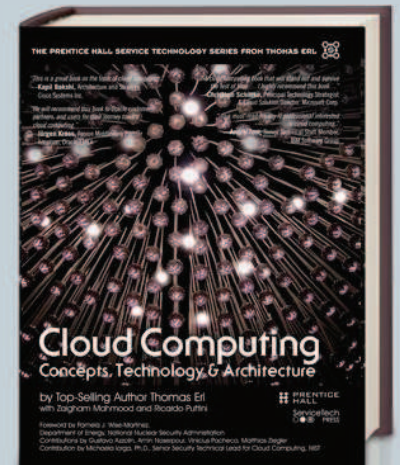# Cloud Computing
Concept, Technology & Architecture

Chapter 04
Fundamental Concepts and Models

Taken from textbook "Cloud Computing - Concepts, Technology and Architecture"

Contents

- Cloud delivery and cloud deployment models are discussed in detail, following sections that establish common cloud characteristics and roles and boundaries.

  - 4.1 Role and Boundaries
  - 4.2 Cloud Characteristics
  - 4.3 Cloud Delivery
  - 4.4 Cloud Deployment Models

- ## Cloud Provider
 - The organization that provides cloud-based IT resources is the cloud provider.
  - Cloud providers normally own the IT resources for lease by cloud consumers, and could also resell IT resources leased from other 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.
  - The cloud consumer uses a cloud service consumer to access a cloud service.

Figure 4.1
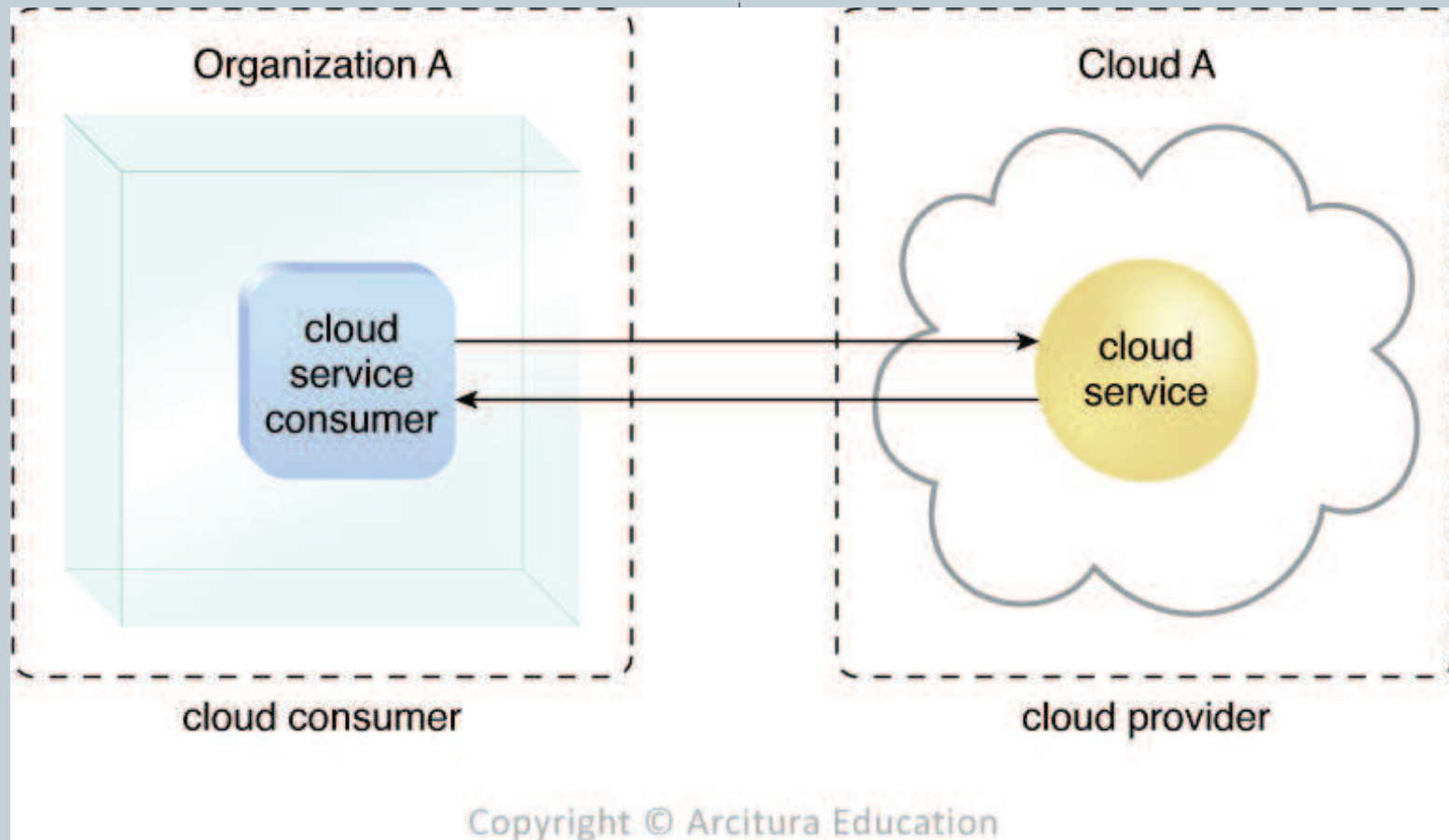
Figure 4.1 - A cloud consumer (Organization A) interacts with a cloud service from a cloud provider (that owns Cloud A). Within Organization A, the cloud service consumer is being used to access the cloud service.
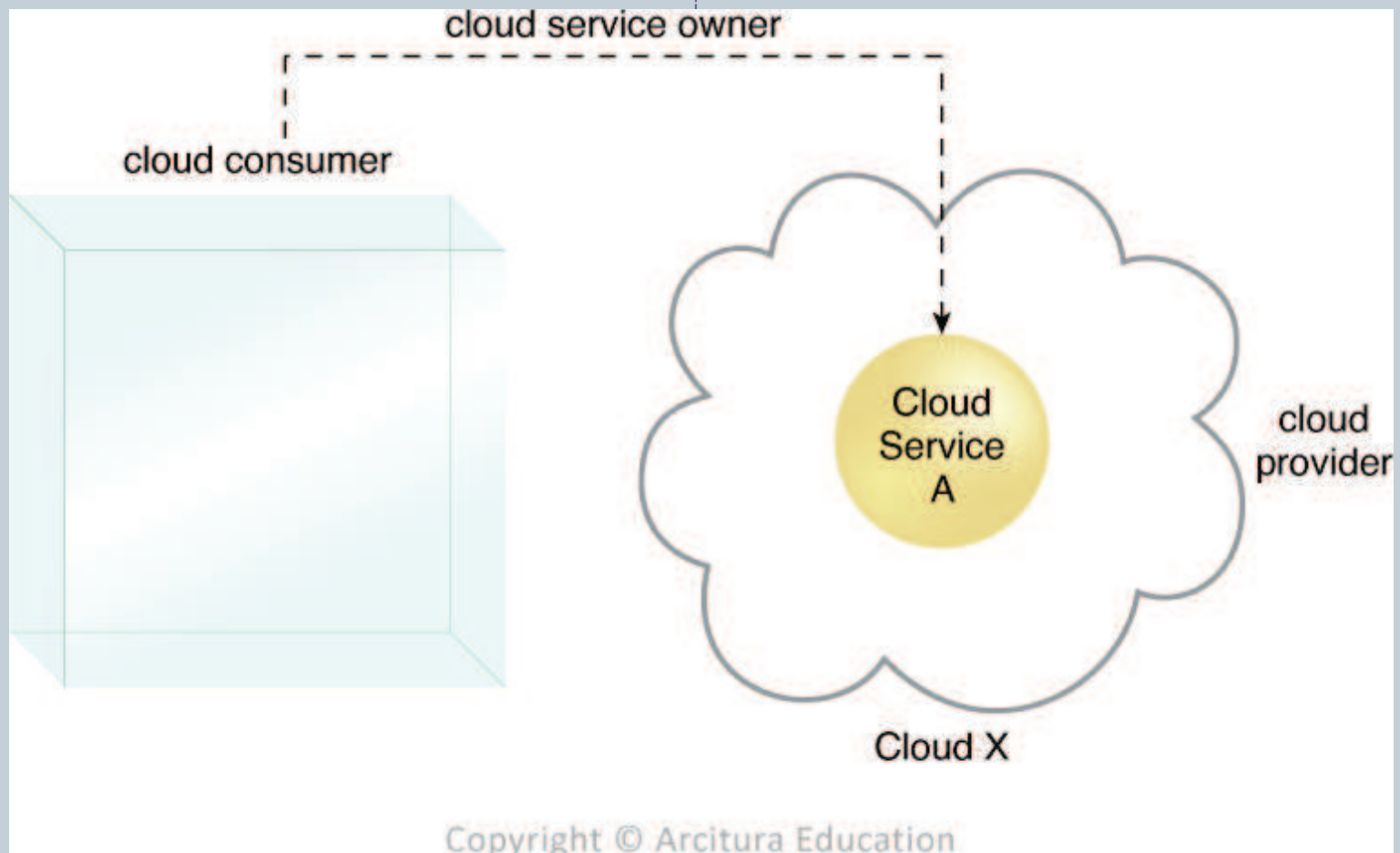
- ## Cloud Service Owner
  - The person organization that legally owns a cloud service is called a cloud service owner.
  - The cloud service owner can be cloud consumer, or the cloud provider that owns the cloud within which the cloud service resides.
  - A cloud consumer that owns a cloud service hosted by a third party cloud does not necessarily need to be the user of the cloud service.
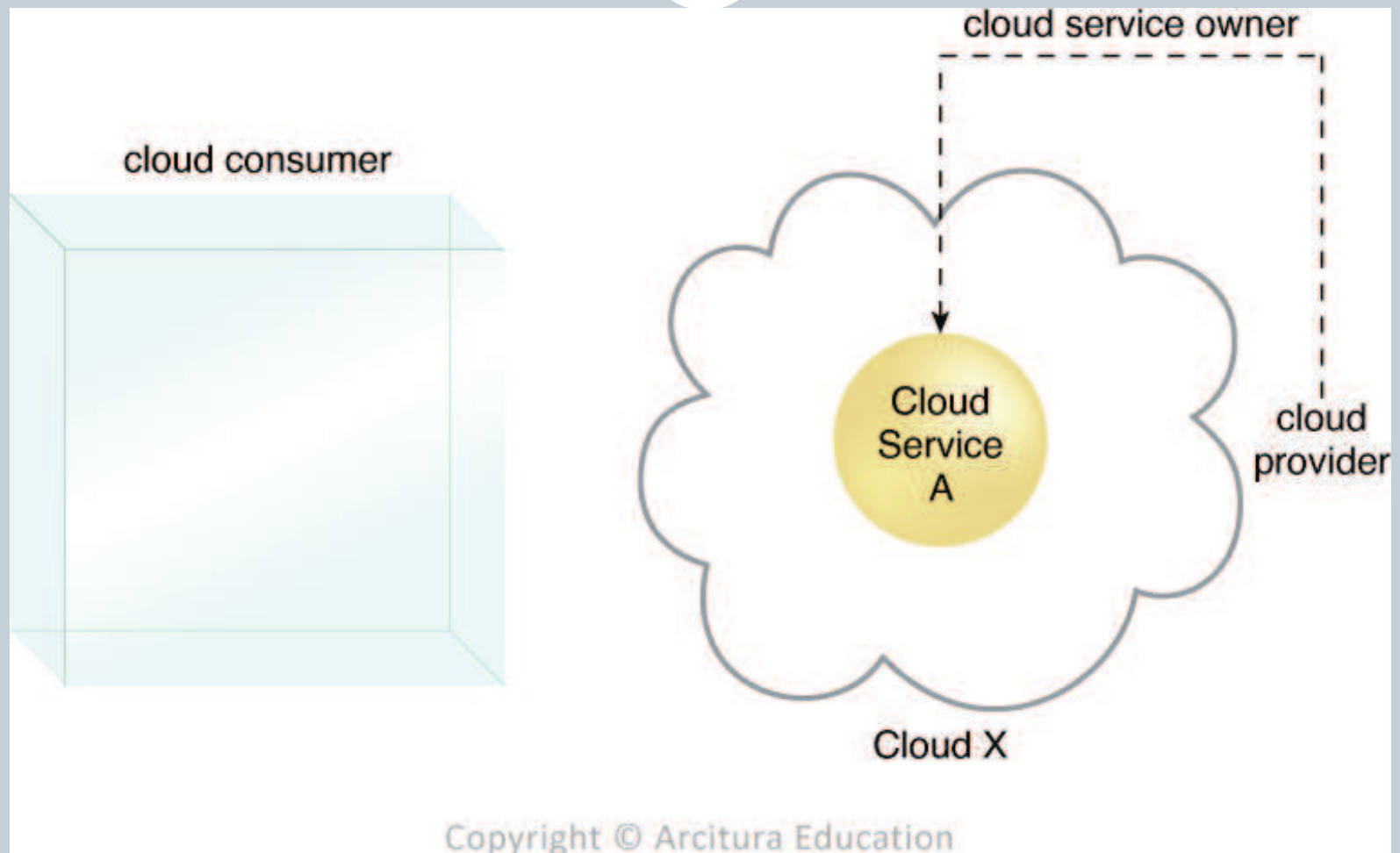 - A cloud service owner ≠ a cloud resource owner

Figure 4.2

cloud service owner

cloud consumer

Cloud Service A

cloud provider

Cloud X

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

Figure 4.3

7

cloud service owner

cloud consumer

Cloud Service A

cloud provider

Cloud X

- *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.*
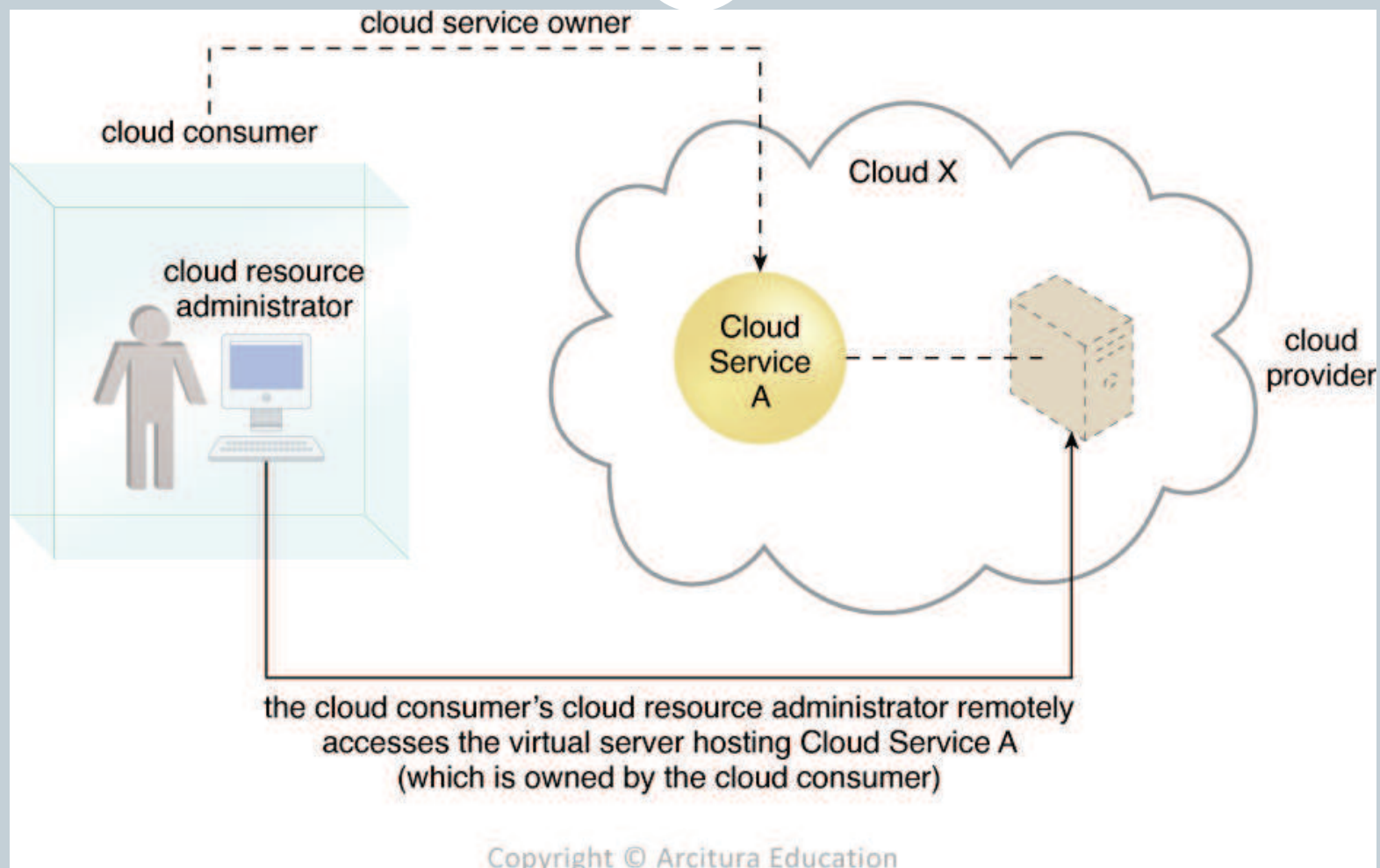
- Cloud Resource Administrator
  - A cloud service administrator is the person or organization responsible for administering a cloud-based IT resource (including IT services).
  - The cloud consumer or cloud provider , or even third-party organization could be a cloud resource administrator.

Figure 4.4

the cloud consumer's cloud resource administrator remotely
accesses the virtual server hosting Cloud Service A
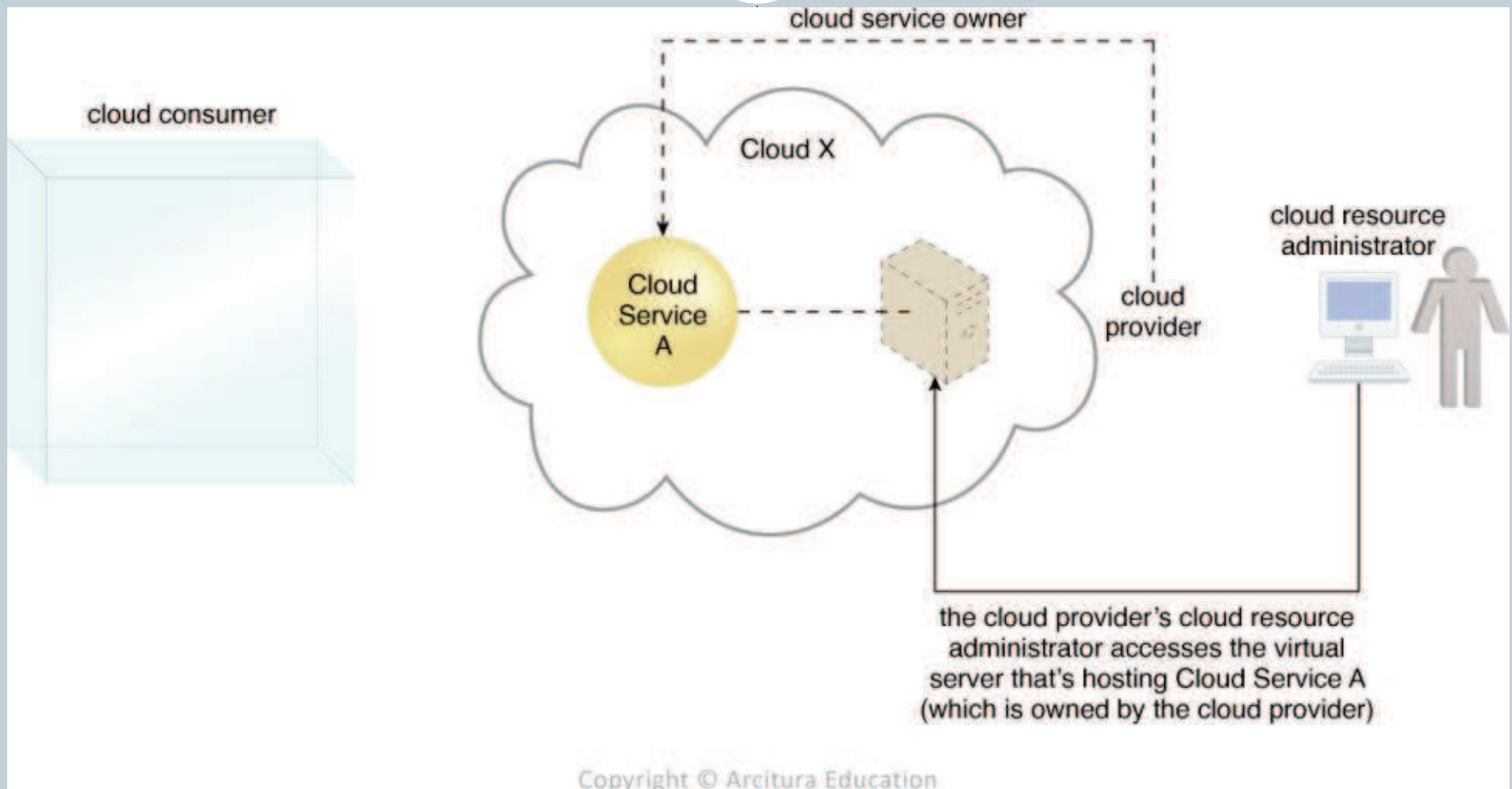(which is owned by the cloud consumer)

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- *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.*

Figure 4.5

cloud service owner

cloud consumer

Cloud X

Cloud Service A

cloud resource administrator

cloud provider

the cloud provider's cloud resource administrator accesses the virtual server that's hosting Cloud Service A (which is owned by the cloud provider)

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- *Figure 4.5 - A cloud resource administrator can be with a cloud provider organization for which it can administer IT resources, both internal and externally available, that belong to the cloud provider*

- The NIST cloud computing reference architecture defines the following supplementary roles:
  - Cloud Auditor – A third-party (often accredited) that conducts independent assessments of cloud environments assumes the role of the cloud auditor.
  - Cloud Broker – This role is assumed by a party that assumes the responsibility of managing and negotiating usage of cloud services between cloud consumers and cloud providers.
  - Cloud Carrier – The arty responsible for providing the wire-level connectivity between cloud consumers and cloud providers assumes the role of the cloud carrier.
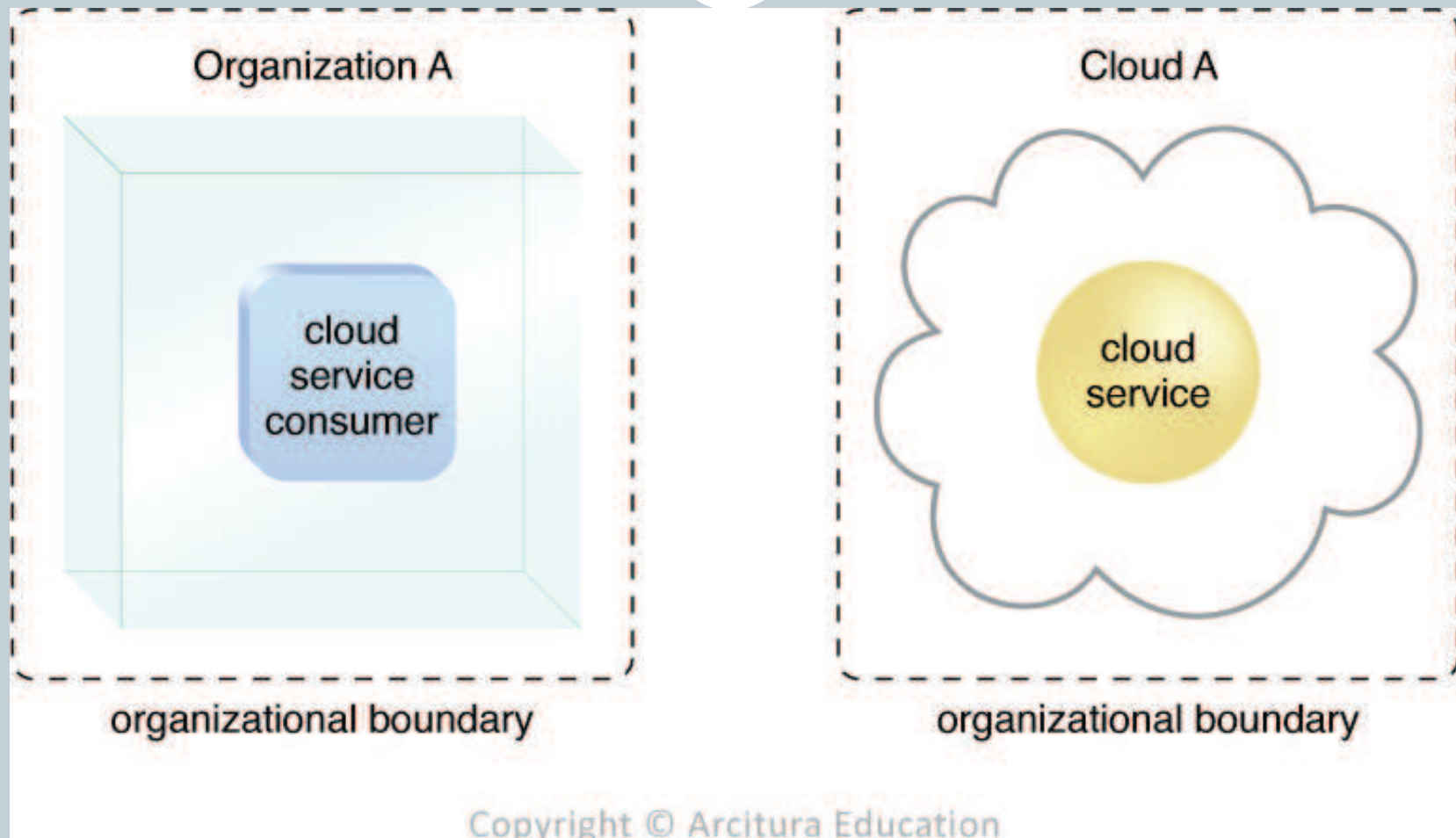
- ## Organizational Boundary

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

  - The organizational boundary does not represent the boundary of an actual organization, only an organizational set of IT assets and IT resources.

Figure 4.6

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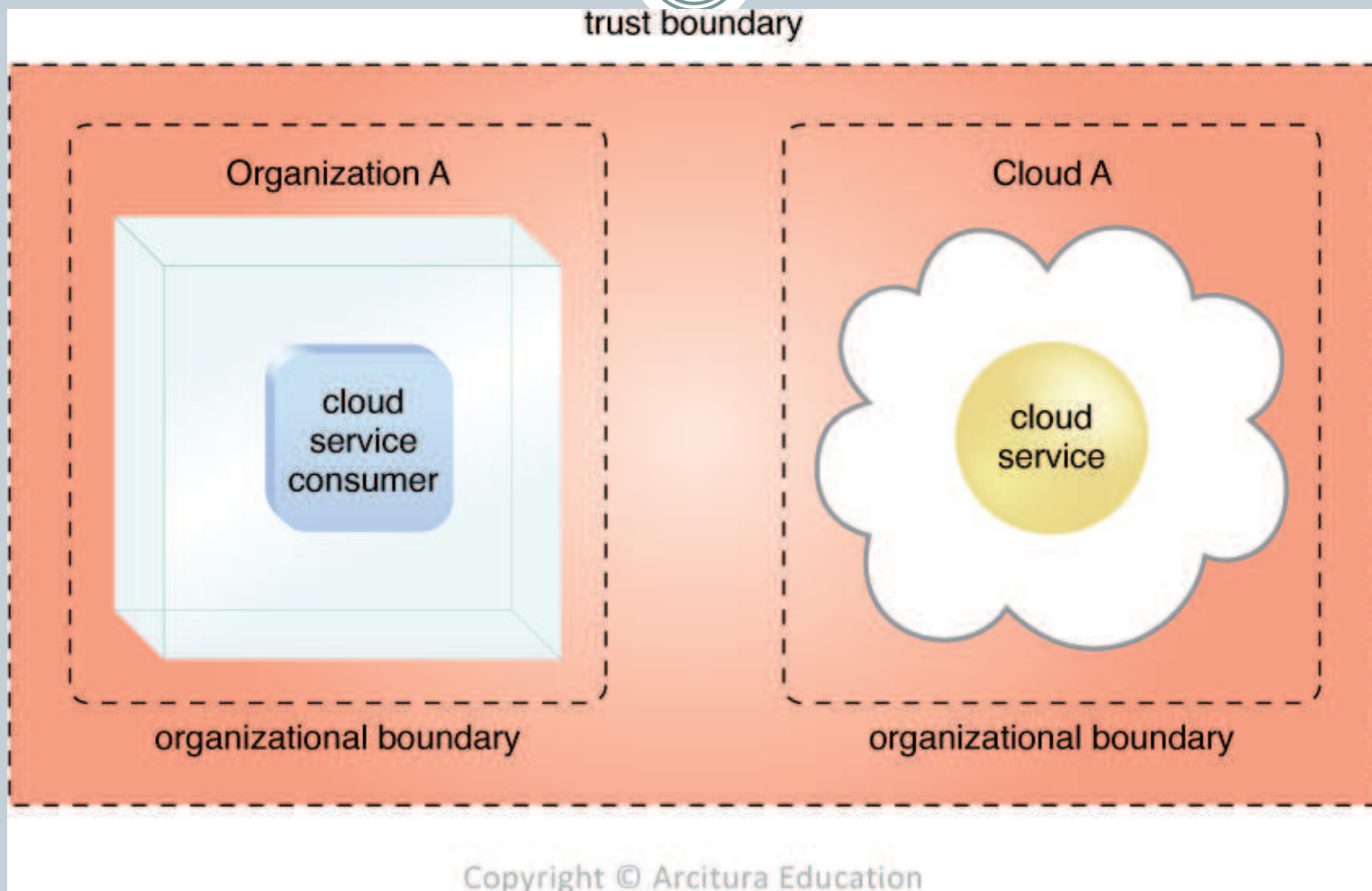
- ## Trust Boundary

  - When a cloud consumer accesses could-based IT resources, it needs to extend its trust beyond the physical boundary of the organization to include parts of the cloud environment.

  - An trust boundary is a logical perimeter that typically spans beyond physical boundaries to represents the extent to which IT resources are trusted.

  - When analyzing cloud environments, the trust boundary is most frequently associated with the trust issued by the organization acting as the cloud consumer.

Figure 4.7

- *Figure 4.7 - An extended trust boundary encompasses the organizational boundaries for the cloud provider and the cloud consumer.*

Summary of Key Points

- 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.

4.2 Cloud Characteristics (1/2)

1. ## On-demand usage
   - It enables the service-based and usage-based features.
2. ## Ubiquitous usage
   - Required support for a range of devices, transport protocols, interfaces, and security technologies.
3. ## Multitenancy (and Resource Pooling)
   - Multitenancy requires IT resources to be dynamically assigned or reassigned, according to cloud service consumer demands.
4. ## Elasticity
5. ## Measured Usage
6. ## Resiliency (Note: it is excluded in NIST's definition)

4.2 Cloud Characteristics (2/2)

1. On-demand usage
2. Ubiquitous usage
3. Multitenancy (and Resource Pooling)
4. Elasticity
   - It is closely associated with the reduced investment and proportional cost benefits.
5. Measured Usage
   - The ability to keep track of the usage of IT resources, primarily by cloud consumers.
6. Resiliency (Note: it is excluded in NIST's definition)
   - Is a form of failover that distributes redundant implementations of IT resources across physical locations.
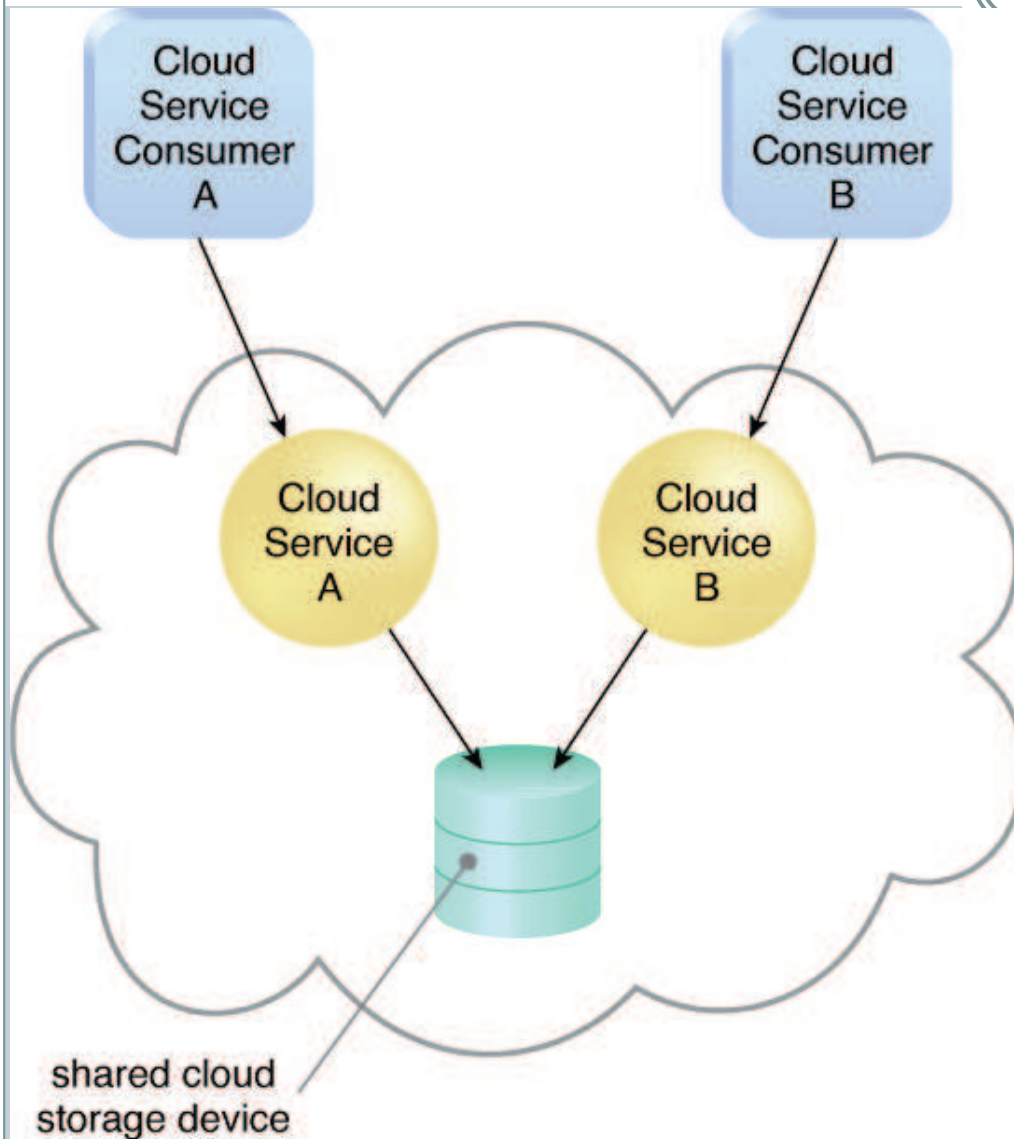
Figure 4.8
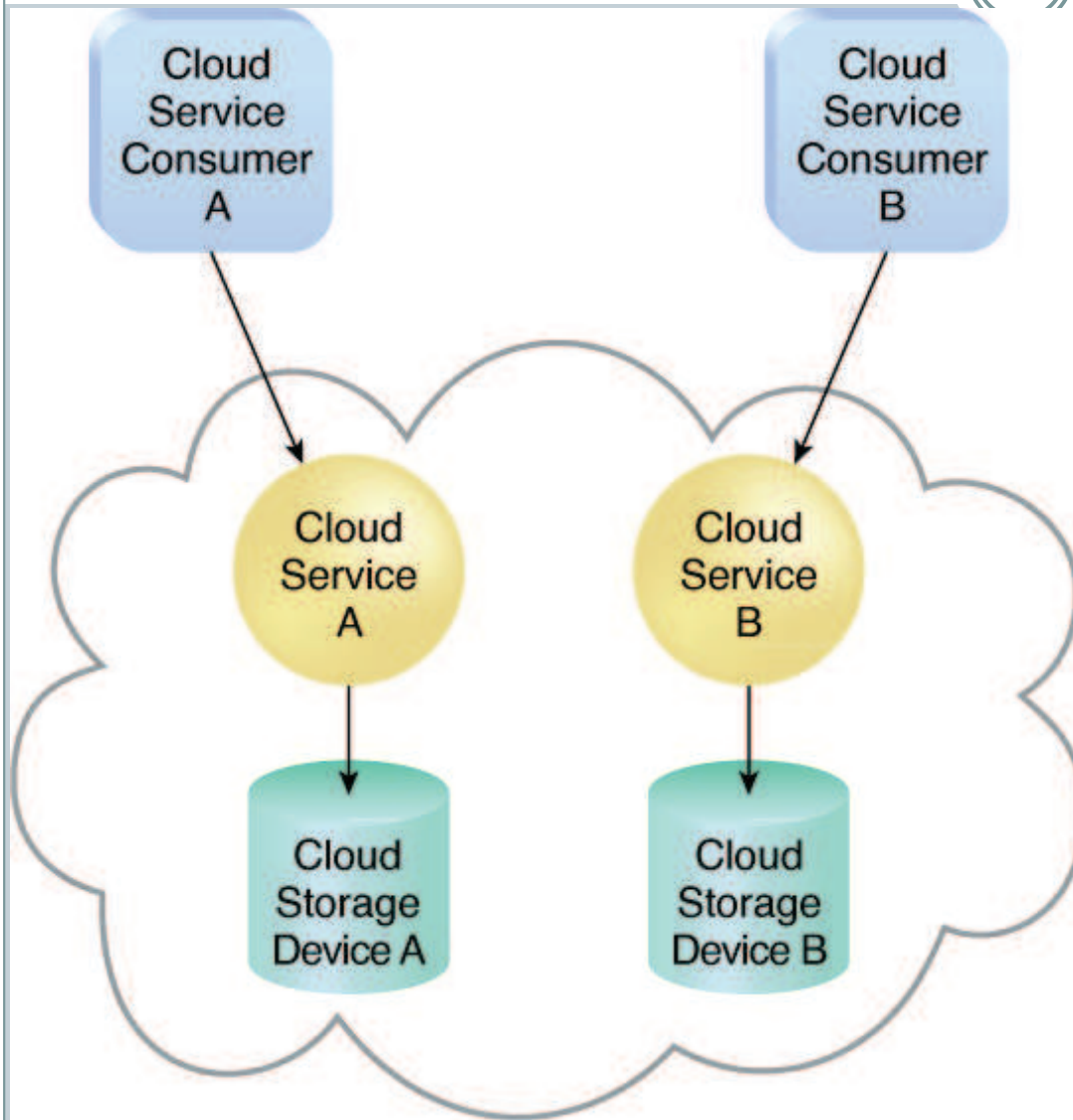
Figure 4.8 - In a single-tenant environment, each cloud consumer has a separate IT resource instance.
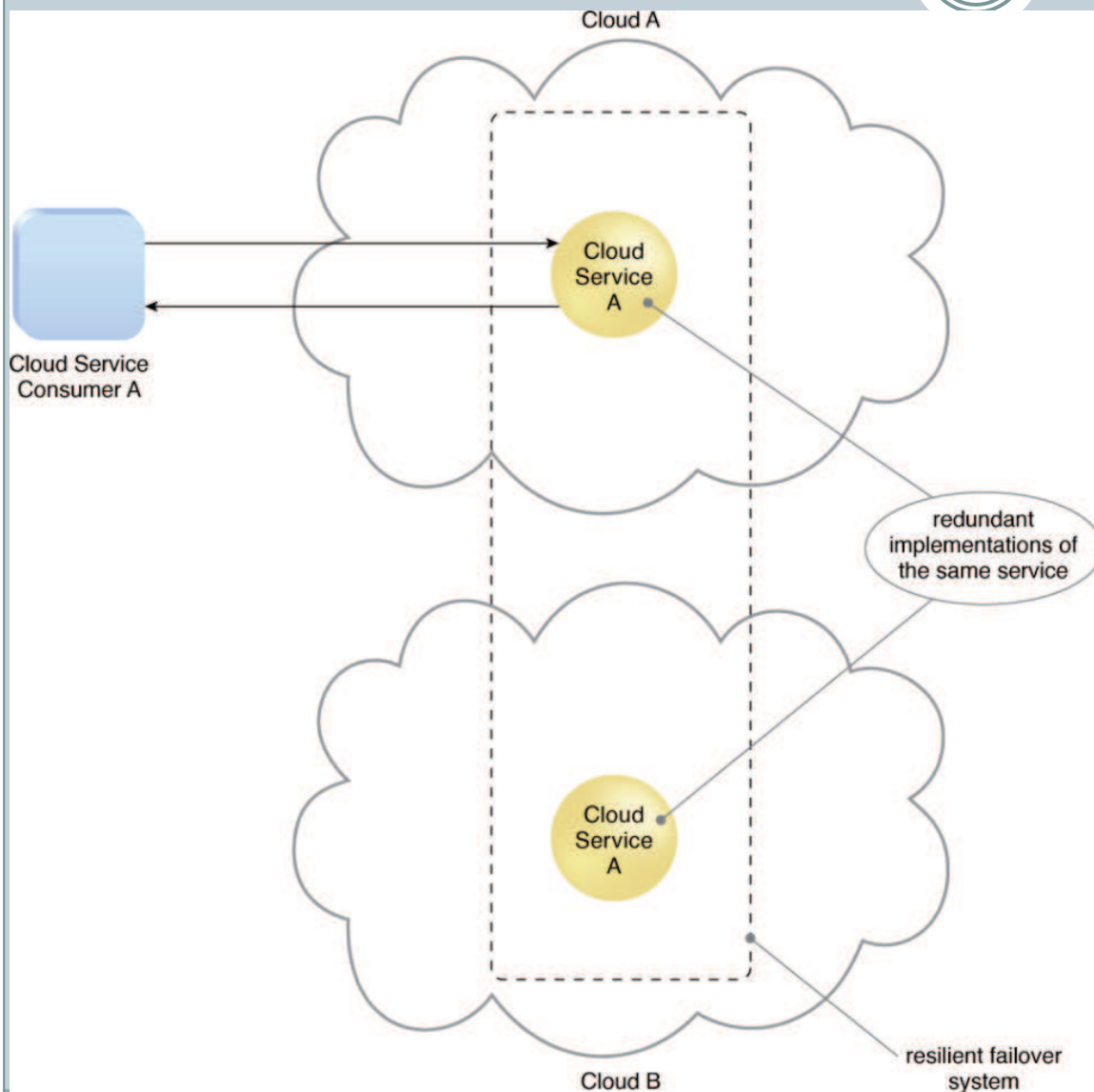
Figure 4.9

20

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

Figure 4.10

Cloud A

Cloud Service
Consumer A

Cloud
Service
A

redundant
implementations of
the same service

Cloud
Service
A

resilient failover
system

Cloud B

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

Summary of Key Points (1/2)

- 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.

- 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.
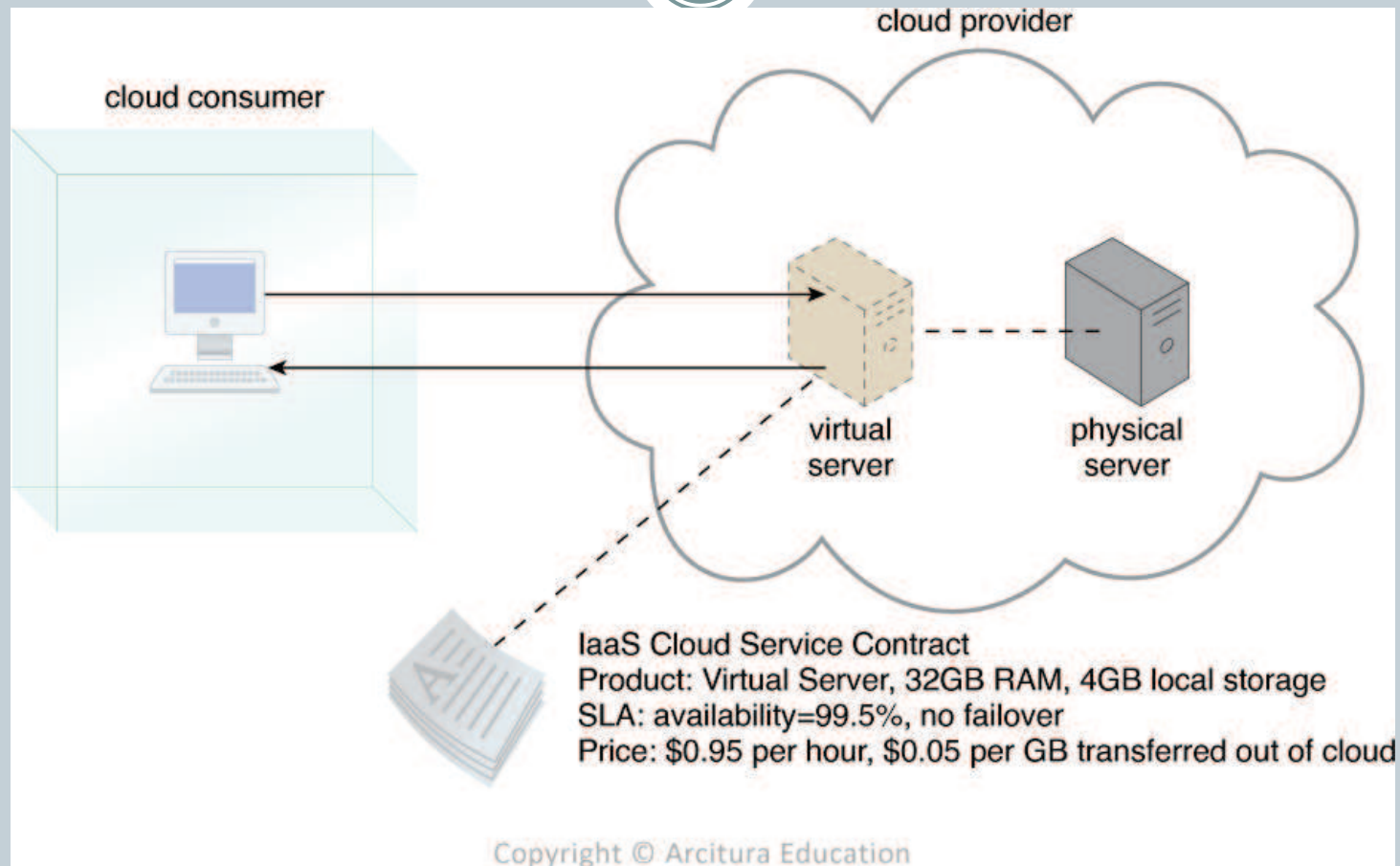
4.3 Cloud Delivery Models - Introduction

- Infrastructure-as-a-Service (IaaS)
- Platform-as-a-Service (PaaS)
- Software-as-a-Service (SaaS)
- ◆ Variations are emerged by comprised of a distinct combination of IT resources, such as
  - ➢ storage-as-a-service
  - ➢ database-as-a-service
  - ➢ security-as-a-service
  - ➢ communication-as-a-service
  - ➢ integration-as-a-service, etc

Figure 4.11

cloud provider

cloud consumer

virtual
server

physical
server

IaaS Cloud Service Contract
Product: Virtual Server, 32GB RAM, 4GB local storage
SLA: availability=99.5%, no failover
Price: $0.95 per hour, $0.05 per GB transferred out of cloud

- *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.*

- Infrastructure-as-a-Service (IaaS)

➢ IaaS represents a self-contained IT environment comprised of infrastructure-centric IT resources that can e accessed and managed via cloud service-based interfaces and tools.

➢ IaaS usually includes hardware, network, connectivity, operating systems, and other raw IT resources.

➢ With IaaS, IT resources are typically virtualized and packaged into bundles.

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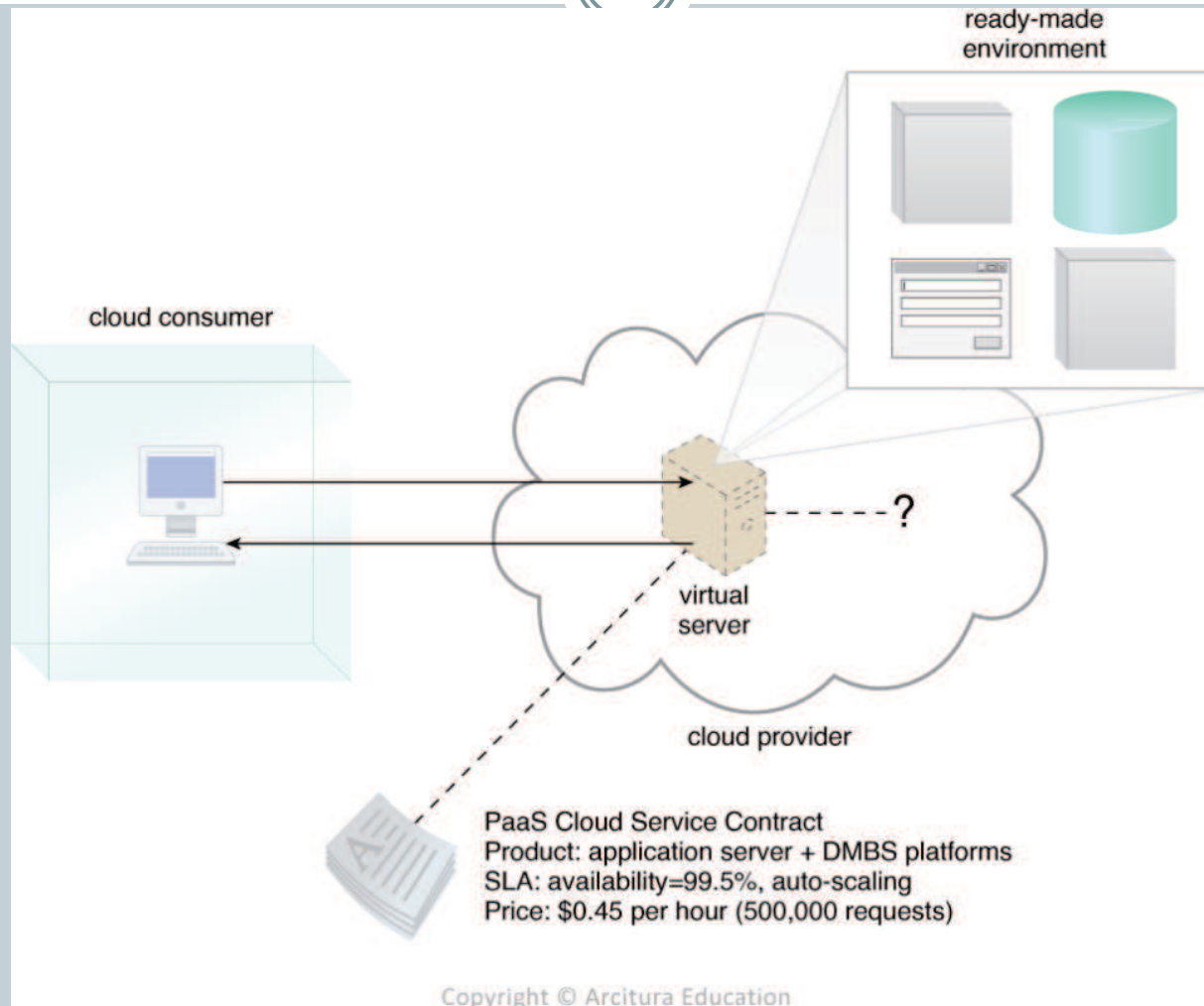
- *Figure 4.12 - A cloud consumer is accessing a ready-made PaaS environment. The question mark indicates that the cloud consumer is intentionally shielded from the implementation details of the platform.*

- Platform-as-a-Service (PaaS)

➢ It represents a pre-defined ready-to-use environment typically comprised of already deployed and configured IT resources.

➢ PaaS relies on the usage of a ready-made environment that establishes a set of pre-packaged products and tools used to support the entire delivery lifecycle of custom applications.

➢ As an example, GAE offers a Java and Python-based environement.

Figure 4.13

SaaS Cloud Service Contract
SLA: response time=0.5ms
Price: $0.05 per 100 requests
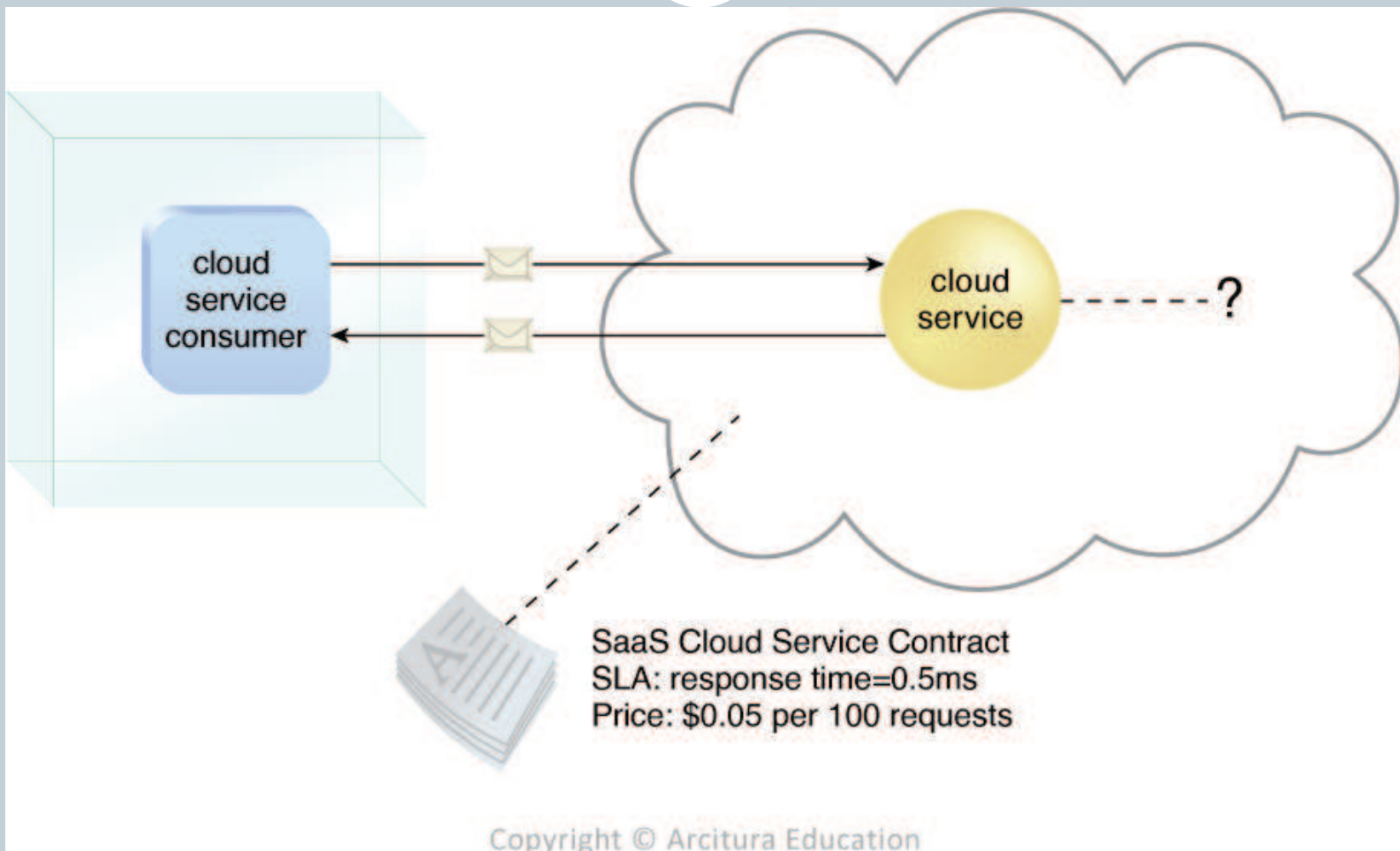
- *Figure 4.13 - The cloud service consumer is given access the cloud service contract, but not to any underlying IT resources or implementation details.*

- Service-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 offerings.

➤ A cluud consumer is generally granted very limited administrative control over a SaaS implementation.

- ## Comparing Cloud Delivery Models
  - ○ See table 4.1 and table 4.2

Table 4.1 A comparison of typical cloud delivery model 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 4.2 Typical activities carried out by cloud consumers and cloud providers in relation to the 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 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 monitors usage by cloud consumers
IaaS	sets up and configures bare infrastructure, and installs, manage, and monitors any needed software	provisions and manages the physical processing, storage, networking, and hosting required monitors usage by cloud consumers

- ## Combining Cloud Delivery Models

  - ### IaaS + PaaS

    - For instance, the cloud provider offering the PaaS environment chose to lease an IaaS environment from a different cloud provider.

  - ### IaaS + PaaS + SaaS

    - For instance, by adding on to the preceding layered architecture, the 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.
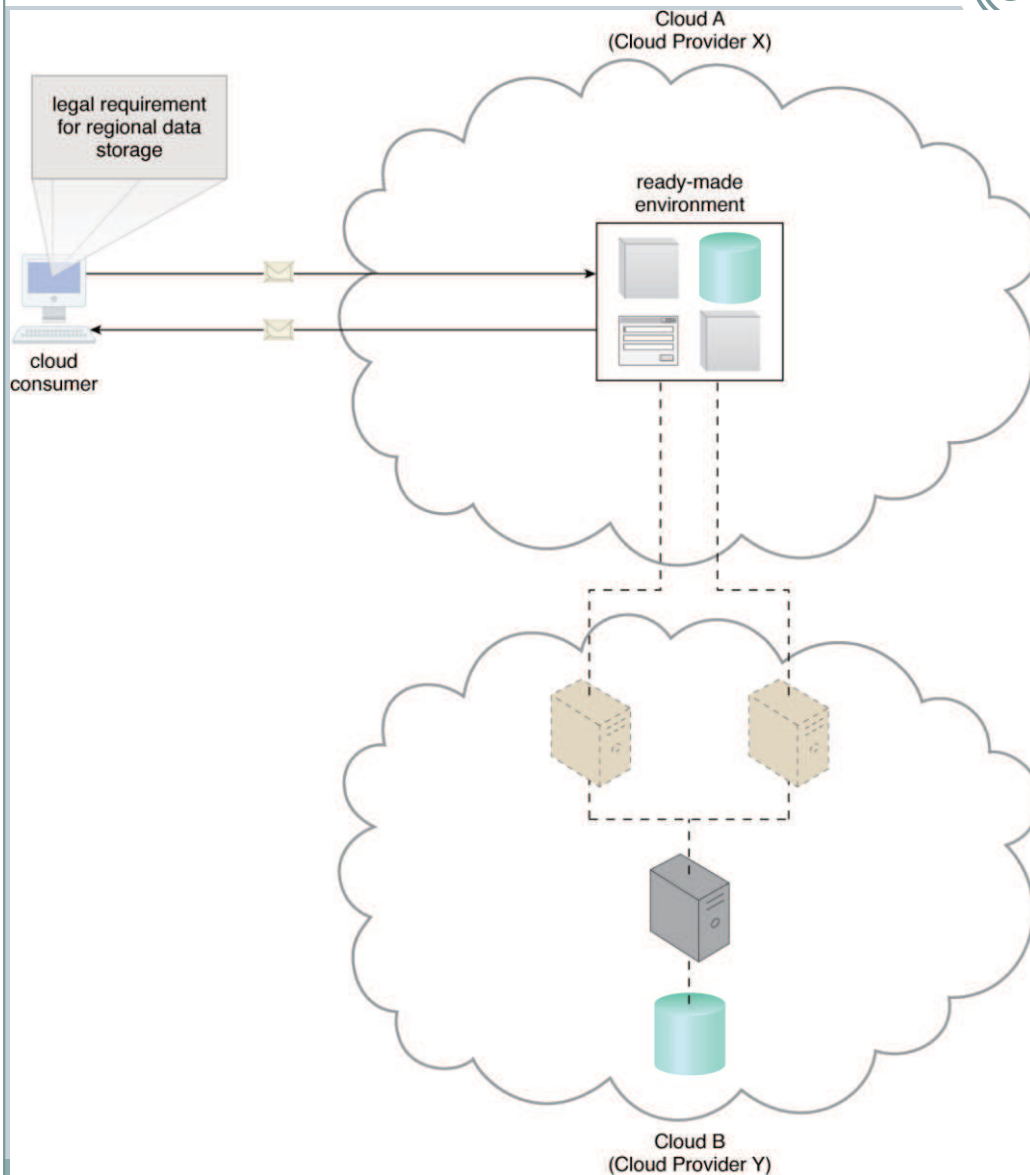
Figure 4.14

35

Copyright © Arcitura Education
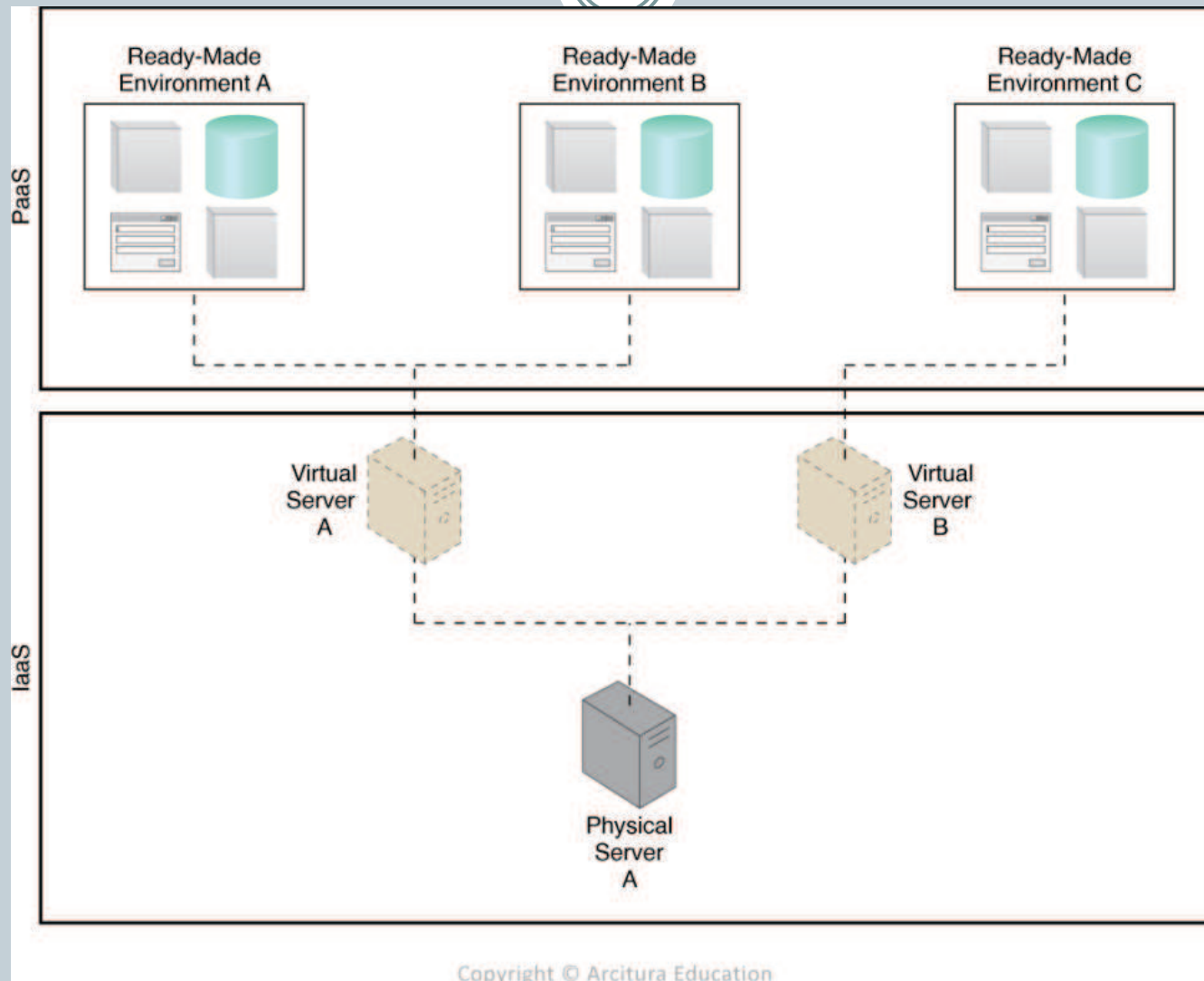
- *Figure 4.14 - A PaaS environment based on the IT resources provided by an underlying IaaS environment.*

Figure 4.15

Cloud A
(Cloud Provider X)

legal requirement for regional data storage

ready-made environment

cloud consumer
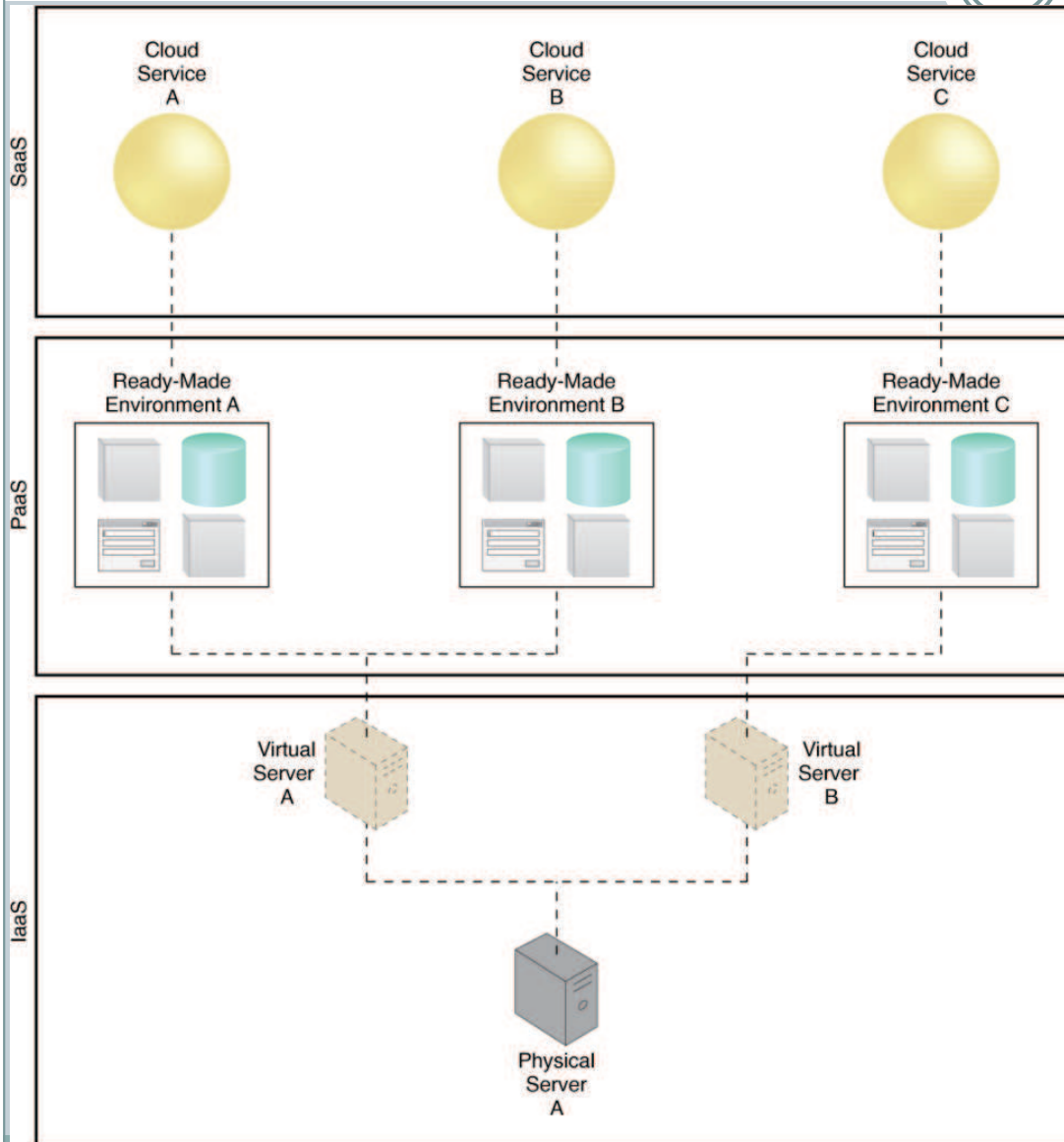
Cloud B
(Cloud Provider Y)

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- *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.*

Figure 4.16

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

Summary of Key Points (1/2)

- The IaaS delivery model offers cloud consumers a high level of administrative control over "raw" infrastructure-based IT resources.

- The PaaS delivery model enables a cloud provider to offer a preconfigured environment that cloud consumers can use to build and deploy cloud services and solutions, albeit with decreased administrative control.

Summary of Key Points (2/2)

- SaaS is a cloud deliver 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.
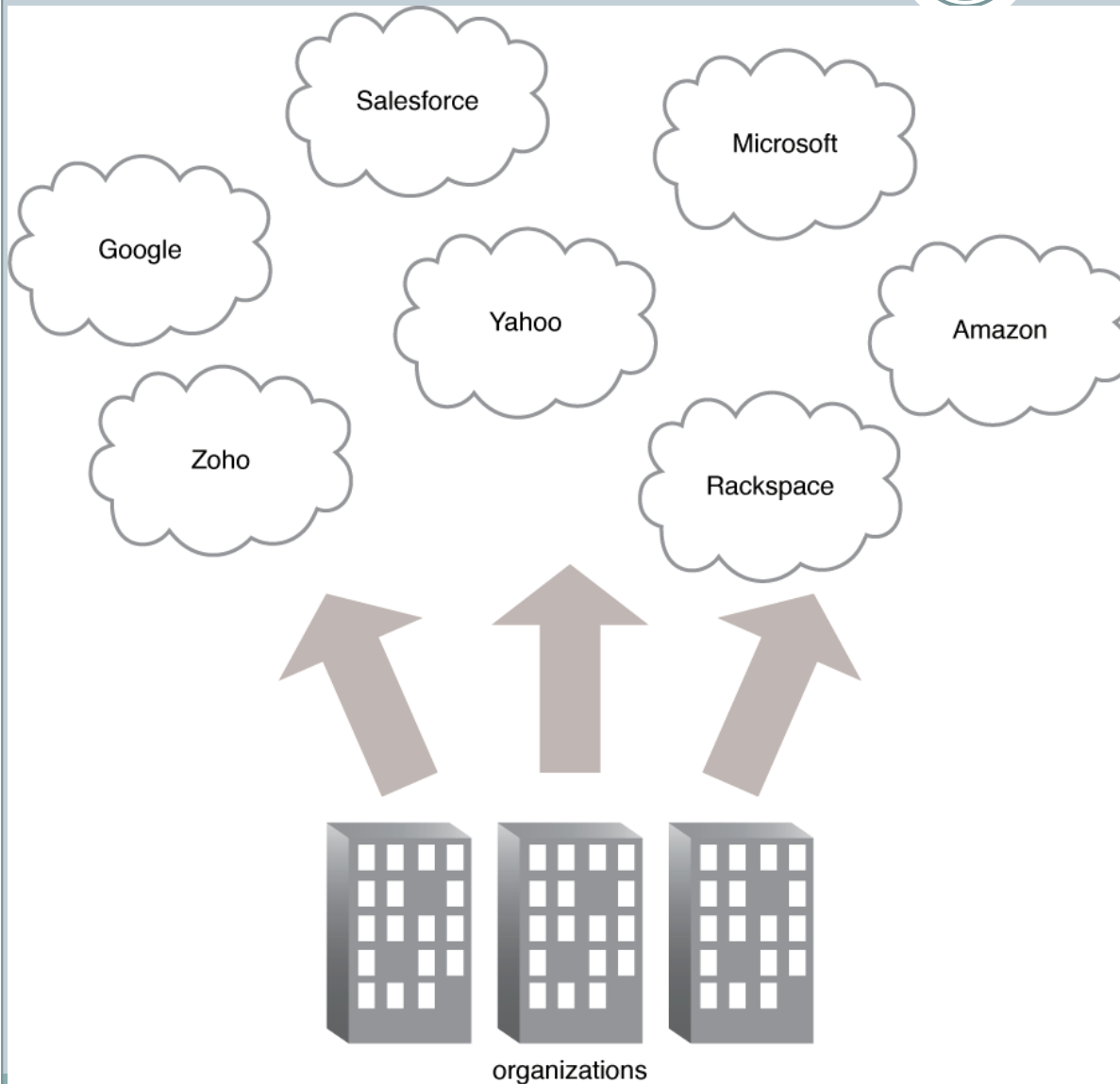
4.4 Cloud Deployment Models (1/)

- Public clouds (Figure 4.17)
- Community clouds (Figure 4.18)
- Private clouds (Figure 4.19)
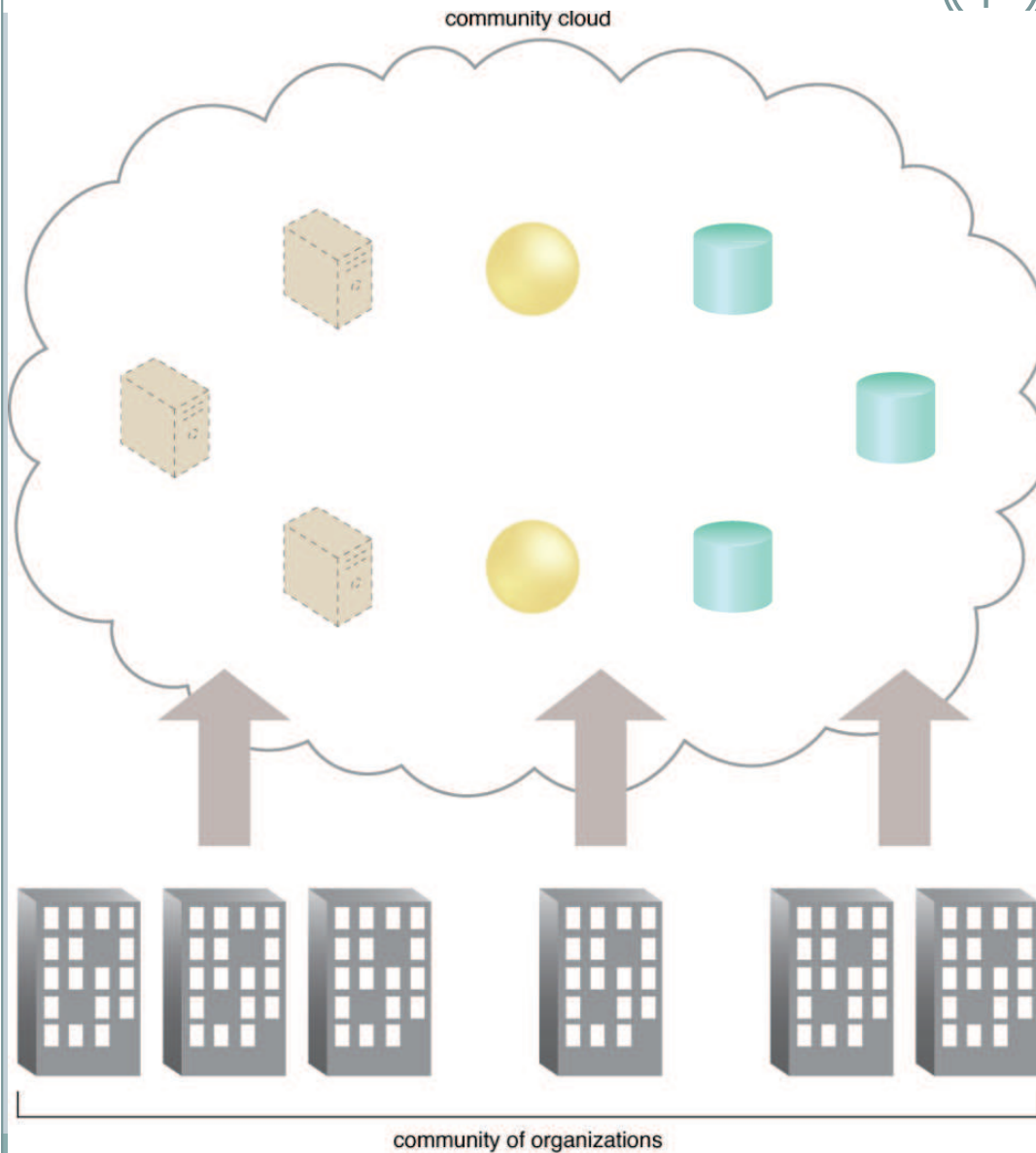- Hybrid clouds (Figure 4.20)

Figure 4.17

- *Figure 4.17 - Organizations act as cloud consumers when accessing cloud services and IT resources made available by different cloud providers.*
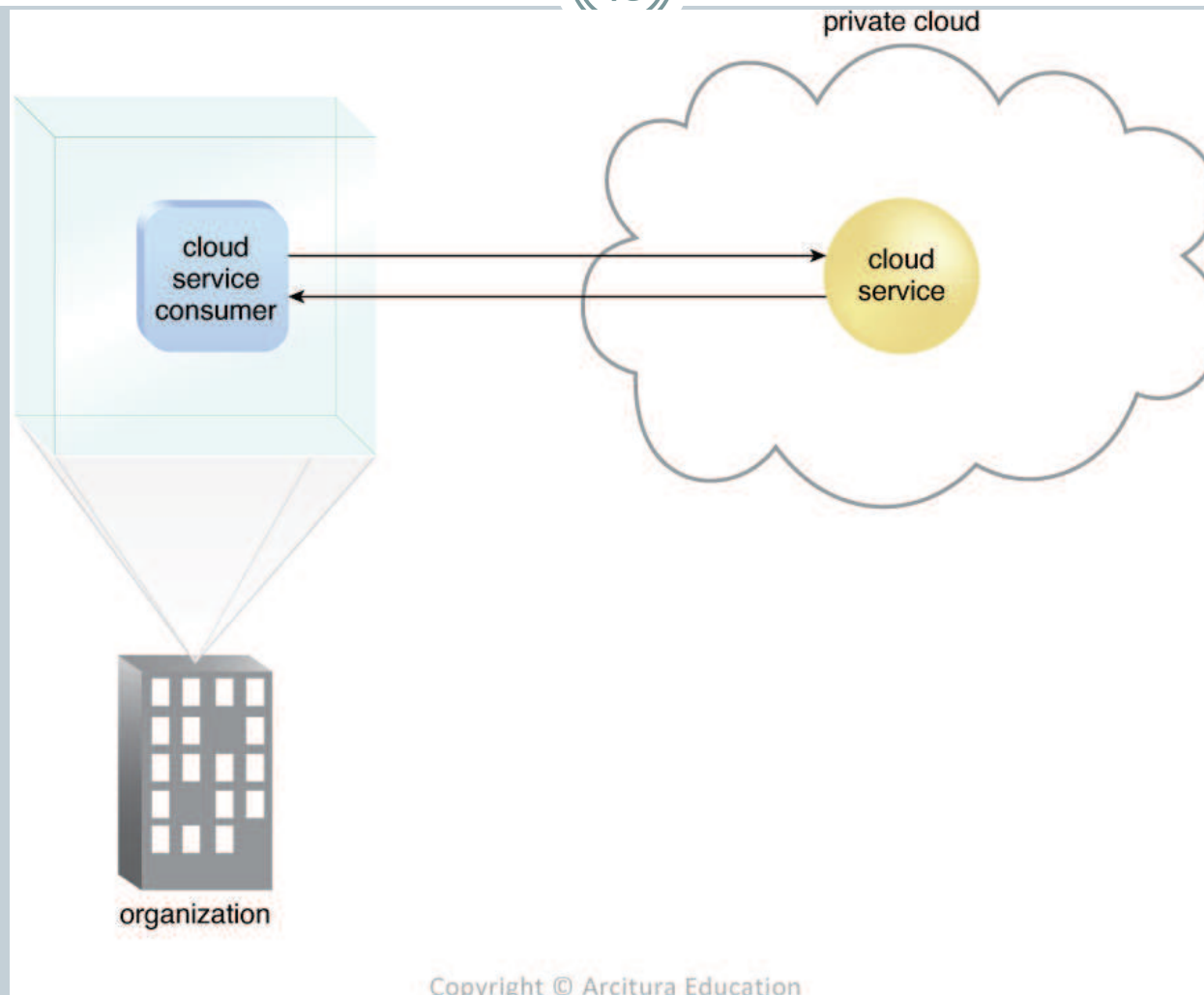
Figure 4.18

community cloud

community of organizations

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- *Figure 4.18 - An example of a "community" of organizations accessing IT resources from a community cloud.*
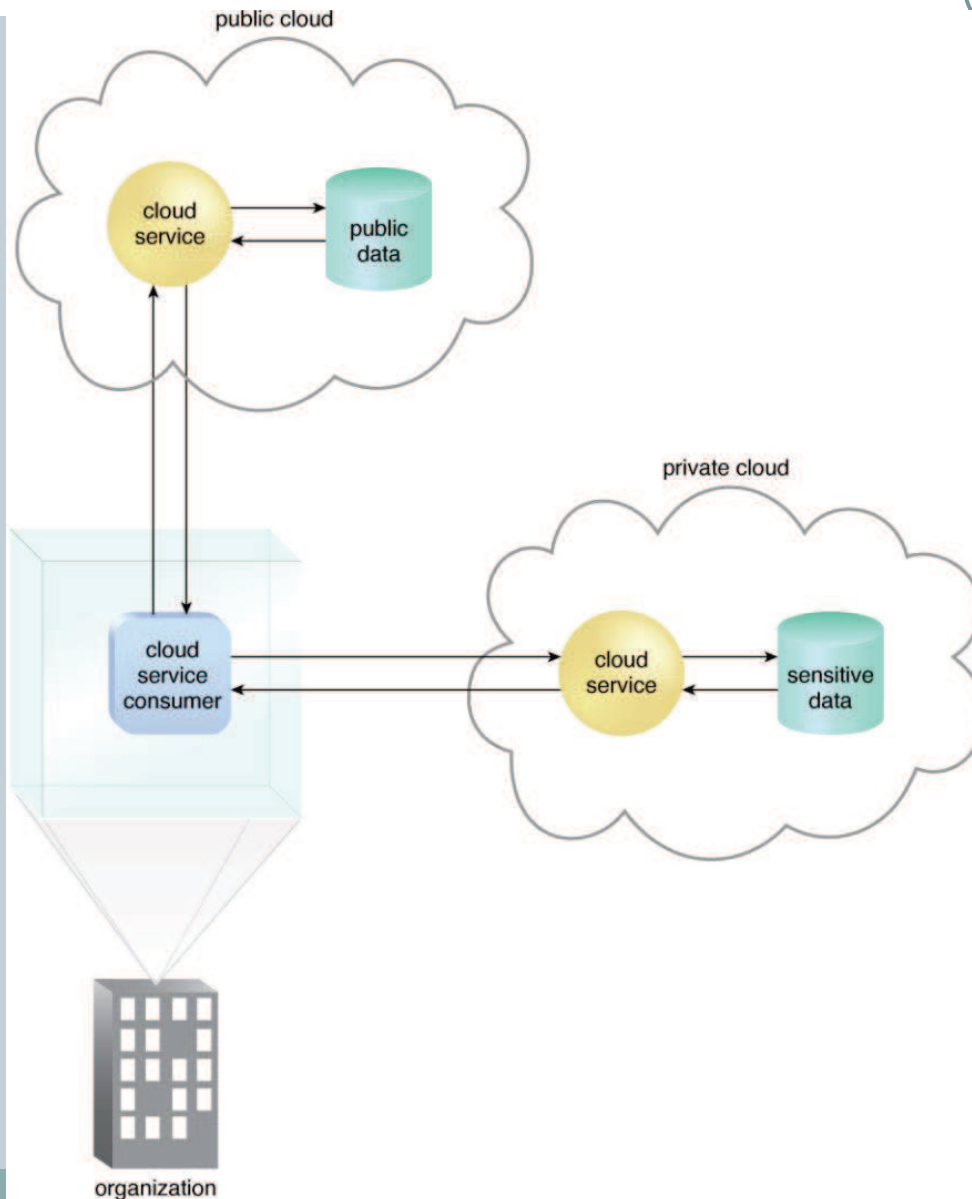
Figure 4.19

- *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.*

Figure 4.20

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

Summary of Key Points

- 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 cloud deployment models.