UNIT - 5

SLO-1 :
Cloud Computing : Cloud Enabling Technologies

Drivers for Cloud Computing

Business requirements

- Organizations are under increasing pressure to improve efficiency and transformation of IT processes to achieve more with less
- Better agility and higher availability at reduced expenditure
- Reduced time-to-market
- Accelerated pace of innovation

IT challenges to meet business requirements are:

- Serving customers worldwide round the clock, refreshing technology quickly, faster provisioning of IT resources –

all at reduced cost

These challenges are addressed with the emergence of cloud computing

What is Cloud Computing?

- A model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., servers, storage, networks, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.– NIST

Cloud Enabling Technologies

Enabling technologies of cloud computing

- Grid computing
- utility computing
- virtualization
- service-oriented architecture

Cloud Enabling Technologies

Technologies	Description
Grid computing	• Form of distributed computing • Enables resources of numerous computers in a network to work on a single task at the same time • Grid computing enables parallel computing and is best for large workloads
Utility computing	• Service provisioning model that offers computing resources as a metered service • Makes computing resources available to customers, as required, and charges them based on usage

Cloud Enabling Technologies

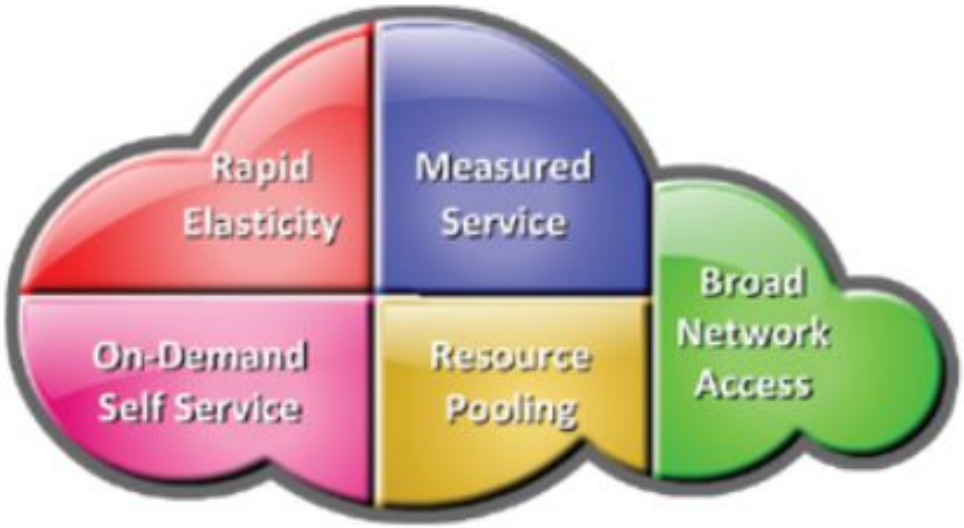
Technologies	Description
Virtualization	• Abstracts physical characteristics of IT resources from resource users • Enables resource pooling and creating virtual resources from pooled resources • Virtualization provides better flexibility for provisioning of IT resources compared to provisioning in a non-virtualized environment
Service-oriented architecture(SOA)	• Provides a set of services that can communicate with each other • These services work together to perform some activity or simply pass data among services.

SLO-2 :
Characteristics of Cloud Computing

Characteristics of Cloud Computing

Essential Cloud characteristics

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



1. On-demand self-service

- Enables consumers to unilaterally provision computing capabilities (examples: server time and storage capacity) as needed automatically without requiring human interaction with each service provider
- Consumers view service catalogue via a Web-based user interface and use it to request for a service
- Consumers can either leverage the "ready-to-use" services or change a few service parameters to customize the services.

2. Broad Network Access

- Computing capabilities are available over the network
- Computing capabilities are accessed from a broad range of client platforms such as:
  - Desktop
  - Computer
  - Laptop
  - Tablet
  - Mobile device

3. Resource Pooling

- Provider's computing resources are pooled to serve multiple consumers using a multitenant model
- Virtual resources dynamically assigned and reassigned according to consumer demand
- There is a sense of location independence in that the customer generally has no control or knowledge over the exact location of the provided resources.
- But may be able to specify location at a higher level of abstraction (for example, country, state, or data center).
- Examples of resources include storage, processing, memory, and network bandwidth.

4. Rapid Elasticity

- Computing capabilities can be elastically provisioned and released
- Computing capabilities are scaled rapidly, commensurate with consumer's demand

For example,

- an organization might require double the number of web and application servers for a specific duration to accomplish a specific task.
- For the remaining period, they might want to release idle server resources to cut down the expenses.
- The cloud enables consumers to grow and shrink the demand for resources dynamically

5. Measured Service

- Cloud computing provides a metering system that continuously monitors resource consumption and generates reports
  - Resource usage can be monitored, controlled, and reported, providing transparency for both the provider and consumer of the utilized service

SLO – 1:
Benefits of Cloud Computing

Cloud computing offers the following key benefits:

Reduced IT cost:

- Cloud services can be purchased based on pay-per-use or subscription pricing.
- This reduces or eliminates the consumer's IT capital expenditure (CAPEX).

Business agility:

- Cloud computing provides the capability to allocate and scale computing capacity quickly.
- Cloud computing can reduce the time required to provision and deploy new applications and services from months to minutes.
- This enables businesses to respond more quickly to market changes and reduce time-to-market.

Benefits of Cloud Computing

Flexible scaling:

- Cloud computing enables consumers to scale up, scale down, scale out, or scale in the demand for computing resources easily.
- Consumers can unilaterally and automatically scale computing resources without any interaction with cloud service providers.
- The flexible service provisioning capability of cloud computing often provides a sense of unlimited scalability to the cloud service consumers.

Benefits of Cloud Computing…

High availability:

- Cloud computing has the capability to ensure resource availability at varying levels depending on the consumer's policy and priority.
- Redundant infrastructure components (servers, network paths, and storage equipment, along with clustered software) enable fault tolerance for cloud deployments.
- These techniques can encompass multiple data centers located in different geographic regions, which prevents data unavailability due to regional failures.

SLO – 2 :
Cloud Service Models

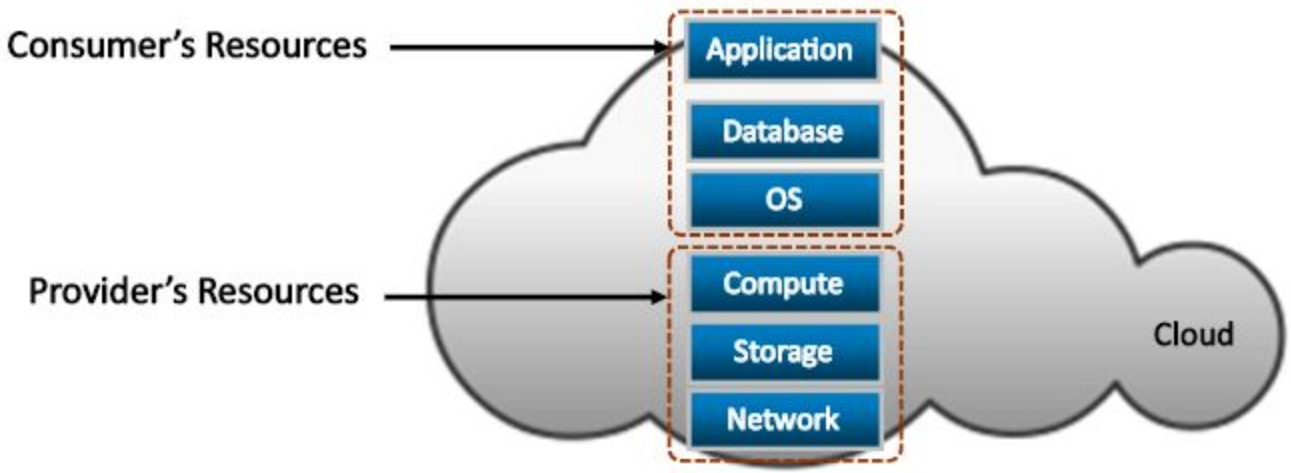
Cloud Service Models

According to NIST, cloud service offerings are classified primarily into three models:

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

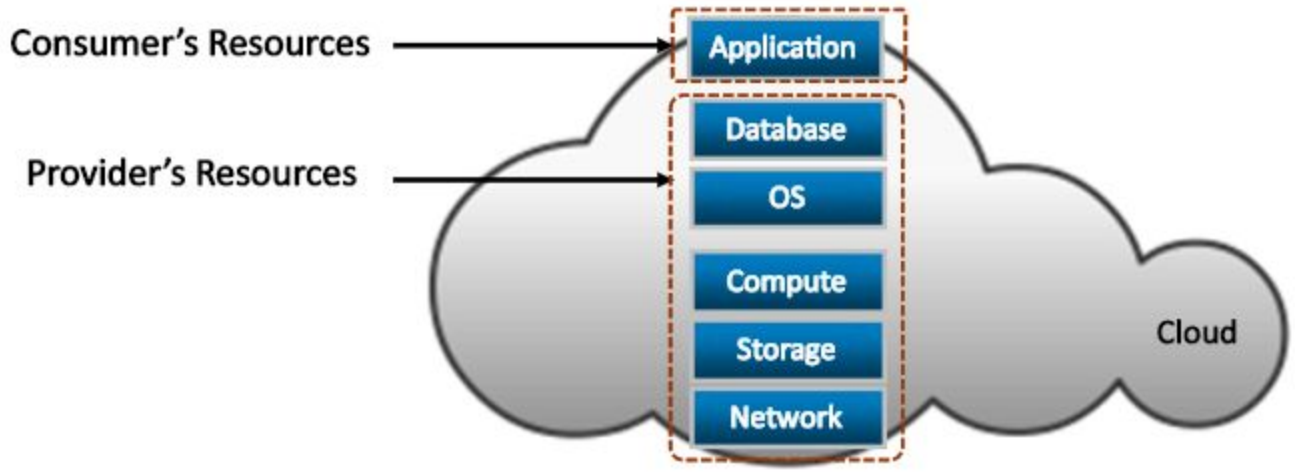
Infrastructure-as-a-Service

- Consumers deploy their software, including OS and application on provider's infrastructure
  - Computing resources such as processing power, memory, storage, and networking components are offered as service
  - Example: Amazon Elastic Compute Cloud
- Consumers have control over the OSs and deployed applications



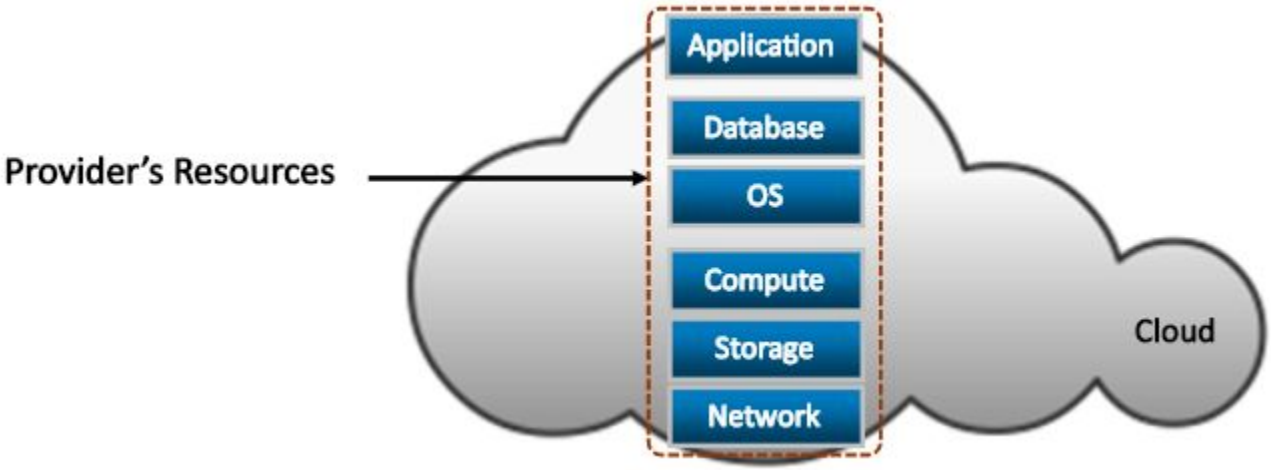
Platform-as-a-Service

- Consumers deploy consumer-created or acquired applications onto provider's computing platform
- Computing platform is offered as a service
- Example: Google App Engine and Microsoft Windows Azure Platform
- Consumer has control over deployed applications



Software-as-a-Service

- Consumers use provider's applications running on the cloud infrastructure
  - Applications are offered as a service
  - Examples: EMC Mozy and Salesforce.com
- Service providers exclusively manage computing infrastructure and software to support services
- The consumers may be allowed to change a few application configuration settings to customize the applications.



SLO – 1 :
Cloud Deployment Models

Cloud Deployment Models

According to NIST, cloud computing is classified into four deployment models

1. **public**
2. **private**
3. **community**
4. **hybrid**

- which provide the basis for how cloud infrastructures are constructed and consumed.

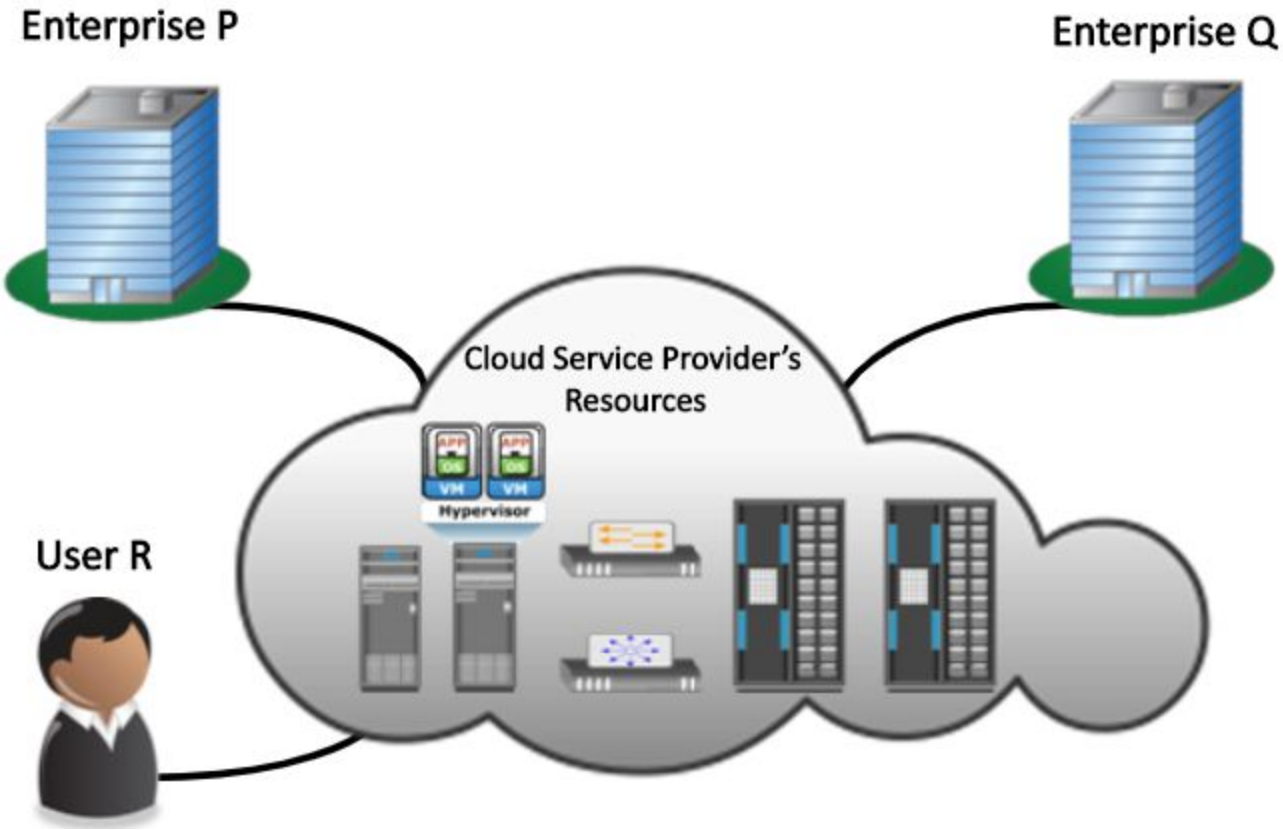
1. Public Cloud

- In a public cloud model, the cloud infrastructure is provisioned for open use by the general public.

- It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them. It exists on the premises of the cloud provider.

- Consumers use the cloud services offered by the providers via the Internet and pay metered usage charges or subscription fees.

Public cloud...



Public Cloud…

- An advantage of the public cloud is its low capital cost with enormous scalability.
- However, for consumers, these benefits come with certain risks: no control over the resources in the cloud, the security of confidential data, network performance, and interoperability issues.
- Popular public cloud service providers are Amazon, Google, and Salesforce.com.

2. Private Cloud

- In a private cloud model, the cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers (for example, business units).
- It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises.

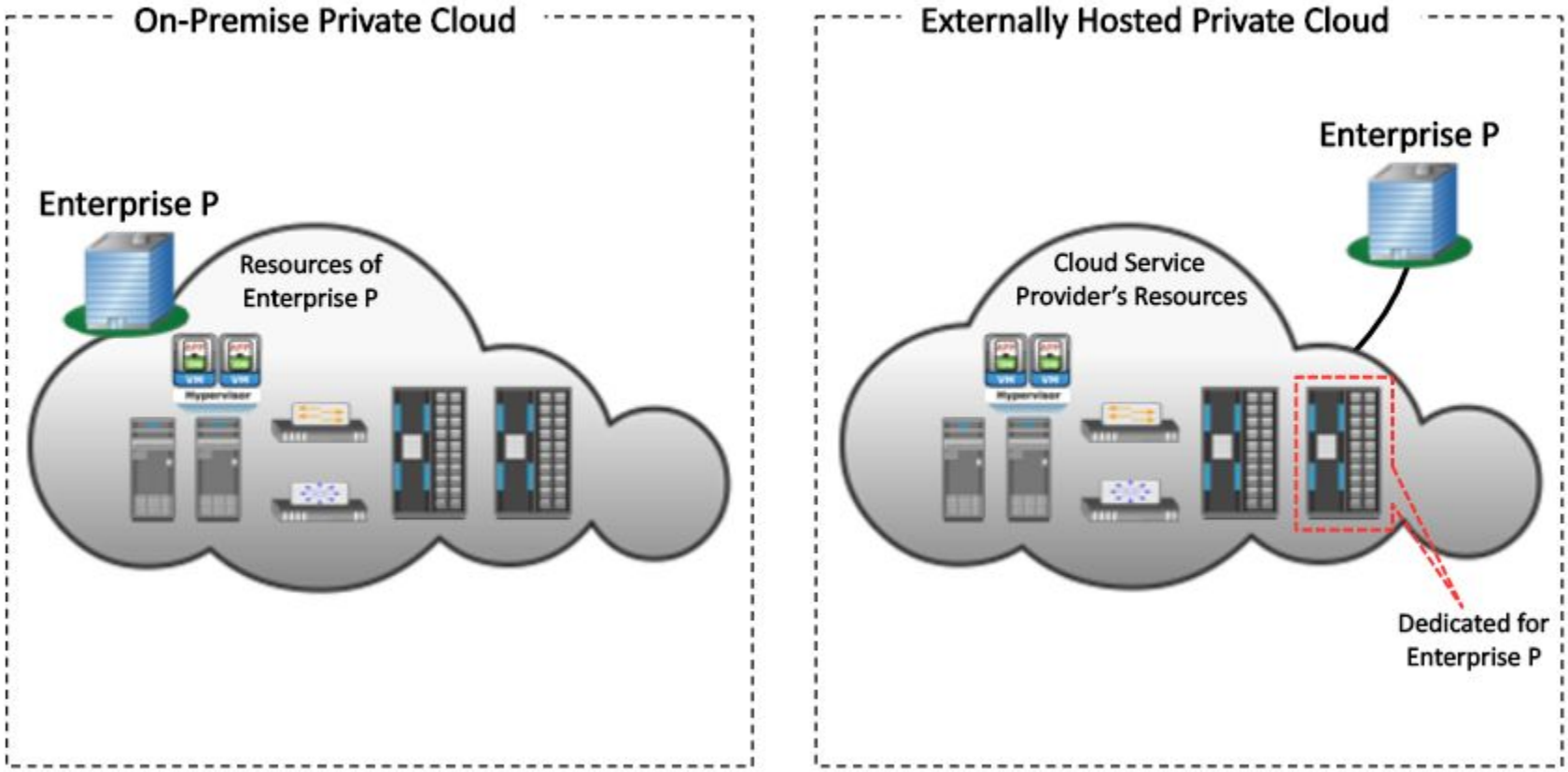
Private Cloud…

Following are two variations to the private cloud model:

1. On-premise private cloud:

- The on-premise private cloud, also known as internal cloud, is hosted by an organization within its own data centers
- Enables organizations to standardize their cloud service management processes and security, although this model has limitations in terms of size and resource scalability.
- Organizations would also need to incur the capital and operational costs for the physical resources.
- This is best suited for organizations that require complete control over their applications, infrastructure configurations, and security mechanisms.

On-premise and externally hosted private clouds



Private Cloud…

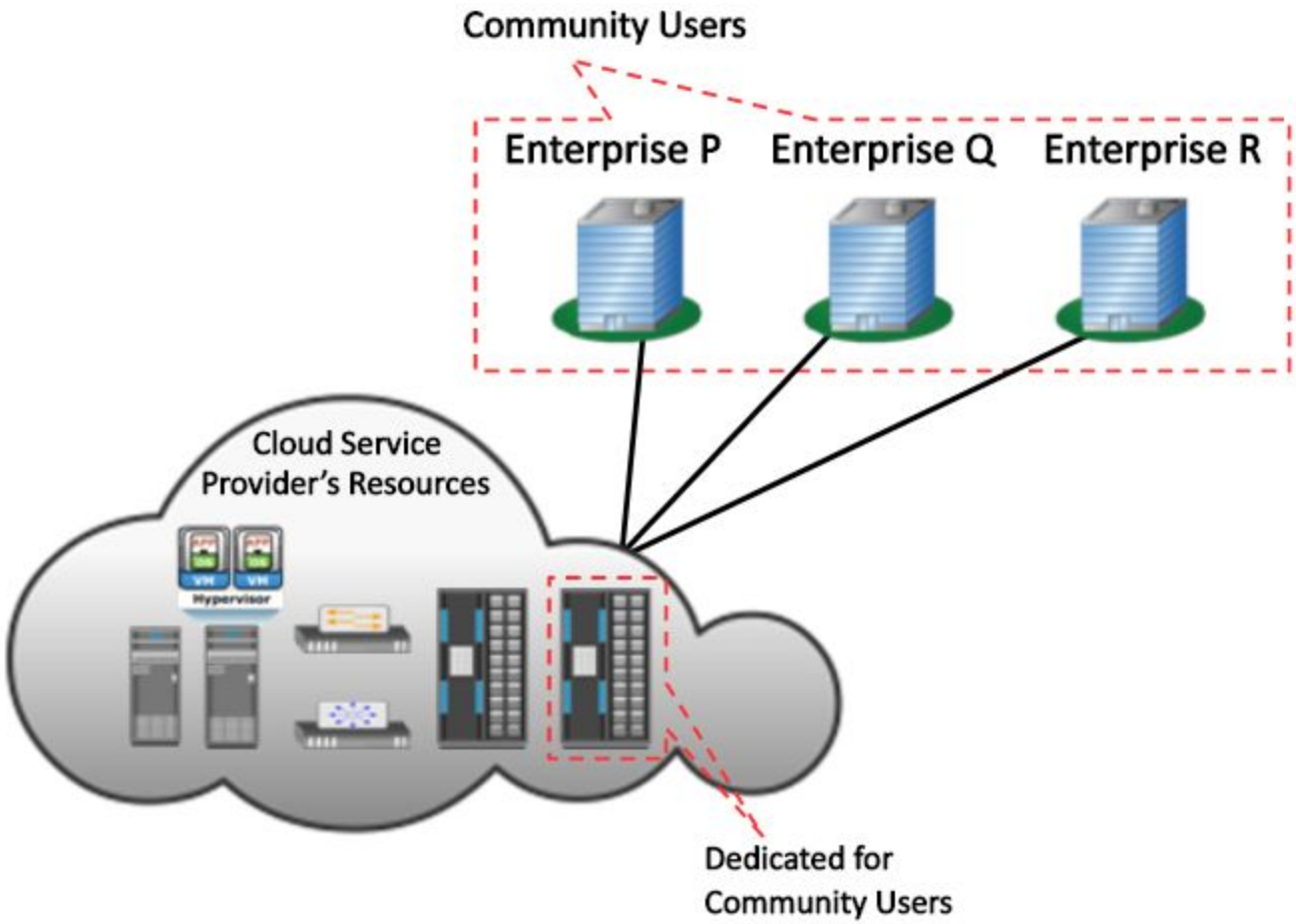
2. Externally hosted private cloud:

- This type of private cloud is hosted external to an organization and is managed by a third party organization.
- The third-party organization facilitates an exclusive cloud environment for a specific organization with full guarantee of privacy and confidentiality

3. Community Cloud

- In a community cloud model, the cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns
  - **Example :** mission, security requirements, policy, and compliance considerations
- It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises

Community cloud...



Community Cloud…

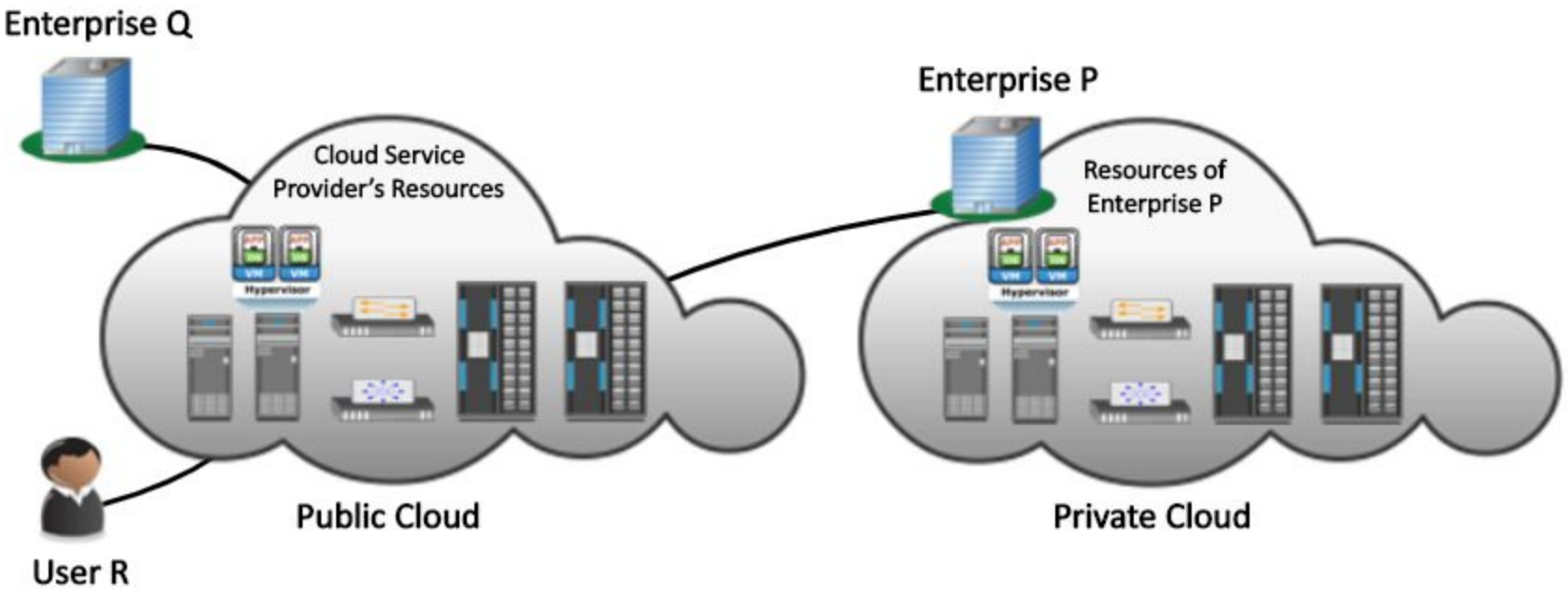
- In a community cloud, the costs spread over to fewer consumers than a public cloud.
- Hence, this option is more expensive but might offer a higher level of privacy, security, and compliance.

  Example : government agencies.
- If various agencies within the government operate under similar guidelines, they could all share the same infrastructure and lower their individual agency's investment.

4. Hybrid Cloud

- In a hybrid cloud model, the cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities
- The hybrid model allows an organization to deploy less critical applications and data to the public cloud, leveraging the scalability and cost-effectiveness of the public cloud.
- The organization's mission-critical applications and data remain on the private cloud that provides greater security.

Hybrid Cloud



SLO – 2 :
Cloud Infrastructure Mechanisms : Logical Network Perimeter

Cloud infrastructure mechanisms

- Cloud infrastructure mechanisms are foundational building blocks of cloud environments that establish primary artifacts to form the basis of fundamental cloud technology architecture

Cloud infrastructure mechanisms are,

1. **Logical Network Perimeter**
2. **Virtual Server**
3. **Cloud Storage Device**
4. **Cloud Usage Monitor**
5. **Resource Replication**
6. **Ready-Made Environment**

- Not all of these mechanisms are necessarily broad-reaching, nor does each establish an individual architectural layer
- Instead, they should be viewed as core components that are common to cloud platforms

1. Logical Network Perimeter

- Defined as the isolation of a network environment from the rest of a communications network.
  - the logical network perimeter establishes a virtual network boundary that can encompass and isolate a group of related cloud-based IT resources that may be physically distributed.

- The dashed line notation used to indicate the boundary of a logical network perimeter

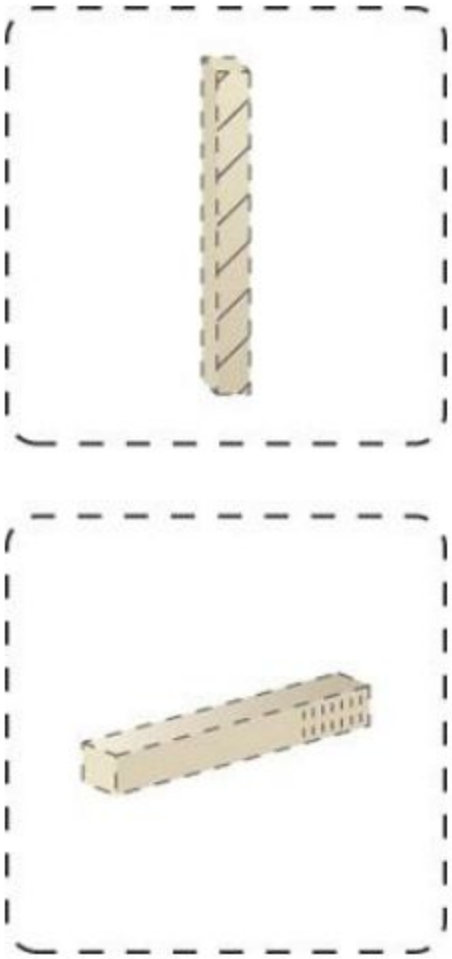
Logical Network Perimeter...

This mechanism can be implemented to:

- isolate IT resources in a cloud from non-authorized users
- isolate IT resources in a cloud from non-users
- isolate IT resources in a cloud from cloud consumers
- control the bandwidth that is available to isolated IT resources

•Logical network perimeters are typically established via network devices that supply and control the connectivity of a data center and are commonly deployed as virtualized IT environments that include:

Logical Network Perimeter...



- **Virtual Firewall –** An IT resource that actively filters network traffic to and from the isolated network while controlling its interactions with the Internet.
- **Virtual Network** – Usually acquired through VLANs, this IT resource isolates the network environment within the data center infrastructure.

The symbols used to represent a virtual firewall (top) and a virtual network (bottom).

Two logical network perimeters surround the cloud consumer and cloud provider environments

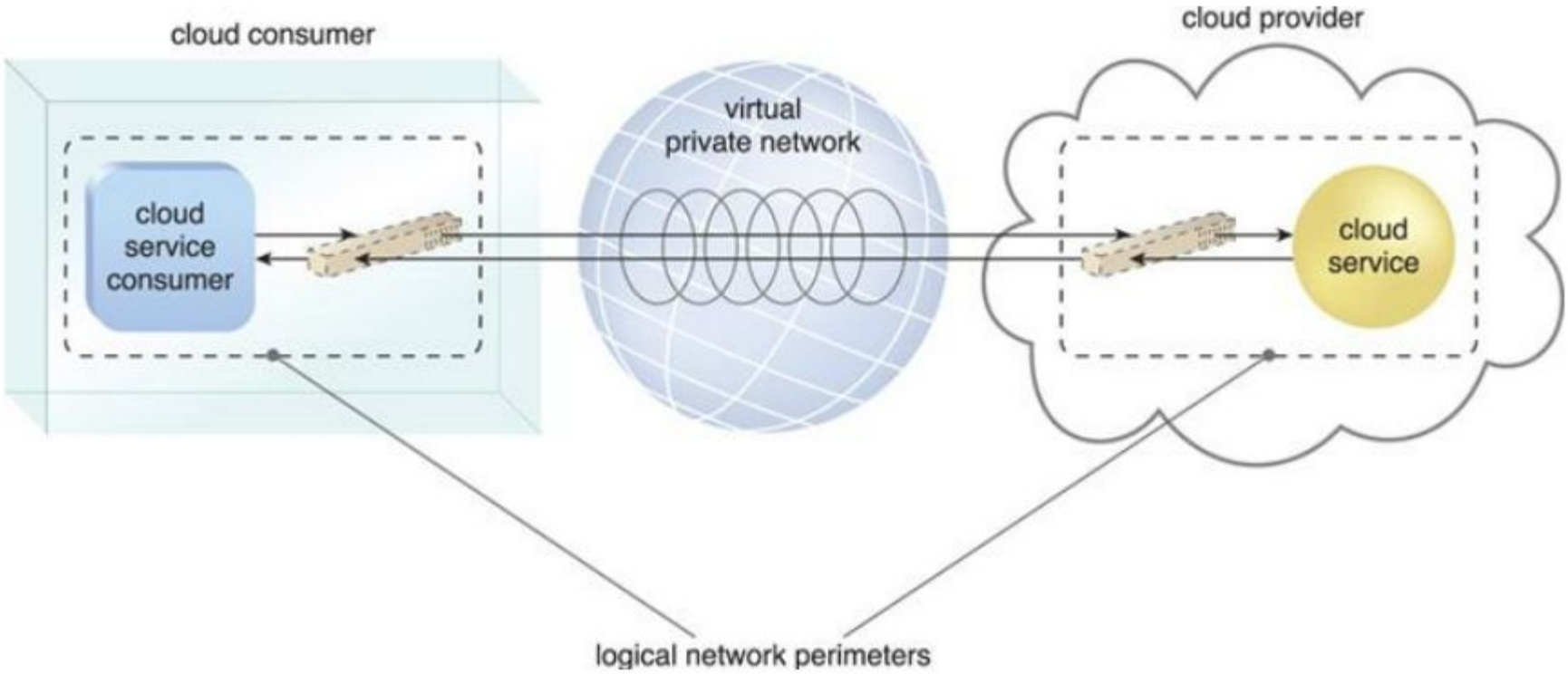


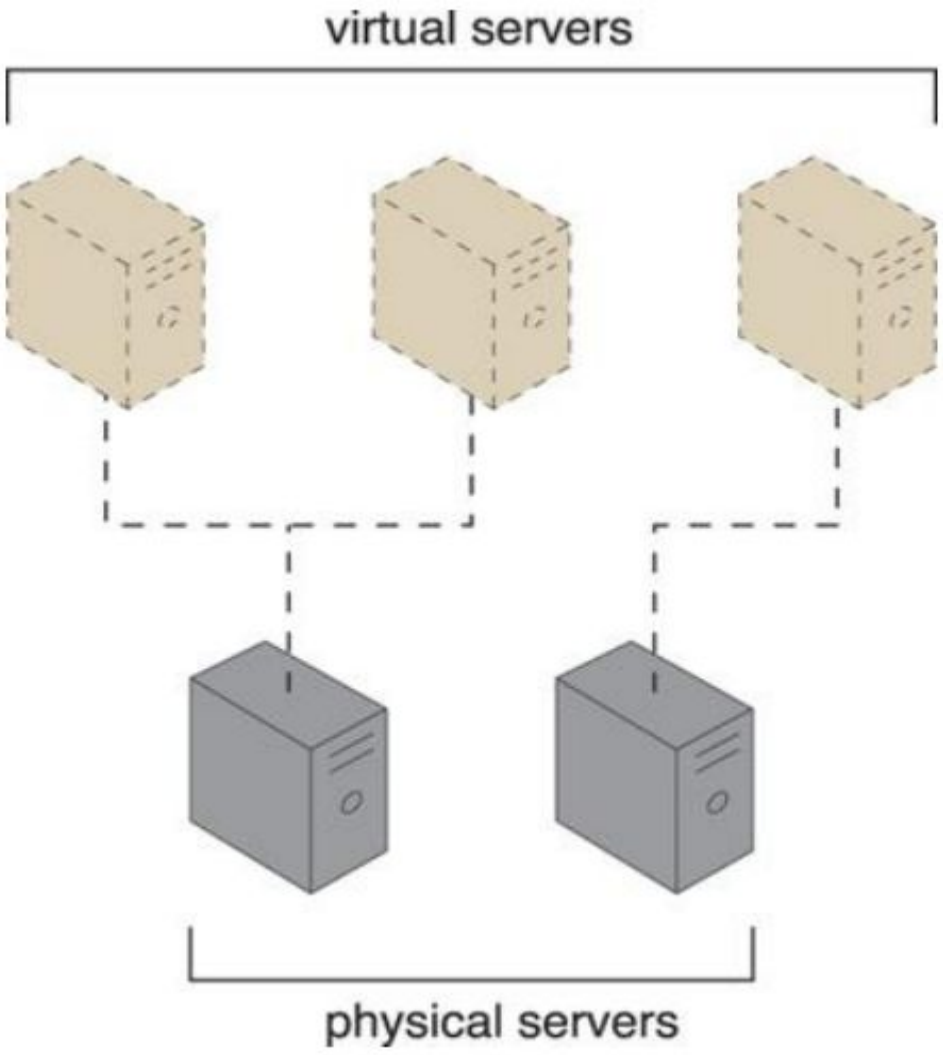
Figure depicts a scenario in which one logical network perimeter contains a cloud consumer's on-premise environment, while another contains a cloud provider's cloud-based environment. These perimeters are connected through a VPN that protects communications, since the VPN is typically implemented by point-to-point encryption of the data packets sent between the communicating endpoints.

SLO – 4 & 5 :
Virtual Server, Cloud Storage Device

2. Virtual Server

- A virtual server is a form of virtualization software that emulates a physical server
- Virtual servers are used by cloud providers to share the same physical server with multiple cloud consumers by providing cloud consumers with individual virtual server instances.
- Figure shows three virtual servers being hosted by two physical servers.

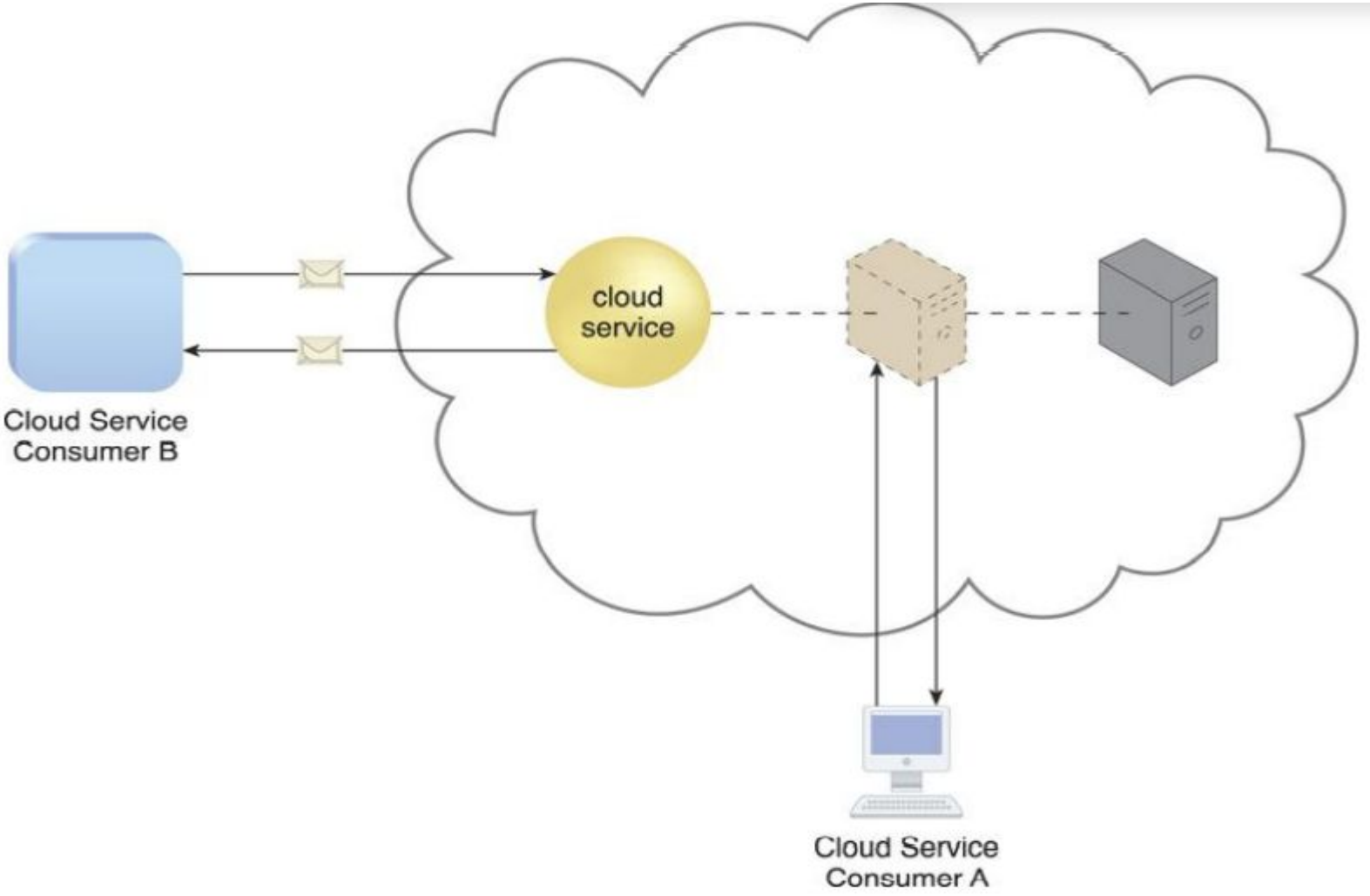
The first physical server hosts two virtual servers, while the second physical server hosts one virtual server



Virtual Server…

- The virtual server represents the most foundational building block of cloud environments.
- Each virtual server can host numerous IT resources, cloud-based solutions, and various other cloud computing mechanisms.
- The instantiation of virtual servers from image files is a resource allocation process that can be completed rapidly and on-demand.
- Cloud consumers that install or lease virtual servers can customize their environments independently from other cloud consumers that may be using virtual servers hosted by the same underlying physical server.
- Figure depicts a virtual server that hosts a cloud service being accessed by Cloud Service Consumer B, while Cloud Service Consumer A accesses the virtual server directly to perform an administration task.

A virtual server hosts an active cloud service and is further accessed by a cloud consumer for administrative purposes



3. Cloud Storage Device

- The cloud storage device mechanism represents storage devices that are designed specifically for cloud-based provisioning.
- Instances of these devices can be virtualized
- Provide fixed-increment capacity allocation in support of the pay-per-use mechanism
- Cloud storage devices can be exposed for remote access via cloud storage services.

Cloud Storage Device

- A primary concern related to cloud storage is the security, integrity, and confidentiality of data.
- Another issue applies specifically to the performance of large databases.
- LANs provide locally stored data with network reliability and latency levels that are superior to those of WANs.

Cloud Storage Device

Cloud Storage Levels

- Cloud storage device mechanisms provide common logical units of data storage, such as:

  Files – Collections of data are grouped into files that are located in folders.

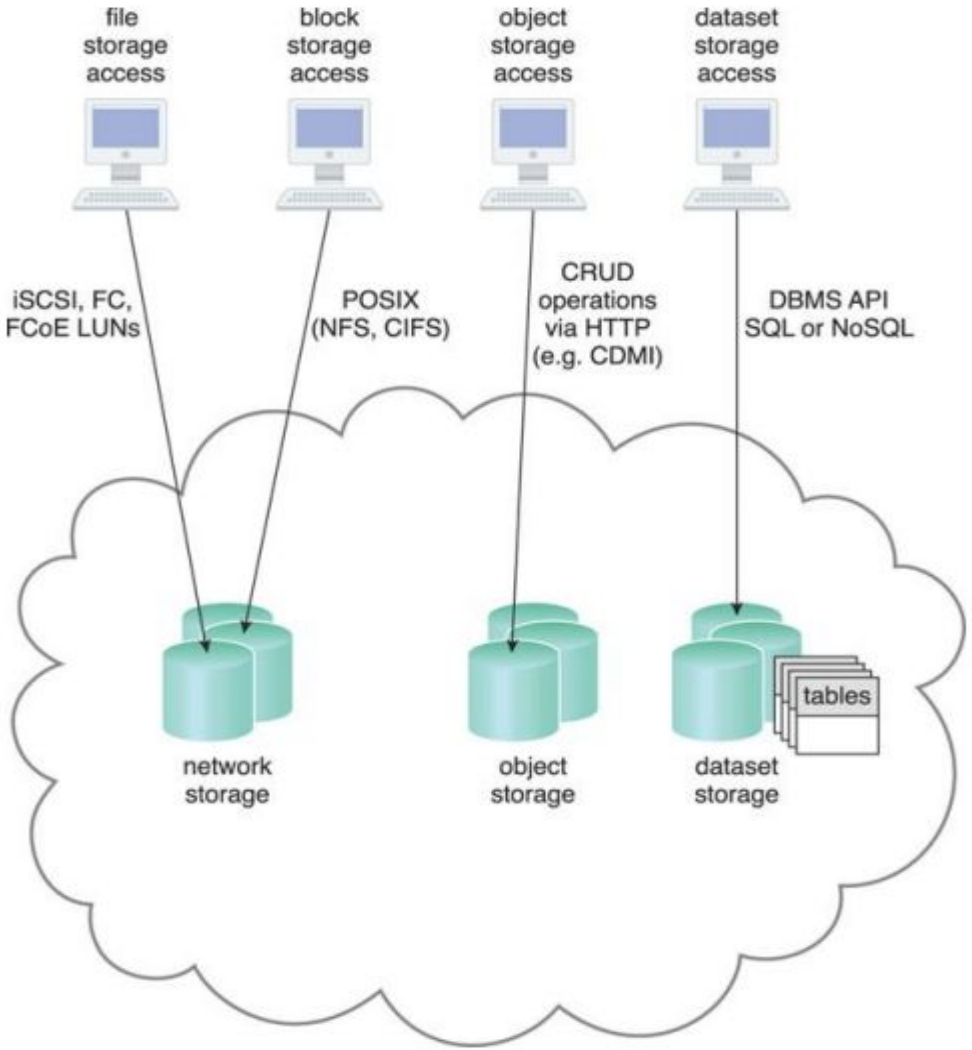
  Blocks – The lowest level of storage and the closest to the hardware, a block is the smallest unit of data that is still individually accessible.

  Datasets – Sets of data are organized into a table-based, delimited, or record format.

  Objects – Data and its associated metadata are organized as Web-based resources.

- Each of these data storage levels is commonly associated with a certain type of technical interface which corresponds to a particular type of cloud storage device and cloud storage service used to expose its API (Figure).

Different cloud service consumers utilize different technologies to interface with virtualized cloud storage devices. (Adapted from the CDMI Cloud Storage Reference Model.)



Network Storage Interfaces

- Legacy network storage most commonly falls under the category of network storage interfaces.
- It includes storage devices in compliance with industry standard protocols, such as,
  - SCSI for storage blocks
  - Server Message Block (SMB),
  - Common Internet File System (CIFS)
  - Network File System (NFS) for file and network storage.
- Storing individual data in separate files and organized into folders and subfolders.
- Original files are often replaced by the new files that are created when data has been modified.

Network Storage Interfaces

- When a cloud storage device mechanism is based on this type of interface, its data searching and extraction performance will tend to be suboptimal.
- Block storage requires data to be in a fixed format (known as a data block), which is the smallest unit that can be stored and accessed and the storage format closest to hardware.
- Using either the logical unit number (LUN) or virtual volume block-level storage will typically have better performance than file-level storage.

Object Storage Interfaces

- Various types of data can be referenced and stored as Web resources. This is referred to as object storage, which is based on technologies that can support a range of data and media types.
- Cloud Storage Device mechanisms that implement this interface can typically be accessed via REST or Web service-based cloud services using HTTP as the prime protocol.

Database Storage Interfaces

- Cloud storage device mechanisms based on database storage interfaces typically support a query language in addition to basic storage operations.
- This classification of storage interface is divided into two main categories according to storage structure, as follows.

1. **Relational Data Storage**

- Traditionally, many on-premise IT environments store data using relational databases or relational database management systems (RDBMSs).
- Relational databases (or relational storage devices) rely on tables to organize similar data into rows and columns.
- Tables can have relationships with each other to give the data increased structure, to protect data integrity, and to avoid data redundancy (which is referred to as data normalization).
- Working with relational storage commonly involves the use of the industry standard Structured Query Language (SQL).

Database Storage Interfaces

- A cloud storage device mechanism implemented using relational data storage could be based on any number of commercially available database products,
  - such as IBM DB2, Oracle Database, Microsoft SQL Server, and MySQL.
- Challenges with cloud-based relational databases commonly pertain to scaling and performance.
- Scaling a relational cloud storage device vertically can be more complex and cost-ineffective than horizontal scaling.
- Databases with complex relationships and/or containing large volumes of data can be afflicted with higher processing overhead and latency, especially when accessed remotely via cloud services.

Database Storage Interfaces

2. Non-Relational Data Storage

- Non-relational storage (also commonly referred to as NoSQL storage) moves away from the traditional relational database model in that it establishes a "looser" structure for stored data with less emphasis on defining relationships and realizing data normalization.
- The primary motivation for using non-relational storage is to avoid the potential complexity and processing overhead that can be imposed by relational databases.
- Also, non-relational storage can be more horizontally scalable than relational storage.

Database Storage Interfaces

- Non-relational repositories don't tend to support relational database functions, such as transactions or joins.
- Normalized data exported into a non-relational storage repository will usually become denormalized, meaning that the size of the data will typically grow.
- Cloud providers often offer non-relational storage that provides scalability and availability of stored data over multiple server environments.
- However, many non-relational storage mechanisms are proprietary and therefore can severely limit data portability.

SLO – 1 :
Cloud Usage Monitor

4. Cloud Usage Monitor

- The cloud usage monitor mechanism is a lightweight and autonomous software program responsible for collecting and processing IT resource usage data.

Three common agent-based implementation formats:

1. **Monitoring Agent**
2. **Resource Agent**
3. **Polling Agent**

- Each can be designed to forward collected usage data to a log database for postprocessing and reporting purposes.

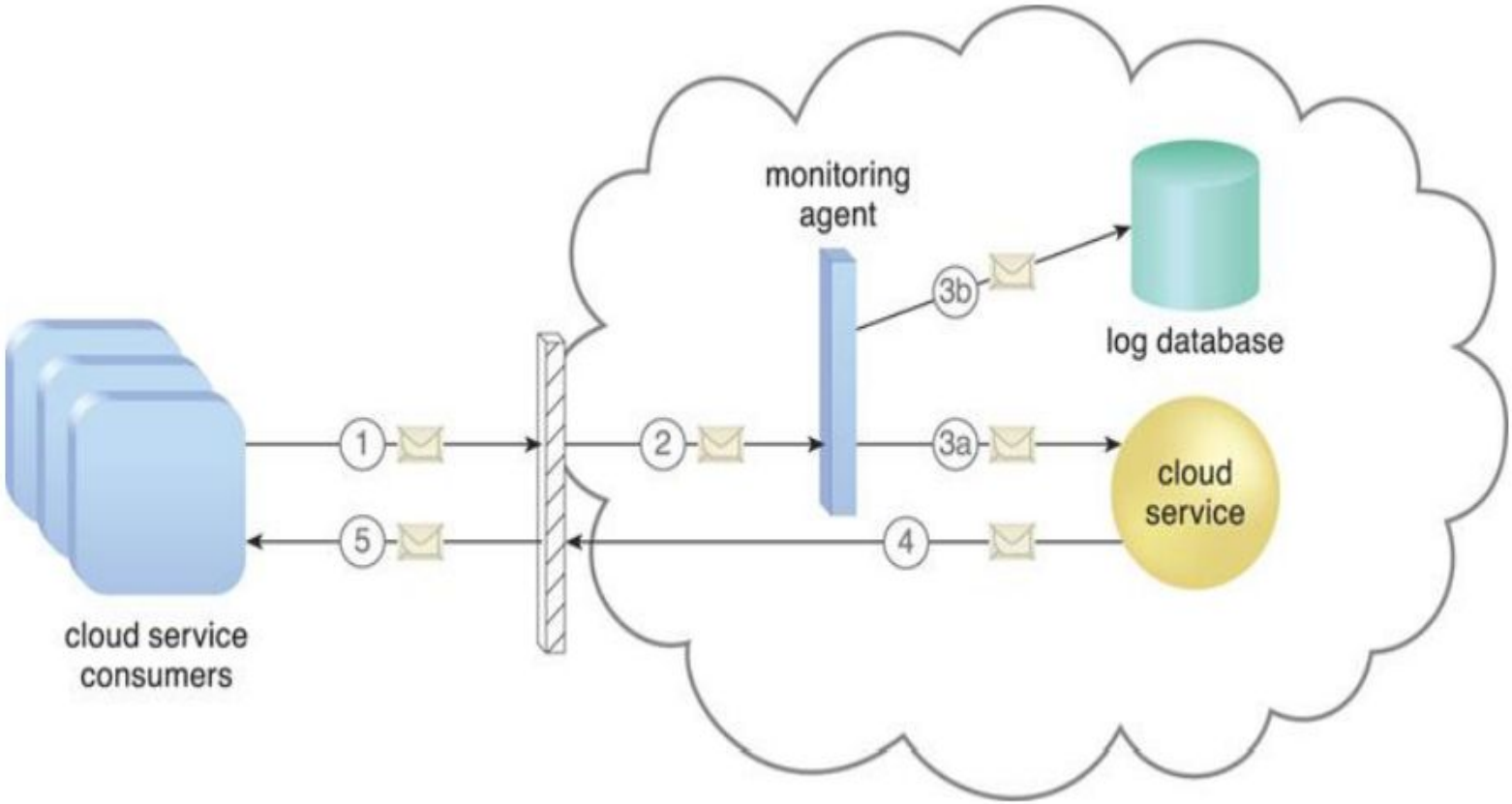
Cloud Usage Monitor

1. Monitoring Agent

- A monitoring agent is an intermediary, event-driven program that exists as a service agent and resides along existing communication paths to transparently monitor and analyze dataflows (Figure).
- This type of cloud usage monitor is commonly used to measure network traffic and message metrics.

Cloud Usage Monitor

A cloud service consumer sends a request message to a cloud service (1). The monitoring agent intercepts the message to collect relevant usage data (2) before allowing it to continue to the cloud service (3a). The monitoring agent stores the collected usage data in a log database (3b). The cloud service replies with a response message (4) that is sent back to the cloud service consumer without being intercepted by the monitoring agent (5).

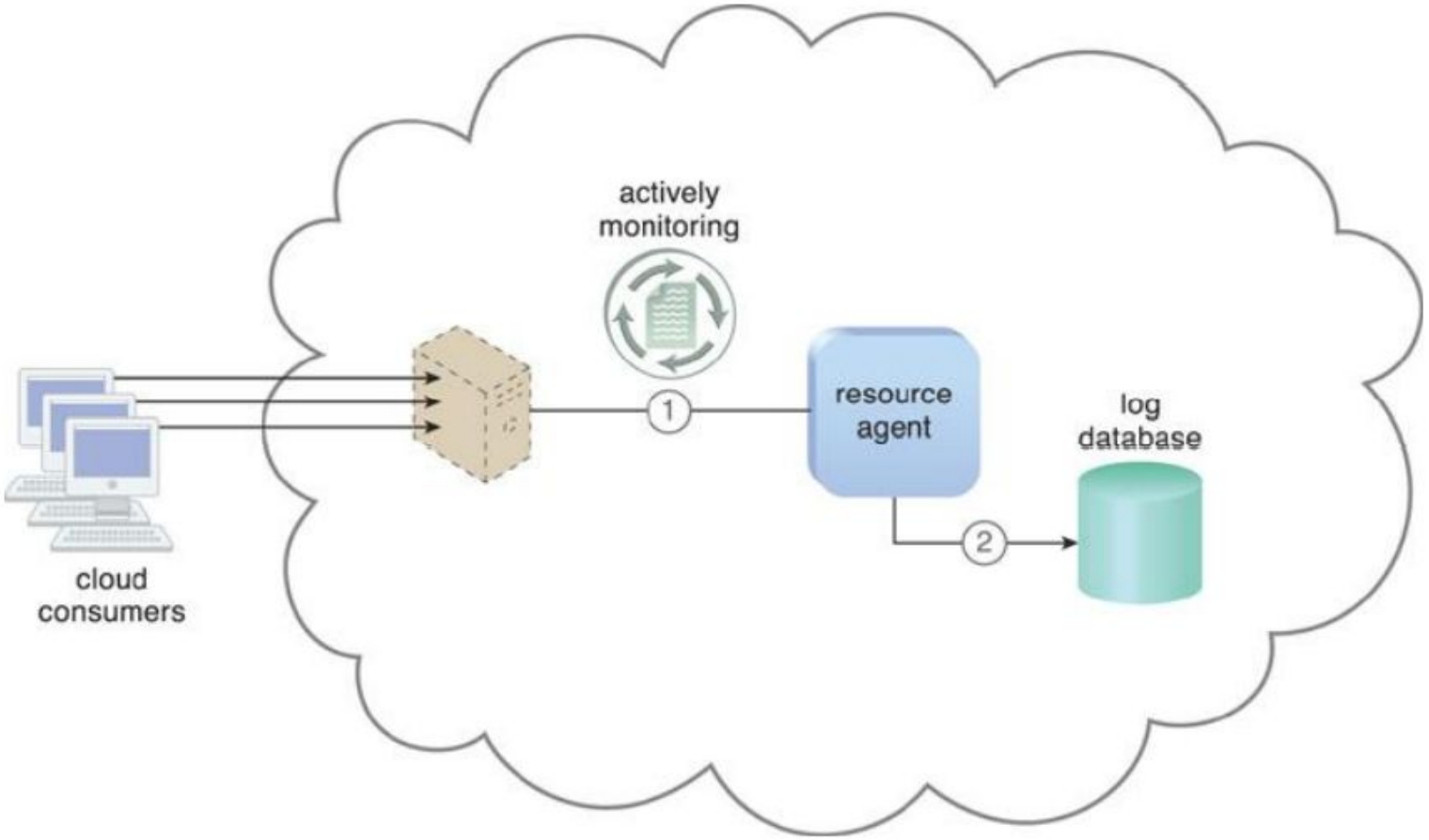


Cloud Usage Monitor

2. Resource Agent

- A resource agent is a processing module that collects usage data by having event-driven interactions with specialized resource software (Figure).
- This module is used to monitor usage metrics based on pre-defined, observable events at the resource software level, such as initiating, suspending, resuming, and vertical scaling.

Cloud Usage Monitor



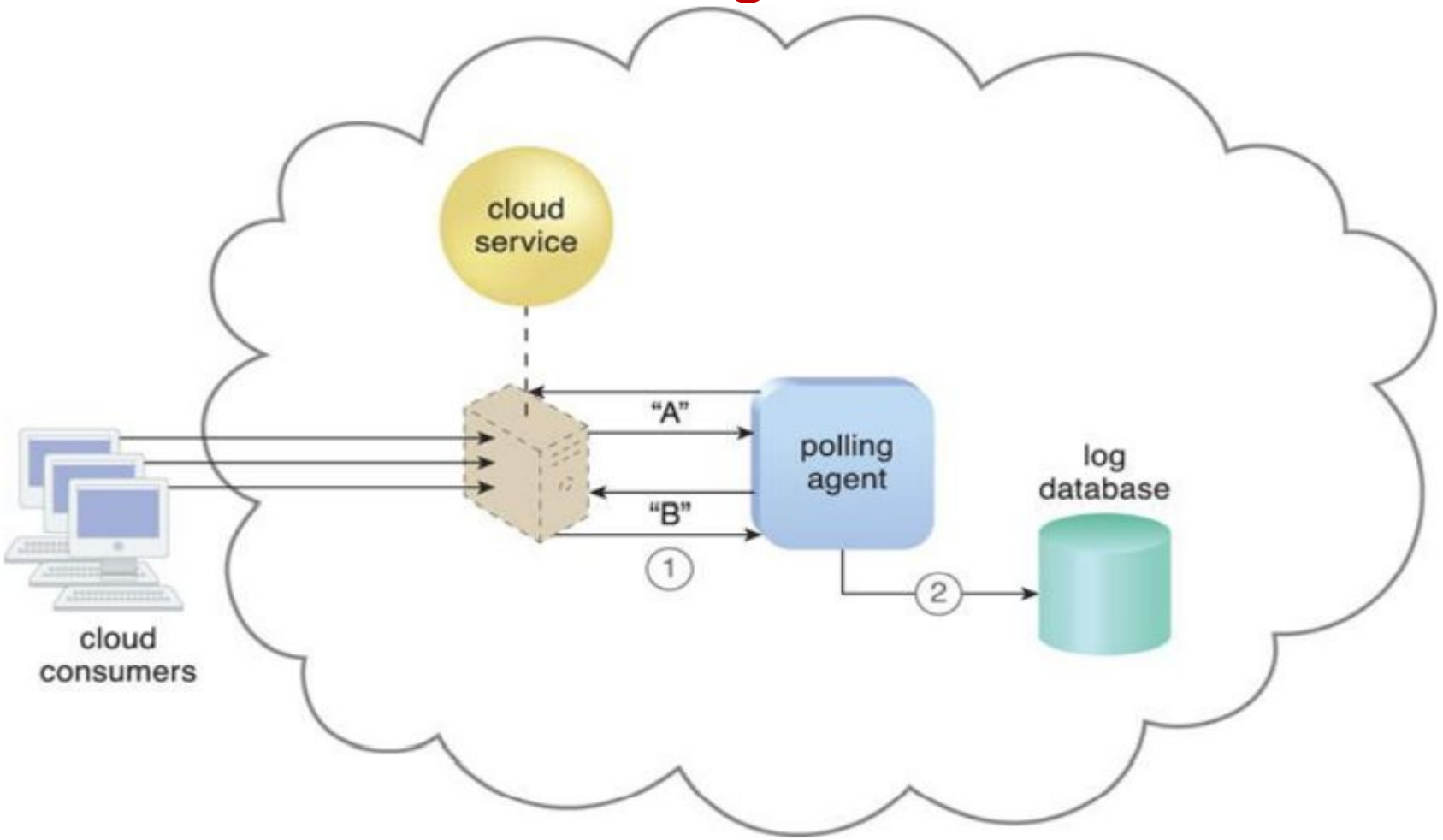
The resource agent is actively monitoring a virtual server and detects an increase in usage (1). The resource agent receives a notification from the underlying resource management program that the virtual server is being scaled up and stores the collected usage data in a log database, as per its monitoring metrics (2).

Cloud Usage Monitor

3. Polling Agent

- A polling agent is a processing module that collects cloud service usage data by polling IT resources.
- This type of cloud service monitor is commonly used to periodically monitor IT resource status, such as uptime and downtime (Figure).

Cloud Usage Monitor



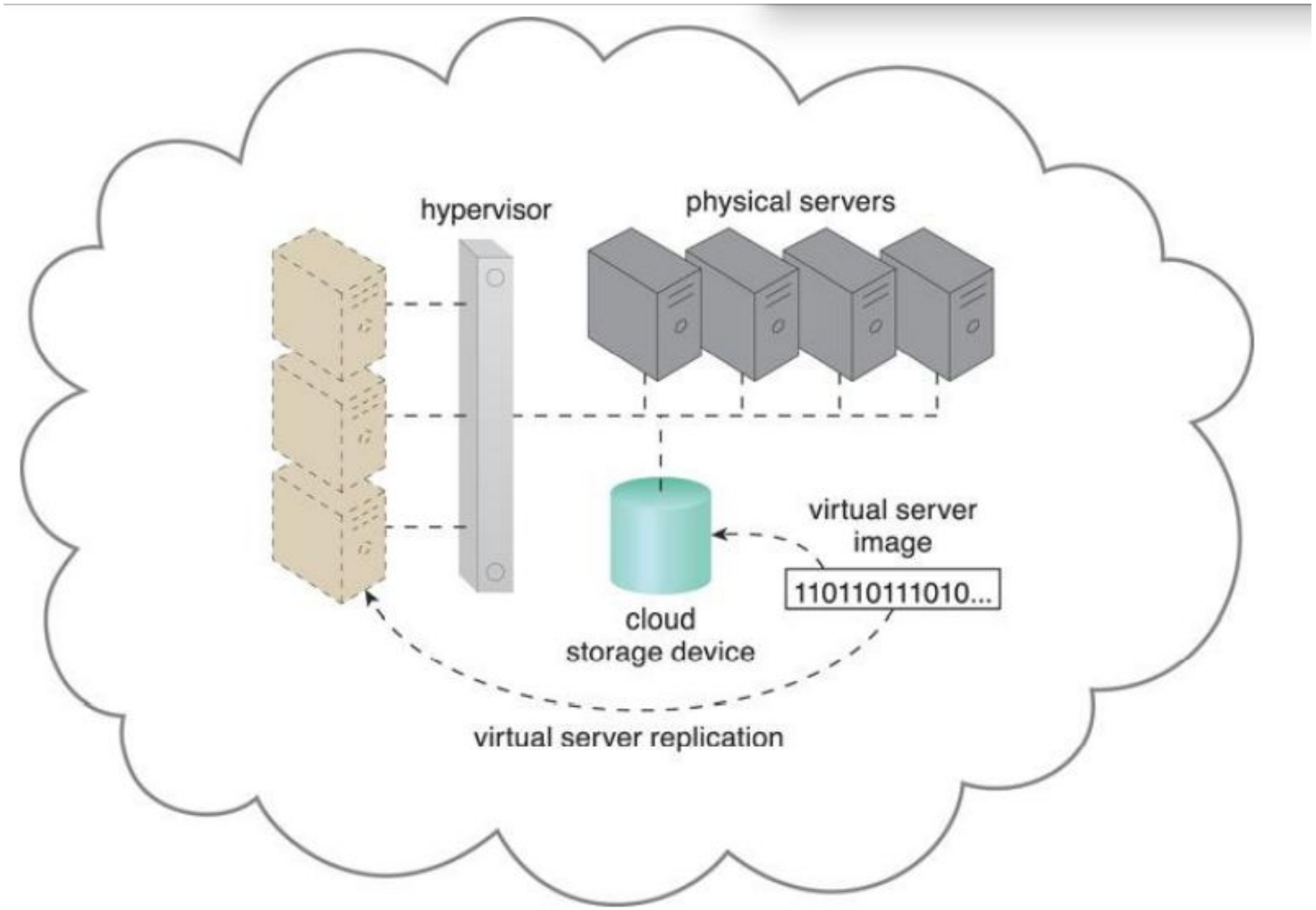
A polling agent monitors the status of a cloud service hosted by a virtual server by sending periodic polling request messages and receiving polling response messages that report usage status "A" after a number of polling cycles, until it receives a usage status of "B" (1), upon which the polling agent records the new usage status in the log database (2).

SLO – 2 :
Resource Replication

5. Resource Replication

- Defined as the creation of multiple instances of the same IT resource, replication is typically performed when an IT resource's availability and performance need to be enhanced.
- Virtualization technology is used to implement the resource replication mechanism to replicate cloud-based IT resources (Figure).

The hypervisor replicates several instances of a virtual server, using a stored virtual server image

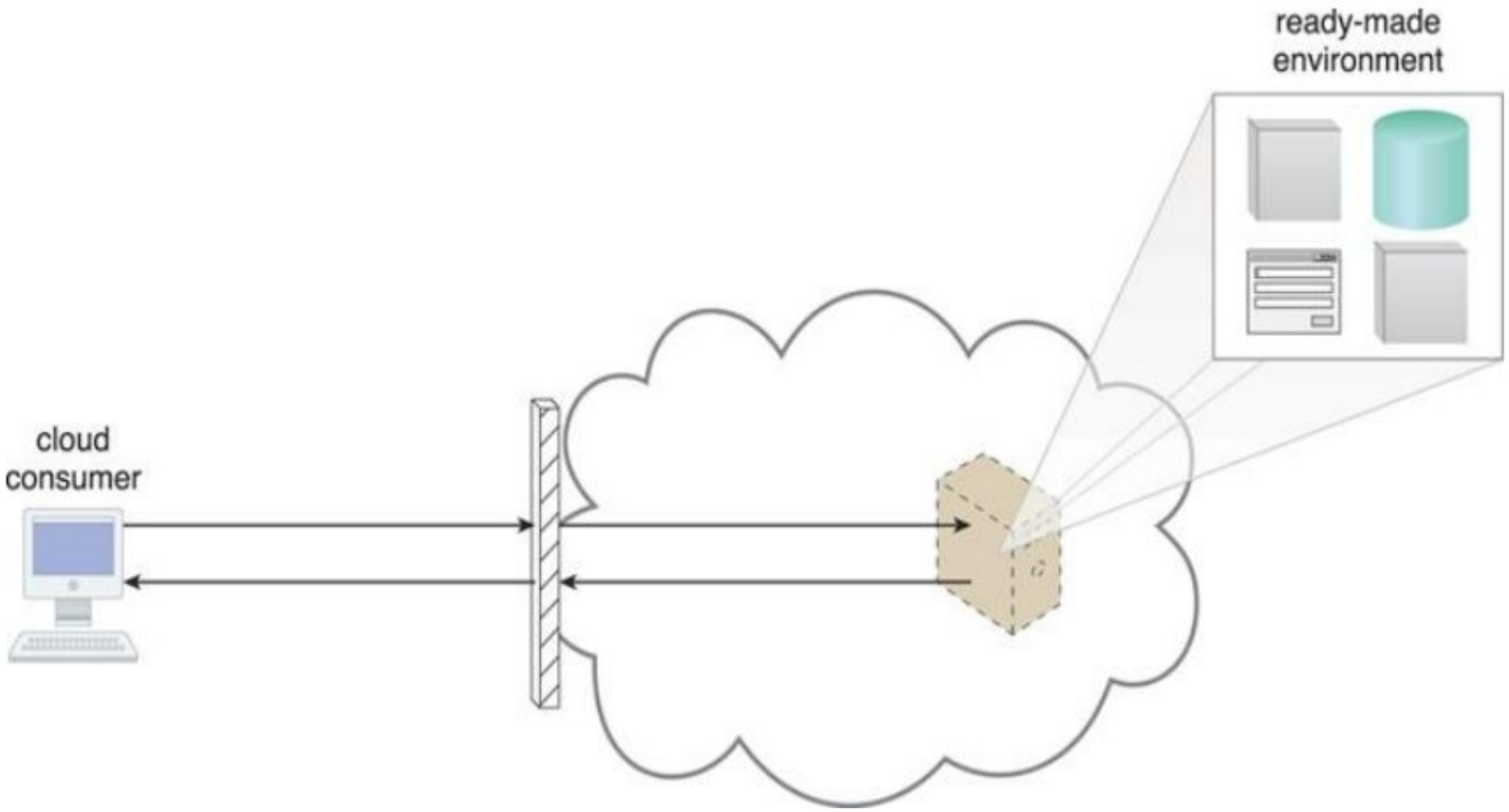


SLO – 1 :
Ready-Made Environment

6. Ready-Made Environment

- The ready-made environment mechanism (Figure) is a defining component of the PaaS cloud delivery model that represents a predefined, cloud-based platform comprised of a set of already installed IT resources, ready to be used and customized by a cloud consumer.
- These environments are utilized by cloud consumers to remotely develop and deploy their own services and applications within a cloud.
- Typical readymade environments include pre-installed IT resources, such as databases, middleware, development tools, and governance tools.

A cloud consumer accesses a ready-made environment hosted on a virtual server



Ready-Made Environment

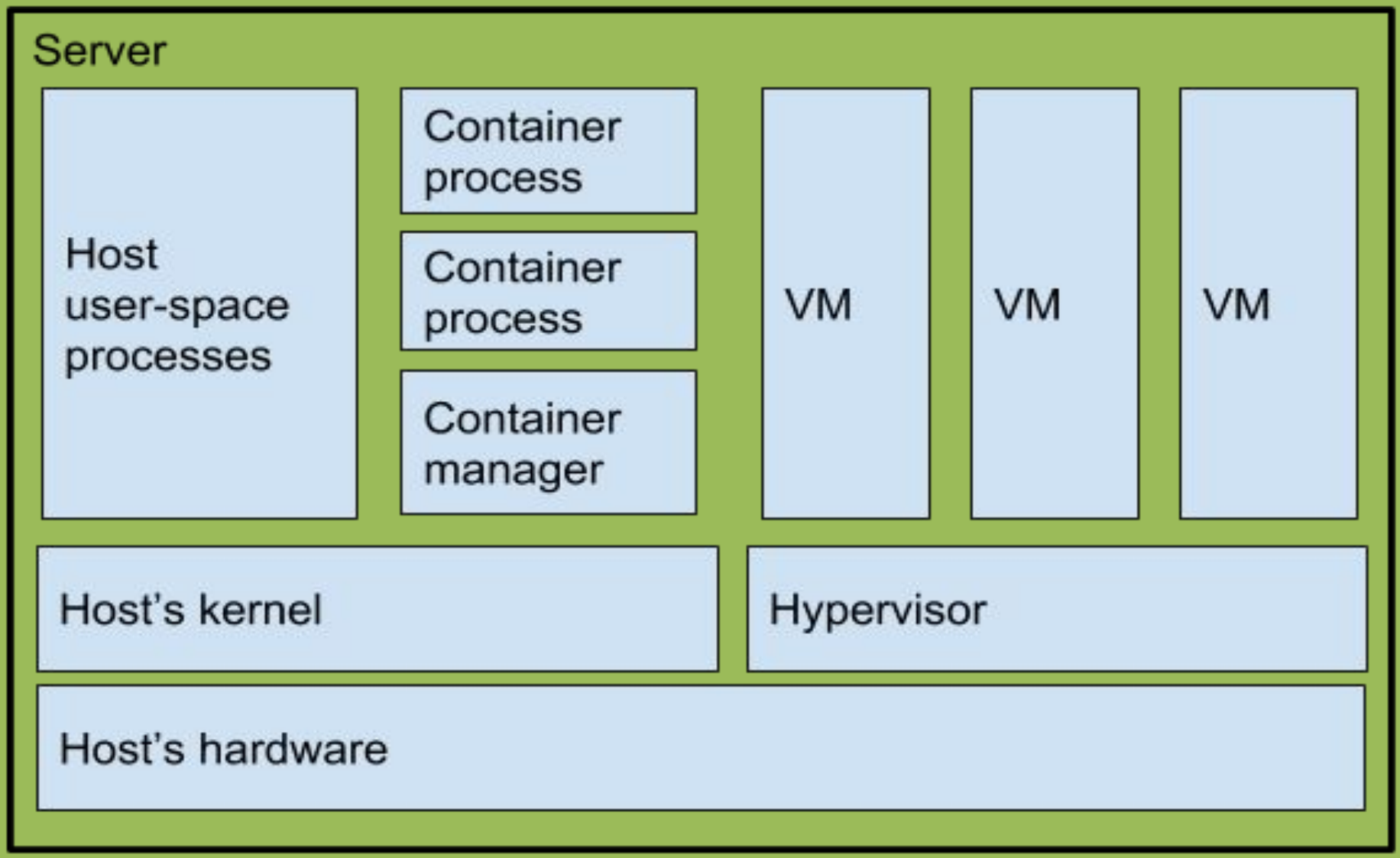
- A ready-made environment is generally equipped with a complete software development kit (SDK) that provides cloud consumers with programmatic access to the development technologies that comprise their preferred programming stacks.
- Some cloud providers offer runtime execution environments for cloud services that are based on different runtime performance and billing parameters.
  - For example, a front-end instance of a cloud service can be configured to respond to time-sensitive requests more effectively than a back-end instance.

SLO – 2 :
Container

What is a container?

- There are a bunch of definitions of what a container is.
  - Nigel Poulton's definition is an "Isolated area of an OS with resource limits usage applied."
  - The Wikipedia's definition says "containers is a generic term for an operating system level virtualization. There are a number of such implementations including Docker, lxc, and rkt."
  - In the Unix/Linux System Admin book they describe a container to be an isolated group of processes that are restricted to a private root file system and process namespace.

Container


Server
Host user-space processes
Container process
Container process
Container manager
VM
VM
VM
Host's kernel
Hypervisor
Host's hardware

What is the difference between a process, a container, and a VM?

	Process	Container	VM
Definition	A representation of a running program.	Isolated group of processes managed by a shared kernel.	A full OS that shares host hardware via a hypervisor.
Use case	Abstraction to store state about a running process.	Creates isolated environments to run many apps.	Creates isolated environments to run many apps.
Type of OS	Same OS and distro as host,	Same kernel, but different distribution.	Multiple independent operating systems.
OS isolation	Memory space and user privilieges.	Namespaces and cgroups.	Full OS isolation.
Size	Whatever user's application uses.	Images measured in MB + user's application.	Images measured in GB + user's application.
Lifecycle	Created by forking, can be long or short lived, more often short.	Runs directly on kernel with no boot process, often is short lived.	Has a boot process and is typically long lived.

SLO – 1 :
Cloud Challenges

Cloud Challenges

- Although there is growing acceptance of cloud computing, both the cloud service consumers and providers have been facing some challenges.

1. Challenges – Consumer's Perspective
2. Cloud Challenges – Provider's Perspective

Challenges – Consumer's Perspective

- Security and regulation
  - Consumers are indecisive to transfer control of sensitive data
  - Regulation may prevent organizations from using cloud services
- Network latency
  - Real time applications may suffer due to network latency and limited bandwidth
- Supportability
  - Service provider might not support proprietary environments Incompatible hypervisors could impact VM migration
- Vendor lock-in
  - Lack of standardization across cloud-based platforms
    - Restricts consumers from changing their cloud service providers

Cloud Challenges – Provider's Perspective

- Service warranty and service cost
  - Resources must be kept ready to meet unpredictable demand
  - Hefty penalty, if SLAs are not fulfilled
- Complexity in deploying vendor software in the cloud
  - Many vendors do not provide cloud-ready software licenses
  - Higher cost of cloud-ready software licenses
- No standard cloud access interface
  - Cloud consumers want open APIs
  - Need agreement among cloud providers for standardization

SLO – 2 :
Cloud Adoption Considerations

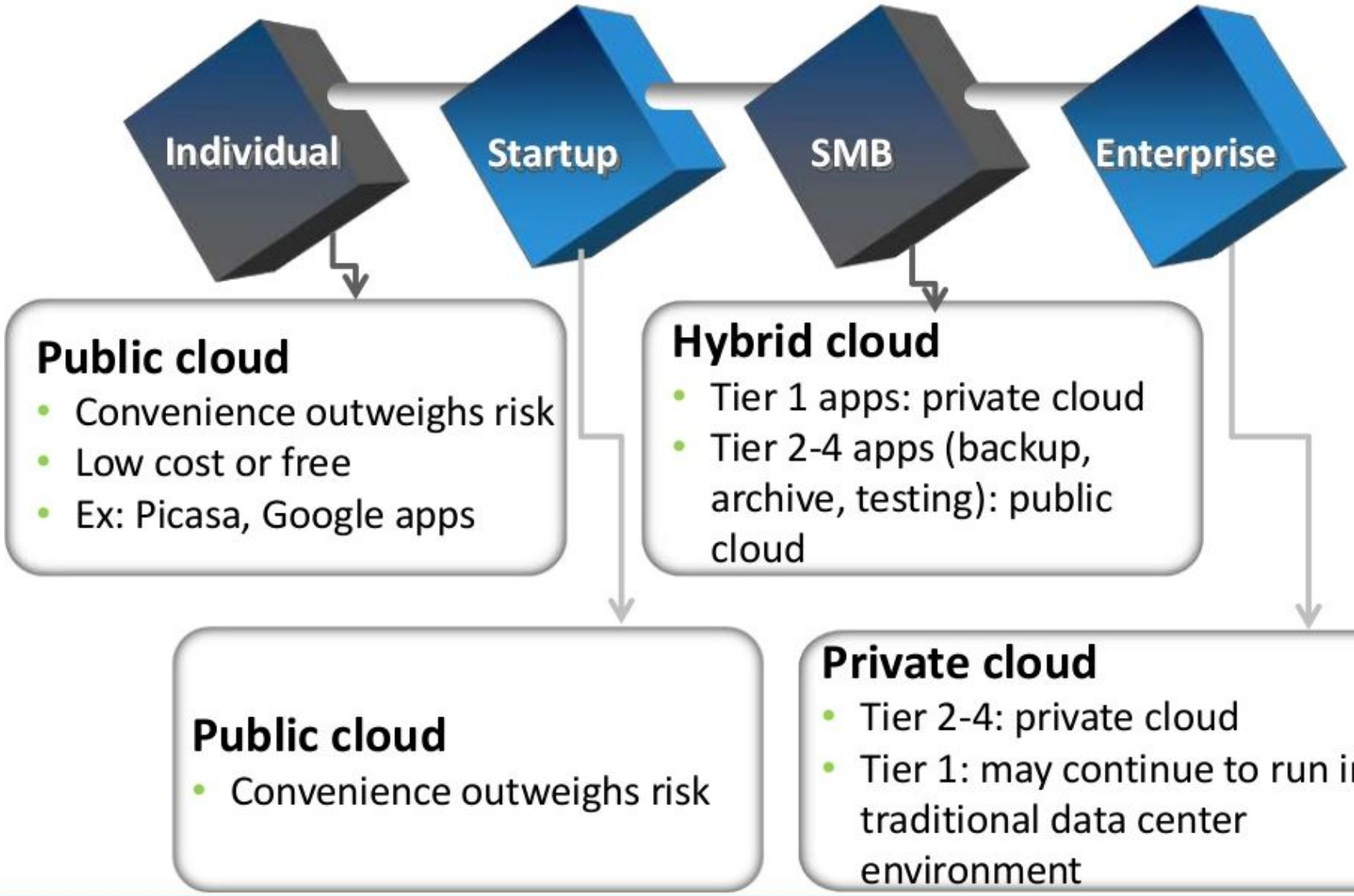
Cloud Adoption Considerations

- Organizations that decide to adopt cloud computing always face this question: "How does the cloud fit the organization's environment?"
- They need to consider various factors before moving their business processes to the cloud.
- Even individuals seeking to use cloud services need to understand some cloud adoption considerations.

Selection of a deployment model

- Risk versus convenience is a key consideration for deciding on a cloud adoption strategy. This consideration also forms the basis for choosing the right cloud deployment model.
- A public cloud is usually preferred by individuals and start-up businesses. For them, the cost reduction offered by the public cloud outweighs the security or availability risks in the cloud.
- Small- and medium-sized businesses (SMBs) have a moderate customer base, and any anomaly in customer data and service levels might impact their business.
- Therefore, they may not be willing to deploy their tier 1 applications, such as Online Transaction Processing (OLTP), in the public cloud. A hybrid cloud model fits in this case.

What Deployment Model Fits for You?



Selection of a deployment model

- The tier 1 applications should run on the private cloud, whereas less critical applications such as backup, archive, and testing can be deployed in the public cloud.
- Enterprises typically have a strong customer base worldwide.
- They usually enforce strict security policies to safeguard critical customer data. Because they are financially capable, they might prefer building their own private clouds.

Choosing Applications for Public Cloud

Some key questions to ask before migrating a consumer application to the public cloud:

- Is the application compatible to cloud platform software? Is it a legacy application?
- Is the application proprietary and mission-critical? Does the application provide competitive advantage?
- Is the application workload network traffic intensive? Will application performance be impacted by network latency and limited network bandwidth?
- Does the application communicate with other data center resources or applications?

Financial advantage

- A careful analysis of financial benefits provides a clear picture about the cost-savings in adopting the cloud.
- Compare both the Total Cost of Ownership (TCO) and the Return on Investment (ROI) in the cloud
- Requires analysis of financial benefits in adopting cloud
- Consider CAPEX (Capital expenditure) and OPEX (Operational expenditure) to deploy and maintain own infrastructure

Cost of Owning Infrastructure		Cloud Adoption Cost
CAPEX	OPEX	OPEX
• Servers • Storage • Operating system (OS) • Application • Network equipments • Real estate	• Power and cooling • Personnel • Bandwidth • Maintenance • Support • Backup	• Migration • Compliance and security • Subscription fee

Selection of a cloud service provider:

Some key questions to ask before selecting a provider:

- How long and how well has the provider been delivering the services?
- How well does the provider meet the organization's current and future requirements?
- How easy is it to add or remove services?
- How easy is it to move to another provider, when required?
- What happens when the provider upgrades their software? Is it forced on everyone? Can you upgrade on your own schedule?
- Does the provider offer the required security services?
- Does the provider meet your legal and privacy requirements?
- Does the provider have good customer service support?

Service-level agreement (SLA)

- Cloud service providers typically mention quality of service (QoS) attributes such as throughput and uptime, along with cloud services.
- The QoS attributes are generally part of an SLA, which is the service contract between the provider and the consumers.
- The SLA serves as the foundation for the expected level of service between the consumer and the provider.
- Before adopting the cloud services, consumers should check whether the QoS attributes meet their requirements.

References

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- **Thomas Erl, "Cloud Computing: Concepts, Technology & Architecture", Prentice Hall.**