UNIT-5
CLOUD COMPUTING

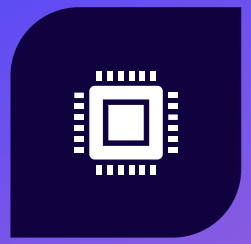
Cloud Computing

- A widely adopted definition of cloud computing comes from the U.S. National Institute of Standards and Technology (NIST Special Publication 800-145):
- *Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provision*

Cloud Enabling Technologies

- *Grid computing* is a form of distributed computing that enables the resources of numerous heterogeneous computers in a network to work together on a single task at the same time.
- *Utility computing* is a service-provisioning model in which a service provider makes computing resources available to customers, as required, and charges them based on usage..
- *Virtualization* is a technique that abstracts the physical characteristics of IT resources from resource users. It enables the resources to be viewed and managed as a pool and lets users create virtual resources from the pool.
- *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

Characteristics of Cloud Computing



ON-DEMAND SELF-SERVICE: A CONSUMER CAN UNILATERALLY PROVISION COMPUTING CAPABILITIES, SUCH AS SERVER TIME AND NETWORK STORAGE, AS NEEDED, AUTOMATICALLY WITHOUT REQUIRING HUMAN INTERACTION WITH EACH SERVICE PROVIDER.

BROAD NETWORK ACCESS: CAPABILITIES ARE AVAILABLE OVER THE NETWORK AND ACCESSED THROUGH STANDARD MECHANISMS THAT PROMOTE USE BY HETEROGENEOUS THIN OR THICK CLIENT PLATFORMS (FOR EXAMPLE, MOBILE PHONES, TABLETS, LAPTOPS, AND WORKSTATIONS).

RESOURCE POOLING: THE PROVIDER'S COMPUTING RESOURCES ARE POOLED TO SERVE MULTIPLE CONSUMERS USING A MULTITENANT MODEL, WITH DIFFERENT PHYSICAL AND VIRTUAL RESOURCES DYNAMICALLY ASSIGNED AND REASSIGNED ACCORDING TO CONSUMER DEMAND.

RAPID ELASTICITY: CAPABILITIES CAN BE ELASTICALLY PROVISIONED AND RELEASED, IN SOME CASES AUTOMATICALLY, TO SCALE RAPIDLY OUTWARD AND INWARD COMMENSURATE WITH DEMAND.

MEASURED SERVICE: CLOUD SYSTEMS AUTOMATICALLY CONTROL AND OPTIMIZE RESOURCE USE BY LEVERAGING A METERING CAPABILITY AT SOME LEVEL OF ABSTRACTION APPROPRIATE TO THE TYPE OF SERVICE

Benefits of Cloud Computing

- **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..
- **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.
- **High availability:** Cloud computing has the capability to ensure resource availability at varying levels depending on the consumer's policy and priority.

Cloud Service Models

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

Infrastructure-as-a-Service (IaaS)

Platform-as-a-Service (PaaS) and

Software-as-a-Service (SaaS).

CLOUD SERVICE MODELS

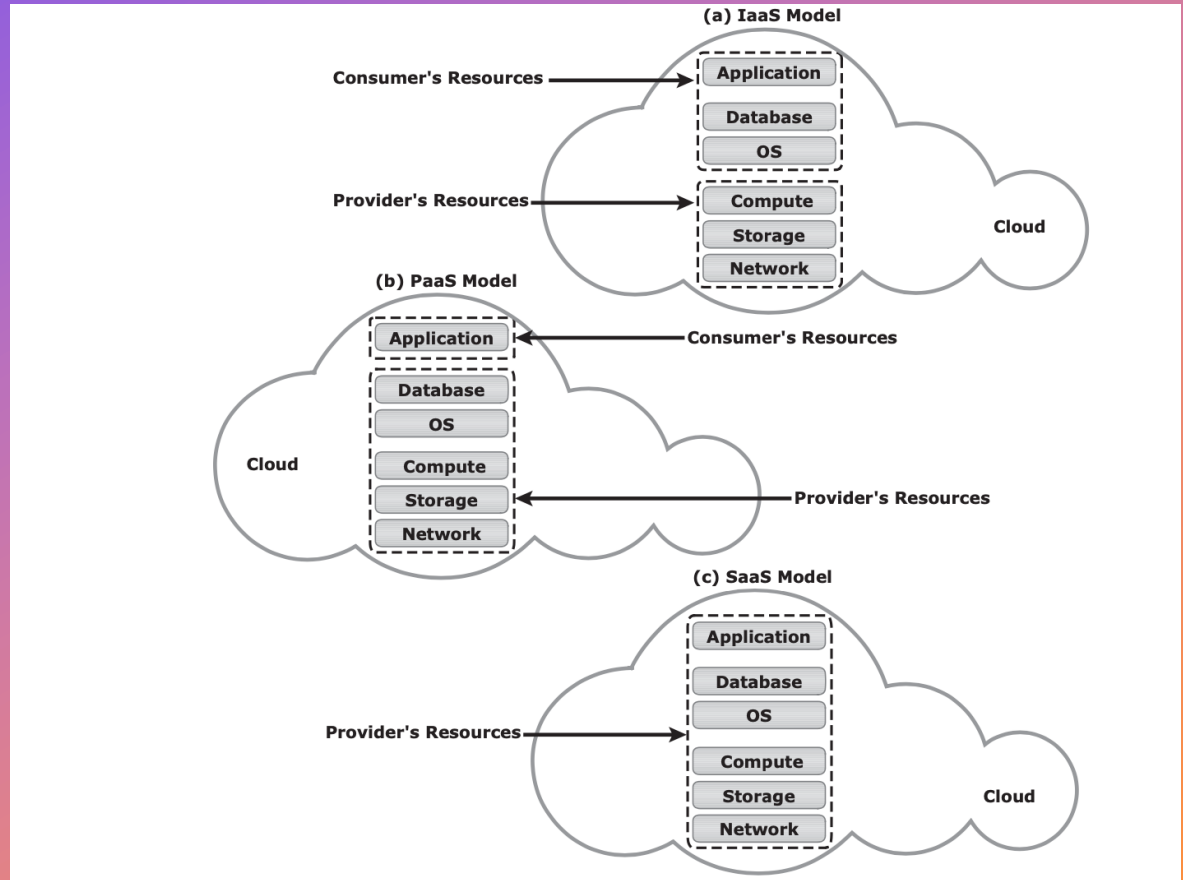


Figure 13-1: IaaS, PaaS, and SaaS models

IaaS

The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications.

The consumer does not manage or control the underlying cloud infrastructure but has control over operating systems and deployed applications

Possibly limited control of select networking components (for example, host firewalls).

PaaS

The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider.

The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, or storage, but has control over the deployed applications and possibly configuration settings for the application-hosting environment.

PaaS is also used as an application development environment, offered as a service by the cloud service provider.

The consumer may use these platforms to code their applications and then deploy the applications on the cloud. Because the workload to the deployed applications varies, the scalability of computing resources is usually guaranteed by the computing platform, transparently. Google App Engine and Microsoft Windows Azure Platform are examples of PaaS.

SaaS

The capability provided to the consumer is to use the provider’s applications running on a cloud infrastructure.

The applications are accessible from various client devices through either a thin client interface, such as a web browser (for example, web-based e-mail), or a program interface.

The consumer does not manage or control the underlying cloud infrastructure including network, servers, operating systems, storage, or even individual application capabilities, with the possible exception of limited user-specific application configuration settings.

Cloud Deployment Models

- According to NIST, cloud computing is classified into four deployment models —
- Public
- Private
- Community, and
- Hybrid — which provide the basis for how cloud infrastructures are constructed and consumed.

PUBLIC CLOUD

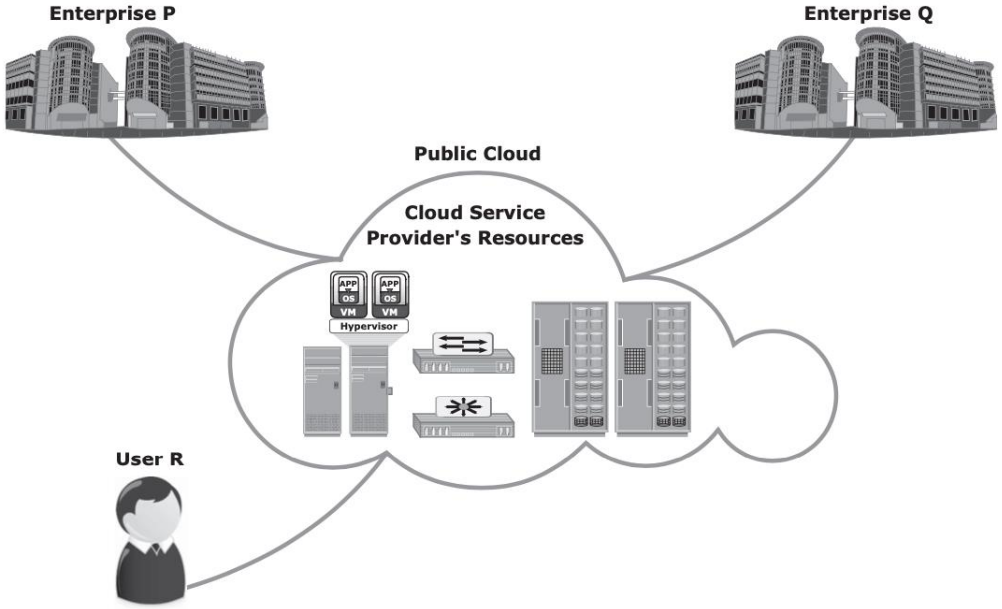
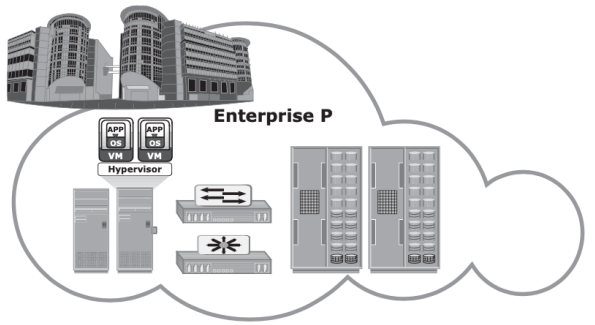
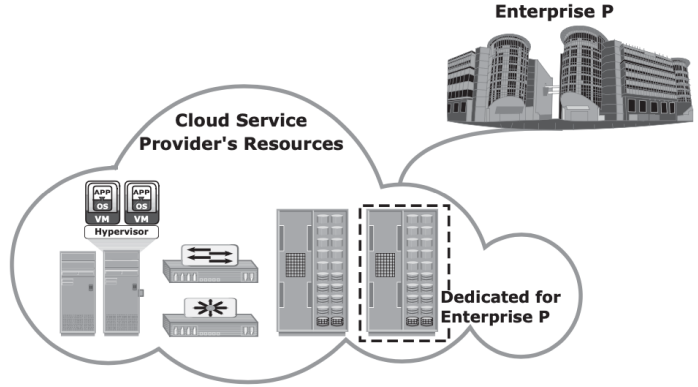


Figure 13-2: Public cloud

PRIVATE CLOUD



(a) On-Premise Private Cloud



(b) Externally Hosted Private Cloud

COMMUNITY CLOUD

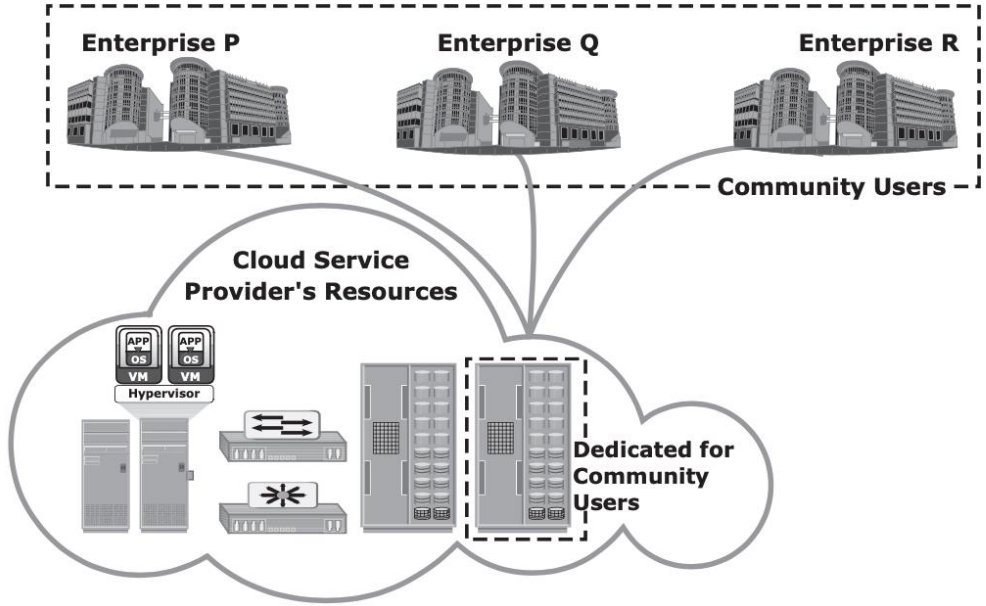


Figure 13-4: Community cloud

HYBRID CLOUD

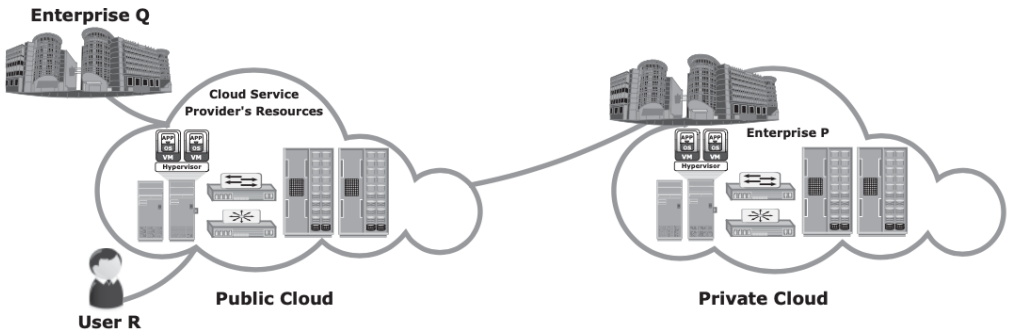


Figure 13-5: Hybrid cloud

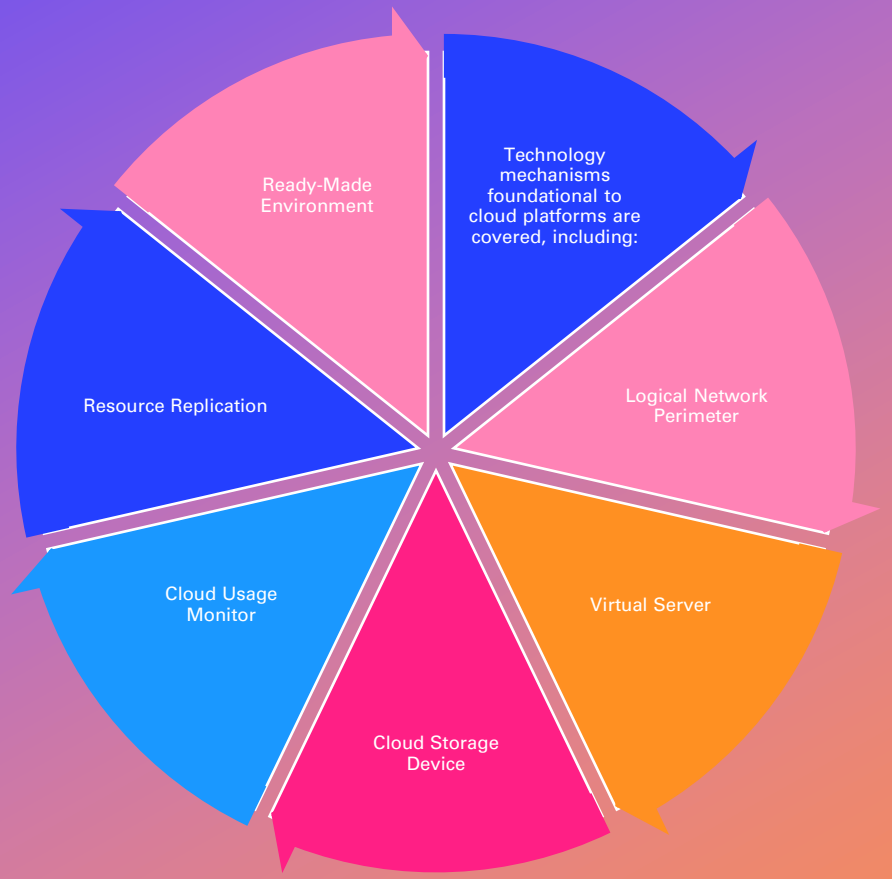
Cloud computing infrastructure

A cloud computing infrastructure is the collection of hardware and software that enables the five essential characteristics of cloud computing. Cloud computing infrastructure usually consists of the following layers:

Physical infrastructure	Virtual infrastructure	Applications and platform software	Cloud management and service creation tools

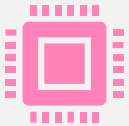
The resources of these layers are aggregated and coordinated to provide cloud services to the consumers

Cloud Infrastructure Mechanism

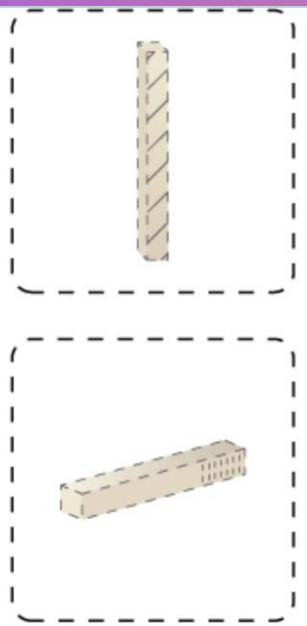


Logical Network Perimeter

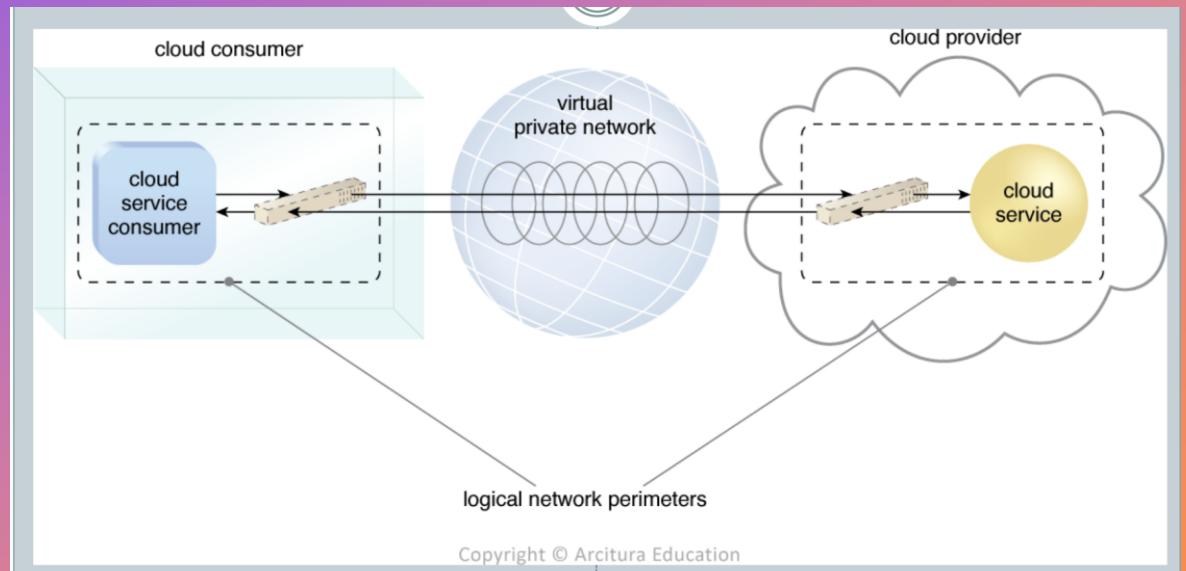
The isolation of a network environment from the rest of communications network, the logical network perimeter establishes a virtual network boundary that can encompass and isolate a group of related cloud-based IT resources that may be physically distributed.



Logical network perimeter can be implement to isolate IT resources in a cloud from cloud users and control the bandwidth via network devices by deploying virtual firewall and virtual network.

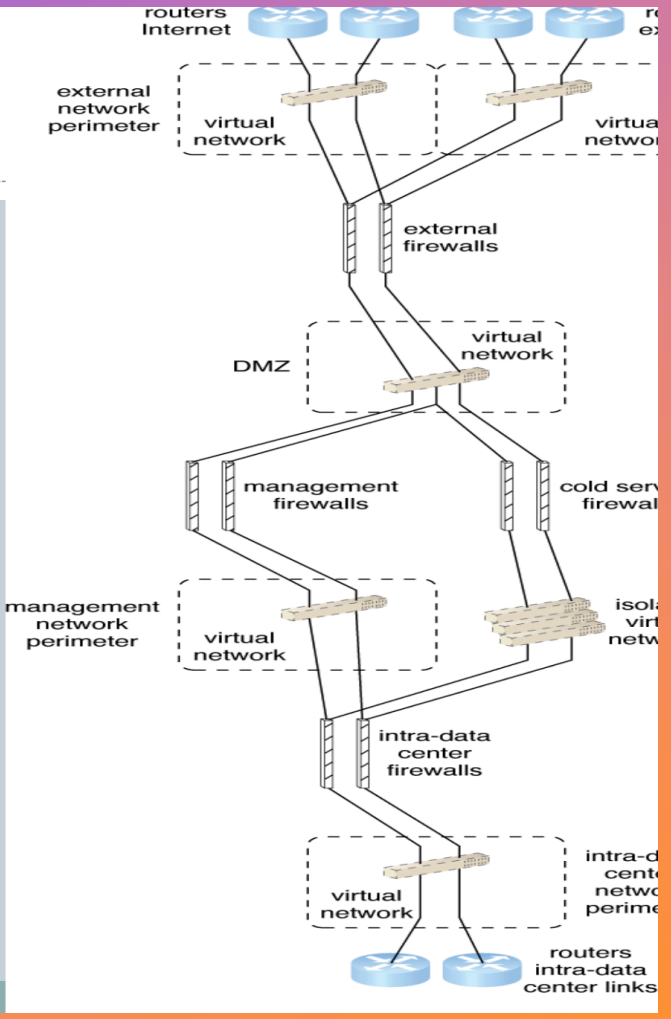


- *Figure 7.2 Virtual firewall (top) and virtual network. (bottom)*



- *Figure 7.3 – Two logical network perimeters surround the cloud consumer and cloud provider environments.*

- *Figure 7.4 - A logical network layout is established through a set of logical network perimeters using various firewalls and virtual networks.*



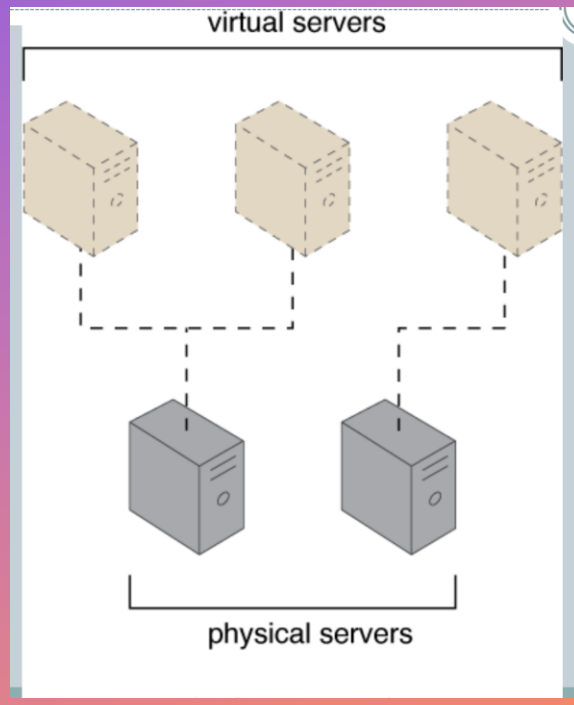
Virtual server

A virtual server is a form of virtualization software that emulates a physical service.

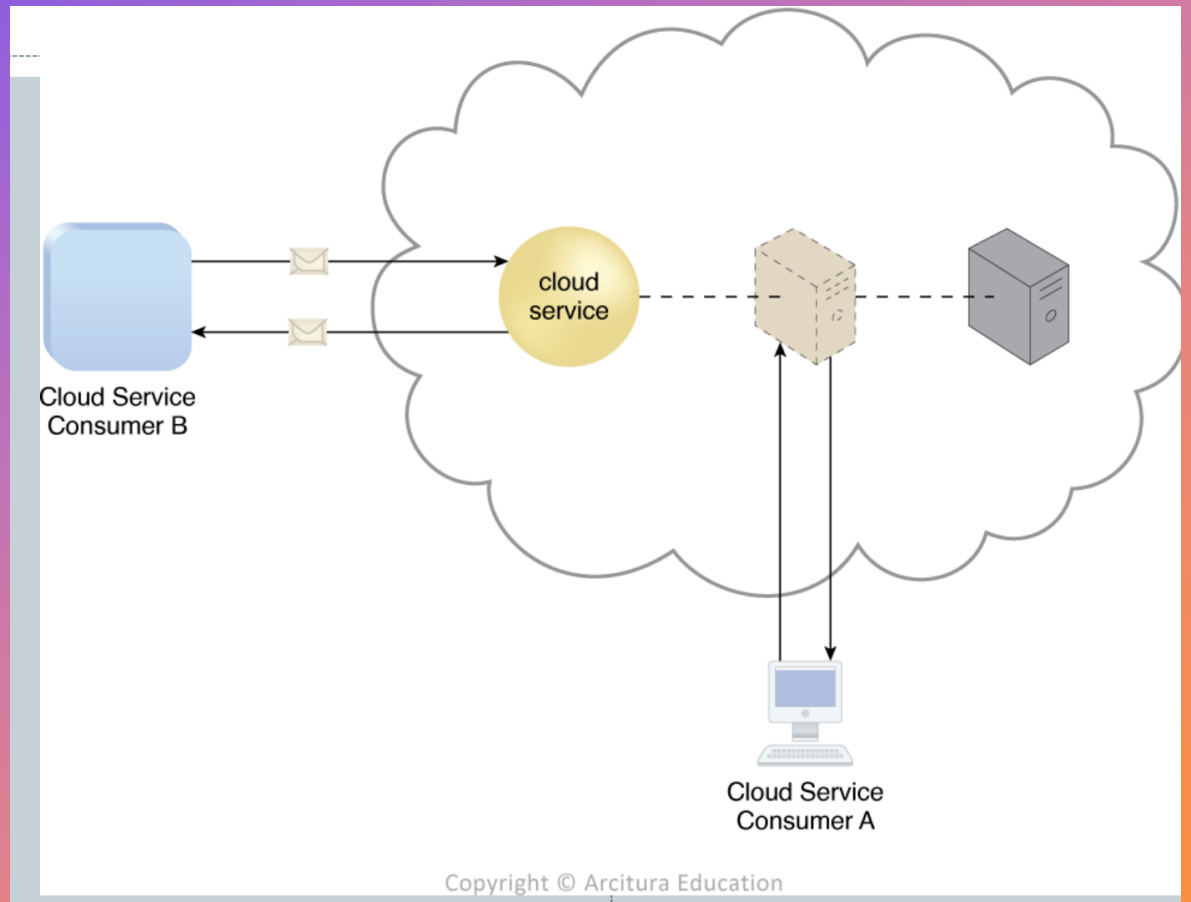
The virtual server represents the mode fundamental building block of cloud environment.

The instantiation of virtual servers from image files is a resource allocation process that can be completed rapidly and on-demand.

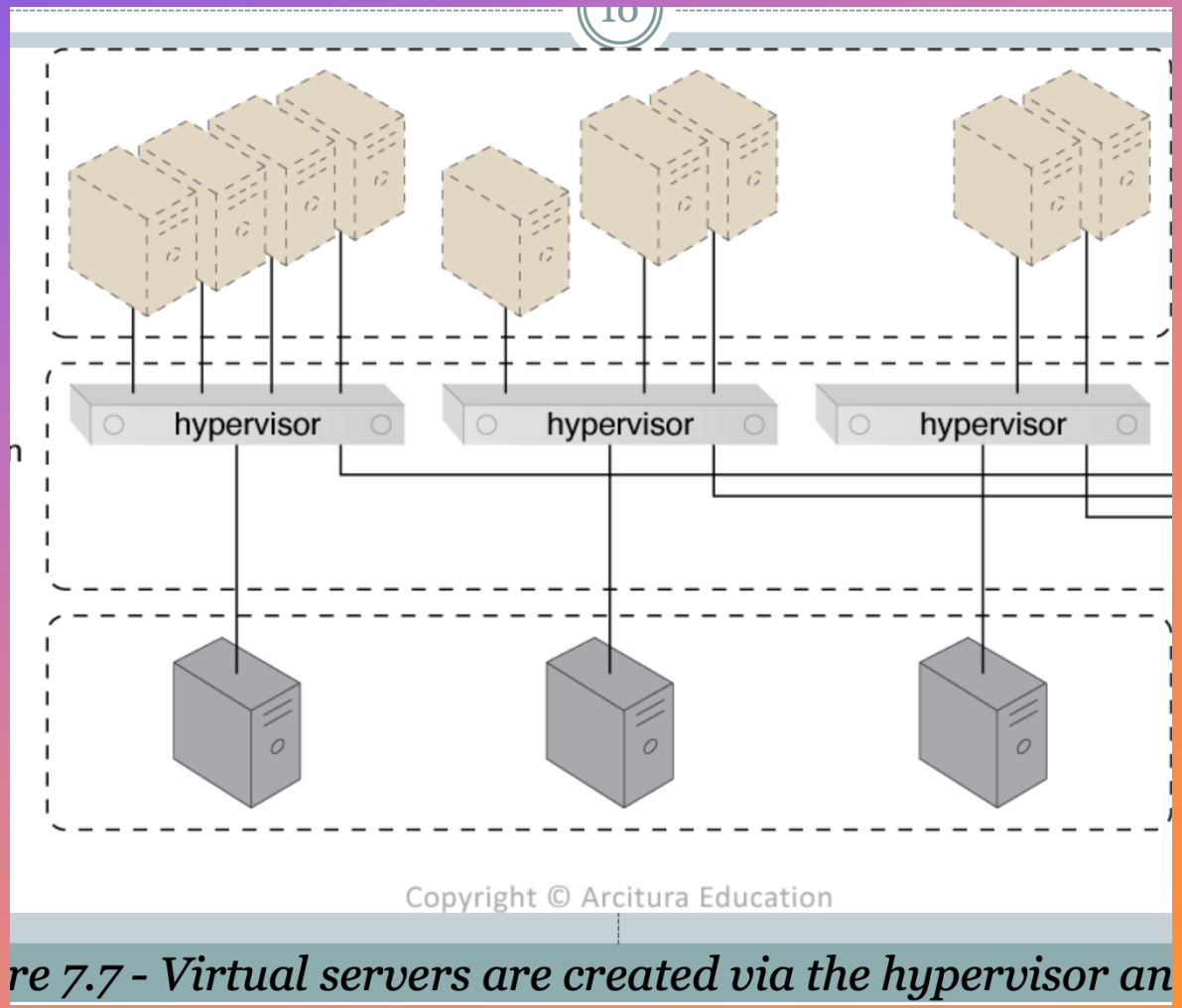
Cloud customers that install or lease virtual servers can customize their environments independently from other customers.



- *Figure 7.5 - The first physical server hosts two virtual servers, while the second physical server hosts one virtual server.*



ure 7.6 - A virtual server hosts an active cloud service ar
ther accessed by a cloud consumer for administrative pu



re 7.7 - Virtual servers are created via the hypervisor an

Cloud Storage Device

The cloud storage device mechanism represents storage devices that are designed specifically for cloud-based provisioning.

Cloud storage devices are commonly able to provide fixed-increment capacity allocation in support of the pay-per-use mechanism.

The primary concern related to cloud storage is the security, integrity, and confidentiality.

Cloud Storage Device(Cont.,)

There are several levels in providing common logical units of data storage:

files – located in a folder

Blocks – lowest level of storage closest to the HW

Datasets – table-based, delimited, or record collection

Objects – web-based resources

Cloud Storage Device(Cont.,)

According to different storage levels, there are three kinds of interfaces implemented:

Network storage interfaces – files or blocks

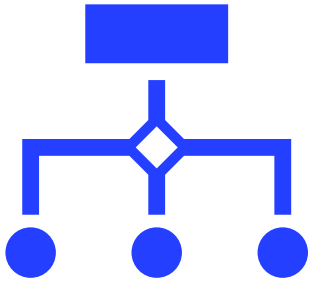
Object storage interfaces – web resources

Databasre storage interfaces – relational or nonrelational (NoSQL)

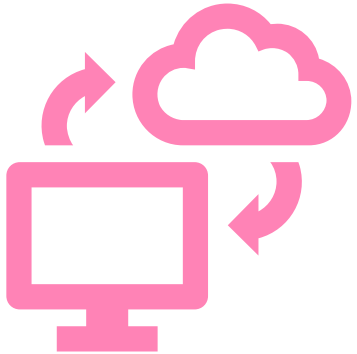
Cloud usage monitor

- The cloud usage monitor mechanism is a lightweight and autonomous software program responsible for collecting and processing IT resource usage.
- Three common agent-based implementation formats: monitoring agent
- Resource agent
- Polling agent
- Each monitor agent can be designed to forward collected usage data to a log database for postprocessing and reporting purposes. monitoring agent is usually an event-driven program to network traffic and message metrics.
- resource agent monitors usage metrics based on pre-defined, observable events at the resource software level, such as initiating, suspending, resuming, and vertical scaling.
- polling agent polls IT resources to periodically monitor IT resource status, eg. up or down time.

Resource Replication

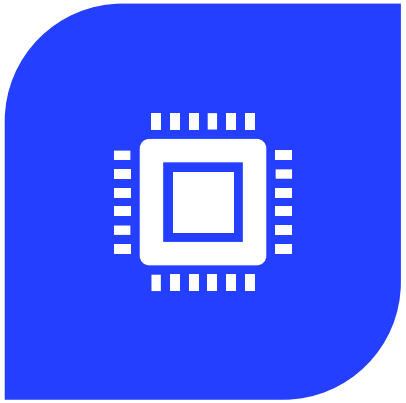


Replication is usually performed when resource's availability and performance need to be enhanced.



Resource replication mechanism usually uses virtualization technology to replicate cloud-based IT resources.

Ready-made environment



THE READY-MADE ENVIRONMENT MECHANISM IS A DEFINING COMPONENT OF THE PAAS CLOUD DELIVERY MODEL THAT REPRESENTS A PLATFORM COMPRESSED OF A SET OF ALREADY INSTALLED IT RESOURCES, READY TO BE USED AND CUSTOMIZED BY A CLOUD CONSUMER.

READY-MADE ENVIRONMENTS ARE UTILIZED BY CLOUD CONSUMERS TO REMOTELY DEVELOP AND DEPLOY THEIR OWN SERVICES AND APPLICATIONS WITHIN A CLOUD BY PROVIDING WITH A COMPLETE SOFTWARE DEVELOPMENT KIT (SDK).

TYPICAL READY-MADE ENVIRONMENTS INCLUDE PREINSTALLED IT RESOURCE

Cloud Challenges

Challenges for Consumers

Business-critical data requires protection and continuous monitoring of its access.

If the data moves to a cloud model other than an on-premise private cloud, consumers could lose absolute control of their sensitive data.

Although most of the cloud service providers offer enhanced data security, consumers might not be willing to transfer control of their business-critical data to the cloud.

Challenges for Providers

1. Cloud service providers usually publish a service-level agreement (SLA) so that their consumers know about the availability of service, quality of service, downtime compensation, and legal and regulatory clauses.

2. Alternatively, customer-specific SLAs may be signed between a cloud service provider and a consumer. SLAs typically mention a penalty amount if cloud service providers fail to provide the service levels.

3. Therefore, cloud service providers must ensure that they have adequate resources to provide the required levels of services.

4. Because the cloud resources are distributed and service demands fluctuate, it is a challenge for cloud service providers to provision physical resources for peak demand of all consumers and estimate the actual cost of providing the services.

Cloud Adoption Considerations

1. **Selection of a deployment model:** Risk versus convenience is a key con- sideration for deciding on a cloud adoption strategy. This consideration also forms the basis for choosing the right cloud deployment model

2. **Application suitability:** Not all applications are good candidates for a public cloud. This may be due to the incompatibility between the cloud platform software and the consumer applications, or maybe the organization plans to move a legacy application to the cloud.

3. **Financial advantage:** A careful analysis of financial benefits provides a clear picture about the cost-savings in adopting the cloud

4. **Selection of a cloud service provider:** The selection of the provider is important for a public cloud. Consumers need to find out how long and how well the provider has been delivering the services.

5. **Service-level agreement (SLA):** Cloud service providers typically men- tion quality of service (QoS) attributes such as throughput and uptime, along with cloud services.

Usage of Cloud services with open source cloud tools

- An open source cloud is developed using open source technologies and software.
- This covers any public, private or hybrid cloud models providing SaaS, IaaS and PaaS that have been built and operate entirely on open source technologies.
- In today’s transformational digital journey, the business, social, economic and technology trends play a major part in shaping the future of an enterprise.
- Cloud computing has become central to many enterprise IT models, and a number of enterprise architects are trying to make cloud systems as effective and beneficial as possible

What is driving the adoption of cloud services?

- Reduced capex and opex to deliver business services.
- It minimises IT costs by reducing delivery times and improves the quality of the app development process.
- Changing business model – enterprises will soon become integrators of the best-of-the-breed services through collaboration.
- New regulatory requirements driven by a global collaborative economy and a need to address open markets.
- A digital explosion that is raising the bar to deliver a better customer experience.
- Transformation and optimisation across different process stacks — sales, front-office, middle office and back office.

Characteristics of the open source cloud

- The open source cloud has the following characteristics:
- No vendor lock-in and there is seamless integration of the enterprise applications, products and systems developed/deployed by different organisations and vendors.
- The source code will be made available for the community, for adopters and end users to study and modify the software and to redistribute copies of either the original or the modified version. Source code will also be free from any royalty.
- With no vendor monopoly, the use of free and open standards is possible. With data transferability and open data formats, there are greater opportunities to share data across interoperable platforms.
- Adoption of open source software enhances the interoperability with other enterprise solutions because the reuse of recommended software stacks, libraries and components is possible.

Cloud computing layers using open source

Cloud computing layers and the respective open source products, tools and software that map to each layer of the cloud computing infrastructure.

The layers cover the cloud market, the cloud broker platform, cloud management, SaaS, PaaS, IaaS, the cloud platform, virtualisation software/management, and hardware, which are used across enterprise applications.

The following sections briefly describe the technologies to be adopted on the cloud, and the equivalent open source components and products.

CLOUD COMPUTING LAYERS AND OPEN SOURCE