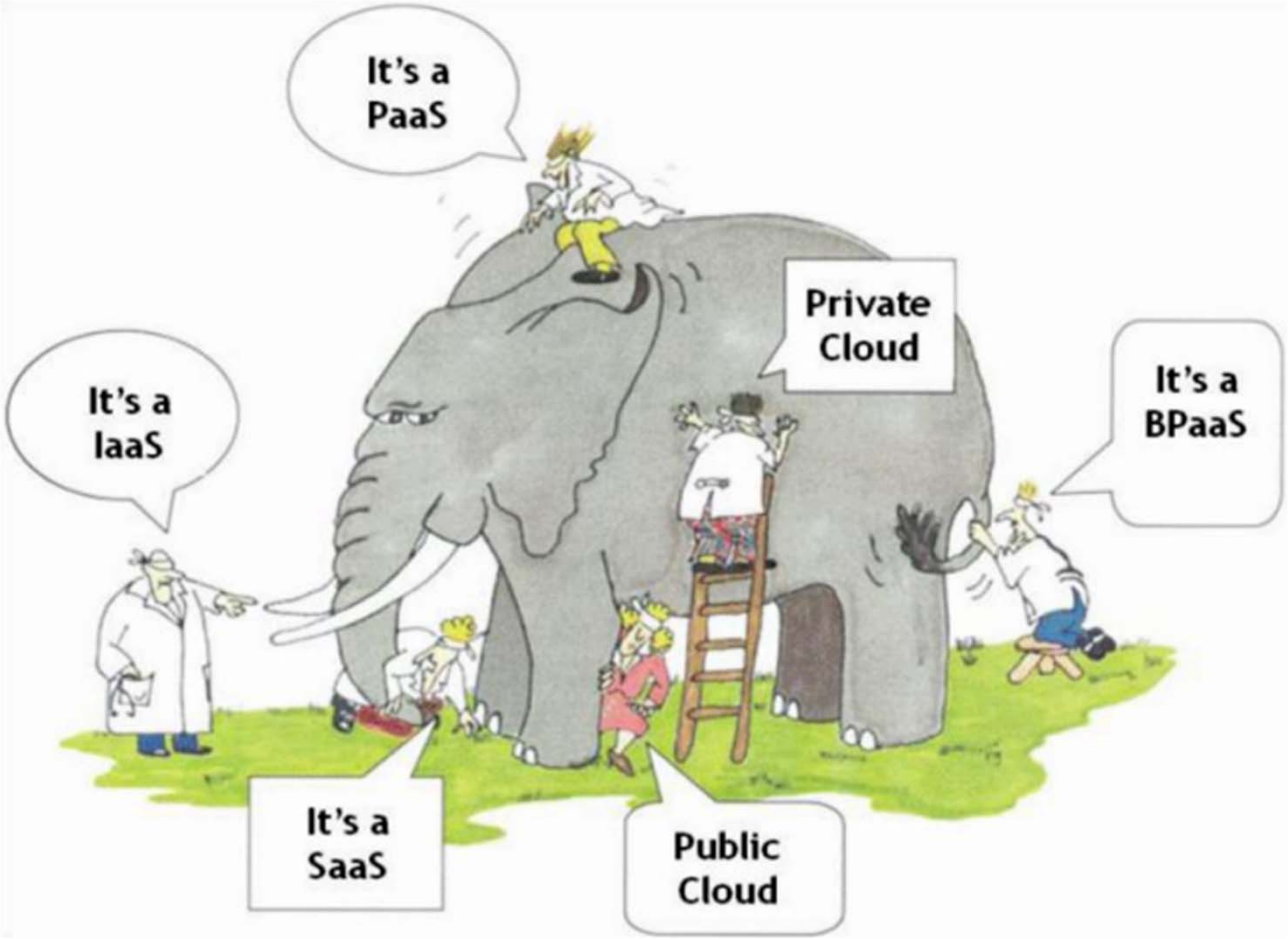
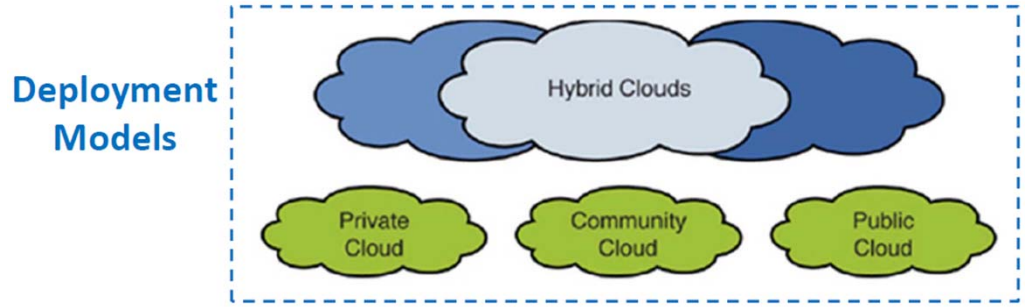
L02: Concepts and Models



Outline

- NIST Definition
- Cloud Characteristics
- Cloud Service (Delivery) Models

- Conceptual Reference Architecture
  - Actor Roles and Organizational Boundaries
  - Interactions between the Actors
  - Key Functions of Cloud Providers
- Cloud Deployment Models



- Summary

Key Terms

1. Elasticity
2. On-demand self service
3. Pay-per-use (measured service)
4. Multi-tenancy (location independent resource pooling)
5. Cloud service (delivery) models
6. Cloud deployment models
7. Cloud actors
8. Trust boundary

Cloud Computing (NIST 2011)

".. 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**.

Composed of *five* essential characteristics, *three* service models and *four* deployment models"

CHARACTERISTICS

1. On-demand self-service
2. Broad network access
3. Resource pooling
4. Rapid elasticity
5. Measured service
6. Resiliency

SERVICE MODELS

1. Software-as-a-Service (SaaS)
2. Platform-as-a-Service (PaaS)
3. Infrastructure-as-a-Service (IaaS)

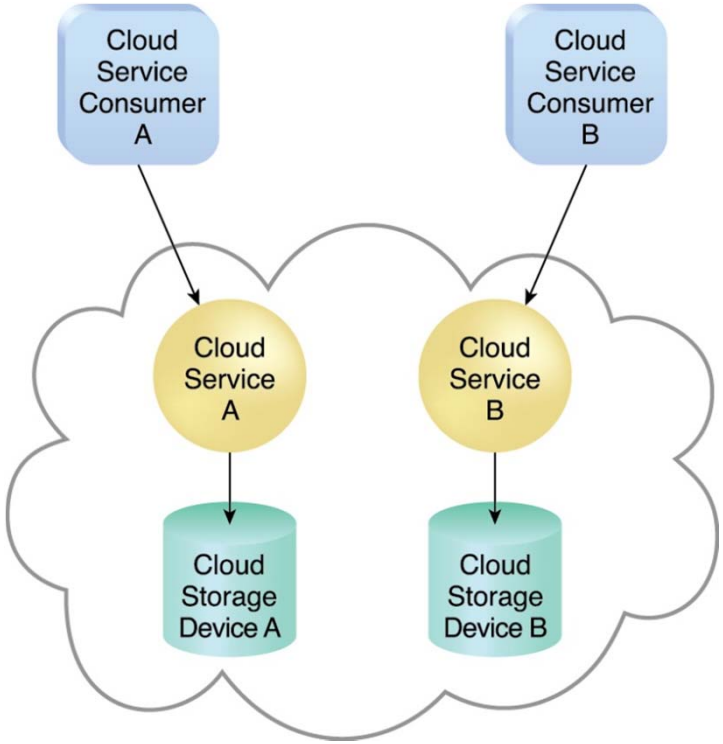
DEPLOYMENT MODELS

1. Private Cloud
2. Community Cloud
3. Public Cloud
4. Hybrid Cloud

CLOUD CHARACTERISTICS

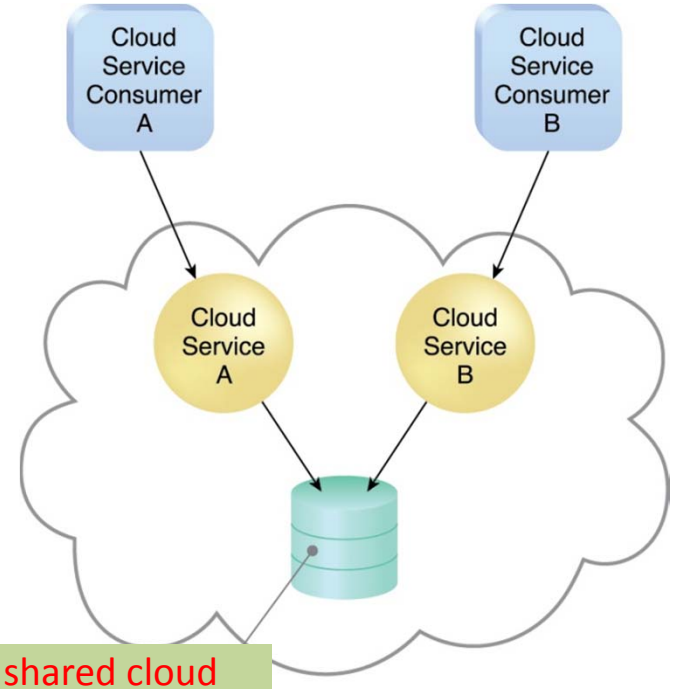
1. On-demand self-service through a service portal
2. Broad network access (ubiquitous access)
3. Location-independent resource pooling (multi-tenancy)
4. Rapid elasticity – time to market / fast deployment
5. Measured service (pay-per-use)
6. Resiliency

Single vs Multi-tenancy



Single-tenant - each cloud consumer has a separate IT resource instance.

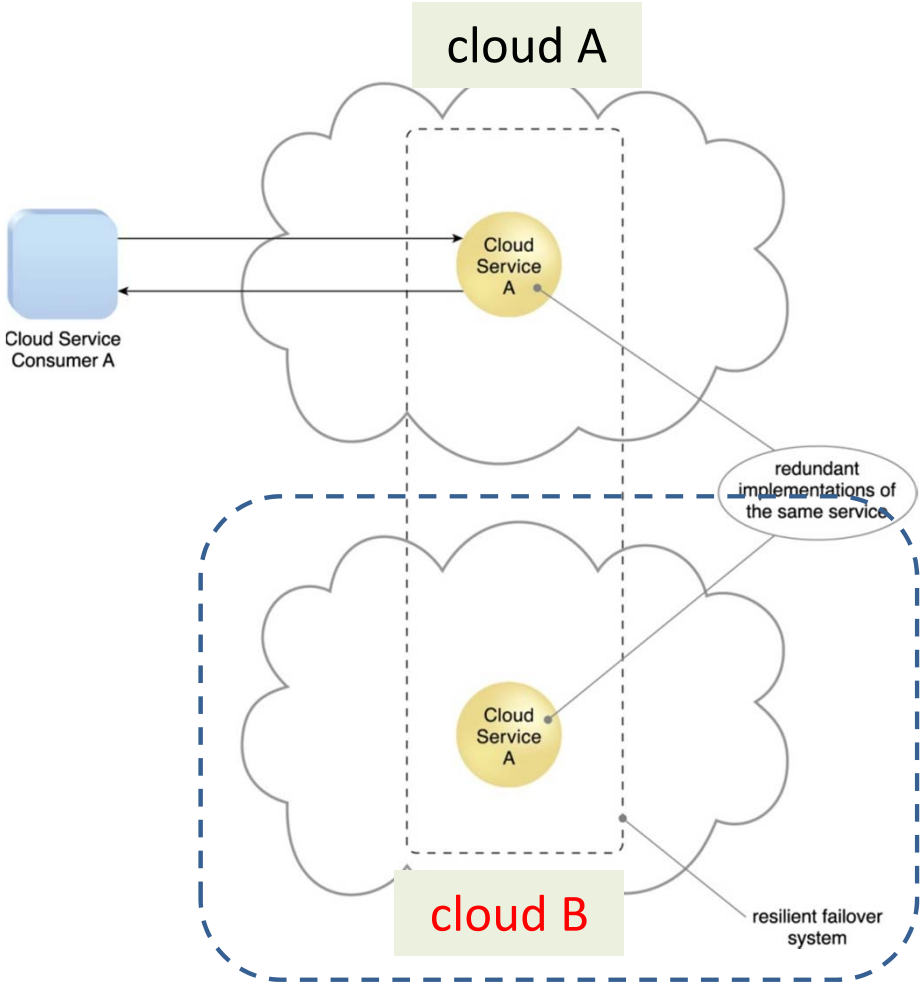
Why?



Multi-tenancy - a single instance of an IT resource, such as a cloud storage device, serves multiple consumers.

back

Resiliency



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

Cloud Service Models

- **Software-as-a-Service (SaaS):** use provider's applications over a network, e.g., Salesforce.com, Google apps
- **Platform-as-a-Service (PaaS):** deploy customer-related applications to a cloud, e.g., Google's app engine, Amazon AWS, Microsoft Windows Azure
- **Infrastructure-as-a-Service (IaaS):** rent processing, storage, network capacity and other fundamental computing resources, e.g., Amazon EC2, Savvis Symphony

To be considered "cloud", services must be deployed on top of a cloud infrastructure that has the key characteristics.

Why?

Cloud Service Models

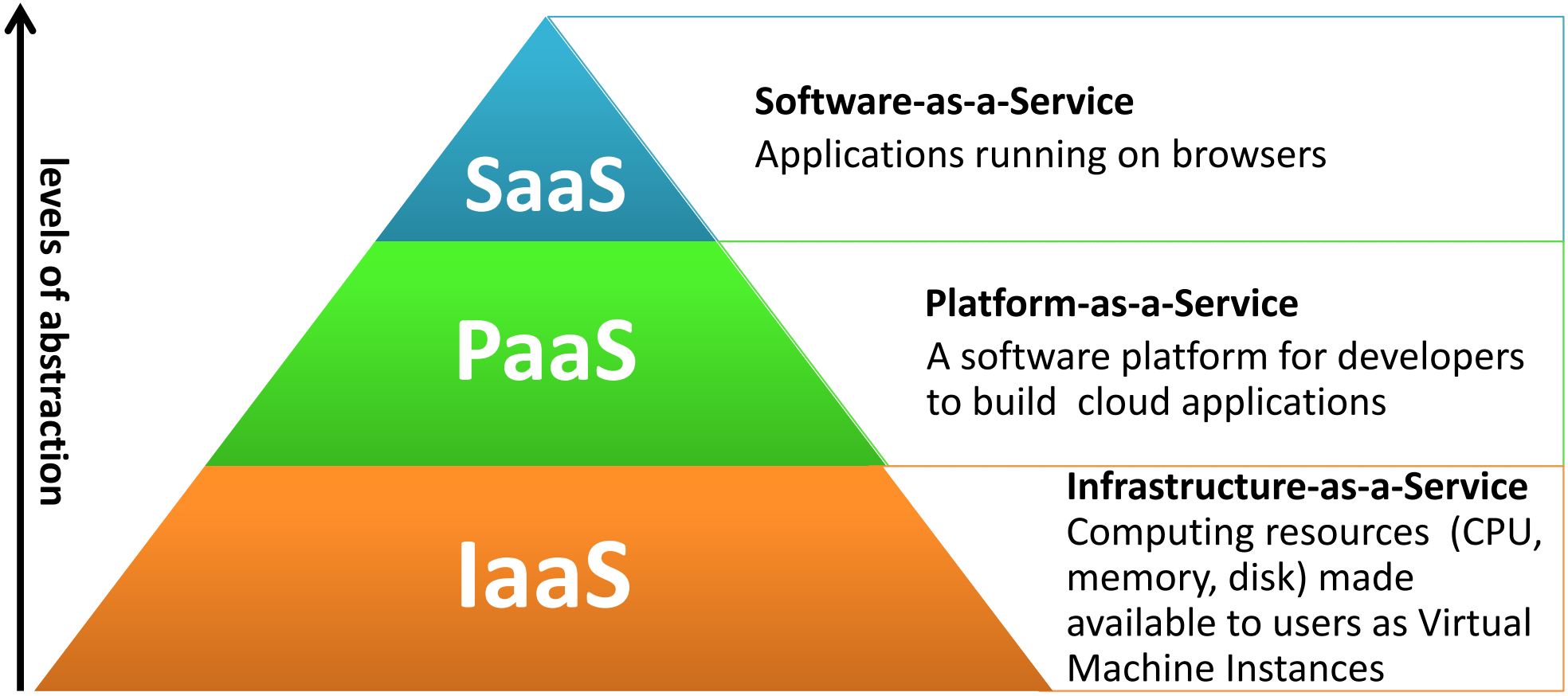
- **Software-as-a-Service (SaaS):** use provider's applications over a network, e.g., Salesforce.com, Google apps
- **Platform-as-a-Service (PaaS):** deploy customer-related applicati… …nazon AWS, Mi…
- **Infrastru…** …orage, network …uting resources, e.g., Amazon EC2, SAVVIS Symphony

Why?
different levels of abstraction provides ease of use (minimum setup), reduce management effort, fast deployment

To be considered "cloud", services must be deployed on top of a cloud infrastructure that has the key characteristics.

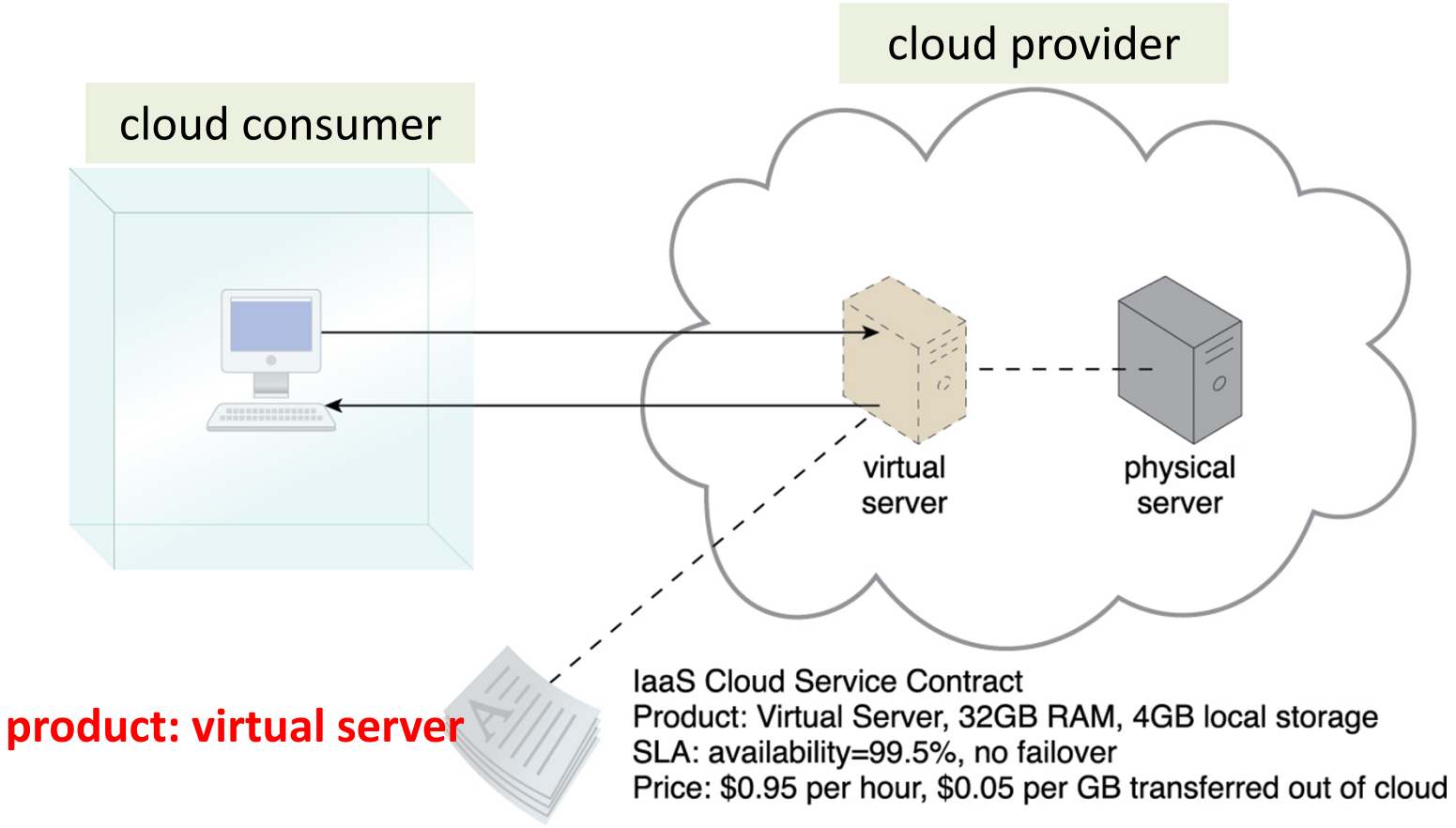
Why?

Cloud Service (Delivery*) Models



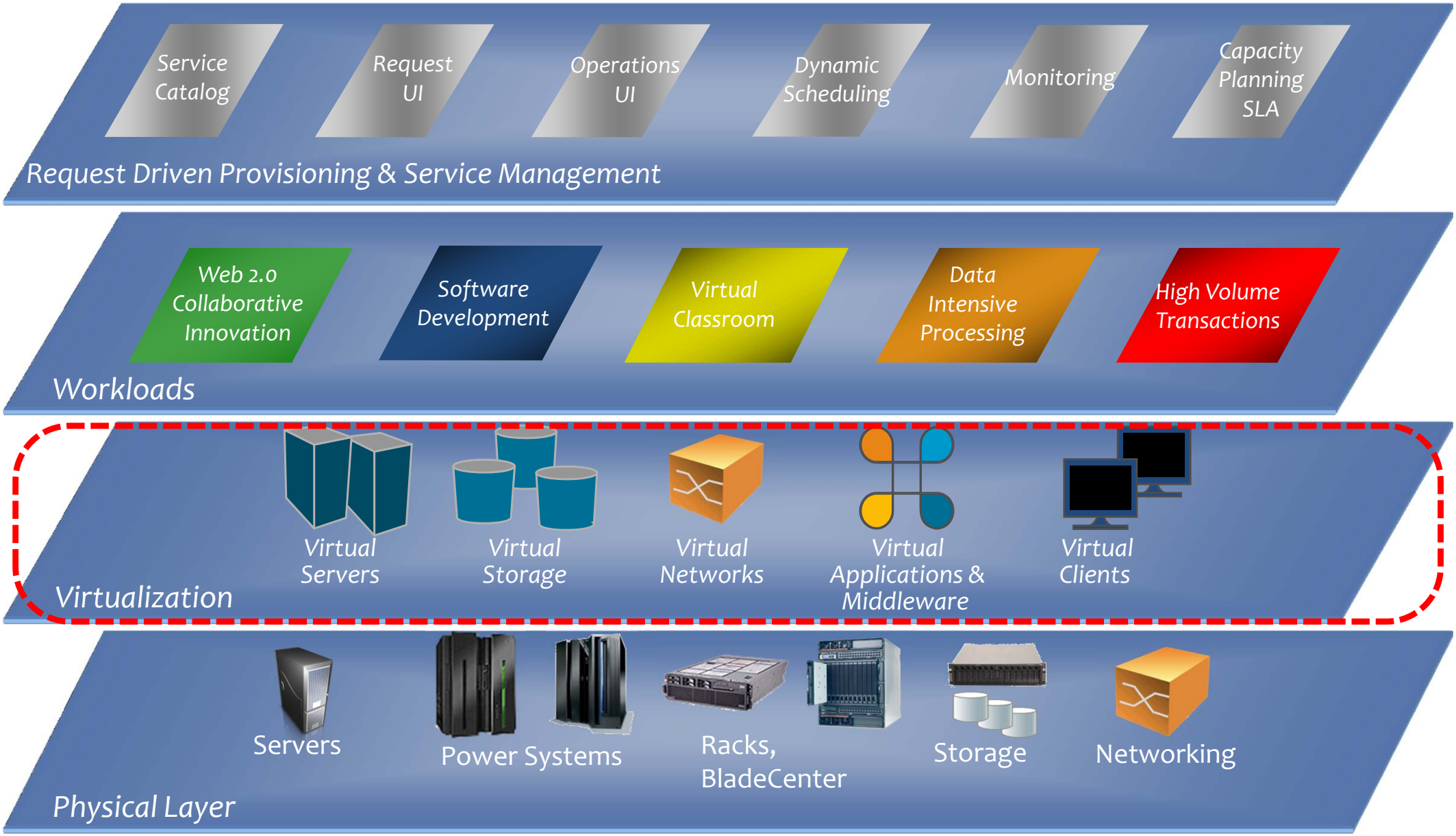
* - service model is referred to as delivery model in our main text

Infrastructure-as-a-Service (IaaS)

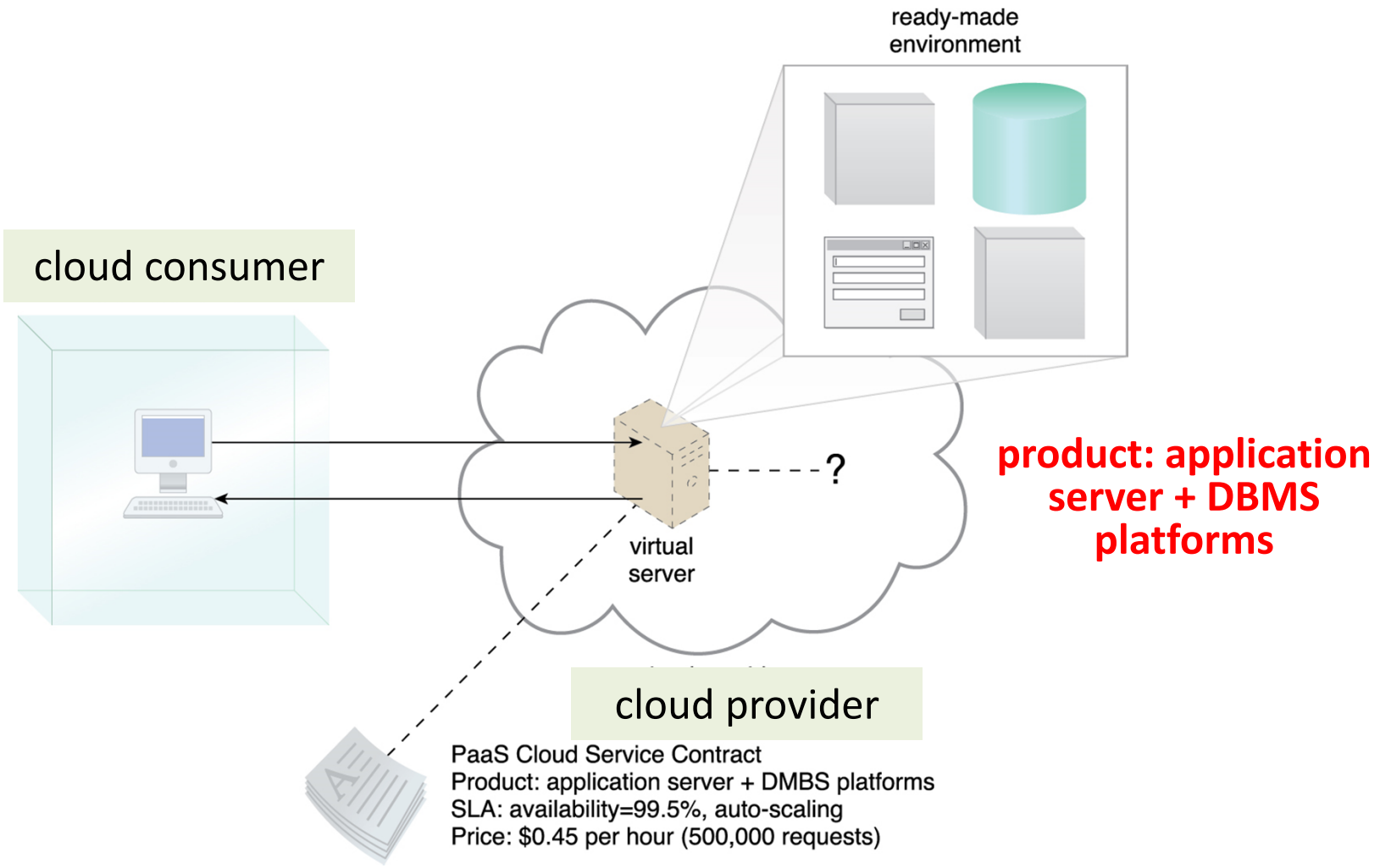


A cloud consumer is using **a virtual server** within an IaaS environment. Cloud consumers are provided with a range of contractual guarantees by the cloud provider, pertaining to characteristics such as *capacity*, *performance*, and *availability*.

IaaS

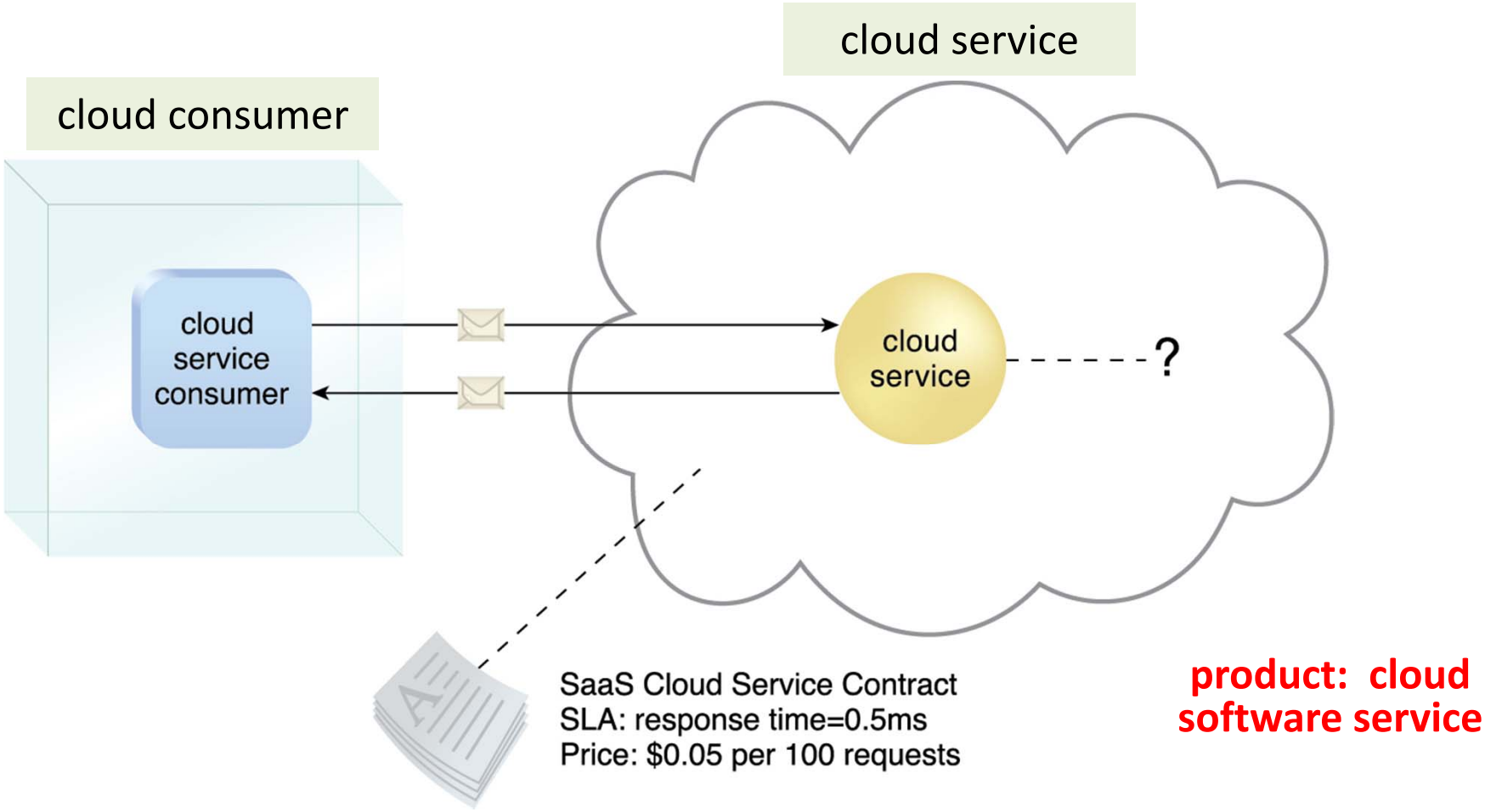

Service Catalog
Request UI
Operations UI
Dynamic Scheduling
Monitoring
Capacity Planning SLA
Request Driven Provisioning & Service Management
Web 2.0 Collaborative Innovation
Software Development
Virtual Classroom
Data Intensive Processing
High Volume Transactions
Workloads
Virtual Servers
Virtual Storage
Virtual Networks
Virtual Applications & Middleware
Virtual Clients
Virtualization
Servers
Power Systems
Racks, BladeCenter
Storage
Networking
Physical Layer

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)



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

Variations of Service Models

- 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
- …

Everything-as-a-Service

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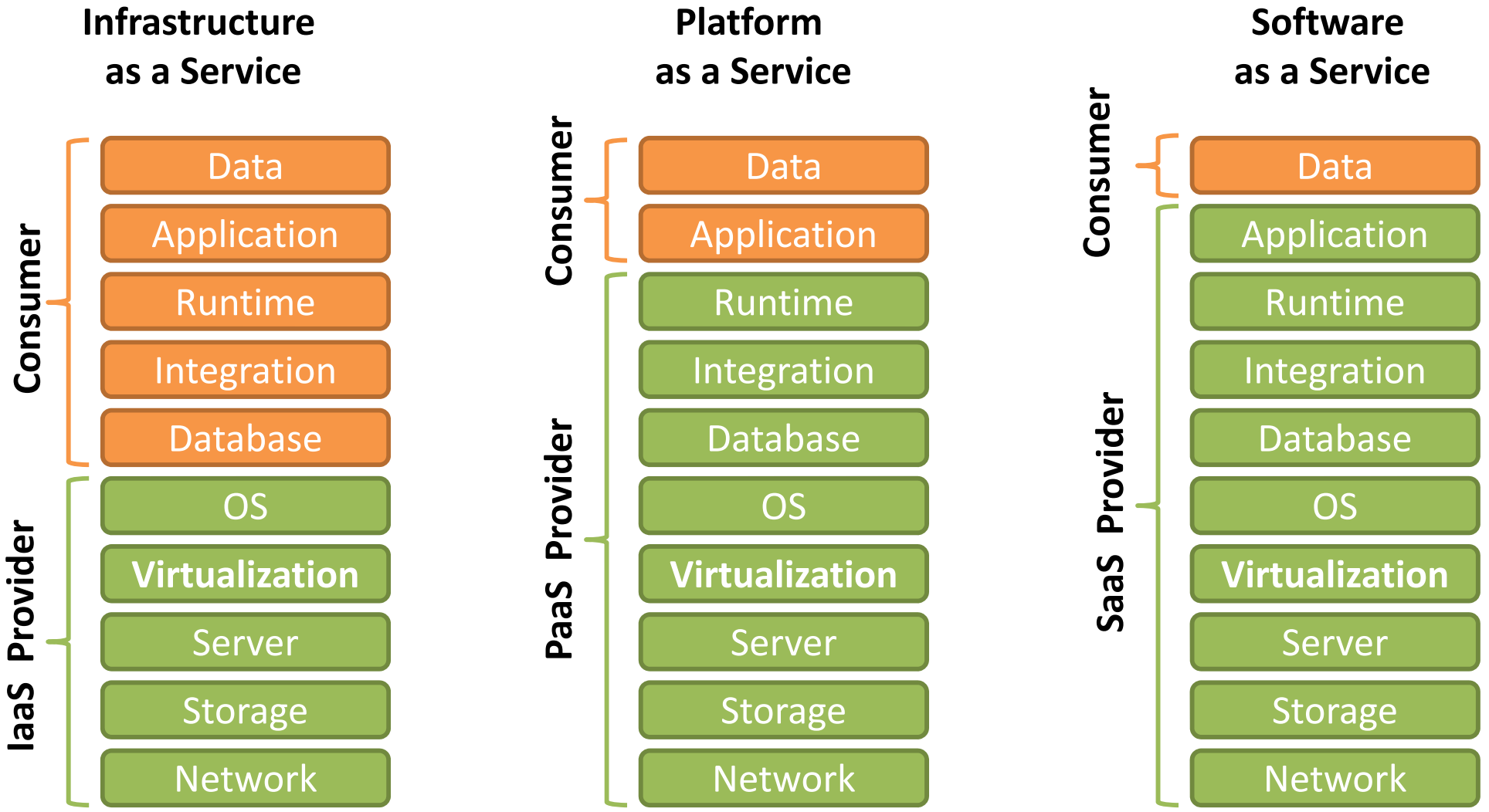
Comparison of Service Models



Comparison

Cloud Service 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.

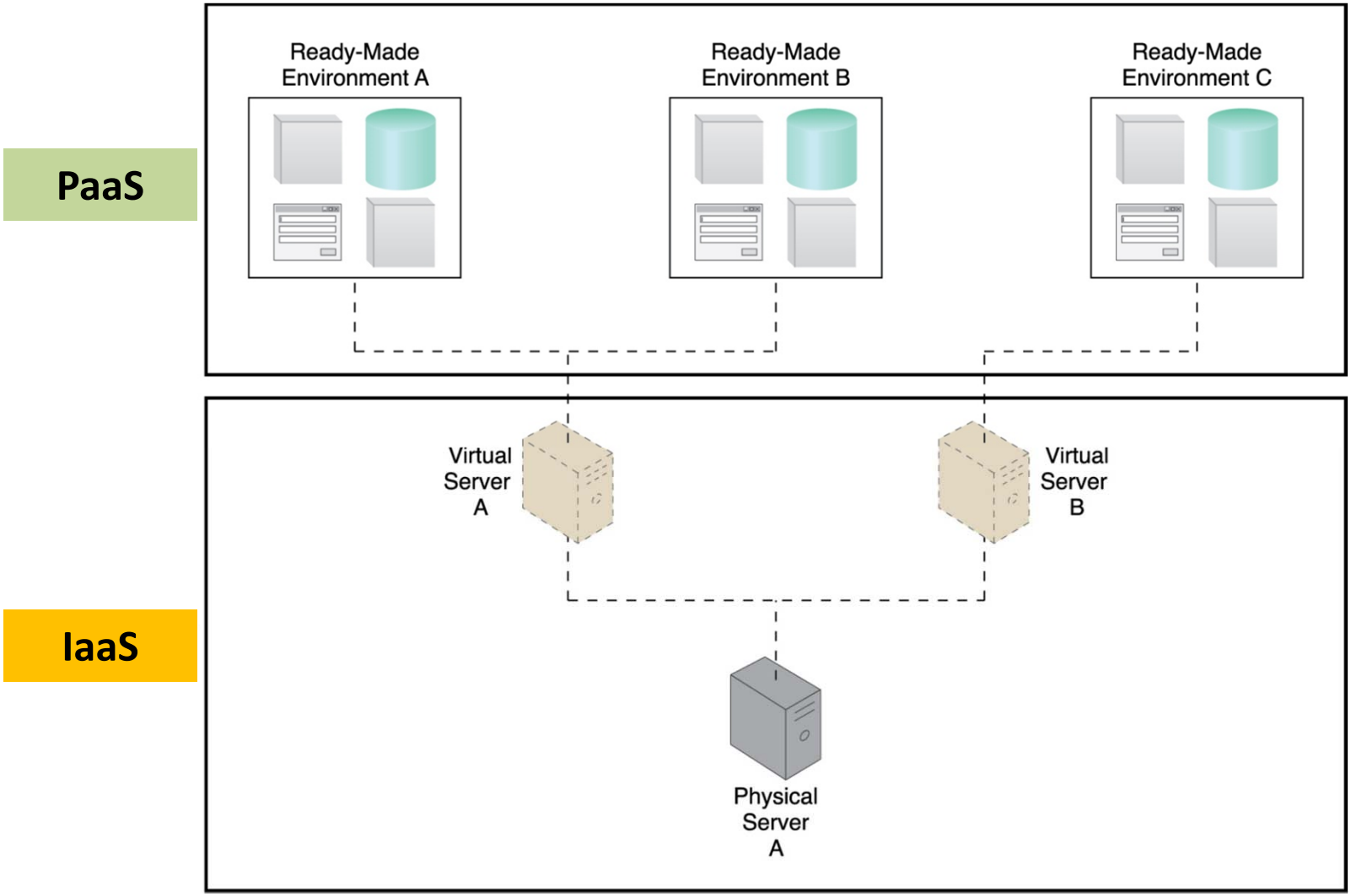
A comparison of typical cloud delivery model control levels.

Comparison

Cloud Service 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 solution	• 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, manages, and monitors any needed software	• Provisions and manages the physical processing, storage, networking, and hosting required • Monitors usage by cloud consumers

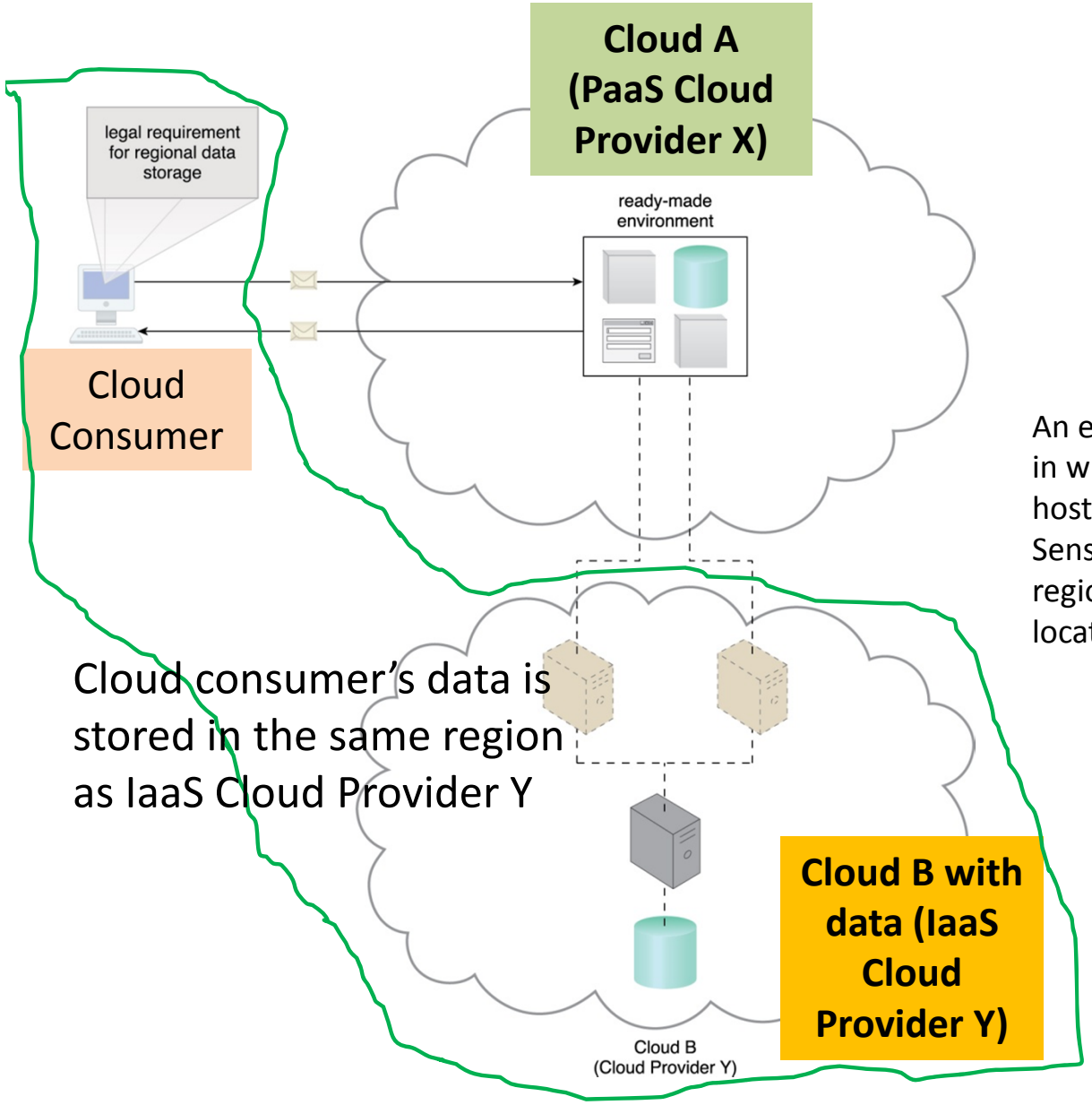
Typical activities carried out by cloud consumers and cloud providers in relation to the cloud delivery model

Combining IaaS and PaaS



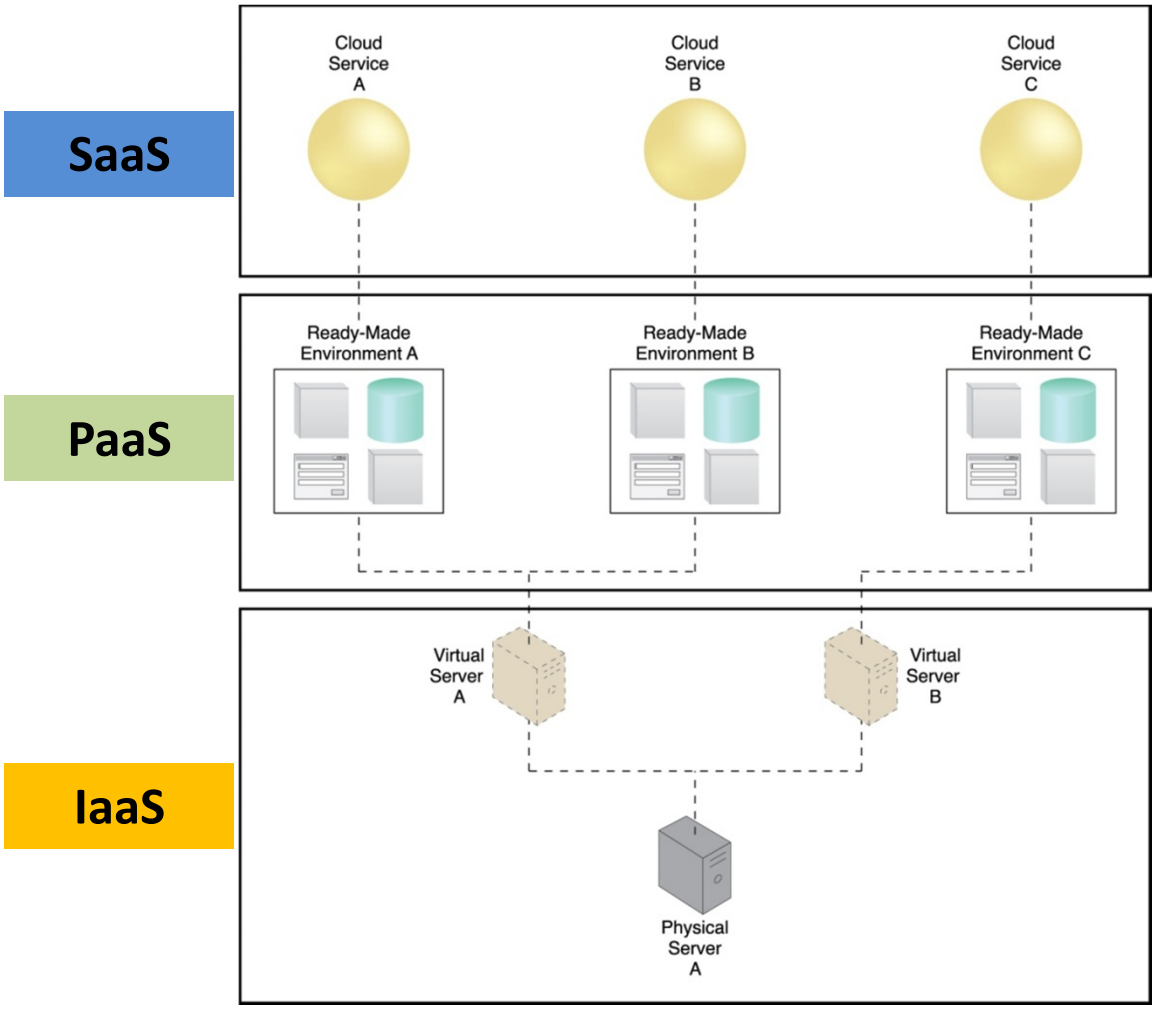
A PaaS environment based on the IT resources provided by an underlying IaaS environment.

Example: Meeting Legal Requirement for Data Storage



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 IaaS, PaaS and SaaS



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

Pros and Cons of Service Models

Service Models	Pros	Cons
Traditional	highest flexibility	long time-to-market
IaaS	scalability, no hw procure	privacy
PaaS	DB, Frameworks, middleware ready	vendor lock in
SaaS	time-to-market	lowest flexibility

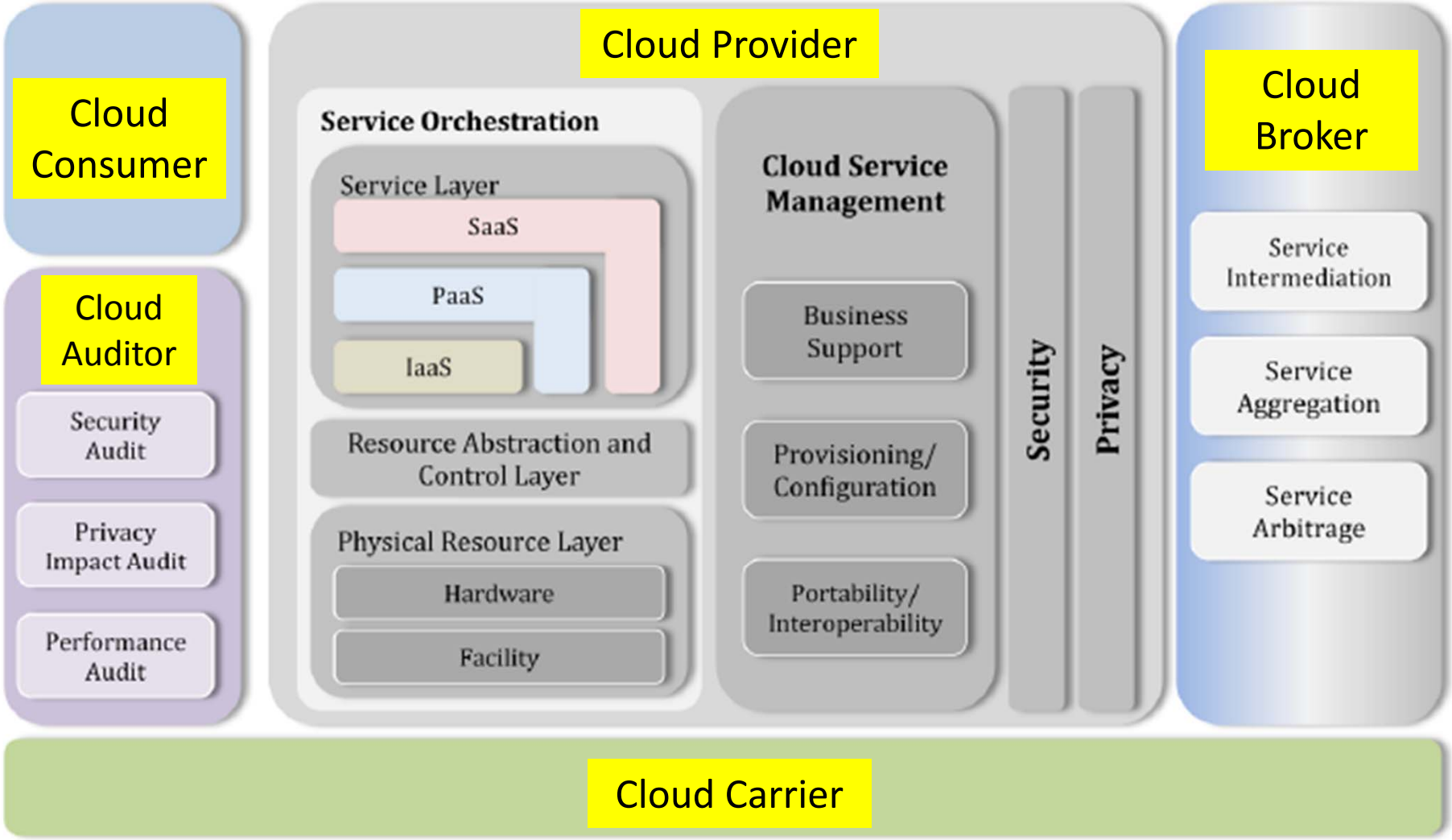
NIST Reference Model (2011)

- Focuses on the requirements of "**what**" cloud services provide, not a "how to" design solution and implementation
- Does not represent the system architecture of a specific cloud computing system
- But provide a common reference framework for describing, discussing and developing a system-specific architecture

vendor and implementation independent

NIST (National Institute of Standards & Technology), US Department of Commerce

Cloud Computing Reference Architecture



Cloud Computing Reference Architecture

- 5 major actors:
  - Cloud consumer
  - Cloud provider
  - Cloud auditor
  - Cloud broker
  - Cloud carrier

- Each actor is an entity (a person or an organization) that participates in a transaction or process and/or performs tasks in cloud computing

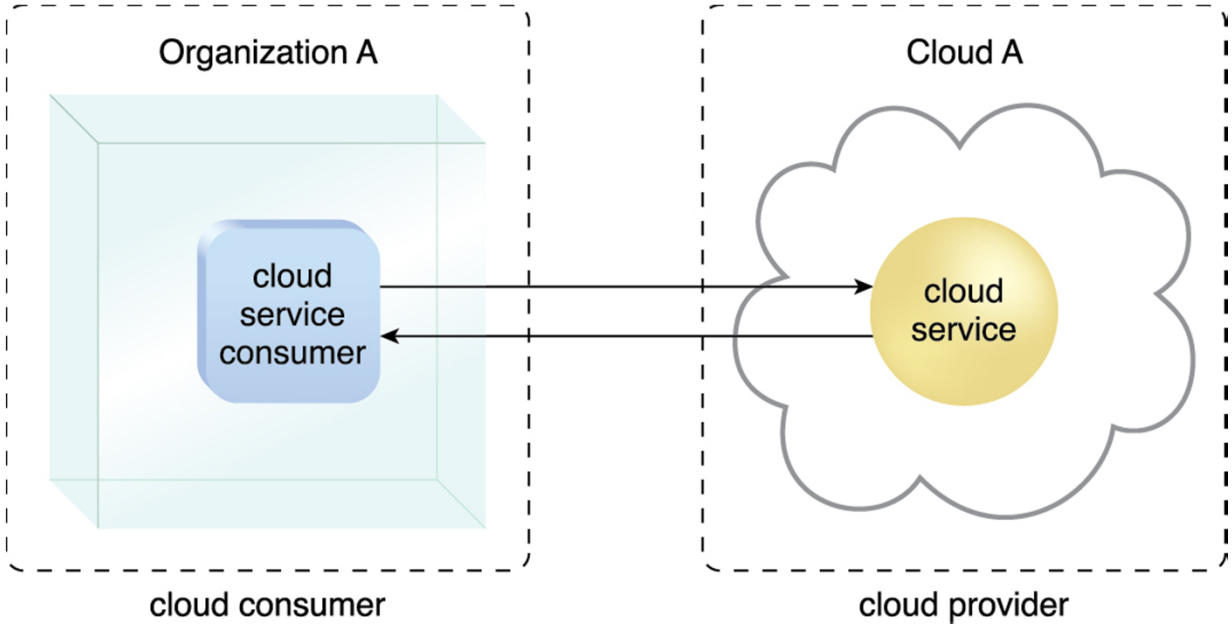
- A cloud consumer may request cloud services from a cloud provider directly or via a cloud broker (with many providers)

- A cloud auditor conducts independent audits and may contact the others to collect necessary information

ACTOR ROLES AND BOUNDARIES

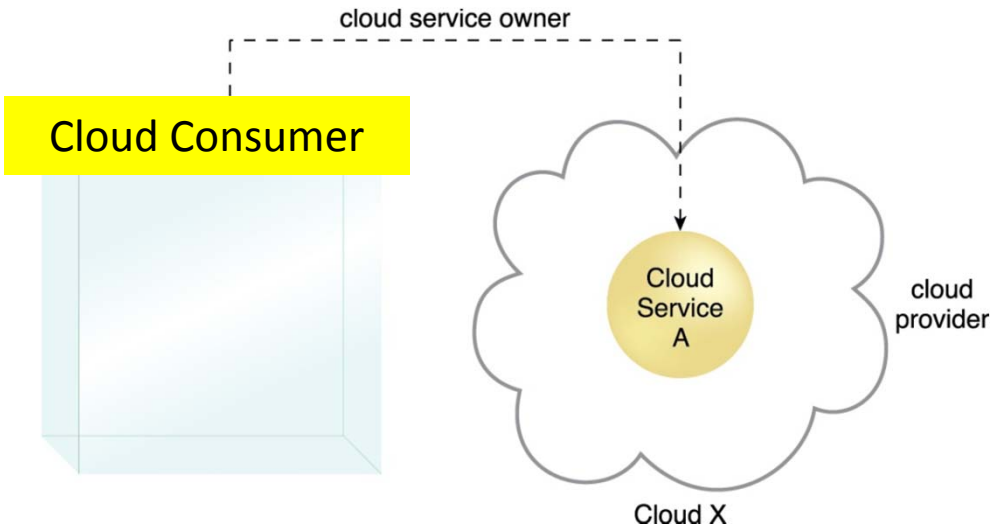
1. **Cloud Consumer** - a person or organization that maintains a business relationship with, and uses service from, **Cloud Providers**

2. **Cloud Providers** – a person, organization or entity responsible for making a service available to interested parties

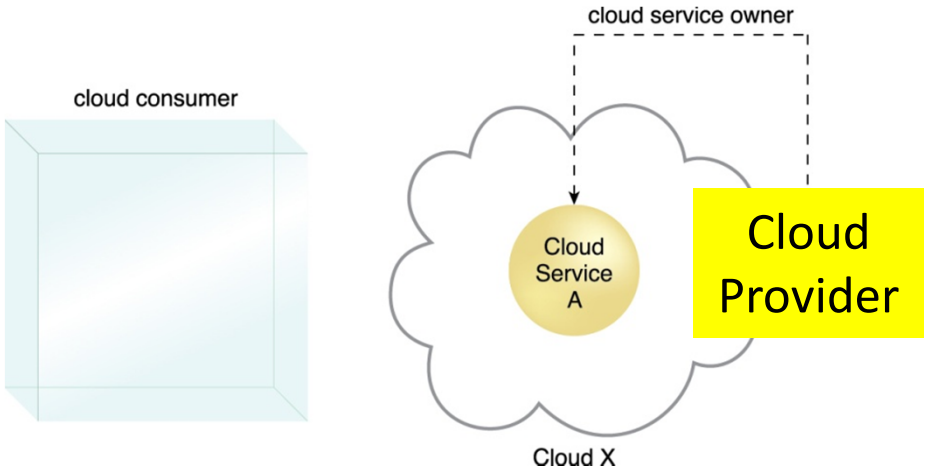


A cloud consumer (Organization A) interacts with a cloud service from a **cloud provider** (that **owns Cloud A**). Within Organization A, the cloud service consumer is being used to access the cloud service.

Examples of Cloud Service Owner



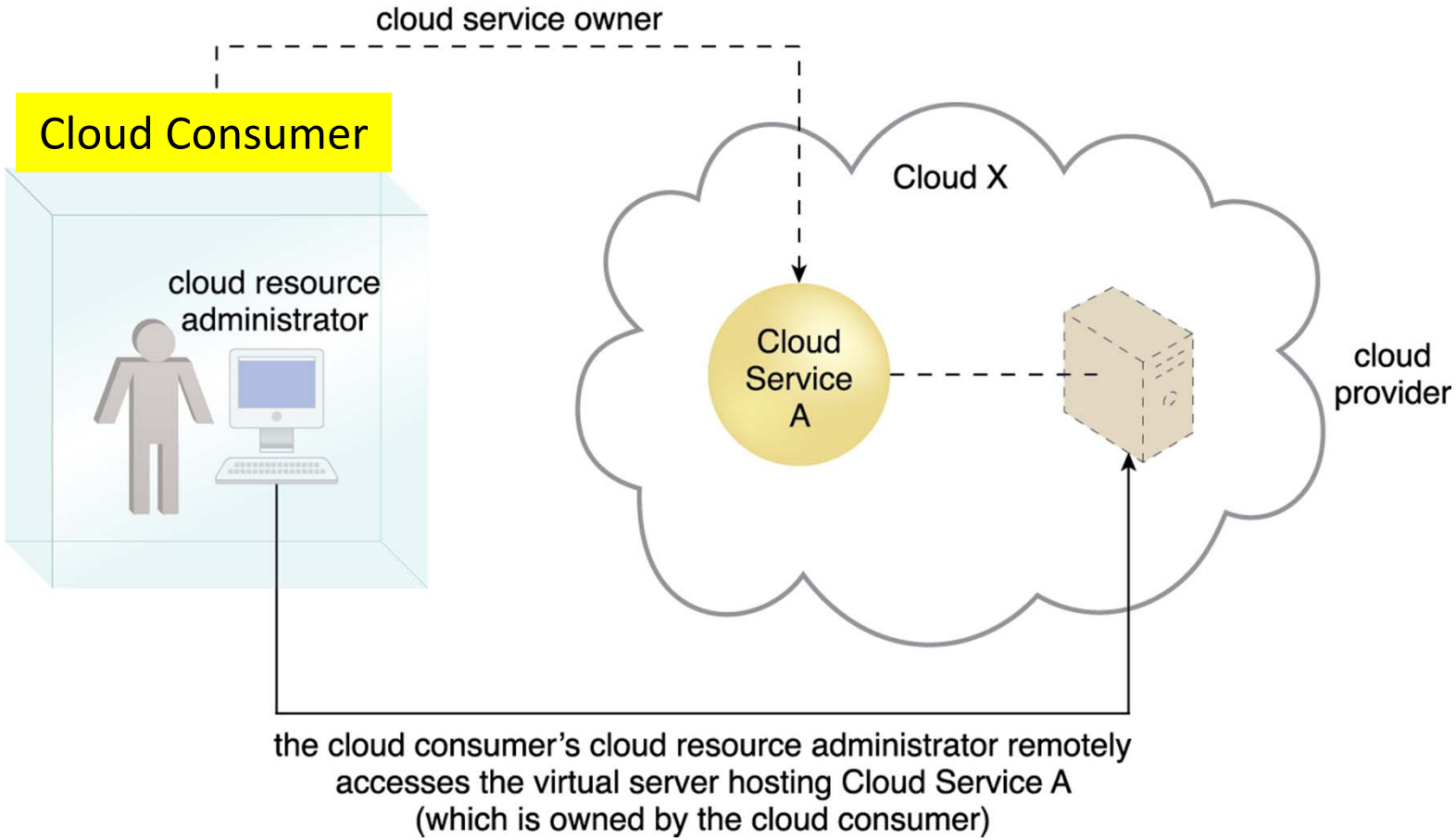
A **cloud consumer** can be a cloud service owner when it deploys its own service in a cloud.



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

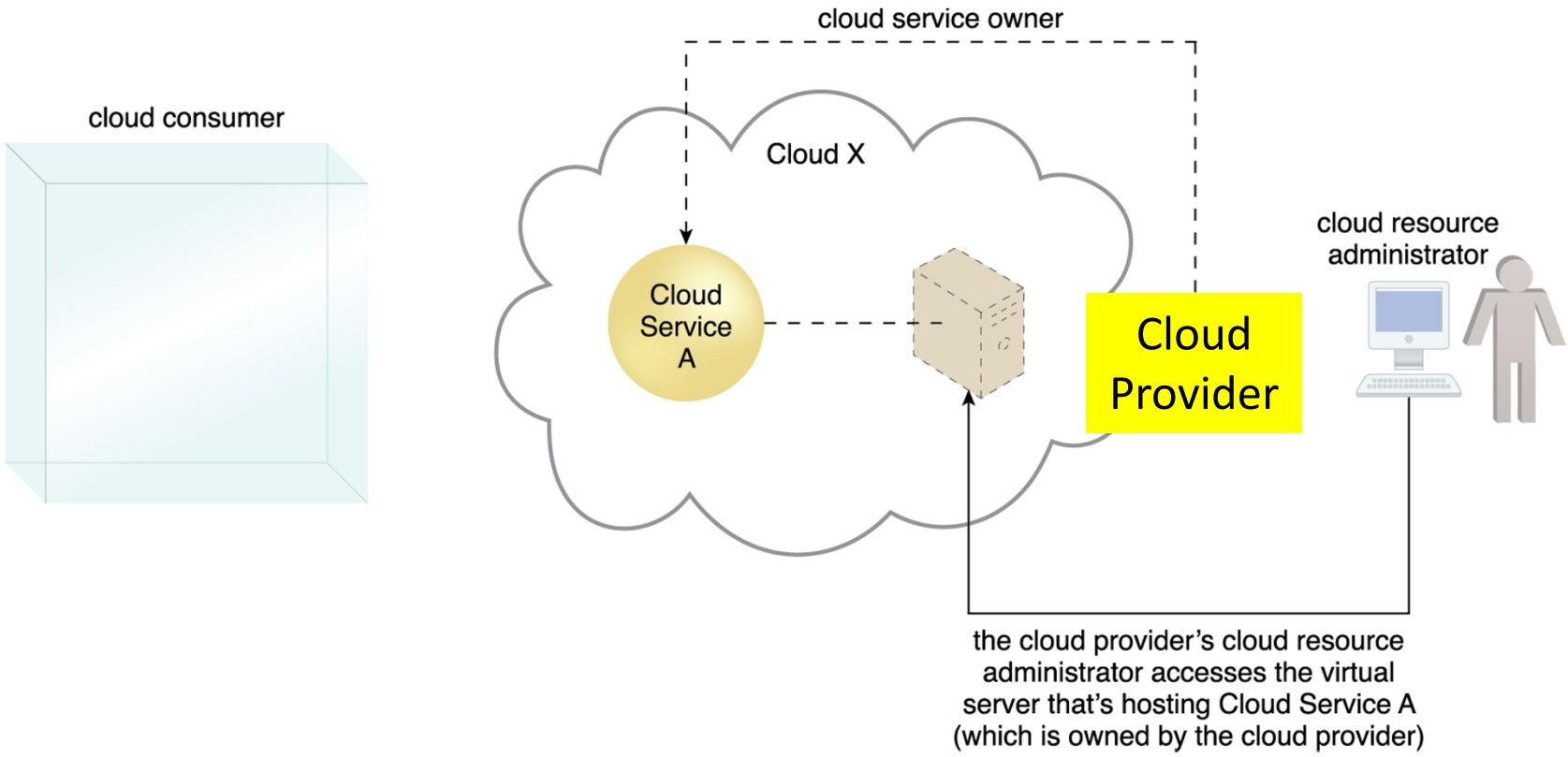
Cloud Consumer



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 Provider



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.

Actor Roles

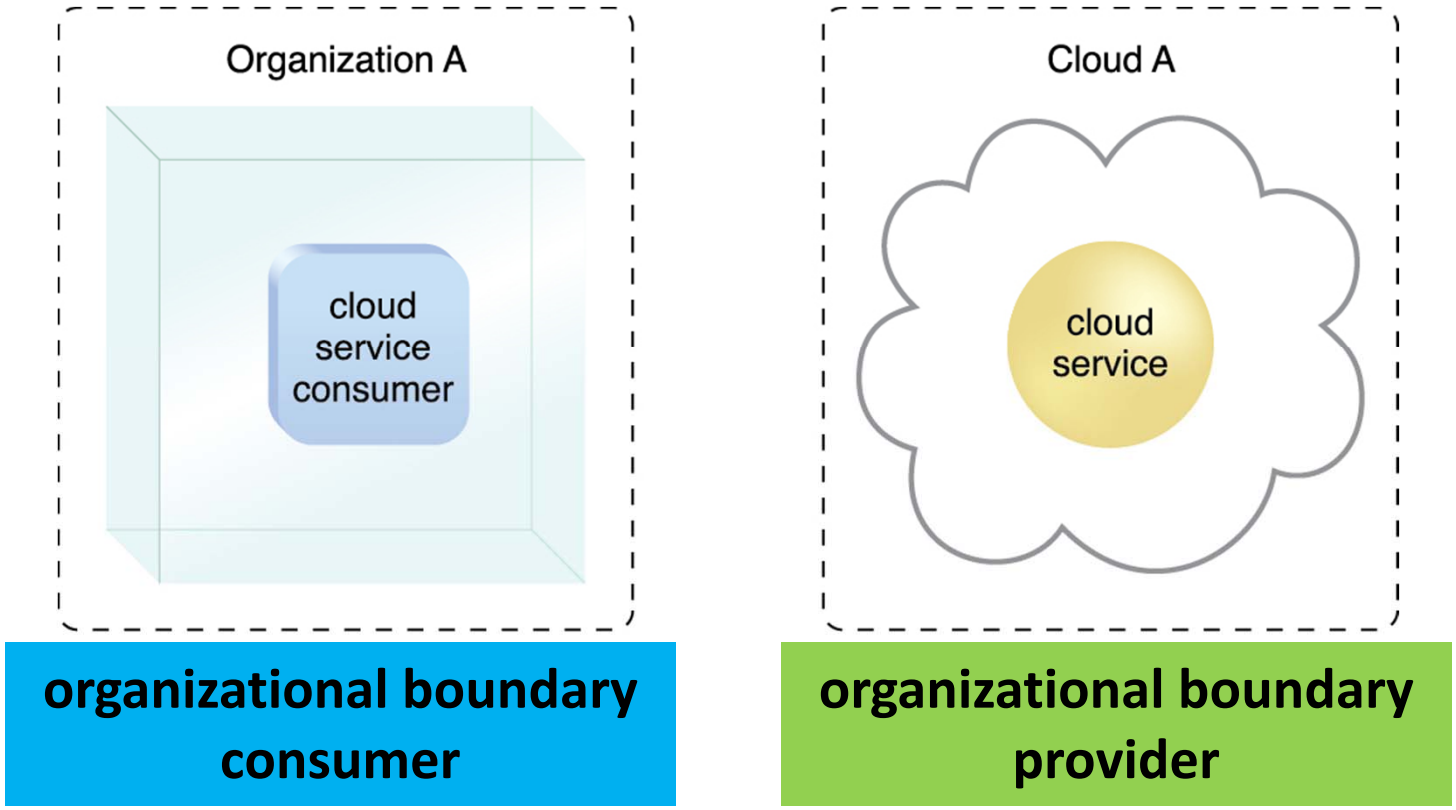
3. **Cloud Auditor** – a party that conducts independent assessment of cloud services, information system operations, performance and security of the cloud implementation

4. **Cloud Broker** – an entity that manages the use, performance an delivery of cloud services, and negotiates relationships between Cloud Providers and Cloud Consumers

5. **Cloud Carrier** – an intermediary that provides connectivity and transport of cloud services from Cloud Providers to Cloud Consumers

Organizational Boundaries

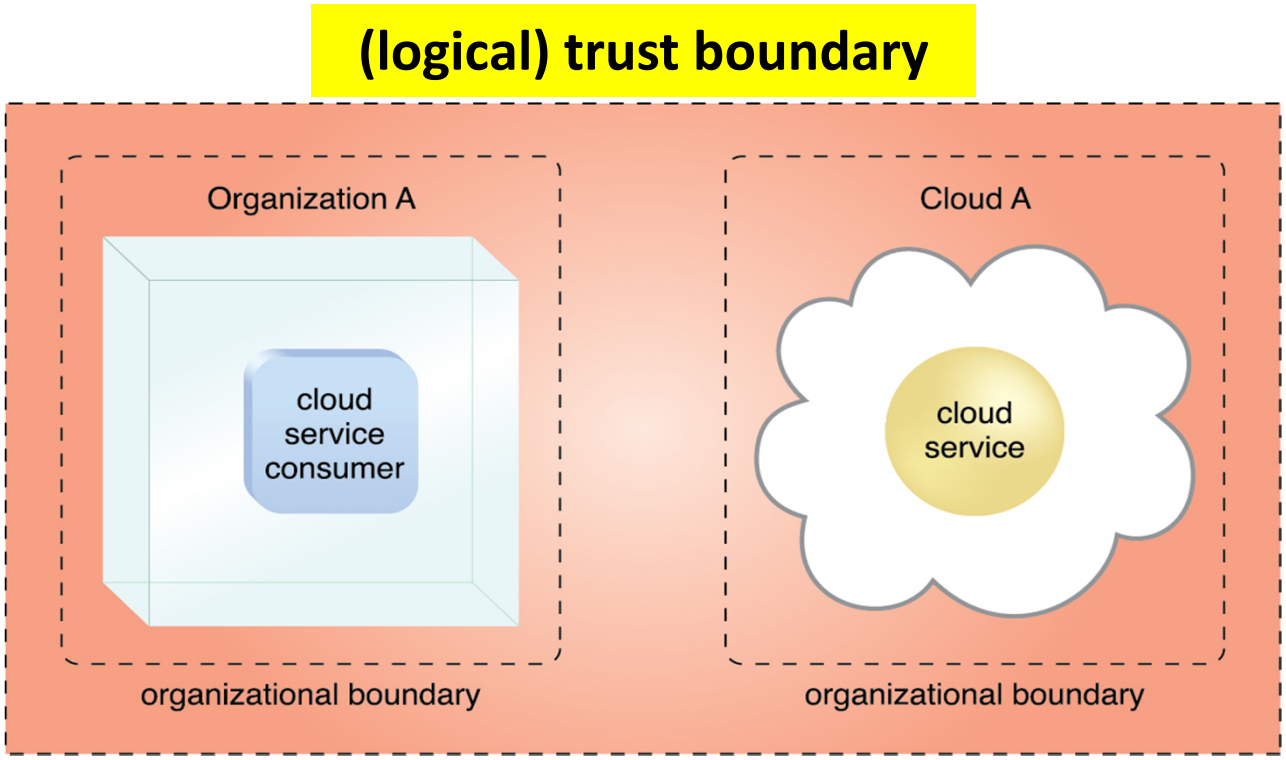
- represents the **physical scope of IT resources** owned and governed by an organization



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

Trust Boundary

- a **logical perimeter** that represents which IT resources are trusted by an organization



implications?

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

Trust Boundary

- a **logical perimeter** that represents which IT resources are trusted by an organization

Implications:

- increased security vulnerabilities
- reduced operational governance control
- multi-tenancy: overlapping trust boundaries

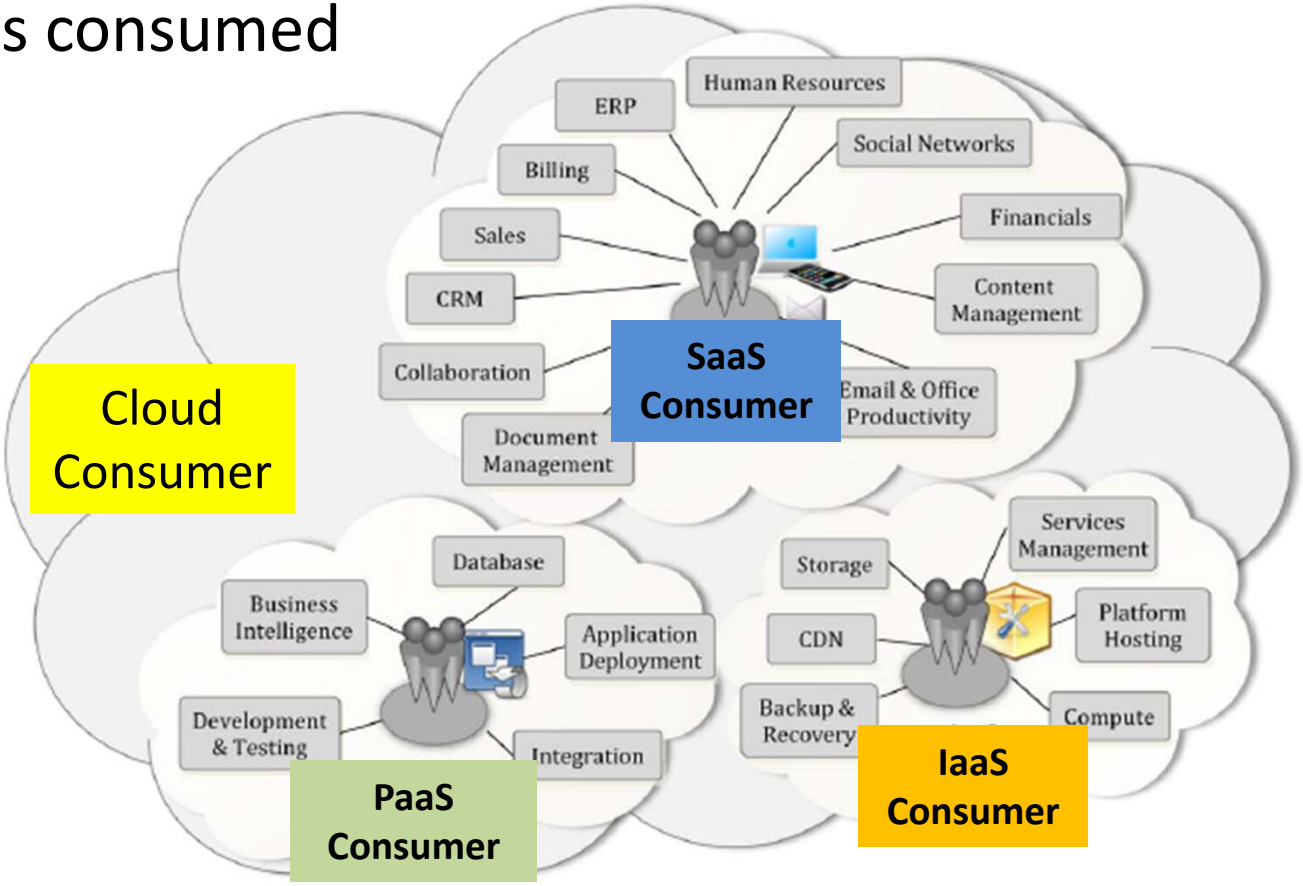
cations?

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

Cloud Consumer

- Browses cloud provider service catalog, requests the appropriate service, sets up service contracts (including price and SLAs) with the cloud provider, and uses the service

- Services consumed



SaaS Cloud Consumer

- an organization that provides members with access to software applications, end-users who **directly use** software applications, or software application administrators who configure applications for end-users

- billed based on the number of end-users, the time used, the network bandwidth consumed, the amount of data stored or the duration of stored data

PaaS Cloud Consumer

- Employ tools and execution resources provided by cloud providers to **develop, test, deploy and manage** the **applications** hosted in a cloud environment

- Application developers who design and implement application software, application testers who run and test applications in cloud-based environment, application deployers who publish applications into the cloud, or application administrators who configure and monitor application performance on a platform

- Billed based on processing, storage and network resources consumed by the PaaS application, and the duration of the platform used

IaaS Cloud Consumer

- Have access to cloud resources (virtual computers, network-accessible storage, network infrastructure components, …) on which they deploy and run arbitrary software
- system developers, system administrators and IT managers interested in creating, installing, managing and monitoring services for IT infrastructure operations
- Billed based on the amount or duration of resources consumed such as CPU hours used, volume and duration of data stored, network bandwidth consumed, number of IP addressed used

Types of Cloud Provider

- An entity (person or organization) responsible for making a service available to interested parties

- Acquires and manages the computing infrastructure required for providing the services, runs the cloud software that provides the services and make arrangement to deliver the services to the cloud consumers through network access

- *SaaS cloud provider* deploys, configures, maintains and updates the operation of the software applications on a cloud infrastructures to provision services at the expected SLAs to cloud consumers. Cloud consumers have limited administrative control of the applications.

Types of Cloud Provider

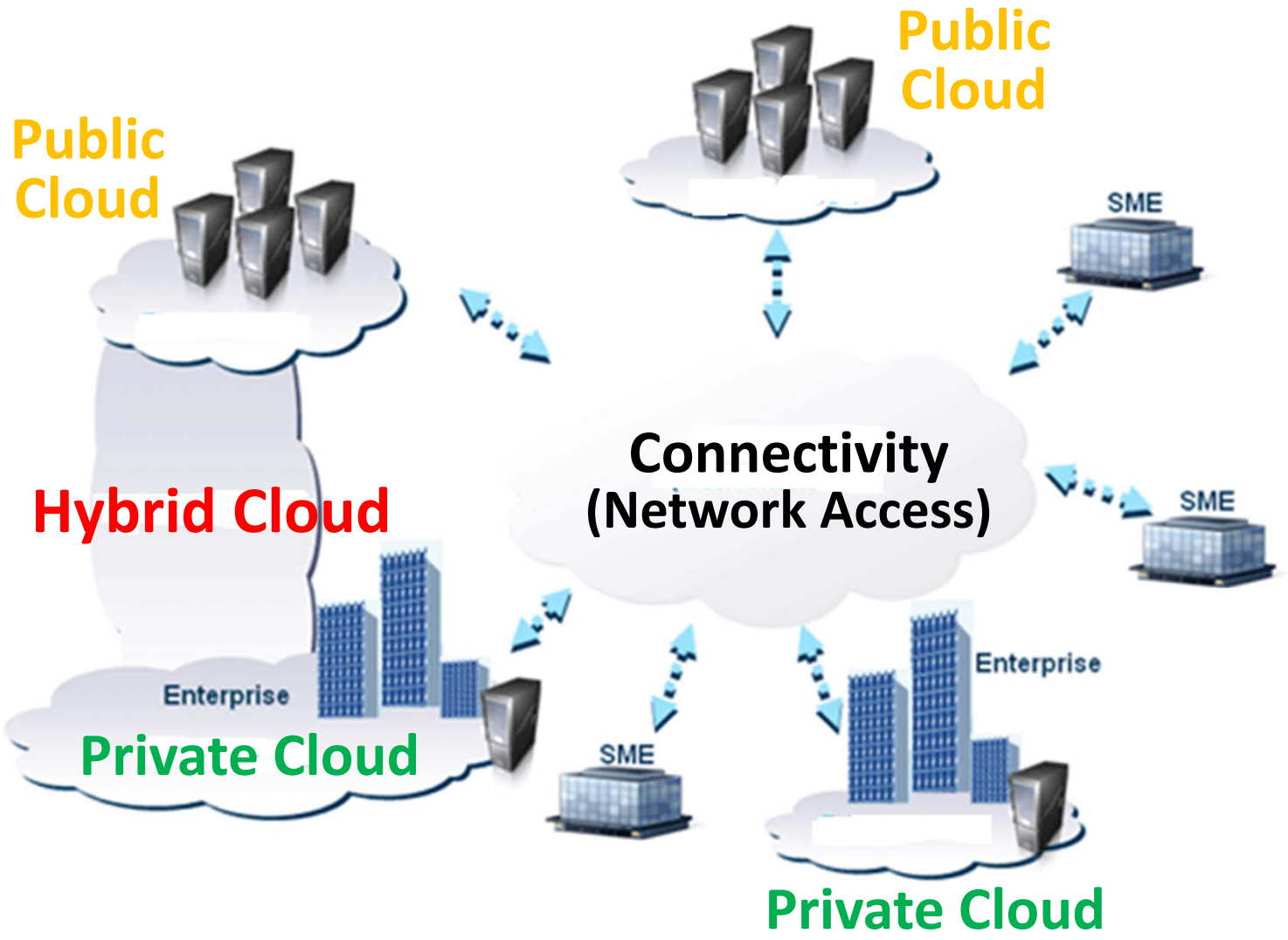
- *PaaS cloud provider* manages the computing infrastructure for the platform and runs the cloud platform component software such as runtime software execution stack and databases. Supports the development, deployment and management process of the PaaS cloud consumer

- *IaaS cloud provider* acquires the physical computing resources underlying the service, including the servers, networks, storage and hosting infrastructures. Computing resources are made available to IaaS cloud consumer through a set of service interfaces and computing resource abstractions such as virtual machines and virtual network interfaces.

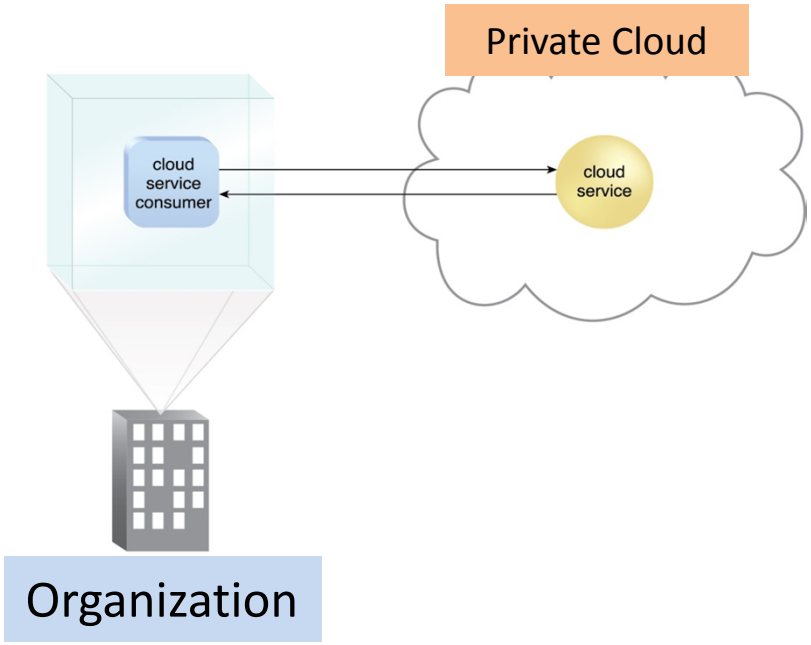
Cloud Deployment Models

- **Private cloud**
  - Solely for an organization
  - For enterprises/corporations with large scale IT
- **Public cloud**
  - Available to general public over a public network
  - Open market for on demand computing and IT resources
  - Concerns: Limited SLA, reliability, availability, security, trust and confidence
  - Examples: IBM, Google, Amazon, …
- **Community cloud**
  - Shared by several organizations and supporting a specific community
- **Hybrid (federated) cloud**
  - Two or more public and private cloud that interoperate
  - Extends private cloud(s) by connecting it to other cloud vendors to make use of their available cloud services

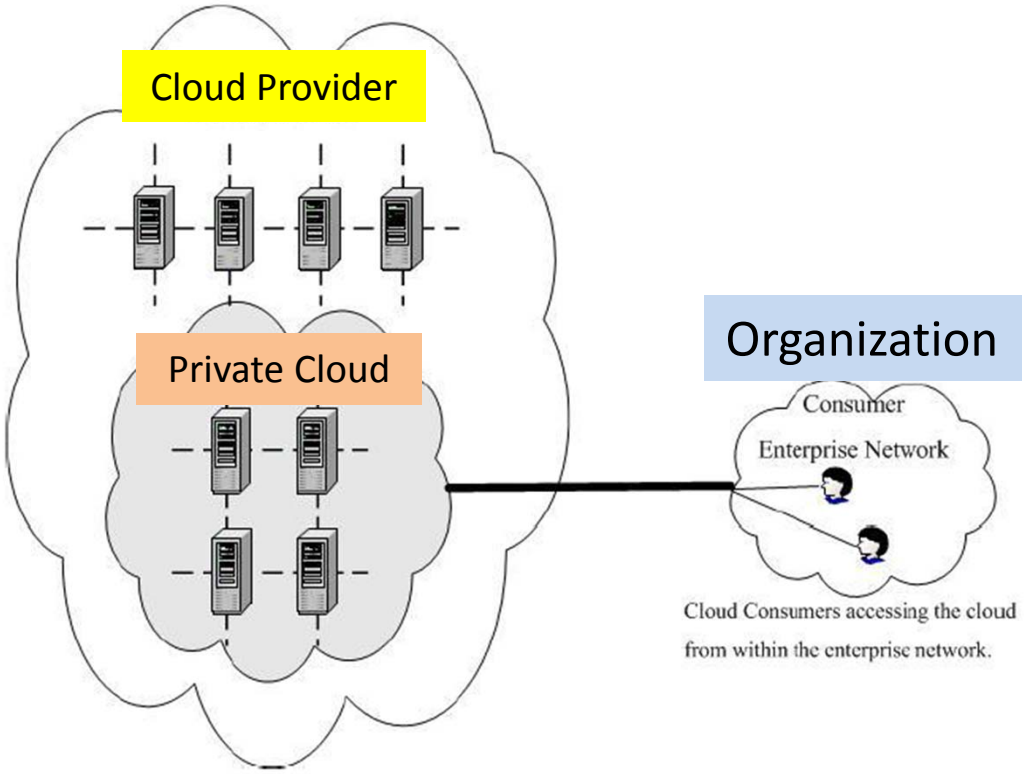
Types of Clouds



Private Clouds - Examples

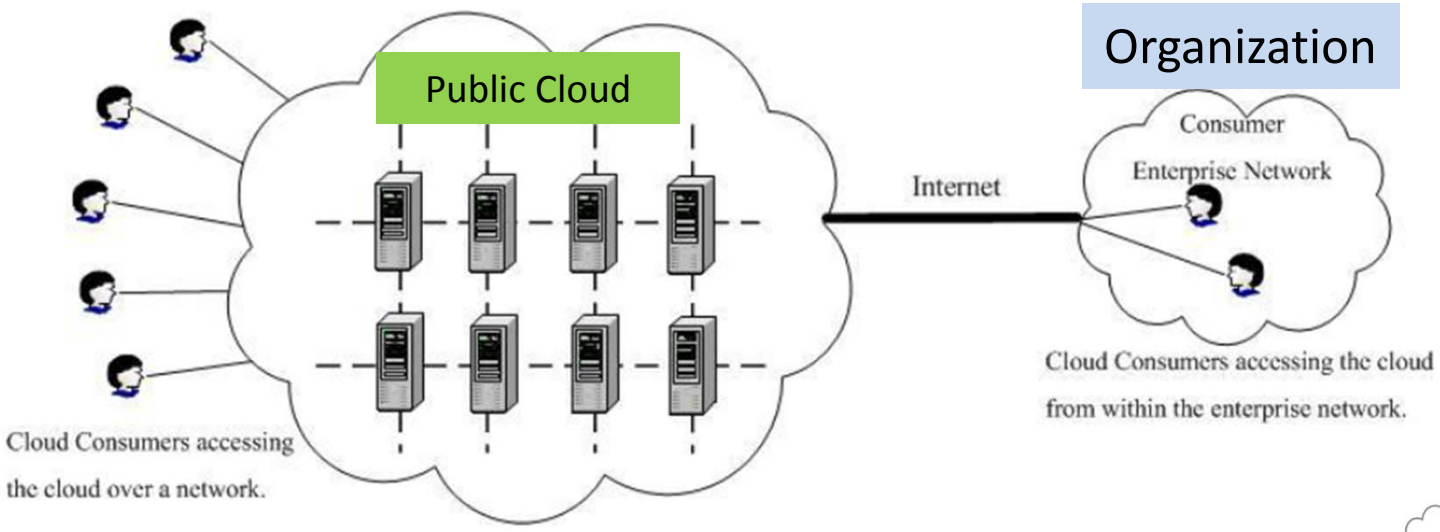


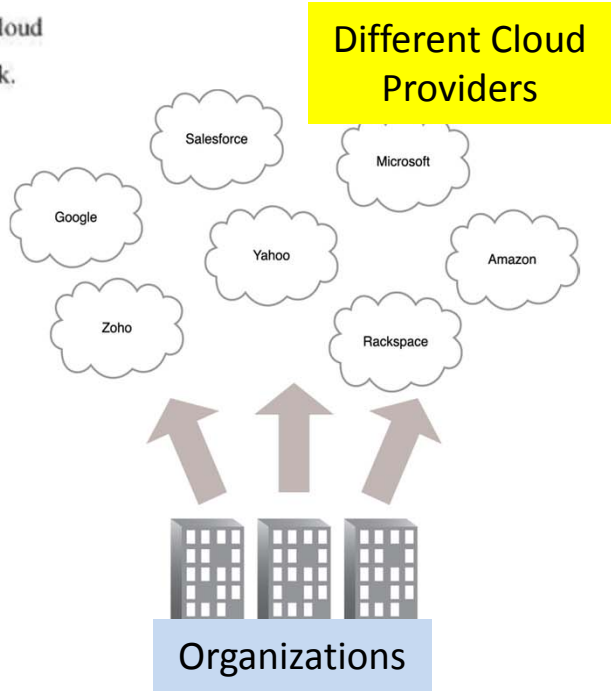
On-site Private Cloud: A cloud service consumer in the organization's on-premise environment accesses a cloud service hosted on the same organization's private cloud via a virtual private network.



Out-sourced Private Cloud

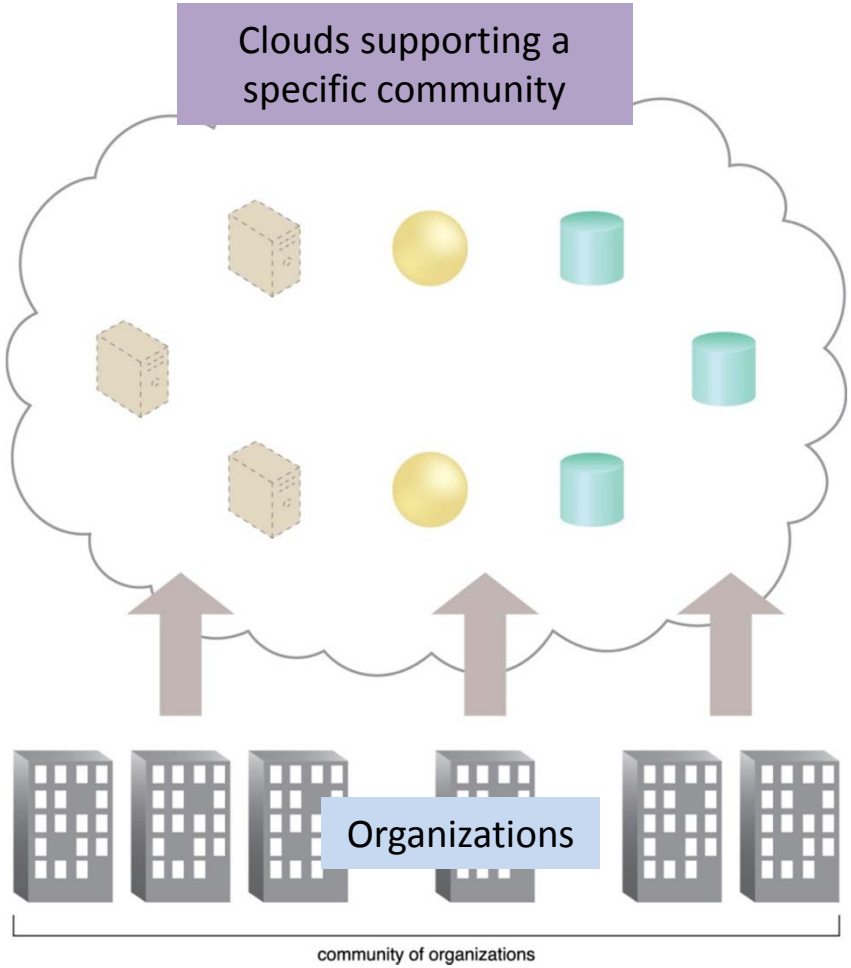
Public Clouds





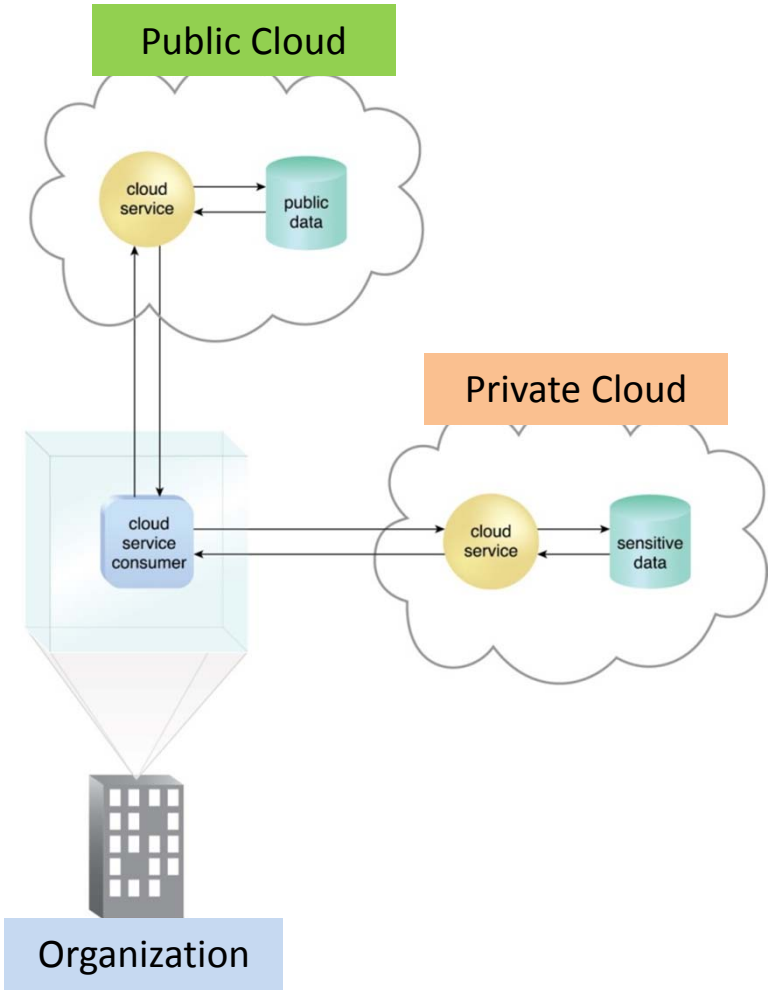
Example: Organizations act as cloud consumers when accessing cloud services and IT resources made available by different cloud providers.

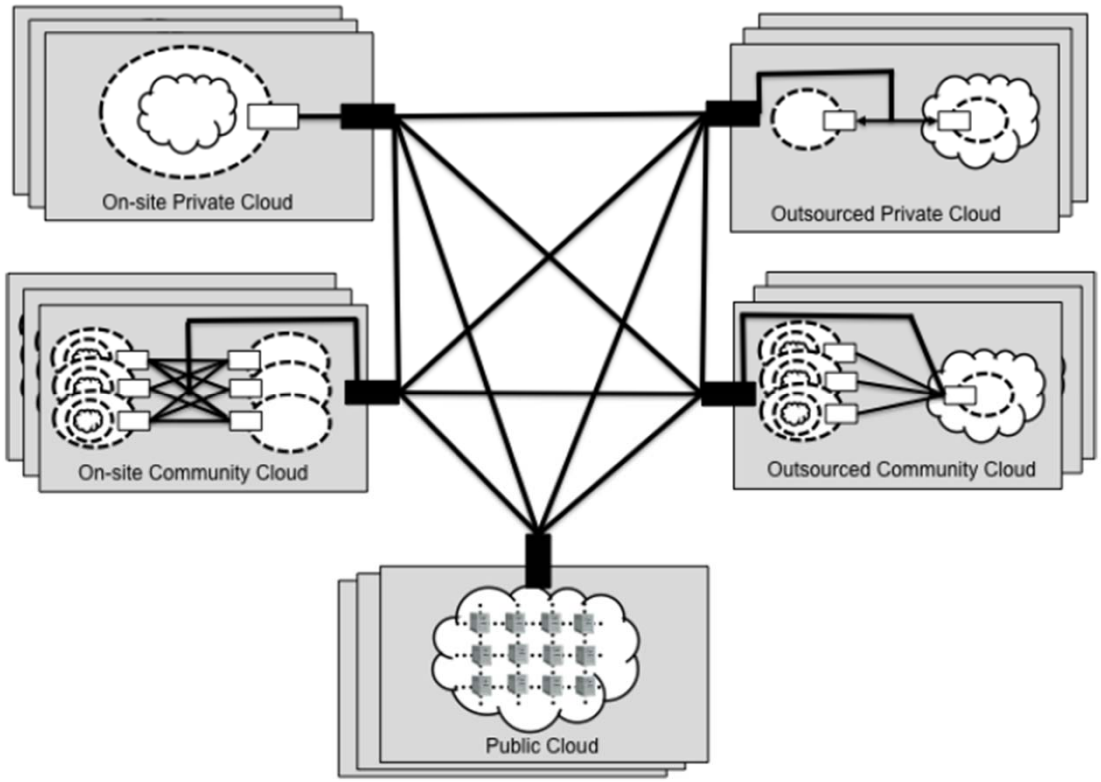
Community Clouds



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

Hybrid Clouds



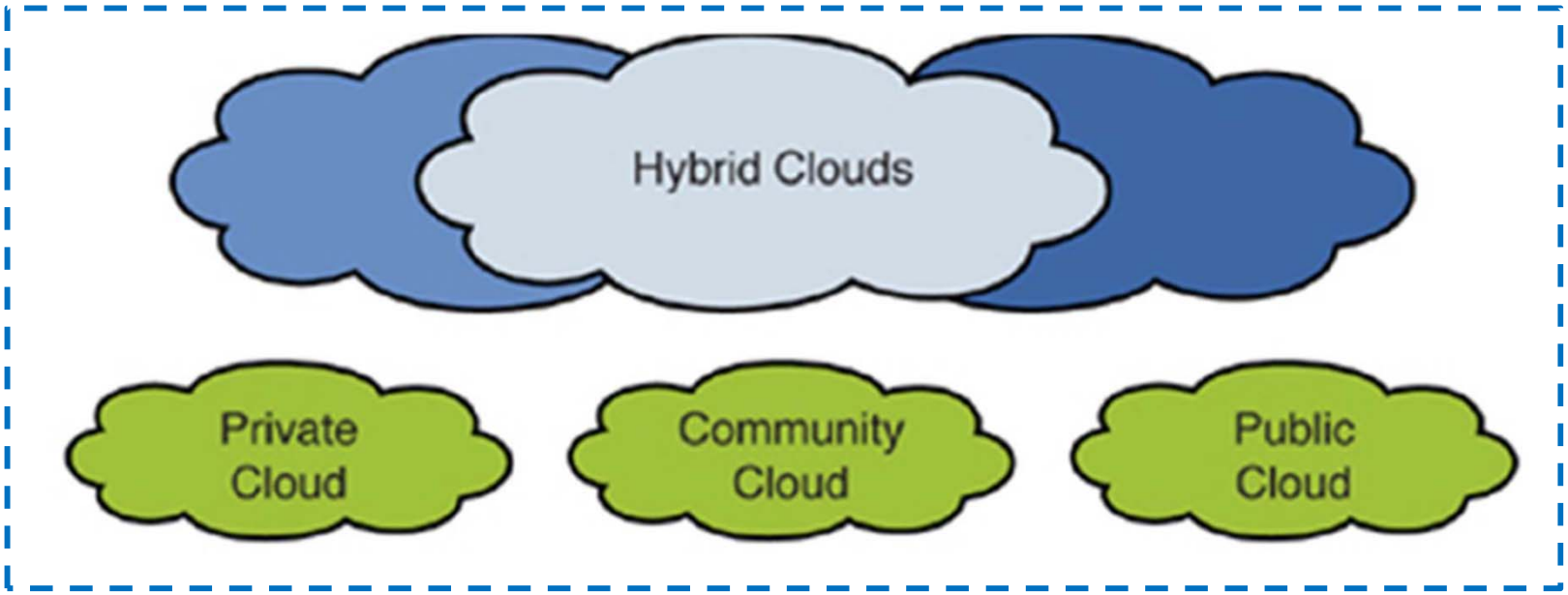


An organization using a hybrid cloud architecture that utilizes both a private and public cloud.

Cloud Service and Deployment Models

Service Models

Deployment Models



Summary

- Main cloud characteristics
- Cloud service models
- Organization of cloud reference architecture
- Cloud deployment models

References

- NIST Cloud Computing Reference Architecture, NIST Report, 2011.

- Chapter 4, Cloud Computing: Concepts, Technology and Architecture, Thomas Erl, Zaigham Mahmood and Ricardo Puttini, Prentice-Hall, 2013.

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