

# Cloud Computing

# What is Cloud Computing?

- **Cloud Computing** is a general term used to describe a new class of network based computing that takes place over the Internet,
  - basically a step on from Utility Computing
  - a collection/group of integrated and networked hardware, software and Internet infrastructure (called a platform).
  - Using the Internet for communication and transport provides hardware, software and networking services to clients
- These platforms hide the complexity and details of the underlying infrastructure from users and applications by providing very simple graphical interface or API (Applications Programming Interface).

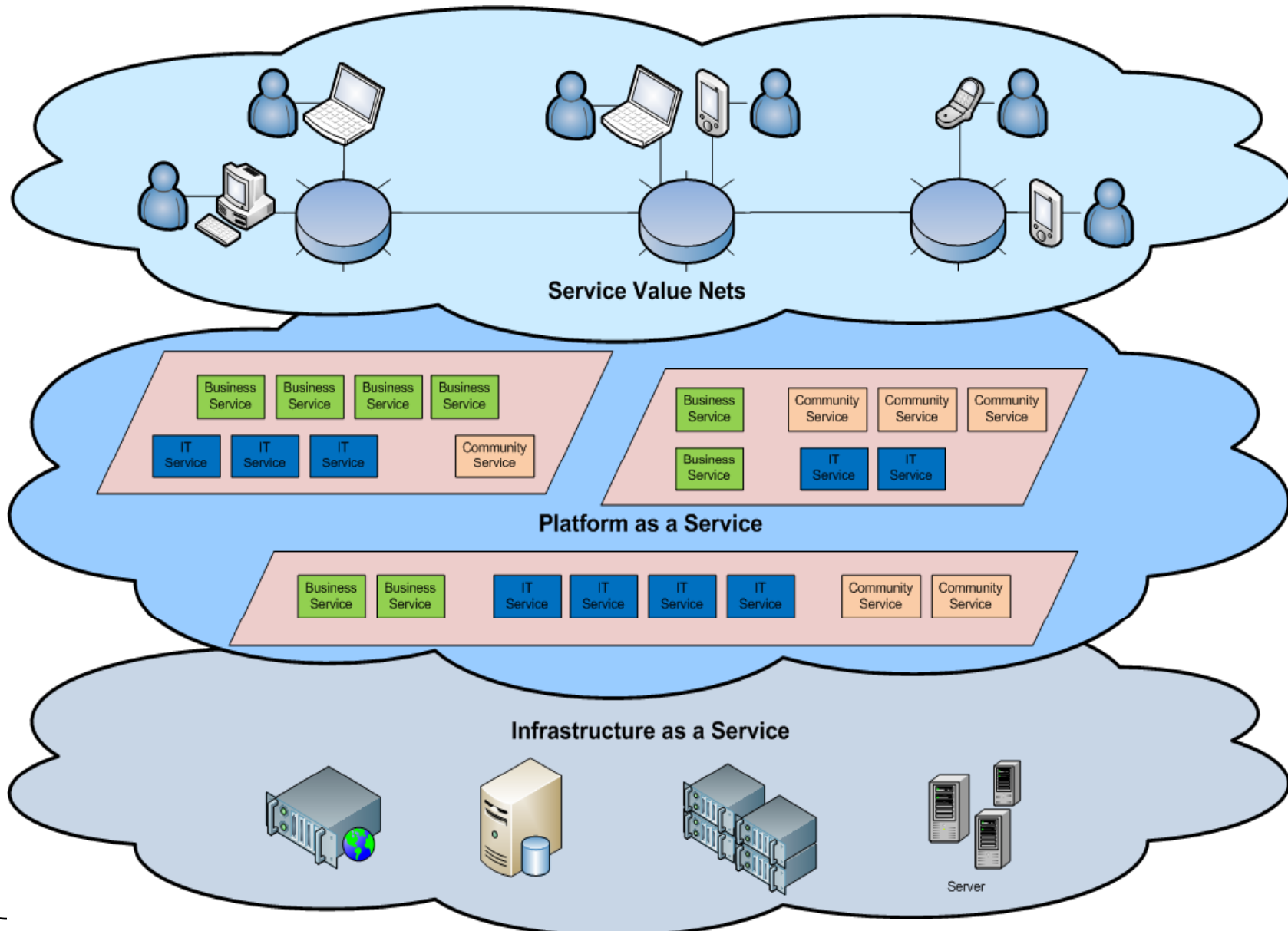
# What is Cloud Computing?

- In addition, the platform provides on demand services, that are always on, anywhere, anytime and any place.
- Pay for use and as needed, elastic
  - scale up and down in capacity and functionalities
- The hardware and software services are available to
  - general public, enterprises, corporations and businesses markets

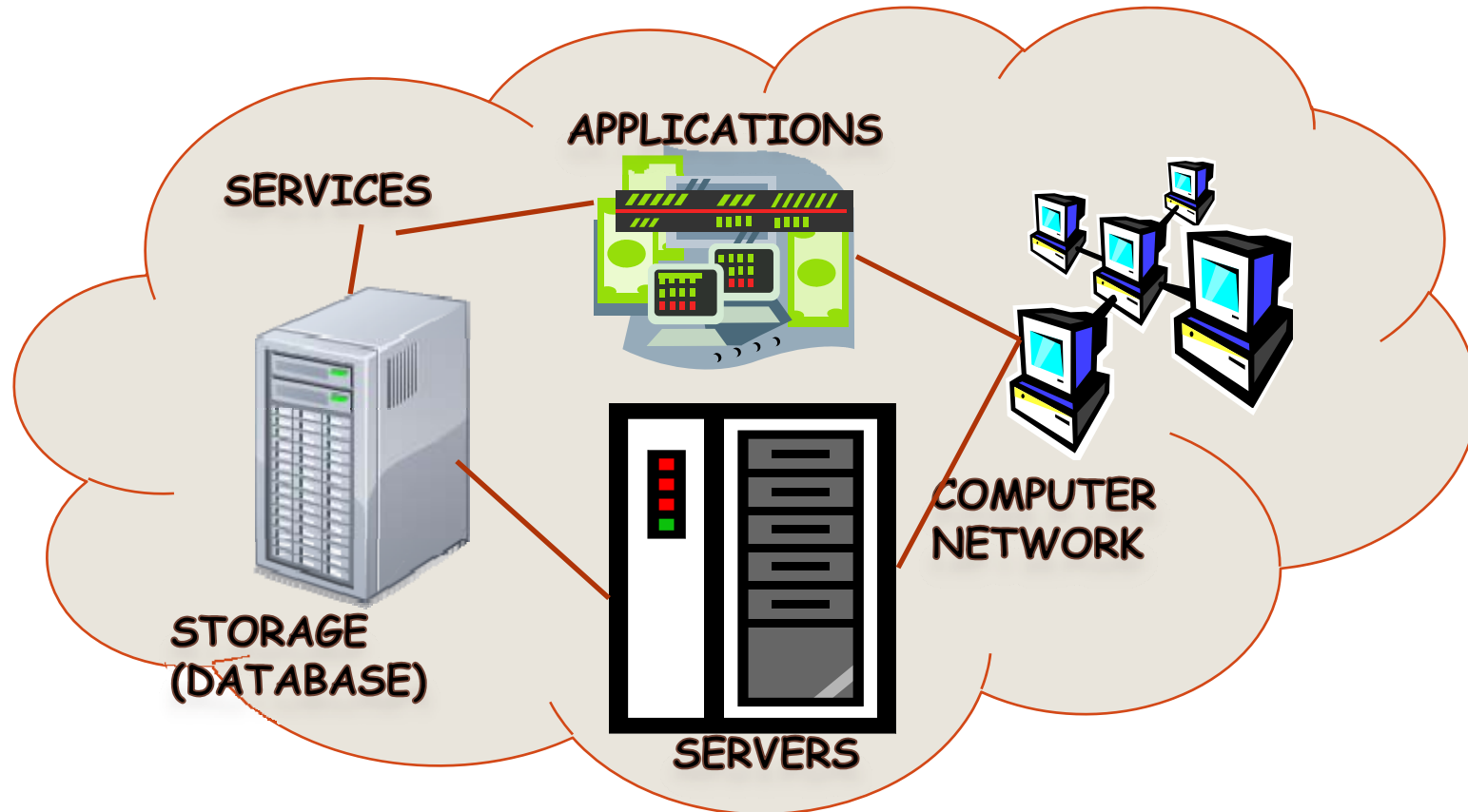
# Cloud Summary

- Cloud computing is an umbrella term used to refer to Internet based development and services
- A number of characteristics define cloud data, applications services and infrastructure:
  - **Remotely hosted:** Services or data are hosted on remote infrastructure.
  - **Ubiquitous:** Services or data are available from anywhere.
  - **Commodified:** The result is a utility computing model similar to traditional that of traditional utilities, like gas and electricity - you pay for what you would want!

# Cloud Architecture



# What is Cloud Computing



- Shared pool of configurable computing resources
- On-demand network access
- Provisioned by the Service Provider

# Cloud Computing Characteristics

## Common Characteristics:

**Massive Scale**

**Resilient Computing**

**Homogeneity**

**Geographic Distribution**

**Virtualization**

**Service Orientation**

**Low Cost Software**

**Advanced Security**

## Essential Characteristics:

**On Demand Self-Service**

**Broad Network Access**

**Rapid Elasticity**

**Resource Pooling**

**Measured Service**

# Cloud Service Models

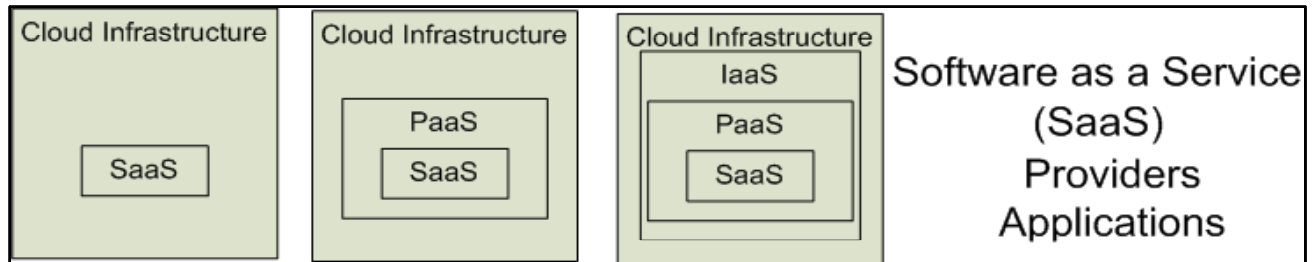
Software as a Service (SaaS)

Platform as a Service (PaaS)

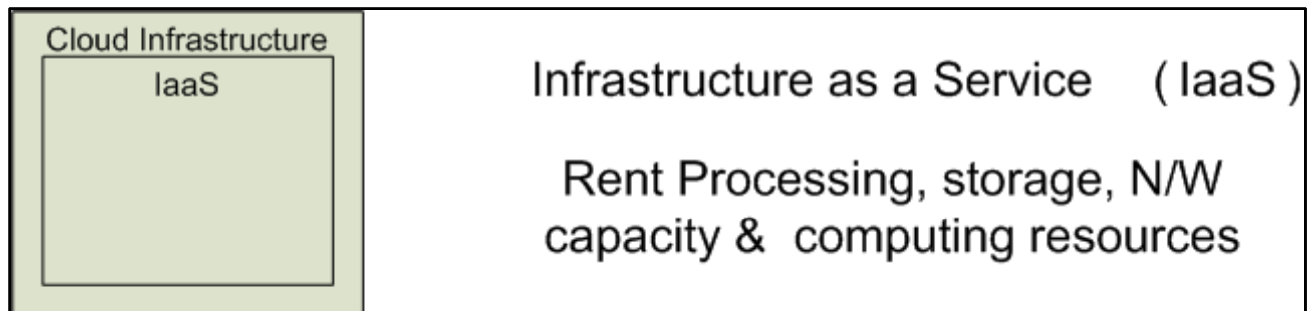
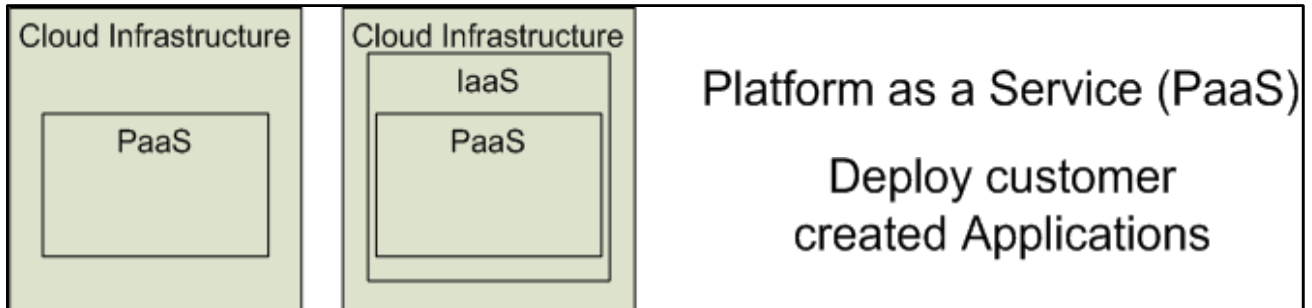
Infrastructure as a Service (IaaS)

SalesForce CRM

LotusLive



Google App





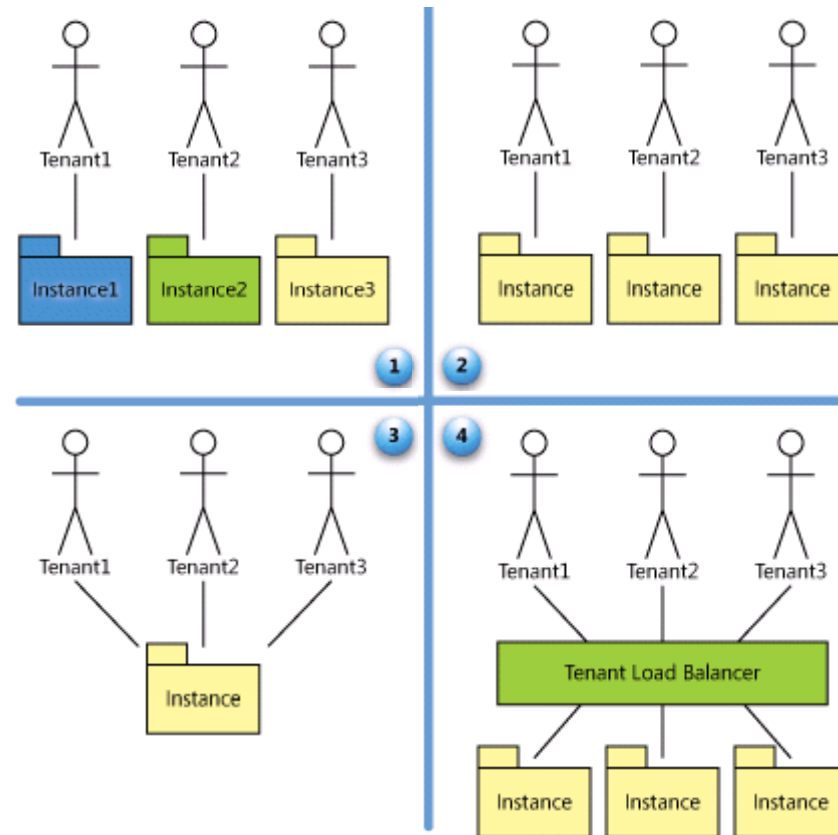
# SaaS Maturity Model

Level 1: Ad-Hoc/Custom –  
One Instance per customer

Level 2: Configurable per  
customer

Level 3: configurable & Multi-  
Tenant-Efficient

Level 4: Scalable, Configurable &  
Multi-Tenant-Efficient



# Different Cloud Computing Layers

<b>Application Service (SaaS)</b>	MS Live/ExchangeLabs, IBM, Google Apps; Salesforce.com Quicken Online, Zoho, Cisco
<b>Application Platform</b>	Google App Engine, Mosso, Force.com, Engine Yard, Facebook, Heroku, AWS
<b>Server Platform</b>	3Tera, EC2, SliceHost, GoGrid, RightScale, Linode
<b>Storage Platform</b>	Amazon S3, Dell, Apple, ...

# Cloud Computing Service Layers

		Services	Description
Application Focused	Services	Services	Services - Complete business services such as PayPal, OpenID, OAuth, Google Maps, Alexa
	Application	Application	Application - Cloud based software that eliminates the need for local installation such as Google Apps, Microsoft Online
	Development	Development	Development - Software development platforms used to build custom cloud based applications (PAAS & SAAS) such as Salesforce
Infrastructure Focused	Platform	Platform	Platform - Cloud based platforms, typically provided using virtualization, such as Amazon ECC, Sun Grid
	Storage	Storage	Storage - Data storage or cloud based NAS such as CTERA, iDisk, CloudNAS
	Hosting	Hosting	Hosting - Physical data centers such as those run by IBM, HP, NaviSite, etc.

# Basic Cloud Characteristics

- The “**no-need-to-know**” in terms of the underlying details of infrastructure, applications interface with the infrastructure via the APIs.
- The “**flexibility and elasticity**” allows these systems to scale up and down at will
  - utilising the resources of all kinds
    - CPU, storage, server capacity, load balancing, and databases
- The “**pay as much as used and needed**” type of utility computing and the “**always on!, anywhere and any place**” type of network-based computing.

# Basic Cloud Characteristics

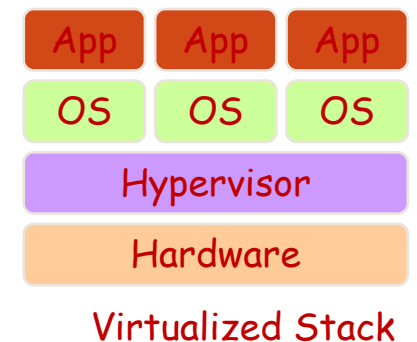
- Cloud are transparent to users and applications, they can be built in multiple ways
  - branded products, proprietary open source, hardware or software, or just off-the-shelf PCs.
- In general, they are built on clusters of PC servers and off-the-shelf components plus Open Source software combined with in-house applications and/or system software.

# Software as a Service (SaaS)

- SaaS is a model of software deployment where an application is hosted as a service provided to customers across the Internet.
- SaaS alleviates the burden of software maintenance/support
  - but users relinquish control over software versions and requirements.
- Terms that are used in this sphere include
  - **Platform as a Service (PaaS)** and
  - **Infrastructure as a Service (IaaS)**

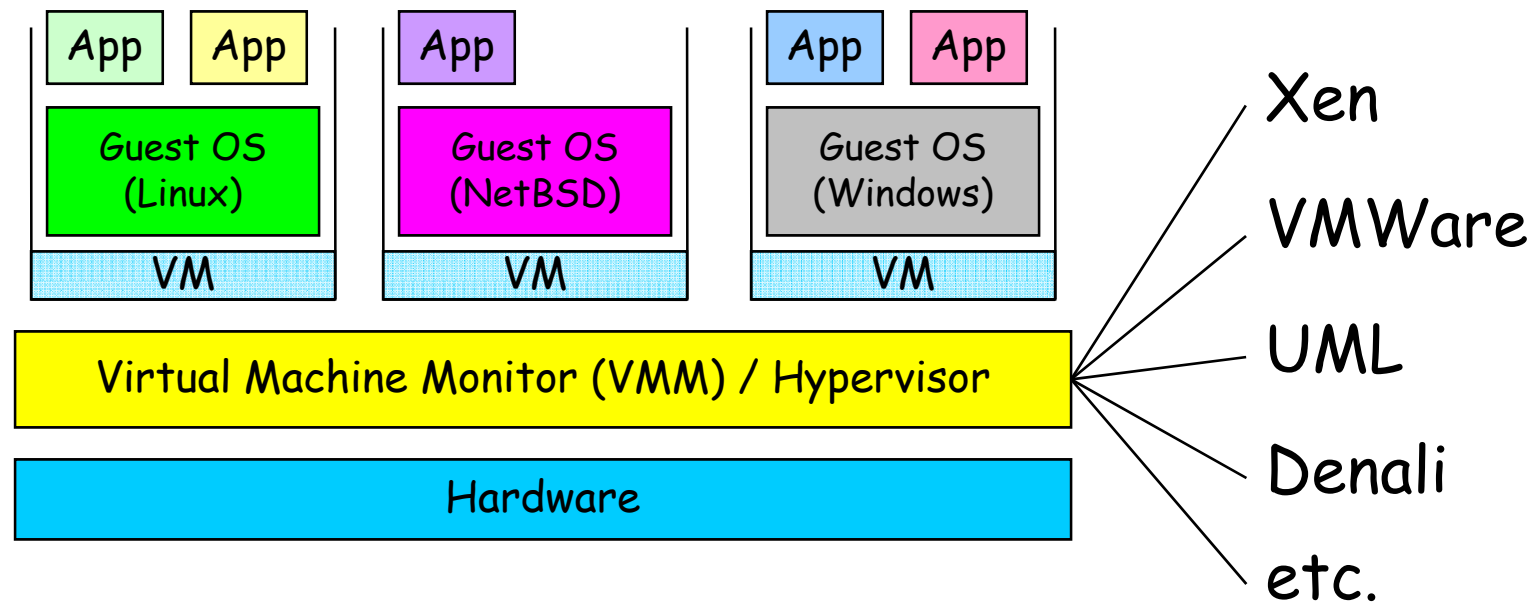
# Virtualization

- Virtual workspaces:
  - An abstraction of an execution environment that can be made dynamically available to authorized clients by using well-defined protocols,
  - Resource quota (e.g. CPU, memory share),
  - Software configuration (e.g. O/S, provided services).
- Implement on Virtual Machines (VMs):
  - Abstraction of a physical host machine,
  - Hypervisor intercepts and emulates instructions from VMs, and allows management of VMs,
  - VMWare, Xen, etc.
- Provide infrastructure API:
  - Plug-ins to hardware/support structures



# Virtual Machines

- VM technology allows multiple virtual machines to run on a single physical machine.



*Performance:* Para-virtualization (e.g. Xen) is very close to raw physical performance!



# Virtualization in General

- Advantages of virtual machines:
  - Run operating systems where the physical hardware is unavailable,
  - Easier to create new machines, backup machines, etc.,
  - Software testing using “clean” installs of operating systems and software,
  - Emulate more machines than are physically available,
  - Timeshare lightly loaded systems on one host,
  - Debug problems (suspend and resume the problem machine),
  - Easy migration of virtual machines (shutdown needed or not).
  - Run legacy systems!

# What is the purpose and benefits?

- Cloud computing enables companies and applications, which are system infrastructure dependent, to be infrastructure-less.
- By using the Cloud infrastructure on “pay as used and on demand”, all of us can save in capital and operational investment!
- Clients can:
  - Put their data on the platform instead of on their own desktop PCs and/or on their own servers.
  - They can put their applications on the cloud and use the servers within the cloud to do processing and data manipulations etc.

# Cloud-Sourcing

- Why is it becoming a Big Deal:
  - Using high-scale/low-cost providers,
  - Any time/place access via web browser,
  - Rapid scalability; incremental cost and load sharing,
  - Can forget need to focus on local IT.
- Concerns:
  - Performance, reliability, and SLAs,
  - Control of data, and service parameters,
  - Application features and choices,
  - Interaction between Cloud providers,
  - No standard API – mix of SOAP and REST!
  - Privacy, security, compliance, trust...

# Some Commercial Cloud Offerings



Amazon Elastic Compute Cloud (Amazon EC2) - Beta



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Cloud Computing

Cloudware - Cloud Computing Without Compromise



**MOSSO**  
the hosting cloud



**VERIO**  
An NTT Communications Company

# Cloud Taxonomy

## Infrastructure Services

### Storage

- Amazon S3
- Amazon EBS
- CTERA Portal
- Mosso Cloud Files
- Nirvanix

### Compute

- Amazon EC2
- Serve Path GoGrid
- Elastra
- Mosso Cloud Servers
- Joyent Accelerators
- AppNexus
- Flexiscale
- ElasticHosts
- Hosting.com CloudNine
- Terramark
- GridLayer
- ITRICITY
- LayeredTech

### Services Management

- RightScale
- enStratus
- Scalr
- CohesiveFT
- Kaavo
- CloudStatus
- Ylastic
- Dynect
- CloudFoundry
- NewRelic
- Cloud42

## Cloud Software

### Data

- 10Gen MongoDB
- Oracle Coherence
- Gemstone Gemfire
- Apache CouchDB
- Apache HBase
- Hypertable
- TerraCotta
- Tokyo Cabinet
- Cassandra
- memcached

### Compute

- Globus Toolkit
- Xeround
- Beowulf
- Sun Grid Engine
- Hadoop
- OpenCloud
- Gigaspace
- DataSynapse
- Xeround

### Cloud Management

- 3Tera App Logic
- OpenNebula
- Open.ControlTier
- Enomaly Enomalism
- Altor Networks
- VMware vSphere
- OnPathTech
- CohesiveFT VPN Cubed
- Hyperic
- Eucalyptus
- Reductive Lbs Puppet
- OpenQRM
- Appistry

### File Storage

- EMC Atmos
- ParaScale
- Zmanda
- CTERA

### Appliances

- PingIdentity
- Symplified
- rPath
- Vordel

## CLOUD TAXONOMY

## Platform Services

### General Purpose

- Force.com
- Etelos
- LongJump
- AppJet
- Rollbase
- Bungee Labs Connect
- Google App Engine
- Engine Yard
- Caspio
- Qrimp
- MS Azure Services Platform
- Mosso Cloud Sites

### Business Intelligence

- Aster DB
- Quantivo
- Cloud9 Analytics
- Blink Logic
- K2 Analytics
- LogiXML
- Oco
- Panorama
- PivotLink
- Sterna
- ColdLight Neuron
- Infobright
- Vertica

### Integration

- Amazon SQS
- MuleSource Mule OnDemand
- Boomi
- SnapLogic
- OpSource Connect
- Cast Iron
- Microsoft BizTalk Services
- gnip
- SnapLogic SaaS Solution Packs
- Applan Anywhere
- HubSpan
- Informatica On-Demand

### Development & Testing

- Keynote Systems
- Mercury
- SOASTA
- SkyTap
- Aptana
- LoadStorm
- Collabnet
- Dynamicsoft

### Database

- Google BigTable
- Amazon SimpleDB
- FathomDB
- Microsoft SDS

## Software Services

### Desktop Productivity

- Zoho
- IBM Lotus Live
- Google Apps
- Desktoptwo
- Parallels
- ClusterSeven

### Sales

- Xactly
- LucidEra
- StreetSmarts
- Success Metrics

### Legal

- DirectLaw
- Advologix
- Fios
- Sertifi

### Financials

- Concur
- Xero
- Workday
- Beam4d

### Billing

- Aria Systems
- eVapt
- OpSource
- Redi2
- Zuora

### CRM

- NetSuite
- Parature
- Responsys
- Rightnow
- Salesforce.com
- LiveOps
- MSDynamics
- Oracle On Demand

### Backup & Recovery

- JungleDisk
- Mozy
- Zmanda Cloud Backup
- OpenRSM
- Synclplicity

### Content Management

- Clickability
- SpringCM
- CrownPoint

### Social Networks

- Ning
- Zemby
- Amitive

### Human Resources

- Taleo
- Workday
- ICIMS

### Collaboration

- Box.net
- DropBox

# Cloud Storage

- Several large Web companies are now exploiting the fact that they have data storage capacity that can be hired out to others.
  - allows data stored remotely to be temporarily cached on desktop computers, mobile phones or other Internet-linked devices.
- Amazon's Elastic Compute Cloud (EC2) and Simple Storage Solution (S3) are well known examples
  - Mechanical Turk

# Amazon Simple Storage Service (S3)

- Unlimited Storage.
- Pay for what you use:
  - \$0.20 per GByte of data transferred,
  - \$0.15 per GByte-Month for storage used,
  - Second Life Update:
    - 1TBytes, 40,000 downloads in 24 hours - \$200,



# Utility Computing – EC2

- Amazon Elastic Compute Cloud (EC2):
  - Elastic, marshal 1 to 100+ PCs via WS,
  - Machine Specs...,
  - Fairly cheap!
- Powered by Xen – a Virtual Machine:
  - Different from Vmware and VPC as uses “para-virtualization” where the guest OS is modified to use special hyper-calls:
  - Hardware contributions by Intel (VT-x/Vanderpool) and AMD (AMD-V).
  - Supports “Live Migration” of a virtual machine between hosts.
- Linux, Windows, OpenSolaris
- Management Console/AP



# EC2 – The Basics

- Load your image onto S3 and register it.
- Boot your image from the Web Service.
- Open up required ports for your image.
- Connect to your image through SSH.
- Execute you application...

# Opportunities and Challenges

- The use of the cloud provides a number of opportunities:
  - It enables services to be used without any understanding of their infrastructure.
  - Cloud computing works using economies of scale:
    - It potentially lowers the outlay expense for start up companies, as they would no longer need to buy their own software or servers.
    - Cost would be by on-demand pricing.
    - Vendors and Service providers claim costs by establishing an ongoing revenue stream.
  - Data and services are stored remotely but accessible from “anywhere”.

# Opportunities and Challenges

- In parallel there has been backlash against cloud computing:
  - Use of cloud computing means dependence on others and that could possibly limit flexibility and innovation:
    - The others are likely become the bigger Internet companies like Google and IBM, who may monopolise the market.
    - Some argue that this use of supercomputers is a return to the time of mainframe computing that the PC was a reaction against.
  - Security could prove to be a big issue:
    - It is still unclear how safe out-sourced data is and when using these services ownership of data is not always clear.
  - There are also issues relating to policy and access:
    - If your data is stored abroad whose policy do you adhere to?
    - What happens if the remote server goes down?
    - How will you then access files?
    - There have been cases of users being locked out of accounts and losing access to data.

# Advantages of Cloud Computing

- Lower computer costs:
  - You do not need a high-powered and high-priced computer to run cloud computing's web-based applications.
  - Since applications run in the cloud, not on the desktop PC, your desktop PC does not need the processing power or hard disk space demanded by traditional desktop software.
  - When you are using web-based applications, your PC can be less expensive, with a smaller hard disk, less memory, more efficient processor...
  - In fact, your PC in this scenario does not even need a CD or DVD drive, as no software programs have to be loaded and no document files need to be saved.

# Advantages of Cloud Computing

- Improved performance:
  - With few large programs hogging your computer's memory, you will see better performance from your PC.
  - Computers in a cloud computing system boot and run faster because they have fewer programs and processes loaded into memory...
- Reduced software costs:
  - Instead of purchasing expensive software applications, you can get most of what you need for free-ish!
    - most cloud computing applications today, such as the Google Docs suite.
  - better than paying for similar commercial software
    - which alone may be justification for switching to cloud applications.

# Advantages of Cloud Computing

- Instant software updates:
  - Another advantage to cloud computing is that you are no longer faced with choosing between obsolete software and high upgrade costs.
  - When the application is web-based, updates happen automatically
    - available the next time you log into the cloud.
  - When you access a web-based application, you get the latest version
    - without needing to pay for or download an upgrade.
- Improved document format compatibility.
  - You do not have to worry about the documents you create on your machine being compatible with other users' applications or OSes
  - There are potentially no format incompatibilities when everyone is sharing documents and applications in the cloud.

# Advantages of Cloud Computing

- Unlimited storage capacity:
  - Cloud computing offers virtually limitless storage.
  - Your computer's current 1 Tbyte hard drive is small compared to the hundreds of Pbytes available in the cloud.
- Increased data reliability:
  - Unlike desktop computing, in which if a hard disk crashes and destroy all your valuable data, a computer crashing in the cloud should not affect the storage of your data.
    - if your personal computer crashes, all your data is still out there in the cloud, still accessible
  - In a world where few individual desktop PC users back up their data on a regular basis, cloud computing is a data-safe computing platform!

# Advantages of Cloud Computing

- Universal document access:
  - That is not a problem with cloud computing, because you do not take your documents with you.
  - Instead, they stay in the cloud, and you can access them whenever you have a computer and an Internet connection
  - Documents are instantly available from wherever you are
- Latest version availability:
  - When you edit a document at home, that edited version is what you see when you access the document at work.
  - The cloud always hosts the latest version of your documents
    - as long as you are connected, you are not in danger of having an outdated version



# Advantages of Cloud Computing

- Easier group collaboration:
  - Sharing documents leads directly to better collaboration.
  - Many users do this as it is an important advantages of cloud computing
    - multiple users can collaborate easily on documents and projects
- Device independence.
  - You are no longer tethered to a single computer or network.
  - Changes to computers, applications and documents follow you through the cloud.
  - Move to a portable device, and your applications and documents are still available.

# Disadvantages of Cloud Computing

- Requires a constant Internet connection:
  - Cloud computing is impossible if you cannot connect to the Internet.
  - Since you use the Internet to connect to both your applications and documents, if you do not have an Internet connection you cannot access anything, even your own documents.
  - A dead Internet connection means no work and in areas where Internet connections are few or inherently unreliable, this could be a deal-breaker.

# Disadvantages of Cloud Computing

- Does not work well with low-speed connections:
  - Similarly, a low-speed Internet connection, such as that found with dial-up services, makes cloud computing painful at best and often impossible.
  - Web-based applications require a lot of bandwidth to download, as do large documents.
- Features might be limited:
  - This situation is bound to change, but today many web-based applications simply are not as full-featured as their desktop-based applications.
    - For example, you can do a lot more with Microsoft PowerPoint than with Google Presentation's web-based offering

# Disadvantages of Cloud Computing

- Can be slow:
  - Even with a fast connection, web-based applications can sometimes be slower than accessing a similar software program on your desktop PC.
  - Everything about the program, from the interface to the current document, has to be sent back and forth from your computer to the computers in the cloud.
  - If the cloud servers happen to be backed up at that moment, or if the Internet is having a slow day, you would not get the instantaneous access you might expect from desktop applications.

# Disadvantages of Cloud Computing

- Stored data might not be secure:
  - With cloud computing, all your data is stored on the cloud.
    - The questions is How secure is the cloud?
  - Can unauthorised users gain access to your confidential data?
- Stored data can be lost:
  - Theoretically, data stored in the cloud is safe, replicated across multiple machines.
  - But on the off chance that your data goes missing, you have no physical or local backup.
    - Put simply, relying on the cloud puts you at risk if the cloud lets you down.

# Disadvantages of Cloud Computing

- HPC(High Performance Computing) Systems:
  - Not clear that you can run compute-intensive HPC applications that use MPI/OpenMP!
  - Scheduling is important with this type of application
    - as you want all the VM to be co-located to minimize communication latency!
- General Concerns:
  - Each cloud systems uses different protocols and different APIs
    - may not be possible to run applications between cloud based systems
  - Amazon has created its own DB system (not SQL 92), and workflow system (many popular workflow systems out there)
    - so your normal applications will have to be adapted to execute on these platforms.

# The Future

- Many of the activities loosely grouped together under cloud computing have already been happening and centralised computing activity is not a new phenomena
- Grid Computing was the last research-led centralised approach
- However there are concerns that the mainstream adoption of cloud computing could cause many problems for users
- Many new open source systems appearing that you can install and run on your local cluster
  - should be able to run a variety of applications on these systems