CLOUD COMPUTING

Module-1

Introduction to Cloud Computing and Examining the Value Proposition

Subject : Cloud Computing

Subject Code : RLIMCA381

What is Cloud Computing?

- Cloud computing refers to applications and services that run on a distributed network using virtualized resources and accessed by common Internet protocols and networking standards.
- It is distinguished by the belief that resources are virtual, limitless and details of the physical systems on which software runs are abstracted from the user.
- Cloud computing makes the utility computing possible with a pay-as-you-go, infinitely scalable, globally available system.

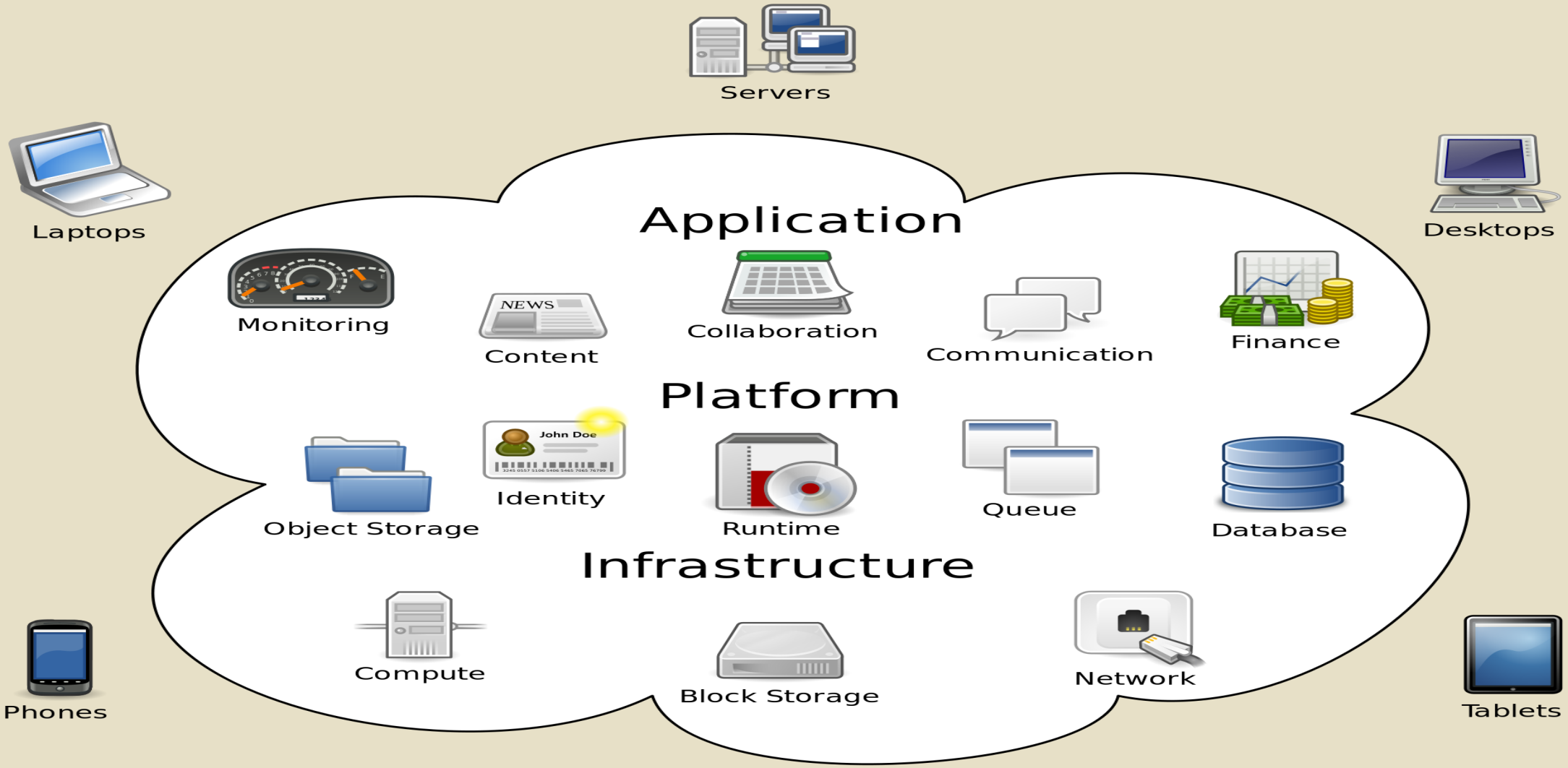
- Cloud computing takes the technology, services, and applications that are similar to those on the internet and turns them into a self-service utility.
- Cloud computing is an representation based on the conception of pooling physical resources and presenting them as a virtual resource.
- It is a new model for provisioning resources, for staging applications, and for platform-independent user access to services.
- Clouds can come in many different types, and the services and applications that run on clouds may or may not be delivered by a cloud service provider.

Abstraction

- Cloud computing abstracts the details of system implementation from users and developers.
- Applications run on physical systems that aren’t specified.
- Data is stored in locations that are unknown.
- Administration of systems is outsourced to others.
- Access by users is made possible from anywhere.

Virtualization

- Cloud computing virtualizes systems by pooling and sharing resources.
- Systems and storage can be provisioned as needed from a centralized infrastructure.
- Costs are assessed on a metered basis
- Multi-tenancy is enabled
- Resources are scalable with agility.

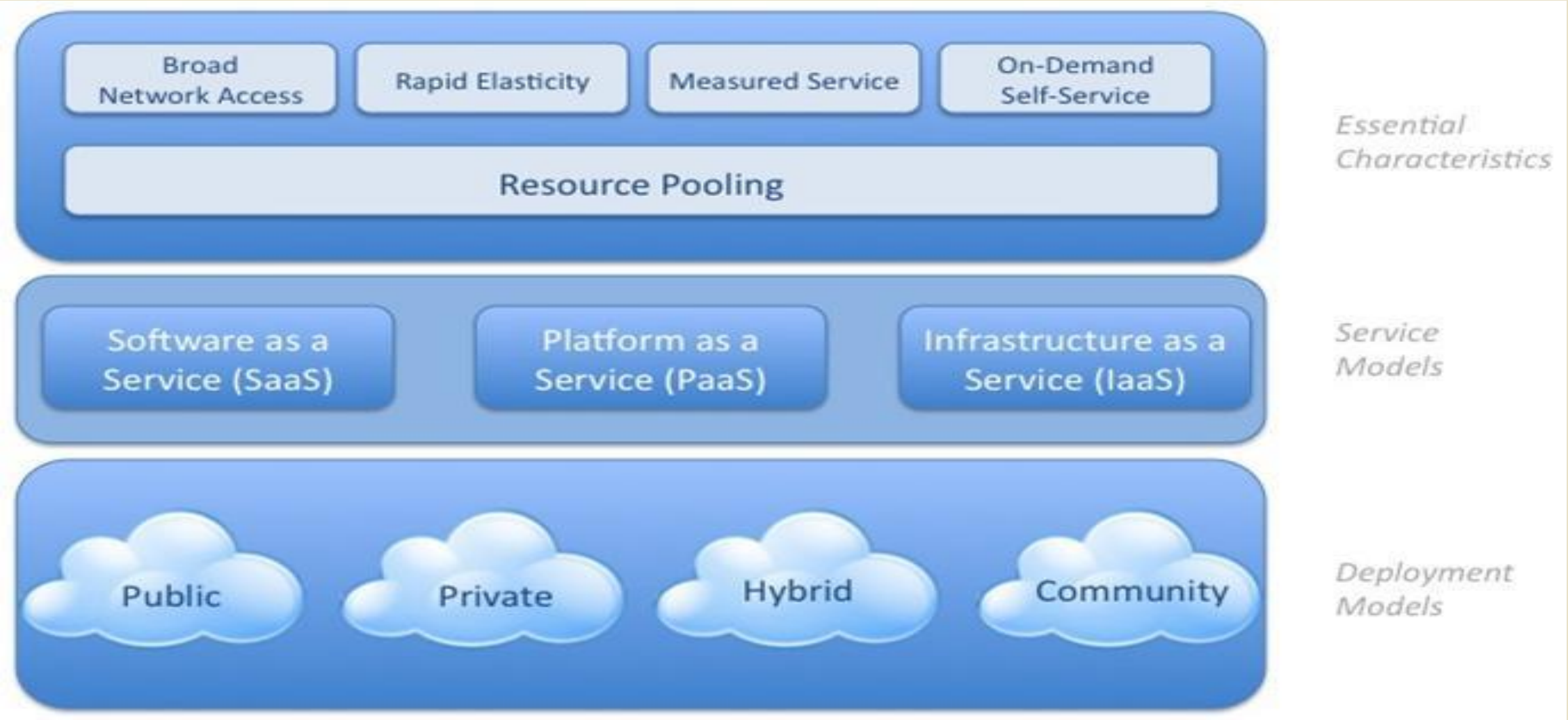


Cloud Computing

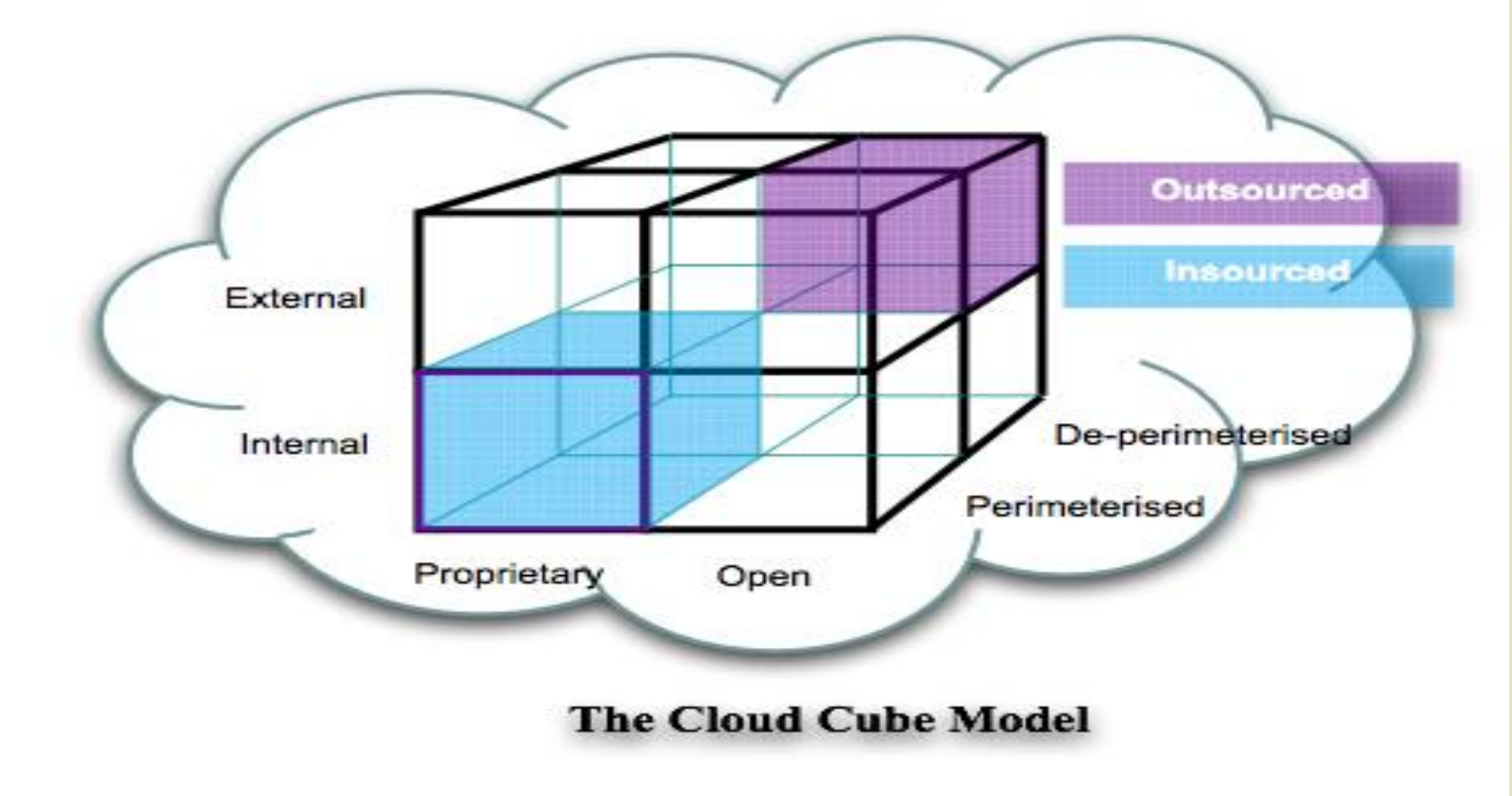
Some Cloud Providers and Applications

Types of Cloud Computing

The NIST Model {National Institute of Standards and Technology}



The Cloud Cube Model



The Cloud Cube Model

- The Open Group maintains an association called the Jericho Forum, whose main focus is how to protect cloud networks.
- The group has an interesting model that attempts to categorize a cloud network based on four dimensional factors.

The four dimensions of the Cloud Cube Model are:

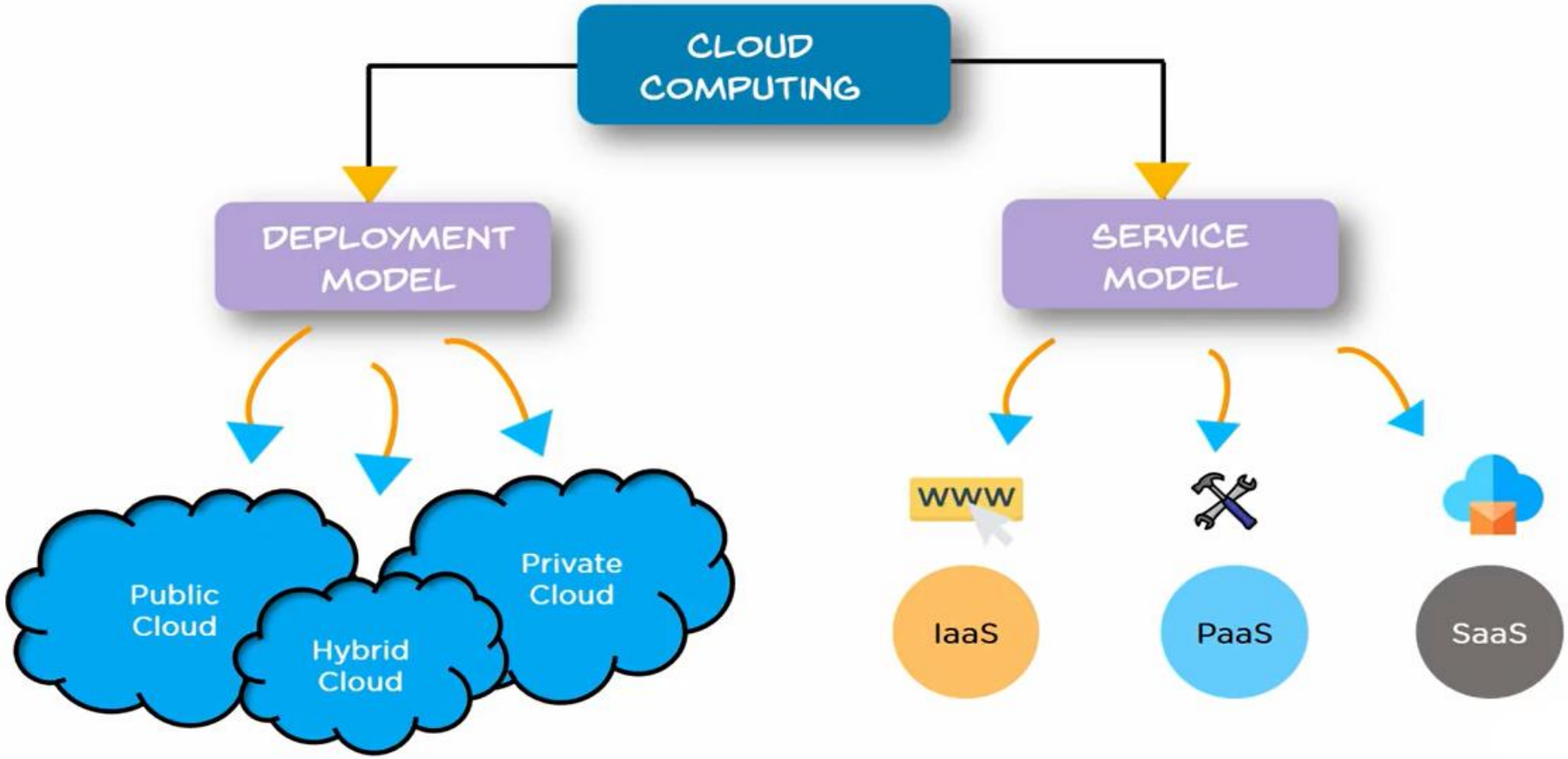
- *Physical location of the data:* *Internal (I) / External (E)* determines your organization's boundaries.
- *Ownership:* *Proprietary (P) / Open (O) is a measure of not only the technology ownership, but of interoperability, ease of data transfer, and degree of vendor application lock-in.*

- *Security boundary: Perimeterised (Per) / De-perimiterised (D-p) is a measure of whether the operation is inside or outside the security boundary or network firewall.*

- *Sourcing: Insourced or Outsourced means whether the service is provided by the customer or the service provider.*

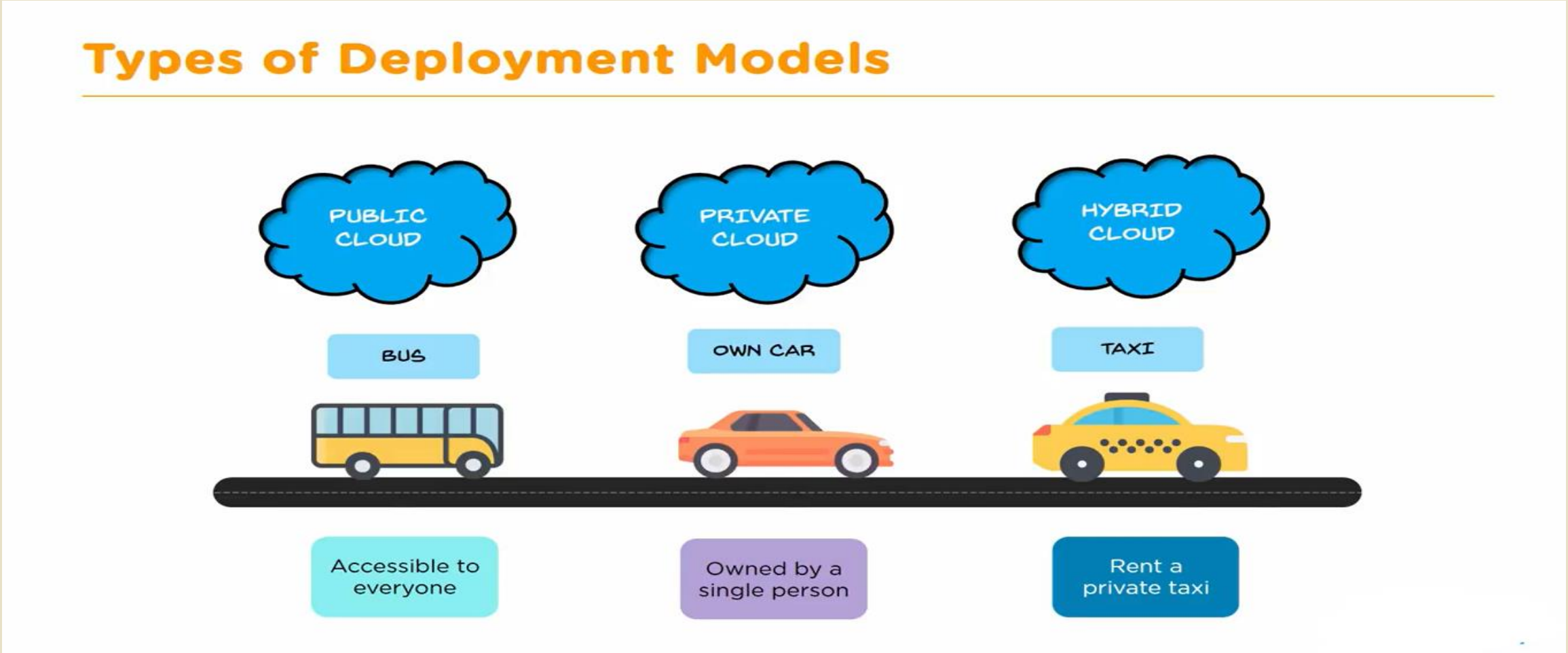
- Taken together, the fourth dimension corresponds to two different states in the eight possible cloud forms: Per (IP, IO, EP, EO) and D-p (IP, IO, EP, EO).

Types of Cloud Computing

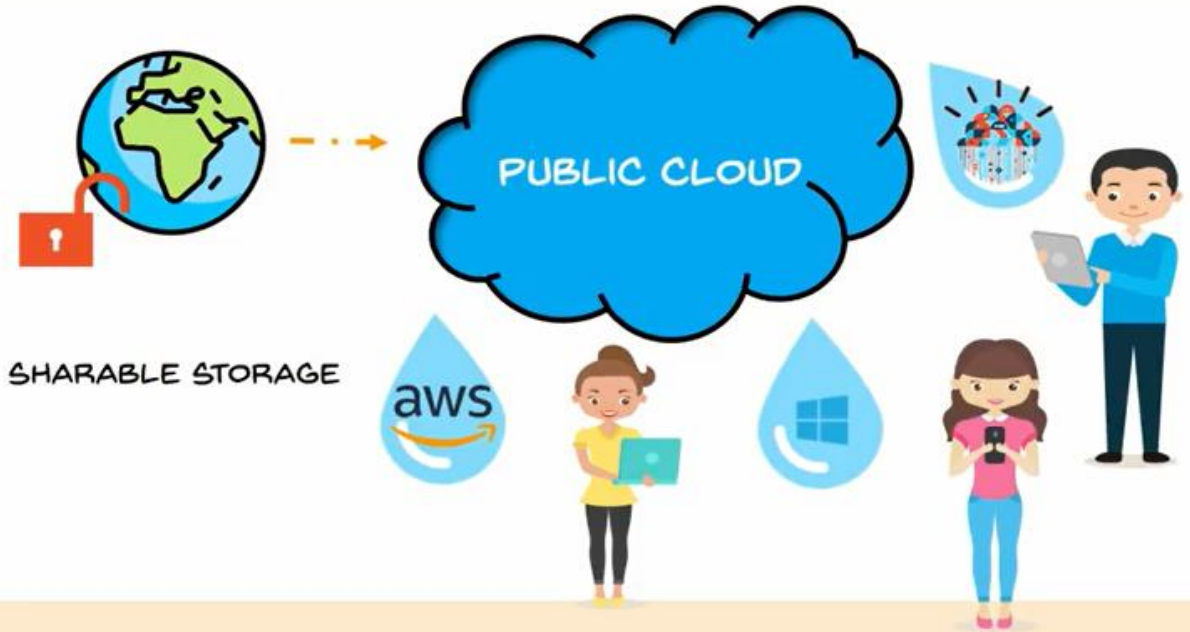


Deployment Model

A deployment model defines the purpose of the cloud and the nature of how the cloud is located



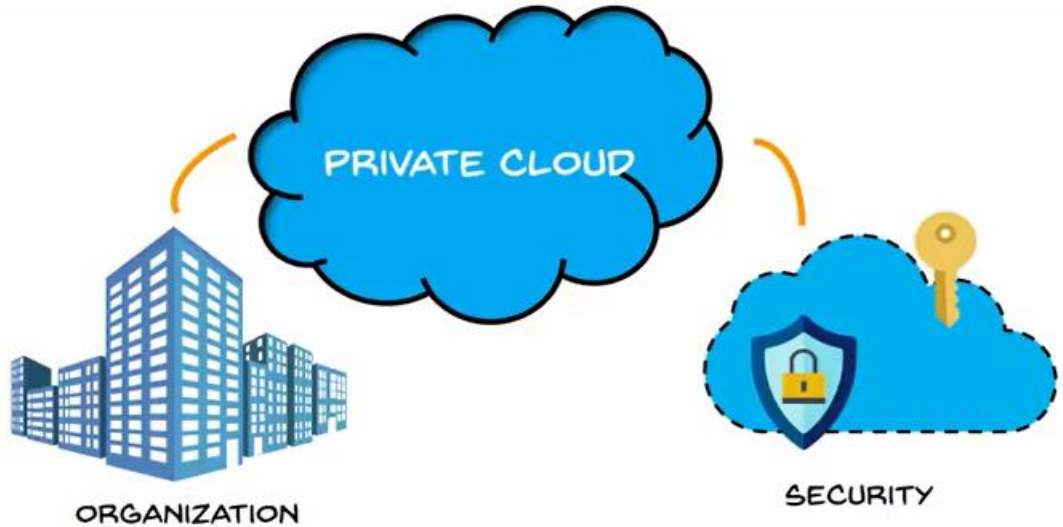
Public Cloud



The cloud infrastructure is made available to the general public over the internet and is owned by a cloud provider

Example: AWS, Microsoft Azure, IBM's Blue Cloud and Sun Cloud

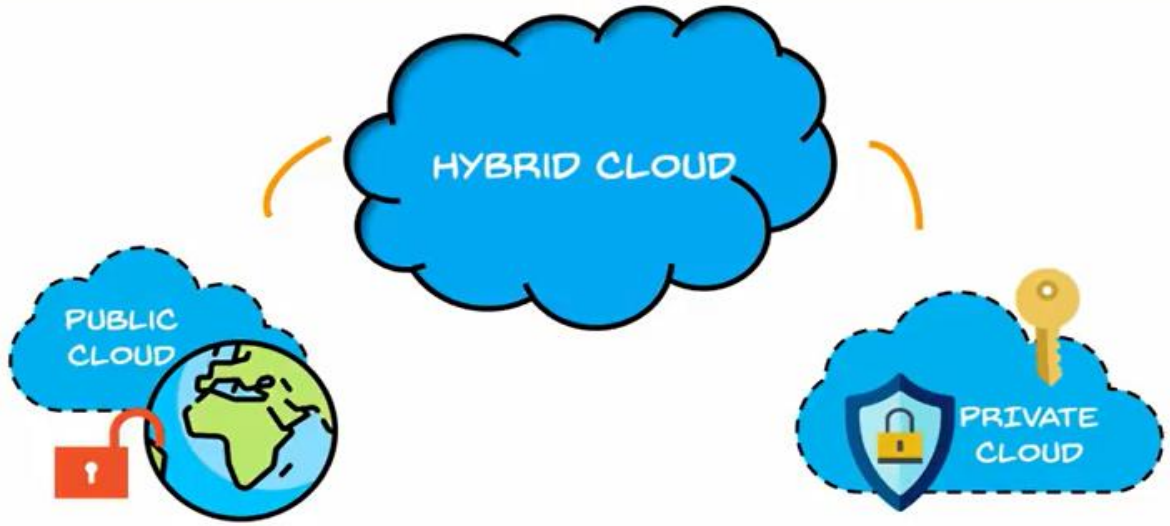
Private Cloud



The cloud infrastructure is exclusively operated by a single organization. It can be managed by the organization or a third party and may exist on-premise or off-premise

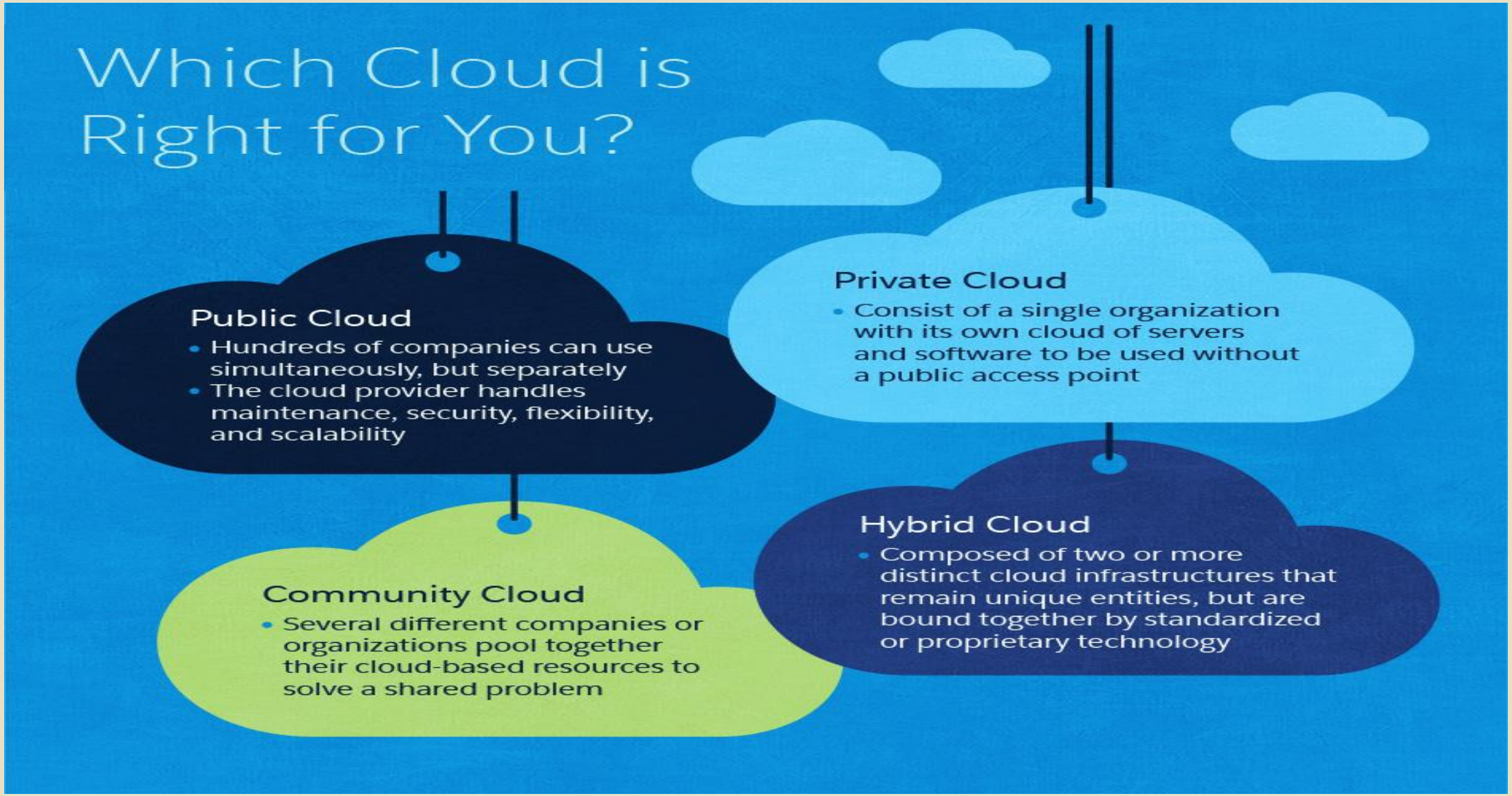
Example: AWS, VMware

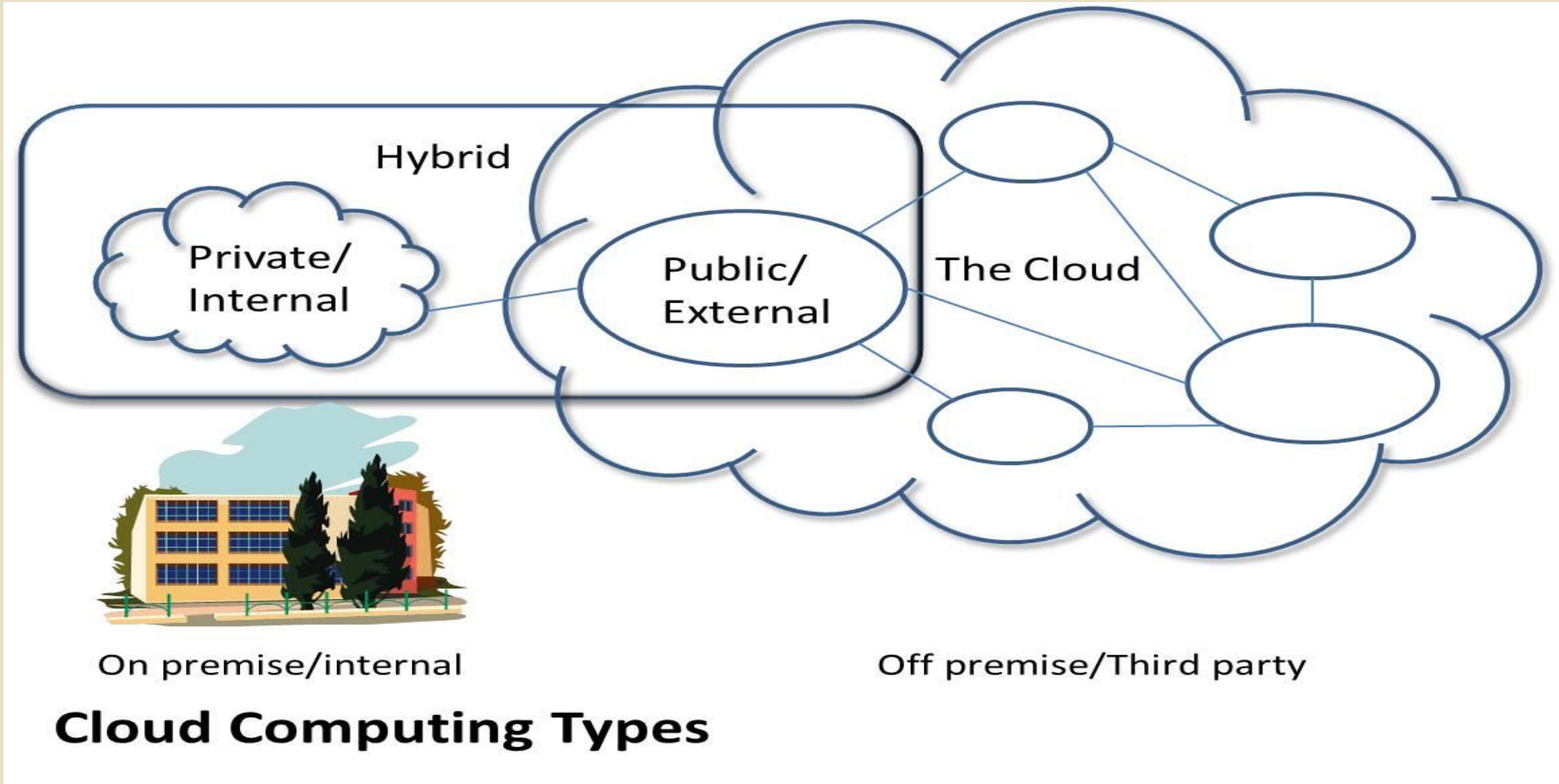
Hybrid Cloud



It consists the functionalities of both public and private cloud

For example:
Federal agencies opt for private clouds when sensitive information is involved
Also, they use the public cloud to share datasets with general public or other government departments

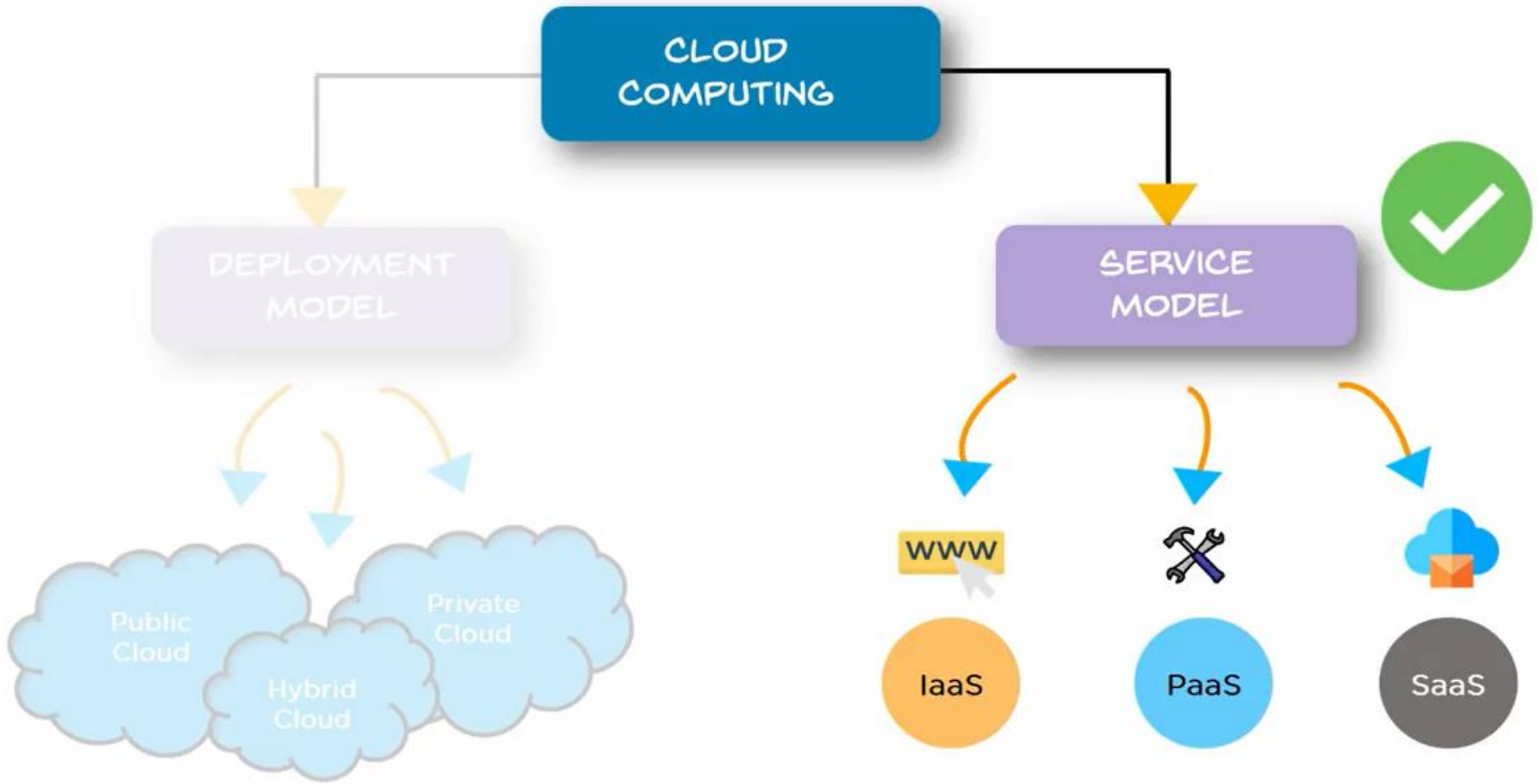

Which Cloud is Right for You?
Public Cloud
• Hundreds of companies can use simultaneously, but separately
• The cloud provider handles maintenance, security, flexibility, and scalability
Private Cloud
• Consist of a single organization with its own cloud of servers and software to be used without a public access point
Community Cloud
• Several different companies or organizations pool together their cloud-based resources to solve a shared problem
Hybrid Cloud
• Composed of two or more distinct cloud infrastructures that remain unique entities, but are bound together by standardized or proprietary technology



Cloud Computing Types

Service Model

Types of Service Models



Types of Service Models

Which cloud service is suitable for you?

IAAS

If your business needs a virtual machine, opt for Infrastructure as a Service

PAAS

If your company requires a platform for building software products, pick Platform as a Service

SAAS

If your business doesn't want to maintain any IT equipment, then choose Software as a Service

Service Models

Categorization of cloud computing based on Service types are:

1. SaaS: Software as a Service
2. PaaS: Platform as a Service
3. IaaS : Infrastructure as a Service

These three are combinedly known as the *SPI model* of cloud computing.

SaaS

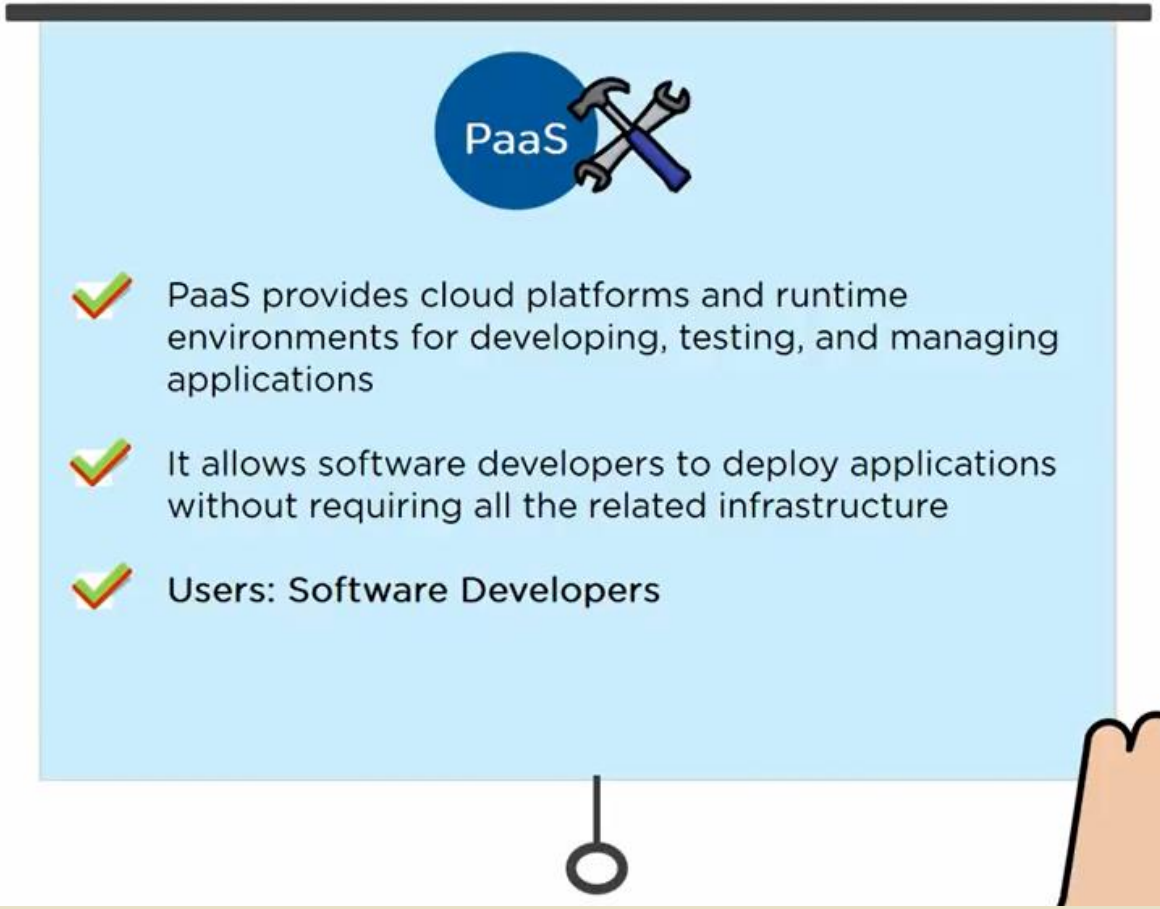
SaaS

- In SaaS, cloud providers host and manage the software application on a pay-as-you-go pricing model
- All software and hardware are provided and managed by a vendor so you don't have to maintain anything
- Users: End Customers

SaaS: Software as a Service

- SaaS is a complete operating environment with applications, management, and the user interface.
- In the SaaS model, the application is provided to the client through a thin client interface (a browser, usually), and the customer's responsibility begins and ends with entering and managing its data and user interaction.
- Everything from the application down to the infrastructure is the Vendor's responsibility.
- Mainly used by end users.
- Eg: GoogleApps, Gmail, Oracle On Demand, SalesForce.com, SQL Azure

PaaS


PaaS
PaaS provides cloud platforms and runtime environments for developing, testing, and managing applications
It allows software developers to deploy applications without requiring all the related infrastructure
Users: Software Developers
PAAS PRODUCTS AND SERVICES
amazon web services EBS
Google app engine
Microsoft Azure

PaaS: Platform as a Service

- Provides virtual machines, operating systems, applications, services, development frameworks, transactions, and control structures.
- The client can deploy its applications on the cloud infrastructure or use applications that were programmed using languages and tools that are supported by the PaaS service provider.
- The service provider manages the cloud infrastructure, the operating systems, and the enabling software.
- The client is responsible for installing and managing the application that it is deploying. Mainly used by Developers.
- Eg: GoGrid CloudCenter, Google AppEngine, Windows Azure Platform

IaaS

- IaaS is a cloud service that provides basic computing infrastructure
- Services are available on PAY-FOR-WHAT-YOU-USE model
- IaaS providers include Amazon Web Services, Microsoft Azure and Google Compute Engine
- Users: IT Administrators

IaaS: Infrastructure as a Service

- IaaS provides Virtual machines, virtual storage, virtual infrastructure, and other hardware assets as resources that clients can provision.
- The IaaS service provider manages all the infrastructure, while the client is responsible for all other aspects of the deployment. This can include the operating system, applications, and user interactions with the system.
- Mainly used by System Administrators
- Eg: Amazon Elastic Compute Cloud (EC2), Eucalyptus, GoGrid, FlexiScale, Linode, RackSpace Cloud, Terremark

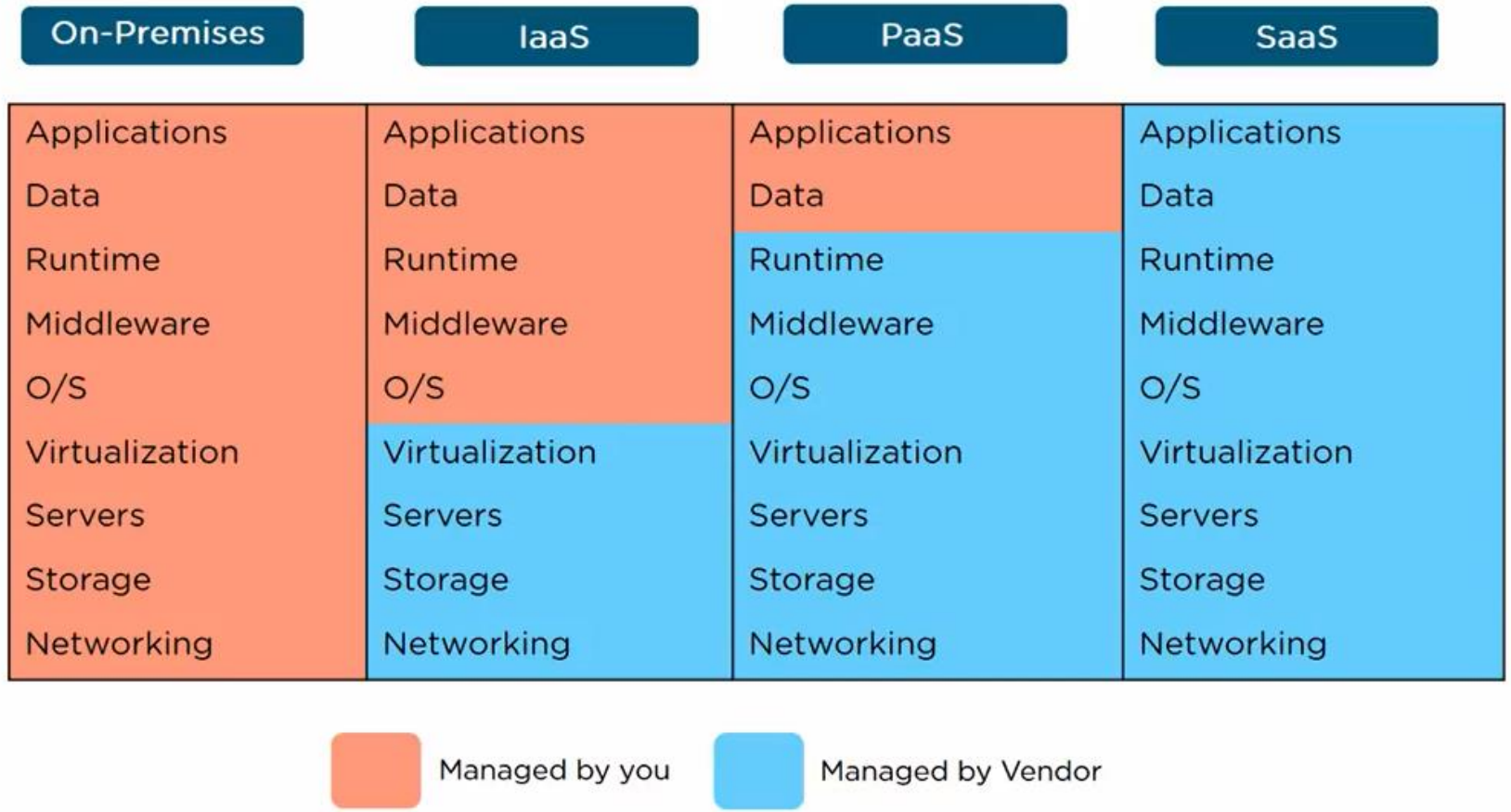
Differences between IaaS, PaaS and SaaS

On-Premises	IaaS	PaaS	SaaS
Made at Home	Buy & bake	Cake delivery	Dine out
Dinning table	Dinning table	Dinning table	Dinning table
Water	Water	Water	Water
Electricity	Electricity	Electricity	Electricity
Oven	Oven	Oven	Oven
Cake Pan	Cake Pan	Cake Pan	Cake Pan
Flour	Flour	Flour	Flour
Sugar	Sugar	Sugar	Sugar
Butter	Butter	Butter	Butter
Eggs	Eggs	Eggs	Eggs

Managed by you

Managed by Vendor

Differences between IaaS, PaaS and SaaS



Benefits of Cloud Computing

Five essential characteristics defined by NIST Model

- *On-Demand Self-Service*: Directly operated by users.
- *Broad Network Access*: Platform independent access to clients. Includes heterogeneous OS, access on devices like laptops, mobile phones, PDA etc.
- *Resource Pooling*: Abstraction mechanism is implemented. Physical / virtual resources are dynamically allocated and reallocated.
- *Rapid Elasticity*: Automatic or manual scaling of resources as and when required is made possible.
- *Measured services*: Pay-as-per-use system is used for charging the services used by customers.

Characteristics of Cloud Computing

- *Paradigm Shift*
- *Benefits*
- *Disadvantages*

Paradigm Shift

- A drastic change in the way the computing resources are deployed and used.
- Infrastructure, computers, storage, networking capacity etc are leased or rented.
- Use of advanced technologies helps computing powers accessible through computers, mobile phones etc, with the help of internet.
- Computing has become faster, cheaper, reliable and globally accessible. Due to this, dependency on cloud services increased drastically over years.

Top Cloud Applications in use:

- Collaboration applications
  - ✓Eg: Google Drive, Dropbox, Skype, Hangouts
- Web applications/Web serving
  - ✓Eg: Google Docs, Silverlight, Apache, Internet Information Server(IIS)
- Cloud backup
- Business applications
- Personal productivity Applications
  - ✓Eg: Google Apps, MS Office, Open Office

Additional Advantages of Cloud Computing

- *Lower cost*
- *Ease of utilization*: No need to worry about HW or SW licenses for implementing our services.
- *Quality of service*
- *Reliability*: Automatic load balancing and failover facilities implemented.
- *Outsourced IT Management*: Computing infrastructure is managed by someone else. Users need to concentrate only on business. IT staffing cost can be reduced considerably.
- *Simplified maintenance and upgrade.*
- *Low barriers to entry*: Low capital expenditure required for new business

Disadvantages of Cloud Computing

- *Customizing:* Cloud applications and services may not be as customizable as you might require. Applications developed in-house serves better support in this case.
- *Huge data transfer over internet:* Large organizations or those who run each and every applications on cloud requires huge data transfer. This creates latency in processing speed.
- *Privacy and Security:* Data and applications are managed by third party. Data is transferred via communication medium that are not under direct control of the client. Hence security and privacy is at risk.

- *Dealing with stateless system:* Internet protocols such as HTTP enables communication between the client and provider. The communication methods, transmission routes, data sequences and chances of faulty medium might results in a stateless system. For transactional coherency, the help of service brokers, transaction managers and other middleware must be added to system.

- *Regulatory Compliance Issues:* Data stored in various locations across the world are subject to the jurisdiction of respective countries. Various rules and regulation apply to data at rest and data that is transmitted. Cloud providers are bound to obey the rules of respective nations.

Open Standards

- *Definition*
- *Standards*
- *Examples*

Assessing the Role of Open Standards

- "Open Standards" are standards made available to the general public and are developed and maintained via a collaborative and mutually agreed process.
- It facilitate interoperability and data exchange among different products or services and are intended for widespread adoption.
- The cloud computing technology is the result of the convergence of many different standards.
- Cloud computing changes the manner in which services and applications are deployed. Hence, the role of open standards becomes crucial.

◦ The cloud computing industry is working with the following architectural standards:

- ✓ Platform virtualization of resources
- ✓ Service-oriented architecture
- ✓ Web-application frameworks
- ✓ Deployment of open-source software
- ✓ Standardized Web services
- ✓ Autonomic systems
- ✓ Grid computing

- Without standards, the industry creates proprietary systems with vendor lock-in.
- Since, clients do not want to be locked into any single system, there is a strong industry push to create standards-based clouds.
- These standards help to enable different business models that cloud computing vendors can support, such as SaaS, Web 2.0 applications, and utility computing.
- These businesses require open standards so that data is both portable and universally accessible.

- *OpenStack*
  - An open source project by the company Rackspace.com.
- *EUCALYPTUS*
  - The company Eucalyptus Systems was formed in 2009 to support the commercialization of the Eucalyptus Cloud Computing Platform.
  - A Linux-based software platform for IaaS systems based on computer clusters. Most of the major Linux vendors support this project. It works with a number of technologies for system virtualization.
  - It has an interface that can connect to Amazon's compute and storage cloud systems (EC2 and S3)
  - EUCALYPTUS: "Elastic Utility Computing Architecture for Linking Your Programs to Useful Systems."

Value of Cloud for Enterprise

- *Measuring the Cloud's Value*
- *Categories*
- *Avoiding Capital Expenditures and Right-Sizing*
- *Total Cost of Ownership*
- *Service Level Agreement*
- *Defining Licensing Models*

Value of Cloud for Enterprise

- Cloud computing is particularly valuable because it shifts capital expenditures into operating expenditures.
- This has the benefit of decoupling growth from cash on hand or from requiring access to capital.
- It also shifts risk away from an organization and onto the cloud provider.

Measuring the Cloud's Value

- Cloud computing presents new opportunities to users and developers because it is based on the paradigm of a shared multitenant utility.
- Provides numerous system characteristics that completely alter the economics of IT infrastructures and allows new types of access and business models for user applications.
- *Who will benefit?* Any application or process that benefits from economies of scale, commoditization of assets, and conformance to programming standards.
- *Who will not benefit?* Any application or process that requires a completely customized solution, imposes a high degree of specialization, and requires access to proprietary technology.

- A cloud is defined as the combination of the infrastructure of a datacenter with the ability to provision hardware and software.
- A service that concentrates on hardware follows the Infrastructure as a Service (IaaS) model.
- When you add a software stack, such as an operating system and applications to the service, the model shifts to the Software as a Service (SaaS) model.
- When the service requires the client to use a complete hardware/software/application stack, it uses Platform as a Service (PaaS) model.

- Companies becomes cloud providers for the following reasons:
  - ✓ *Profit*
  - ✓ *Optimization:* Full utilization of already existing infrastructure.
  - ✓ *Strategic:* For marketing company's products.
  - ✓ *Extension:* Branded cloud computing platform extend the customer relationships by offering additional service options.
  - ✓ *Presence:* To establish a presence in market before competitors can emerge.
  - ✓ *Platform:* A Cloud service provider can become a hub master at the centre of many ISV's (Independent Software Vendor) offerings.

Early Adopters and new applications

1. Messaging and team collaboration applications
2. Cross enterprise integration projects
3. Infrastructure consolidation, server, and desktop virtualization efforts
4. Social strategy companies
5. Web content delivery services
6. Data analytics and computation
7. Mobility applications for the enterprise
8. CRM applications
9. Experimental deployments, test bed labs, and development efforts
10. Backup and archival storage

The law of cloudonomics

1. Utility services cost less even though they cost more.

Utilities charge a premium for their services, but customers save money by not paying for services that they aren't using.

2. On-demand trumps forecasting.

The ability to provision and tear down resources (de-provision) captures revenue and lowers costs.

3. The peak of the sum is never greater than the sum of the peaks.

A cloud can deploy less capacity because the peaks of individual tenants in a shared system are averaged over time by the group of tenants.

.

4. Aggregate demand is smoother than individual.

Multi-tenancy also tends to average the variability intrinsic in individual demand. With a more predictable demand and less variation, clouds can run at higher utilization rates than captive systems. This allows cloud systems to operate at higher efficiencies and lower costs.

5. Average unit costs are reduced by distributing fixed costs over more units of output.

Cloud vendors have a size that allows them to purchase resources at significantly reduced prices.

6. Superiority in numbers is the most important factor in the result of a combat (Clausewitz).

Weinman argues that a large cloud's size has the ability to repel botnets and DDoS attacks better than smaller systems do.

7. Space-time is a continuum (Einstein/Minkowski).

The ability of a task to be accomplished in the cloud using parallel processing allows real-time business to respond quicker to business conditions and accelerates decision making providing a measurable advantage.

8. Dispersion is the inverse square of latency.

Cutting latency in half requires four times the number of nodes in a system.

9. Don't put all your eggs in one basket.

Large cloud providers with geographically dispersed sites worldwide therefore achieve reliability rates that are hard for private systems to achieve.

10. An object at rest tends to stay at rest (Newton).

Private datacenters tend to be located in places where the company or unit was founded or acquired. Cloud providers can site their datacenters in what are called "greenfield sites."

A greenfield site is one that is environmentally friendly: locations that are on a network backbone, have cheap access to power and cooling, where land is inexpensive, and the environmental impact is low.

Laws of Behavioral Cloudonomics

1. People are risk averse and loss averse.
2. People have a flat-rate bias.
3. People have the need to control their environment and remain anonymous.
4. People fear change.
5. People value what they own more than what they are given.
6. People favor the status quo and invest accordingly.
7. People discount future risk and favor instant gratification.
8. People favor things that are free.
9. People have the need for status.
10. People are incapacitated by choice.

Measuring cloud computing costs

- The cost of a cloud computing deployment is roughly estimated to be

  $Cost_{CLOUD} = \Sigma(UnitCost_{CLOUD} \text{ x } (Revenue – Cost_{CLOUD}))$
- where the unit cost is usually defined as the cost of a machine instance per hour or another resource.
- To compare your cost benefit with a private cloud, you will want to compare the value you determine in the previous equation with the same calculation:
- $Cost_{DATACENTER} = \Sigma(UnitCost_{DATACENTER} \text{ x } (Revenue –(Cost_{DATACENTER}/Utilization))$
- The CostDATACENTER consists of the summation of the cost of each of the individual systems with all the associated resources, as follows:
- CostDATACENTER = 1nΣ(UnitCostDATACENTER x (Revenue –

(CostDATACENTER/Utilization))SYSTEM*n*,

- where the sum includes terms for System 1, System 2, System 3, and so on.

Defining Licensing Models

When you purchase shrink-wrapped software, you are using that software based on a licensing agreement called a EULA or End User License Agreement. The EULA may specify that the software meets the following criteria:

- • It is yours to own.
- • It can be installed on a single or multiple machines.
- • It allows for one or more connections.
- • It has whatever limit the ISV(**independent software vendor)** has placed on its software.

In most instances, the purchase price of the software is directly tied to the EULA.

Avoiding Capital Expenditures

- Biggest reason for new business's failure: *Capitalization.*
- Growth will be difficult when revenues don’t cover the expansion requirements.
- A company wishing to grow would normally be faced with the following options:
  - Buy the new equipment, and deploy it in-house
  - Lease the equipment for a set period of time
  - Outsource the operation to a managed-services organization

- Cloud computing is a good option when the cost of infrastructure and management is high.
- This is true especially in case of legacy applications and systems where maintaining the system capabilities costs significantly.
- A major part of Cloud Computing’s value proposition is its ability to convert capital expenses (CapEX) to Operating expenses (OpEx) through a usage pricing scheme that is elastic and can be right-sized.
- The conversion of real assets to virtual ones provides protection against lack of money to establish necessary infrastructure.

- Moving expenses onto the OpEx side of a budget allows an organization to transfer risk to their cloud provider.

Right-Sizing

- Providing the organization with adequate resources for its smooth operation.
- In situations where demand is unpredictable and change can be rapid, right-sizing a cloud computing solution demands automated solutions.

  Eg: Amazon Web Services' Auto Scaling feature for its EC2 service

Computing Total Cost of Ownership

- TCO is the financial estimate for the cost of the use of a product or service over its lifetime.
- Cost of using cloud services is compared with the same services developed and used in-house or on-premises.
- Over-all cost including the running and maintenance cost needs to be compared.

Specifying Service Level Agreement

- A Service Level Agreement (SLA) is the contract for performance negotiated between you and a service provider.
- SLAs usually specify these parameters:
  - ✓Availability of the service (uptime)
  - ✓Response times or latency
  - ✓Reliability of the service components
  - ✓Responsibilities of each party
  - ✓Warranties

Defining Licensing Models

- End User License Agreement(EULA) on a purchased software follows any of these criteria:
  - *It is yours to own*
  - *It can be installed on a single or multiple machines*
  - *It allows for one or more connection.*
  - *It has whatever limit the ISV (Independent Software Vendor) has placed on its software.*

Understanding Cloud Architecture

- *Exploring Cloud Computing Stack*
- *Composability*
- *Infrastructure*
- *Platforms*
- *Virtual Appliances*
- *Communication Protocols*
- *Applications*
- *Connecting to Cloud*

Exploring the Cloud Computing Stack

- Cloud computing builds on the architecture developed for staging large distributed network applications on the Internet.
- To these standard networking protocols, cloud computing adds the advances in system virtualization.
- The cloud creates a system where resources can be pooled and partitioned as needed.
- Cloud architecture can couple software running on virtualized hardware in multiple locations to provide an on-demand service to the user.

- The abstraction and metered service separates the architectural requirements of cloud computing systems from usual internet application.
- General descriptions of cloud computing in terms of two architectural layers:
  - A "client" as a front end
  - The “cloud” as a backend
- These two components are composed of several component layers, complementary functionalities, and a mixture of standard and proprietary protocols.

- Cloud computing model delivers an encapsulated information technology service that is often controlled through an Application Programming Interface (API).
- A cloud can be created within an organization’s own infrastructure or outsourced to another datacenter.
- Resources in a cloud are virtualized because they are easier to modify and optimize.
- From a user’s perspective, it is important that the resources appear to be infinitely scalable, that the service be measurable, and that the pricing be metered.

Composability

- Applications built in the cloud often have the property of being built from a collection of components, a feature referred to as composability.
- A composable system uses components to assemble services that can be tailored for a specific purpose using standard parts.
- Composablity of hardware and software is a highly desirable characteristic from a developer or user’s standpoint, because it makes system design easier to implement and solutions more portable and interoperable.

- A composable component must be:
  - *Modular:* It is a self-contained and independent unit that is cooperative, reusable, and replaceable.
  - *Stateless:* A transaction is executed without regard to other transactions or requests. Some cloud computing applications provide managed states through brokers, transaction monitors, and service buses.
- IaaS : Highly composable
- Pass : Moderately composable
- SaaS : Less composable

Benefits of composablity:

- ✓Easier to assemble systems
- ✓Cheaper system development
- ✓More reliable operation
- ✓A larger pool of qualified developers
- ✓A logical design methodology

- Designing of composable systems in cloud computing is called the Service Oriented Architecture (SOA).
- The essence of a service oriented design is that services are constructed from a set of modules using standard communications and service interfaces.
- Eg: Services designed using Web Services Description Language (WSDL), data exchange between services using some form of Extensible Markup Language (XML), and the communications between the services using the Simple Object Access Protocol (SOAP) protocol.

Infrastructure

- Most IaaS providers rely on virtual machine technology to deliver servers that can run applications.
- Virtual servers behaves like real servers, delivering a certain number of microprocessor (CPU) cycles, memory access and network bandwidth to customers.
- Virtual machines are containers that are assigned specific resources.
- The software that runs in the virtual machines is what defines the utility of the cloud computing system.

- The Virtual Machine Monitor(VMM), also called a hypervisor, is the low-level software that allows different operating systems to run in their own memory space and manages 1/0 for the virtual machines.
- Applications are custom developed by developers with appropriate services to serve the requirements which can create additional threads of execution and can scale as and when required.

Platforms

- A platform in the cloud is a software layer that is used to create higher levels of service.
  - Eg: Salesforcecorn’s Forcecom Platform, Windows's Azure Platform, Google Apps and the Google AppEngine
- They offer all the hosted hardware and software needed to build and deploy Web applications or services that are custom built by the developer.
- Platforms represent nearly the full cloud software stack, except the presentation layer that represents the user interface.

- The software that is installed is constructed from components and services and controlled through the API that the platform provider publishes.
  - For example, Windows's Azure Platform allows developers to run on a Hyper-V VM, support ASP.NET application framework, SQL Server, and can be programmable within Visual Studio.
- Depending upon the vendor, different tools will be available, such as, developer tools for team collaboration, testing tools, tools for measuring program performance and attributes, database and Web service integration, storage tools etc

- Platforms often provides tools and utilities to aid in application design and deployment.
- Users interact with the platform, consuming services through that API, leaving the platform to manage and scale the service appropriately.
- An API can control data flow, communications, and other important aspects of the cloud application.
- Many platforms offer user interface development tools based on HTML, JavaScript, or some other technology.

Virtual Appliances

- Refers to a software that installs as middleware onto a virtual machine. It is a platform instance, occupying the middle of the cloud computing stack.
  - ✓Eg: Virtual servers: application modules that run a particular machine instance or image type.
  - ✓Eg: Applications such as a Web server or database server that can run on a virtual machine image.
- Since, the appliance being one of the standardized components, it is used as the basis for assembling more complex services.

- Virtual appliances remove the need for application configuration and maintenance by cloud users.
- File formats like Open Virtualization Format (OVF) helps converting a virtual appliance from one platform to another. It is supported by major virtualization platform vendors like VMware, Microsoft, Oracle and Citrix.
- Examples of Virtual appliances: HelpdeskLive, Jumpbox, VirtualBox, ThoughtPolice

Communication Protocols

- Enables interprocess communication (IPC) between clients and server over distributed networking.
- Various forms of RPC (Remote Procedure Call) implementations (including DCOM, Java RMI, and CORBA)* are used for engaging services and managing transactions over a stateless network.
- Web-centric RPC technology XML-RPC, uses platform independent XML data to encode program calls that are transported over HTTP.

** DCOM: Distributed Component Object Model*
RMI: Remote Method Invocation
CORBA: Common Object Request Broker Architecture
XML: Extensible Markup Language

- Most widely used message-passing standard is the Simple Object Access Protocol(SOAP) which uses XML for its messages and uses RPC and HTTP for message passing.
- SOAP forms the basis for most of the Web services stacks in use today.
- Web Services Description Language (WSDL): commonly used model for discovery and description of Web-based resources which uses SOAP messaging.

- Most commonly used Data Exchange Standards are:
  - REST
    - ✓ Stands for Representational State Transfer.
    - ✓ It is a method for standardizing resources on the web.
    - ✓ Rest assigns a global identifier to a resource so there is a uniform method for accessing information sources.
    - ✓ In most modern implementations, the basis for cloud computing transactions such as initiation, processing and completion are based on the rules of REST.
  - ATOM
    - ✓ Also called Atom Publishing Protocol[APP]

Applications

- The applications of cloud computing are practically limitless.
- With the right middleware and proper applications for execution, a cloud computing system could execute all the programs a normal computer could run.
- Potentially, everything from generic word processing software to customized computer programs designed for a specific company could work on a cloud computing system.

Connecting to Cloud

- Most common connecting methods:
  - A web browser
  - A proprietary application
- Methods for securely connecting over these connections:
  - Use a secure protocol for data transfer such as HTTPS, FTP etc
  - Using VPN or remote transfer protocols like MS-RDP where data protected by tunneling mechanism
  - Through encrypted data transmission

Understanding Services and Applications by Type

- *IaaS*
  - *IaaS Workloads*
  - *Pods, Aggregation, Silo*
- *PaaS*
- *SaaS*
  - *Open SaaS and SOA*
  - *Mashups*

Defining Infrastructure as a Service (IaaS)

- You can broadly partition cloud computing into four layers that form a cloud computing ecosystem, as shown in Figure 4.1.
- The Application layer forms the basis for Software as a Service (SaaS), while the Platform layer forms the basis for Platform as a Service (PaaS) models.
- Infrastructure as a Service (IaaS) creates what may be determined to be a utility computing model, something that you can tap into and draw from as you need it without significant limits on the scalability of your deployment.
- You pay only for what you need when you need it. IaaS may be seen to be an incredibly disruptive technology, one that can help turn a small business into a large business nearly overnight.

- This is a most exciting prospect; one that is fueling a number of IaaS startups during one of the most difficult recessions of recent memory.
- Infrastructure as a Service (IaaS) is a cloud computing service model in which hardware is virtualized in the cloud. In this particular model, the service vendor owns the equipment: servers, storage, network infrastructure, and so forth.
- The developer creates virtual hardware on which to develop applications and services. Essentially, an IaaS vendor has created a hardware utility service where the user provisions virtual resources as required.

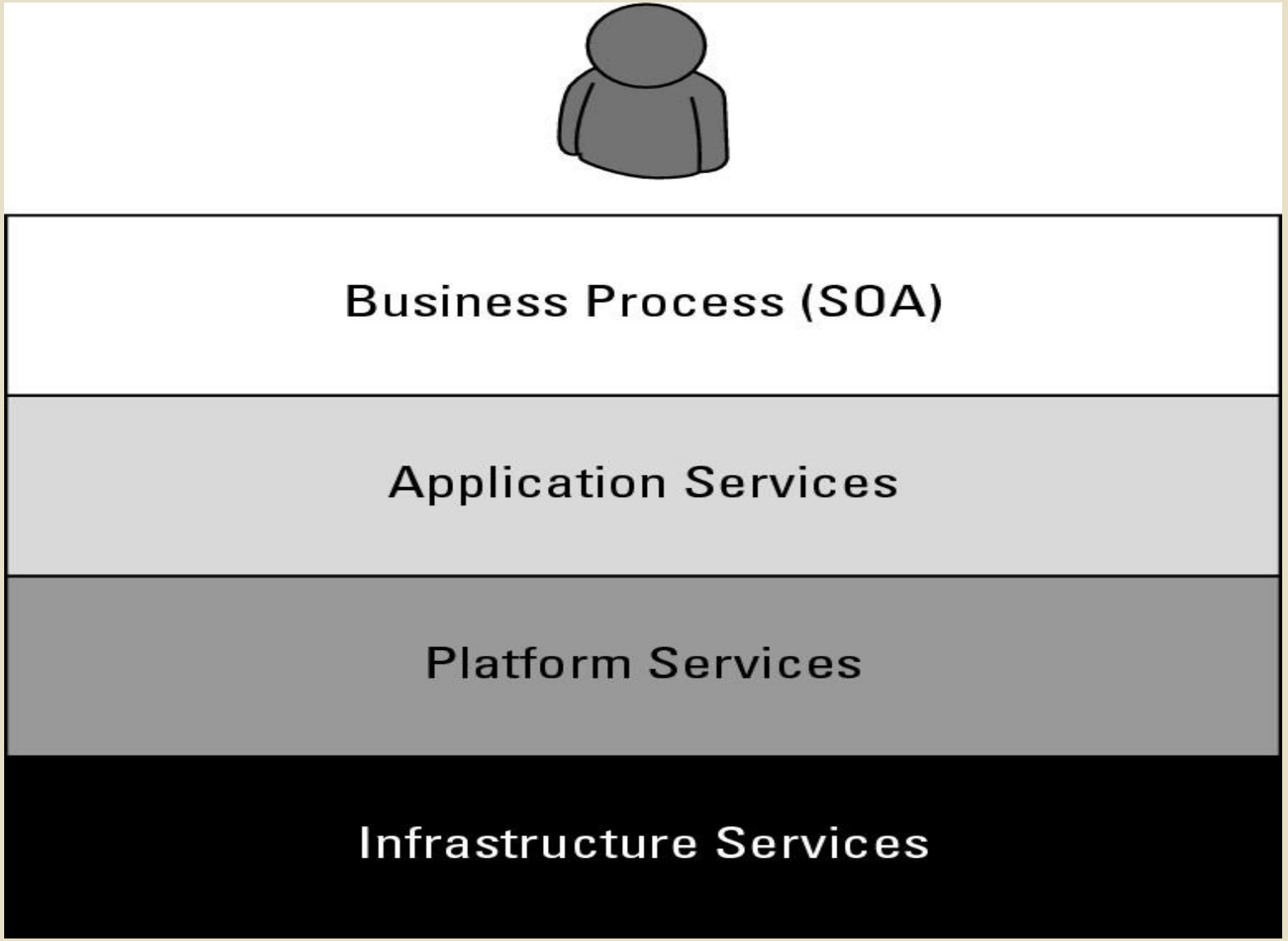

Business Process (SOA)
Application Services
Platform Services
Infrastructure Services

Figure 4.1

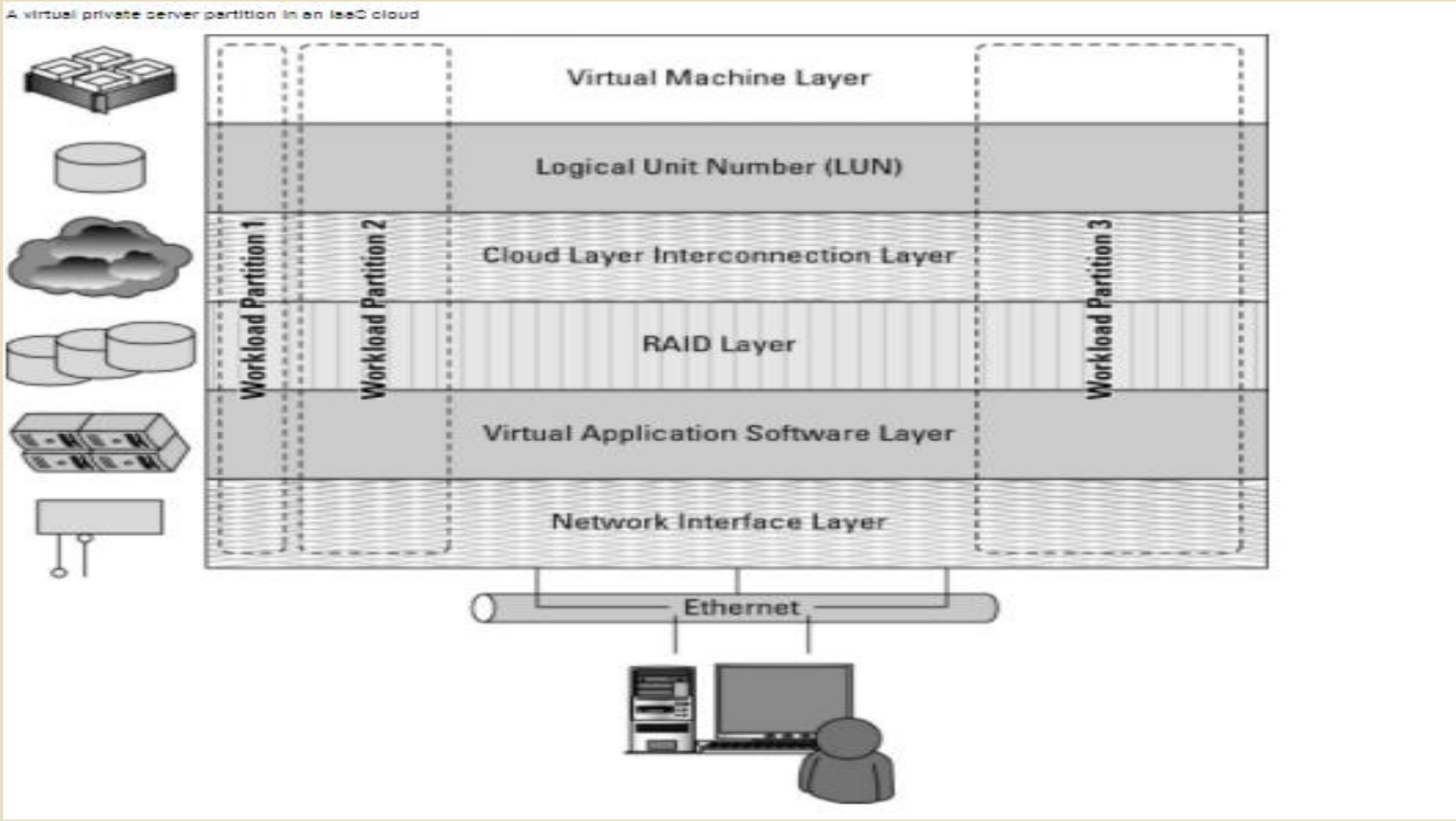
- The developer interacts with the IaaS model to create virtual private servers, virtual private storage, virtual private networks, and so on, and then populates these virtual systems with the applications and services it needs to complete its solution.
- In IaaS, the virtualized resources are mapped to real systems. When the client interacts with an IaaS service and requests resources from the virtual systems, those requests are redirected to the real servers that do the actual work.

IaaS Workloads

- The fundamental unit of virtualized client in an IaaS deployment is called a *workload*. A workload simulates the ability of a certain type of real or physical server to do an amount of work.
- The work done can be measured by the number of Transactions Per Minute (TPM) or a similar metric against a certain type of system.
- In addition to throughput, a workload has certain other attributes such as Disk I/Os measured in Input/Output Per Second IOPS, the amount of RAM consumed under load in MB, network throughput and latency, and so forth.

- In a hosted application environment, a client's application runs on a dedicated server inside a server rack or perhaps as a standalone server in a room full of servers.
- In cloud computing, a provisioned server called an instance is reserved by a customer, and the necessary amount of computing resources needed to achieve that type of physical server is allocated to the client's needs.

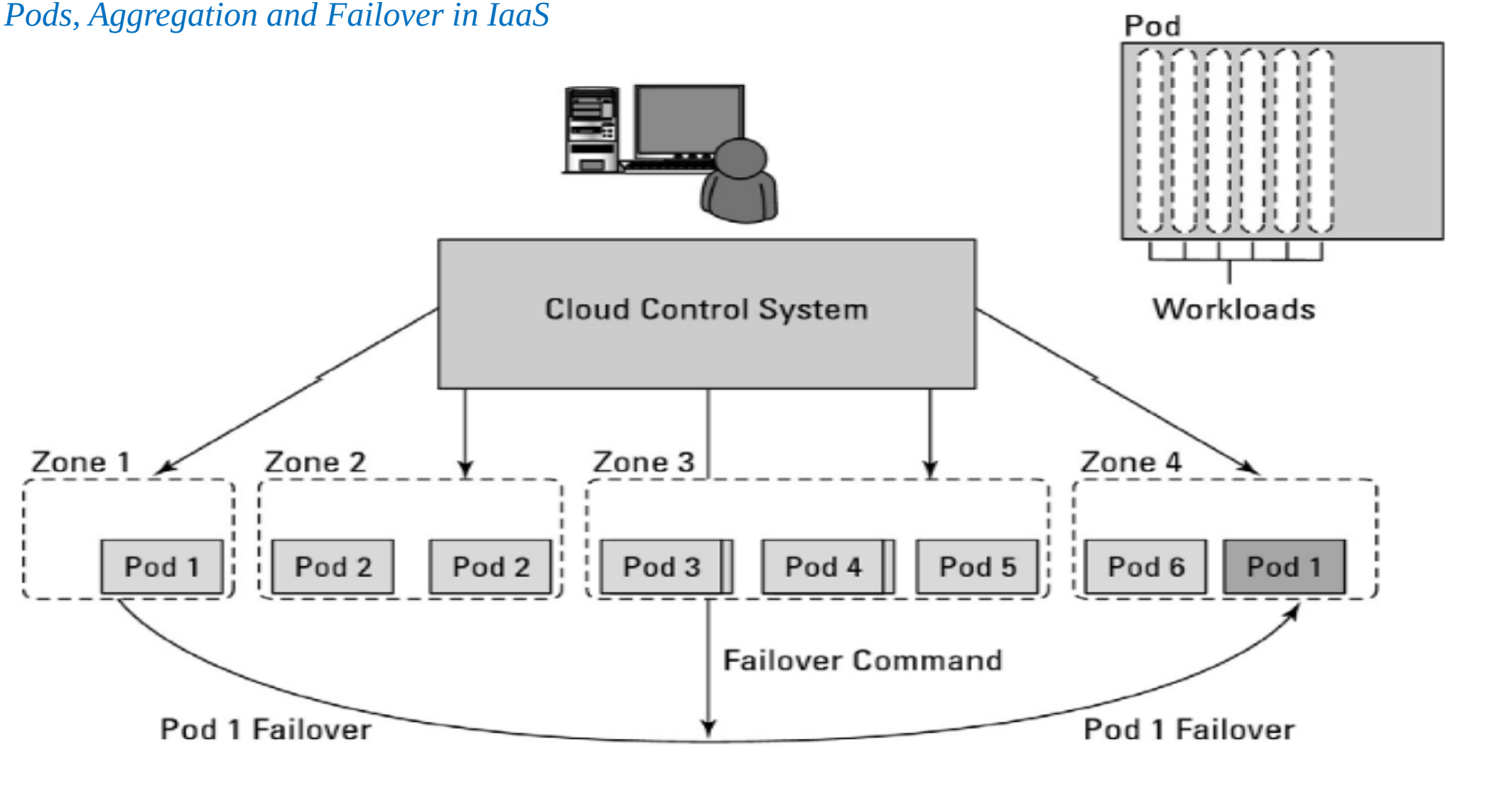
Figure shows how three virtual private server instances are partitioned in an IaaS stack. The three workloads require three different sizes of computers: small, medium, and large.



- A client would reserve machine resources that is required to run each of these workloads.
- The IaaS infrastructure runs the server instances *[created from a pool of virtualized machines, RAID storage, and network interface capacity]* in the data centre. These three layers are expressions of physical systems that are represented as logical units.
- LUNs and the virtual application software layers are logical constructs.
- From an architectural standpoint, the client in an IaaS infrastructure is assigned its own private network, where, the workloads are configured as per the requirement and can be monitored and controlled through APIs.

- The classic example of an IaaS service model is Amazon.com's Amazon Web Services (AWS). AWS has several data centers in which servers run on top of a virtualization platform (Xen) and may be partitioned into logical compute units of various sizes. Developers can then apply system images containing different operating systems and applications or create their own system images. Storage may be partitions, databases may be created, and a range of services such a messaging and notification can be called upon to make distributed application work correctly.

Pods, Aggregation and Failover in IaaS



Pods

- Workloads support a certain number of users.
- When you reach the limit of the largest virtual machine instance possible, you must make a copy or clone of the instance to support additional users.
- A group of users within a particular instance is called a *POD*.
- Sizing limitations for pods is serious concern while building large cloud-based applications.
- Pods are managed by a Cloud Control System (CCS).
  - Eg: In AWS, the CCS is the AWS Management Console.

Aggregation

- Pods are *aggregated* into pools within an IaaS region or site called an availability zone.
- In very large cloud computing networks, when systems fail, they fail on a pod-by-pod basis, or on a zone-by-zone basis.
- A failover system between zones gives IaaS private clouds a very high degree of availability.
  - Eg: In AWS' IaaS infrastructure, the availability zones are organized around the company's data centres in Northern California, Northern Virginia, Ireland and Singapore.

Silo

- When a cloud computing infrastructure isolates user clouds from each other, the management system is incapable of interoperating it with other private clouds. This creates an "*information silo*", or simply a "*silo*".
- Silos are processing domains that are sealed off from the outside, thus imposing restrictions on interoperability.
- Silos are usually created, when you create a private virtual network within an IaaS framework.
- Though silos aren't as flexible as open systems and are subject to vendor lock-in, they can be protected and secured in ways that an open system can't be.

Defining Platform as a Service (PaaS)

- The PaaS model describes a software environment in which a developer can create customized solutions using the development tools provided by the platform/vendor.
- Platforms are based on specific types of development languages, application frameworks, or other constructs.
- A PaaS model provides the tools and development environment to deploy applications on another vendor’s application.

- PaaS systems must offer a way to create user interfaces, and thus support standards such as HTML, JavaScript, or other rich media technologies.
- A customers customize the available platform to enter and retrieve data, perform actions, get results.
- The vendor is responsible for all the operational aspects of the service, maintenance of hardware and software, and managing the product's lifecycle.
  - Eg: Google’s App Engine platform. Developers program on App Engine using APIs published by Google’s. Development framework tools, structure of the file system and data stores, are defined by Google.

Defining Software as a Service (SaaS)

- The most complete cloud computing service model.
- The complete infrastructure including computing hardware and software, as well as the solution itself, are provided by a vendor as a complete service offering. Eg: Gmail.
- SaaS may be described as software that is deployed on a hosted service and can be accessed globally over the Internet, most often in a browser.

- Except user interaction with the software, all other aspects of the service are abstracted away.
- SaaS applications may be:
  - *Customizable (Eg: Salesforce.com with custom API).*
  - *Non customizable (Eg:office suite).*
- SaaS applications include custom software such as billing and invoicing systems, Customer Relationship Management (CRM) applications, Help Desk applications, Human Resource (HR) solutions etc.

SaaS characteristics

1. Available globally on demand, over the internet, through a browser.
2. The typical license is subscription-based or usage-based and is billed on a recurring basis
3. The software and the service are monitored and maintained by the vendor.
4. Cheaper due to reduced distribution and maintenance costs and minimal end-user system costs.

5. Automated upgrades, updates, and patch management and much faster rollout of changes.
6. SaaS applications often have a much lower barrier to entry than their locally installed competitors, and they scale on demand.
7. All users have the same version of the software so each user’s software is compatible with another’s.
8. SaaS supports multiple users and provides a shared data model through a single-instance, multi-tenancy model.

Open SaaS and Service Oriented Architecture (SOA)

- SaaS software is largely based on open source software, which is referred to as Open SaaS.
- The advantages of using open source software are that systems are much cheaper to deploy because you don’t have to purchase the operating system or software, there is less vendor lock-in, and applications are more portable.
- The popularity of open source software (like Linux, APACHE, MySQL), and the number of people who are trained in it make Open SaaS an attractive proposition.
- Companies that deploy open source software in the cloud earns better profit, resulting in lower development costs and more robust solutions.

Mashups

- The componentized nature of SaaS solutions support a feature called *Mashups*.
- A *mashup* is an application that can display a Web page that shows data and supports features from two or more sources.
  - Eg:Adding user /location details to Google maps. Live traffic updates in Maps
- Mashups are considered one of the premier examples of Web 2.0, and that is technology's ability to support social network systems. They are incredibly useful hybrid Web applications.

- A mashup requires three separate components:
  - ✓ *An interactive user interface* (created with HTML/XHTML, Ajax, javaScript, or CSS).
  - ✓ *Web services that can be accessed using an API*, and whose data can be bound and transported by Web service protocols (such as SOAP, REST, XML/HTTP, XML/RFC).
  - ✓ *Data transfer* in the form of XML, KML, JSON etc.

KML : Keyhole Markup Language
JSON : JavaScript Object Notation