



SNS COLLEGE OF ENGINEERING

Kurumbapalayam(Po), Coimbatore – 641107

An Autonomous Institution



DEPARTMENT OF COMPUTER SCIENCE AND DESIGN

COURSE CODE AND NAME:19TS501& CLOUD COMPUTING

UNIT 3: CLOUD ARCHITECTURE, SERVICES AND STORAGE

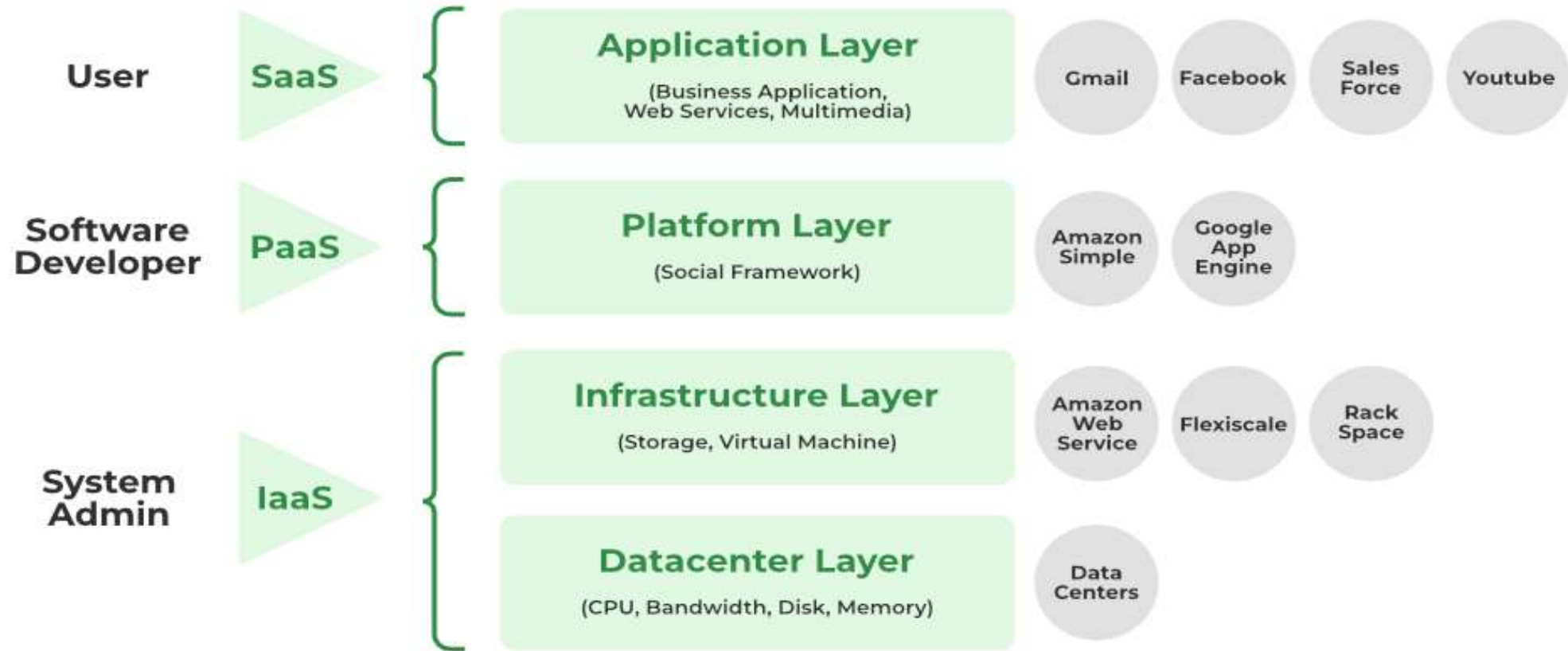


LAYERED CLOUD ARCHITECTURE DESIGN

- It is possible to organize all the concrete realizations of cloud computing into a layered view covering the entire, from hardware appliances to software systems.
- All of the physical manifestations of cloud computing can be arranged into a layered picture that encompasses anything from software systems to hardware appliances.
- Utilizing cloud resources can provide the “computer horsepower” needed to deliver services.
- This layer is frequently done utilizing a data center with dozens or even millions of stacked nodes.



Cloud Computing Layers





APPLICATION LAYER

- The application layer, which is at the top of the stack, is where the actual cloud apps are located.
- Cloud applications, as opposed to traditional applications, can take advantage of the **automatic-scaling** functionality to gain greater performance, availability, and lower operational costs.
- This layer consists of different Cloud Services which are used by cloud users.
- Users can access these applications according to their needs. Applications are divided into **Execution layers** and **Application layers**.



Applications are divided into

❑ **Execution layers and**

❑ **Application layers.**

- The application layer, in particular, is responsible for processing IP traffic handling protocols like Telnet and FTP.
- Other examples of application layer systems include web browsers, SNMP protocols, HTTP protocols, or HTTPS, which is HTTP's successor protocol.



PLATFORM LAYER

- The operating system and application software make up this layer.
- Users should be able to rely on the platform to provide them with **Scalability, Dependability, and Security Protection** which gives users a space to create their apps, test operational processes, and keep track of execution outcomes and performance.
- SaaS application implementation's application layer foundation.
- The objective of this layer is to deploy applications directly on virtual machines.



INFRASTRUCTURE LAYER

- It is a layer of virtualization where physical resources are divided into a collection of virtual resources using virtualization technologies like Xen, KVM, and VMware.
- **This layer serves as the Central Hub of the Cloud Environment,** where resources are constantly added utilizing a variety of virtualization techniques.
- A base upon which to create the platform layer. constructed using the virtualized network, storage, and computing resources.
- Give users the flexibility they want.
- Automated resource provisioning is made possible by virtualization, which also improves infrastructure management.



DATA CENTER LAYER

- In a cloud environment, this layer is responsible for **Managing Physical Resources** such as servers, switches, routers, power supplies, and cooling systems.
- Providing end users with services requires all resources to be available and managed in data centers.
- Physical servers connect through high-speed devices such as routers and switches to the data center.
- In software application designs, the division of business logic from the persistent data it manipulates is well-established.
- This is due to the fact that the same data cannot be incorporated into a single application because it can be used in numerous ways to support numerous use cases.



- There are five major actors in NIST cloud computing reference architecture .
- These actors are listed below
 - Cloud Consumer.
 - Cloud Provider.
 - Cloud Carrier.
 - Cloud Auditor.
 - Cloud Broker.



1. Cloud Consumer

- Cloud consumer is the main participants of cloud computing environment.
- A cloud consumer is a person or organization that use the cloud services such as SaaS, PaaS and IaaS.
- A cloud consumer browses the service catalog provided by a cloud provider, cloud consumer requests the appropriate service.
- Cloud provider sets up cloud environment for the service and make a contracts with the cloud consumer for the use of the service.
- Cloud consumers need cloud **Service Level Agreement(SLA)**.



2. Cloud Provider

- A cloud provider is responsible for making a service available to the cloud consumer. Cloud provider may be a person , team or an organization.
- A Cloud Provider maintain and manages the different cloud computing services for the consumer and makes arrangement to deliver the cloud services to the Cloud Consumers suing network access or internet.
- In context to **Software as a Service** Cloud provider is responsible for deploys, configuring, maintaining and updating the operation of the software applications on a cloud infrastructure so that the services are provisioned as per the required levels by the cloud consumers.
- The major responsibilities of cloud provider in context to software as a service are to manage , control the applications and overall infrastructure.



3. Cloud Auditor

- A cloud auditor is a dedicated team of technically skilled person that can perform an independent examination or review of cloud service controls with the intent to express strength and weakness of the process and some suggestion or improvement.
- Audits are performed to verify the standards of services after checking the evidence.
- Major role of a cloud auditor is to evaluate the services provided by a cloud provider against the parameters such as security controls, privacy impact and performance etc.

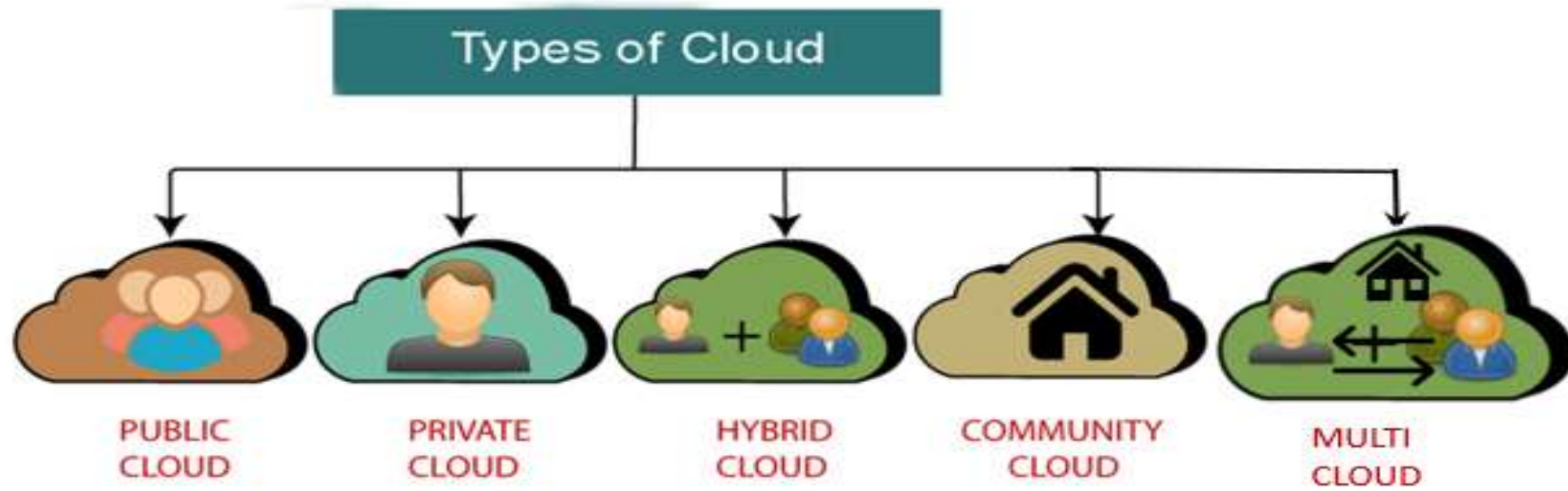


4. Cloud Broker

- Some time services integrations becomes more complex due to which it becomes difficult for the cloud consumer to manage the cloud service.
- In such situation cloud consumer request cloud services from cloud broker.
- Cloud Broker acts as mediator between consumer and provider.
- A cloud broker manages the delivery of cloud services , their performance and use.
- A cloud broker negotiates relationships between cloud providers and cloud consumers.



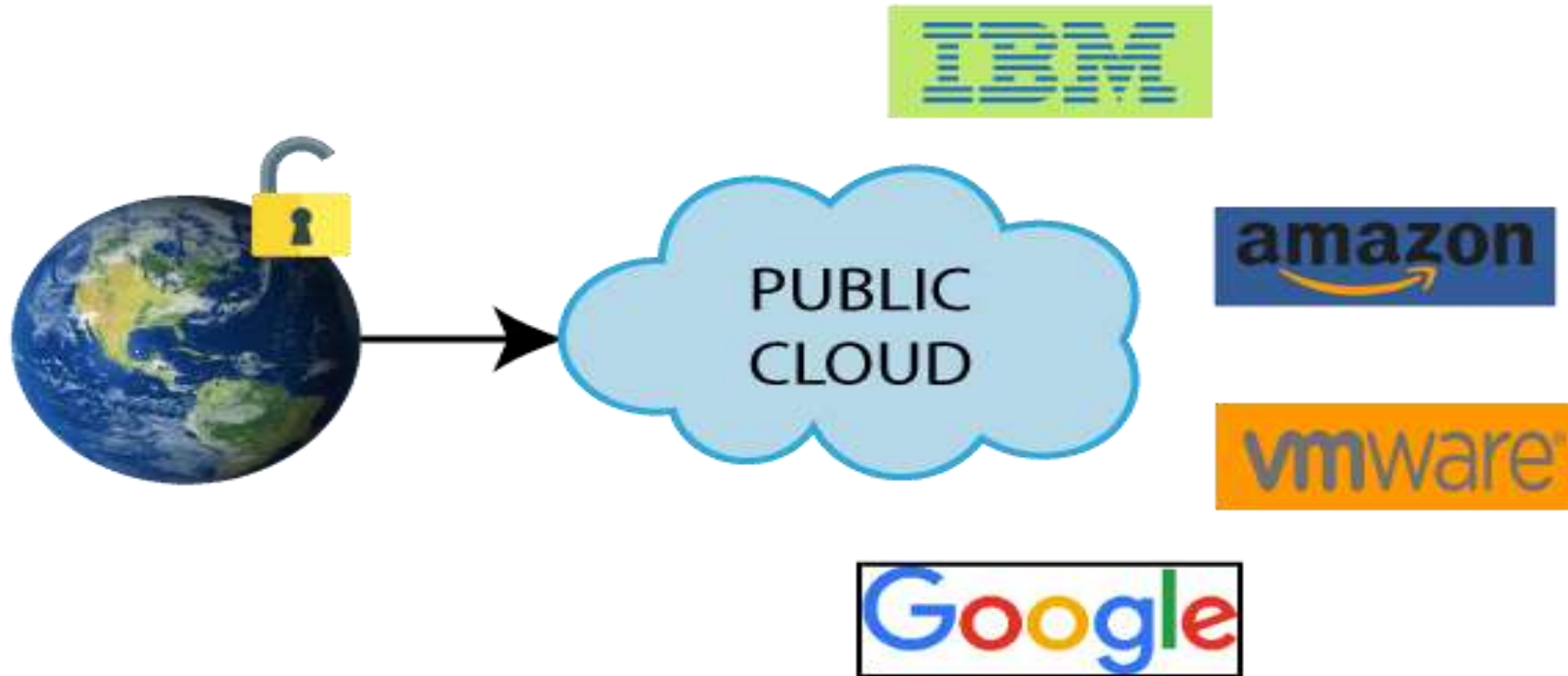
- In general, a cloud broker involves in three types of activities which are as follow
- **Service Intermediation**
- **Service Aggregation**
- **Service Arbitrage**





Public Cloud

- Public cloud is open to all to store and access information via the Internet using the pay-per-usage method.
- Due to its open architecture, anyone with an internet connection may use the public cloud, regardless of location or company size.
- Users can use the CSP's numerous services, store their data, and run apps.
- By using a pay-per-usage strategy, customers can be assured that they will only be charged for the resources they actually use, which is a smart financial choice.





Characteristics of Public Cloud

- **Accessibility:** Public cloud services are available to anyone with an internet connection. Users can access their data and programs at any time and from anywhere.
- **Shared Infrastructure:** Several users share the infrastructure in public cloud settings. Cost reductions and effective resource use are made possible by this.
- **Scalability:** By using the public cloud, users can easily adjust the resources they need based on their requirements, allowing for quick scaling up or down.
- **Pay-per-Usage:** When using the public cloud, payment is based on usage, so users only pay for the resources they actually use. This helps optimize costs and eliminates the need for upfront investments.



Advantages of Public Cloud

- There are the following advantages of Public Cloud -
- Public cloud is owned at a lower cost than the private and hybrid cloud.
- Public cloud is maintained by the cloud service provider, so do not need to worry about the maintenance.
- Public cloud is easier to integrate. Hence it offers a better flexibility approach to consumers.
- Public cloud is location independent because its services are delivered through the internet



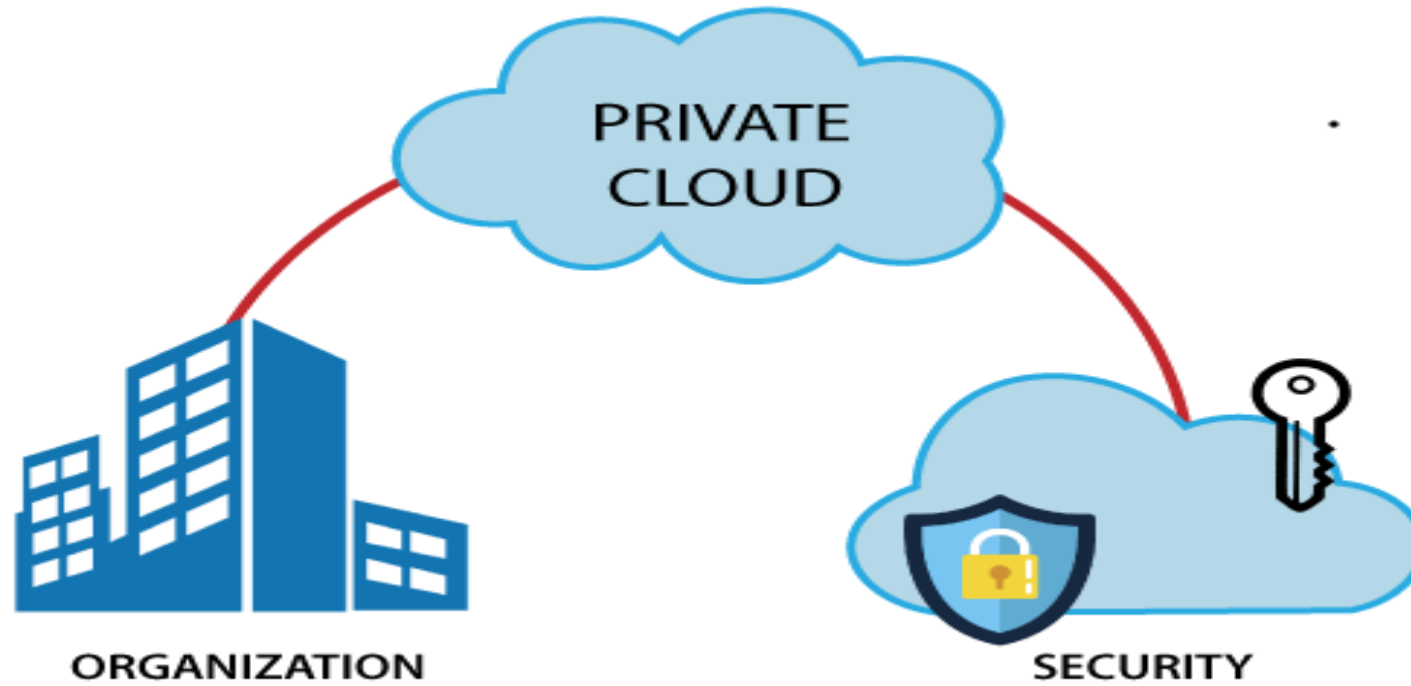
Disadvantages of Public Cloud

- Public Cloud is less secure because resources are shared publicly.
- Performance depends upon the high-speed internet network link to the cloud provider.
- The data is not under the control of the client.
- Dependency on the cloud service provider for availability and service level agreements.
- Compliance challenges in meeting industry-specific regulations and standards.



Private Cloud

- Private cloud is also known as an **internal cloud** or **corporate cloud**.
- It is used by organizations to build and manage their own data centers internally or by the third party.
- It can be deployed using Opensource tools such as Openstack and Eucalyptus.





Characteristics of Private Cloud

- The private cloud has the following key characteristics:
- **Exclusive Use:** Private cloud is dedicated to a single organization, ensuring the resources and services are tailored to its needs. It is like having a personal cloud environment exclusively for that organization.
- **Control and Security:** Private cloud offers organizations higher control and security than public cloud options. Organizations have more control over data governance, access controls, and security measures.
- **Customization and Flexibility:** Private cloud allows organizations to customize the infrastructure according to their specific requirements. They can configure resources, networks, and storage to optimize performance and efficiency.
- **Scalability and Resource Allocation:** The private cloud can scale and allocate resources. According to demand, businesses may scale up or down their infrastructure, effectively using their resources.



Advantages of Private Cloud

- There are the following advantages of the Private Cloud -
- Private cloud provides a high level of security and privacy to the users.
- Private cloud offers better performance with improved speed and space capacity.
- It allows the IT team to quickly allocate and deliver on-demand IT resources.
- The organization has full control over the cloud because it is managed by the organization itself. So, there is no need for the organization to depend on anybody.

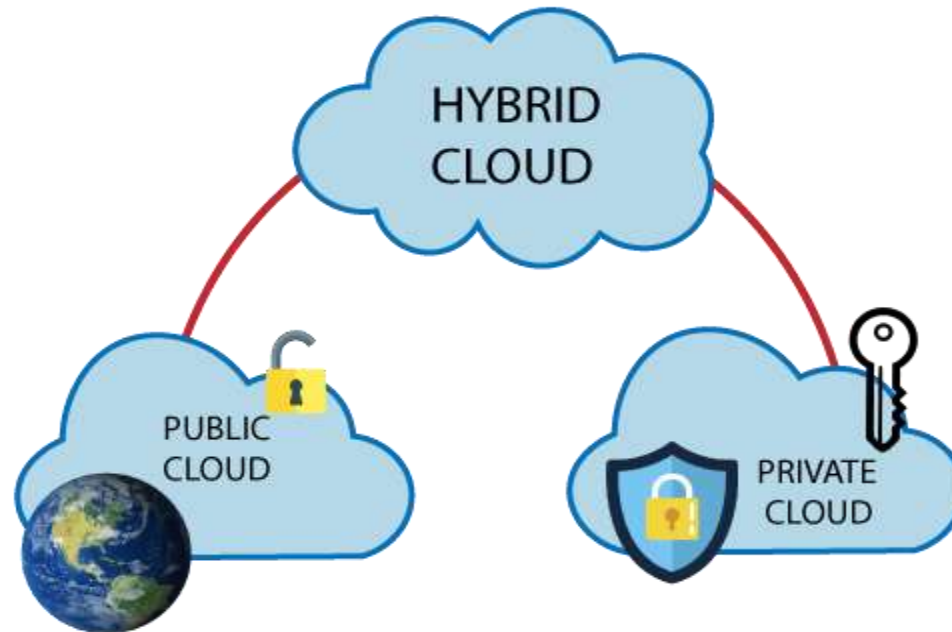


Disadvantages of Private Cloud

- Skilled people are required to manage and operate cloud services.
- Private cloud is accessible within the organization, so the area of operations is limited.
- Private cloud is not suitable for organizations that have a high user base, and organizations that do not have the prebuilt infrastructure, sufficient manpower to maintain and manage the cloud.
- Higher upfront costs and ongoing maintenance expenses.

Hybrid Cloud

- Hybrid Cloud is a combination of the public cloud and the private cloud





- **Hybrid Cloud = Public Cloud + Private Cloud**
- Hybrid cloud is partially secure because the services which are running on the public cloud can be accessed by anyone, while the services which are running on a private cloud can be accessed only by the organization's users.
- **Example:** Google Application Suite (Gmail, Google Apps, and Google Drive), Office 365 (MS Office on the Web and One Drive), Amazon Web Services.



Characteristics of Hybrid Cloud

- **Integration of Public and Private Clouds:** Hybrid cloud seamlessly integrates public and private clouds, allowing organizations to leverage both advantages
- **Flexibility and Scalability:** Hybrid cloud offers resource allocation and scalability flexibility
- **Enhanced Security and Control:** Hybrid cloud allows organizations to maintain higher security and control over their sensitive data and critical applications.
- **Cost Optimization:** Hybrid cloud enables organizations to optimize costs by utilizing the cost-effective public cloud for non-sensitive workloads while keeping mission-critical applications and data on the more cost-efficient private cloud..



Advantages of Hybrid Cloud

- There are the following advantages of Hybrid Cloud -
- Hybrid cloud is suitable for organizations that require more security than the public cloud.
- Hybrid cloud helps you to deliver new products and services more quickly.
- Hybrid cloud provides an excellent way to reduce the risk.
- Hybrid cloud offers flexible resources because of the public cloud and secure resources because of the private cloud.



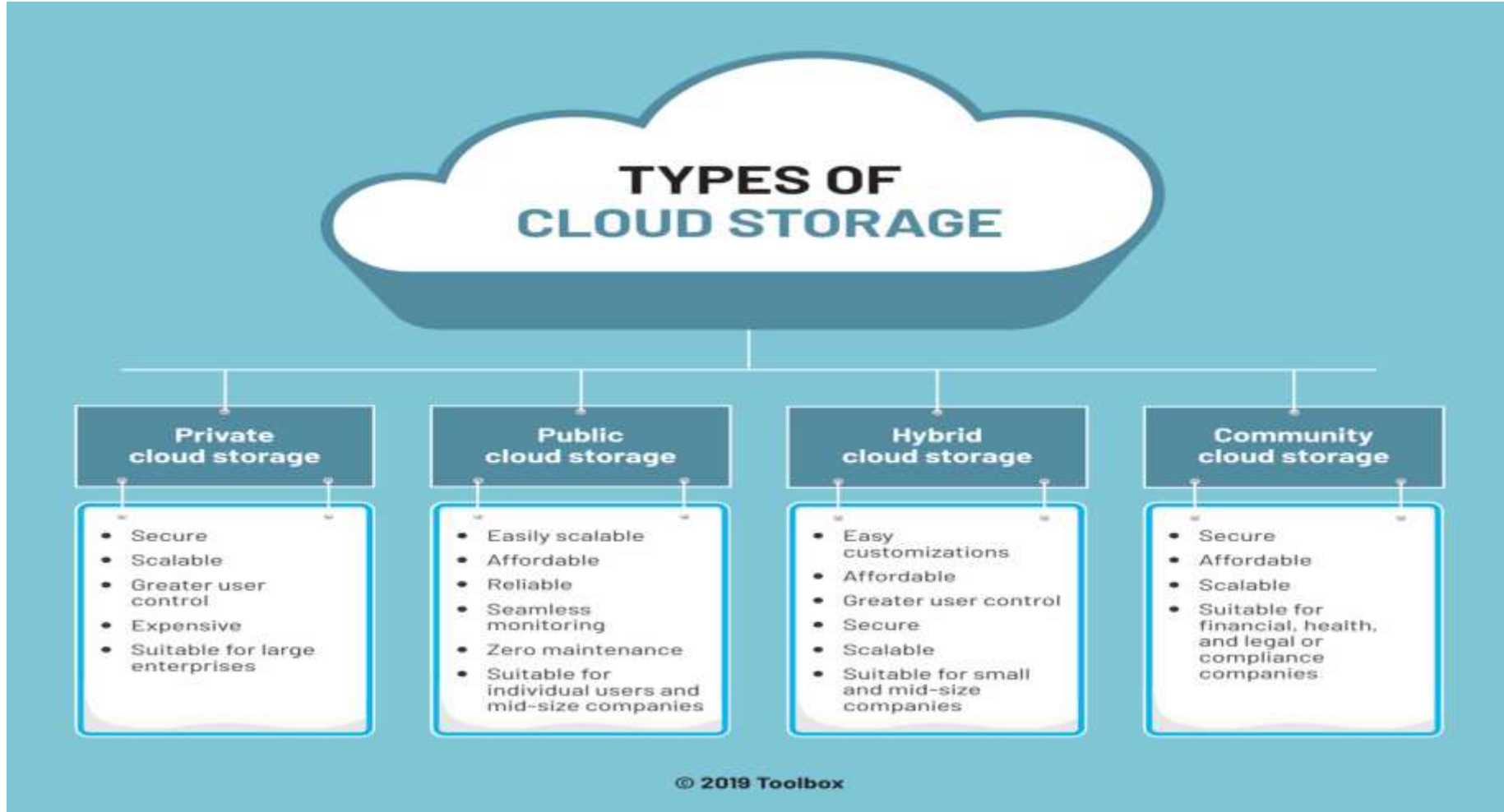
Disadvantages of Hybrid Cloud

- In Hybrid Cloud, security feature is not as good as the private cloud.
- Managing a hybrid cloud is complex because it is difficult to manage more than one type of deployment model.
- In the hybrid cloud, the reliability of the services depends on cloud service providers.
- Potential challenges in data integration and ensuring seamless connectivity between different cloud platforms.



Cloud storage

- Cloud storage is a data deposit model in which digital information such as documents, photos, videos and other forms of media are stored on virtual or cloud servers hosted by third parties.
- It allows you to transfer data on an offsite storage system and access them whenever needed.





1. Private cloud storage

- Private cloud storage is also known as enterprise or internal cloud storage.
- Data is stored on the company or organization's intranet in this case.
- This data is protected by the company's own firewall.
- Private cloud storage is a great option for companies with expensive data centers and can manage data privacy in-house.
- A major advantage of saving data on a private cloud is that it offers complete control to the user.
- On the other hand, one of the major drawbacks of private cloud storage is the cost and effort of maintenance and updates.
- The responsibility of managing private cloud storage lies with the host company.



2. Public cloud storage

- Public cloud storage requires few administrative controls and can be accessed online by the user and anyone else who the user authorizes.
- With public cloud storage, the user/company doesn't need to maintain the system.
- Public cloud storage is hosted by different solution providers, so there's very little opportunity for customizing the security fields, as they are common for all users.
- Amazon Web Services (AWS), IBM Cloud, Google Cloud, and Microsoft Azure are a few popular public cloud storage solution providers.
- Public cloud storage is easily scalable, affordable, reliable and offers seamless monitoring and zero maintenance.



3. Hybrid cloud storage

- Hybrid cloud storage is a combination of private and public cloud storage.
- As the name suggests, hybrid cloud storage offers the best of both worlds to the user – the security of a private cloud and the personalization of a public cloud. In a hybrid cloud, data can be stored on the private cloud, and information processing tasks can be assigned to the public cloud as well, with the help of cloud computing services.
- Hybrid cloud storage is affordable and offers easy customization and greater user control.



4. Community cloud storage

- Community cloud storage is a variation of the private cloud storage model, which offers cloud solutions for specific businesses or communities.
- In this model, cloud storage providers offer their cloud architecture, software and other development tools to meet the community's requirements.
- Any data is stored on the community-owned private cloud storage to manage the community's security and compliance needs.
Community cloud storage is a great option for health, financial or legal companies with strict compliance policies.



Advantages of cloud storage

1. Flexibility and ease of access:

- Cloud storage means that your data is not tied down to any one location.
- Various stakeholders can access assets stored on the cloud from a location and device of their choice without any download or installation hassles.



2.Remote management support:

Cloud storage also paves the way for remote management either by internal IT teams or by managed service providers (MSPs).

They can troubleshoot without being present on-site, speeding up issue resolution.



3. Fast scalability:

- A major benefit of cloud storage is that you can provision new resources with only a few clicks without the need for any additional infrastructure.
- When faced with an unprecedented increase in data volumes, this feature aids business continuity.



4.Redundancy for backup:

- Data redundancy (i.e., replicating the same data in multiple locations) is essential for an effective backup mechanism.
- The cloud ensures your data is kept secure in a remote location in case of a natural disaster, accident, or cyberattack.



5. Long-term cost savings:

In the long-term, cloud storage can save you significantly in the costs of hardware equipment, storage facilities, power supply, and personnel, which are sure to multiply as your organization grows.



Challenges of cloud storage:

1. Risk of vendor lock-in:

- If all your data is stored in a single public cloud platform, there's a risk of vendor lock-in and potential inflexibilities.
- Address this with a hybrid or multi-cloud blueprint where there is sufficient interoperability between environments.



2.Security issues around multi-tenancy:

- Public cloud environments are shared by multiple tenants, which can multiply your security vulnerabilities.
- You can prevent this through cloud data protection and by leveraging the private cloud for sensitive data.



3. Fragmentation of IT landscape:

- Unplanned cloud storage adoption can cause your IT landscape to become fragmented over time.
- That's why you need a detailed strategic blueprint outlining your short, mid, and long-term cloud roadmap.

4. Outage and downtime risk:

- Cloud platforms managed by external providers could suffer from an outage, rendering the data and applications stored in these environments inaccessible.
- Service level agreements should specify downtime metrics, and you need additional redundancy for your most critical data.



5.Short-term budget overruns:

- Cloud cost worries are extremely common, where data storage and storage processes occupy more space than estimated.
- A cloud resource management tool can help address this, giving you visibility and control.



STORAGE AS A SERVICE

- Storage as a service (STaaS) is a subscription model where a client rents cloud space from a third-party provider and uses the space to store their digital information.
- Small-scale clients like individual users and local offices often take advantage of this digital storage, but cloud service providers can also partner with medium-sized businesses and large enterprises.
- Organizations that use a STaaS model can store and back up massive amounts of data in various formats and access information as necessary.
- Some STaaS providers offer advanced capabilities like database as a service, which allows organizations to write data tables using provider resources.



Here are some important details about how storage as a service works:

1. Service-level agreements

- A service-level agreement (SLA) is a contract that defines what a client can expect from a cloud service provider.
- It outlines factors like the cost, performance expectations, uptime, read and write access speed and types of data that the client can store in the cloud.
- It also specifies how much data the client can store and indicates the remedies the provider implements if it doesn't achieve the agreed-on service level.
- While SLAs can have different payment terms, clients usually pick a subscription tier and pay the appropriate monthly or annual fee to ensure continued access to digital storage services.



2. Performance expectations

- If a client has lots of data that they plan to mostly leave alone, they may opt for cold storage.
- Cold storage offers reduced access performance but a better deal for storing large amounts of information.
- Warm or hot storage may be more appropriate if the client wants to access their information regularly.
- The improved performance of warm or hot storage usually makes its higher cost worth it, as clients can reliably retrieve data and compute helpful insights as to the organization's growth.



3.Data types

- Aside from cold and warm storage, there are more specific data types that can influence the cost of an organization's subscription plan.
- Here are the three main types:

3.1 Object-based storage:

- If an organization has large amounts of cold data, it might benefit from object-based storage.
- This model is scalable and makes it easy to retrieve information thanks to the metadata attached to every file.



Cloud Storage Providers:

1. Dropbox

- Ideal for users having limited data. This platform offers a state-of-the-art workspace to store files at a central location.
- Access it from any geographical location 24X7.
- Computers, mobiles as well as tablets can access files in Dropbox.



Features:

- It can be employed by users of any size.
- Permits you to share files with anybody.
- Admin controls make team management a breeze
- Shared data is secured.

Disadvantage:

- Plans start off with a mere 2GB of free data which may be insufficient for many.



2. Microsoft OneDrive

- OneDrive is a built-in feature of Windows 10's File Explorer. To use it you need not download any extra app.
- Hence it is extremely convenient for Windows 10 users. Microsoft's Photos app has the option of employing OneDrive in order to sync images across all your respective devices.
- Recently AutoCAD has been added to OneDrive a move that may please as well as attract AutoCAD users.
- The Personal Vault feature provides an extra layer of security. An app exists for iOS as well as Android devices.
- There is also a handy app in the App Store meant for Mac users.



3. Google Drive

- Google Drive is one of today's most powerful cloud storage services

Advantages:

- Huge free storage space is offered.
- State-of-the-art productivity suite for collaboration purposes.
- Apps designed for different platforms

Disadvantages:

- Everything is stored locally by the consumer desktop utility
- Privacy is a major and relevant concern



4. iCloud

- The novelty of this platform is that it is the best as well as the most ideal cloud storage provider for Apple aficionados.
- Moreover, it works great for private users.
- The cloud storage platform functions on operating systems that include iOS, Mac OS as well as Windows.



Features:

- It claims to fame that it is the prestigious Apple company's proprietary cloud storage platform.
- Users can collaborate with applications that include Notes, Keynote as well as Pages.
- Resumes each conversation from the pausing time
- It reaches peak performance on changing the phone.



5. Amazon Drive

- It is a fact that Amazon Simple Storage Services works wonderfully well for programmers. Amazon Drive used to fare comparatively poorly earlier.
- That scenario is no longer the same.
- The former has sync services for various operating systems including Windows, Android, Mac OS as well as iOS. The drawback is the absence of a Linux client.
- The service moves files leveraging block-level file copying techniques.
- Presently every member of Amazon Prime is allocated 5GB of storage space for using Amazon Drive.



6. Box

- This cloud storage provider has a plethora of business-oriented features.
- It boasts of expanded privacy controls too.
- The solution's drawback is the upload limit. The former offers 10GB free of cost.
- It also offers a 14-day free trial for each package.



S3

- Simple Storage Service is a scalable, high-speed, web-based cloud storage service.
- The service is designed for online backup and archiving of data and applications .
- Amazon S3 was designed with a minimal feature set and created to make web-scale computing easier for developers.



S3 features

- S3 provides 99.999999999% durability for objects stored in the service and supports multiple security and compliance certifications.
- An administrator can also link S3 to other AWS security and monitoring services, including Cloud Trail, Cloud Watch and Macie.
- There's also an extensive partner network of vendors that link their services directly to S3.
- Data can be transferred to S3 over the public internet via access to S3 application programming interfaces (APIs).
- There's also Amazon S3 Transfer Acceleration for faster movement over long distances, as well as AWS Direct Connect for a private, consistent connection between S3 and an enterprise's own data center.



S3 use cases

- data storage;
- data archiving;
- application hosting for deployment, installation and management of web apps;
- software delivery;
- data backup;
- disaster recovery (DR)



S3 storage classes

S3 comes in seven storage classes:

1.S3 Standard

- It is suitable for frequently accessed data that needs to be delivered with low latency and high throughput.
- S3 Standard targets applications, dynamic websites, content distribution and big data workloads.

2.S3 Intelligent-Tiering

- It is most suitable for data with access needs that are either changing or unknown. S3 Intelligent-Tiering has four different access tiers: Frequent Access, Infrequent Access (IA), Archive and Deep Archive.
- Data is automatically moved to the most inexpensive storage tier according to customer access patterns.



3.S3 Standard-IA

- It offers a lower storage price for data that is needed less often but that must be quickly accessible.
- This tier can be used for backups, DR and long-term data storage.

4.S3 One Zone-IA

- It is designed for data that is used infrequently but requires rapid access on the occasions that it is needed.
- Use of S3 One Zone-IA is indicated for infrequently accessed data without high resilience or availability needs, data that is able to be recreated and backing up on-premises data.



5.S3 Glacier

- ❑ It is the least expensive storage option in S3, but it is strictly designed for archival storage because it takes longer to access the data.
- ❑ Glacier offers variable retrieval rates that range from minutes to hours.

6.S3 Glacier Deep Archive

- ❑ It has the lowest price option for S3 storage.
S3 Glacier Deep Archive is designed to retain data that only needs to be accessed once or twice a year.

7.S3 Outposts

- ❑ It adds S3 object storage features and APIs to an on-premises AWS Outposts environment.
- ❑ S3 Outposts is best used when performance needs call for data to be stored near on-premises applications or to satisfy specific data residency requirements.



3.2 File storage:

- File storage organizes information in a navigable hierarchy like a file directory.
- While this type of storage is more challenging to scale, it's ideal for project collaborations and compatible with cold or hot storage.

3.3 Block storage:

- Block storage segments data and distributes the pieces to ensure quick access, which mimics the process of writing data to a solid-state drive or a standard hard disk drive.
- The efficiency results in higher costs and is usually most appropriate for warm or hot storage.



Advantages of STaaS

1. More affordable short-term costs

- The monthly or annual costs of STaaS are usually much more affordable than the expenses of installing physical infrastructure.
- Organizations pay for only the storage space they require, allowing them to allocate funds to other departments.
- A single subscription fee also offers additional functionality like multimedia storage, disaster recovery, information repositories and database as a service.



2. Scalability

- Even if an organization doesn't plan to scale its operations anytime soon, implementing STaaS leaves this possibility open for the future.
- Scalability allows organizations to host more data, cater to larger audiences and adapt to technological advancements in their industries.
- Organizations can increase storage space simply by adjusting the terms of their SLAs, which starkly contrasts with attempts to improve physical infrastructure.
- Upgrading servers and maintaining equipment to host large amounts of data can require lots of time and money.



3.Security

- Cloud service providers prioritize security to maintain a good reputation among customers and protect their own information.
- Security methods vary between vendors, but most clients can expect essential features like encryption during data transmission.
- Additionally, STaaS allows clients to store data in different locations to improve the chances of positive disaster recovery results.



Disadvantages of STaaS

1. Greater cost over time

- If an organization uses STaaS for long enough, the subscription costs may exceed the installation cost of physical infrastructure.
- Some businesses want to invest in lasting capital, but considering the maintenance costs often encourages them to reconsider.
- The higher long-term costs of a STaaS subscription are often worth the continuous support, security and scalability.



2.Limited customization

- Providers offer cloud infrastructure that various clients can use, meaning customization options may be limited.
- Many organizations can accept the limited functionality, as it's more affordable than creating personalized infrastructures.
- If your organization requires specific capabilities, you can work with a provider that's more flexible with cloud architecture.



3.Challenges with provider partnerships

- Working with a provider can be challenging, especially if your organization can't accommodate potential downtime or the task of migrating between providers.
- Another challenge you might face is hidden fees if you exceed bandwidth limitations.
- Organizations can ensure a positive STaaS experience by choosing a reputable provider that prioritizes security and transparency.