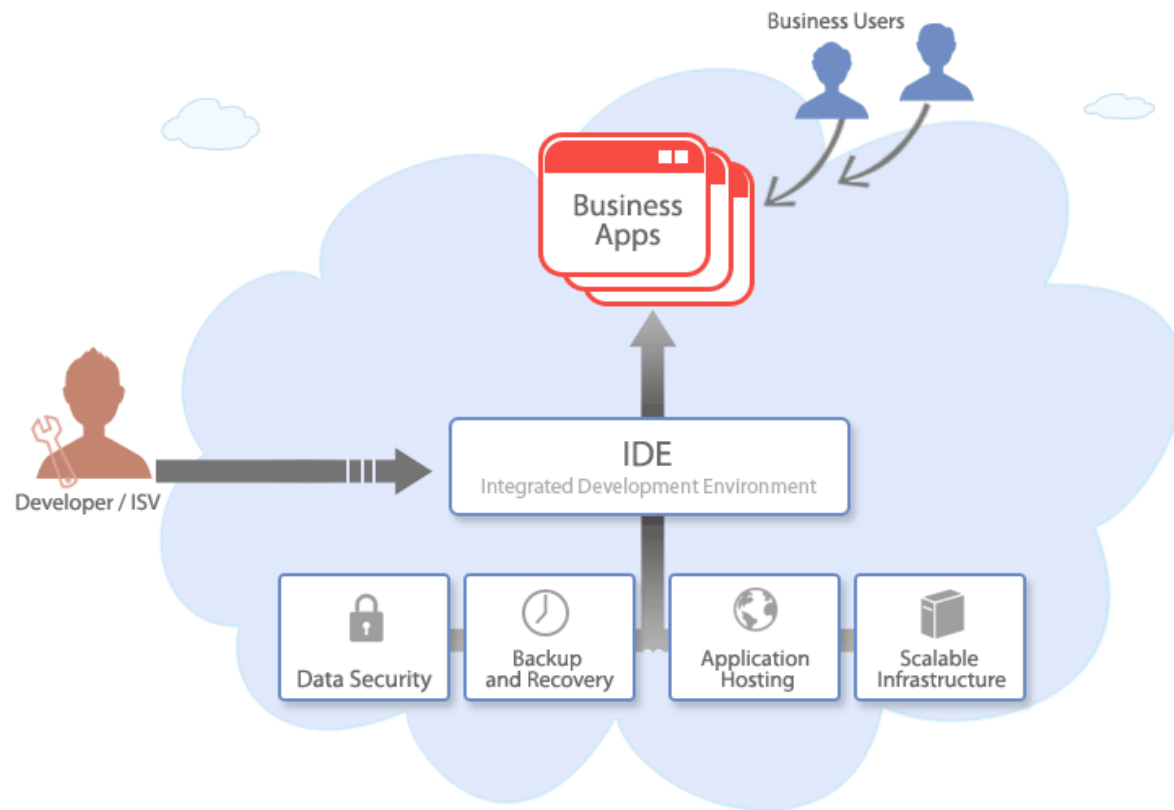


# Layers of Cloud Computing (cont.)

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- Infrastructure-as-a-service (IaaS) refers to computing resources as a service which includes virtualized computers with guaranteed processing power and reserved bandwidth for storage and Internet access
- Platform-as-a-Service (PaaS) is similar to IaaS, but also includes operating systems and required services for a particular application. In other words, PaaS is IaaS with a custom software stack for the given application
- The data-Storage-as-a-Service (dSaaS) provides storage that the consumer is used including bandwidth requirements for the storage

# The concept of Platform-as-a-Service



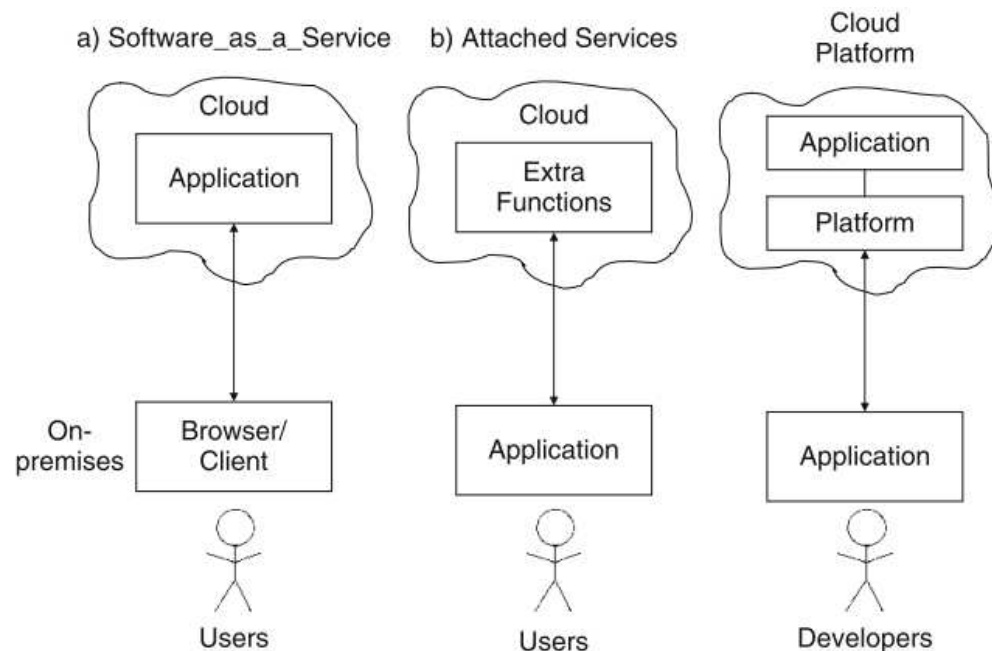
# Platform-as-a-Service

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- Platform as a Service (PaaS) is a delivery of a computing platform over the web
- PaaS enables you to create web applications quickly, without the cost and complexity of buying and managing the underlying software/hardware
- PaaS provides all the facilities required to support the complete life cycle of building and delivering web applications entirely on the web
- As Platform-as-a-Service (PaaS) is available as a service, the developer and ISV's get full control of the application development and deployment

# Three categories of cloud services

- According to Chappell (2008) there are three categories of cloud services



# Three categories of cloud services (cont.)

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- 1. **SaaS:** The entire application is running in the cloud
  - The client contains a simple browser to access the application
  - A well-known example of SaaS is [www.salesforce.com](http://www.salesforce.com)
- 2. The application runs on the client
  - It accesses useful functions and services provided in the cloud
  - An example of this type of cloud services on the desktop is Apple's iTunes
  - The desktop application plays music, while the cloud service is used to purchase a new audio and video content

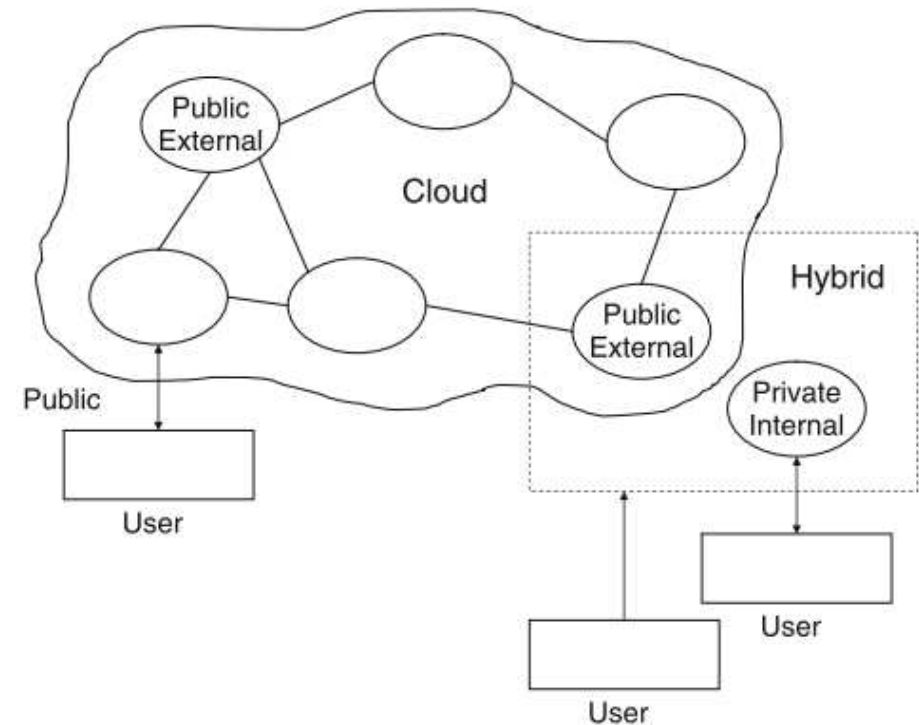
# Three categories of cloud services (cont.)

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- 3. A cloud platform for creating applications, which is used by developers
  - The application developers create a new SaaS application using the cloud platform

# Types of Cloud Computing

- There are three types of cloud computing
  - Public cloud
  - Private cloud
  - Hybrid cloud



# Public Cloud

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- In the public cloud (or external cloud) computing resources are dynamically provisioned over the Internet via Web applications or Web services from an off-site third-party provider
- Public clouds are run by third parties, and applications from different customers are likely to be mixed together on the cloud's servers, storage systems, and networks



# Private Cloud

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- Private cloud (or internal cloud) refers to cloud computing on private networks
- Private clouds are built for the exclusive use of one client, providing full control over data, security, and quality of service
- Private clouds can be built and managed by a company's own IT organization or by a cloud provider

# Hybrid Cloud

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- A hybrid cloud environment combines multiple public and private cloud models
- Hybrid clouds introduce the complexity of determining how to distribute applications across both a public and private cloud

# Enabling Technologies

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- Key technologies that enabled cloud computing are as follows
  - Virtualization
  - Web service and service-oriented architecture (SOA)
  - Service flows and workflows
  - Web 2.0 and mashup

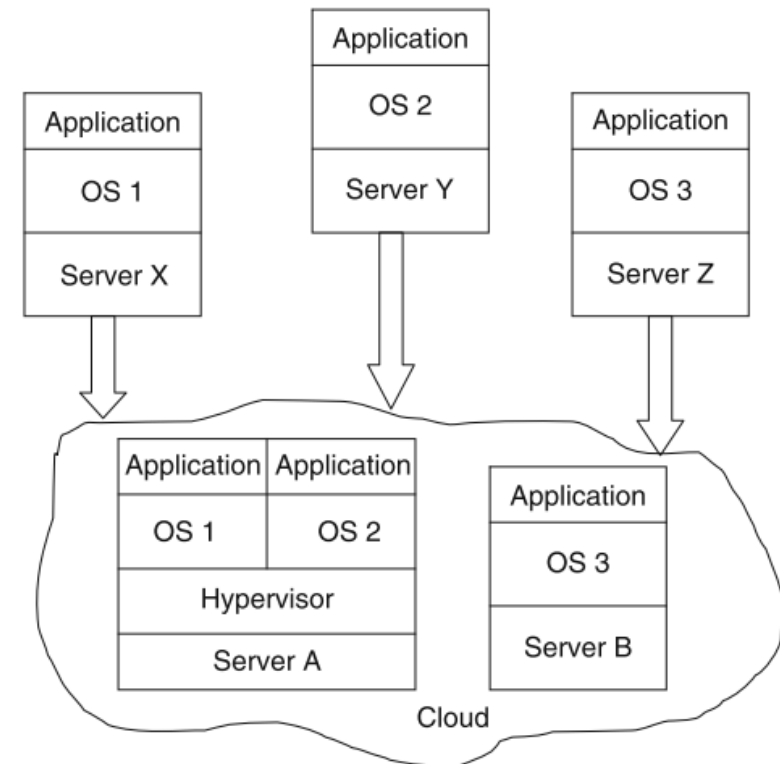
# Virtualization

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- The advantage of cloud computing is the ability to virtualize and share resources among different applications with the objective for better server utilization
- **Example**
  - In non-cloud computing three independent platforms exist for three different applications running on its own server
  - In the cloud, servers can be shared, or virtualized, for operating systems and applications resulting in fewer servers (in specific example 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



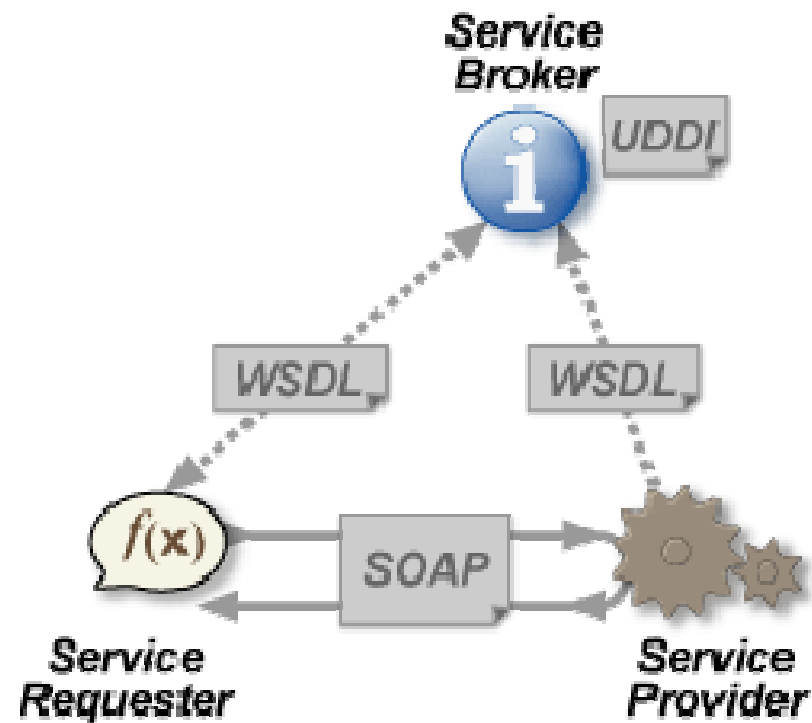
# Web Service and Service Oriented Architecture

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- Cloud services are typically designed as Web services, which follow industry standards including WSDL, SOAP, and UDDI
- A Service Oriented Architecture organizes and manages Web services inside clouds
- A SOA also includes a set of cloud services, which are available on various distributed platforms

# Web Service and Service Oriented Architecture (cont.)

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# Service Flow and Workflows

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- The concept of service flow and workflow refers to an integrated view of service-based activities provided in clouds
- Workflows have become one of the important areas of research in the field of database and information systems



# Web 2.0 and Mashup

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- Web 2.0 is a new concept that refers to the use of Web technology and Web design to enhance creativity, information sharing, and collaboration among users
- On the other hand, Mashup is a web application that combines data from more than one source into a single integrated storage tool.
- Both technologies are very beneficial for cloud computing

# Cloud Computing Features

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- Scalability and on-demand services
  - Cloud computing provides resources and services for users on demand. The resources are scalable over several data centers.
- User-centric interface
  - Cloud interfaces are location independent and can be accessed by well established interfaces such as Web services and Internet browsers.
- Guaranteed Quality of Service (QoS)
  - Cloud computing can guarantee QoS for users in terms of hardware/CPU performance, bandwidth, and memory capacity.

# Cloud Computing Features (cont.)

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- Autonomous system
  - The cloud computing systems are autonomous systems managed transparently to users. However, software and data inside clouds can be automatically reconfigured and consolidated to a simple platform depending on user's needs.
- Pricing
  - Cloud computing does not require up-front investment. No capital expenditure is required. Users pay for services and capacity as they need them.

# Cloud Computing Standards

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- Cloud computing standards have not been yet fully developed; however a number of existing typically lightweight, open standards have facilitated the growth of cloud computing

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Applications	Communications: HTTP, XMPP Security: OAuth, OpenID, SSL/TLS Syndication: Atom
Client	Browsers: AJAX Offline: HTML5
Implementations	Virtualization: OVF
Platform	Solution stacks: LAMP
Service	Data: XML, JSON Web services: REST

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# Cloud Computing Security

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- One of the critical issues in implementing cloud computing is taking virtual machines, which contain critical applications and sensitive data, to public and shared cloud environments.
- Therefore, potential cloud computing users are concerned about the following security issues
  - Will the users still have the same security policy control over their applications and services?
  - Can it be proved to the organization that the system is still secure and meets SLAs?
  - Is the system complaint and can it be proved to company's auditors?

# Cloud Computing Security (cont.)

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- In traditional data centers, the common approaches to security include perimeter firewall, demilitarized zones, network segmentation, intrusion detection and prevention systems, and network monitoring tools.
- The security requirements for cloud computing providers begins with the same techniques and tools as for traditional data centers, which includes the application of a strong network security perimeter.
- However, physical segmentation and hardware-based security cannot protect against attacks between virtual machines on the same server

# Cloud Computing Security (cont.)

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- Intrusion detection and prevention systems need to be able to detect malicious activity in the VM level, regardless of the location of the VM within the virtualized cloud environment.
- In summary, the virtual environments that deploy the security mechanisms on virtual machines including firewalls, intrusion detection and prevention, integrity monitoring, and log inspection, will effectively make VM cloud secure and ready for deployment.

# Cloud Computing Platforms

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- Cloud computing has great commercial potential.
- According to market research firm IDC, IT cloud services spending will grow from about \$16B in 2008 to about \$42B in 2012 and to increase its share of overall IT spending from 4.2% to 8.5%.

Company	Cloud computing platform	Year of launch	Key offerings
Amazon.com	AWS (Amazon Web Services)	2006	Infrastructure as a service (Storage, Computing, Message queues, Datasets, Content distribution)
Microsoft	Azure	2009	Application platform as a service (.Net, SQL data services)
Google	Google App. Engine	2008	Web Application Platform as a service (Python run time environment)
IBM	Blue Cloud	2008	Virtualized Blue cloud data center
Salesforce.com	Force.com	2008	Proprietary 4GL Web application framework as an on Demand platform



# Pricing

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- Pricing for cloud platforms and services is based on three key dimensions:
  - (i) storage, (ii) bandwidth, and (iii) compute
- **Storage** is typically measured as average daily amount of data stored in GB over a monthly period.

## Pricing (cont.)

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- **Bandwidth** is measured by calculating the total amount of data transferred in and out of platform service through transaction and batch processing. Generally, data transfer between services within the same platform is free in many platforms.
- **Compute** is measured as the time units needed to run an instance, or application, or machine to servicing requests. Table 6 compares pricing for three major cloud computing platforms.

# Pricing comparison for major cloud computing platforms

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Resource	UNIT	Amazon	Google	Microsoft
Stored data	GB per month	\$0.10	\$0.15	\$0.15
Storage transaction	Per 10 K requests	\$0.10		\$0.10
Outgoing bandwidth	GB	\$0.10 – \$0.17	\$0.12	\$0.15
Incoming bandwidth	GB	\$0.10	\$0.10	\$0.10
Compute time	Instance Hours	\$0.10 – \$1.20	\$0.10	\$0.12

# Cloud Computing Challenges

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- **Performance**
- **Security and Privacy**
- **Control**
- **Bandwidth Costs**
- **Reliability**