# 18CSE07 & CLOUD COMPUTING

## UNIT-I

## UNDERSTANDING CLOUD TECHNOLOGY

Origins and Influences–Basic Concepts and Terminology – Goals and Benefits–Risks and Challenges– Roles and Boundaries– Cloud Characteristics–Cloud Delivery Models: IaaS, PaaS, SaaS – Cloud Deployment Models: Public, Private, Community, Hybrid Clouds

- Cloud computing - the data centres available for users over the Internet where they can save their databases and files.
- This data can easily be accessed over the internet anytime and anywhere.
- In cloud computing, we can manipulate, configure and access the hardware and software remotely.
- In general, cloud computing is accessing and storing the files and databases over the internet instead of accessing it on your computer's hard drive.
- Cloud computing offers platform independence, the software is not required to be installed on any PC. There is portability in cloud computing.

# Origins and Influences - Brief History

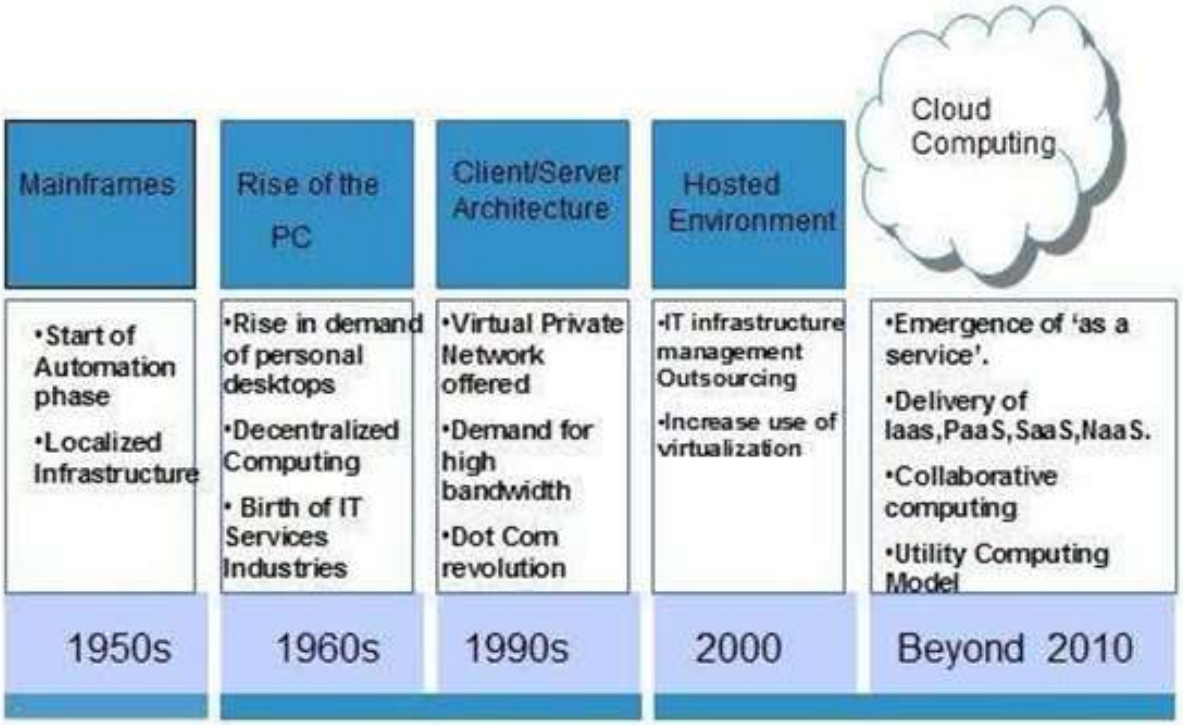
- Computer scientist John McCarthy publicly proposed in 1961:

*"If computers of the kind I have advocated become the computers of the future, then computing may someday be organized as a public utility just as the telephone system is a public utility... The computer utility could become the basis of a new and important industry."*

- In 1969, Leonard Kleinrock, stated:

*"As of now, computer networks are still in their infancy, but as they grow up and become sophisticated, we will probably see the spread of 'computer utilities' ...".*

# History of Cloud Computing




The evolution of cloud computing started in 1950 with mainframe computing. Here multiple users are allowed to access a mainframe.

After 20 years around 1970, the concept of virtualization came. Virtualization software made it possible to execute one or more operating systems simultaneously in an isolated environment.

# Definitions

Gartner

- "...a style of computing in which scalable and elastic IT-enabled capabilities are delivered as a service to external customers using Internet technologies.“

Forrester

- "...a standardized IT capability (services, software, or infrastructure) delivered via Internet technologies in a pay-per-use, self-service way.“

NIST (National Institute of Standards and Technology)

- "Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models."

# Definitions

*Cloud computing is a specialized form of distributed computing that introduces utilization models for remotely provisioning scalable and measured resources*

# Business Drivers for Cloud Computing

**Capacity Planning**

- Capacity planning is the process of determining and fulfilling future demands of an organization's IT resources, products, and services
- A discrepancy between the capacity of an IT resource and its demand can result in a system becoming either inefficient (over-provisioning) or unable to fulfill user needs (under-provisioning). Capacity planning is focused on minimizing this discrepancy to achieve predictable efficiency and performance.

***Different capacity planning strategies exist:***

- *Lead Strategy* - adding capacity to an IT resource in anticipation (expectation) of demand
- *Lag Strategy* - adding capacity when the IT resource reaches its full capacity
- *Match Strategy* - adding IT resource capacity in small increments, as demand increases
- **Capacity planning is challenging because it requires estimating usage load fluctuations.**
  - **Maximum usage of loads impose – unreasonable financial investment**
  - **Under provisioning – leads to transaction losses**

**Cost Reduction**

- technical personnel required to keep the environment operational
- upgrades and patches that introduce additional testing and deployment cycles
- utility bills and capital expense investments for power and cooling
- security and access control measures that need to be maintained and enforced to protect infrastructure resources
- administrative and accounts staff that may be required to keep track of licenses and support arrangements

**Organizational Agility – Scaling its IT resource beyond previously predicted or planned**

- Organizational agility is the measure of an organization's responsiveness to change. Business need the ability to adapt and evolve to successfully face change caused by both internal and external factors.

# Technology Innovations

- **Clustering -** A cluster is a group of independent IT resources that are interconnected and work as a single system.
- **Grid Computing -** A computing grid (or "computational grid") provides a platform in which computing resources are organized into one or more logical pools.
- These pools are collectively coordinated to provide a high performance distributed grid, sometimes referred to as a "super virtual computer."
- Grid computing differs from clustering in that grid systems are much more loosely coupled and distributed. As a result, grid computing systems can involve computing resources that are heterogeneous and geographically dispersed, which is generally not possible with cluster computing-based systems.
- The technological advancements achieved by grid computing projects have influenced various aspects of cloud computing platforms and mechanisms, specifically in relation to common feature-sets such as networked access, resource pooling (IT service(Computation , Network, Storage) to multiple clients), and scalability and resiliency (Recover quickly)

# Technology Innovations

- **Virtualization –is a technology** platform used for the creation of virtual instances of IT resources.
- A layer of virtualization software allows physical IT resources to provide multiple virtual images of themselves so that their underlying processing capabilities can be shared by multiple users.
- virtualization is a technology that allows you to create multiple simulated environments or dedicated resources from a single, physical hardware system

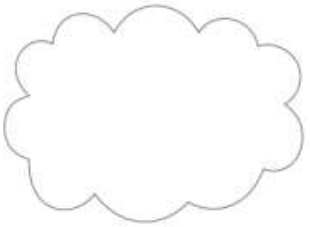
# Cloud enabling Technologies

- Broadband network and Internet architecture
- Data Centre Technology
- Virtualization Technology
- Web Technology
- Multitenant Technology
- Service Technology

# Basic Concepts and Terminology

**Cloud :** A *cloud* refers to a distinct IT environment that is designed for the purpose of remotely provisioning scalable and measured IT resources.

**Figure 3.1**
The symbol used to denote the boundary of a cloud environment.



**IT Resource :** An *IT resource* is a physical or virtual IT-related artifact that can be either software based, such as a virtual server or a custom software program, or hardware-based, such as a physical server or a network device.

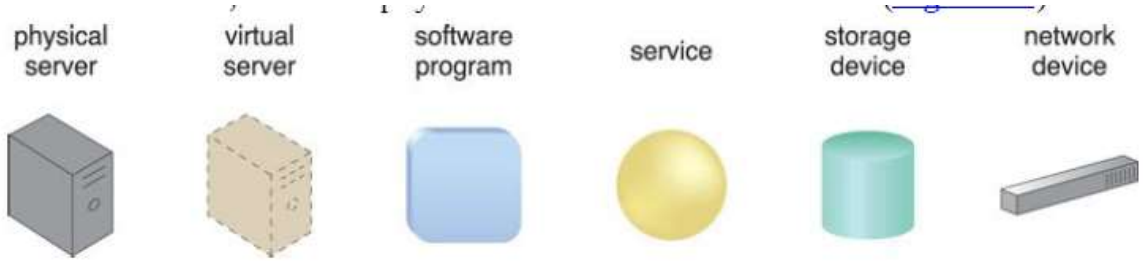



**Figure 3.2.** Examples of common IT resources and their corresponding symbols.

# Basic Concepts and Terminology

**On-Premise :** An IT resource that is hosted in a conventional IT enterprise within an organizational boundary is considered to be located on the premises of the IT enterprise, or *on-premise* for short. (Not cloud based)

- On-Premise IT resource can access cloud based IT rersource
- An On-Premise resource can be moved to cloud
- Redundant deployment of IT resource can exist in both On-Premise and cloud environment

**Scaling :** Scaling, from an IT resource perspective, represents the ability of the IT resource to handle increased or decreased usage demands.

The following are types of scaling:

- *Horizontal Scaling* - scaling out(resource allocation) and scaling in (releasing resource)
- *Vertical Scaling* - scaling up and scaling down

# Basic Concepts and Terminology

## Horizontal Scaling

Allocating(scaling out) or releasing (scaling in ) IT resource of same type

It is common in cloud environment

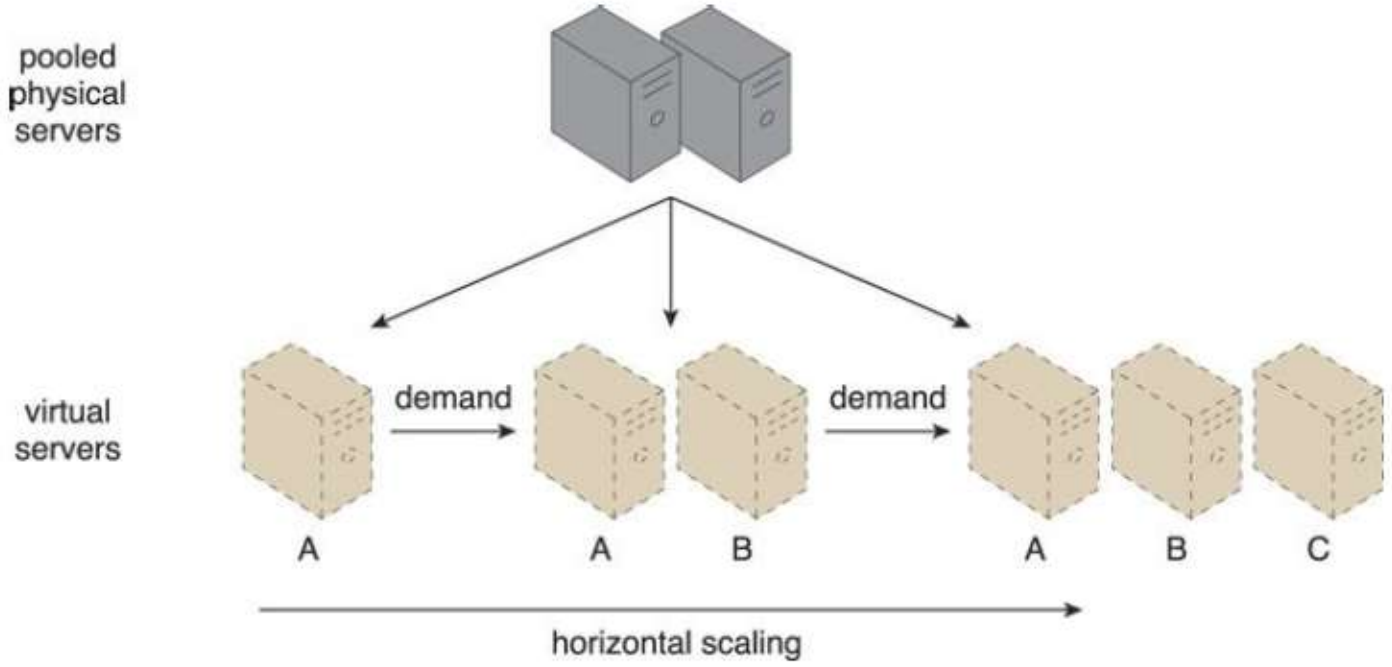



**Figure 3.4.** An IT resource (Virtual Server A) is scaled out by adding more of the same IT resources (Virtual Servers B and C).

# Basic Concepts and Terminology

## Vertical Scaling

- When existing IT resource is replaced by another with higher or lower capacity
- Scaling up – replacing IT resource with another that has higher capacity
- Scaling down - replacing IT resource with another that has lower capacity
- It is less common in cloud environment due to time required for replacement

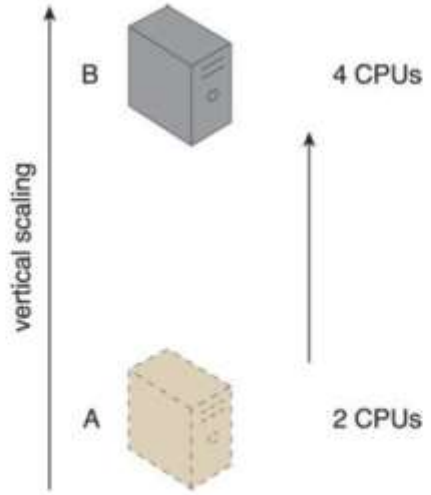



**Figure 3.5.** An IT resource (a virtual server with two CPUs) is scaled up by replacing it with a more powerful IT resource with increased capacity for data storage (a physical server with four CPUs).

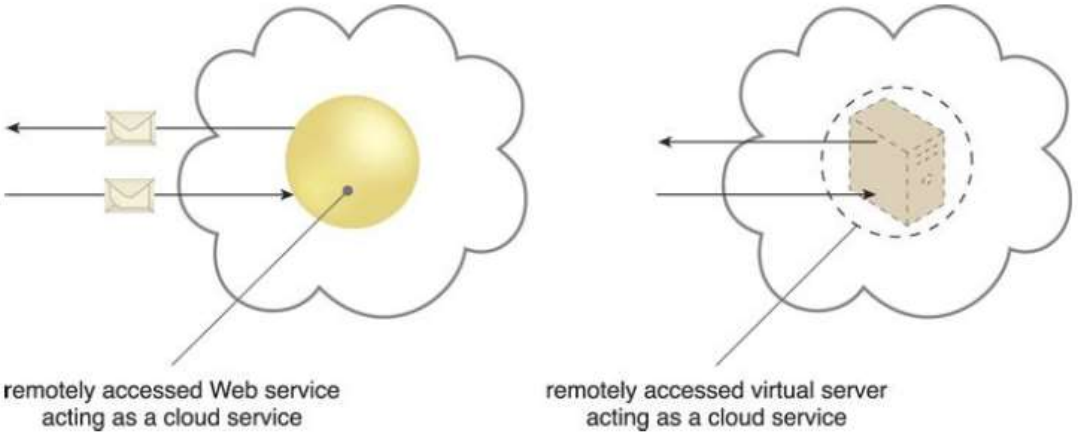
# Basic Concepts and Terminology

**Table 3.1.** A comparison of horizontal and vertical scaling.

| Horizontal Scaling | Vertical Scaling |
|---|---|
| less expensive (through commodity hardware components) | more expensive (specialized servers) |
| IT resources instantly available | IT resources normally instantly available |
| resource replication and automated scaling | additional setup is normally needed |
| additional IT resources needed | no additional IT resources needed |
| not limited by hardware capacity | limited by maximum hardware capacity |

# Basic Concepts and Terminology

**Cloud Service :** A *cloud service* is any IT resource that is made remotely accessible via a cloud.




Cloud service usage conditions are typically expressed in a service level agreement (SLA) – Service contract between a cloud provider and cloud consumer that describes QoS features (availability, reliability, performance) behviours, and limitation of cloud service

**Cloud Service Consumer :** The *cloud service consumer* is a temporary runtime role assumed by a software program when it accesses a cloud service.

# Goals and Benefits

## Reduced Investments and Proportional Costs

The most common economic rationale for investing in cloud-based IT resources is in the reduction or outright elimination of up-front IT investments, namely hardware and software purchases and ownership costs.

A cloud's Measured Usage characteristic represents a feature-set that allows measured operational expenditures (directly related to business performance) to replace anticipated capital expenditures. This is also referred to as *proportional costs*. (gain access to powerful infrastructure without having to purchase it)

**Common measurable benefits to cloud consumers include:**

- On-demand access to pay-as-you-go computing resources on a short-term basis (such as processors by the hour), and the ability to release these computing resources when they are no longer needed.
- The perception of having unlimited computing resources that are available on demand, thereby reducing the need to prepare for provisioning.
- The ability to add or remove IT resources at a fine-grained level, such as modifying available storage disk space by single gigabyte increments.
- Abstraction of the infrastructure so applications are not locked into devices or locations and can be easily moved if needed.

Ex: Using 100 servers for 1 hr costs the same as using 1 server for 100 hrs.

# Goals and Benefits

## Increased Scalability

- By providing pools of IT resources, along with tools and technologies designed to leverage them collectively, clouds can instantly and dynamically allocate IT resources to cloud consumers, on-demand or via the cloud consumer's direct configuration.
- IT resources can be added or released automatically / manually, whenever demand increases or decreases
- Flexible level of scalability to IT resources is directly related to proportional cost benefit

A simple example of usage demand fluctuations throughout a 24 hour period is provided in Figure 3.8.

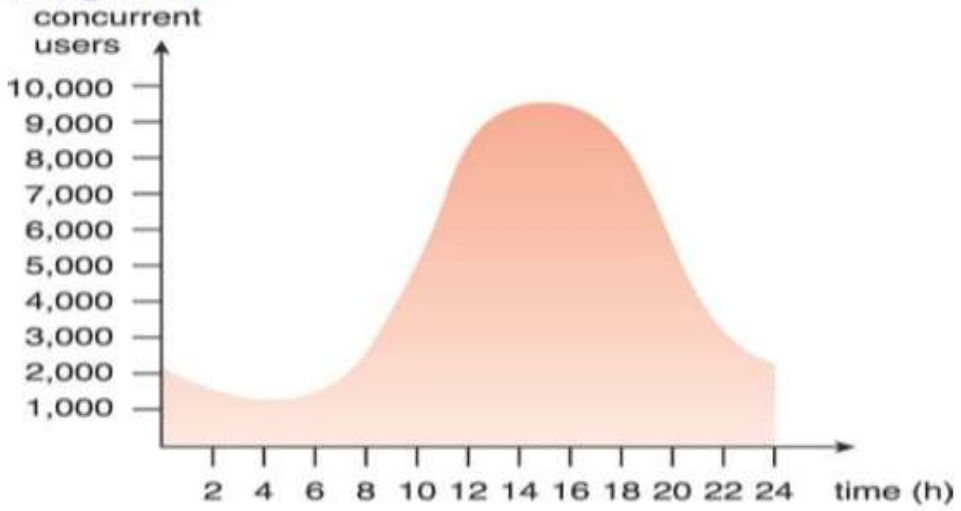



**Figure 3.8.** An example of an organization's changing demand for an IT resource over the course of a day.

# Goals and Benefits

## Increased Availability and Reliability

- The availability and reliability of IT resources are directly associated with tangible business benefits.
- Runtime failures that are not immediately corrected can have a more significant impact during high-volume usage periods.
- Unexpected failure can decrease overall customer confidence

Specifically:

- An IT resource with increased availability is accessible for longer periods of time (for example, 22 hours out of a 24 hour day). Cloud providers generally offer “resilient” IT resources for which they are able to guarantee high levels of availability.
- An IT resource with increased reliability is able to better avoid and recover from exception conditions. The modular architecture of cloud environments provides extensive failover support that increases reliability.

# Risks and Challenges

**Mostly to cloud consumers that use IT resource located in public clouds -** it's very risky to handover any valuable information to the service providers.

**Increased Security Vulnerabilities**

- The remote usage of IT resources **requires** an expansion of **trust boundaries by the cloud consumer** to include the external cloud.
- It can be **difficult to establish** a security architecture that spans such a **trust boundary without vulnerabilities**, unless cloud consumers and cloud providers happen to support the same or compatible security frameworks—which is unlikely with public clouds.
- there can be overlapping trust boundaries from different cloud consumers due to the fact that cloud-based IT resources are commonly shared
- consequence of **overlapping trust boundaries** relates to the cloud provider's privileged access to cloud consumer data.

The overlapping of trust boundaries and the increased exposure of data can provide malicious cloud consumers (human and automated) with greater opportunities to attack IT resources and steal or damage business data.

# Risks and Challenges

- Overlapping trust boundaries leads to malicious cloud consumers (humans and automated) to attack IT resources and steal data
- It can be challenging for cloud provider to offer security mechanism that accommodate requirements of more that one cloud service consumer

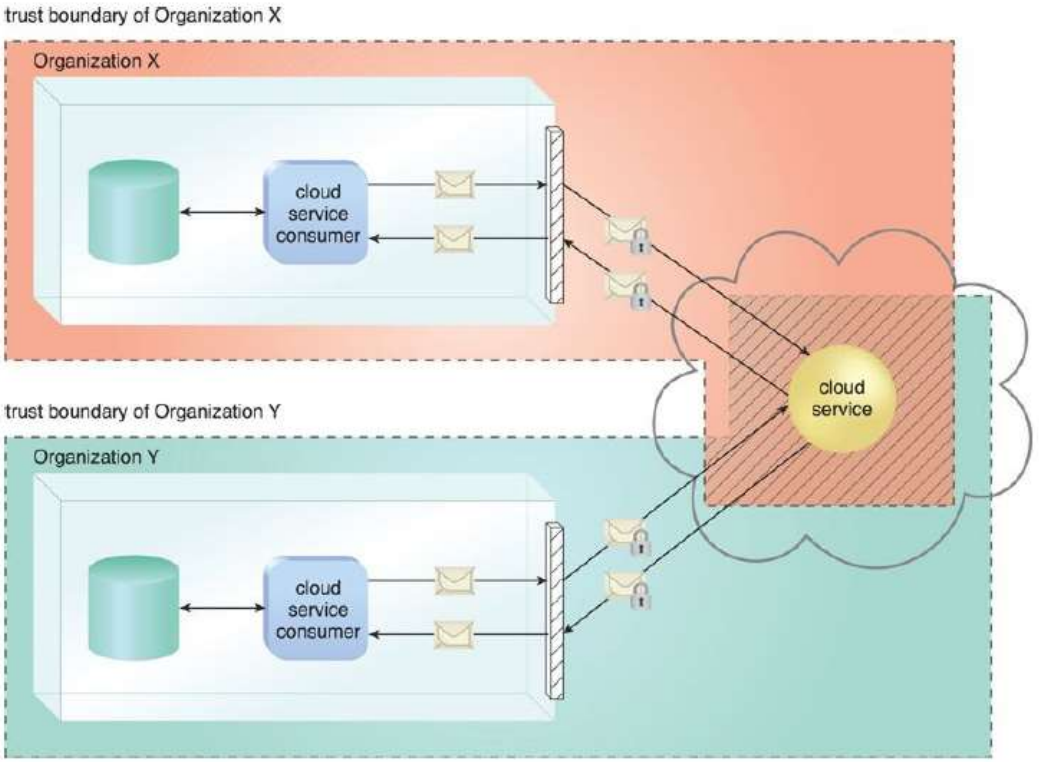



**Figure 3.9.** The shaded area with diagonal lines indicates the overlap of two organizations' trust boundaries.

# Risks and Challenges

## Reduced Operational Governance Control

- Cloud consumers are usually allotted a level of governance control that is lower than that over on-premise IT resources.

This reduced level of governance control can introduce risks associated with how the cloud provider operates its cloud, as well as the external connections that are required for communicate between the cloud and the cloud consumer.

Legal contracts, when combined with SLAs, technology inspections, and monitoring, can mitigate governance risks and issues.

A cloud governance system is established through SLAs, given the "as-a-service" nature of cloud computing.

A cloud consumer must keep track of the actual service level being offered and the other warranties that are made by the cloud provider.

- Example: An unreliable cloud service provider may not maintain guarantees it make in SLAs
- Longer geographic distance between the cloud consumer and cloud provider can require additional network hops that introduce fluctuating latency and bandwidth constraints

# Risks and Challenges

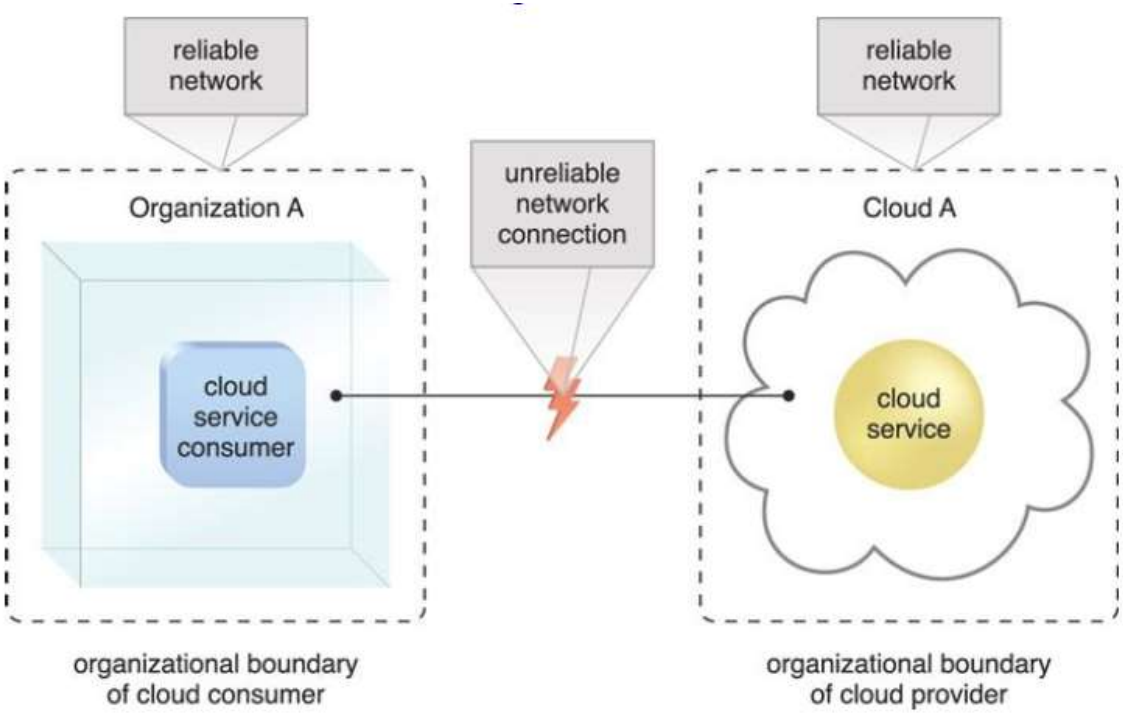


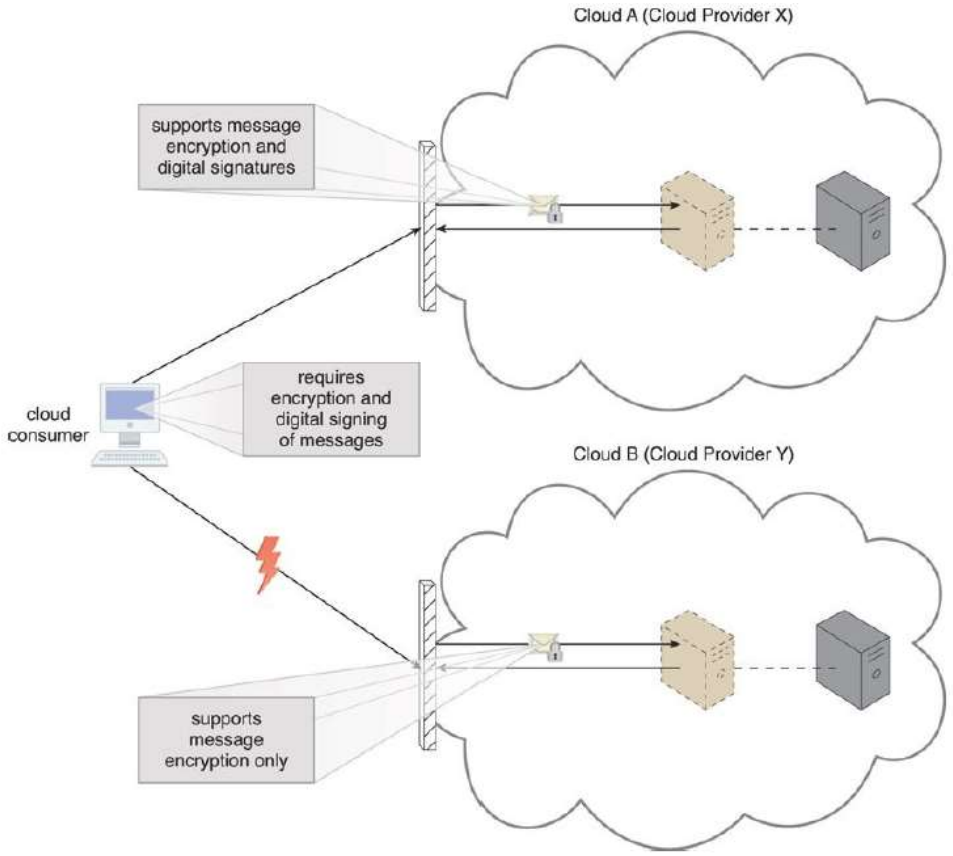

**Figure 3.10.** An unreliable network connection compromises the quality of communication between cloud consumer and cloud provider environments.

Cloud consumer must keep track of the actual service being offered by the cloud provider

# Risks and Challenges

**Limited Portability Between Cloud Providers -** It becomes challenging to switch from one cloud service provider to another.

- Due to a **lack of established industry standards** within the cloud computing industry, public clouds are commonly proprietary to various extents.
- For cloud consumers that have custom-built solutions with dependencies on these proprietary environments, it can be challenging to move from one cloud provider to another.



# Risks and Challenges

**Multi-Regional Regulatory and Legal Issues**

- Third-party cloud providers will frequently establish data centres in affordable or convenient geographical locations.
- Cloud consumers will often not be aware of the physical location of their IT resources and data when hosted by public clouds.
- For some organizations, this can pose serious legal concerns pertaining to industry or government regulations that specify data privacy and storage policies.
- For example: some UK laws require personal data belonging to UK citizenship
- Another potential legal issue pertains to the accessibility and disclosure of data.
- Countries have laws that require some types of data to be disclosed to certain government agencies
- Example: European cloud consumer data that is located in U.S can be more easily accessed by government agencies (due to U.S Patriotic act)

# Roles and Boundaries

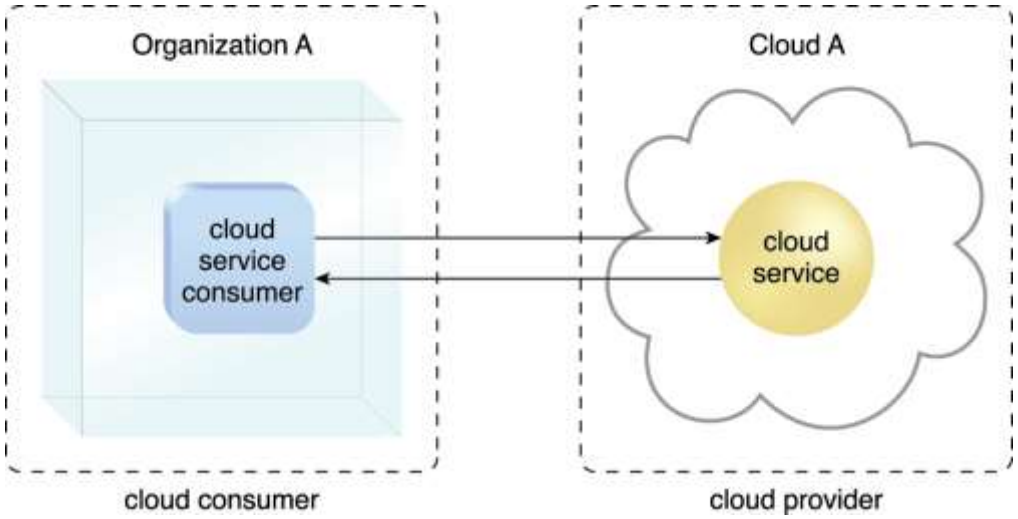
- Cloud Provider
- Cloud Consumer
- Cloud Service Owner
- Cloud Resource Administrator
- Organizational Boundary
- Trust Boundary

# CLOUD PROVIDER

- The organization that provides cloud-based IT resources is the *cloud provider*. - Responsible for making cloud service available to cloud consumer as per agreed SLA
- The cloud provider is further tasked with any required management and administrative duties to ensure the on-going operation of the overall cloud infrastructure.
- Cloud providers normally own the IT resources that are made available for lease by cloud consumers; however, some cloud providers also “resell” IT resources leased from other cloud providers.

# CLOUD CONSUMER

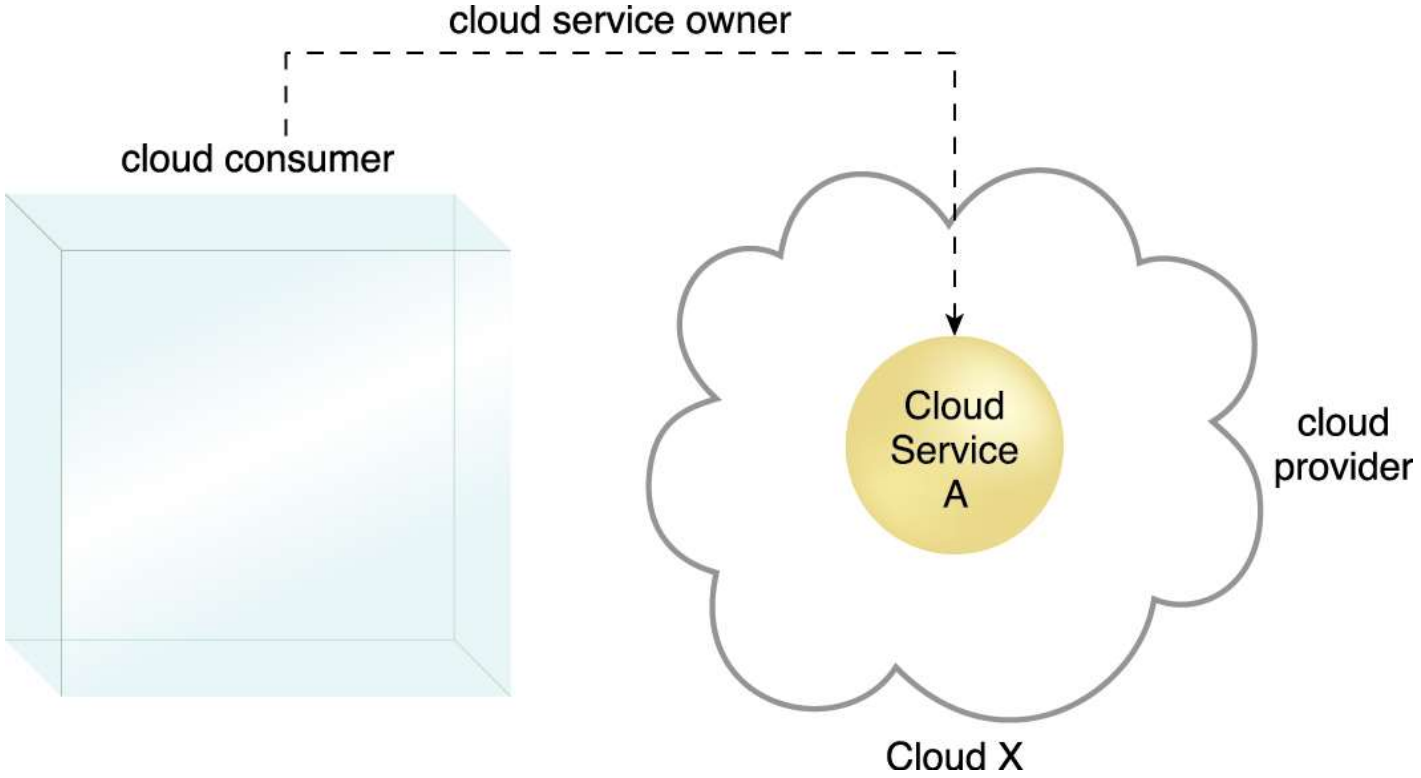
- A *cloud consumer* is an organization (or a human) that has a formal contract or arrangement with a cloud provider to use IT resources made available by the cloud provider.
- Cloud consumer uses a cloud service consumer to access a cloud service.
- Organizations or humans shown *remotely accessing cloud-based IT resources are considered cloud consumers*.




A cloud consumer (Organization A) interacts with a cloud service from a cloud provider (that owns Cloud A). Within Organization A, the cloud service consumer is being used to access the cloud service.

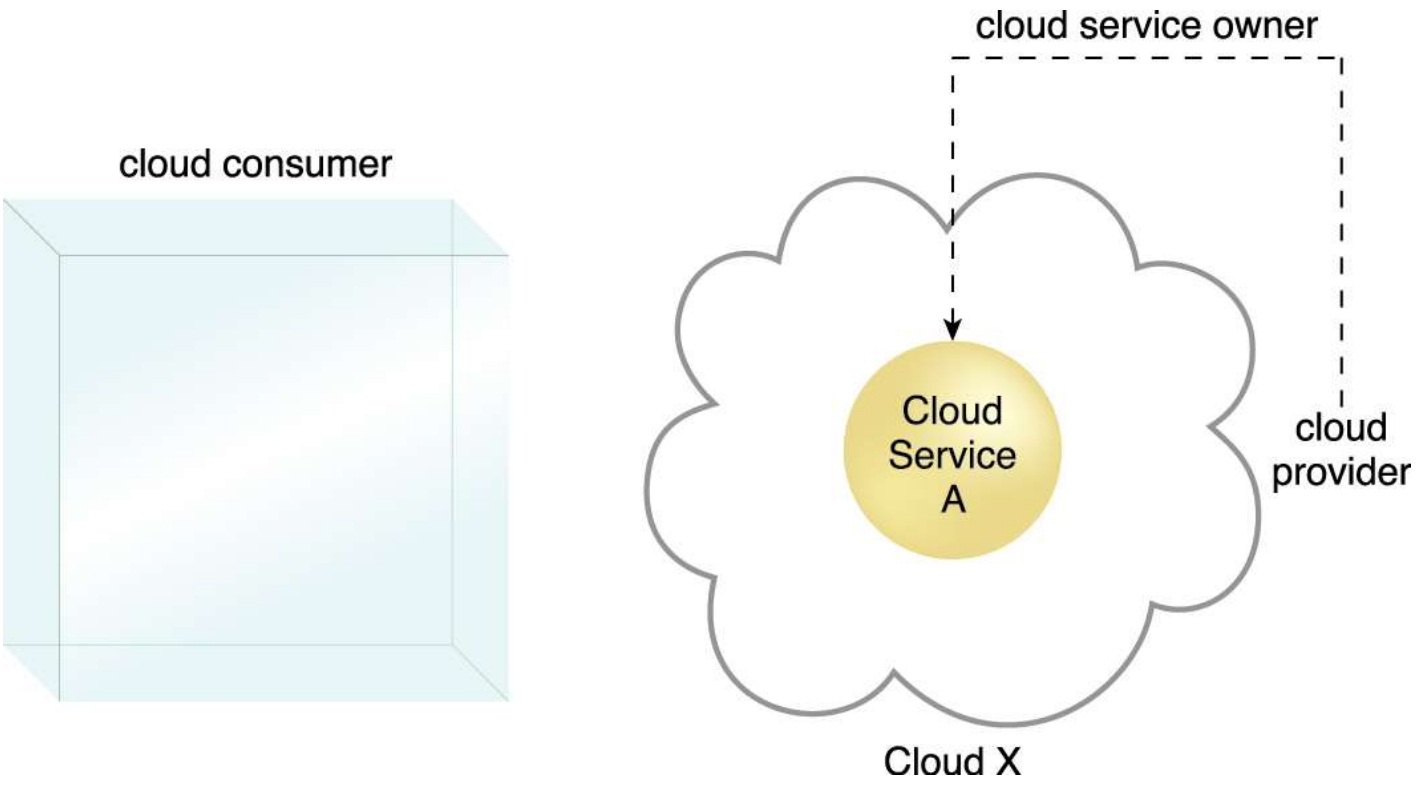
# CLOUD SERVICE OWNER

- The person or organization that legally owns a cloud service is called a *cloud service owner*.




A cloud consumer can be a cloud service owner when it deploys its own service in a cloud.

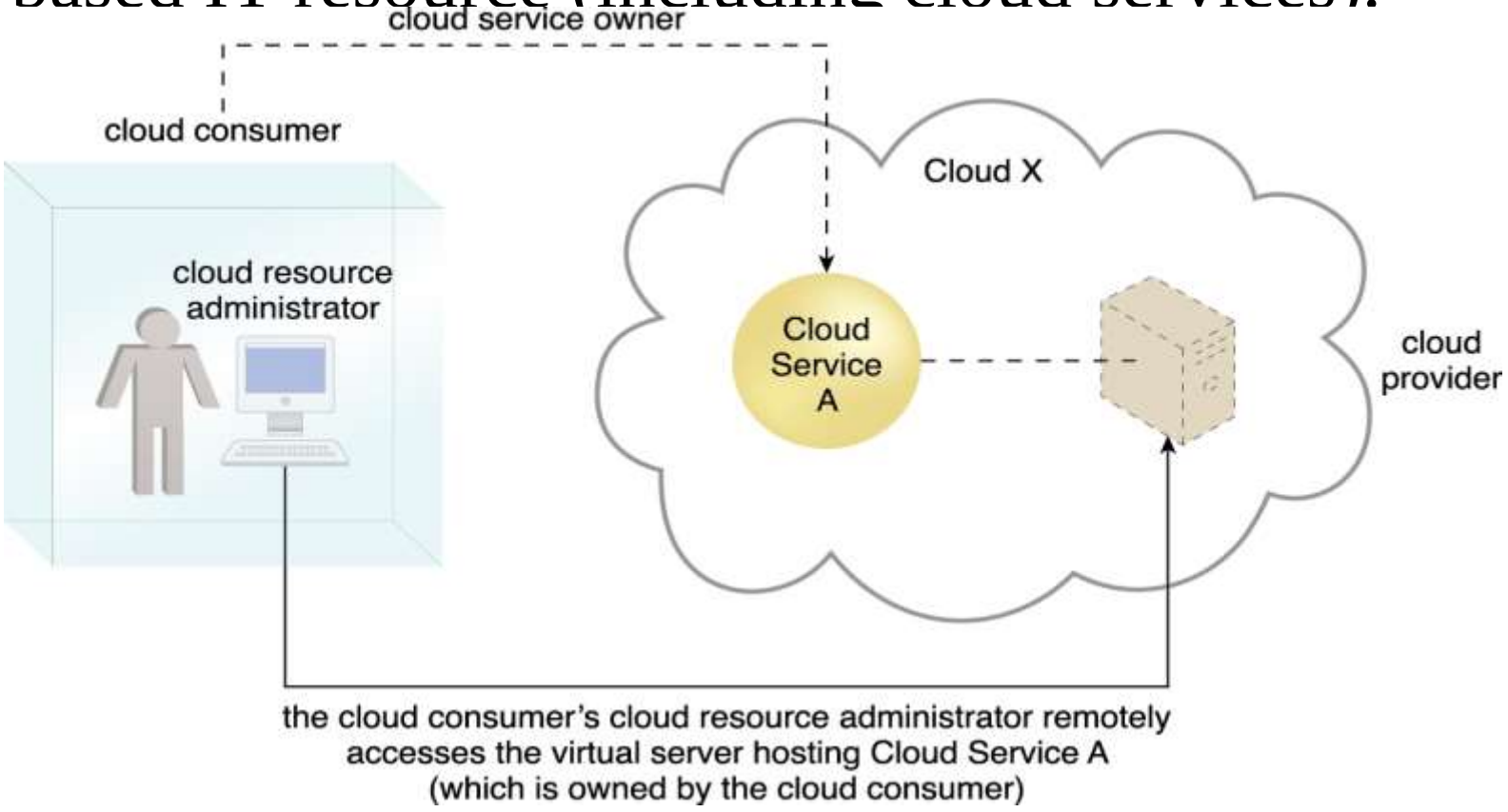
# CLOUD SERVICE OWNER (CONT..)




A cloud provider becomes a cloud service owner if it deploys its own cloud service, typically for other cloud consumers to use.

# CLOUD RESOURCE ADMINISTRATOR

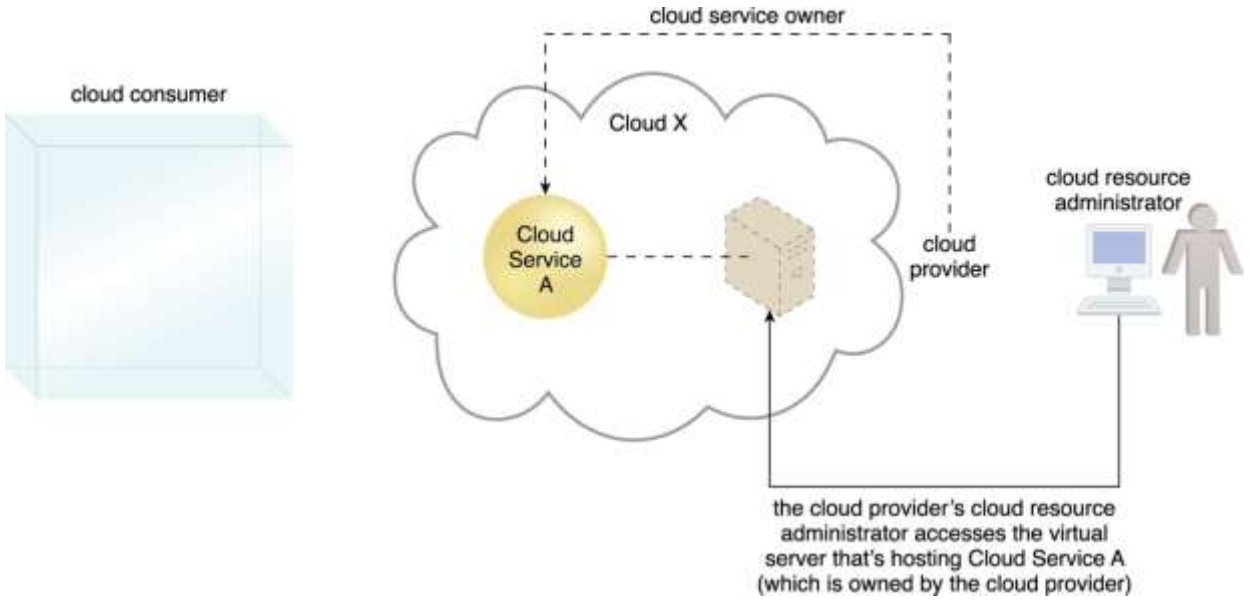
- A *cloud resource administrator* is the person or organization responsible for administering a cloud-based IT resource (including cloud services).




A cloud resource administrator can be with a cloud consumer organization and administer remotely accessible IT resources that belong to the cloud consumer.

# CLOUD RESOURCE ADMINISTRATOR

- Cloud resource administrator can be (or belong to) the cloud consumer or cloud provider of the cloud within which the cloud service resides.

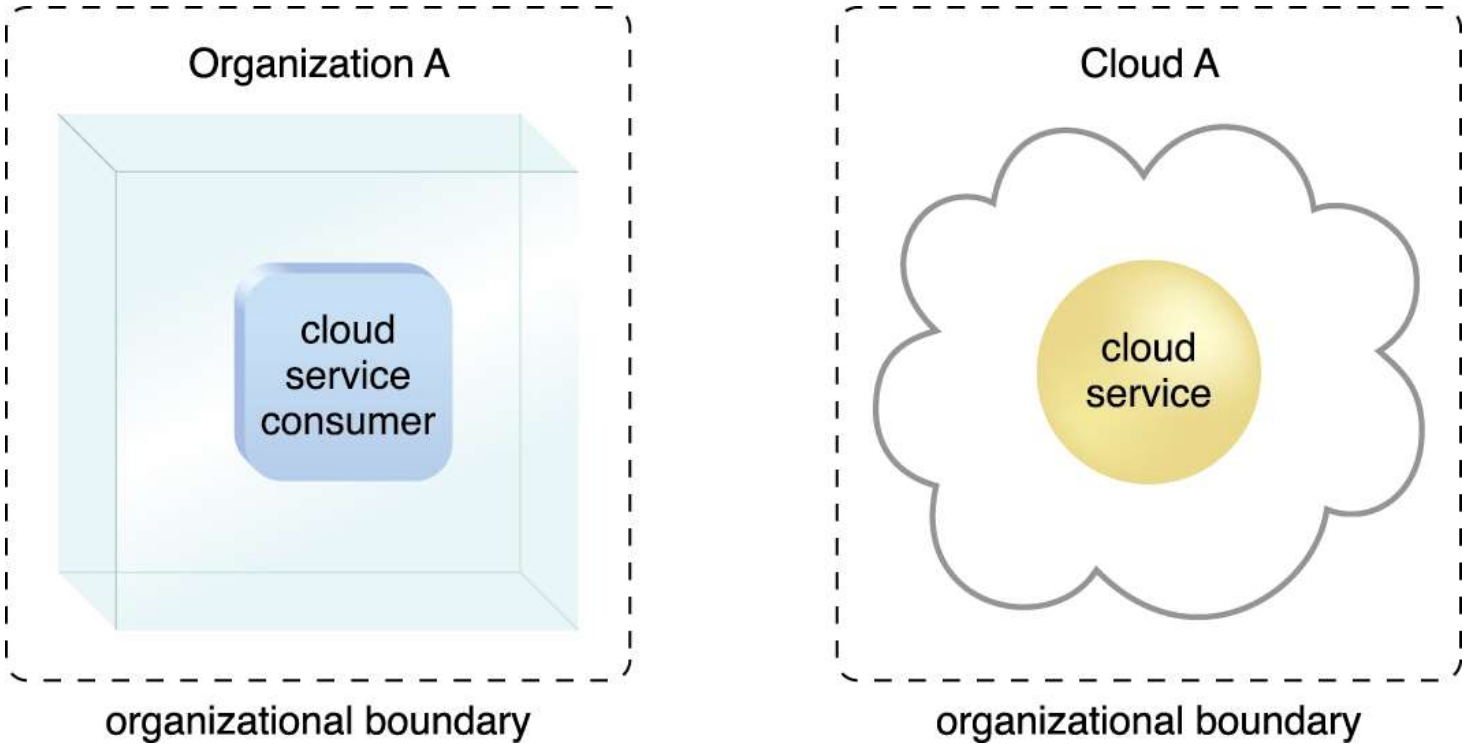



A cloud resource administrator can be with a cloud provider organization for which it can administer the cloud provider's internally and externally available IT resources.

Supplementary roles of administrator: cloud auditor, cloud broker,
cloud carrier (network & telecommunication provider - wire level connectivity)

# ORGANIZATIONAL BOUNDARY

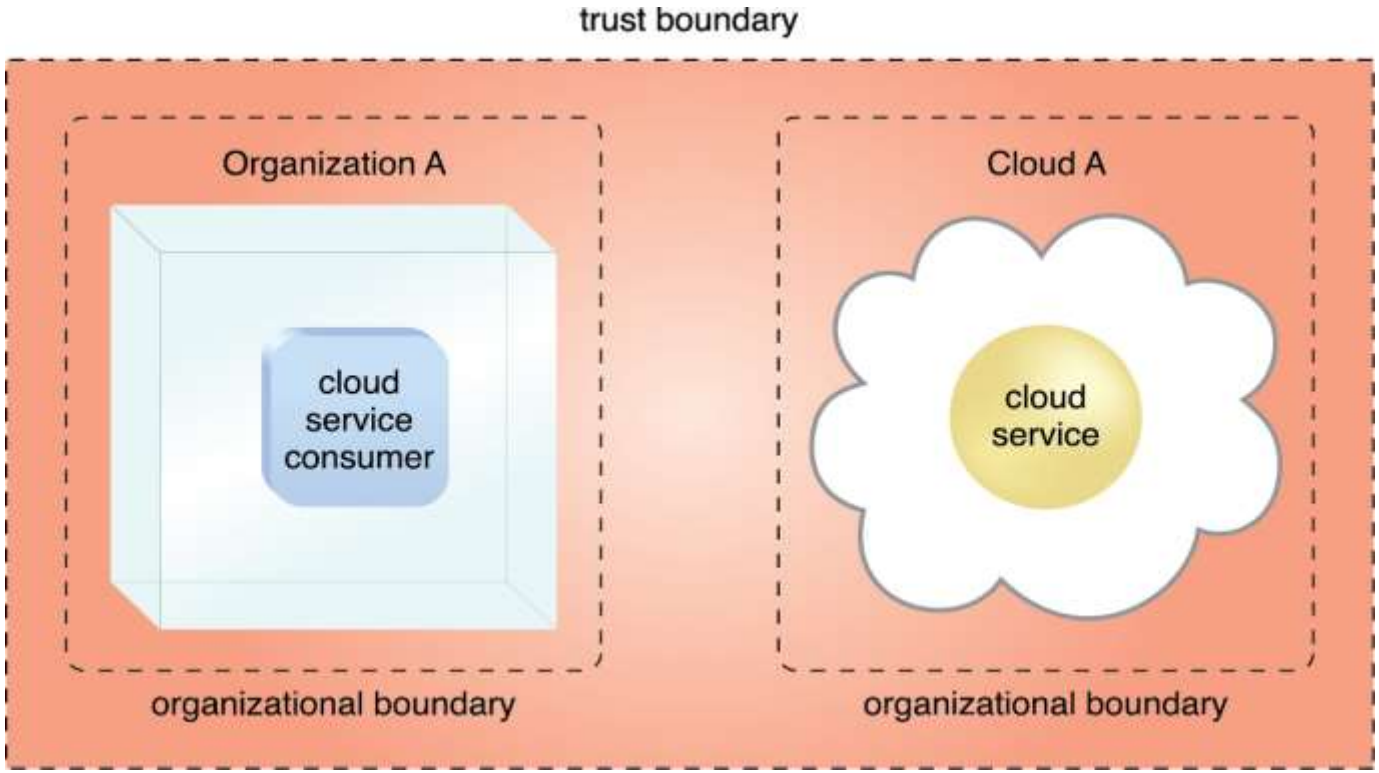
- An *organizational boundary* represents the physical perimeter that surrounds a set of IT resources that are owned and governed by an organization.
- Does not represent boundary of actual organization, represents organization set of IT assets and IT resource




Organizational boundaries of a cloud consumer (left), and a cloud provider (right), represented by a broken line notation.

# TRUST BOUNDARY

- A *trust boundary* is a logical perimeter that typically spans beyond physical boundaries to represent the extent to which IT resources are trusted




An extended trust boundary encompasses the organizational boundaries of the cloud provider and the cloud consumer.

# CLOUD CHARACTERISTICS

- Six specific characteristics are common to the majority of cloud environments:
  - on-demand usage
  - ubiquitous access
  - multitenancy (and resource pooling)
  - elasticity
  - measured usage
  - Resiliency (NIST defines only 5, resiliency is excluded)

## On-Demand Usage

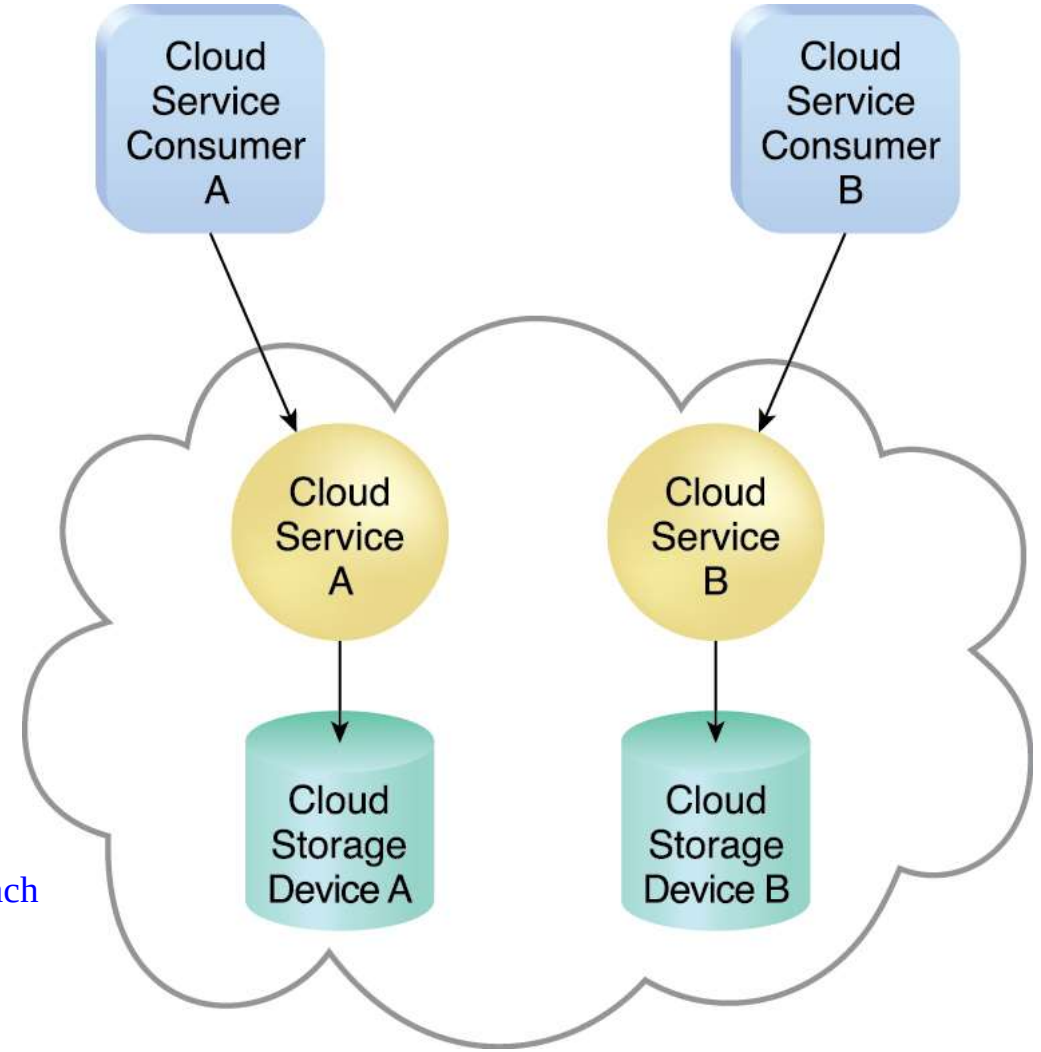
- A cloud consumer can unilaterally access cloud-based IT resources giving the cloud consumer the freedom to self-provision these IT resources or *on-demand self service usage*. *Requires no further human involvement by cloud consumer and cloud provider.*

## Ubiquitous Access

- *Ubiquitous access* represents the ability for a cloud service to be widely accessible.
- Establishing ubiquitous access for a cloud service can require support for a range of devices, transport protocols, interfaces, and security technologies.

# Multitenancy ( and resource pooling)

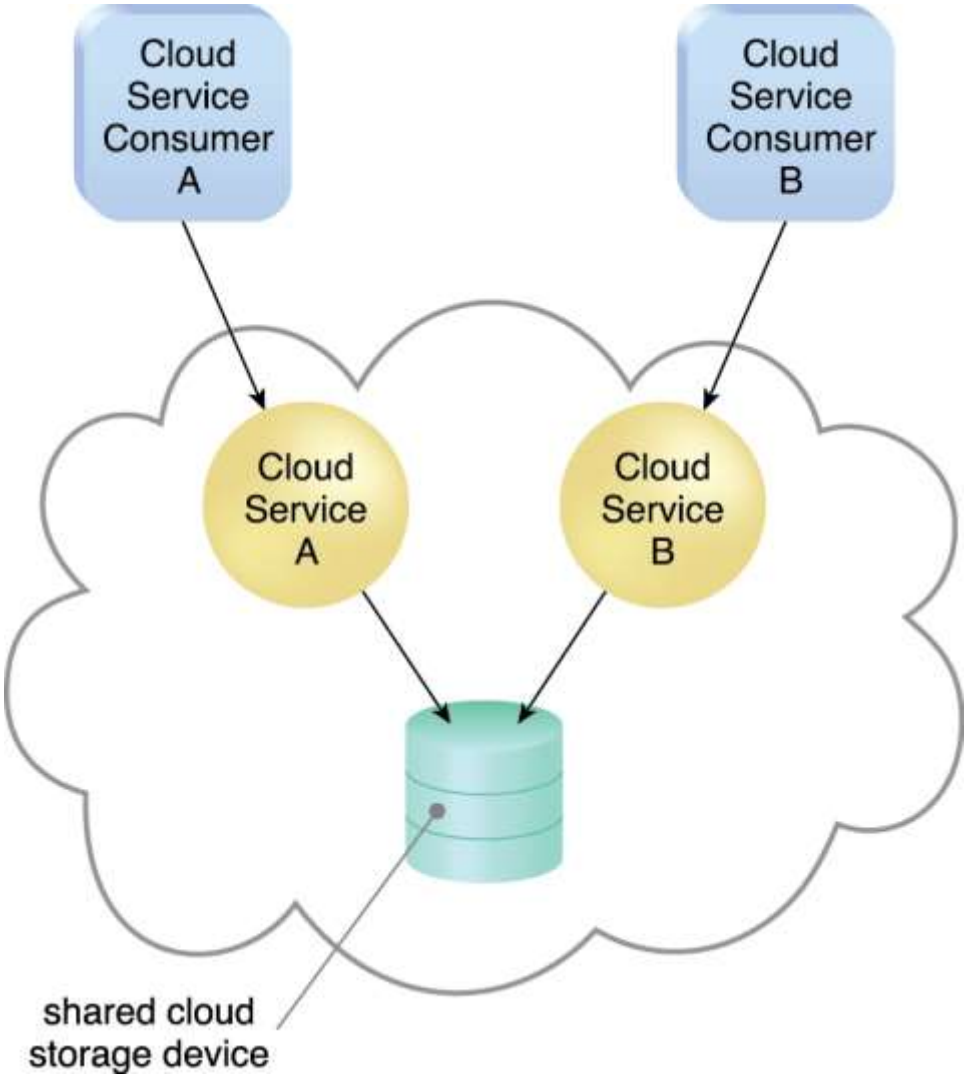
- Characteristic of a software program that enables an instance of the program to serve different consumers (tenants) whereby each is isolated from the other, is referred to as *multitenancy*.




In a single-tenant environment, each cloud consumer has a separate IT resource instance.

# **Multitenancy** (cont..)

- Multitenancy allows several cloud consumers to use the same IT resource or its instance while each remains unaware that it may be used by others.




In a multitenant environment, a single instance of an IT resource, such as a cloud storage device, serves multiple consumers.

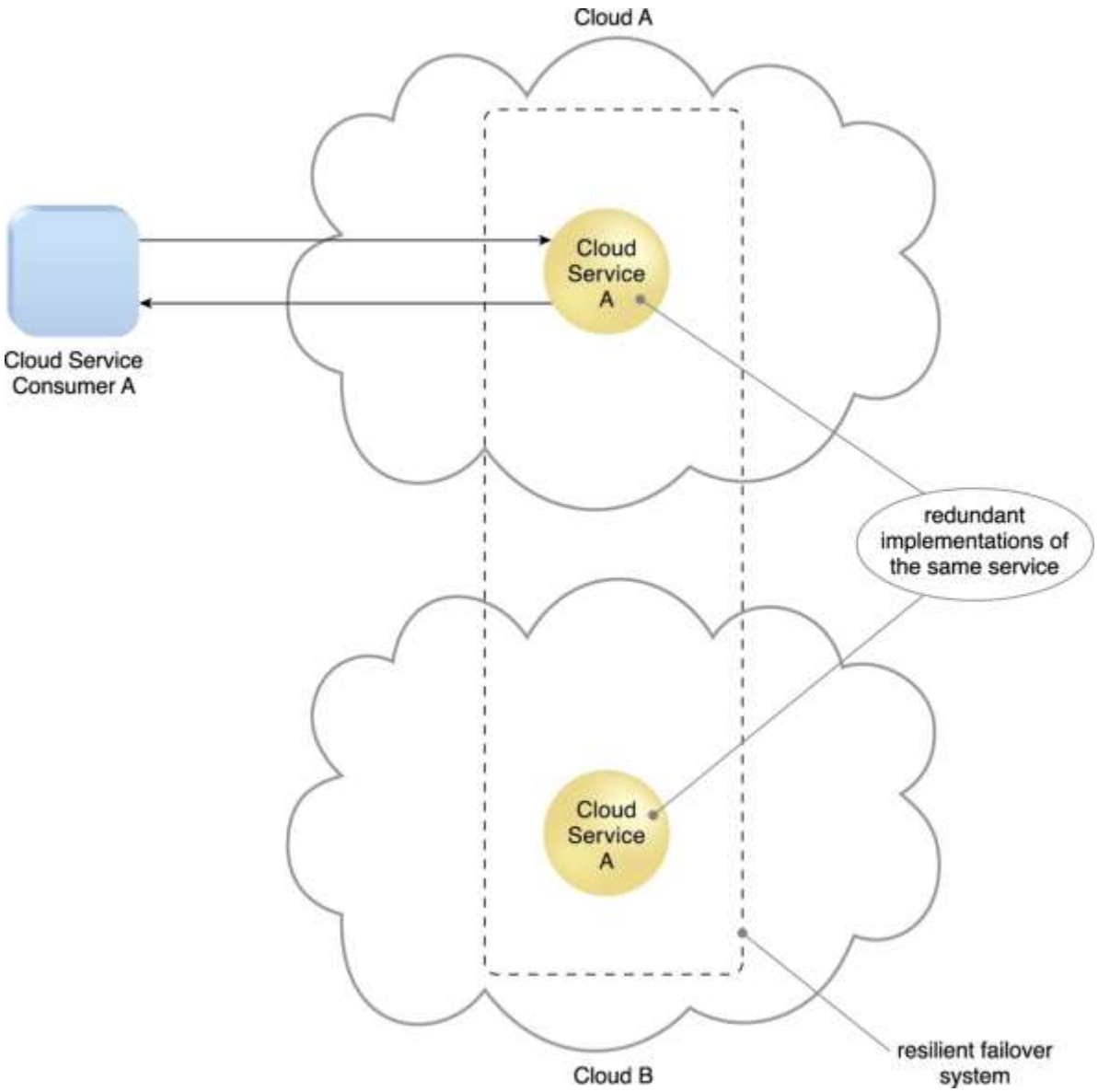
# Elasticity

- *Elasticity* is the automated ability of a cloud to transparently scale IT resources, as required in response to runtime conditions or as pre-determined by the cloud consumer or cloud provider.
- Elasticity is often considered a core justification for the adoption of cloud computing.

# Measured Usage

- *measured usage* characteristic represents the ability of a cloud platform to keep track of the usage of its IT resources, primarily by cloud consumers.
- Can charge a cloud consumer only for the IT resources actually used and/or for the timeframe during which access to the IT resources was granted.
- is closely related to the on-demand characteristic.
- Measured usage is not limited to tracking statistics for billing purposes. It also encompasses the general monitoring of IT resources and related usage reporting

- *Resilient computing* is a form of failover that distributes redundant implementations of IT resources across physical locations.
- *resiliency* can refer to redundant IT resources within the same cloud (but in different physical locations) or across multiple clouds.




A resilient system in which Cloud B hosts a redundant implementation of Cloud Service A to provide failover in case Cloud Service A on Cloud A becomes unavailable.

# CLOUD DELIVERY MODELS

- A *cloud delivery model* represents a specific, pre-packaged combination of IT resources offered by a cloud provider.
- Three common cloud delivery models have become widely established and formalized:
  - Infrastructure-as-a-Service (IaaS)
  - Platform-as-a-Service (PaaS)
  - Software-as-a-Service (SaaS)

**Note:**

- Many specialized variations of the three base cloud delivery models have emerged, each comprised of a distinct combination of IT resources. Some examples include:
  - Storage-as-a-Service
  - Database-as-a-Service
  - Security-as-a-Service
  - Communication-as-a-Service
  - Integration-as-a-Service
  - Testing-as-a-Service
  - Process-as-a-Service

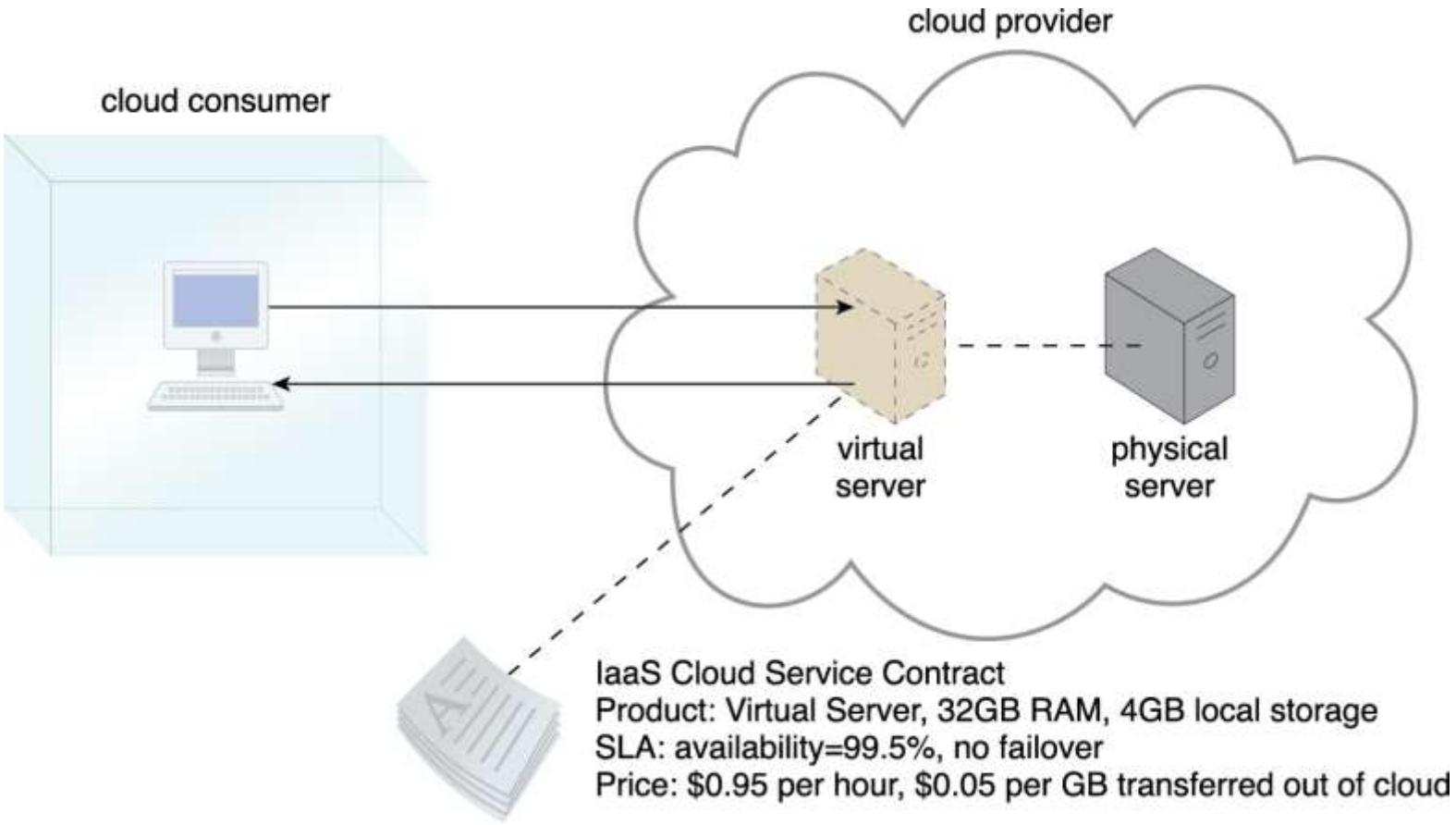
# Infrastructure-as-a-Service (IaaS)

- It acts as a means of delivering on-demand services and computing infrastructure.
- It works very similarly to traditional computer hardware (via operating systems, networks, servers, etc.), but the only difference is that it operates virtually.
- It means that the IT managers don't need to buy physical hardware.
- They can directly purchase the infrastructure in the form of a virtual service from an IaaS provider.
- Whenever a user purchases software, server, cloud space, network equipment, and more, the IaaS provider rents those resources in the form of fully outsourced service (as a demand model).
- IaaS supports dynamic scaling and distributes its resources as a service.
- It thus, generally, allows multiple users on one piece of hardware.
- A few examples of IaaS are Google Computing Engine, AWS (Amazon Web Services), etc.

# Infrastructure-as-a-Service (IaaS)

- IaaS delivery model represents a **self-contained IT environment comprised of infrastructure-centric IT resources** that can be accessed and managed via cloud service-based interfaces and tools.
- Can include hardware, network, connectivity, operating systems, and other "raw" IT resources.
- Are typically virtualized and packaged into bundles that simplify up-front runtime scaling and customization of the infrastructure.
- General purpose of an IaaS environment is to provide cloud consumers with a high level of control and responsibility over its configuration and utilization.
- Used by cloud consumers that require a high level of control over the cloud-based environment they intend to create.
- IaaS environments are generally offered as freshly initialized virtual instances.
- A central and primary IT resource within a typical IaaS environment is the **virtual server.**
- Virtual servers are leased by specifying server hardware requirements, such as processor capacity, memory, and local storage space.

# Infrastructure-as-a-Service (IaaS)



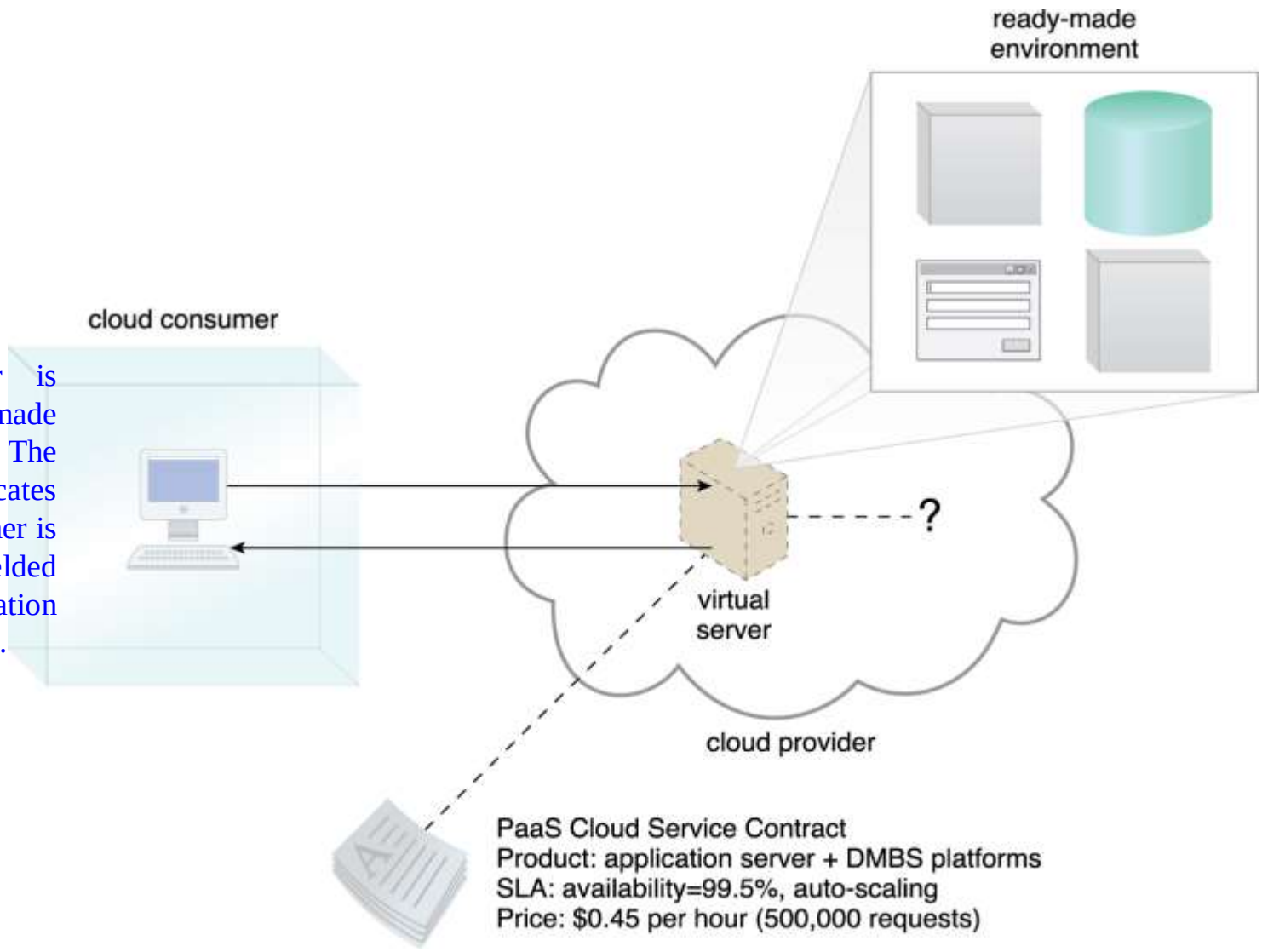

A cloud consumer is using a virtual server within an IaaS environment. Cloud consumers are provided with a range of contractual guarantees by the cloud provider, pertaining to characteristics such as capacity, performance, and availability.

# Platform-as-a-Service (PaaS)

- PaaS delivery model represents a pre-defined "ready-to-use" environment typically comprised of already deployed and configured IT resources.
- Common reasons a cloud consumer would use and invest in a PaaS environment include:
  - The cloud consumer wants to extend on-premise environments into the cloud for scalability and economic purposes.
  - The cloud consumer uses the ready-made environment to entirely substitute an on-premise environment.
  - The cloud consumer wants to become a cloud provider and deploys its own cloud services to be made available to other external cloud consumers.
- By working within a ready-made platform, the cloud consumer is spared the administrative burden of setting up and maintaining the bare infrastructure IT resources provided via the IaaS model.
- The cloud consumer is granted a lower level of control over the underlying IT resources that host and provision the platform.
- Developers and companies can use the framework (that PaaS provides) to easily and quickly customize (and build) apps.
- As a result, the developers can focus on the application software instead while still not paying attention to managing various infrastructure matters (like software updates, operating systems, etc.). So, the IT managers only need to manage the software/application and remove the rest of the clutter.
- *PaaS products are available with different development stacks. For example, Microsoft Azure, Google App Engine offers a Java and Python-based environment.*

# Platform-as-a-Service (PaaS)

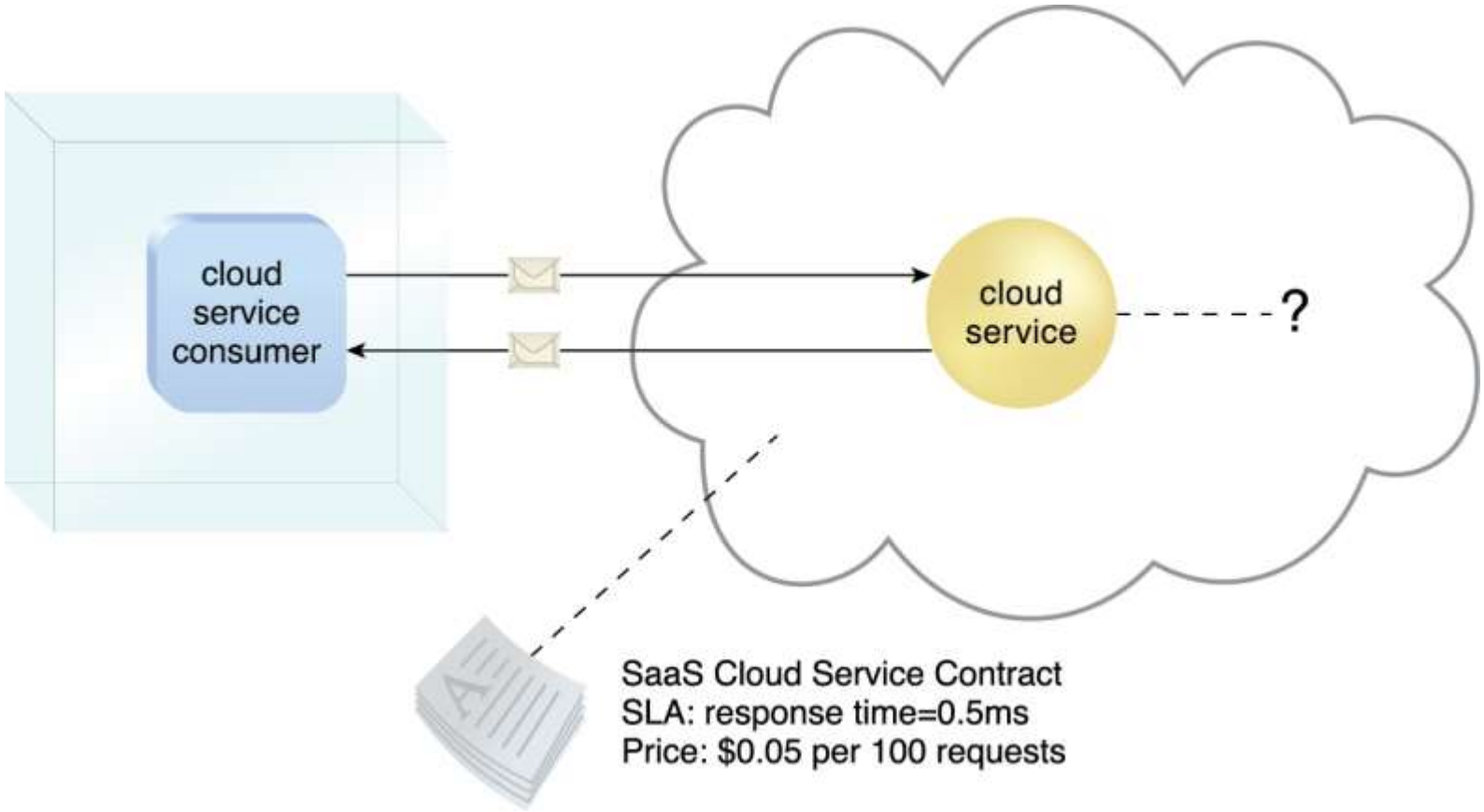
A cloud consumer is accessing a ready-made PaaS environment. The question mark indicates that the cloud consumer is intentionally shielded from the implementation details of the platform.



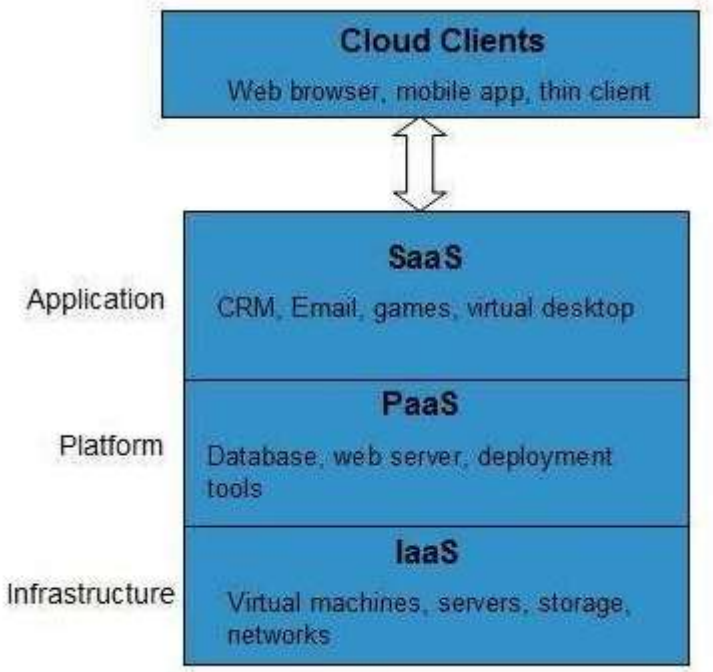
# Software-as-a-Service (SaaS)

- A software program positioned as a shared cloud service and made available as a "product" or generic utility represents the typical profile of a SaaS offering.
- The SaaS delivery model is typically used to make a reusable cloud service widely available (often commercially) to a range of cloud consumers.
- A cloud consumer is generally granted very limited administrative control over a SaaS implementation.
- SaaS provides various software like word processing, email, design software, collaboration software, and other application hosts.
- One can access these SaaS applications directly through web browsers-eliminating the need to install any application on a person's workstation.
- A SaaS vendor manages operating systems, servers, data, applications, storage, and many more.
- Thus, an IT manager only needs to worry about software usage and employee access to it.
- The SaaS hosts its clients' software and the associated data centrally. So, the clients can access them using an online browser via the web.
- A few examples of SaaS services include Google G Suite, Microsoft Office 365, Salesforce, etc.

# Software-as-a-Service (SaaS)




The cloud service consumer is given access the cloud service contract, but not to any underlying IT resources or implementation details.




• In IaaS, providers manage virtualisation, servers, hard drives, storage, and networking.

Example: (AWS) Amazon Web Services, Microsoft Azure.

•PaaS is used for development. With PaaS, one can develop and customize applications.

•PaaS makes it easy to for development, testing, and deployment of applications.

Example: Apparenda

•Software-as-a-service (SaaS) – As it is a service based cloud, the cloud provider delivers a complete software to the client.

• It provides pre-configured hardware resources through a virtual interface. It does not include any Operating System. It allows access to the software only.

Example: Google Apps, Salesforce, Workday.

# COMPARING CLOUD DELIVERY MODELS

| Cloud Delivery Model | Typical Level of Control Granted to Cloud Consumer | Typical Functionality Made Available to Cloud Consumer |
|---|---|---|
| SaaS | usage and usage-related configuration | access to front-end user-interface |
| PaaS | limited administrative | moderate level of administrative control over IT resources relevant to cloud consumer's usage of platform |
| IaaS | full administrative | full access to virtualized infra-structure-related IT resources and, possibly, to underlying physical IT resources |

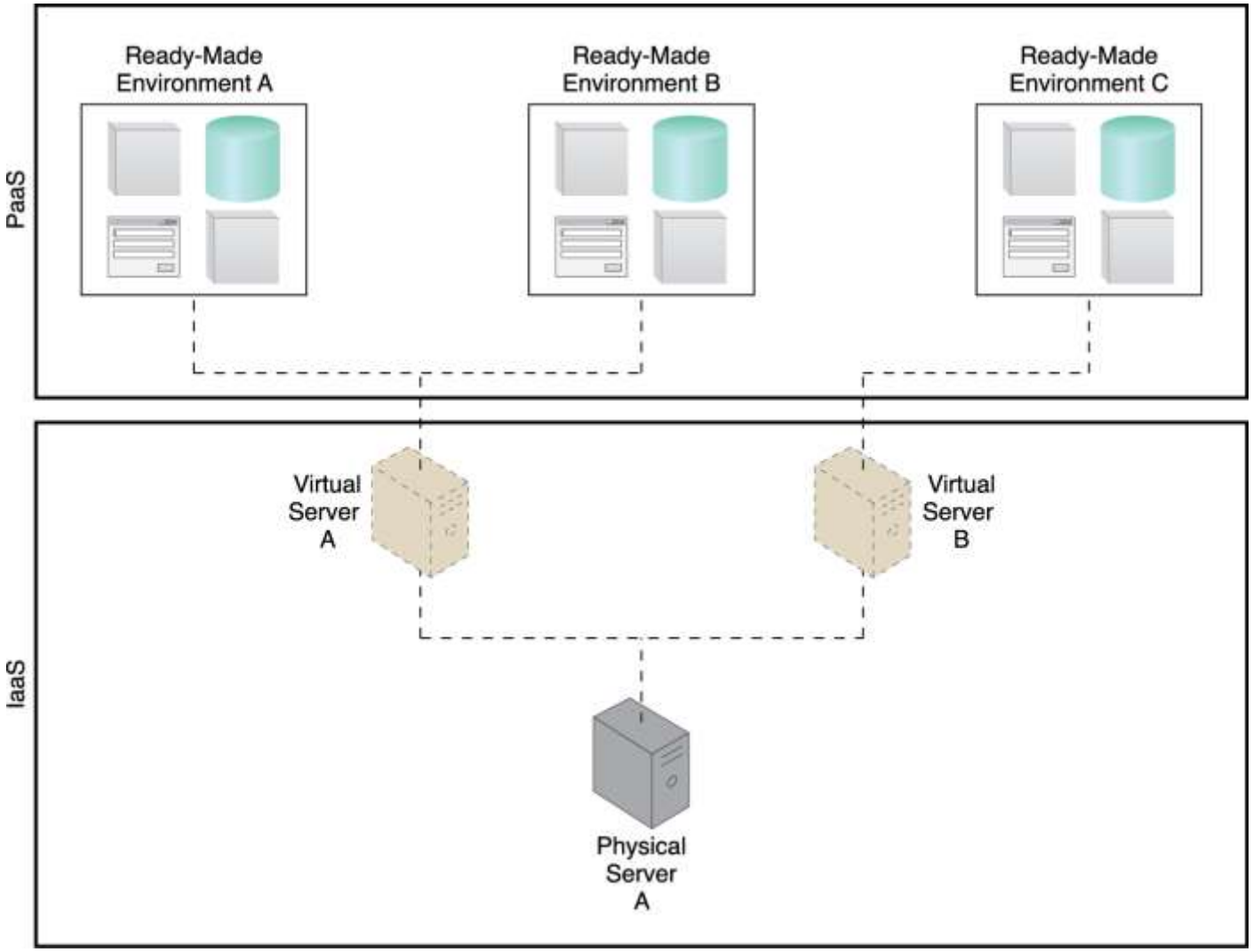
# COMPARING CLOUD DELIVERY MODELS

| Cloud Delivery Model | Common Cloud Consumer Activities | Common Cloud Provider Activities |
|---|---|---|
| SaaS | uses and configures cloud service | implements, manages, and maintains cloud service<br>monitors usage by cloud consumers |
| PaaS | develops, tests, deploys, and manages cloud services and cloud-based solutions | pre-configures platform and provisions underlying infrastructure, middleware, and other needed IT resources, as necessary<br>monitors usage by cloud consumers |
| IaaS | sets up and configures bare infrastructure, and installs, manages, and monitors any needed software | provisions and manages the physical processing, storage, networking, and hosting required<br>monitors usage by cloud consumers |

# COMBINING CLOUD DELIVERY MODELS

## IaaS + PaaS

A PaaS environment based on the IT resources provided by an underlying IaaS environment.

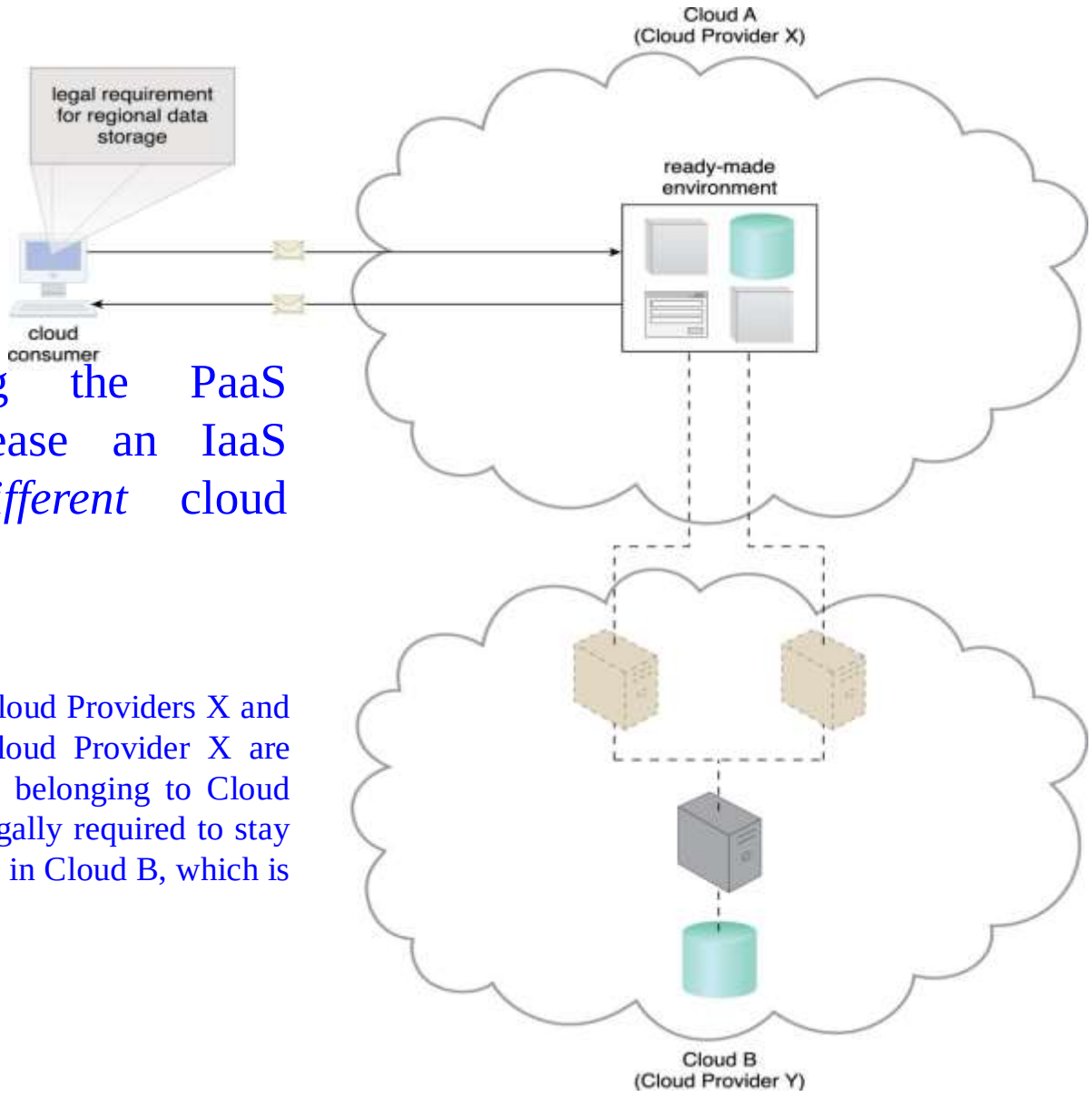


# COMBINING CLOUD DELIVERY MODELS

## IaaS + PaaS

Cloud provider offering the PaaS environment chose to lease an IaaS environment from a *different* cloud provider.

An example of a contract between Cloud Providers X and Y, in which services offered by Cloud Provider X are physically hosted on virtual servers belonging to Cloud Provider Y. Sensitive data that is legally required to stay in a specific region is physically kept in Cloud B, which is physically located in that region.

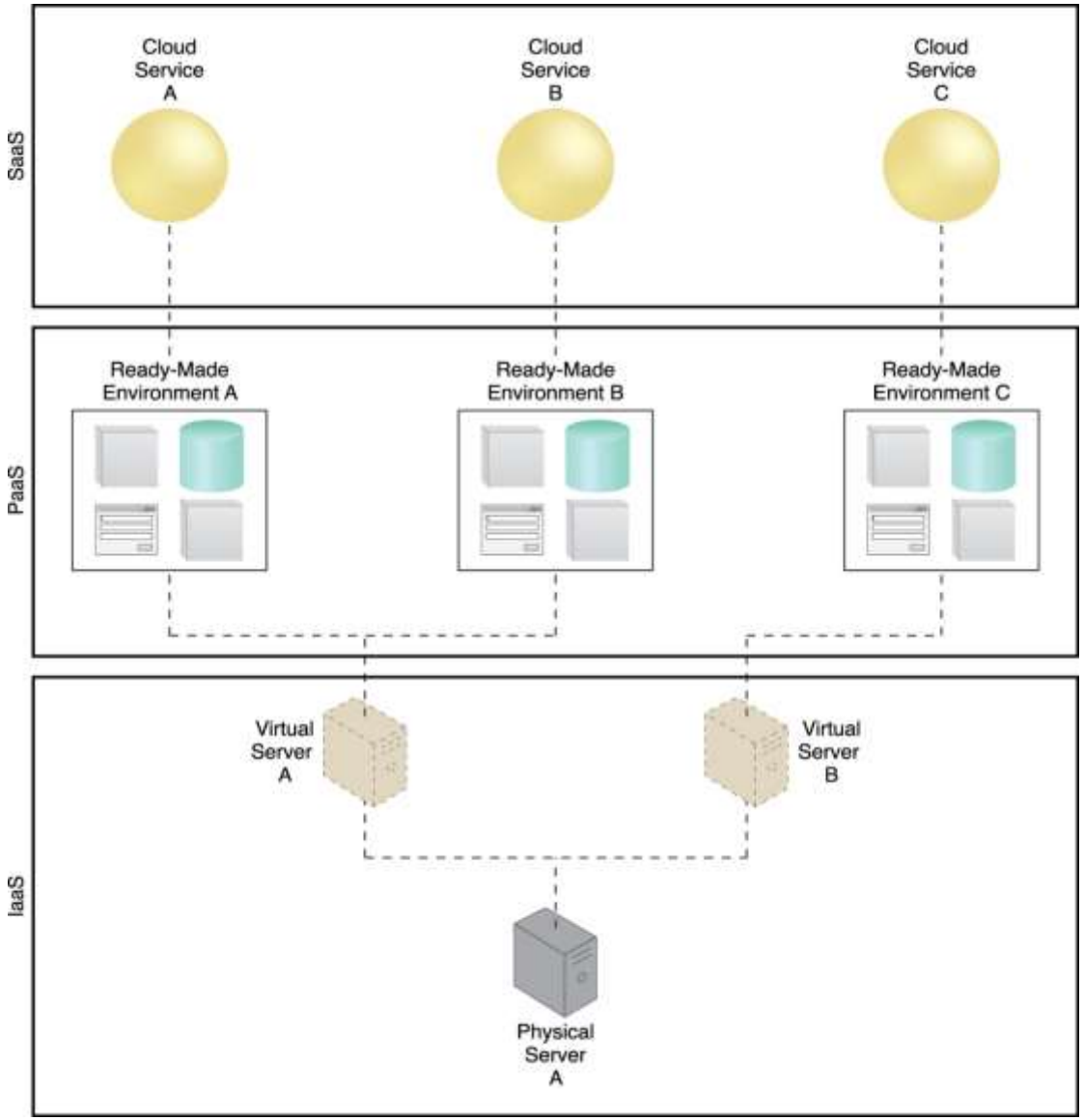


# COMBINING CLOUD DELIVERY MODELS

**IaaSa + PaaS + SaaS**

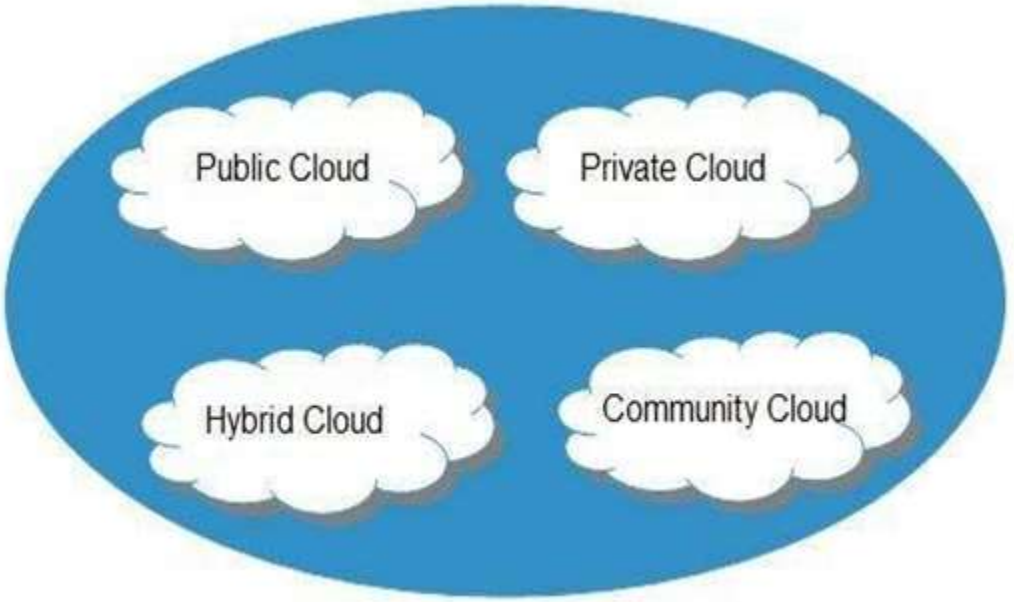
Ready-made environment provided by the PaaS environment can be used by the cloud consumer organization to develop and deploy its own SaaS cloud services that it can then make available as commercial products

A simple layered view of an architecture comprised of IaaS and PaaS environments hosting three SaaS cloud service implementations.



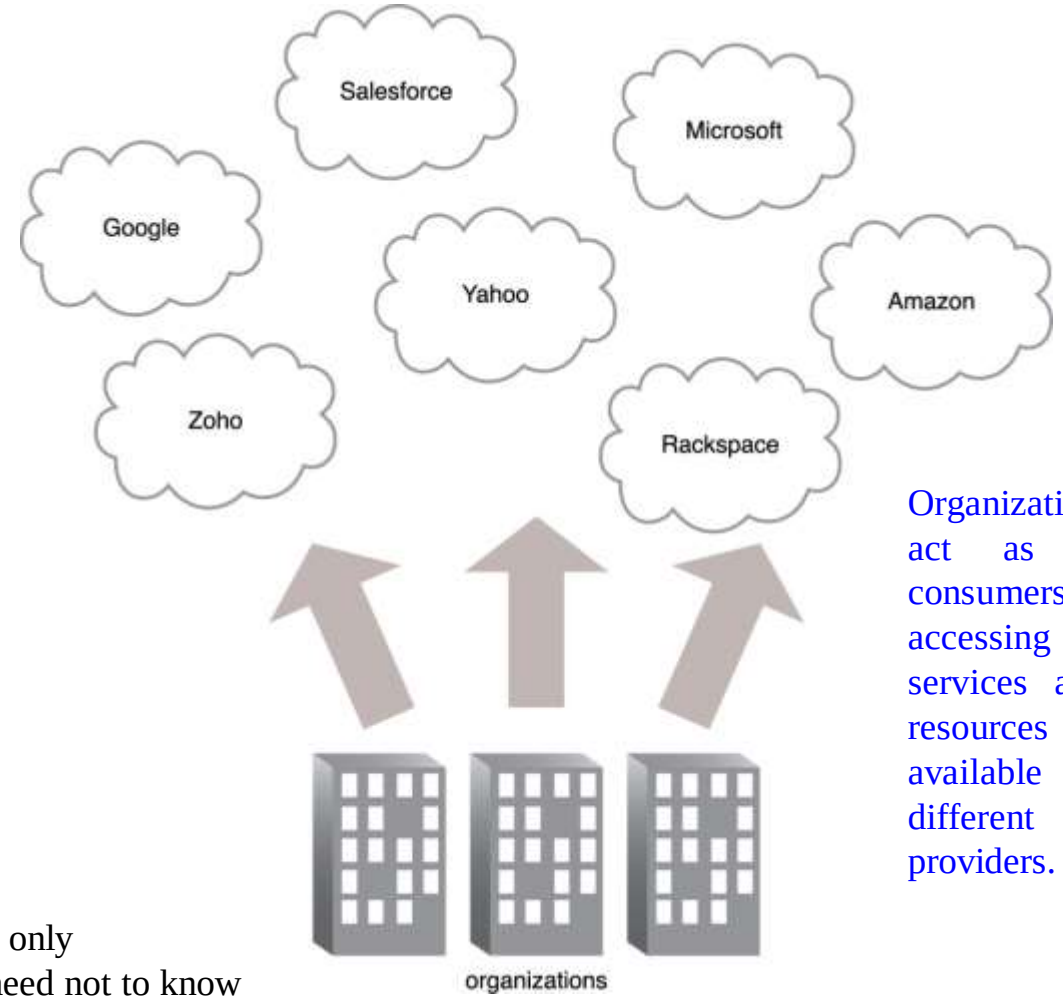
# CLOUD DEPLOYMENT MODELS

- A cloud deployment model represents a specific type of cloud environment, primarily distinguished by ownership, size, and access.
- There are four common cloud deployment models:
  - Public cloud
  - Community cloud
  - Private cloud
  - Hybrid cloud



# PUBLIC CLOUDS – Cloud available in Pay-as-you-go mamnner to general public

- A *public cloud* is a publicly accessible cloud environment owned by a third-party cloud provider. The IT resources on public clouds are usually provisioned via the previously described cloud delivery models and are generally offered to cloud consumers at a cost or are commercialized via other avenues (such as advertisement).
- Public cloud is inexpensive.
- There are no wasted resources because you pay for what you use.




Organizations act as cloud consumers when accessing cloud services and IT resources made available by different cloud providers.

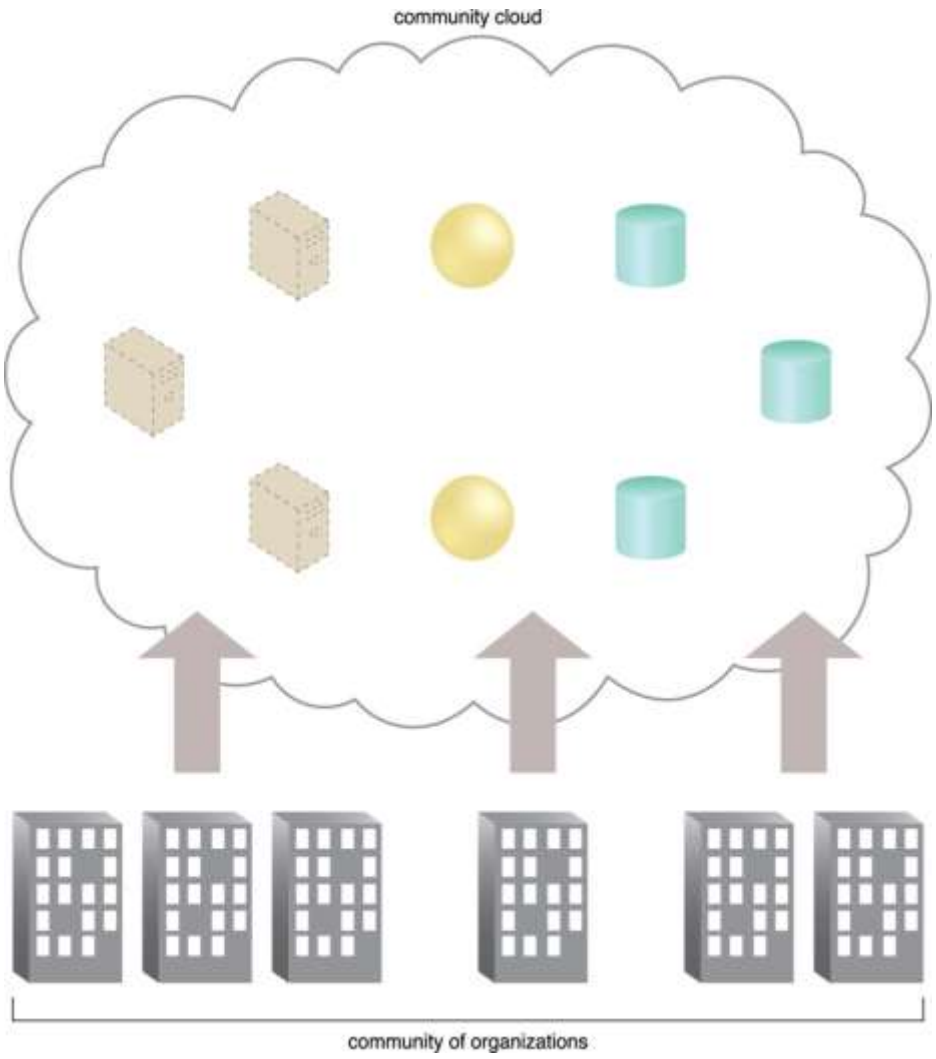
## Example: Email System

Yahoo / Gmail account, user need to have only Computer and internet connection. User need not to know Underlying process. They just using Yahoo / Google cloud All maintaining, testing and developing task are done by Yahoo or Google itself.

# COMMUNITY CLOUDS - **In case of joint venture application, a same cloud infrastructure needs to be constructed and shared by several organizations jointly. They may have use the same framework as well as policies, services, requirements, applications, and concerns.**

- A community cloud is similar to a public cloud except that its access is limited to a specific community of cloud consumers.
- In the Community cloud, the resources are shared between several organizations.
- It allows several companies to work together on the same platform, where they can share their resources.

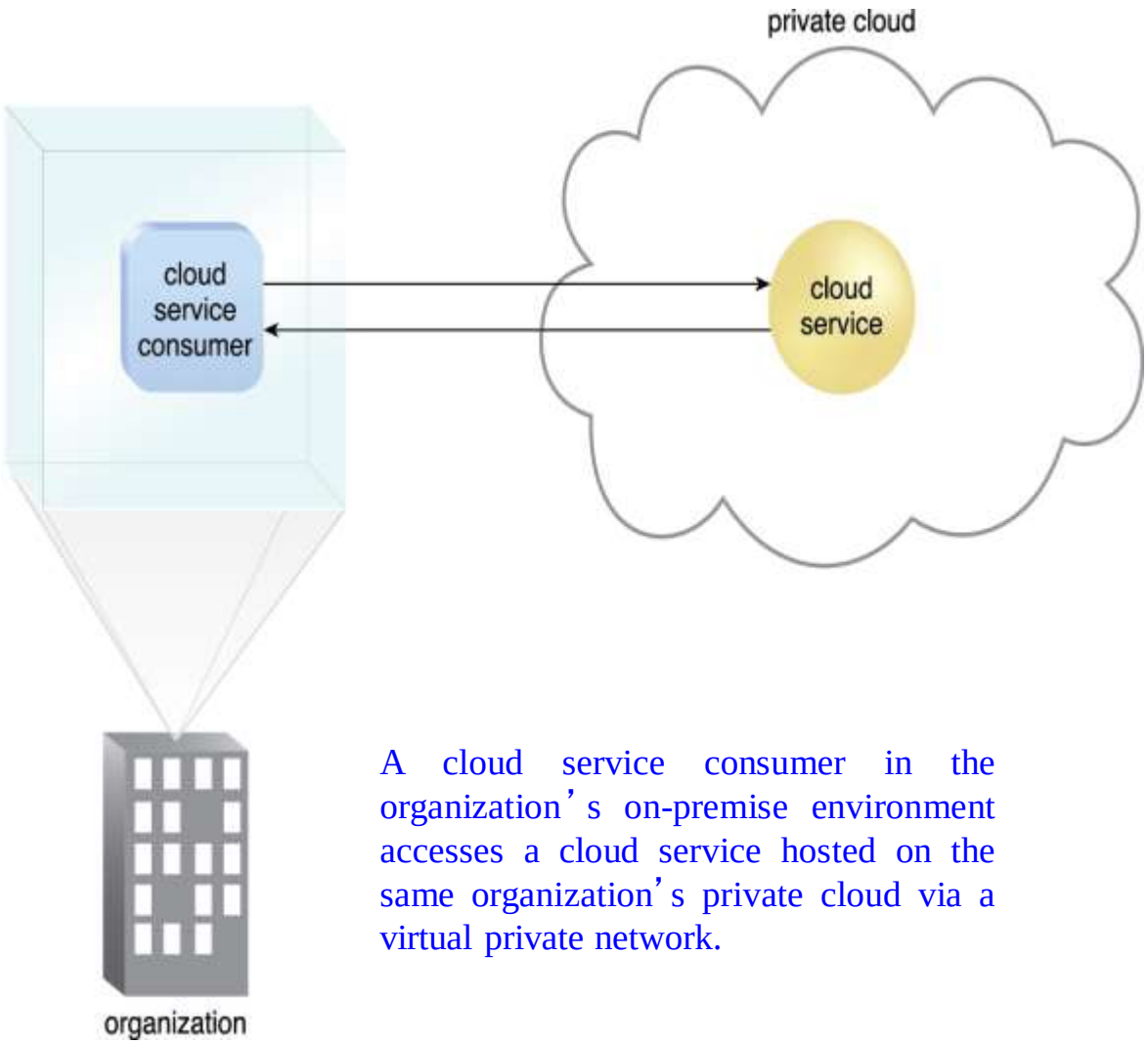
An example of a "community" of organizations accessing IT resources from a community cloud.



# PRIVATE CLOUDS – When a client wants to secure its own data but still need to gain cloud infrastructure

- A private cloud is owned by a single organization.
- Private clouds enable an organization to use cloud computing technology as a means of centralizing access to IT resources by different parts, locations, or departments of the organization.
- Private cloud is the best for business with dynamic or unpredictable computing needs
- Provides high data security and Privacy
- Generally more expensive compared to public cloud
- Othernames internal or corporate cloud

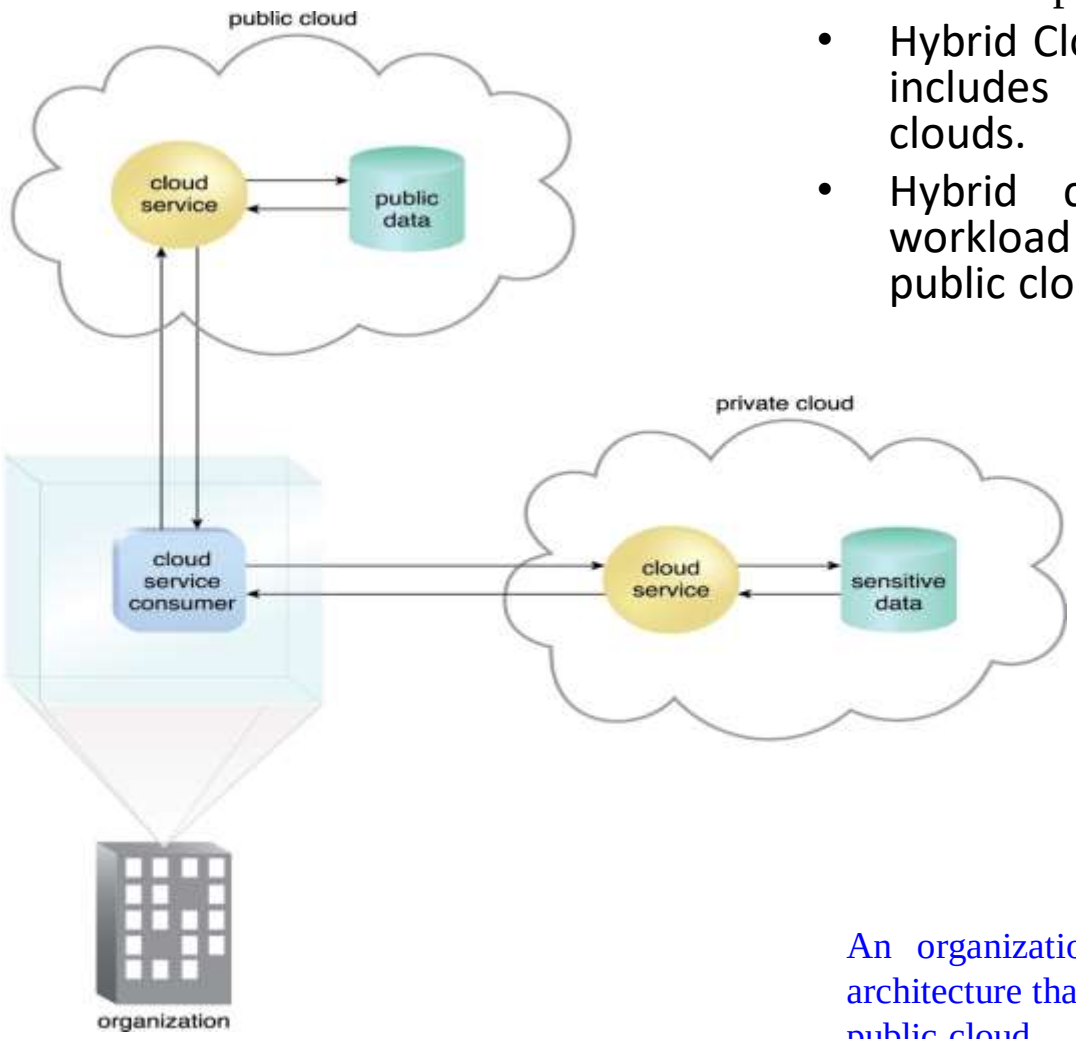
Cloud Providers: AWS, Google, Azure, Dell, IBM




A cloud service consumer in the organization's on-premise environment accesses a cloud service hosted on the same organization's private cloud via a virtual private network.

# HYBRID CLOUDS

- A hybrid cloud is a cloud environment comprised of two or more different cloud deployment models.
- Hybrid Cloud is a cloud service which includes both private and public clouds.
- Hybrid cloud is best for heavy workload because it combines both public cloud and private cloud.




An organization using a hybrid cloud architecture that utilizes both a private and public cloud.

# OTHER CLOUD DEPLOYMENT MODELS

- Additional variations of the four base cloud deployment models can exist. Examples include:
  - *Virtual Private Cloud* – Also known as a "dedicated cloud" or "hosted cloud," this model results in a self-contained cloud environment hosted and managed by a public cloud provider, and made available to a cloud consumer.
  - A virtual private cloud (VPC) is a secure, isolated private cloud hosted within a public cloud. VPC customers can run code, store data, host websites, and do anything else they could do in an ordinary private cloud
  - *Inter-Cloud* – This model is based on an architecture comprised of two or more inter-connected clouds.