Capgemini
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Introduction to Cloud Computing

People matter, results count.

Lesson Objectives

Part I : Introduction to Cloud Computing
Part II : Basic Concepts & Technologies
Part III : Architecture & Infrastructure
Part IV : Cloud Service Models
Part V : Opportunity, Advantages and Disadvantages

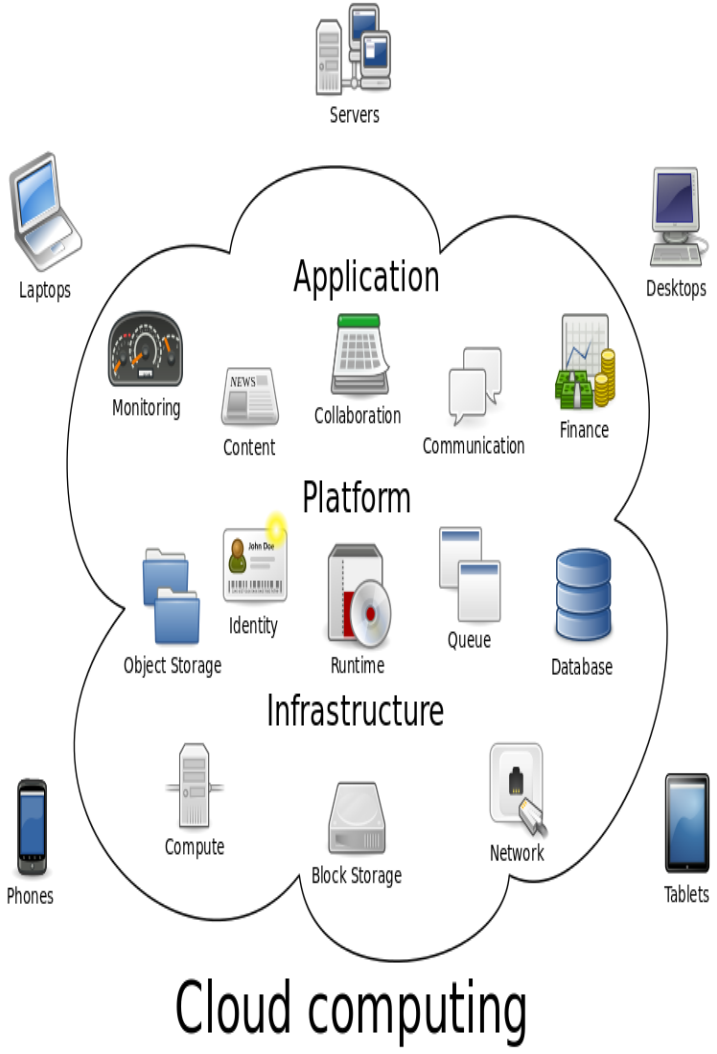
Part I : Introduction to Cloud Computing

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).**

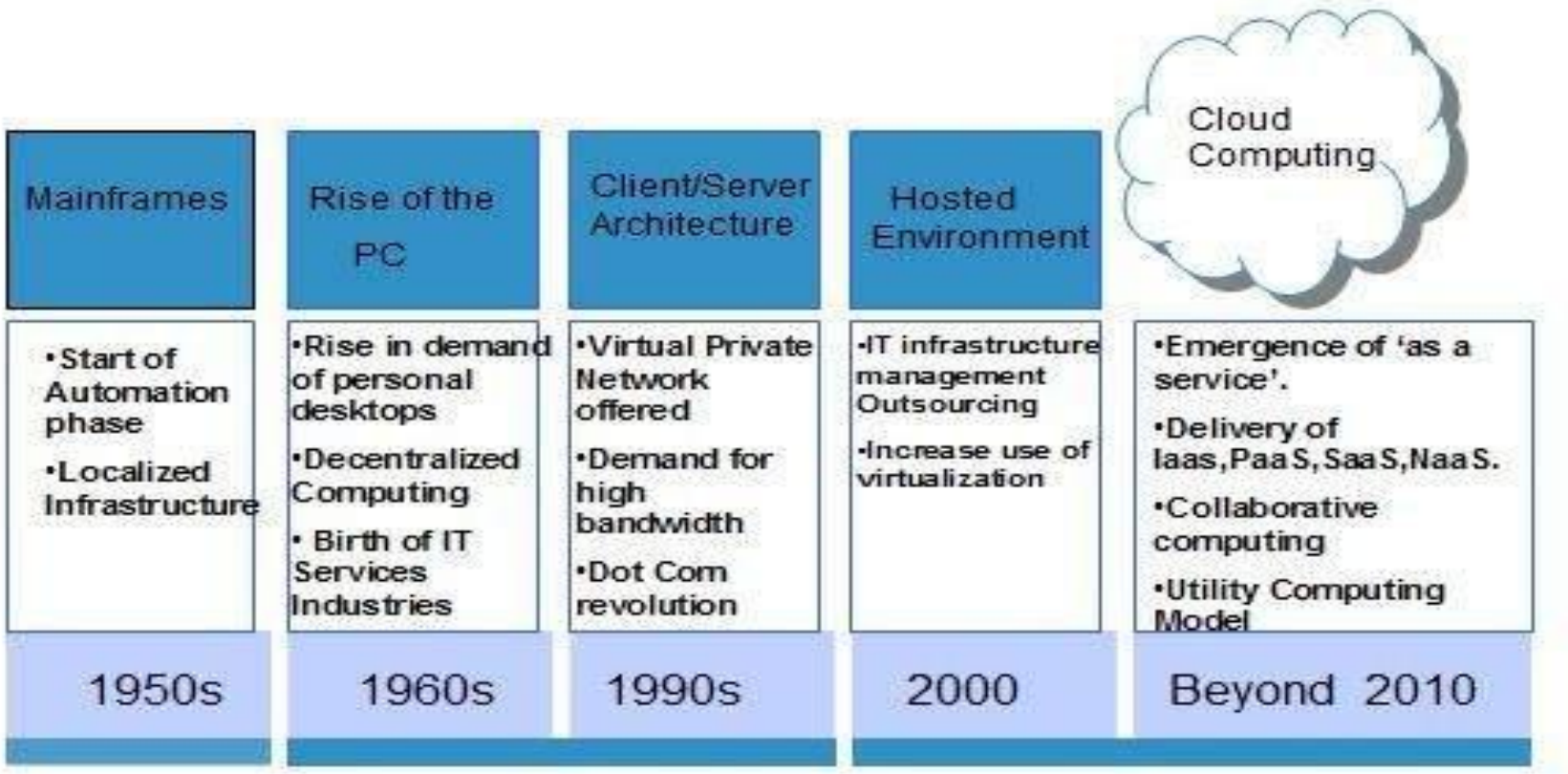
What is Cloud Computing?

- 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



History of Cloud Computing

The concept of **Cloud Computing** came into existence in the year 1950 with implementation of mainframe computers, accessible via **thin/static clients.** Since then, cloud computing has been evolved from static clients to dynamic ones and from software to services.

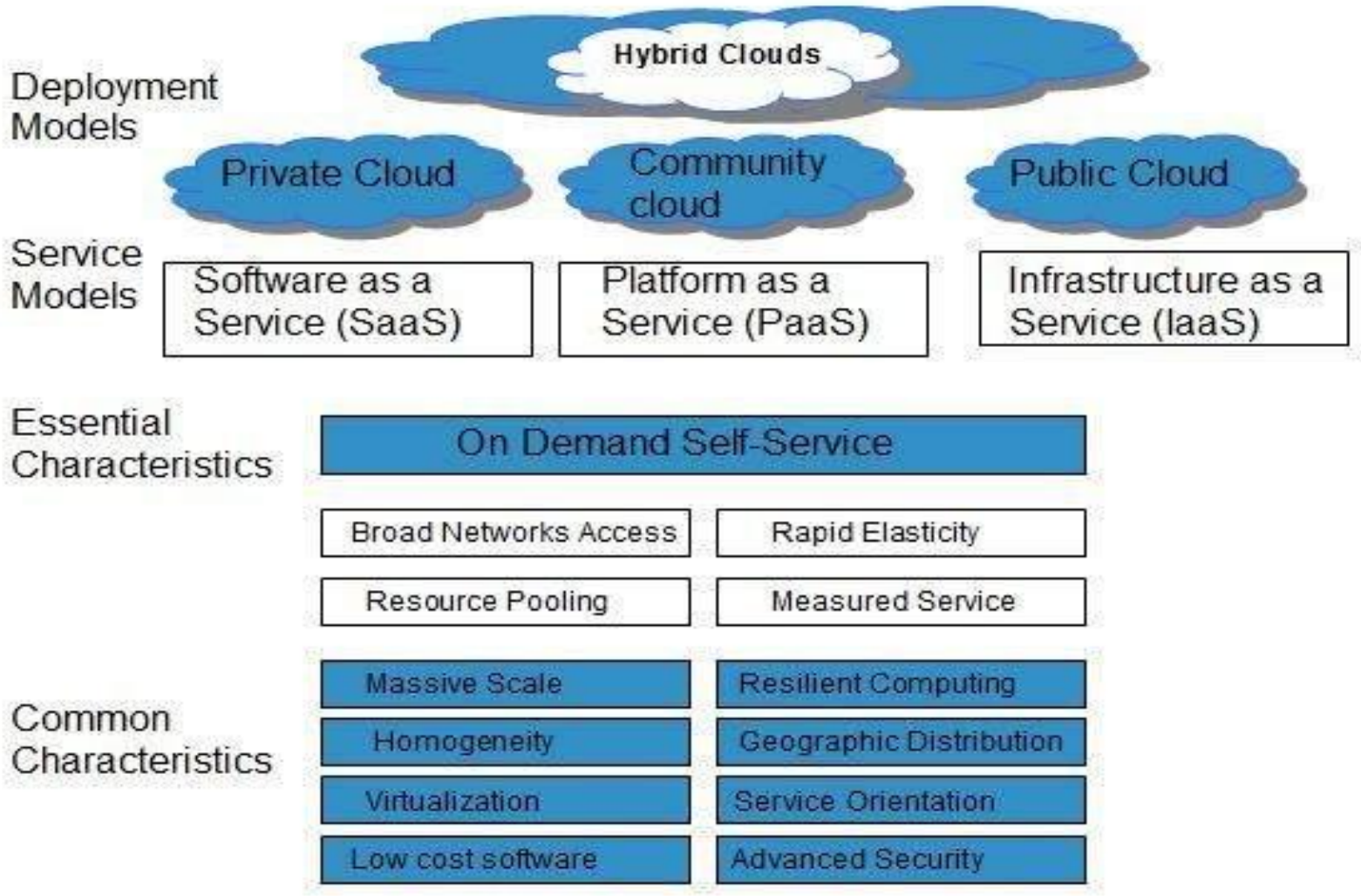


Cloud Summary

- **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!

Basic Cloud Characteristics



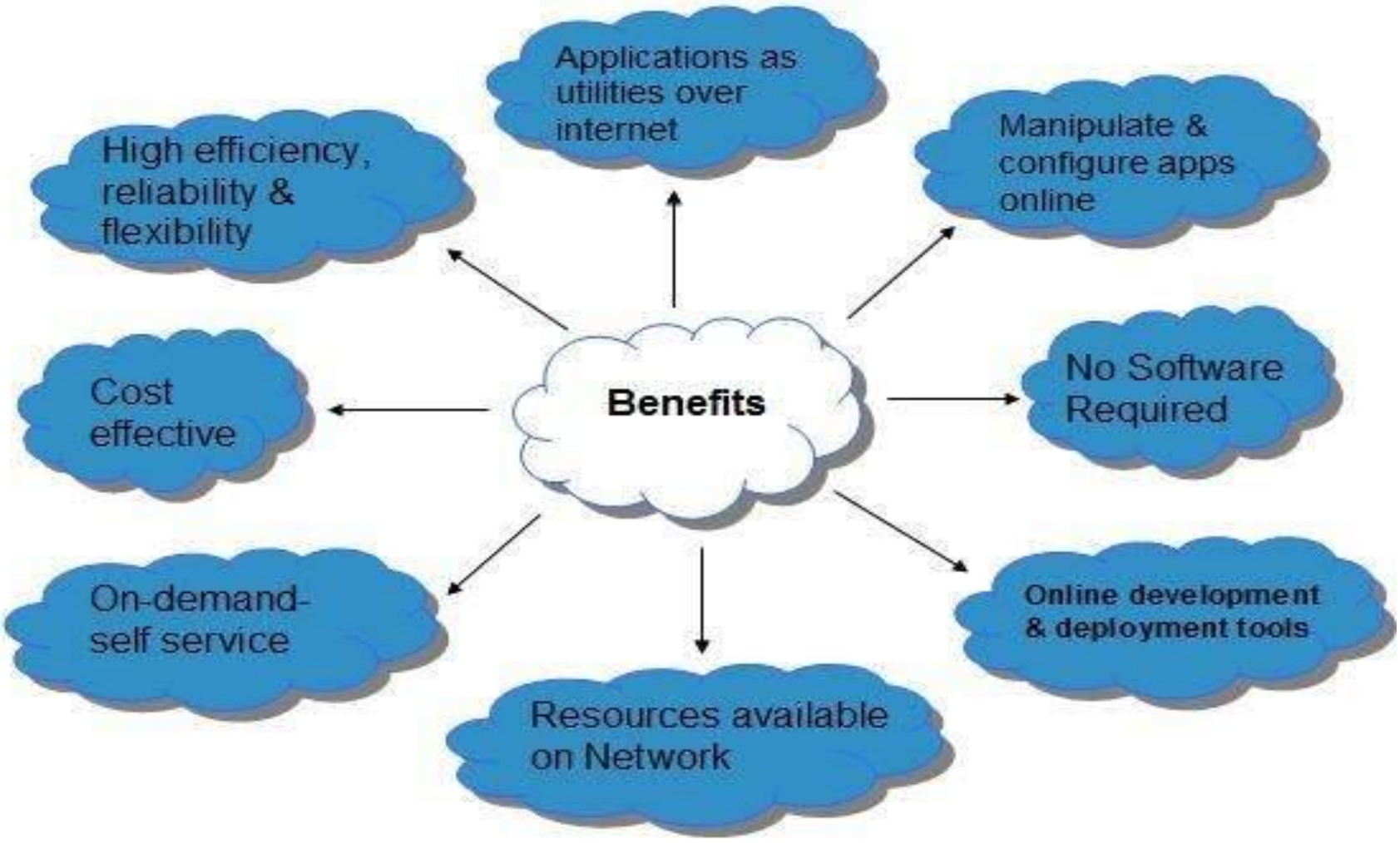
Basic Cloud Characteristics

- **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.**
- **Cloud Computing can be categorized into:**
  - **Cloud applications :** Organizations use cloud applications which is running at data centers owned by someone else accessed via the Internet.
  - **Cloud platforms :** Organizations can also use cloud platforms which are foundations for cloud applications which provides computing resources at data centers across the Internet.
  - **Private clouds :** Cloud platforms used by a single organization inside their own on-premise data center

Benefits of Cloud Computing



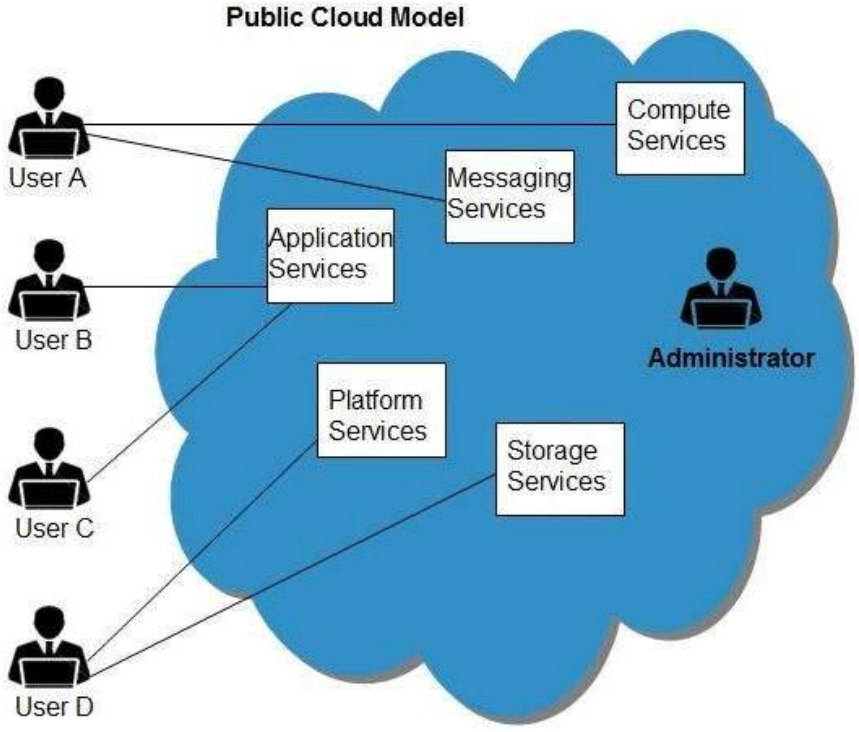
Part II : Basic Concepts & Technologies

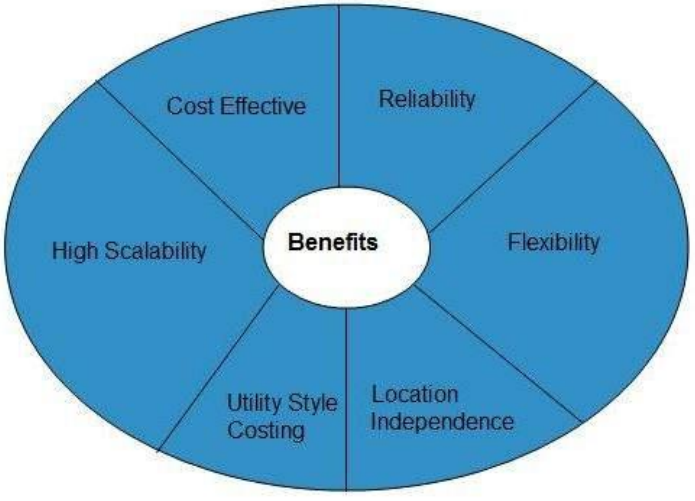
Deployment Models

Deployment models define the type of access to the cloud

➢ PUBLIC CLOUD

The **public cloud** allows systems and services to be easily accessible to the general public. Public cloud may be less secure because of its openness.

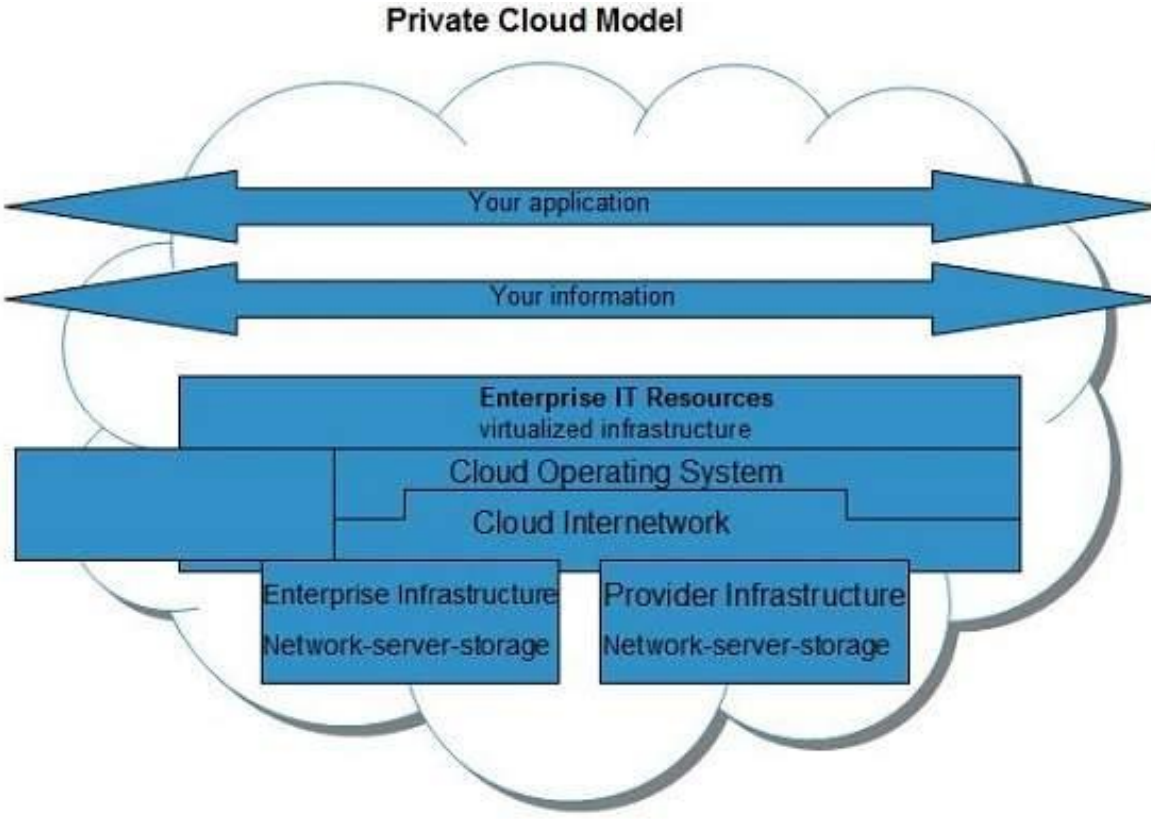


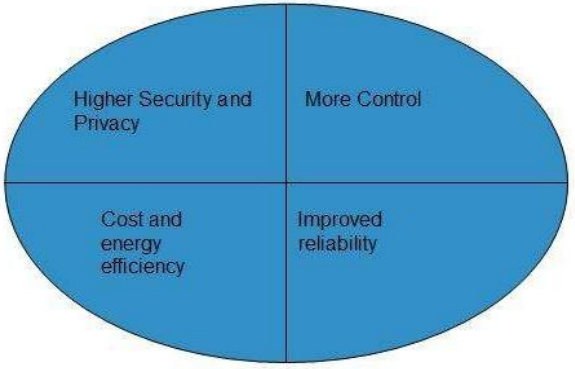


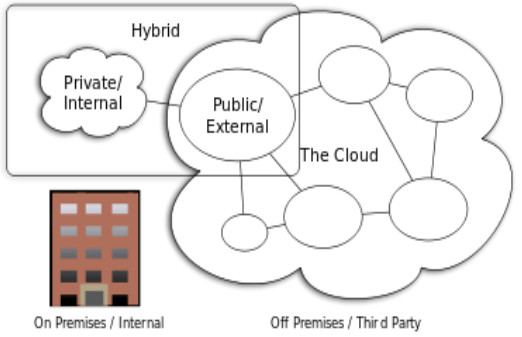
Deployment Models

➢ PRIVATE CLOUD

The **private cloud** allows systems and services to be accessible within an organization. It is more secured because of its private nature.





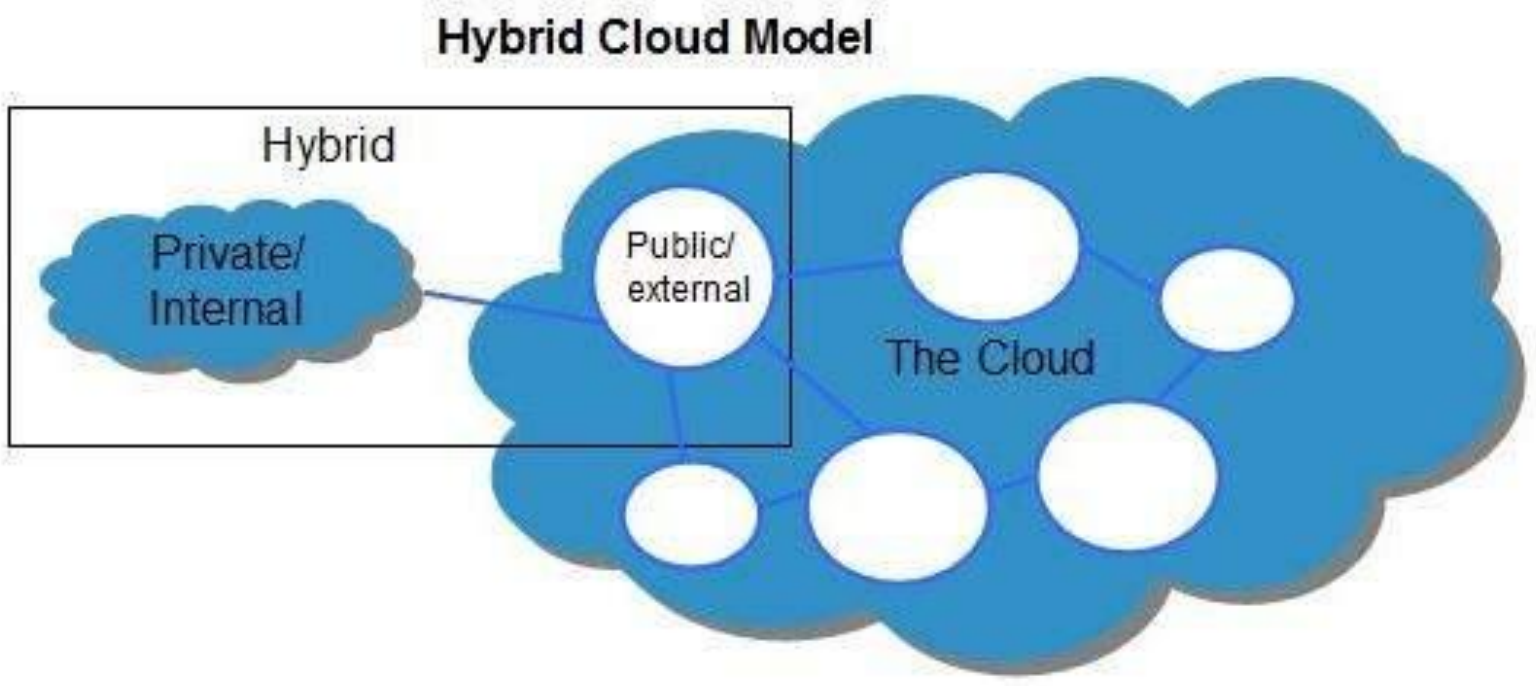


Cloud Computing Types

Deployment Models

➢ HYBRID CLOUD

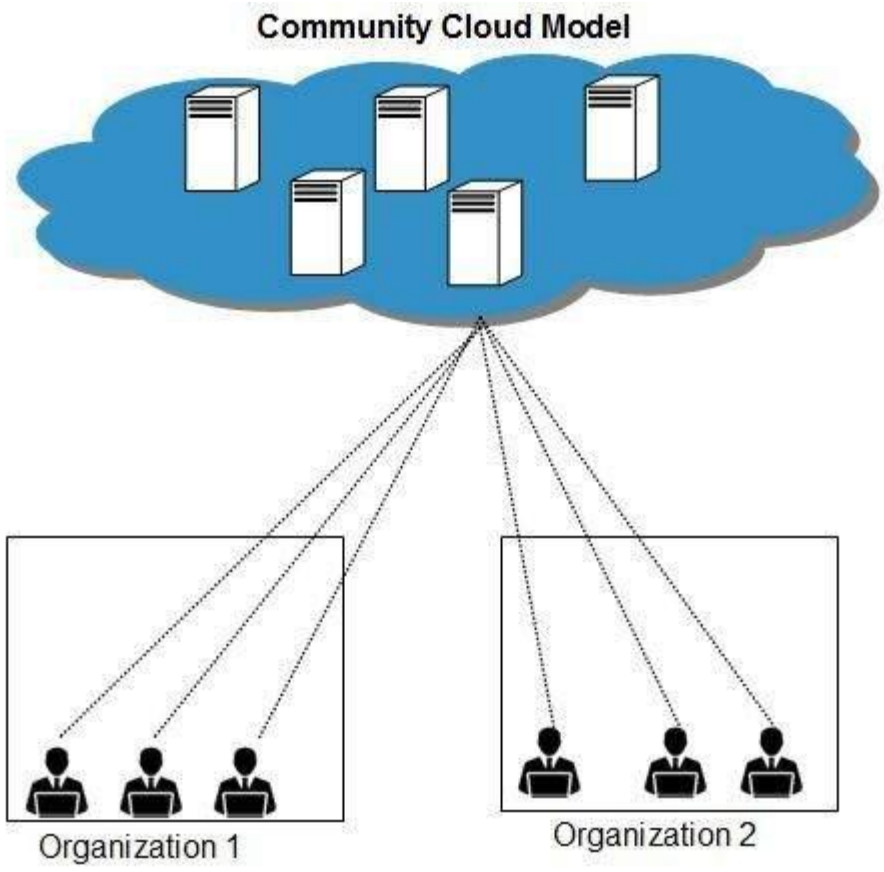
The **hybrid cloud** is a mixture of public and private cloud, in which the critical activities are performed using private cloud while the non-critical activities are performed using public cloud.



Deployment Models

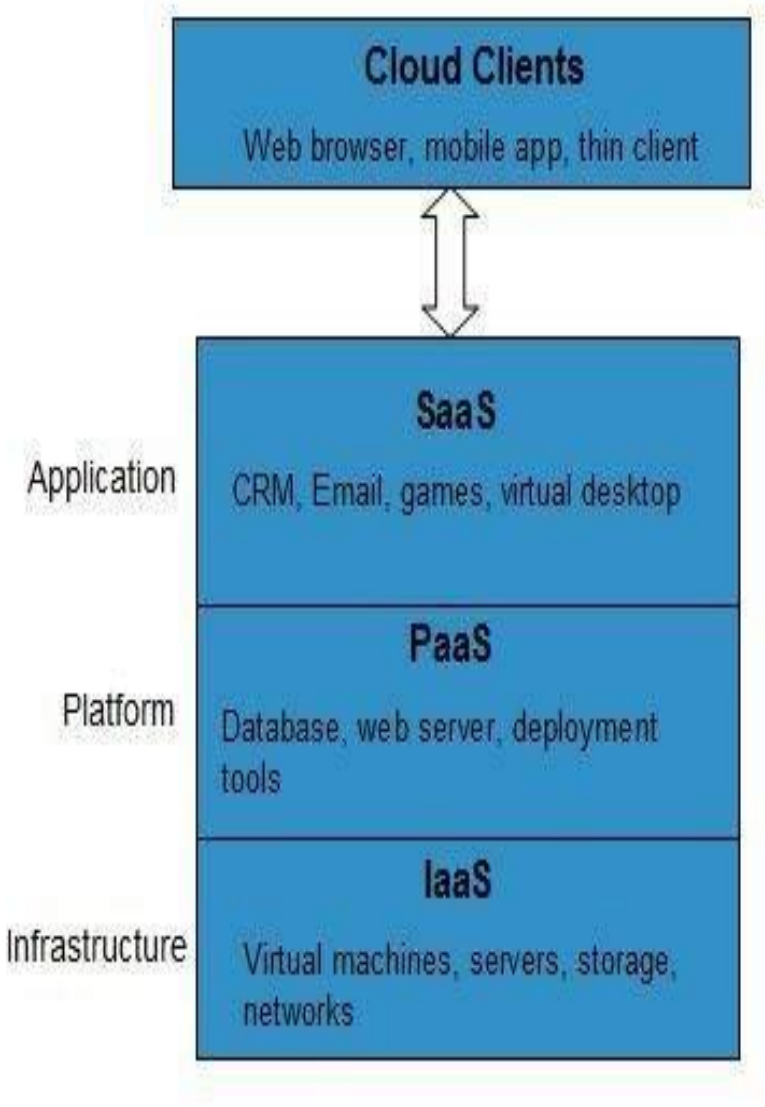
➢ COMMUNITY CLOUD

The **community cloud** allows systems and services to be accessible by a group of organizations.



Service Models

- Cloud computing is based on service models. These are categorized into three basic service models which are -
  - Infrastructure-as–a-Service (IaaS)
  - Platform-as-a-Service (PaaS)
  - Software-as-a-Service (SaaS)
- **Anything-as-a-Service (XaaS)** is yet another service model, which includes Network-as-a-Service, Business-as-a-Service, Identity-as-a-Service, Database-as-a-Service or Strategy-as-a-Service.



Virtualization

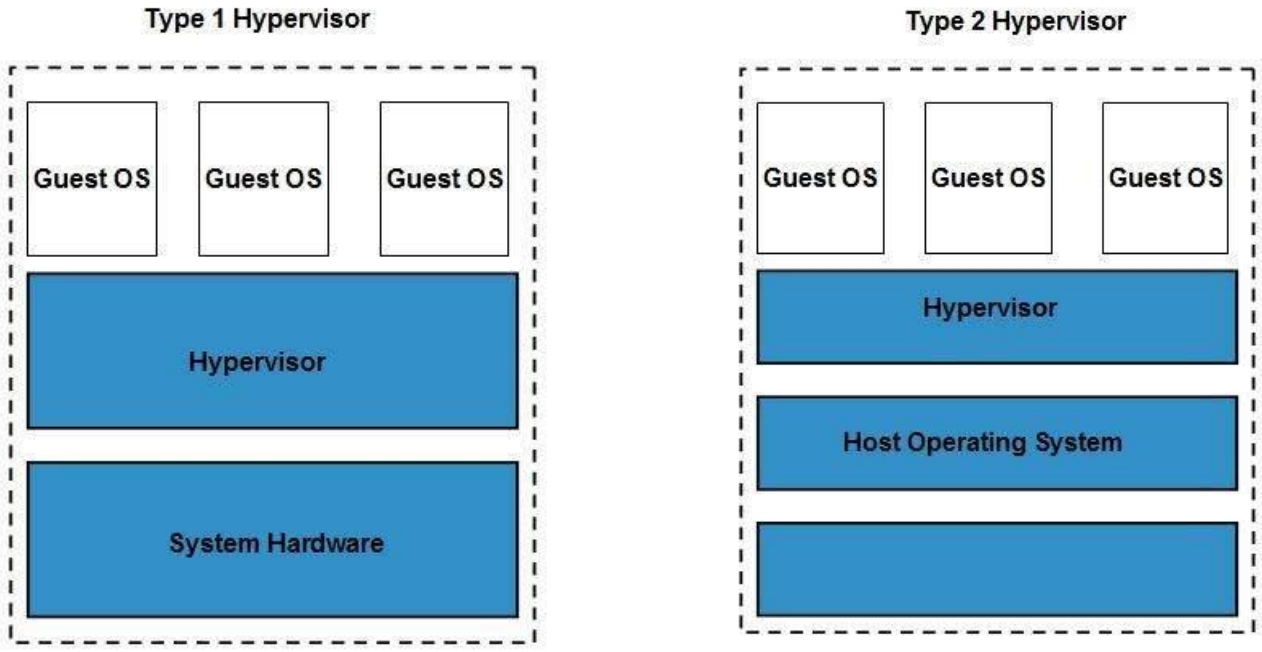
- **Virtualization** is a technique, which **allows to share single physical instance of an application or resource among multiple organizations or tenants** (customers). It does so by **assigning a logical name** to a physical resource and providing a **pointer to that physical resource** on demand.
- The machine on which the virtual machine is created is known as **host machine and virtual machine is referred as a guest machine.** This virtual machine is managed by a software or firmware, which is known as **hypervisor.**

Hypervisor

- The **hypervisor** is a firmware or low-level program that acts as a Virtual Machine Manager. There are two types of hypervisor:
- **Type 1 hypervisor** executes on bare system. LynxSecure, RTS Hypervisor, Oracle VM, Sun xVM Server, VirtualLogic VLX are examples of Type 1 hypervisor. The following diagram shows the Type 1 hypervisor.

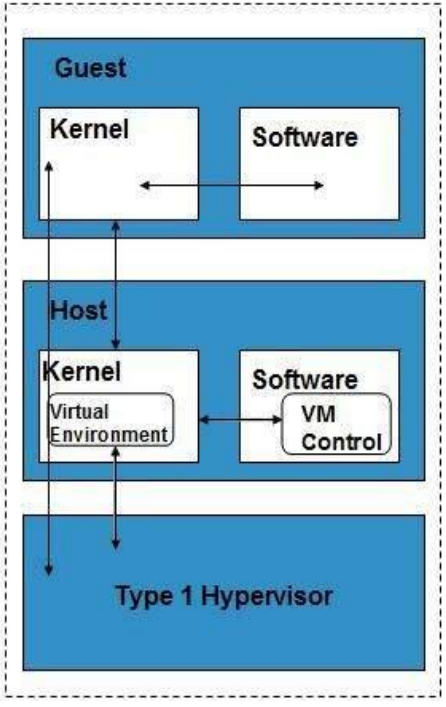
Virtualization

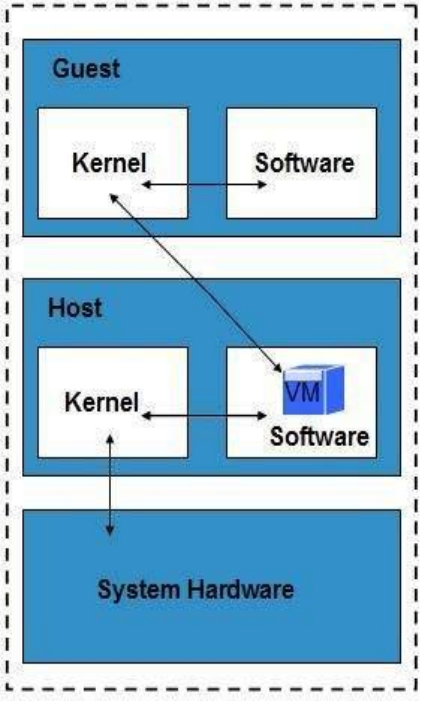
- **Type 1 hypervisor** executes on bare system. LynxSecure, RTS Hypervisor, Oracle VM, Sun xVM Server, VirtualLogic VLX are examples of Type 1 hypervisor.
- **Type 2 hypervisor** is a software interface that emulates the devices with which a system normally interacts.

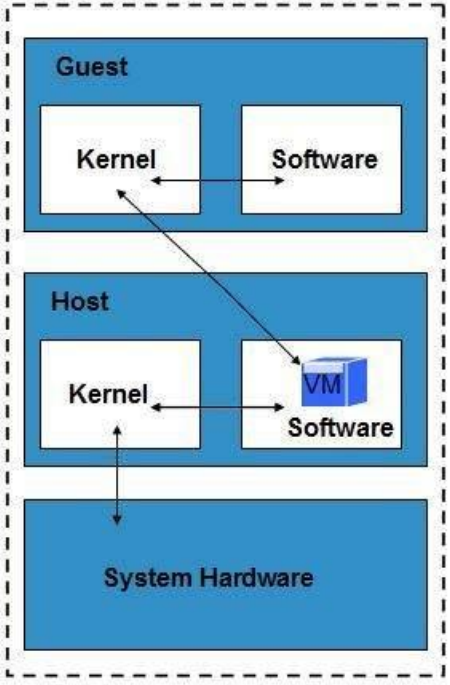


Virtualization

- Here are the three types of hardware virtualization:
  - **Full Virtualization**
  - **Emulation Virtualization**
  - **Para virtualization**

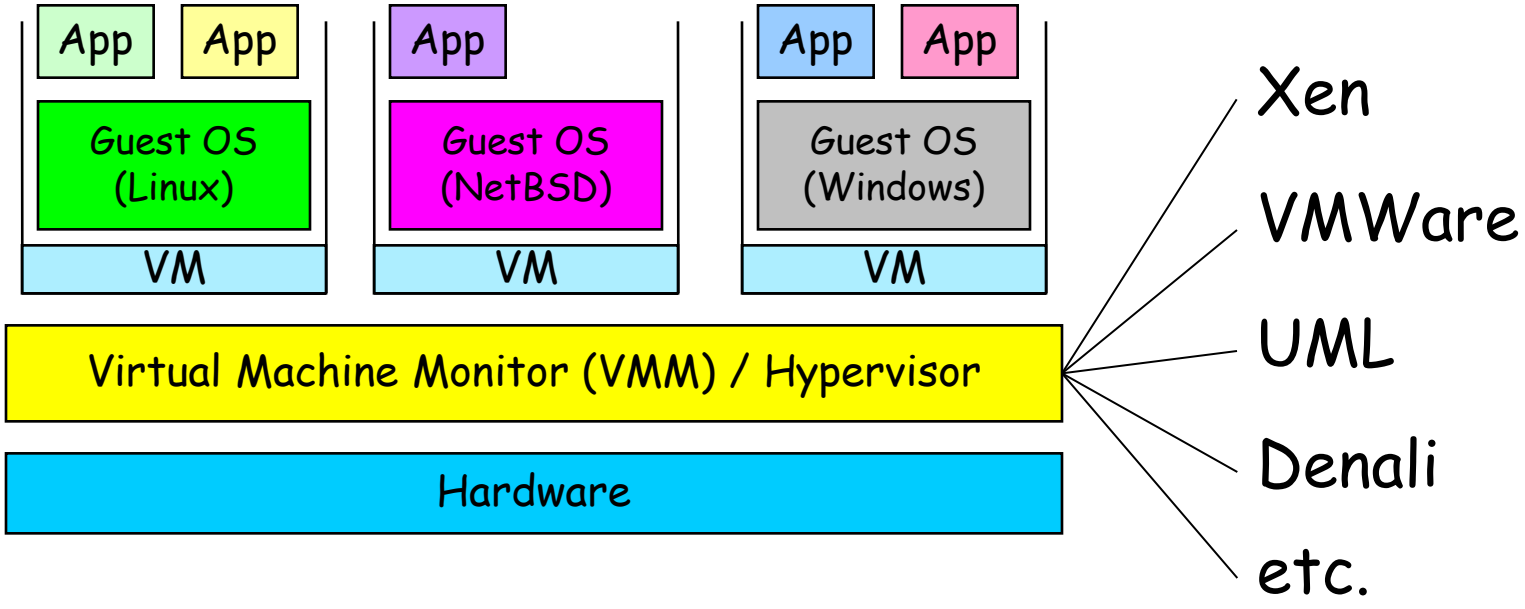






Virtual Machines

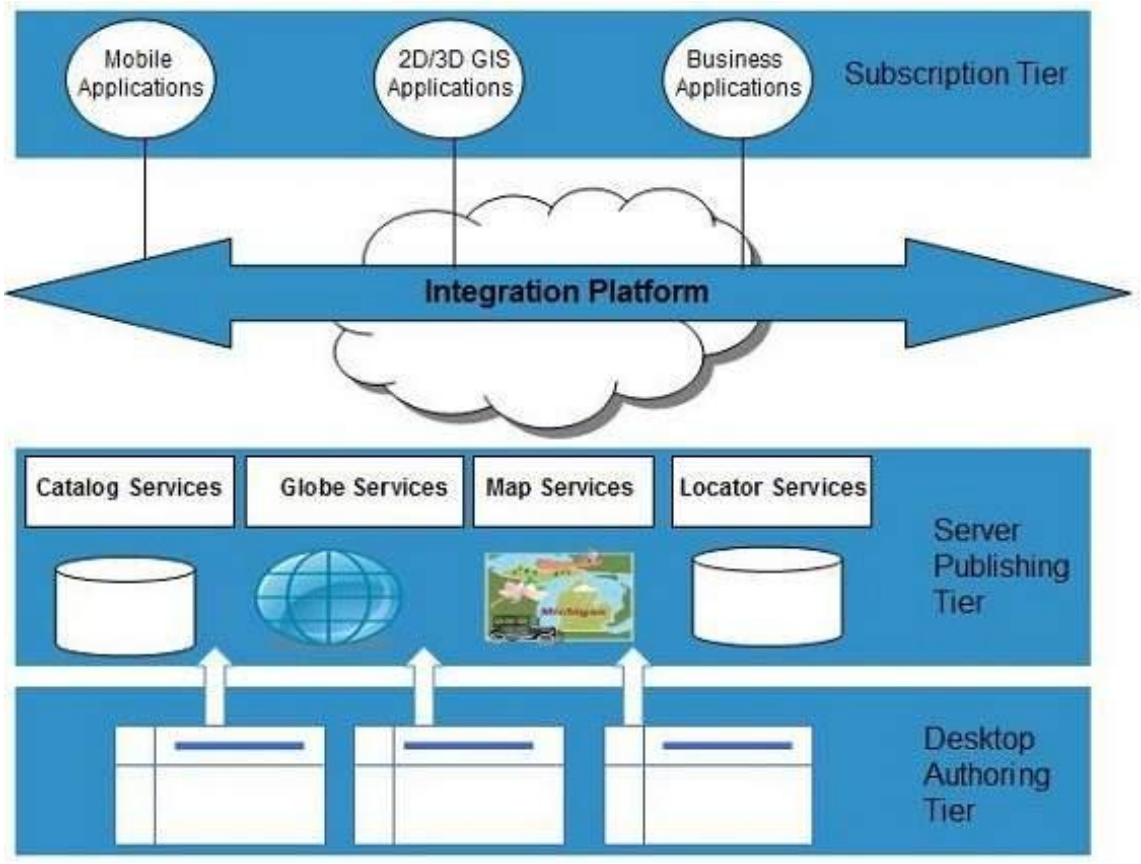
- VM technology allows multiple virtual machines to run on a single physical machine.



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

Service Oriented Architecture (SOA)

Service-Oriented Architecture helps to use applications as a service for other applications regardless the type of vendor, product or technology.

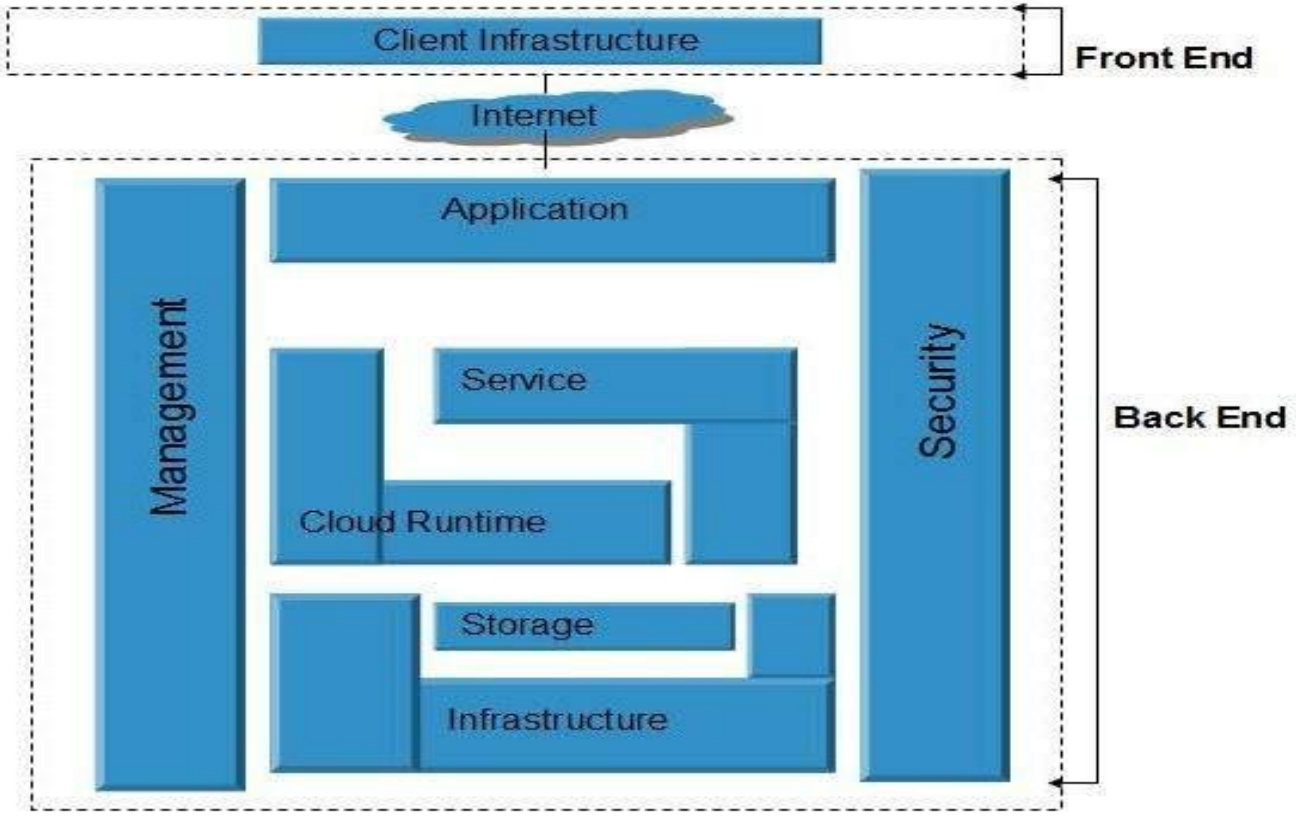


Therefore, it is possible to exchange the data between applications of different vendors without additional programming or making changes to services.

Part III : Architecture & Infrastructure

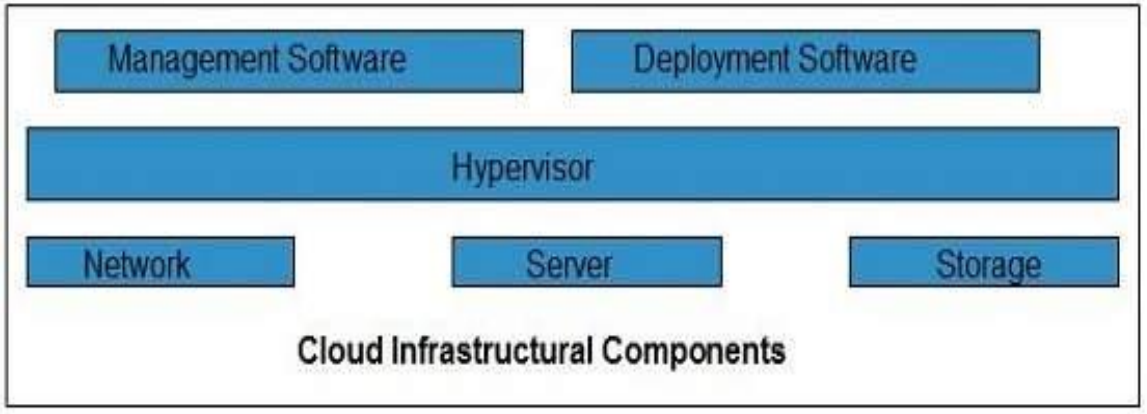
Cloud Architecture

- Cloud Computing architecture comprises of many cloud components, which are loosely coupled. We can broadly divide the cloud architecture into two parts:
  - Front End
  - Back End
- Each of the ends is connected through a network, usually Internet.



Cloud Infrastructure

- **Cloud infrastructure** consists of servers, storage devices, network, cloud management software, deployment software, and platform virtualization.



Hypervisor

Hypervisor is a **firmware** or **low-level program** that acts as a Virtual Machine Manager. It allows to share the single physical instance of cloud resources between several tenants.

Management Software

It helps to maintain and configure the infrastructure.

Cloud Infrastructure

Deployment Software

It helps to deploy and integrate the application on the cloud.

Network

It is the key component of cloud infrastructure. It allows to connect cloud services over the Internet. It is also possible to deliver network as a utility over the Internet, which means, the customer can customize the network route and protocol.

Server

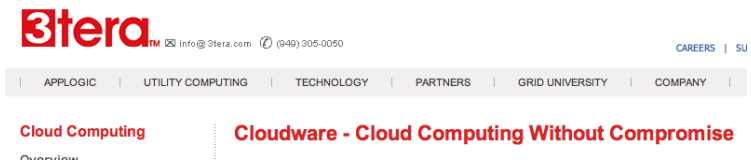
The server helps to compute the resource sharing and offers other services such as resource allocation and de-allocation, monitoring the resources, providing security etc.

Storage

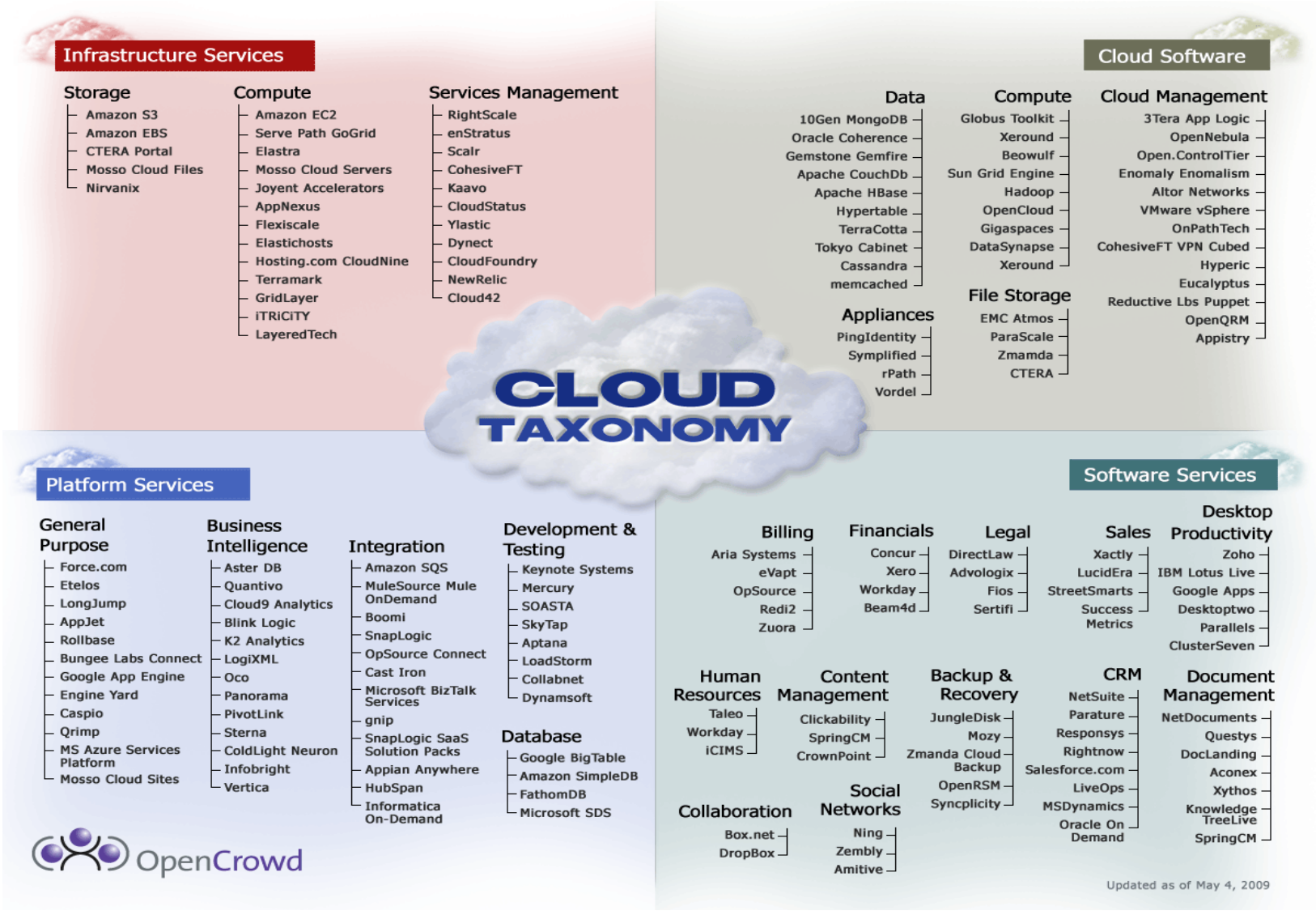
Cloud keeps multiple replicas of storage. If one of the storage resources fails, then it can be extracted from another one, which makes cloud computing more reliable.

Some Commercial Cloud Offerings

Amazon Elastic Compute Cloud (Amazon EC2) - *Beta*



Cloud Taxonomy



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.
- **Cloud Storage is a service that allows to save data on offsite storage system managed by third-party and is made accessible by a web services API.**
- **Amazon's Elastic Compute Cloud (EC2) and Simple Storage Solution (S3) are well known examples**
  - Mechanical Turk

Cloud Storage

- Cloud storage can be broadly classified into two categories:
  - Unmanaged Cloud Storage
  - Managed Cloud Storage

Unmanaged Cloud Storage

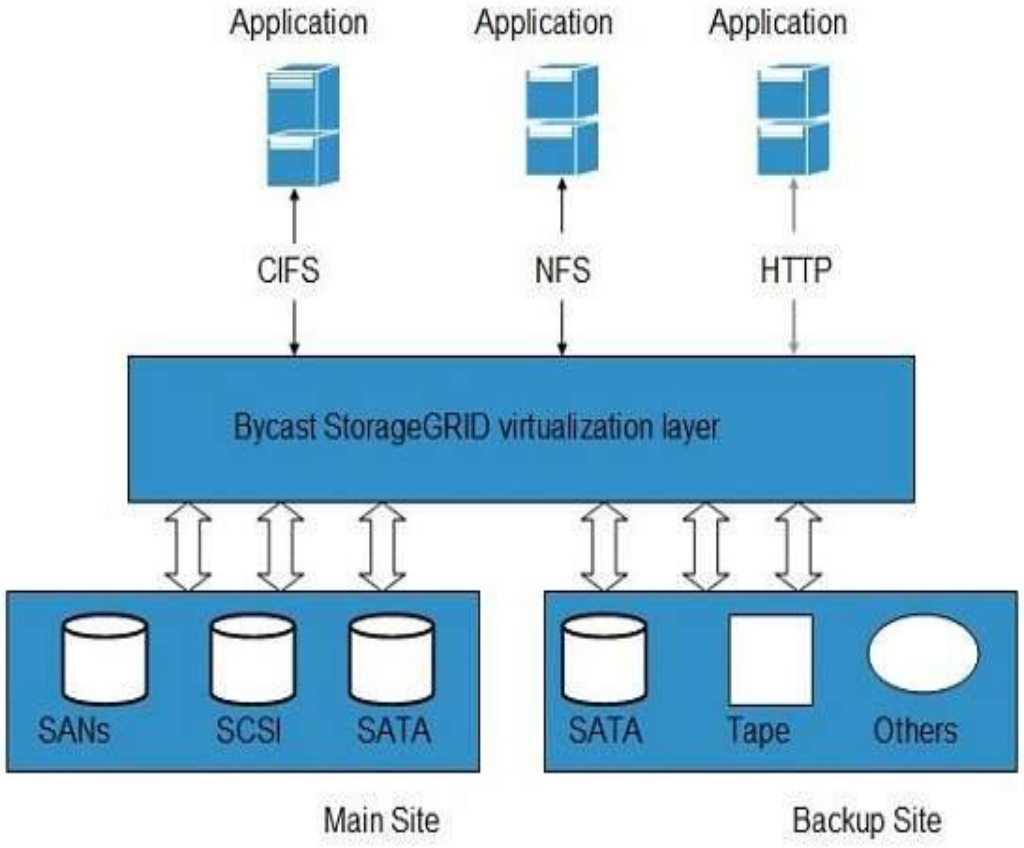
- Unmanaged cloud storage means the storage is preconfigured for the customer. The customer can neither format, nor install his own file system or change drive properties.

Managed Cloud Storage

- Managed cloud storage offers online storage space on-demand. The managed cloud storage system appears to the user to be a raw disk that the user can partition and format.

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…

Part IV : Cloud Service Models

Cloud Service Models

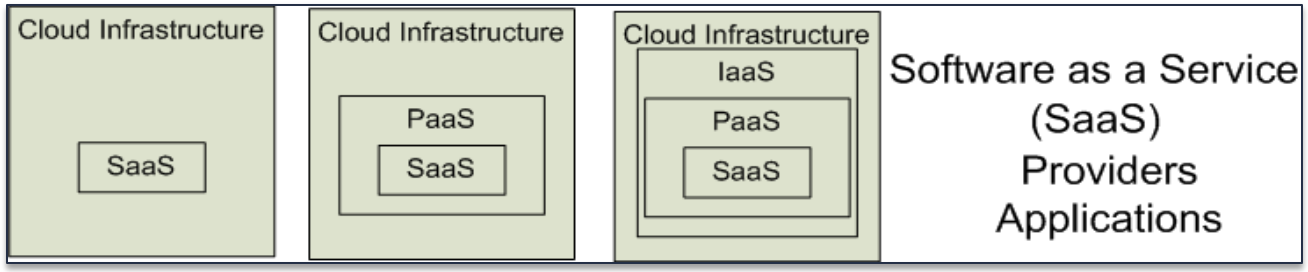
Software as a Service (SaaS)

Platform as a Service (PaaS)

Infrastructure as a Service (IaaS)

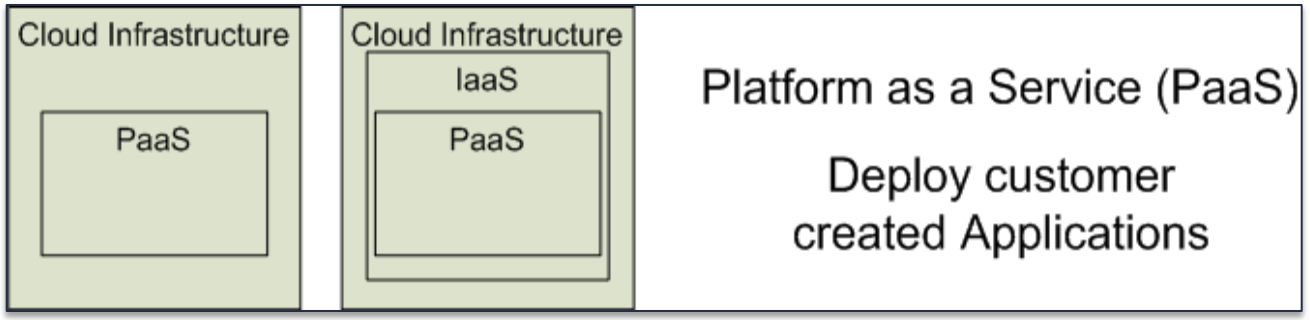
SalesForce CRM

LotusLive



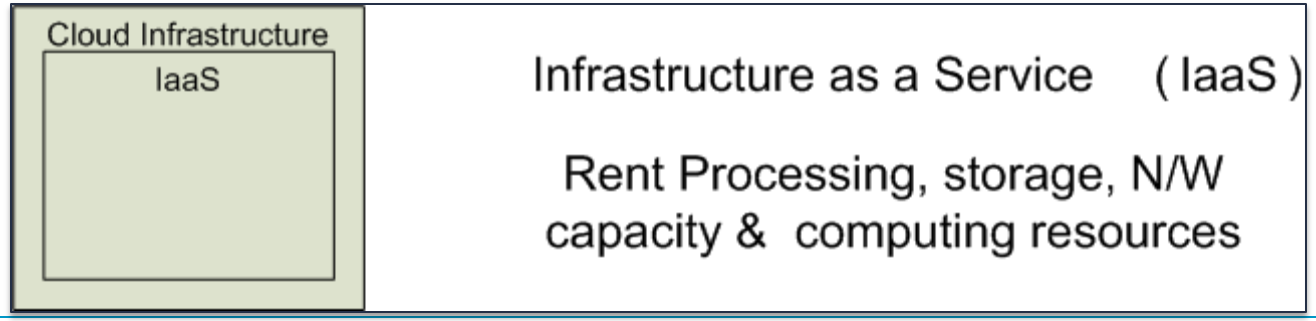
Google App

Windows Azure
The Future Made Familiar



amazon web services

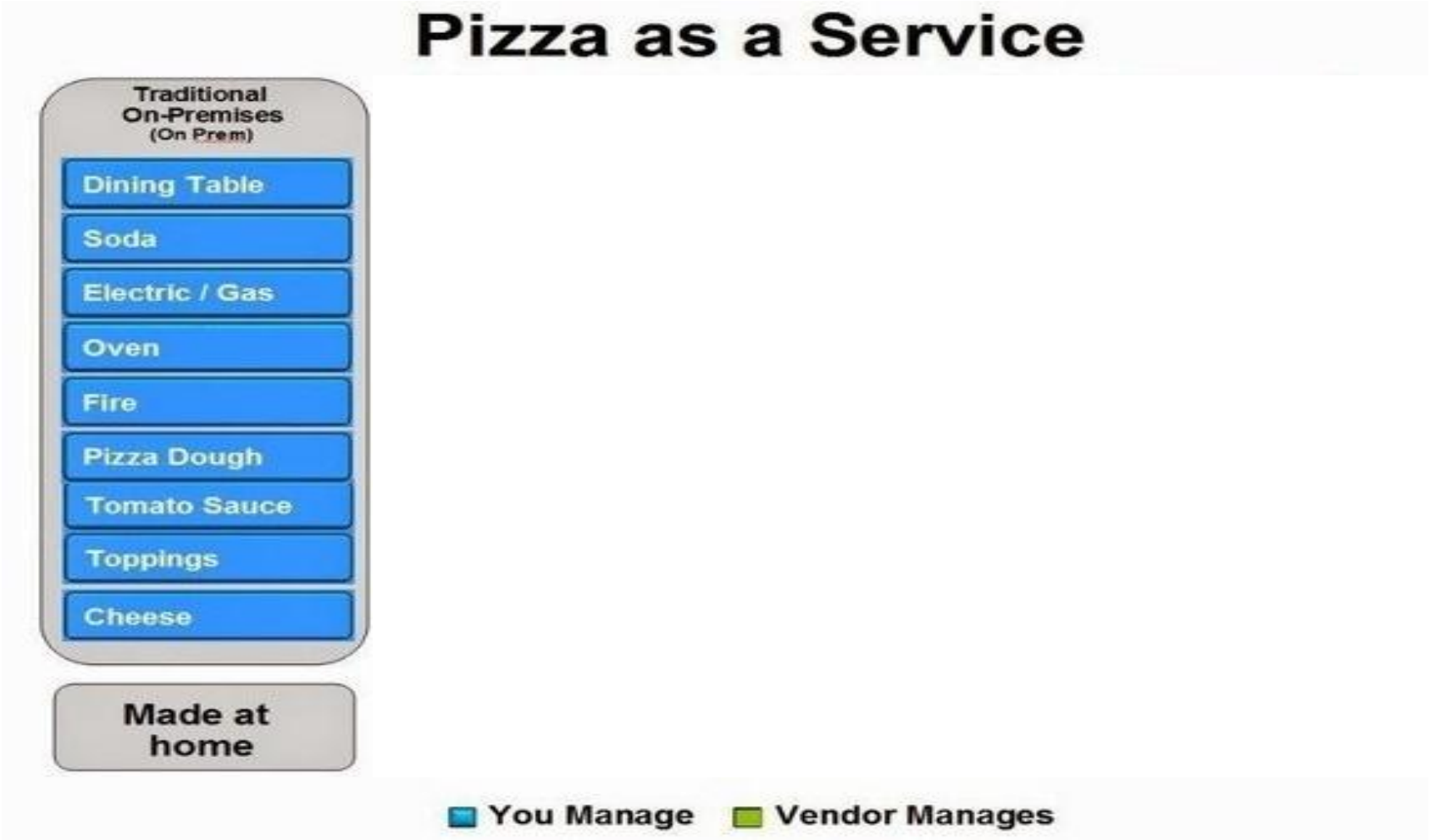
rackspace HOSTING



Cloud Service Models

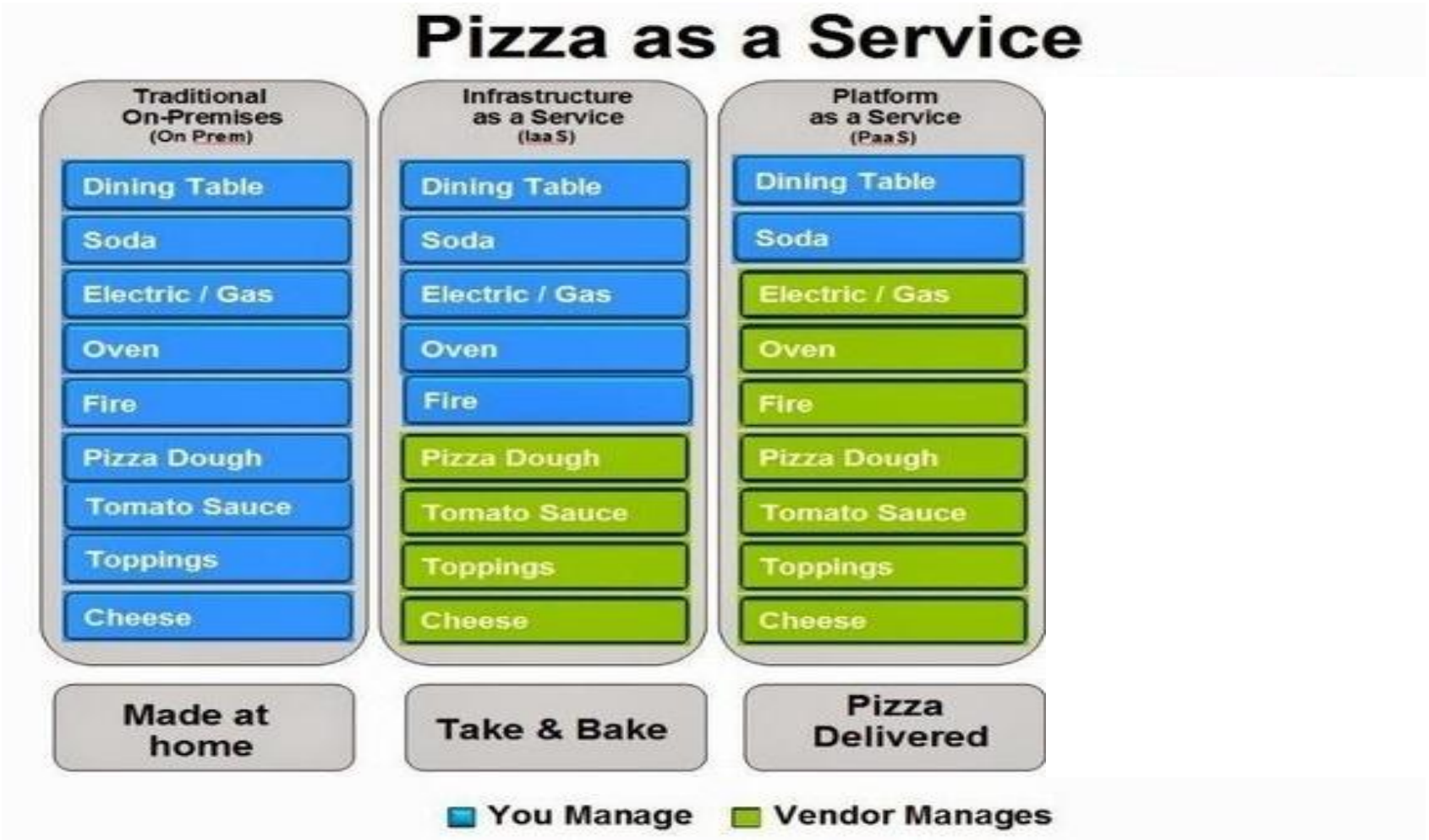
What would you do when u want to have Pizza?

Cloud Service Models

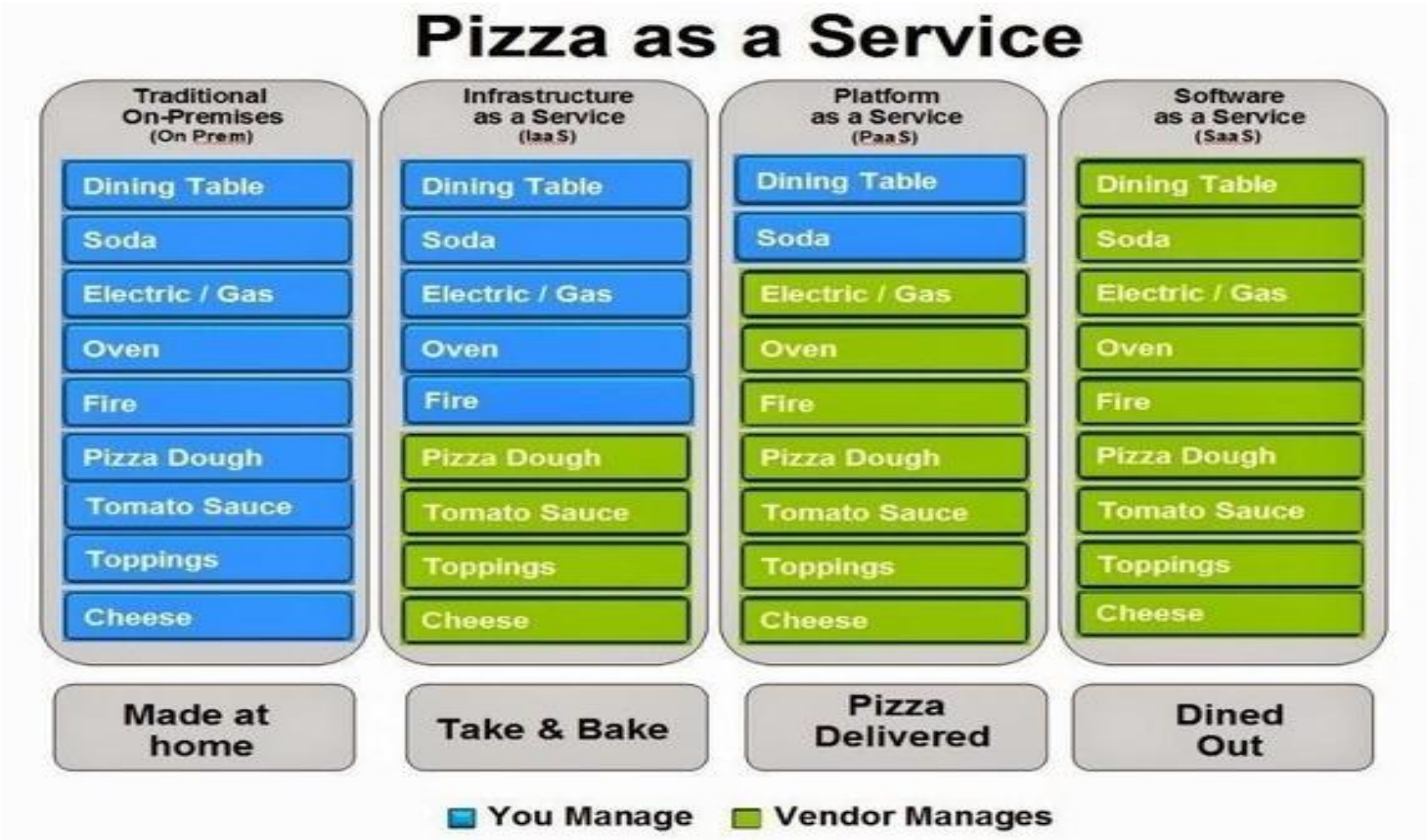


Cloud Service Models

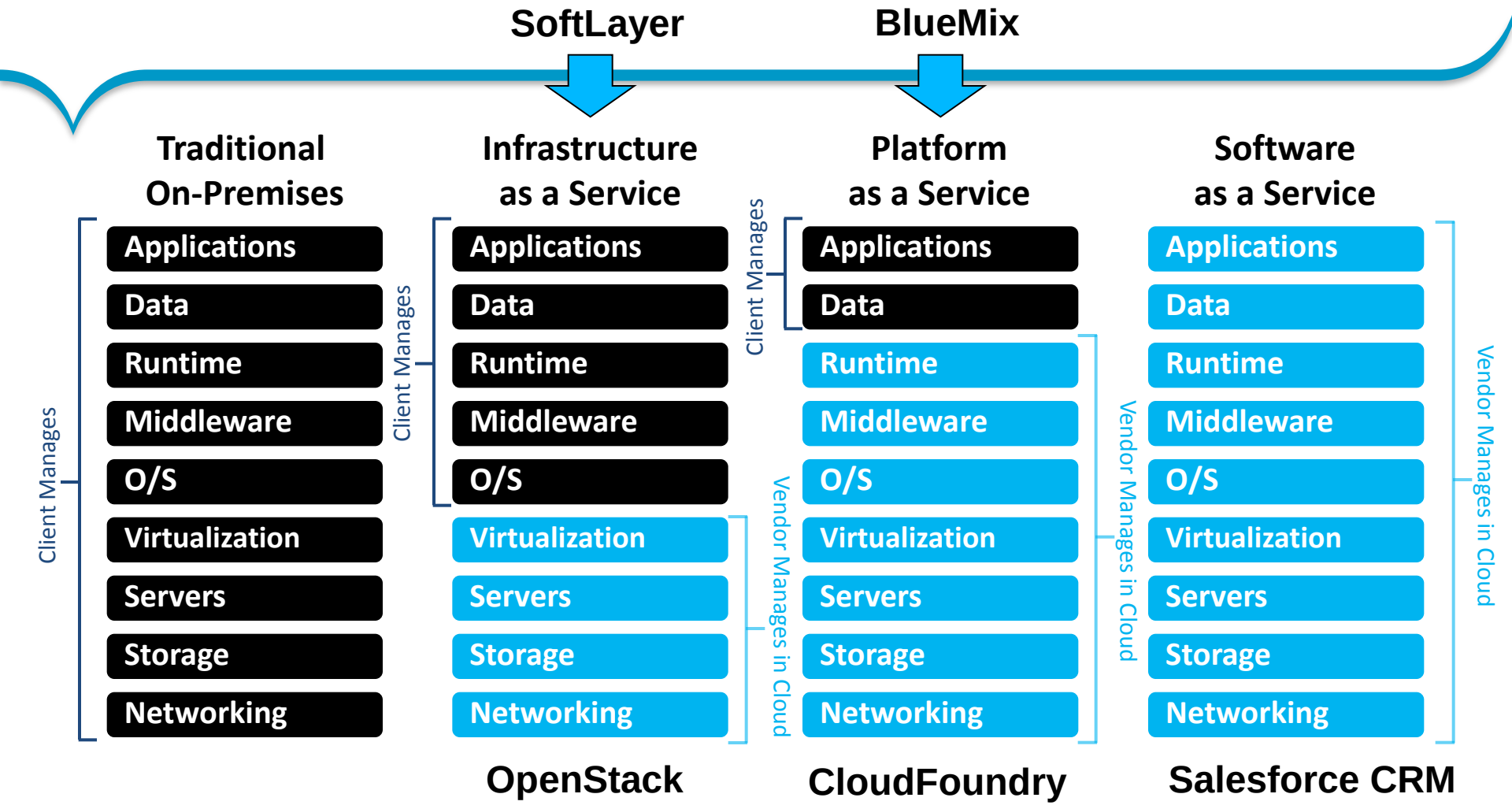
Cloud Service Models



Cloud Service Models



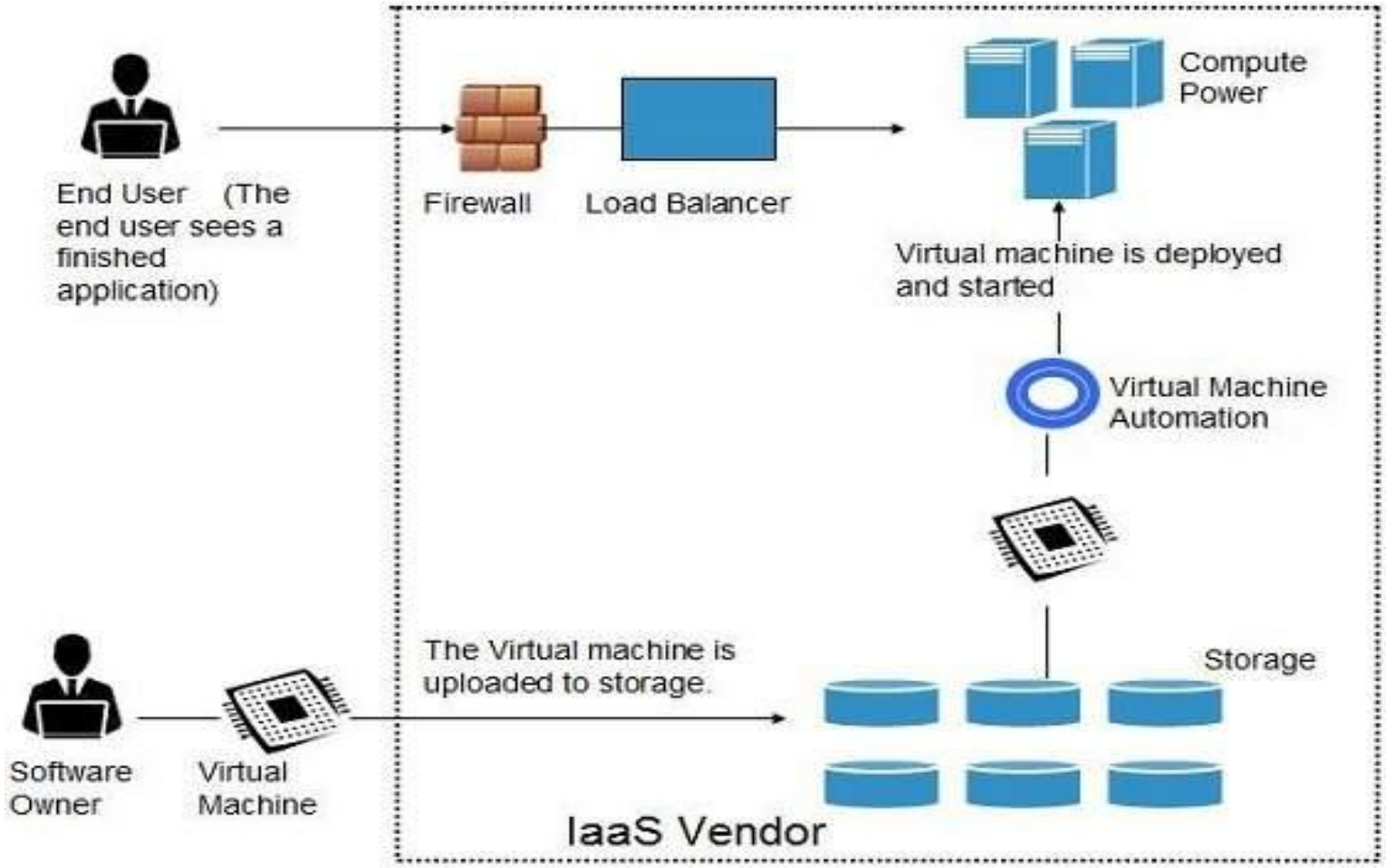
The Big Picture



Infrastructure as a Service (IaaS)

- **Infrastructure-as-a-Service provides access to fundamental resources such as physical machines, virtual machines, virtual storage, etc.**
- Apart from these resources, the IaaS also offers:
  - Virtual machine disk storage
  - Virtual local area network (VLANs)
  - Load balancers
  - IP addresses
  - Software bundles
- All of the above resources are made available to end user via server virtualization. Moreover, these resources are accessed by the customers as if they own them.

Infrastructure as a Service (IaaS)



Infrastructure as a Service (IaaS)

Characteristics

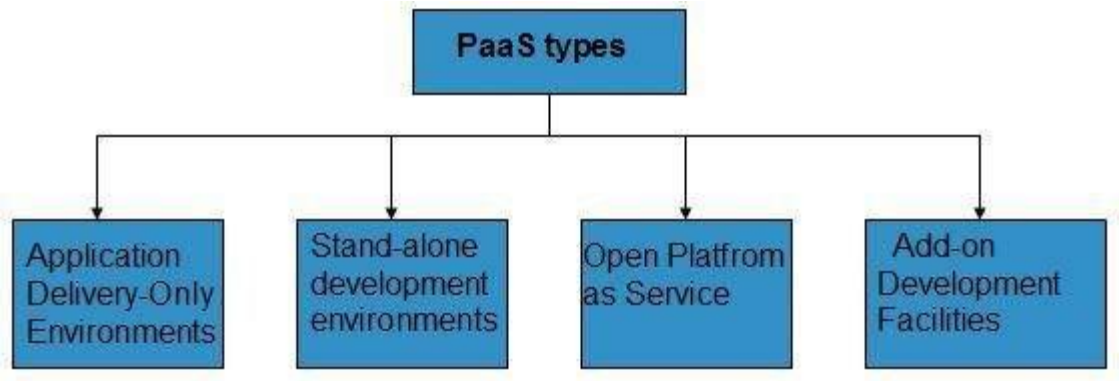
- Virtual machines with pre-installed software.
- Virtual machines with pre-installed operating systems such as Windows, Linux, and Solaris.
- On-demand availability of resources.
- Allows to store copies of particular data at different locations.
- The computing resources can be easily scaled up and down.

Benefits

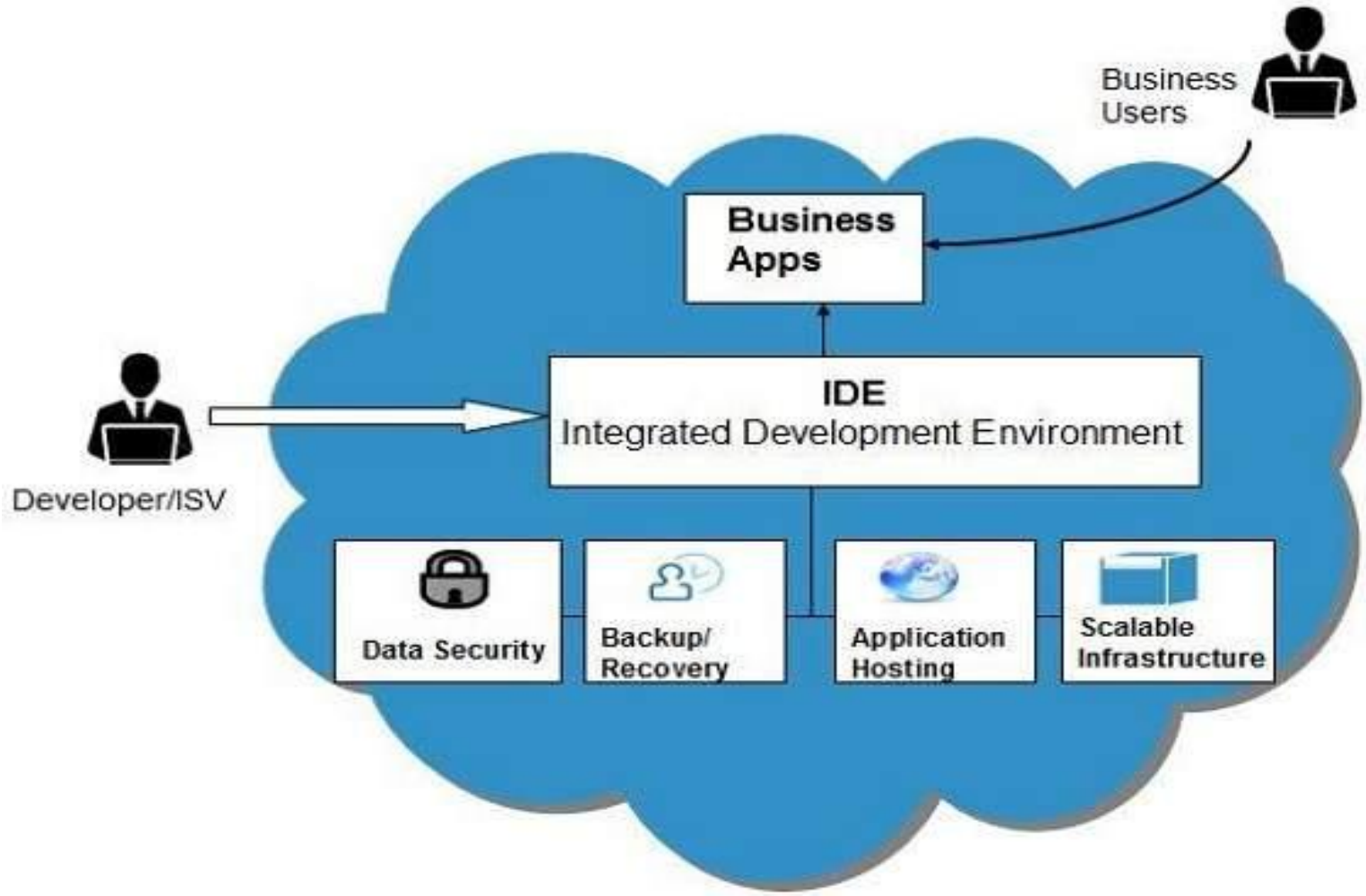
- Full control of the computing resources through administrative access to VMs.
- Flexible and efficient renting of computer hardware.
- Portability, interoperability with legacy applications.

Platform as a Service (PaaS)

- **Platform-as-a-Service** offers the runtime environment for applications. It also offers development and deployment tools required to develop applications.
- PaaS has a feature of **point-and-click** tools that enables non-developers to create web applications.
- **App Engine of Google** and **Force.com** are examples of PaaS offering vendors.
- Developer may log on to these websites and use the **built-in API** to create web-based applications.



Platform as a Service (PaaS)



Platform as a Service (PaaS)

Characteristics

- PaaS offers browser based development environment. It allows the developer to create database and edit the application code either via Application Programming Interface or point-and-click tools.
- PaaS provides built-in security, scalability, and web service interfaces.
- PaaS provides built-in tools for defining workflow, approval processes, and business rules.
- It is easy to integrate PaaS with other applications on the same platform.
- PaaS also provides web services interfaces that allow us to connect the applications outside the platform.

Benefits

- Lower administrative overhead & total cost of ownership
- Scalable solutions
- More current system software

Software as a Service (SaaS)

- One of the most important aspects of cloud computing, is running applications in the cloud. i.e. running applications in data centers own by third parties accessed via the internet
- Running applications on the Public Cloud is commonly referred as Software as a Service(SaaS)
- Cloud applications is nothing but an application which offers CRM(Customer Relationship Management), Email, ERP, Collaboration, Productivity etc.
- Microsoft, Google, Salesforce, SAP, IBM, Oracle, NetSuite & Zoho were some of the important service providers to offer cloud applications.
- There are several SaaS applications listed below:
  - Billing and invoicing system
  - Customer Relationship Management (CRM) applications
  - Help desk applications
  - Human Resource (HR) solutions

Software as a Service (SaaS)

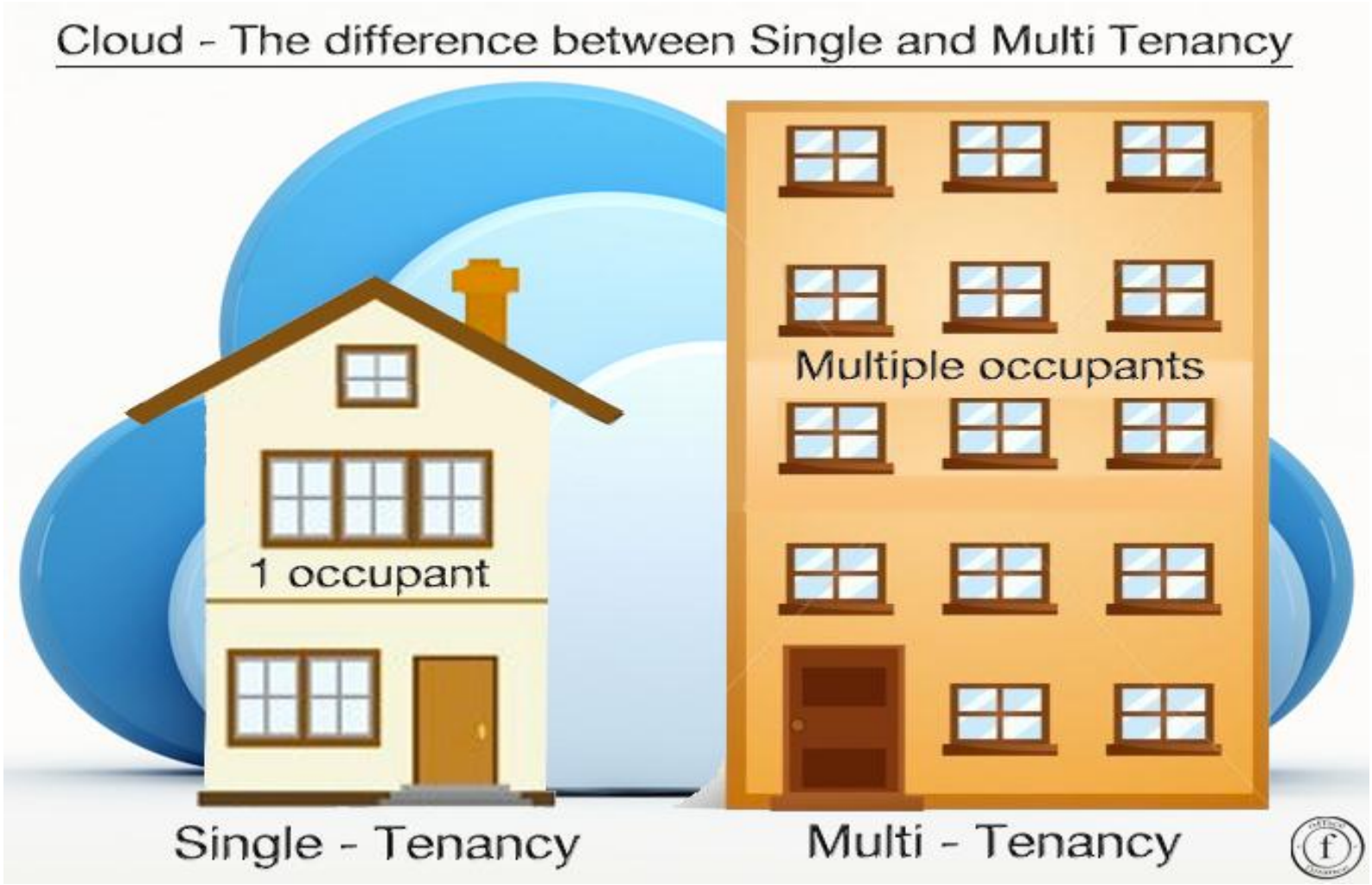
Characteristics

- Here are the characteristics of SaaS service model:
- SaaS makes the software available over the Internet.
- The software applications are maintained by the vendor.
- The license to the software may be subscription based or usage based. And it is billed on recurring basis.
- SaaS applications are cost-effective since they do not require any maintenance at end user side.
- They are available on demand.
- They can be scaled up or down on demand.
- They are automatically upgraded and updated.
- SaaS offers shared data model. Therefore, multiple users can share single instance of infrastructure. It is not required to hard code the functionality for individual users.
- All users run the same version of the software.

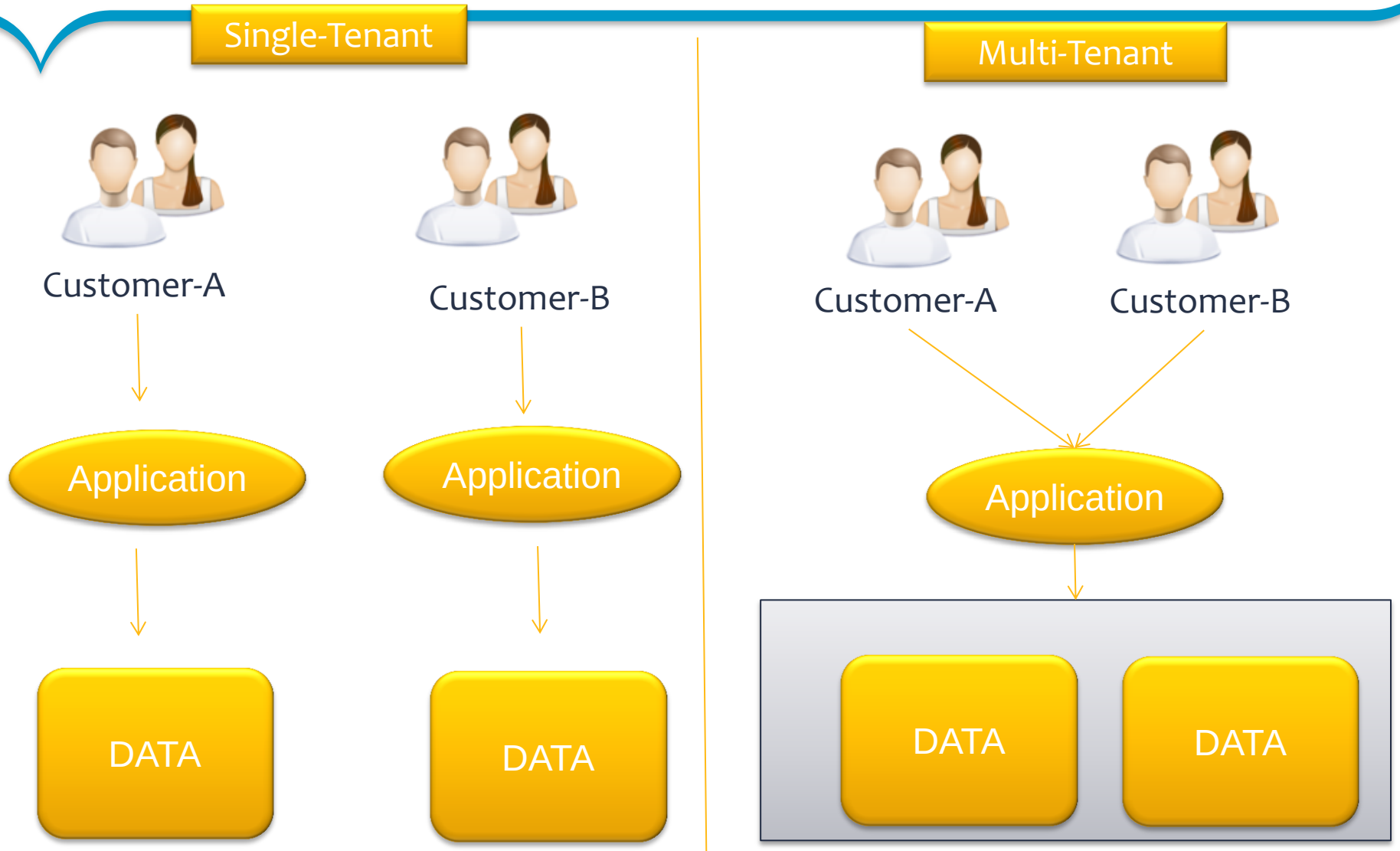
Single-Tenant vs. Multi-Tenant Applications

- SaaS Applications can be classified as Single-Tenant Applications and Multi Tenant Applications.
- Single-Tenant Application : Multiple users or Multiple customer organizations, are assigned with their own copy of the application. It requires one instance for each customer, there's no cost advantage.
- Multi-Tenant Application : Multiple users or Multiple customer organizations, shares a single copy of the application with their data. It is easy to update, to maintain, to work with, and thus provides cost saving to customers

Single-Tenant vs. Multi-Tenant Applications



Single-Tenant vs. Multi-Tenant Applications



SaaS Advantages

- We will get the following benefits when we use SaaS :
- Faster Deployment, because no local installation required
- Usage-based pricing i.e. letting us to pay only for what we use
- Less financial risk by lowering up-front cost, in-fact we have free trail option so that we can try it before we buy
- Easier upgrade, no need to worry about updates application will be up to date

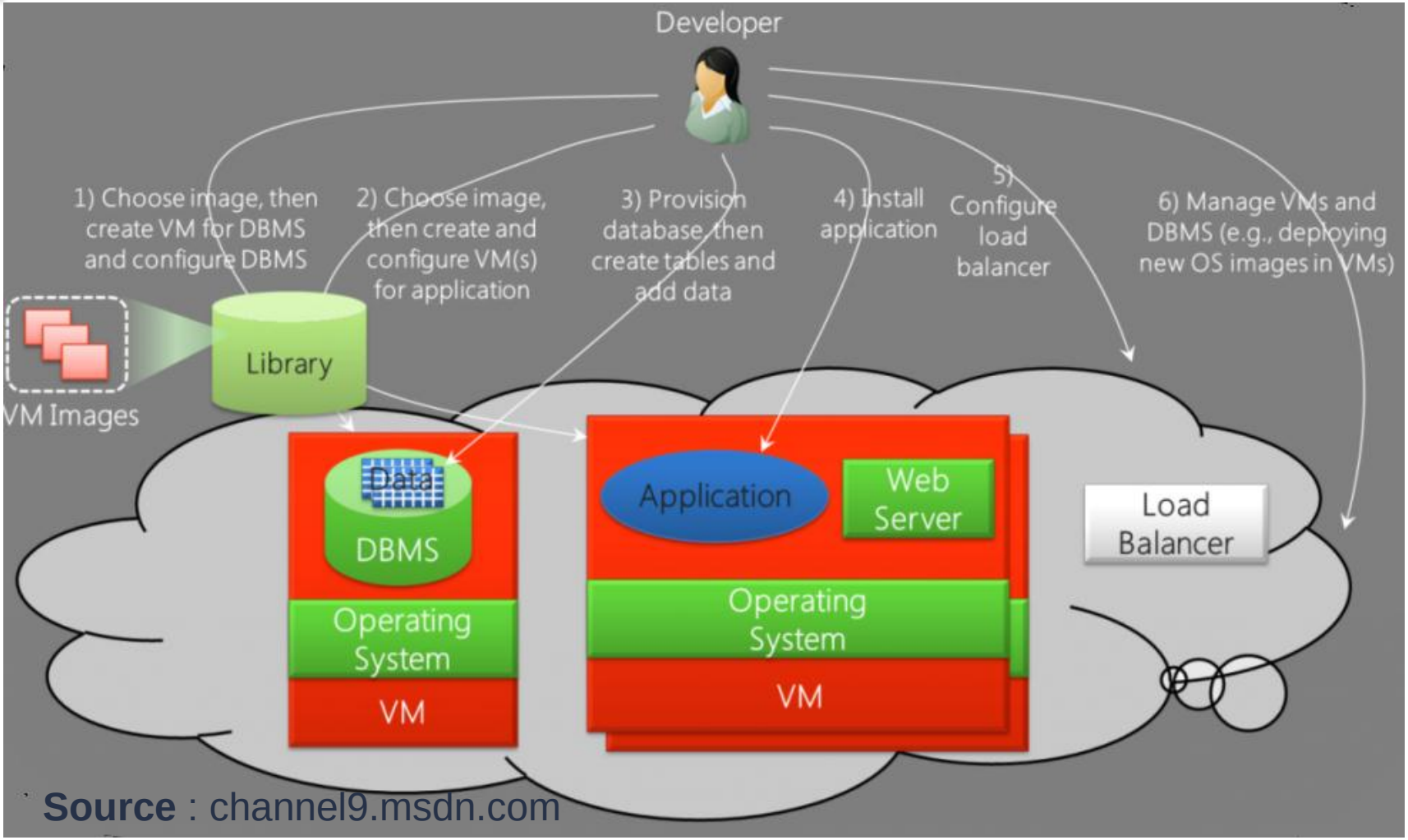
SaaS limitations

- Users will have the following risks when they use SaaS :
- Requires trusted SaaS Provider for availability and data security
- Legal / regulatory concerns can arise due to the data getting stored outside the customer premises.
- App Customization is limited when using a multi-tenant application.
- Harder to integrate with on-premises applications
- Lower performance can arise if customer has low band internet connectivity

IaaS vs. PaaS

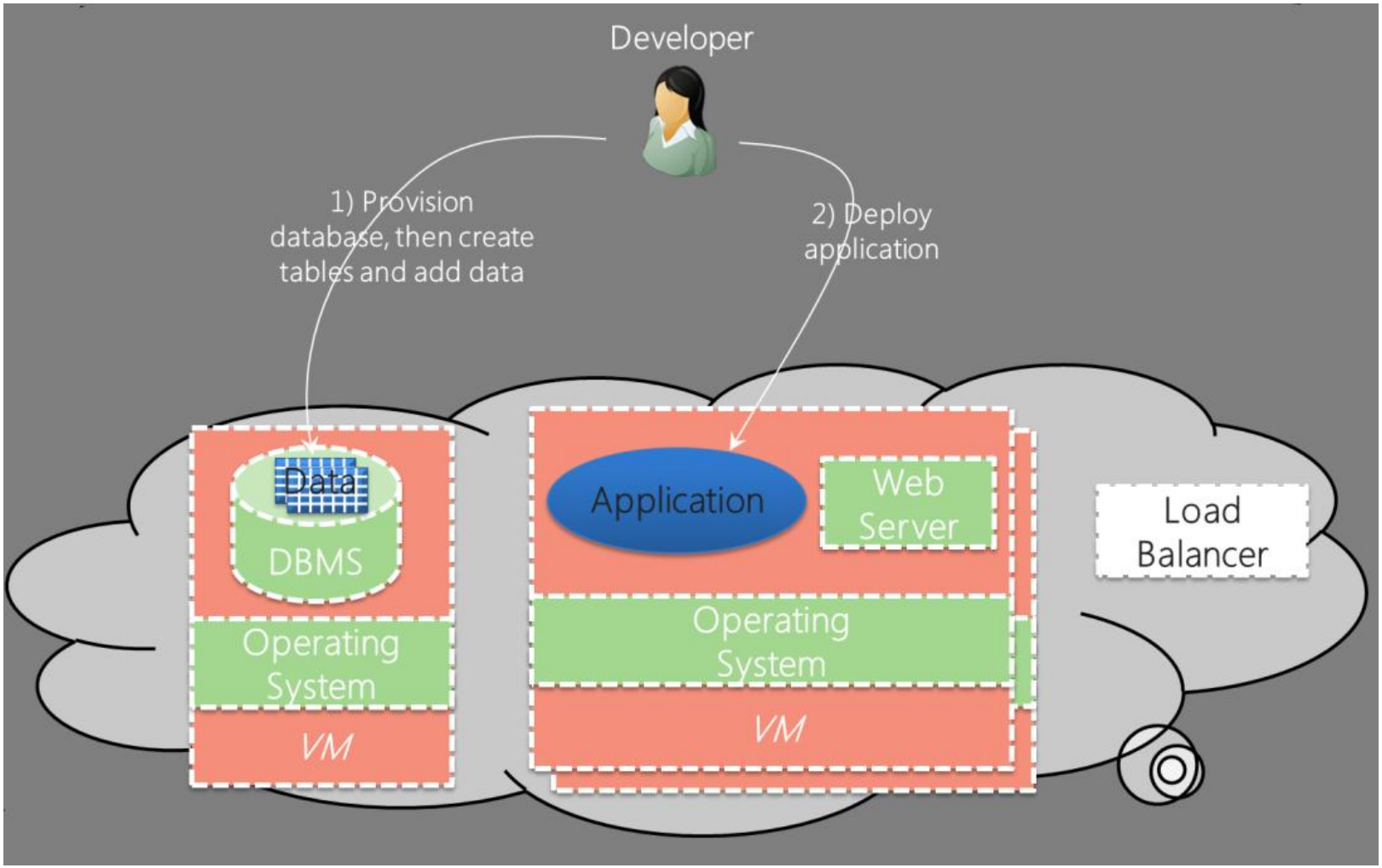
- Infrastructure as a Service (IaaS)
  - Network architects / developers can create virtual machines on demand from a library of preexisting VM images
  - Network architects / developers need to manage VM's and DBMS and configure the load balancers
- Platform as a Service (PaaS)
  - Developers don't create VMs directly rather they provide an application to platform with the platform then runs.
  - It's like a pre-existing application platform so that developers just need to create database , add data and deploy the application, no need to manage VM's

Setting-up an Application on IaaS Environment



Source : channel9.msdn.com

Setting-up an Application on PaaS Environment



PaaS Advantages and Limitation

- Advantages
  - PaaS is faster
  - Developers need to do less work so than applications can be created quickly
  - No need to administer the application, organizations can spend less or supporting their applications
- Limitations
  - PaaS is less familiar to developers, they need to learn the PaaS platform
  - PaaS gives developers less control, they must work with the constraints of PaaS technology.
  - PaaS platforms can be quite different from one another and from the on-premises world, so that there is a chance of locking with vendor.

IaaS or PasS ?

- To create a new cloud native application we can go with either IaaS or PaaS, but choosing PaaS will be very Ideal for this scenario.
- PaaS platforms aren't designed to run standard packaged apps(like install SharePoint in the cloud or SAP), where as IaaS supports Standard Packaged apps.
- Create virtual machines for a DevTest lab works well with IaaS but not well at all with PaaS because PaaS platforms just don't gives us standard VMs.
- Paas doesn’t support VMs for On-Demand Use, where as IaaS supports it.
- IaaS supports disaster recovery, PaaS unlikely to work because disaster recovery is commonly about running your current world unchanged some place else, and PaaS platforms aren't typically designed to do this.

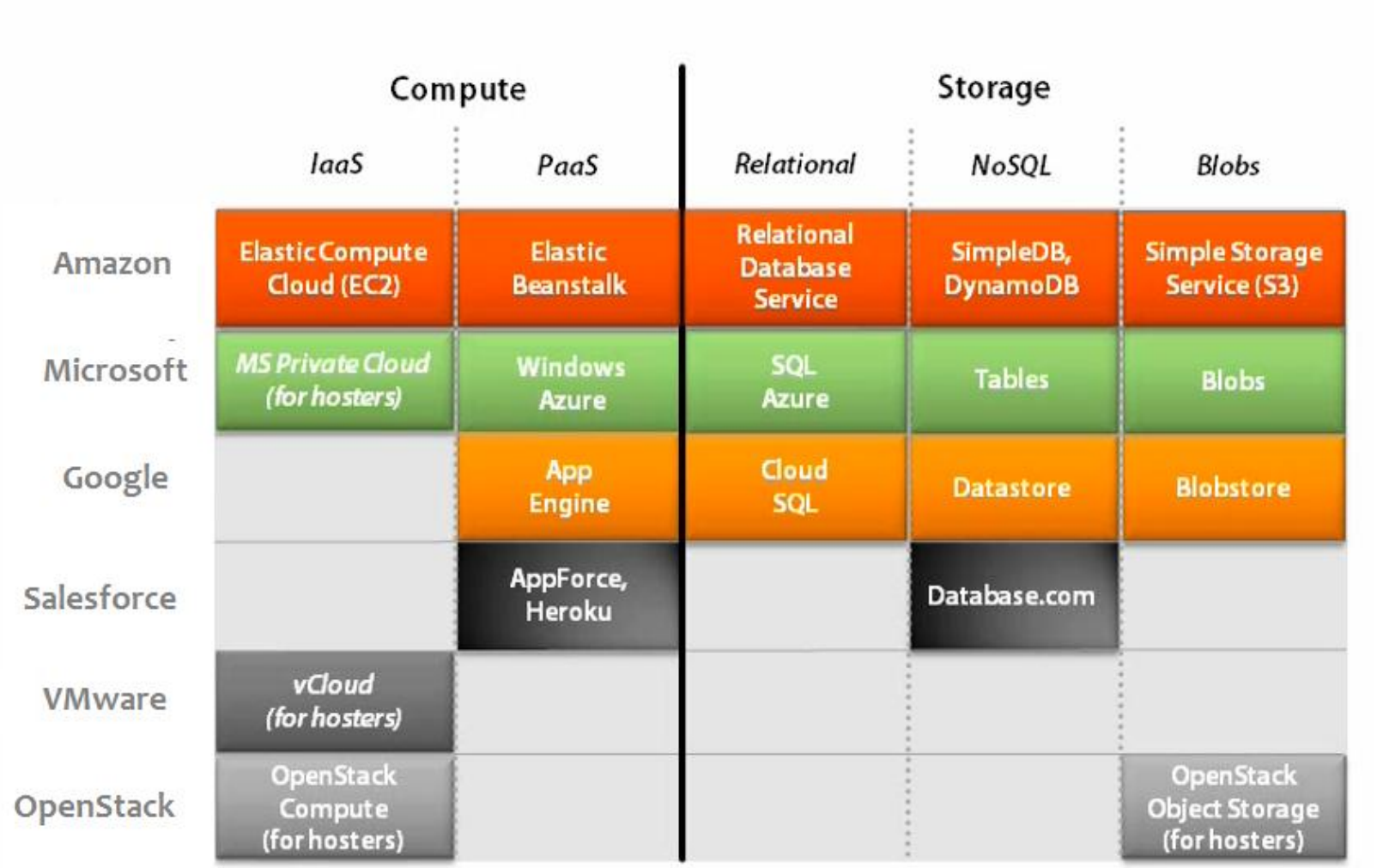
Different Cloud Computing Layers

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
Infrastructure Focused	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.

Cloud Platform Examples



Part V : Opportunity, Advantages and Disadvantages

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 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