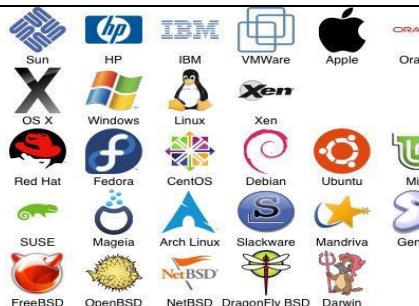
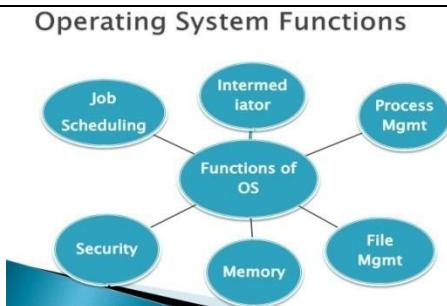
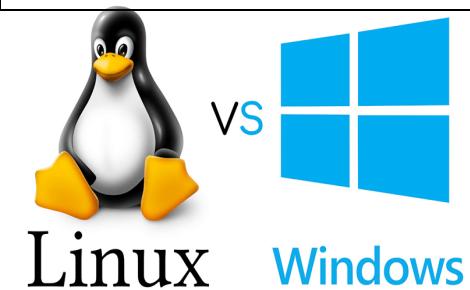


Week 10 Day 1: Cloud Computing Implementation, Technology, Architecture IaaS, PaaS, SaaS Public, Private Hybrid Clouds, Service Deployment Methodology



- **Service and deployment models**
 - **Three service models**
 - Infrastructure as a Service
 - Platform as a Service
 - Software as a Service
 - **Four deployment models**
 - Public Cloud
 - Private Cloud
 - Community Cloud
 - Hybrid Cloud



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 ?



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 ?

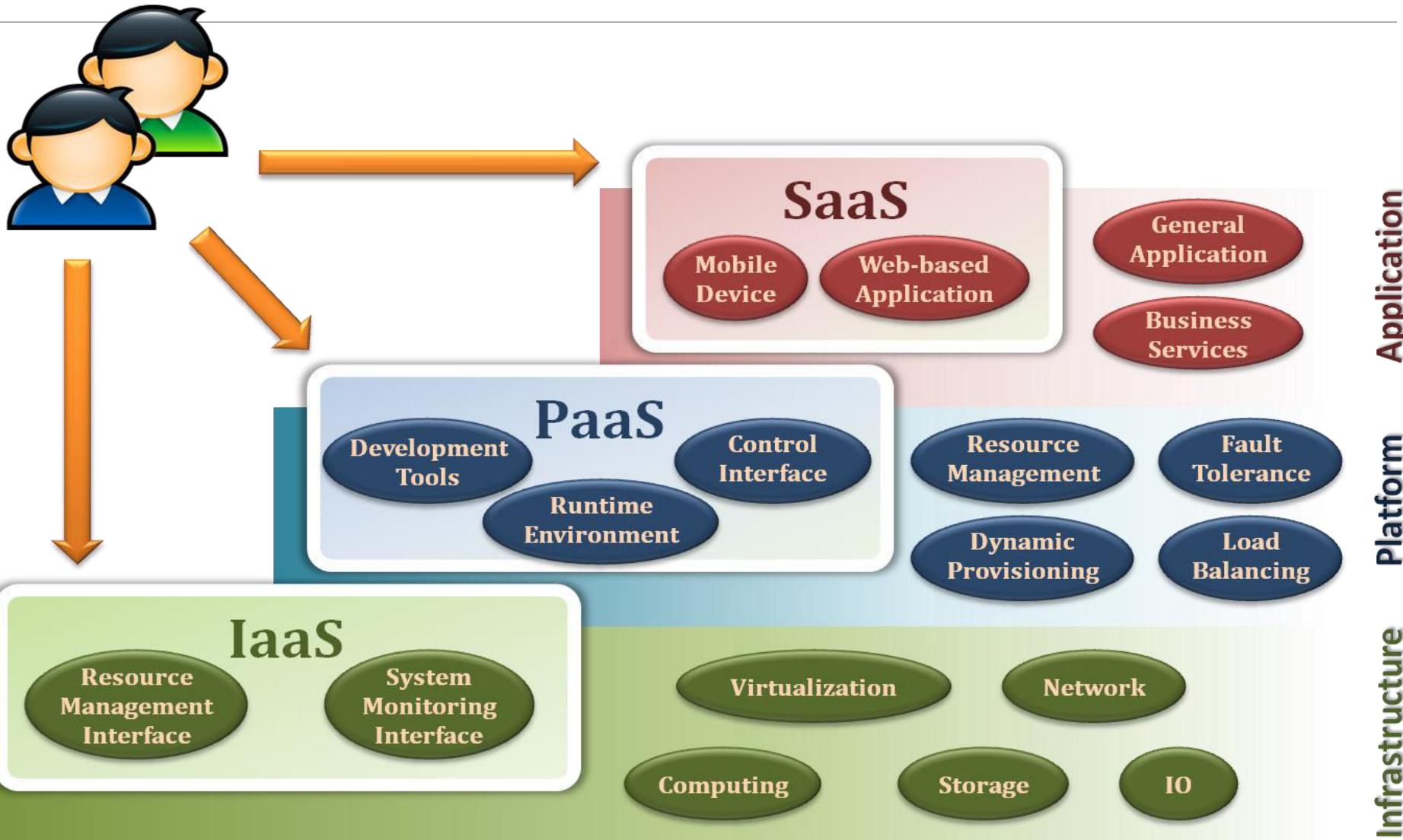
■ Live in a hotel will be a good idea if the only thing you care is enjoy your life!! There is nothing you can do with the house except living in it.



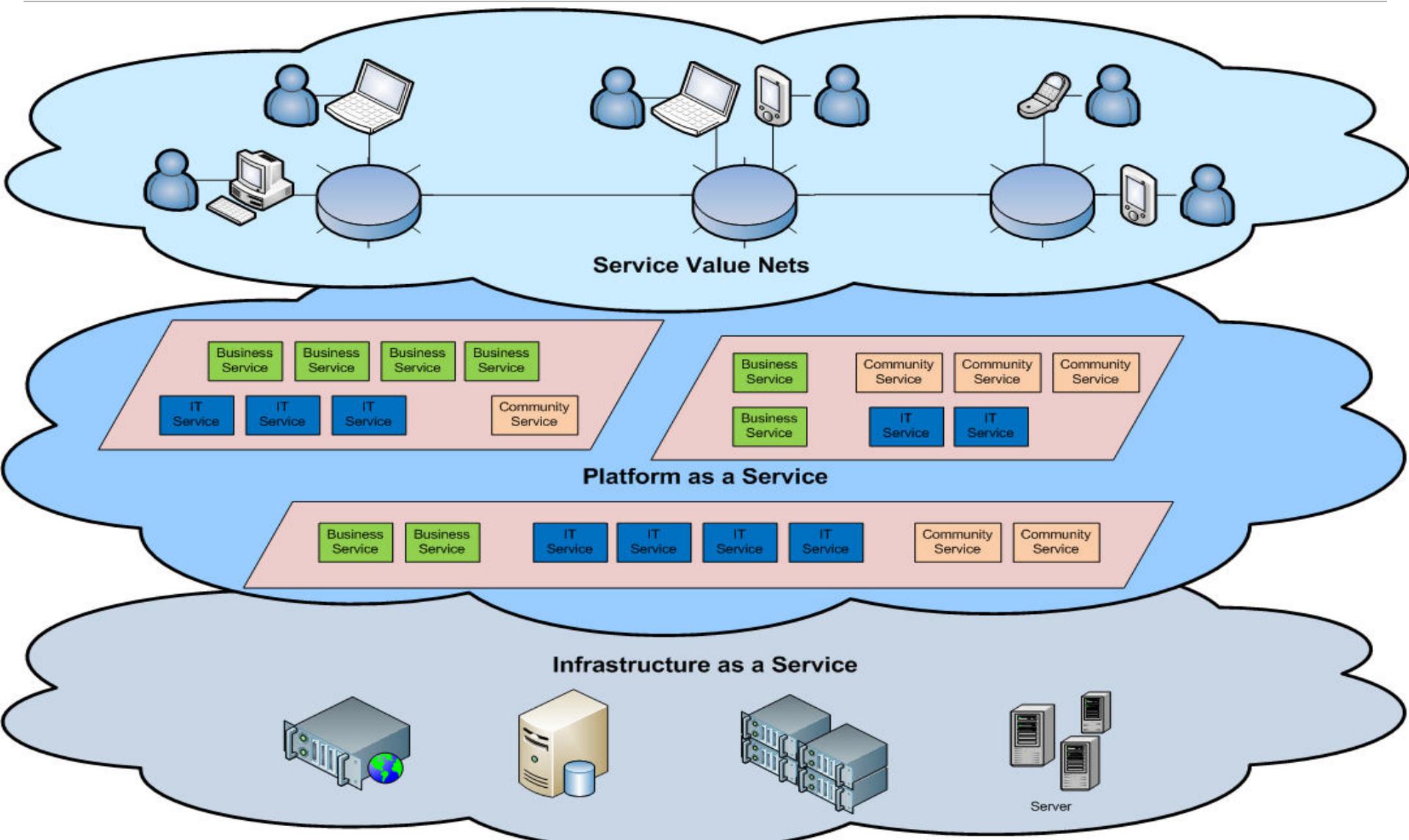
**Let's translate to
Cloud Computing !!**

- **What if you want to have an IT department ?**
 - **Similar to *build a new house* in previous analogy**
 - You can rent some virtualized infrastructure and build up your own IT system among those resources, which may be fully controlled.
 - Technical speaking, use the ***Infrastructure as a Service (IaaS*** solution.
 - **Similar to *buy an empty house* in previous analogy**
 - You can directly develop your IT system through one cloud platform, and do not care about any lower level resource management.
 - Technical speaking, use the ***Platform as a Service (PaaS)*** solution.
 - **Similar to *live in a hotel* in previous analogy**
 - You can directly use some existed IT system solutions, which were provided by some cloud application service provider, without knowing any detail technique about how these service was achieved.
 - Technical speaking, use the ***Software as a Service (SaaS)*** solution.

Service Model Overview



Cloud Architecture

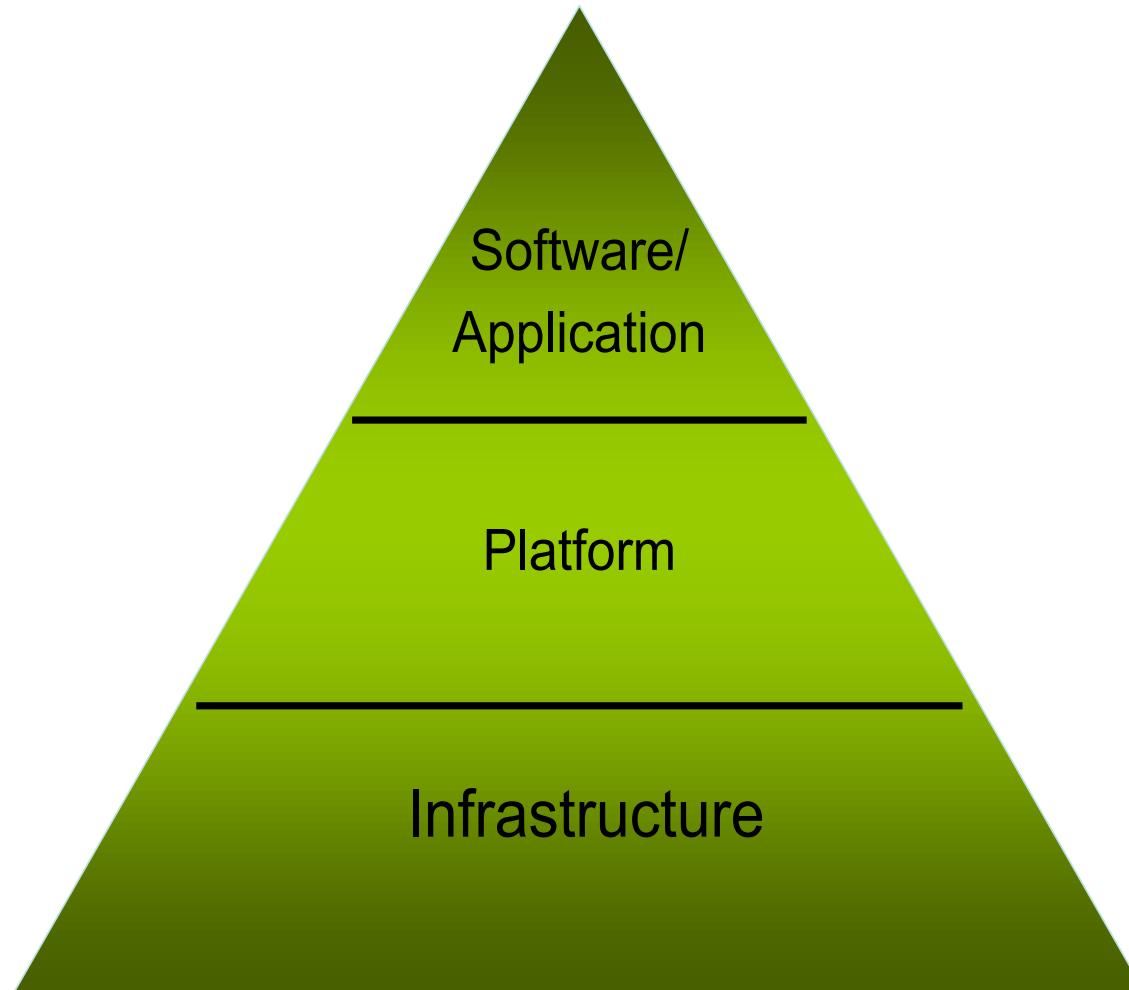


Infrastructure as a Service

Platform as a Service

Software as a Service

SERVICE MODELS



Cloud Service Models

Software as a Service (SaaS)

SalesForce
CRM
LotusLive

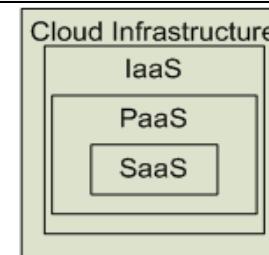
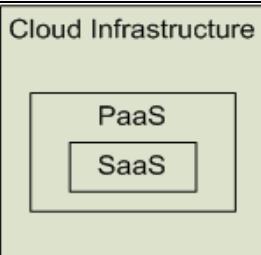
Platform as a Service (PaaS)

Google
App
Engine

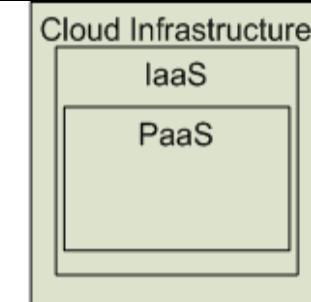
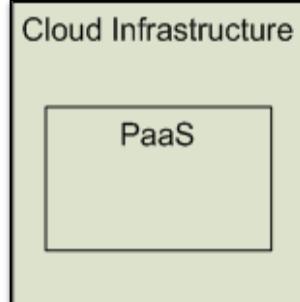
Windows Azure
The Future Made Familiar

Infrastructure as a Service (IaaS)

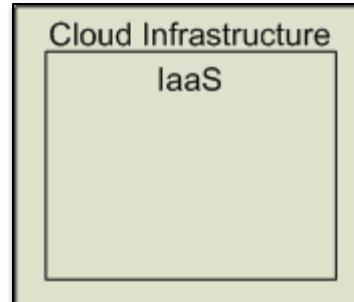
amazon
web services™
Rackspace®
HOSTING



Software as a Service (SaaS)
Providers
Applications



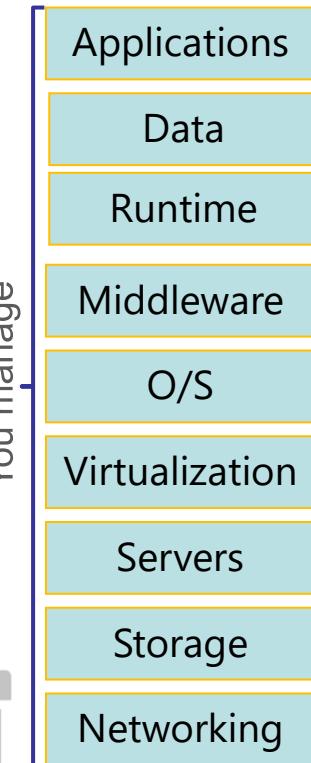
Platform as a Service (PaaS)
Deploy customer
created Applications



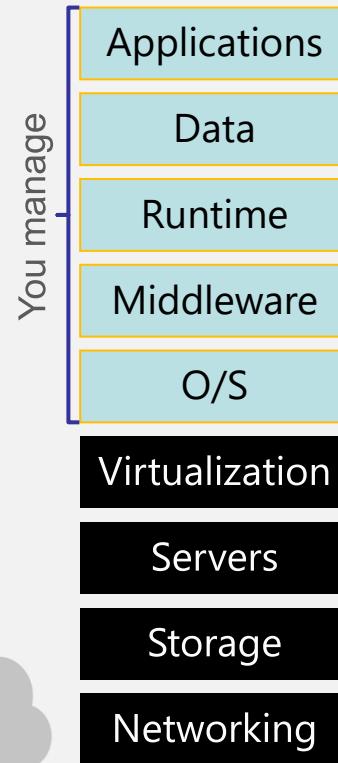
Infrastructure as a Service (IaaS)
Rent Processing, storage, N/W
capacity & computing resources

Cloud Computing Taxonomy

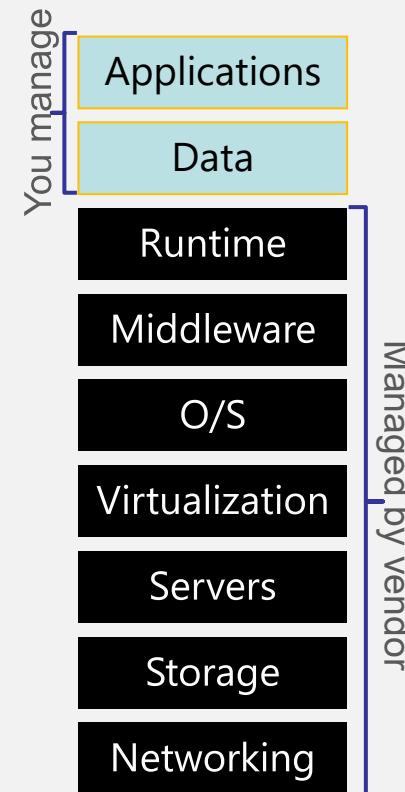
Packaged Software



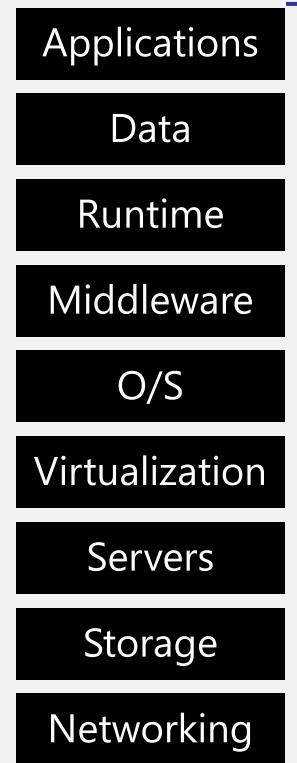
Infrastructure (as a Service)



Platform (as a Service)



Software (as a Service)



You manage

You manage

You manage

Managed by vendor

Managed by vendor

**Higher Cost & More Control
Lower Cost & Higher Agility**

Infrastructure-as-a-Service (IaaS)

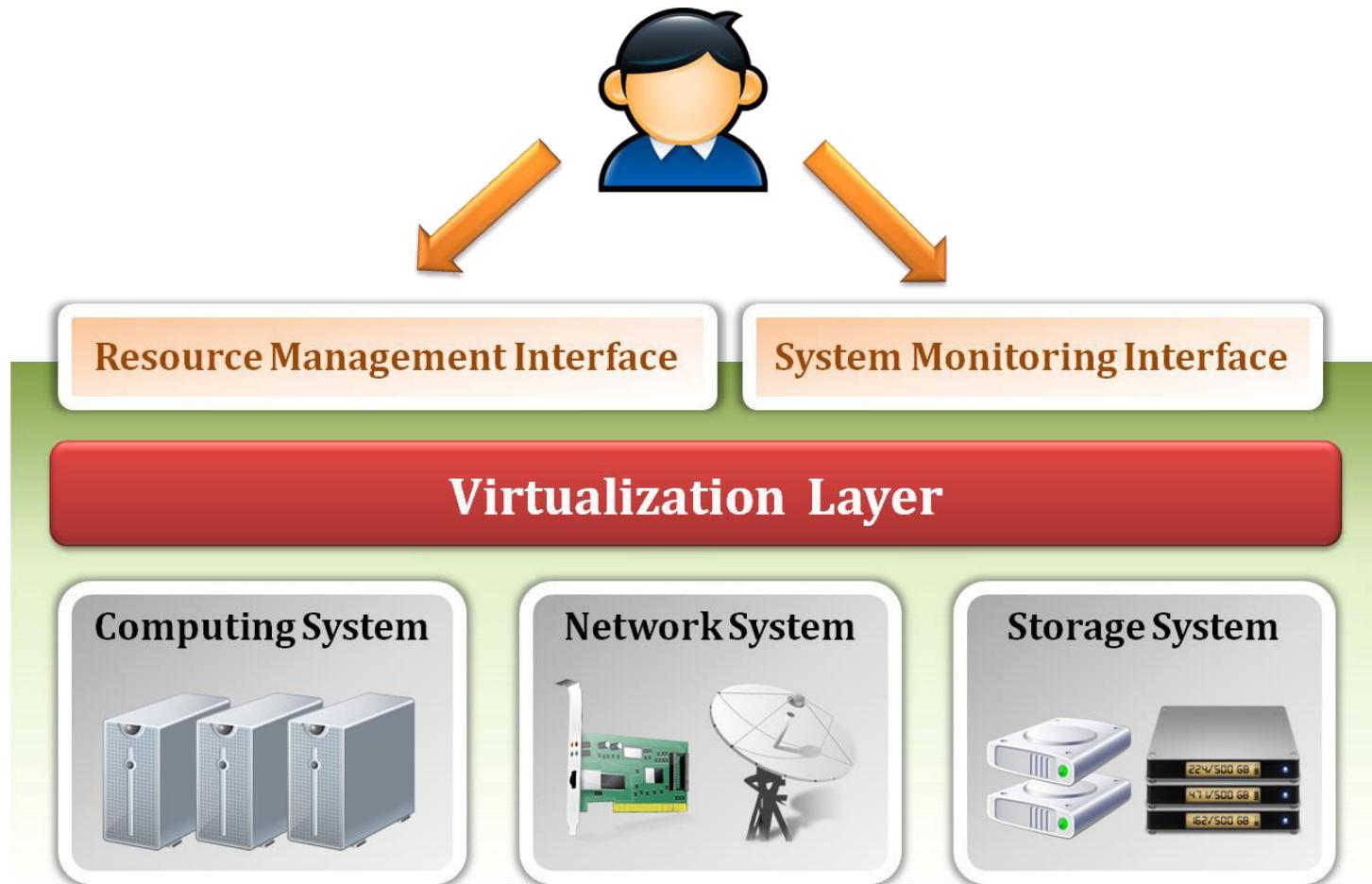
- IaaS is the delivery of technology infrastructure as an on demand scalable service
- A service model that involves outsourcing the basic infrastructure used to support operations--including storage, hardware, servers, and networking components.
- The service provider owns the infrastructure equipment and is responsible for housing, running, and maintaining it. The customer typically pays on a per-use basis.
- The customer uses their own platform (Windows, Unix), and applications
 - Usually billed based on usage
 - Usually multi tenant virtualized environment
 - Can be coupled with Managed Services for OS and application support

- Infrastructure as a Service - IaaS
 - 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.
 - The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems, storage, deployed applications, and possibly limited control of select networking components .
- Examples :
 - Amazon EC2
 - Eucalyptus
 - OpenNebula
 - ... etc

IaaS Examples



- System architecture :



Infrastructure as a Service (IaaS)

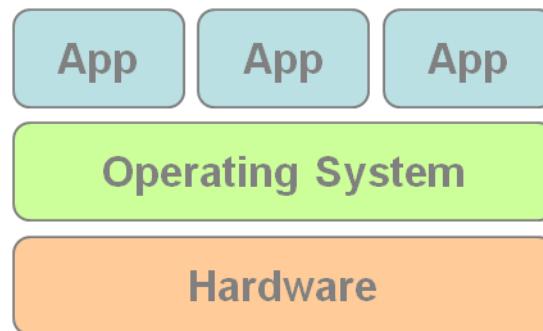
- Cloud service that allows existing applications to run on its hardware.
- Rents out resources dynamically wherever they are needed.
- Services:
 - Compute Servers
 - Data Storage
 - Firewall
 - Load Balancer

- Geographical Presence
 - Responsiveness
 - Availability
- User Interfaces and Access to Servers
 - Providing means of accessing their Cloud
 - Gui
 - CLI
 - Web Services

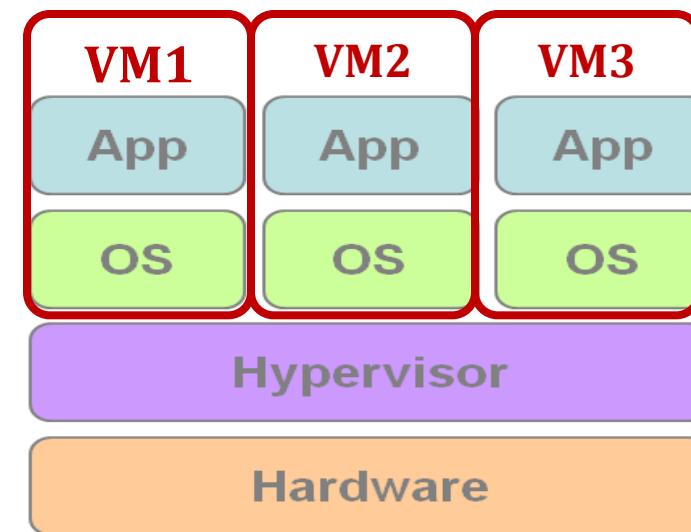
- Advance Reservation of Capacity
 - Time-Frame reservations
- Automatic Scaling and Load Balancing
 - Elasticity of the service
 - One of the most desirable features of an IaaS Cloud
 - Traffic distribution

- Service-Level Agreement
 - As with all services, parties must sign an agreement
 - Metrics
 - Uptime, Performance measures
 - Penalties
 - Amazon
- Hypervisor and Operating System Choice
 - Xen
 - VMWare, vCloud, Citric Cloud Center

- Enabling technique - *Virtualization*
 - Virtualization is an abstraction of logical resources away from underlying physical resources.
 - Virtualization technique shift OS onto hypervisor.
 - Multiple OS share the physical hardware and provide different services.
 - Improve utilization, availability, security and convenience.

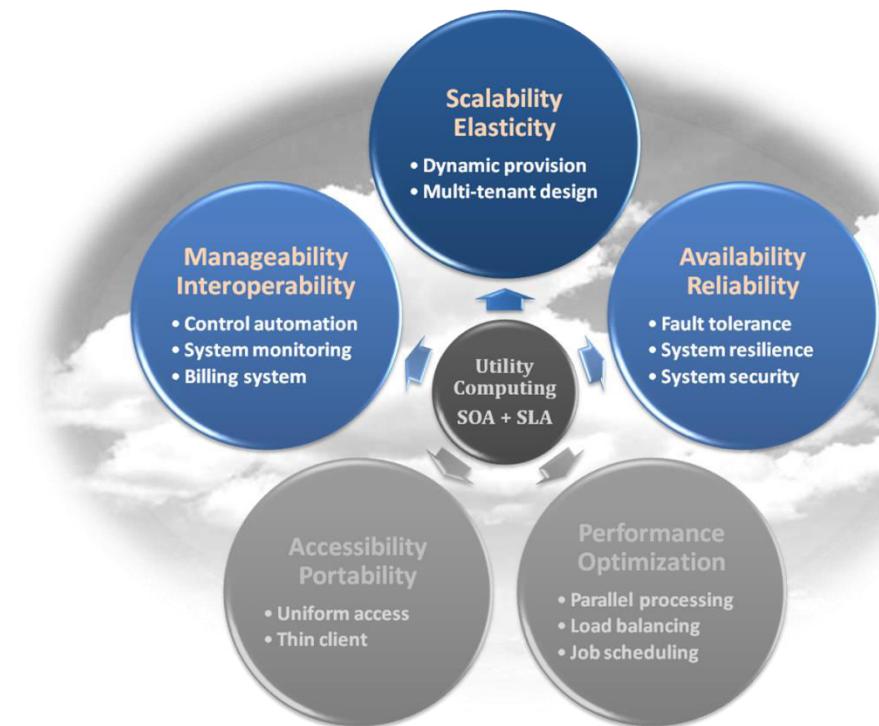


Traditional Stack



Virtualized Stack

- Properties supported by virtualization technique :
 - Manageability and Interoperability
 - Availability and Reliability
 - Scalability and Elasticity



- Provide service – **Resource Management Interface**
 - Several types of virtualized resource :
 - **Virtual Machine** – As an IaaS provider, we should be able to provide the basic virtual machine operations, such as *creation, suspension, resumption* and *termination*, ...etc.
 - **Virtual Storage** – As an IaaS provider, we should be able to provide the basic virtual storage operations, such as *space allocation, space release, data writing* and *data reading*, ...etc.
 - **Virtual Network** – As an IaaS provider, we should be able to provide the basic virtual network operations, such as *IP address allocation, domain name register, connection establishment* and *bandwidth provision*, ...etc.

- Provide service – **System Monitoring Interface**
 - Several types of monitoring metrics :
 - **Virtual Machine** – As an IaaS provider, we should be able to monitor some system states of each virtual machine, such as *CPU loading*, *memory utilization*, *IO loading* and *internal network loading*, ...etc.
 - **Virtual Storage** – As an IaaS provider, we should be able to monitor some storage states of each virtual storage, such as *virtual space utilization*, *data duplication* and *storage device access bandwidth*, ...etc.
 - **Virtual Network** – As an IaaS provider, we should be able to monitor some network states of each virtual network, such as *virtual network bandwidth*, *network connectivity* and *network load balancing*, ...etc.

IaaS Service Providers

Table 1.2. Feature Comparison Public Cloud Offerings (Infrastructure as a Service)

	Geographic Presence	Client UI API Language Bindings	Primary Access to Server	Advance Reservation of Capacity	SLA Uptime	Smallest Billing Unit	Hypervisor	Guest Operating Systems	Automated Horizontal Scaling	Load Balancing	Runtime Server Resizing/Vertical Scaling	Instance Hardware Capacity		
												Processor	Memory	Storage
Amazon EC2	US East, Europe	CLI, WS, Portal	SSH (Linux), Remote Desktop (Windows)	Amazon reserved instances (Available in 1 or 3 years terms, starting from reservation time)	99.95%	Hour	Xen	Linux, Windows	Available with Amazon CloudWatch	Elastic Load Balancing	No	1-20 EC2 compute units	1.7-15 GB	160-1690 GB 1GB-1TB (per EBS volume)
Flexiscale	UK	Web Console	SSH	No	100%	Hour	Xen	Linux, Windows	No	Zeus software loadbalancing	Processors, memory (requires reboot)	1-4 CPUs	0.5-16 GB	20-270 GB
GoGrid		REST, Java, PHP, Python, Ruby	SSH	No	100%	Hour	Xen	Linux, Windows	No	Hardware (F5)	No	1-6 CPUs	0.5-8 GB	30-480 GB
Joyent Cloud	US (Emeryville, CA; San Diego, CA; Andover, MA; Dallas, TX)		SSH, VirtualMin (Web-based system administration)	No	100%	Month	OS Level (Solaris Containers)	OpenSolaris	No	Both hardware (F5 networks) and software (Zeus)	Automatic CPU bursting (up to 8 CPUs)	1/16-8 CPUs	0.25-32 GB	5-100 GB
Rackspace Cloud Servers	US (Dallas, TX)	Portal, REST, Python, PHP, Java, C#/.NET	SSH	No	100%	Hour	Xen	Linux	No	No	Memory, disk (requires reboot) Automatic CPU bursting (up to 100% of available CPU power of physical host)	Quad-core CPU (CPU power is weighed proportionally to memory size)	0.25-16 GB	10-620 GB

- IaaS is the deployment platform that abstract the infrastructure.
- IaaS enabling technique
 - Virtualization
 - Server Virtualization
 - Storage Virtualization
 - Network Virtualization
- IaaS provided services
 - Resource Management Interface
 - System Monitoring Interface

Infrastructure as a Service

Platform as a Service

Software as a Service

SERVICE MODELS

Platform-as-a-Service (PaaS)

- PaaS provides all of the facilities required to support the complete life cycle of building and delivering web applications and services entirely from the Internet.
- A service model that involves outsourcing the basic infrastructure and platform (Windows, Unix)
- PaaS facilitates deploying applications without the cost and complexity of buying and managing the underlying hardware and software where the applications are hosted.
- The customer uses their own applications
 - Typically applications must be developed with a particular platform in mind
 - Multi tenant environments
 - Highly scalable multi tier architecture

- Platform as a Service - PaaS
 - The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages and tools supported by the provider.
 - The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly application hosting environment configurations.
- Examples :
 - Microsoft Windows Azure
 - Google App Engine
 - Hadoop
 - ... etc

Platform as a Service (PaaS)

- Provides all infrastructure needed for a consumer to run applications over the internet.
- PaaS is a Cloud Computing service that offers a computing platform and solution stack for users.
 - Language
 - OS
 - Database
 - Middleware
 - Other applications

- Programming Languages
 - Python
 - Java
 - .Net Languages
 - Ruby
- Programming Frameworks
 - Ruby on Rails
 - Spring
 - Java EE
 - .Net
- Persistence Options

- A PaaS Cloud should be able to support various programming models for different types of Programming.
 - Programming large datasets in clusters of computers (MapReduce)
 - Development of request-based web services and applications
 - Orchestration of a business process in the form of workflows (WorkFlow Model)
 - High-performance distributed execution of tasks.

PaaS Service Providers

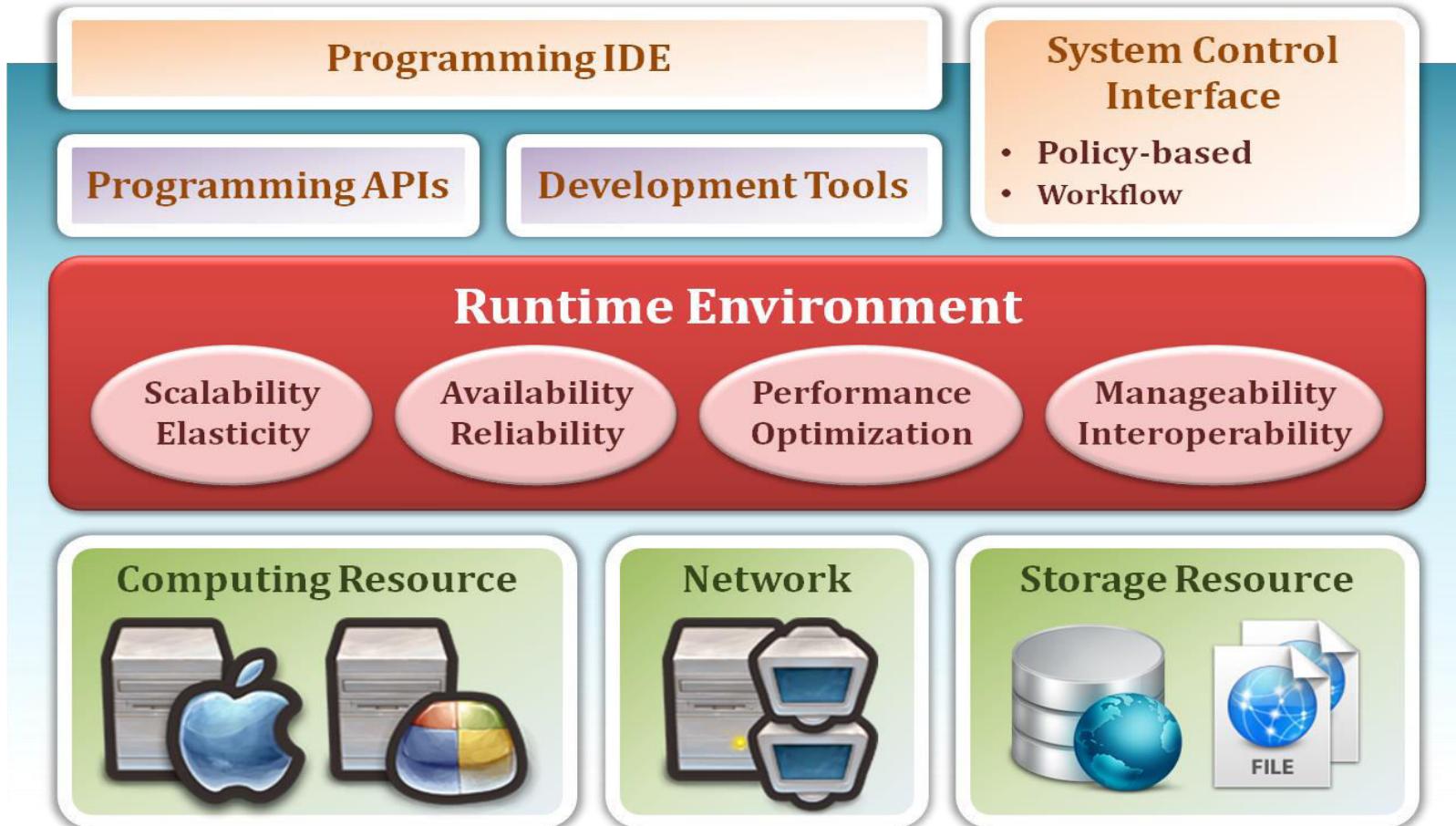
Table 1.3. Feature Comparison of Platform-as-a-Service Cloud Offerings

	Target Use	Programming Language, Frameworks	Developer Tools	Programming Models	Persistence Options	Automatic Scaling	Backend Infrastructure Providers
Aneka	.Net enterprise applications, HPC	.NET	Standalone SDK	Threads, Task, MapReduce	Flat files, RDBMS, HDFS	No	Amazon EC2
AppEngine	Web applications	Python, Java	Eclipse-based IDE	Request-based Web programming	BigTable	Yes	Own data centers
Force.com	Enterprise applications (esp. CRM)	Apex	Eclipse-based IDE, Web-based wizard	Workflow, Excel-like formula language, Request-based web programming	Own object database	Unclear	Own data centers
Microsoft Windows Azure	Enterprise and Web applications	.NET	Azure tools for Microsoft Visual Studio	Unrestricted	Table/BLOB/queue storage, SQL services	Yes	Own data centers
Heroku	Web applications	Ruby on Rails	Command-line tools	Request-based web programming	PostgreSQL, Amazon RDS	Yes	Amazon EC2
Amazon Elastic MapReduce	Data processing	Hive and Pig, Cascading, Java, Ruby, Perl, Python, PHP, R, C++	Karmasphere Studio for Hadoop (Net-Beans-based)	MapReduce	Amazon S3	No	Amazon EC2

PaaS Examples



- System architecture :



- Enabling technique – Runtime Environment Design
 - Runtime environment refers to collection of software services available. Usually implemented by a collection of program libraries.
- Common properties in Runtime Environment :
 - Manageability and Interoperability
 - Performance and Optimization
 - Availability and Reliability
 - Scalability and Elasticity



- Provide service – Programming IDE
 - Users make use of programming IDE to develop their service among PaaS.
 - This IDE should integrate the full functionalities which supported from the underling runtime environment.
 - This IDE should also provide some development tools, such as profiler, debugger and testing environment.
 - The programming APIs supported from runtime environment may be various between different cloud providers, but there are still some common operating functions.
 - Computation, storage and communication resource operation

Platform as a Service

- Provide service – System Control Interface
 - Policy-Based Control
 - Typically described as a principle or rule to guide decisions and achieve rational outcome(s)
 - Make the decision according to some requirements
 - Workflow Control
 - Describe the flow of installation and configuration of resources
 - Workflow processing daemon delivers speedy and efficient construction and management of cloud resources

PaaS - Summary

- PaaS is the development platform that abstract the infrastructure, OS, and middleware to drive developer productivity.
- PaaS enabling technique
 - Runtime Environment
- PaaS provide services
 - Programming IDE
 - Programming APIs
 - Development tools
 - System Control Interface
 - Policy based approach
 - Workflow based approach

Infrastructure as a Service

Platform as a Service

Software as a Service

SERVICE MODELS

Software-as-a-Service (SaaS)

- SaaS is a software delivery methodology that provides licensed multi-tenant access to software and its functions remotely as a Web-based service.
- Also referred to as “software on demand,” this service model involves outsourcing the infrastructure, platform, and software/applications.
- Typically, these services are available to the customer for a fee, pay-as-you-go, or a no charge model.
- The customer accesses the applications over the internet.
 - Usually billed based on usage
 - Usually multi tenant environment
 - Highly scalable architecture

- Software as a Service - SaaS
 - The capability provided to the consumer is to use the provider's applications running on a cloud infrastructure. The applications are accessible from various client devices through a thin client interface such as a web browser (e.g., web-based email).
 - The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.
- Examples :
 - Google Apps (e.g., Gmail, Google Docs, Google sites, ...etc)
 - SalesForce.com
 - EyeOS
 - ... etc

SaaS Examples



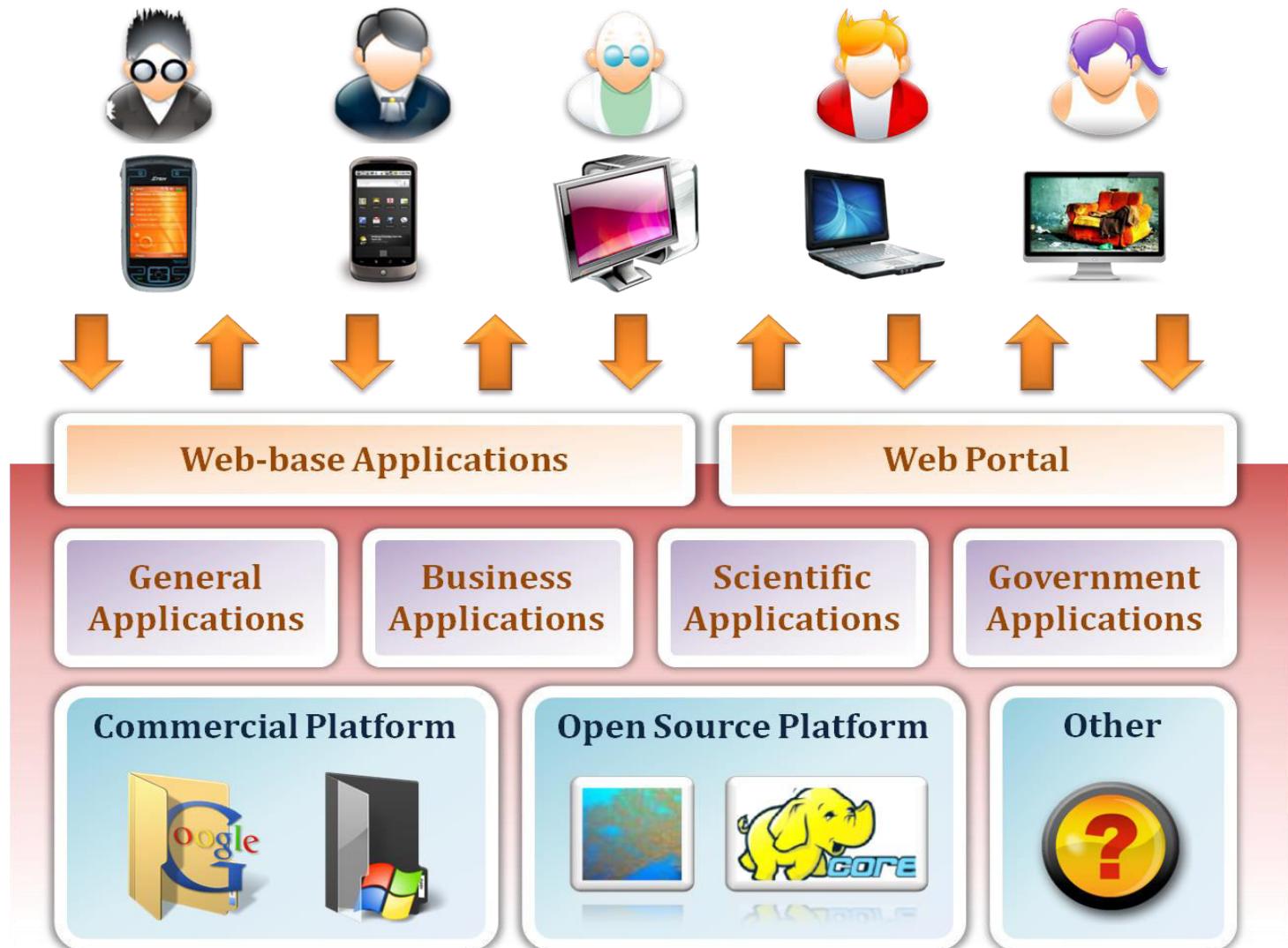
Microsoft Online Services: Business Productivity Online Suite

Microsoft SharePoint Online Microsoft Office Communications Online

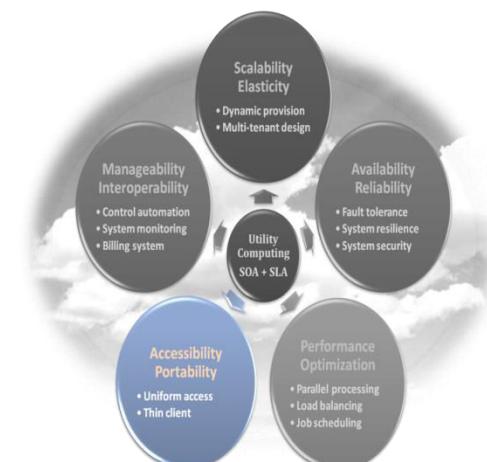
Microsoft Exchange Online Microsoft Office Live Meeting



Software as a Service



- Enabling Technique – Web Service
 - Web 2.0 is the trend of using the full potential of the web
 - Viewing the Internet as a computing platform
 - Running interactive applications through a web browser
 - Leveraging interconnectivity and mobility of devices
 - Enhanced effectiveness with greater human participation
- Properties provided by Internet :
 - Accessibility and Portability



- Provide service – Web-based Applications
 - Conventional applications should translate their access interface onto web-based platform.
 - Applications in different domains
 - *General Applications* – Applications which are designed for general propose, such as *office suit*, *multimedia* and *instant message*, ...etc.
 - *Business Applications* – Application which are designed for business propose, such as *ERP*, *CRM* and *market trading system*, ...etc.
 - *Scientific Applications* – Application which are designed for scientific propose, such as *aerospace simulation* and *biochemistry simulation*, ...etc.
 - *Government Applications* – Applications which are designed for government propose, such as *national medical system* and *public transportation system service*, ...etc.

- **Provide service – Web Portal**
 - Apart from the standard search engine feature, web portals offer other services such as e-mail, news, stock prices, information, databases and entertainment.
 - Portals provide a way for enterprises to provide a consistent look and feel with access control and procedures for multiple applications and databases, which otherwise would have been different entities altogether.
 - Some examples :
 - iGoogle
 - MSNBC
 - Netvibes
 - Yahoo!

Different Cloud Computing Layers

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

Cloud Computing Service Layers

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

- SaaS is the finished applications that you rent and customize.
- SaaS enabling technique
 - Web Service
- SaaS provide services
 - Web-based Applications
 - General applications
 - Business applications
 - Scientific applications
 - Government applications
 - Web Portal

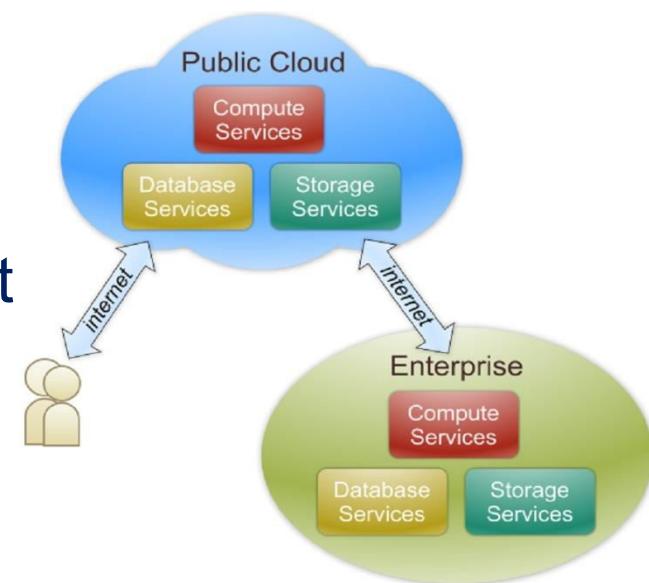
How to deploy a cloud system ?

DEPLOYMENT MODELS



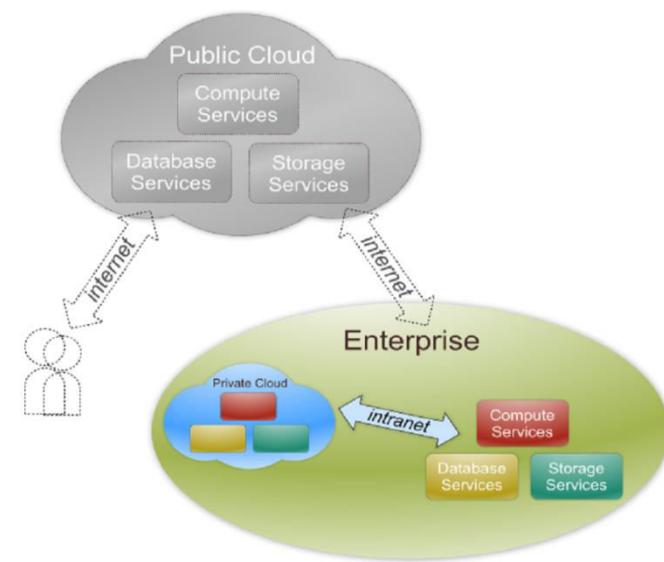
- There are four primary cloud deployment models :
 - Public Cloud
 - Private Cloud
 - Community Cloud
 - Hybrid Cloud
- Each can exhibit the previously discussed characteristics; their differences lie primarily in the scope and access of published cloud services, as they are made available to service 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.
 - Also known as external cloud or multi-tenant cloud, this model essentially represents a cloud environment that is openly accessible.
 - Basic characteristics :
 - Homogeneous infrastructure
 - Common policies
 - Shared resources and multi-tenant
 - Leased or rented infrastructure
 - Economies of scale



- **Private cloud definition**

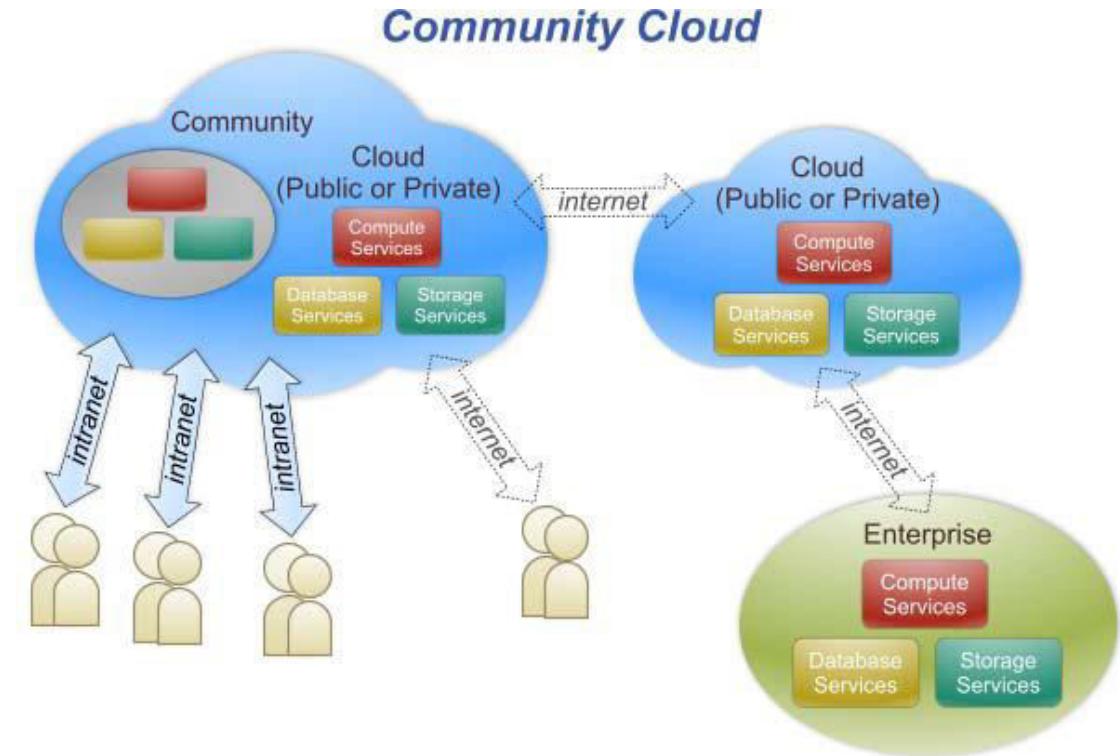
- The cloud infrastructure is operated solely for an organization. It may be managed by the organization or a third party and may exist on premise or off premise.
- Also referred to as internal cloud or on-premise cloud, a private cloud intentionally limits access to its resources to service consumers that belong to the same organization that owns the cloud.
- **Basic characteristics :**
 - Heterogeneous infrastructure
 - Customized and tailored policies
 - Dedicated resources
 - In-house infrastructure
 - End-to-end control



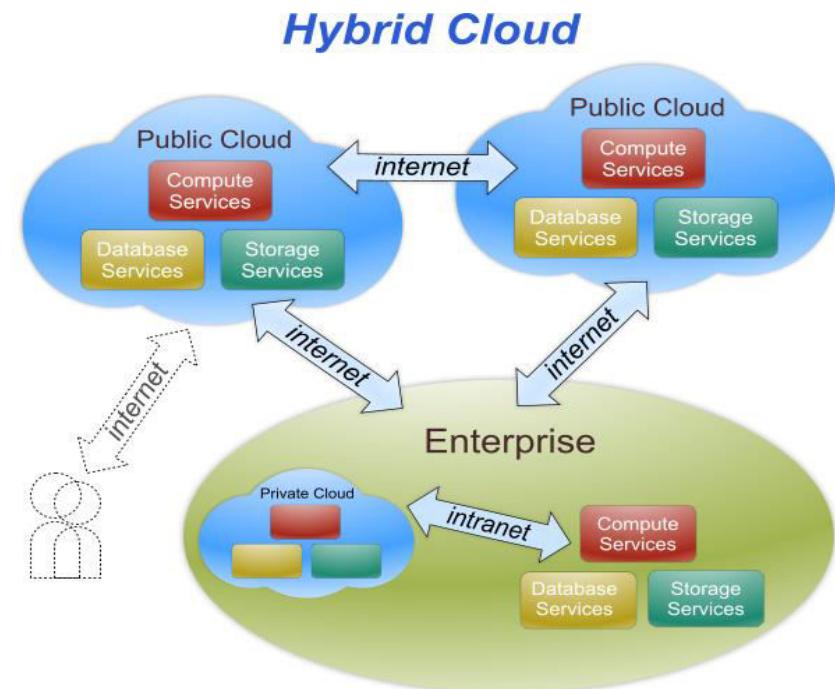
- Comparison :

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

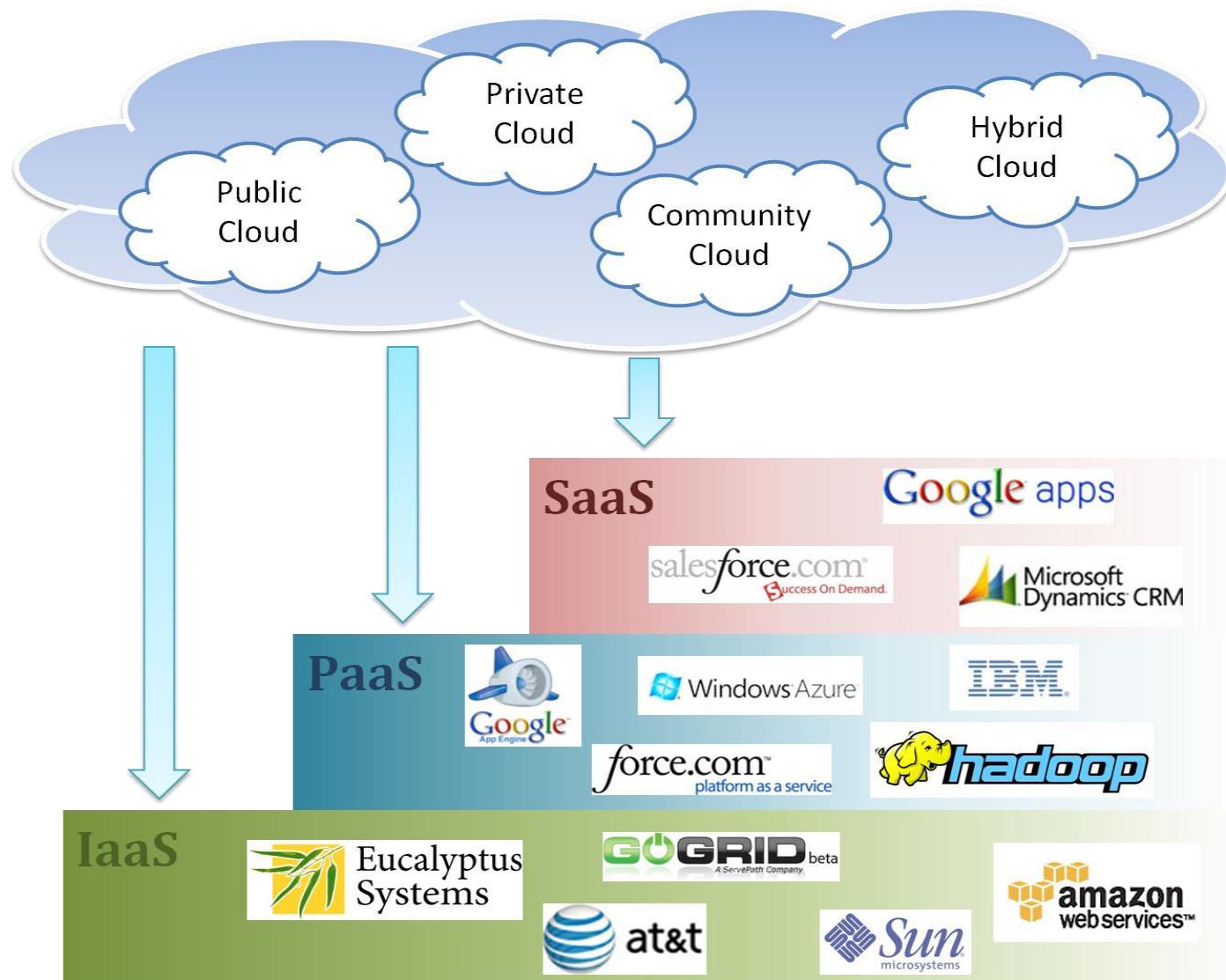
- Community cloud definition
 - The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations).



- Hybrid cloud definition
 - The cloud infrastructure is a composition of two or more clouds (private, community, or public) that 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



1. Hybrid Cloud

- Scalability of the Public Cloud with the control and security of a private cloud

2. Test / Development / QA Platform

- Use cloud infrastructure servers as your test and development platform

3. Disaster Recovery

- Keep images of your servers on cloud infrastructure ready to go in case of a disaster

4. Cloud File Storage

- Backup or Archive your company data to cloud file storage

5. Load Balancing

- Use cloud infrastructure for overflow management during peak usage times

6. Overhead Control

- Lower overhead costs and make your bids more competitive

7. Distributed Network Control and Cost Reporting

- Create an individual private networks for each of your subsidiaries or contracts

8. Messaging Alternatives

- Replace Microsoft Exchange and SharePoint with Google Apps

9. Rapid Deployment

- Turn up servers immediately to fulfill project timelines

10. Functional IT Labor Shift

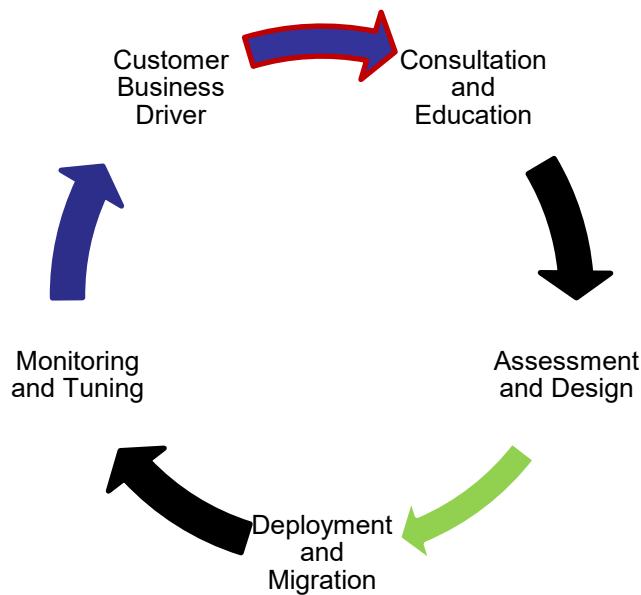
- Refocus your IT labor expense on revenue producing activities

How to get started

- Evaluating the business case for public, private and hybrid cloud models
- Developing an enterprise integration and migration strategy towards cloud provisioning
- Review enterprise applications for SaaS candidates
- Review enterprise requirements for cloud security, governance and standards
- Determine optimal management of your virtualized environment and cloud implementation
- Review case studies from early adopters of SaaS, PaaS and IaaS solutions

Service Deployment Methodology

- It is paramount that IT and business goals are aligned throughout the process when considering a move to cloud computing, such as cost savings, security, control, flexibility, manageability, simplification, ease of use, expandability, reliability, availability...



Proper alignment with business and technical goals

- ***Cloud Assessment and Design***

- Working with business users and IT professionals to define high-level requirements (Business Driver)
- Assessing the Pros and Cons for using Cloud solutions
- Determining appropriate risks and management strategies for Cloud solutions

Proper alignment with business and technical goals

- ***Cloud Solution Selection***

- Determining specific business and technical challenges
- Choosing the right Cloud alternatives (type and delivery model)
- Identifying the management requirements for the different Cloud alternatives
- Defining the solution alternatives and the merits / risks with each

Proper alignment with business and technical goals

- ***Security Assessment & Planning***

Performing Security Assessment (Regulatory Compliance requirements)

Establishing appropriate security controls and processes

Implementing continuous monitoring and response plan for security breaches

Assessment and Design leads to a working solutions document
(published best practice solutions guides)

- Solutions planning
- Investment planning & acquisition
- Integration & test
- Deployment, documentation, operations & maintenance

Effectively Monitoring Your Cloud Ecosystem

- A cloud monitoring solution should identify problems before they become critical and adapt as business requirements change. A nice option may be to deploy a third party monitoring service to ensure customer satisfaction and allow an unbiased perspective on application performance. By implementing a comprehensive monitoring solution IT organization are equipped with the tools to determine real business value for cloud solutions and to provide an important feedback mechanism for tuning their cloud solutions.

- **What is cloud computing in your mind**
 - Clear or Cloudy?
- **Cloud computing is a new paradigm shift of computing**
- **Cloud computing can provide high quality of properties and characteristics based on essentially central ideas**
- **Service models and deployment models provide services that can be used to**
 - Rent fundamental computing resources
 - Deploy and develop customer-created applications on clouds
 - Access provider's applications over network (wired or wireless)

References

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