Cloud Computing (16BT61201)

Unit II: Fundamental Cloud Computing and Models

NOTICE: Slides are extracted from **"*Cloud Computing: Concepts, Technology & Architecture*"** *by Thomas Erl; Ricardo Puttini; Zaigham Mahmood & Other* ***Internet*** *resources.*

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- **Understanding Cloud Computing:**
  - Origins & Influences
  - Basic Concepts & Terminology
  - Goals & Benefits
  - Risks & Challenges
- **Fundamental Concepts and Models:**
  - Roles and Boundaries
  - Cloud Characteristics
  - Cloud Delivery Models
  - Cloud Deployment Models

Part – I

- **Understanding Cloud Computing:**
  - Origins & Influences
  - Basic Concepts & Terminology
  - Goals & Benefits
  - Risks & Challenges

Origins and Influences

Internet based Computer Utilities in Mid 90s:

- Email Services
- Search Engines
- Open Publishing Platforms (Now called as Social Media)

Late 90s:

Salesforce.com introduced remotely provisioned service in to **Enterprise**.

In 2002:

Amazon launched AWS – a suite of enterprise oriented services which are remotely provided such as Storage, Computing resources, Business Functionality.

-- ***Barners & Noble*** – The real player in Book Stores Business

In 2006:

- Cloud Computing emerged, with the launch of Elastic Compute Cloud (EC^2), enabling organizations to "lease" computing capacity and run processing power.
- Google began browser based enterprise applications by then.

Definitions

Gartner's Definition:

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

Definition from Forrester Research:

"*A standardized IT capability (Services, Software, or Infrastructure) delivered via Internet Technologies in a Pay-per-use, self-service way.*"

National Institute of Standards & Technology (NIST)'s Definition:

"*Cloud Computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction..*"

This cloud model is composed of **Five** essentials characteristics, **Three** service models and **Four** deployment models

Our Text Book's Definition:

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

Business Drivers

1. Capacity Planning

Lead Strategy: Adding capacity to an IT resource in anticipation 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.

2. Cost Reduction

Technical Personnel.

Upgrades & Patches for Software.

Capital expenses for power & cooling.

Administrative and Accounts staff.

3. Organizational Agility

4. Technology Innovations

5. Clustering

6. Grid Computing

7. Technology Innovations Vs Enabling Technologies

Concepts & Terminology

❑ Cloud

A Cloud refers to a distinct IT environment that is designed for the purpose of remotely provisioning scalable and measured IT resources, with a **finite boundary**.

❑ IT Resource

An IT Resource is a physical or virtual IT related artifact ; either Software based, or Hardware based.

❑ On-Premise

An IT resource that is hosted in a conventional IT enterprise with in an organizational boundary (which is not on cloud based) is considered to be located on the premises of the IT enterprise.

- An on-premise IT resource can access and interact with a cloud based IT resource.
- An on-premise IT resource can be moved to a cloud, changing it to cloud-based IT resource.
- Redundant deployments of an IT resource can exist in both on=premise and cloud environments.

❑ Cloud Consumers

❑ Cloud Providers

Concepts & Terminology

❑ Scaling

An ability of the IT resource to handle increase or decrease based on usage demands.

1. **Horizontal Scaling:** Scaling **Out** and **In**
2. **Vertical Scaling:** Scaling **Up** and **Down**

Horizontal Scaling	Vertical Scaling
Less Expensive	More Expensive
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

❑ Cloud Service

A Cloud Service is any IT resource that is made remotely accessible via cloud.

❑ Cloud Service Consumer

A Cloud Service consumer is a temporary runtime role assumed by a Software program when it is accesses a cloud service.

Goals and Benefits

- **Reduced Investments and Proportional Costs**

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

- **Increased Scalability**

- **Increased Availability and Reliability**

Risks and Challenges

- **Increased Security Vulnerabilities**

- **Reduced Operational Governance Control**

1. An Unreliable cloud provider may not maintain the guarantees it makes in the SLAs that were published for its cloud services.
2. Longer geographic distances between the cloud consumer and cloud provider can require additional network hops that introduce fluctuating latency and potential bandwidth constraints.

- **Limited Portability between Cloud Providers**

- **Multi-Regional Compliance and Legal Issues**

Part – II

❖ **Fundamental Concepts and Models:**

- Roles and Boundaries
- Cloud Characteristics
- Cloud Delivery Models
- Cloud Deployment Models

Roles and Boundaries

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

Cloud Provider

- The organization that provides cloud-based IT resources is the *Cloud Provider*.
- 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*.

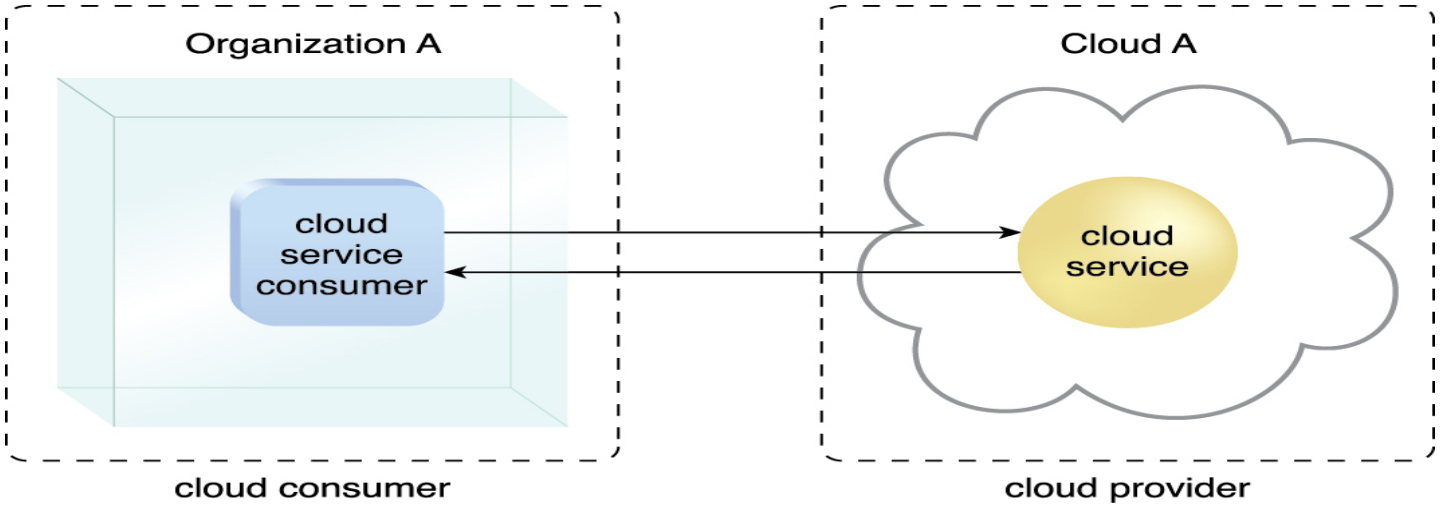

Figure 4.1 A cloud consumer (Organization A) interacts with a cloud service from a cloud provider (that owns Cloud A). Within Organization A, the cloud service consumer is being used to access the cloud service.

Cloud Service Owner

- The person or organization that legally owns a cloud service is called a *Cloud Service Owner*.

Case: 1

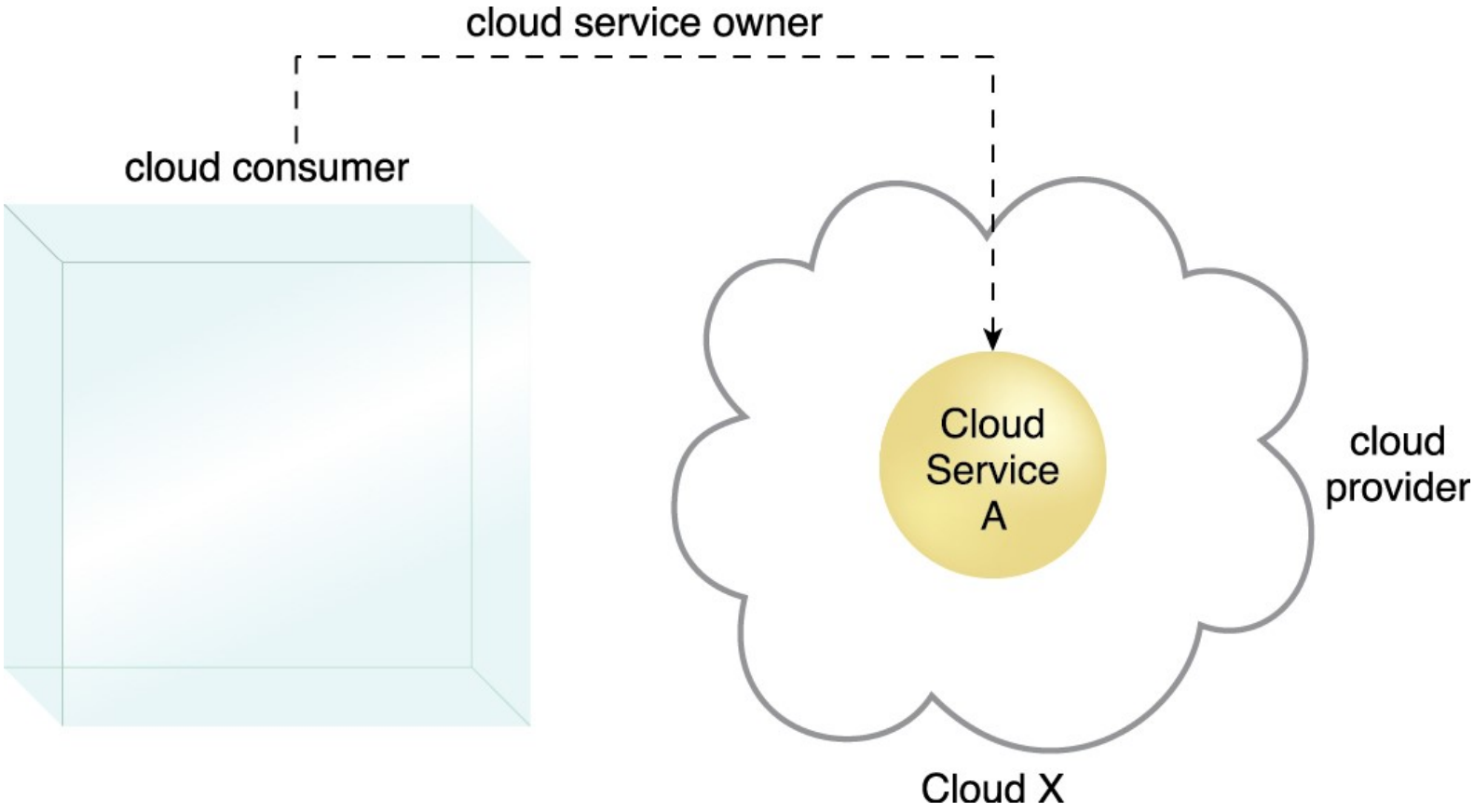

Figure 4.2 A cloud consumer can be a cloud service owner when it deploys **its own service in a cloud.**

Cloud Service Owner

Case: 2

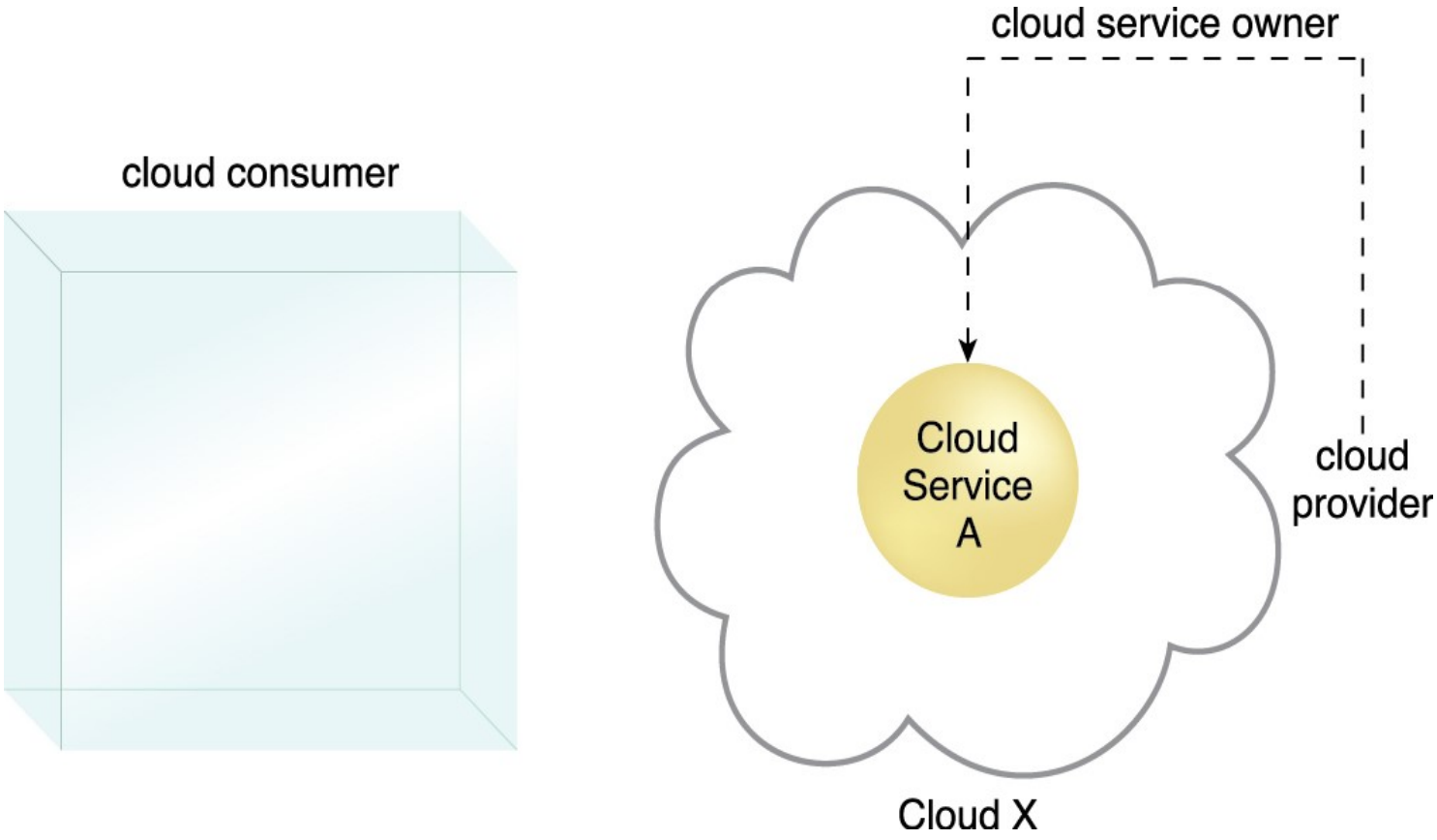

Figure 4.3 A cloud provider becomes a cloud service owner if it deploys **its own cloud service, typically for other cloud consumers to use.**

Cloud Resource Administrator

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

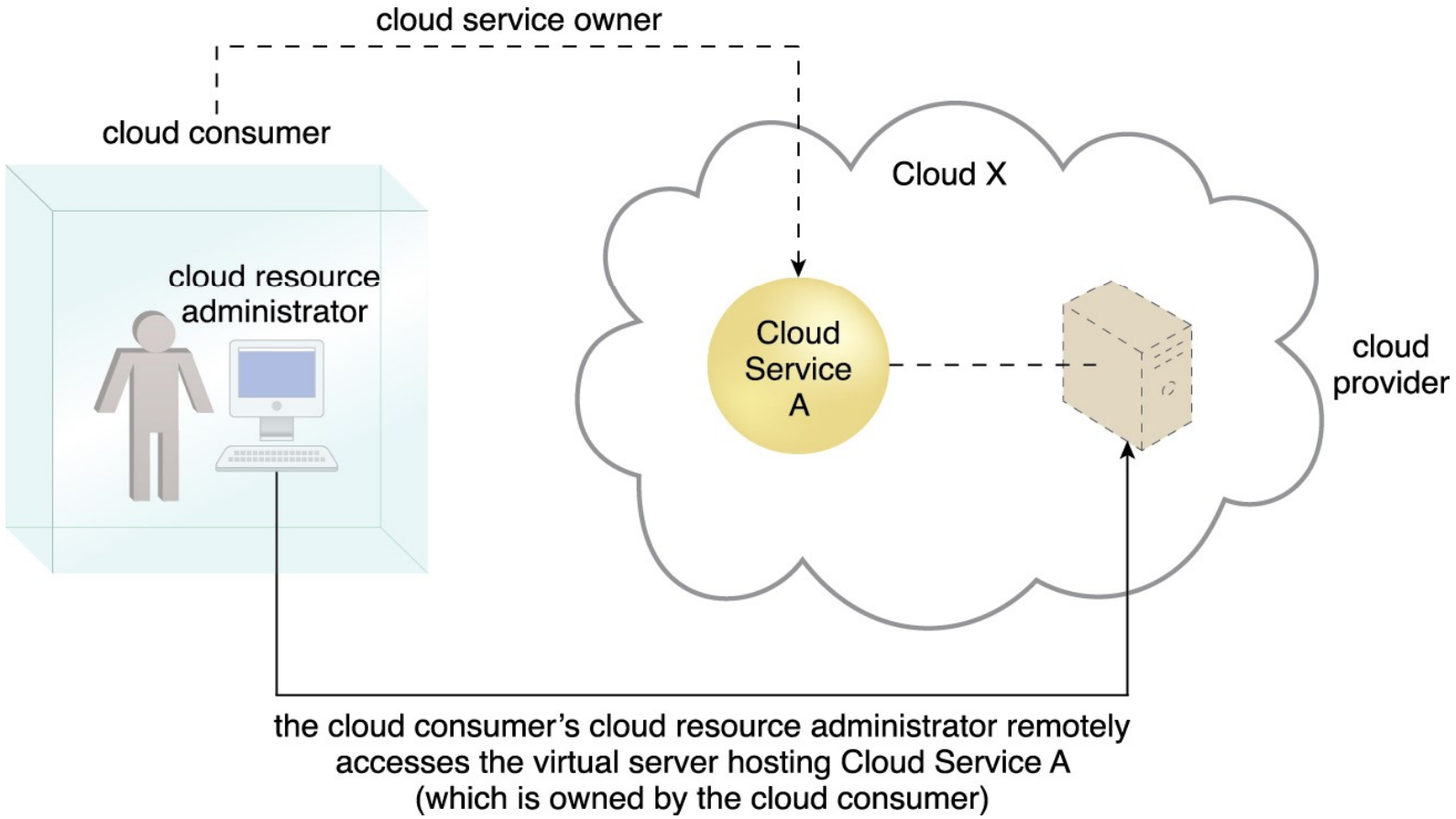

Figure 4.4 A cloud resource administrator can be with a cloud consumer organization and administer remotely accessible IT resources that belong to the cloud consumer.

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.

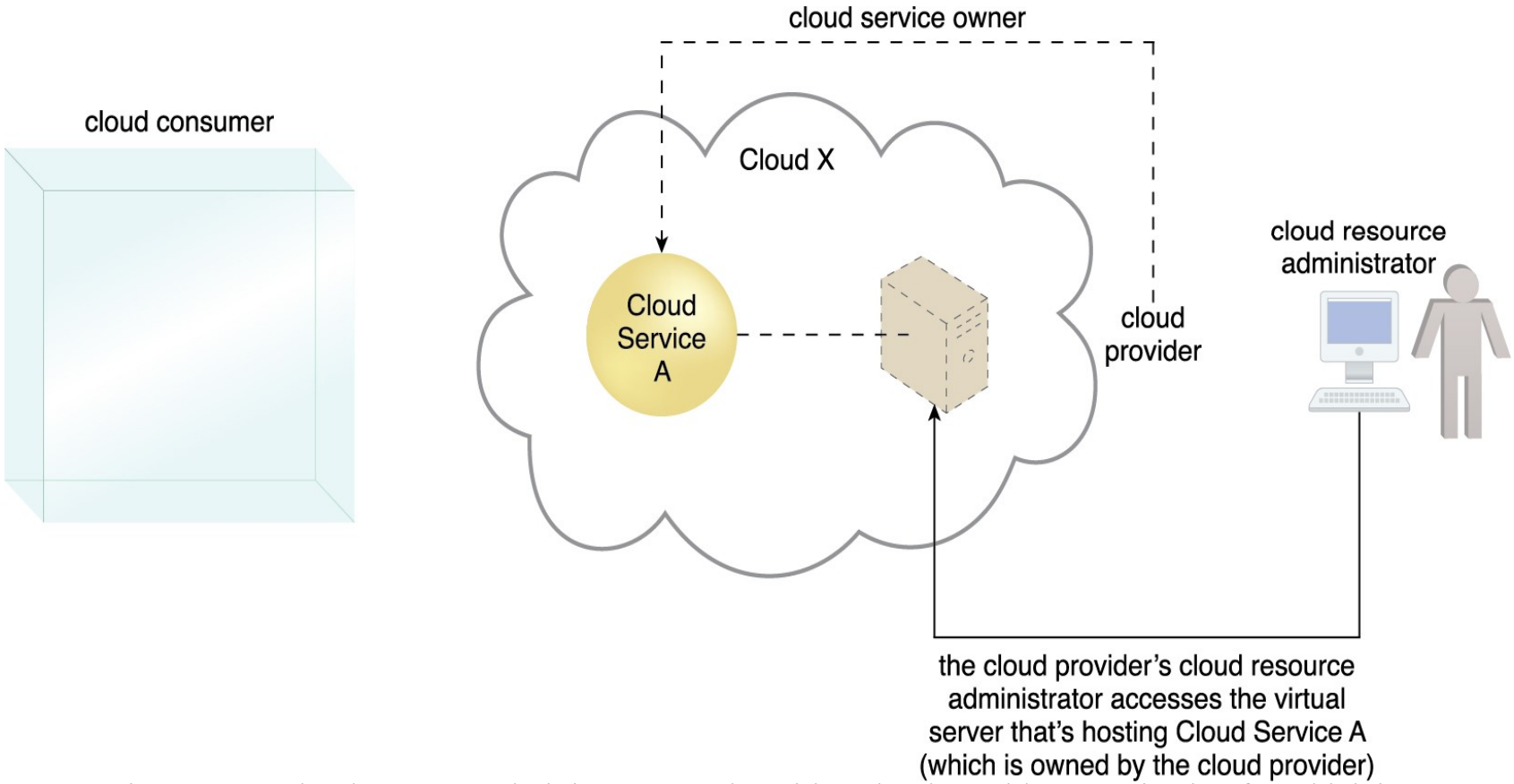

Figure 4.5 A cloud resource administrator can be with a cloud provider organization for which it can administer the cloud provider's internally and externally available IT resources.

Organizational Boundary

- An *Organizational Boundary* represents the physical perimeter that surrounds a set of IT resources that are owned and governed by an organization.

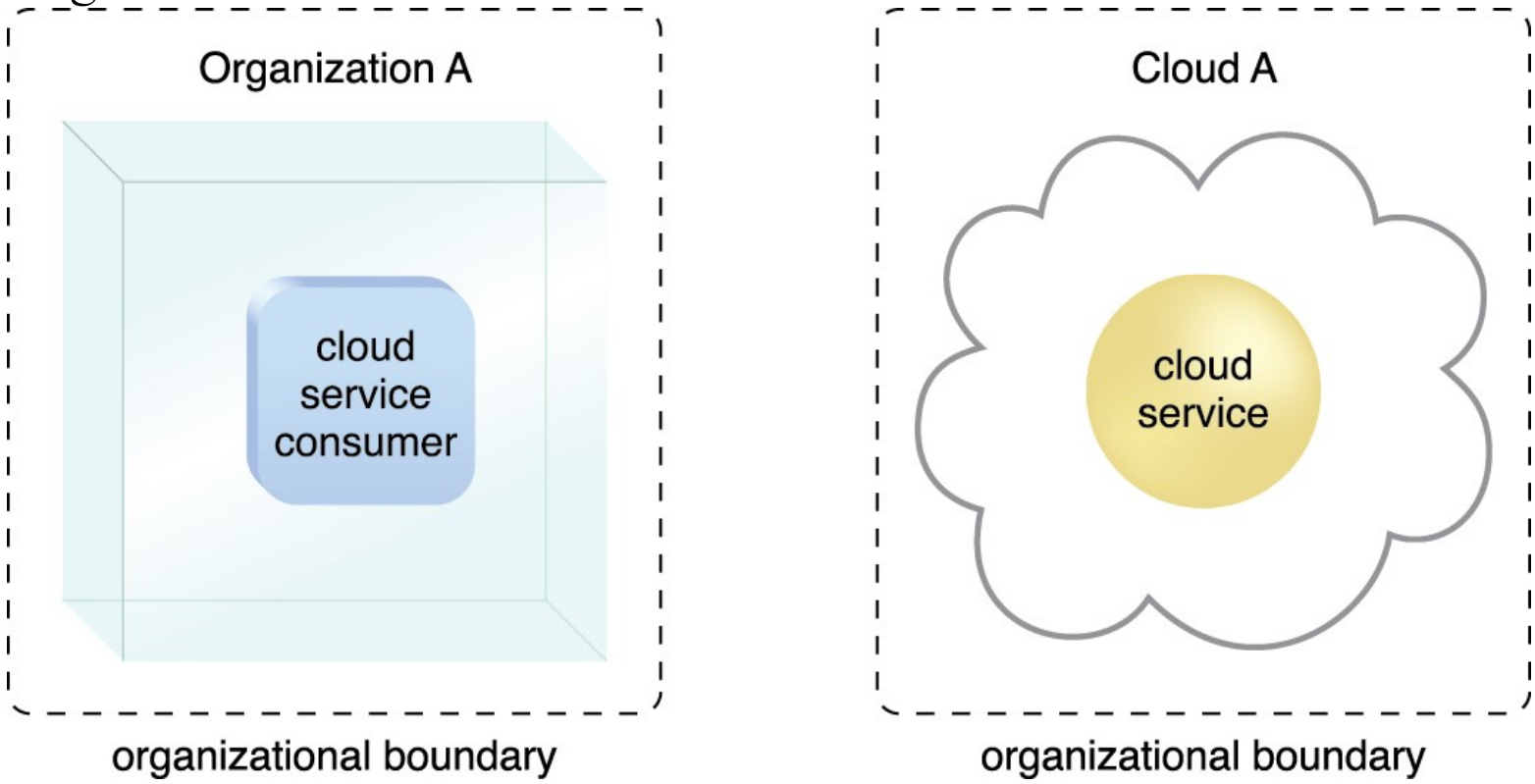

Figure 4.6 Organizational boundaries of a cloud consumer (left), and a cloud provider (right), represented by a broken line notation.

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

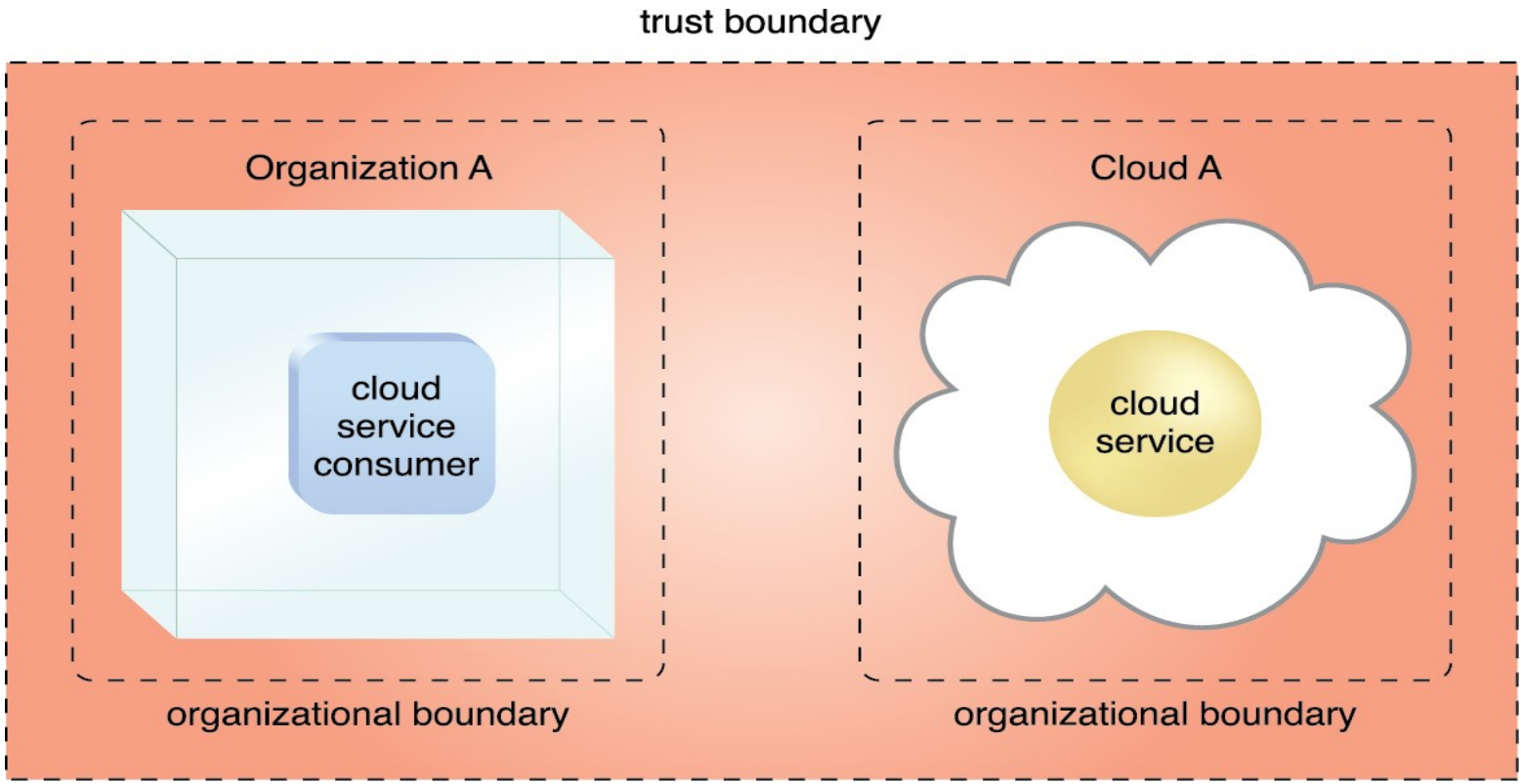

Figure 4.7 An extended trust boundary encompasses the organizational boundaries of the cloud provider and the cloud consumer.

Cloud Characteristics

- Six specific characteristics are common to the majority of cloud environments:
  - On-demand usage
  - Ubiquitous access
  - Multi-tenancy (and resource pooling)
  - Elasticity
  - Measured usage
  - Resiliency (NIST 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 Usage*.

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

- 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*.

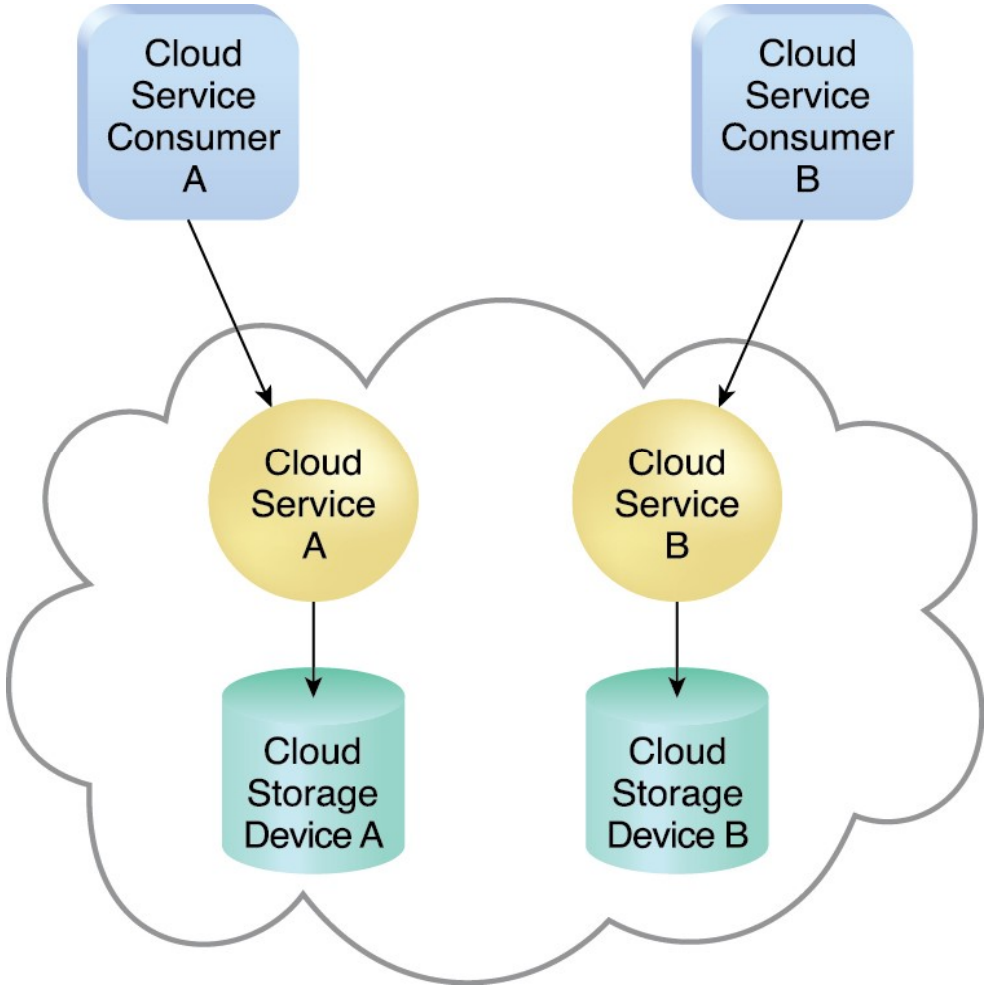

Figure 4.8 In a single-tenant environment, each cloud consumer has a separate IT resource instance.

Multitenancy

- 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.

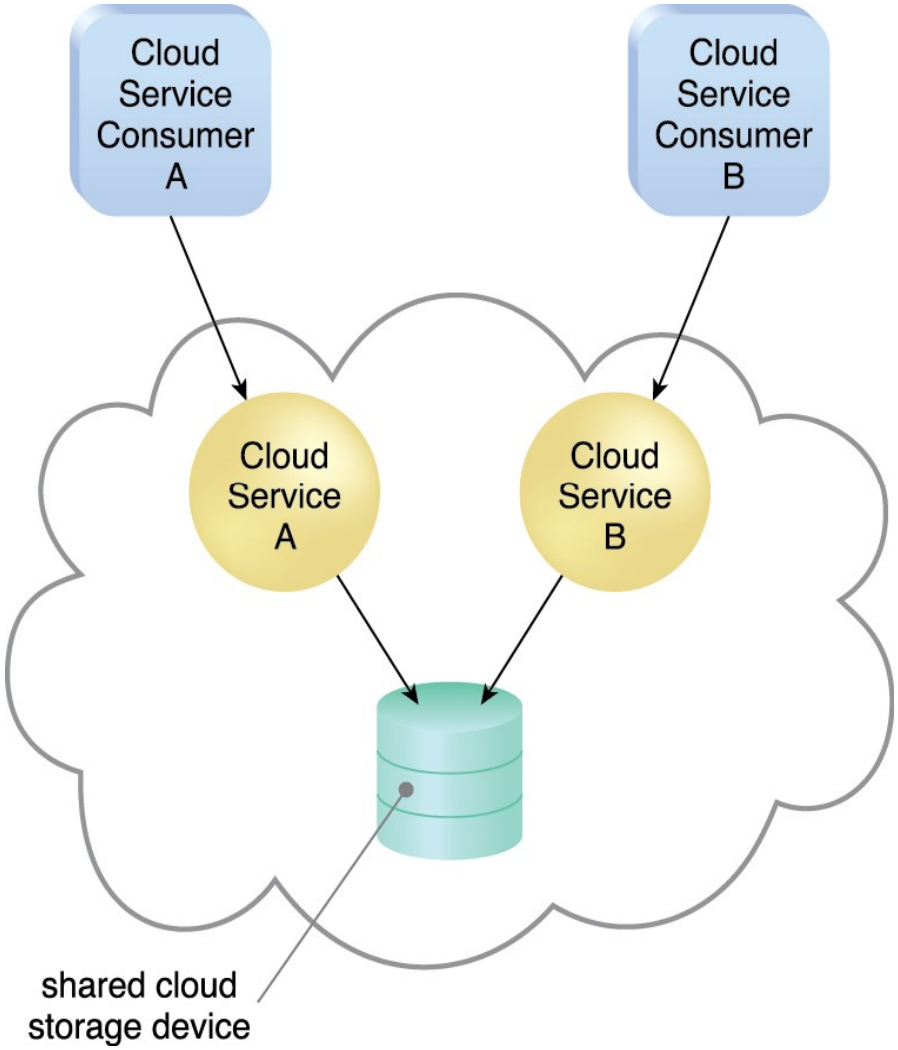

Figure 4.9 In a multitenant environment, a single instance of an IT resource, such as a cloud storage device, serves multiple consumers.

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. It is closely related to the on-demand characteristic.
- 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.
- Measured usage is not limited to tracking statistics for billing purposes. It also encompasses the general monitoring of IT resources and related usage reporting.

Resiliency

- *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.

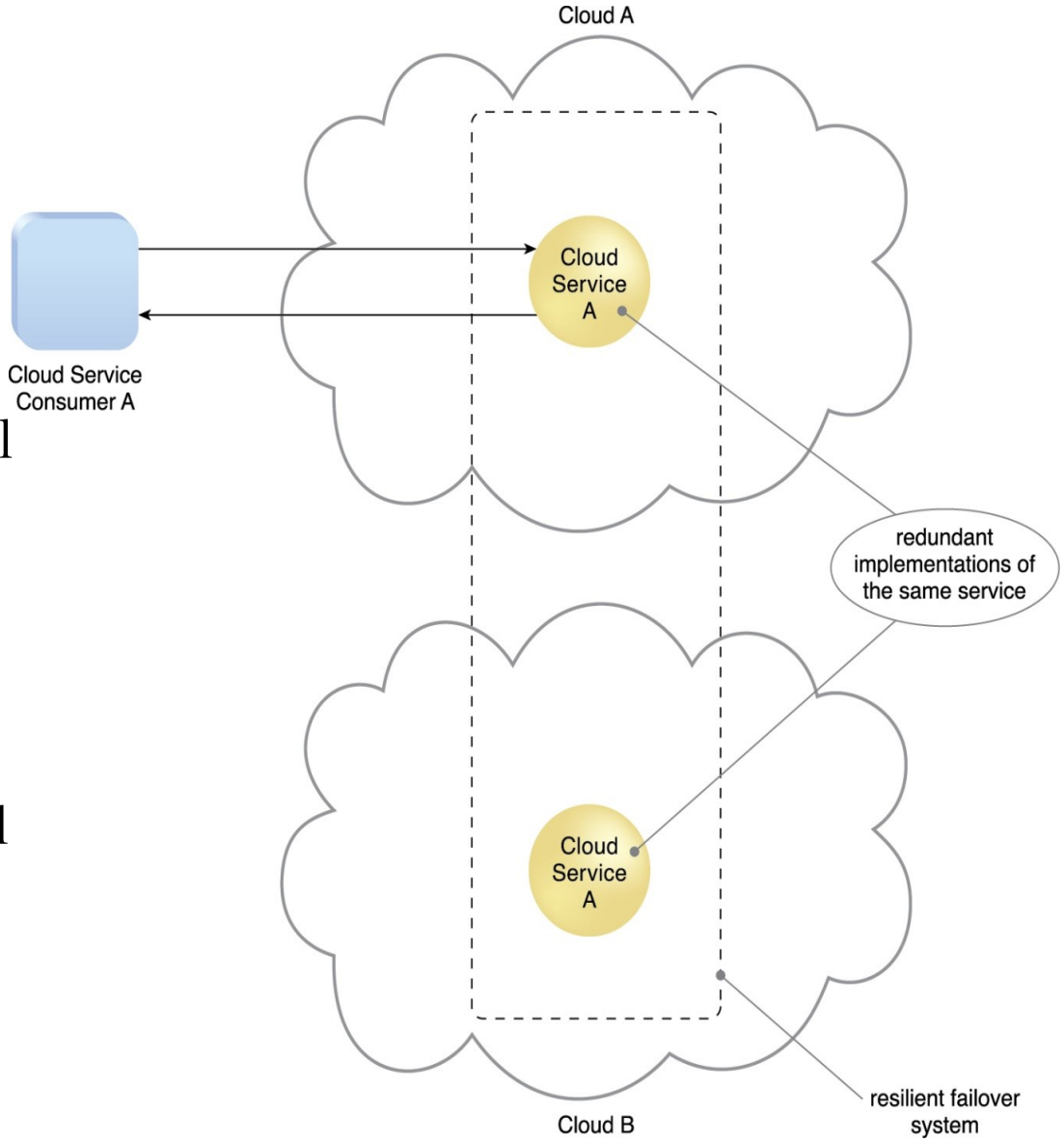

Figure 4.10 A resilient system in which Cloud B hosts a redundant implementation of Cloud Service A to provide failover in case Cloud Service A on Cloud A becomes unavailable.

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
- Security-as-a-Service
- Integration-as-a-Service
- Process-as-a-Service
- Database-as-a-Service
- Communication-as-a-Service
- Testing-as-a-Service

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.

Infrastructure-as-a-Service (IaaS)

- 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)

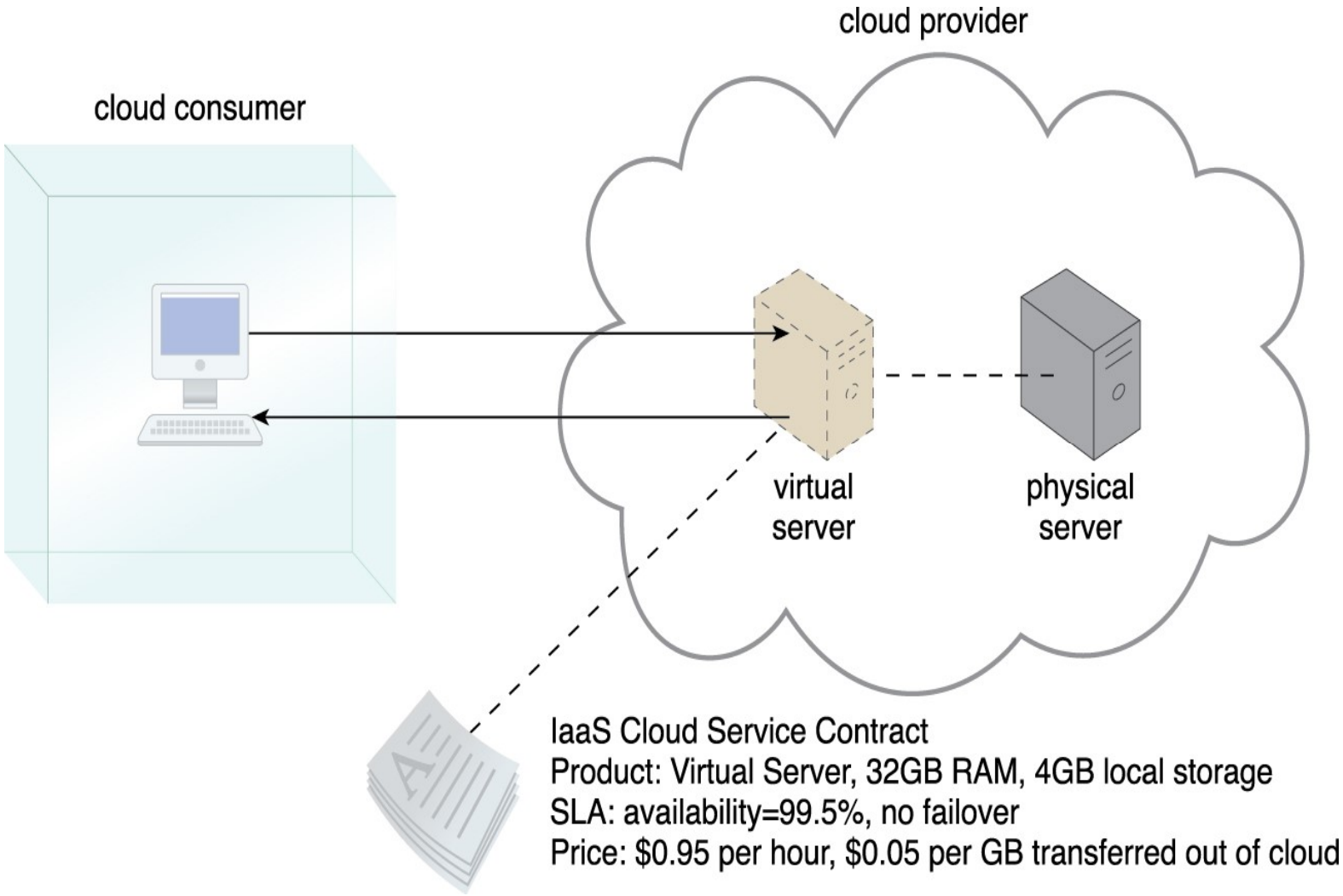

Figure 4.11 A cloud consumer is using a virtual server within an IaaS environment. Cloud consumers are provided with a range of contractual guarantees by the cloud provider, pertaining to characteristics such as capacity, performance, and availability.

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.

Platform-as-a-Service (PaaS)

- 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.
- PaaS products are available with different development stacks.
  For example, Google App Engine offers a Java and Python-based environment.

Platform-as-a-Service (PaaS)

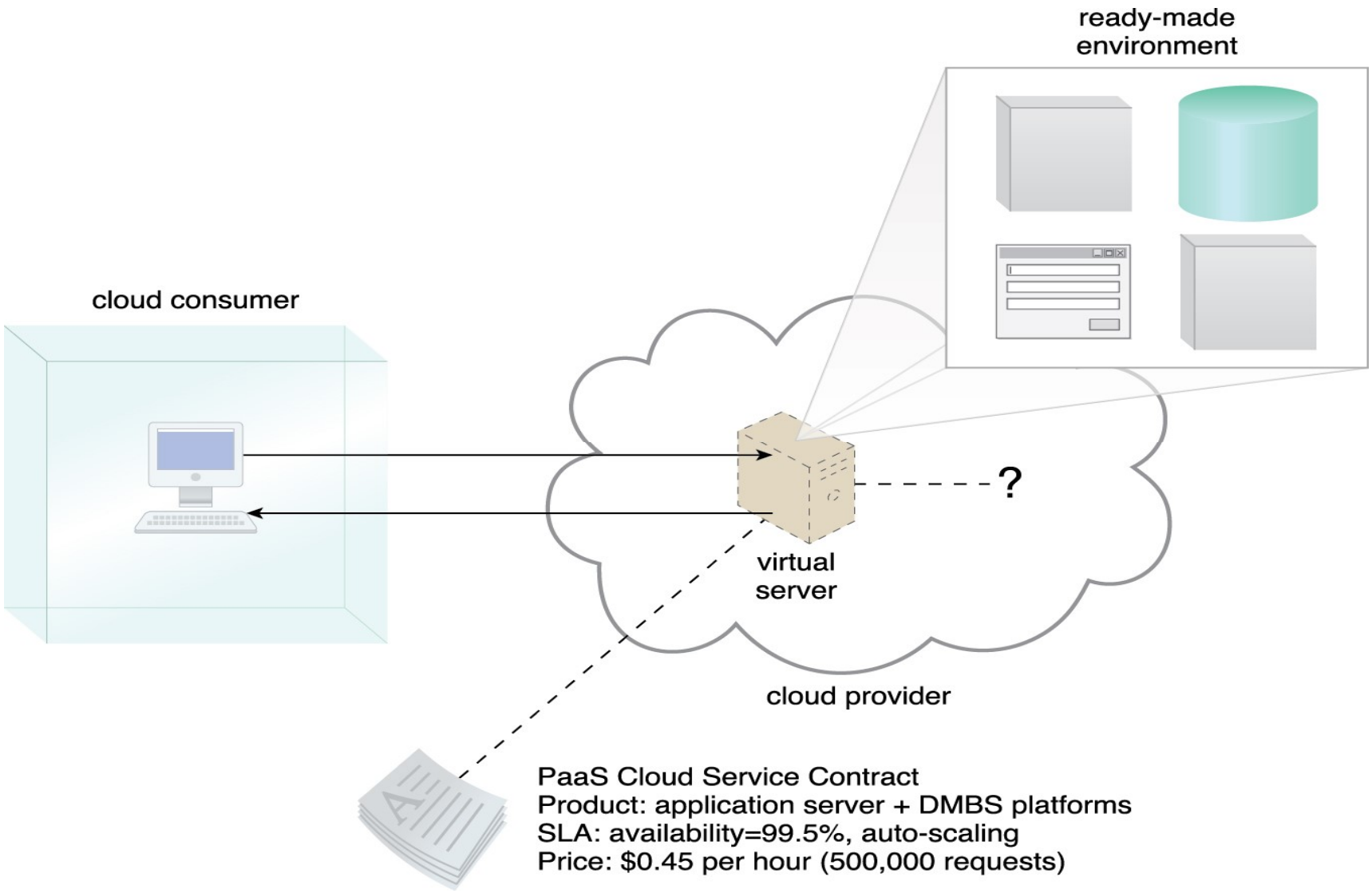

Figure 4.12 A cloud consumer is accessing a ready-made PaaS environment. The question mark indicates that the cloud consumer is intentionally shielded from the implementation details of the platform.

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.

Software-as-a-Service (SaaS)

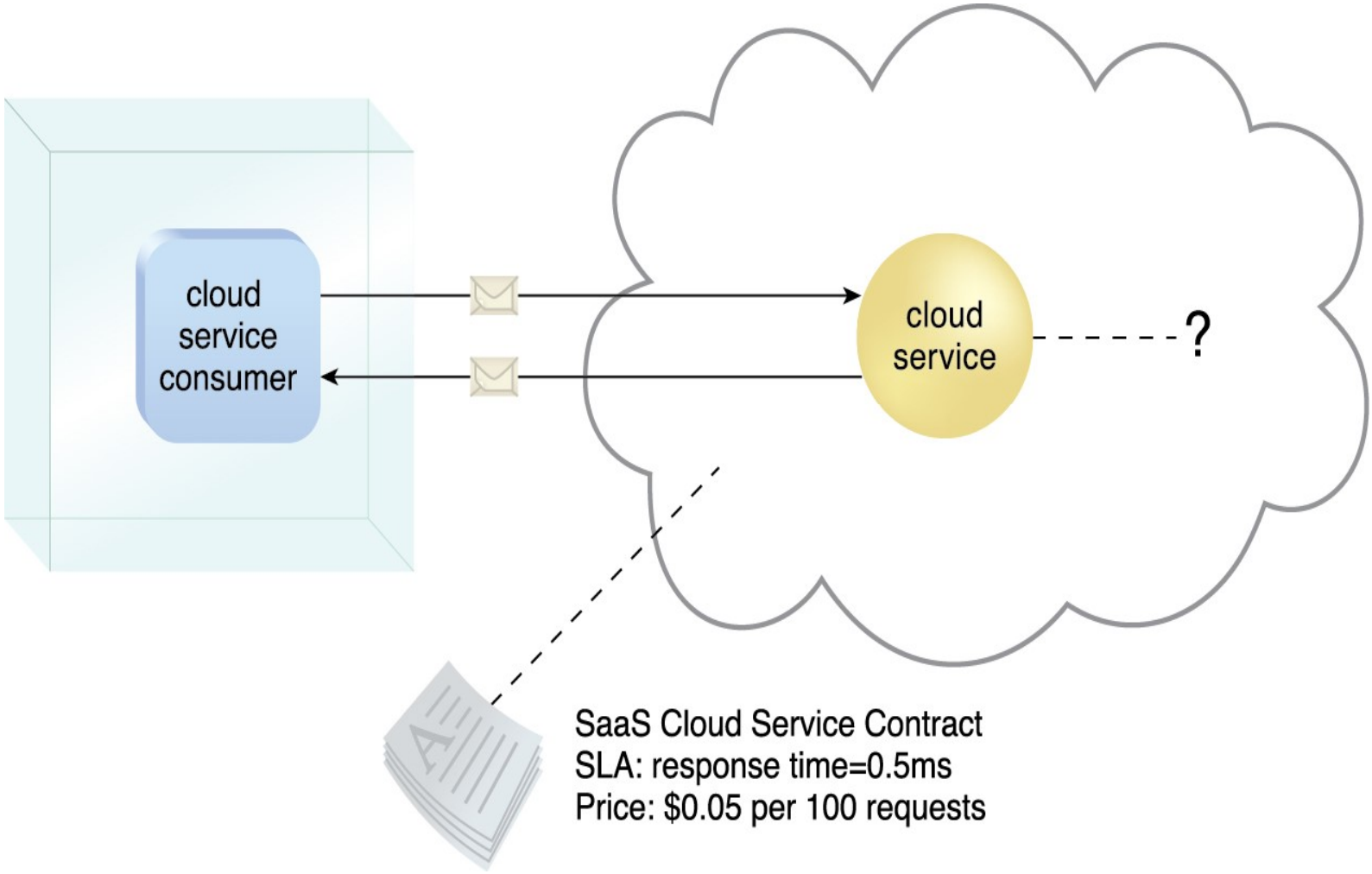

Figure 4.13 The cloud service consumer is given access the cloud service contract, but not to any underlying IT resources or implementation details.

Cloud Delivery Models – Comparison (Control Levels)

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 infrastructure related IT resources and, possibly, to underlying physical IT resources.

Table 4.1 A comparison of typical Cloud delivery model control levels.

Cloud Delivery Models – Comparison (Activities)

Cloud Delivery Model	Common Cloud Consumer Activities	Common Cloud Provider Activities
SaaS	Usage and configures Cloud service.	Implements, Manages and Maintains Cloud services.
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.
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. Monitors usage by Cloud Consumers.

Table 4.2 Typical activities carried out by Cloud Consumers and Cloud Providers in relation to Cloud Delivery Models

Combining Cloud Delivery Models

IaaS + PaaS

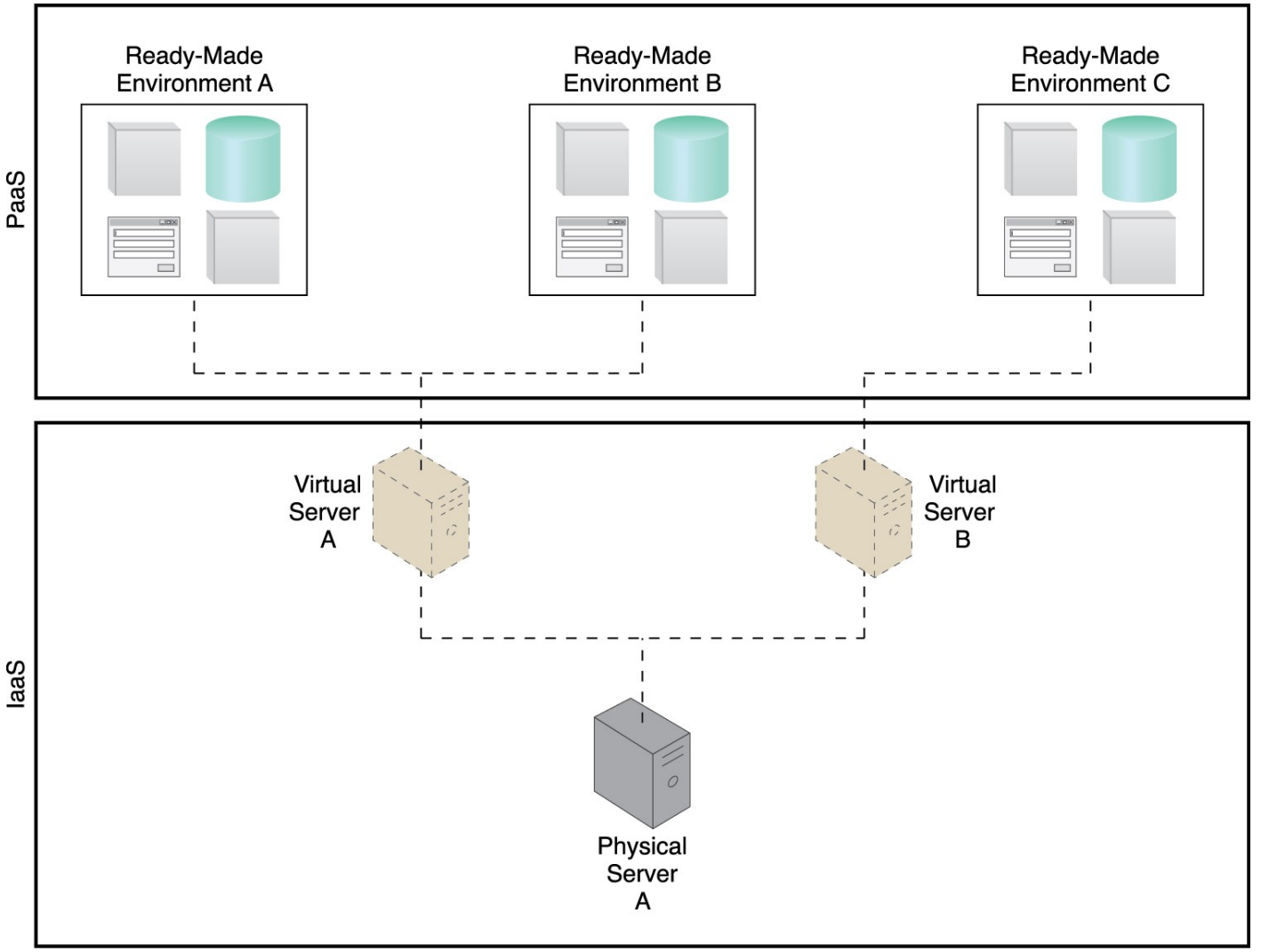

Figure 4.14 A PaaS environment based on the IT resources provided by an underlying IaaS environment.

Combining Cloud Delivery Models

IaaS + PaaS

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

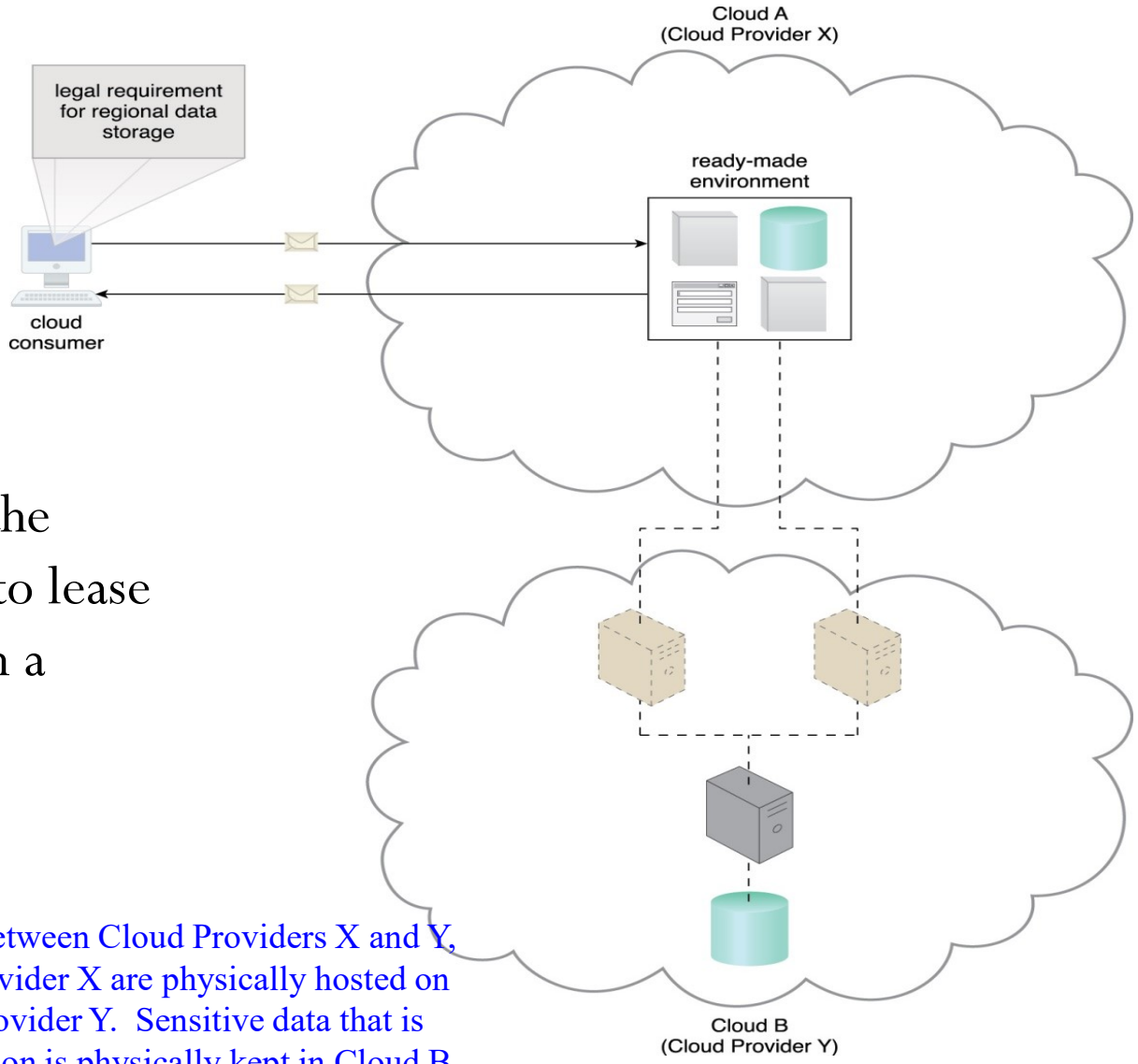

Figure 4.15 An example of a contract between Cloud Providers X and Y, in which services offered by Cloud Provider X are physically hosted on virtual servers belonging to Cloud Provider Y. Sensitive data that is legally required to stay in a specific region is physically kept in Cloud B, which is physically located in that region.

Combining Cloud Delivery Models

IaaS + 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

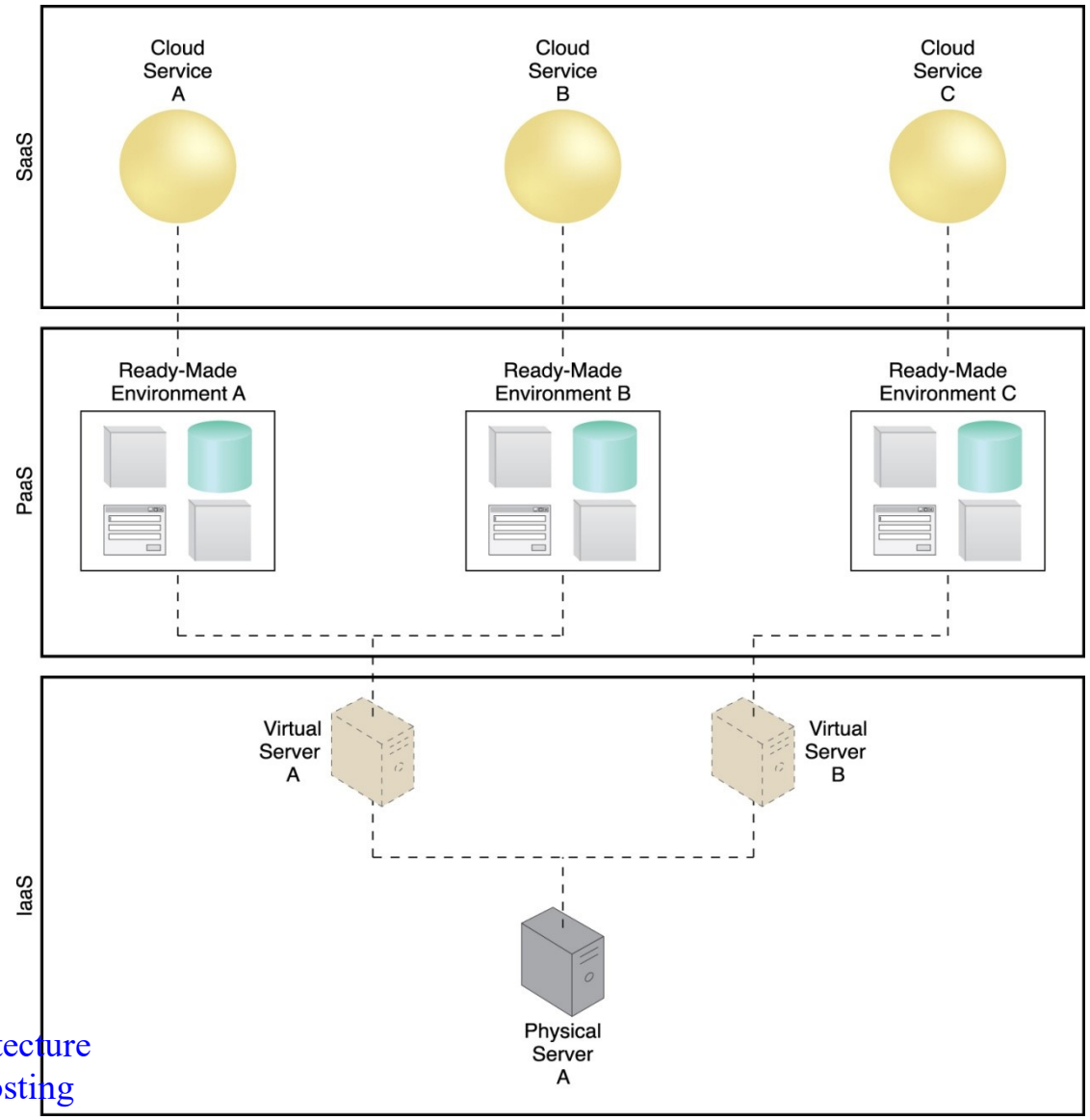

Figure 4.16 A simple layered view of an architecture comprised of IaaS and PaaS environments hosting three SaaS cloud service implementations.

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

- 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*).

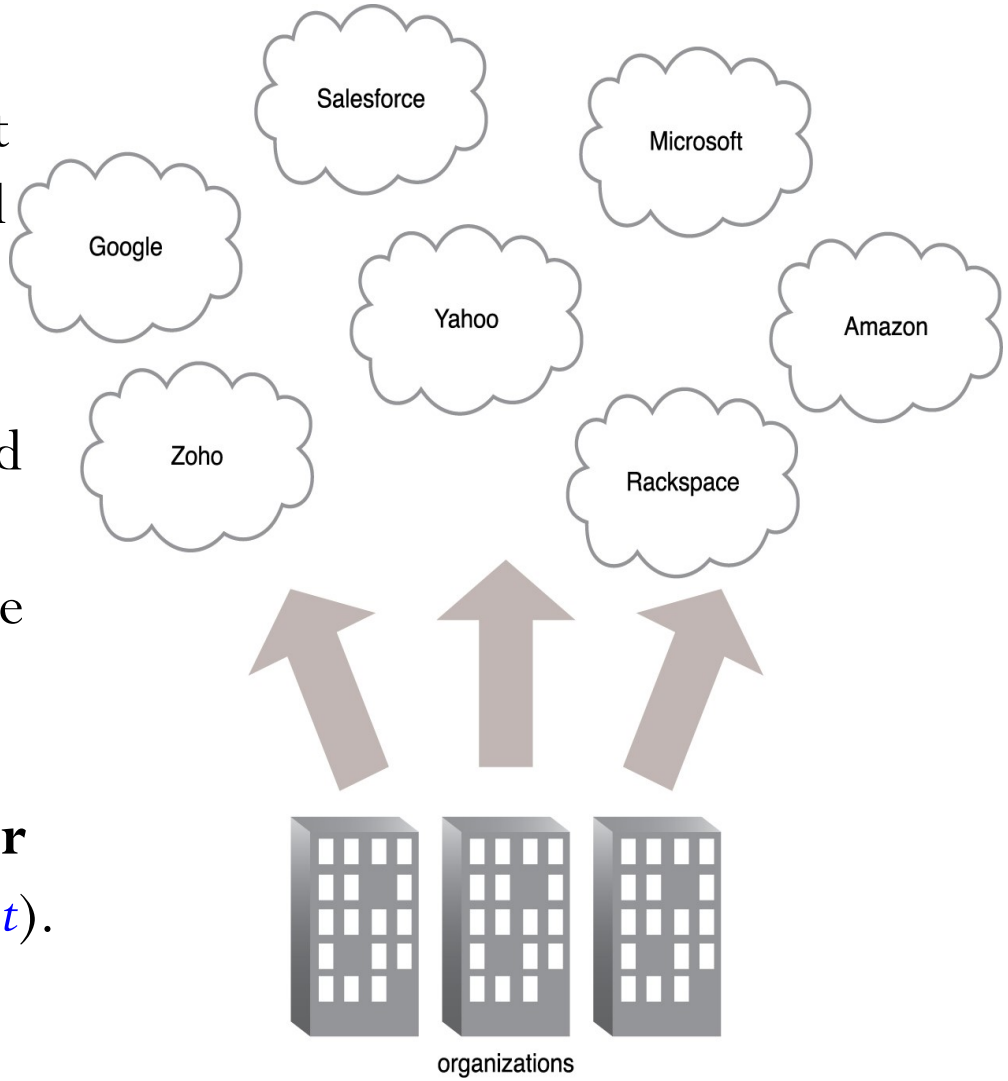

Figure 4.17 Organizations act as cloud consumers when accessing cloud services and IT resources made available by different cloud providers.

Community Clouds

- A *Community Cloud* is similar to a public cloud except that its access is limited to a specific community of cloud consumers.

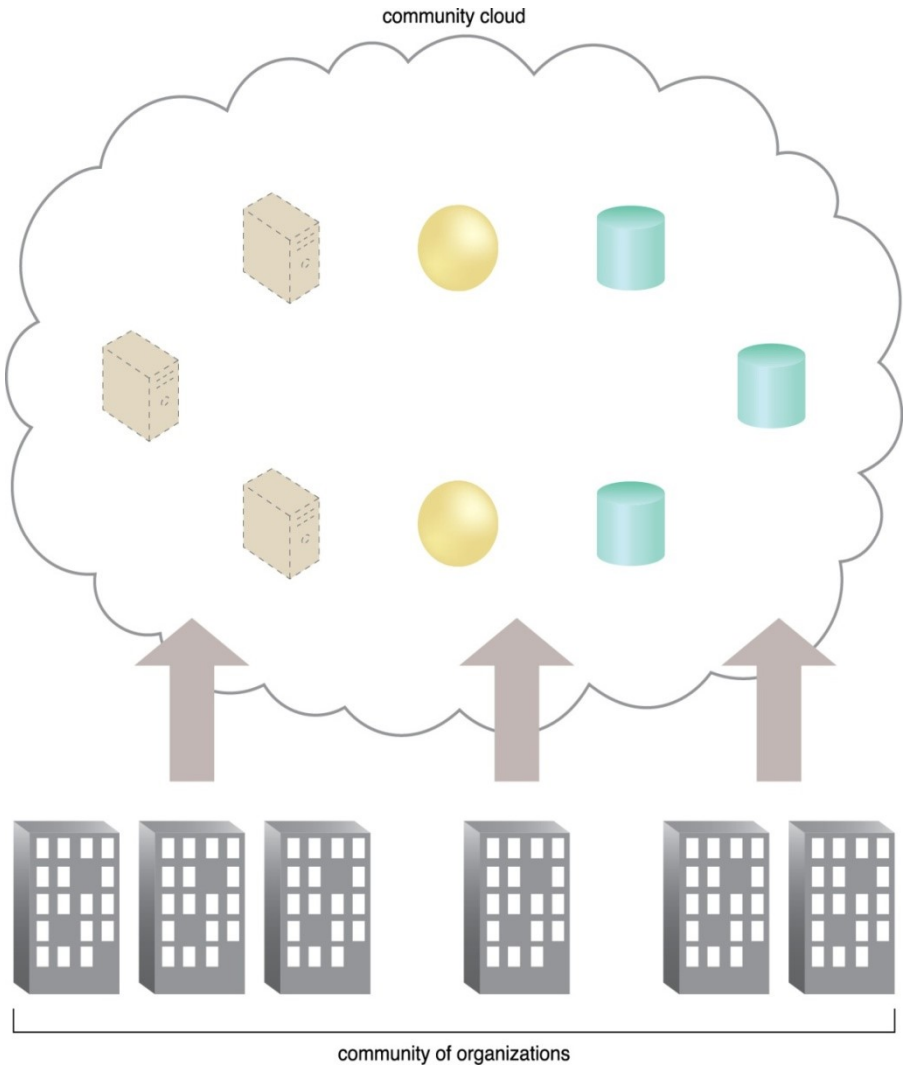

Figure 4.18 An example of a "community" of organizations accessing IT resources from a community cloud.

Private Clouds

- 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.
- Who would manage?
- Is "on-premises or cloud-based"?

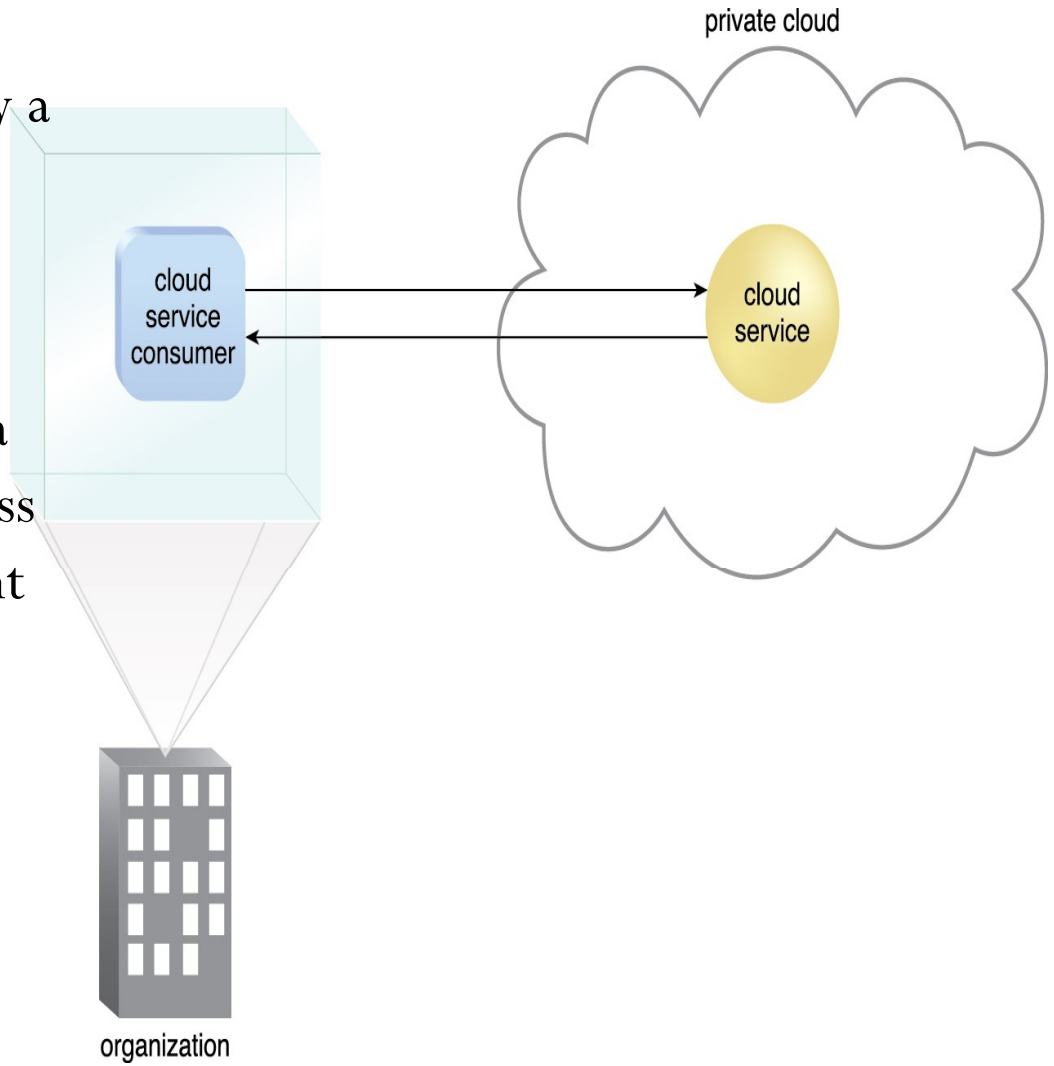

Figure 4.19 A cloud service consumer in the organization's on-premise environment accesses a cloud service hosted on the same organization's private cloud via a virtual private network.

Hybrid Clouds

- A *Hybrid Cloud* is a cloud environment comprised of two or more different cloud deployment models.

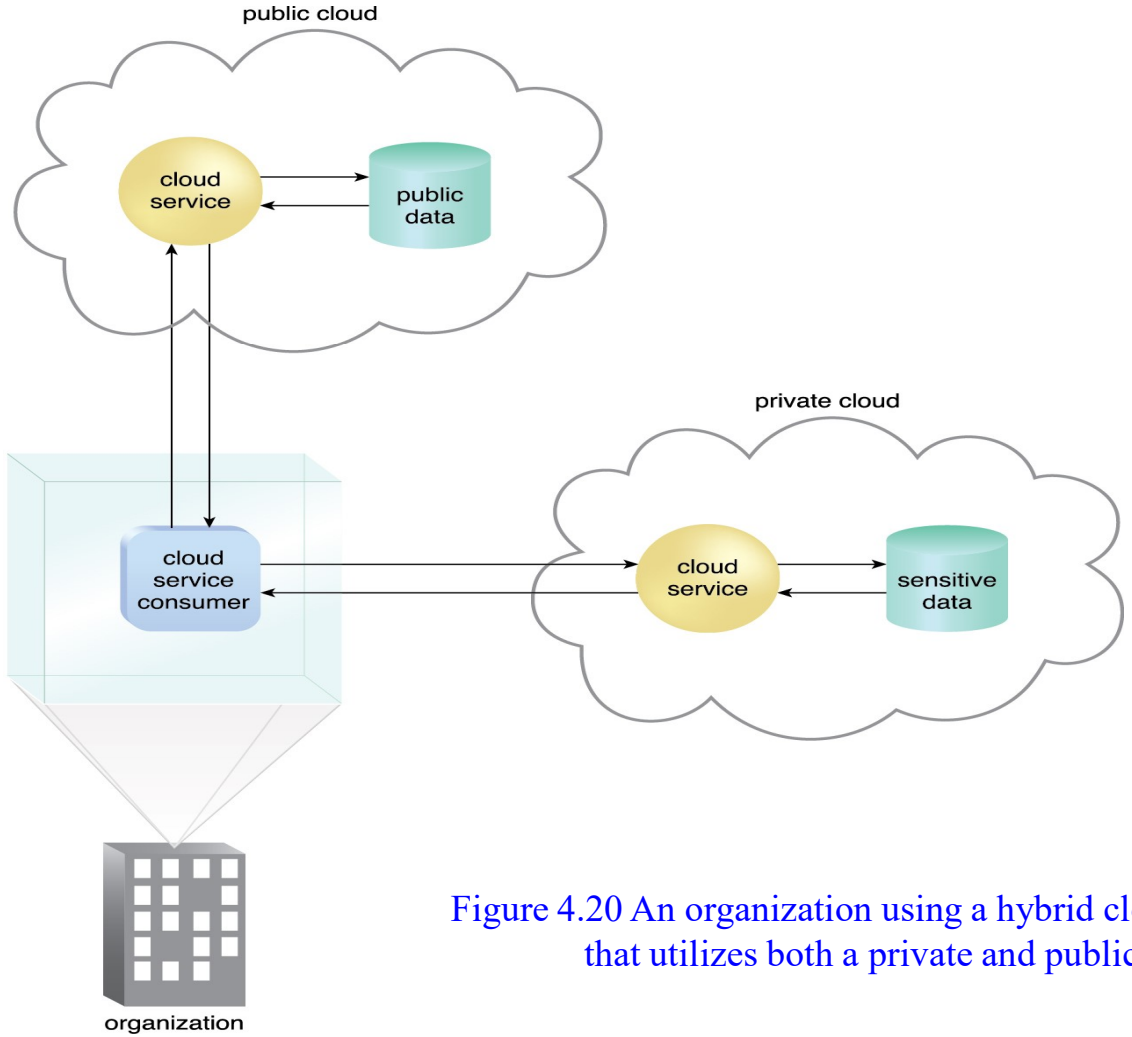

Figure 4.20 An organization using a hybrid cloud architecture that utilizes both a private and public cloud.

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.
- Inter-Cloud : This model is based on an architecture comprised of two or more *Inter-connected Clouds*.

Summary

- Common roles associated with cloud-based interaction and relationships include the cloud provider, cloud consumer, cloud service owner, and cloud resource administrator.
- An organizational boundary represents the physical scope of IT resources owned and governed by an organization. A trust boundary is the logical perimeter that encompasses the IT resources trusted by an organization.
- On-demand usage is the ability of a cloud consumer to self-provision and use necessary cloud-based services without requiring cloud provider interaction. This characteristic is related to measured usage, which represents the ability of a cloud to measure the usage of its IT resources.
- Ubiquitous access allows cloud-based services to be accessed by diverse cloud service consumers, while multitenancy is the ability of a single instance of an IT resource to transparently serve multiple cloud consumers simultaneously.

Summary

- The elasticity characteristic represents the ability of a cloud to transparently and automatically scale IT resources out or in. Resiliency pertains to a cloud's inherent failover features.
- The IaaS cloud delivery model offers cloud consumers a high level of administrative control over "raw" infrastructure-based IT resources.
- The PaaS cloud delivery model enables a cloud provider to offer a pre-configured environment that cloud consumers can use to build and deploy cloud services and solutions, albeit with decreased administrative control.
- SaaS is a cloud delivery model for shared cloud services that can be positioned as commercialized products hosted by clouds.
- Different combinations of IaaS, PaaS, and SaaS are possible, depending on how cloud consumers and cloud providers choose to leverage the natural hierarchy established by these base cloud delivery models.

Summary

- A public cloud is owned by a third party and generally offers commercialized cloud services and IT resources to cloud consumer organizations.
- A private cloud is owned by an individual organization and resides within the organization's premises.
- A community cloud is normally limited for access by a group of cloud consumers that may also share responsibility in its ownership.
- A hybrid cloud is a combination of two or more other cloud deployment models.

Thank You

Text Book to be followed:

Thomas Erl, Zaigham Mahmood and Ricardo Puttini **"Cloud Computing: Concepts, Technology & Architecture"**, *Pearson, 1st Edition, 2013.*