Q. Characteristics of Cloud Computing:

→ **On demand self services:** The cloud computing service does not require any human administrators. Users themselves are able to manage cloud resources as needed.

→ **Broad Network Access:** The computing services are generally provided over standard networks and heterogeneous devices.

→ **Rapid Elasticity:** The computing services should have IT resources that are able to scale in and out quickly and on as needed basis.

→ **Resource pooling:** The IT resources present are shared across multiple applications. Multiple clients are provided service from the same physical resource.

→ **Measured service:** The resource utilization is tracked for each application. Done for various reasons like effective use of resource.

→ **Easy Maintenance:** The services are effortlessly maintained. The downtime sometimes remains low or absolutely zero. The resources undergo several updates. Updates are more viable and perform quicker than previous versions.

→ **Scalability:** It enables cost-effective running of workloads.

→ **Economical:** Helps in reducing IT expenditure of the organization.

→ **Security:** Creates a copy of the data that is stored to prevent any form of data loss.

→ **Remote working:** Users can work from any location.

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Q) Cloud Service Models:

→ Classified primarily into 3 models according to NIST:
  (a). Infrastructure-as-a-Service (IaaS)
  (b). Platform-as-a-service (PaaS)
  (c). Software-as-a-service (SaaS)

(a). Infrastructure-as-a-Service (IaaS):   eg: Amazon Elastic Compute Cloud.
  → Also known as Hardware as a Service (HaaS)   (Amazon EC2)
  → Allows customers to outsource their IT Infrastructure.
  → Clients can dynamically scale the configuration to meet changing requirements and are billed only for the services actually used.
  → IaaS eliminates the need for every organization to maintain their IT Infrastructure.
  → Offered in 3 models: public, private and hybrid.
  public - Infrastructure resides at cloud computing platform vendor's data center.
  private - Infrastructure resides at customer premise.
  hybrid - Combination of both in which the customer selects the best.

(b). Platform-as-a-Service (PaaS):   eg: Google App Engine, Microsoft Windows Azure.
  → Provides a runtime environment
  → Allows programmers to easily create, test, run and deploy web applications.
  → back-end stability is managed by cloud service providers so the end users do not need to worry about managing the Infrastructure.
  → PaaS provides: ① Programming languages
                ② Application frameworks
                ③ Databases
                ④ Other tools required to develop, test and deploy the applications.
  → lower risk, scalability.

(c) Software-as-a-service (SaaS): Eg. EMC Mozy.
→ Also known as On-Demand Software.
→ Provides various business-services to start-up the business.
→ Provides software for document management.
→ Social Networking service providers use SaaS for their convenience.
→ Used to handle the unpredictable number of users and load on e-mail services.
→ It is easy to buy.
→ Services are offered as a one-to-many model. Single instance of application is shared by multiple users.
→ Requires less Hardware.
→ Low-maintenance.
→ No particular hardware/software versions required.

(10). Cloud Deployment Models:

4 deployment Models according to NIST:
(a) public
(b). private
(c). community
(d). hybrid.

(a). public Cloud model: The cloud infrastructure is provisioned for open use by general public.
→ It may be owned, managed and operated by a business, academic or government organization.
→ Consumers use the cloud services offered by the provider via internet and pay the required charges.
→ low capital cost, enormous stability.
→ Popular Public cloud service providers are Amazon, Google and Salesforce.com.

Ⓐ Private Cloud Model: → The cloud Infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers.

→ Cloud may be owned, managed and operated by the organization, a third party or some combination of them.

→ two variations: (i) On premises
                  (ii) Off Premises.

(i) On-premises: → also known as internal cloud.
   → Hosted by an organization within its own data-centers.
   → Best suited for organizations that require complete control over their applications, Infrastructure and security mechanisms.
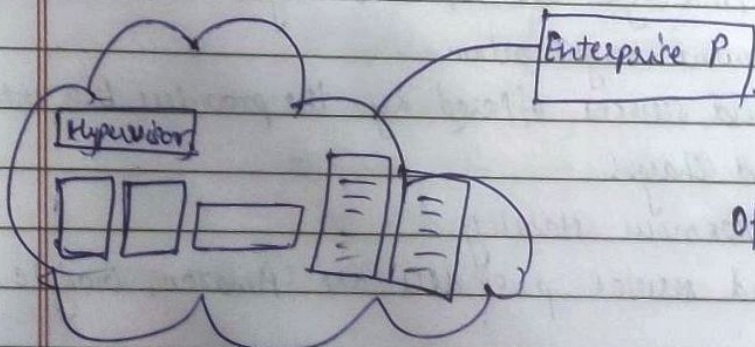
(ii) Off-premises: → Externally hosted private cloud.
   → Hosted external to an organization and managed by third party organization.
   → full guarantee of privacy and confidentiality.
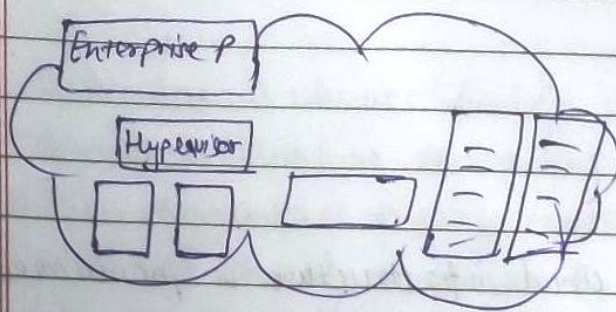
On-premise Private Cloud.


Off-premise Private Cloud.

© Community cloud → The cloud infrastructure is provisioned for special use by a specific community of consumers from organizations.
→ May be owned/managed/operated by one or more of organizations in the community, a third party or some combination of them.
→ May exist on or off premises.
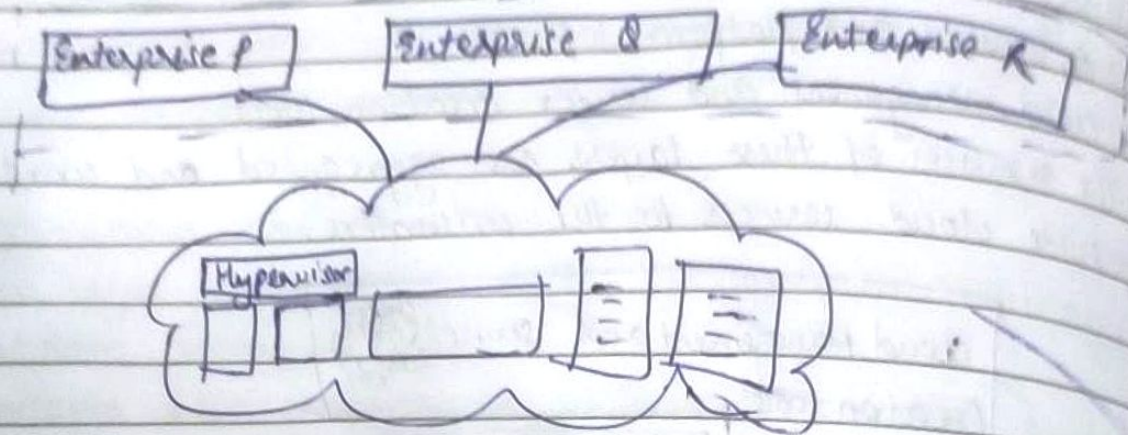
② Hybrid cloud → Cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community or public).
→ Allows an organization to deploy less critical model applications
→ Data remains on private cloud that provides greater security
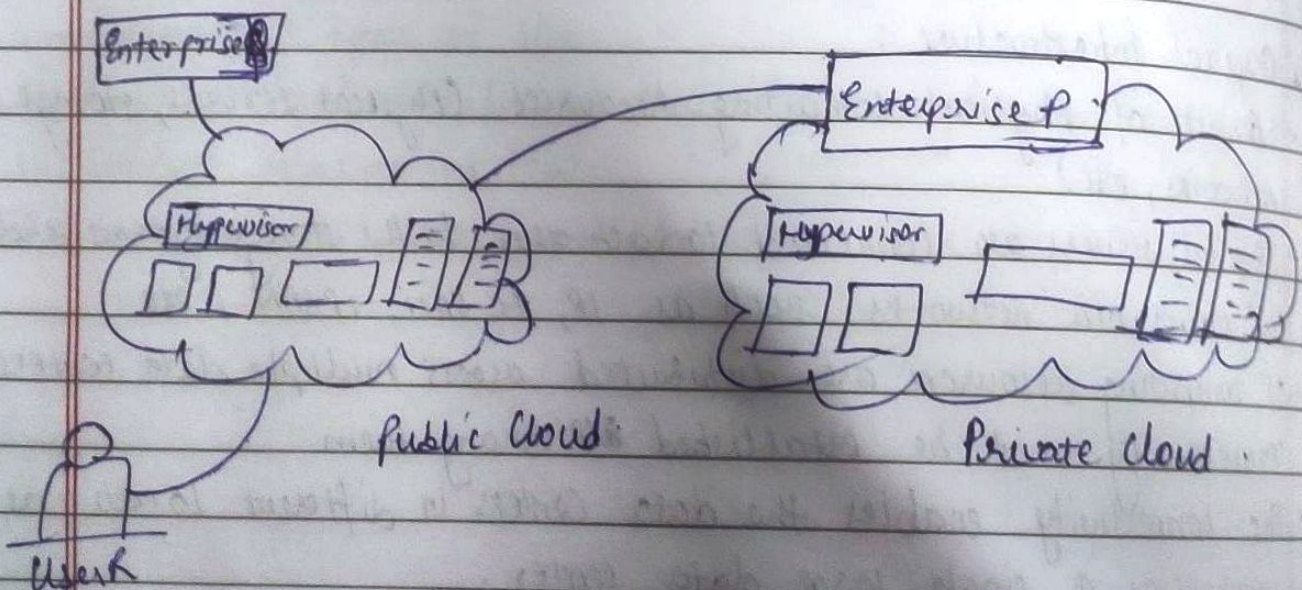
⑪ Cloud Computing Infrastructure:

→ Collection of HW and s/w that enables the 5 essential characteristics of cloud computing.

→ Usually consists of the following layers:

(a) Physical Infrastructure
(b) Virtual Infrastructure
(c) Applications and platform software.
(d) Cloud management and service creation tools.

→ The resources of these layers are aggregated and coordinated to provide cloud services to the consumers.
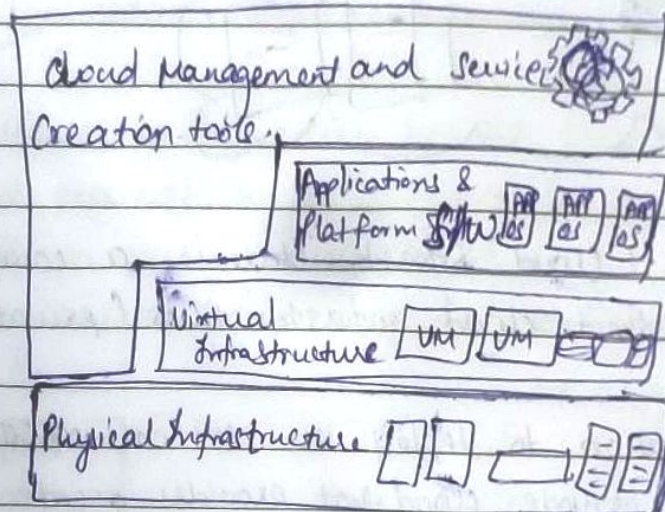
(a) Physical Infrastructure:

→ Consists of physical computing resources. (Physical servers, storage systems, networks, etc).

→ Physical servers are connected to each other, to the storage systems and to the clients via networks such as IP, FC SAN, IP SAN, etc.

→ If computing resources are distributed across multiple data centers, connectivity must be established among them.

→ The connectivity enables the data centers in different locations to works as a single large data center.

④ Virtual Infrastructure :
→ On top of physical Infrastructure.
→ Enables some of cloud characteristics such as resource pooling and rapid elasticity.
→ Helps to reduce cost
→ Better efficiency and optimization.
→ Provides a consolidated view of resource capacity
→ Consolidated resources are managed as a single entity called resource pool.

⑤ Applications and Platform Software :
→ This layer includes a suite of business applications and platform software.
→ Platform s/w provides the enviornment on which business applications run.
→ for SaaS, both the application and platform s/w are provided by cloud service providers.
→ In case of PaaS, only platform service is provided by cloud service providers.

⑥ Cloud Management and service Creation tools :
→ Includes 3 types of s/w.
(i) Physical and virtual infrastructure management s/w.
(ii) Unified Management s/w.
(iii) User - access management software.

⑫ **Cloud Challenges:**

- Challenges for consumers:

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

→ Consumers might not be willing to transfer control of this business - critical data to cloud.

→ Consumers may or may not know in which country their data is stored.

→ Some cloud service providers allow consumers to select the location.

→ mismatch b/w hypervisors.

→ difficulty for consumers to change their cloud service provider.

- Challenges for providers:

→ Cloud service providers must ensure that they have adequate resources to provide the required levels of services.

→ It is a challenge for cloud service providers to estimate the actual cost of providing the services.

→ Some of the software vendors offer standardized cloud licenses at a higher price compared to traditional licensing models.

⑬ **Cloud enabling Technologies:**

(a) · Grid Computing
(b) · Utility Computing
(c) · Virtualization.
(d) · Service - Oriented Architecture.

(a) Grid Computing :
→ form of distributed computing that enables the resources of numerous heterogeneous computers in a N/w to work together on a single task at the same time.
→ Enables parallel computing and is best for large workloads.

(b) Utility Computing :
→ Service provider makes computing resources available to its customers, as required and charges them based on usage.
→ Similar to other utility resources such as electricity where charges are based on consumption.

(c) Virtualization.
→ Technique that abstracts physical characteristics of IT resources from the resource users.
→ Enables the resources to be viewed and managed as a pool and lets users to create virtual resources from the pool.
→ Provides better flexibility.
→ Optimize resource utilization and delivering resources more efficiently.

(d). 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.