Cloud Computing

Unit 1: Introduction to Cloud Computing

Importance of Cloud Computing, Characteristics, Pros and Cons of Cloud Computing, Migrating into the Cloud, Seven-step model of migration into a Cloud, Trends in Computing. Cloud Service Models: SaaS, PaaS, IaaS, Storage. Cloud Architecture: Cloud Computing Logical Architecture, Developing Holistic Cloud Computing Reference Model, Cloud System Architecture, Cloud Deployment Models.

What is Cloud Computing?

Cloud computing means storing and accessing the data and programs on remote servers that are hosted on the internet instead of the computer's hard drive or local server. Cloud computing is also referred to as Internet-based computing, it is a technology where the resource is provided as a service through the Internet to the user. The data which is stored can be files, images, documents, or any other storable document.

Cloud computing refers to the delivery of computing services—including servers, storage, databases, networking, software, analytics, and more—over the internet ("the cloud") on a pay-as-you-go basis. Instead of owning physical hardware or managing infrastructure, users access and utilize resources and applications provided by a third-party cloud service provider.

Cloud computing is the delivery of computing resources — including storage, processing power, databases, networking, analytics, artificial intelligence, and software applications — over the internet (the cloud). By outsourcing these resources, companies can access the computational assets they need, when they need them, without needing to purchase and maintain a physical, on-premise IT infrastructure. This provides flexible resources, faster innovation, and economies of scale. For many companies, a cloud migration is directly related to data and IT modernization.

Some operations which can be performed with cloud computing are –

- Storage, backup, and recovery of data
- Delivery of software on demand
- Development of new applications and services
- Streaming videos and audio

Key aspects of cloud computing include:

1. On-Demand Access: Users can access resources instantly and as needed, without manual setup.
2. Scalability: Services can easily scale up or down based on demand, providing flexibility without the need for substantial infrastructure changes.

3. Resource Pooling: Cloud providers use a multi-tenant model, efficiently allocating and reallocating resources as needed among multiple customers.
4. Broad Network Access: Cloud services are accessible over the internet from various devices.
5. Measured Service: Users are billed based on their usage, allowing for cost-effective pay-as-you-go models.

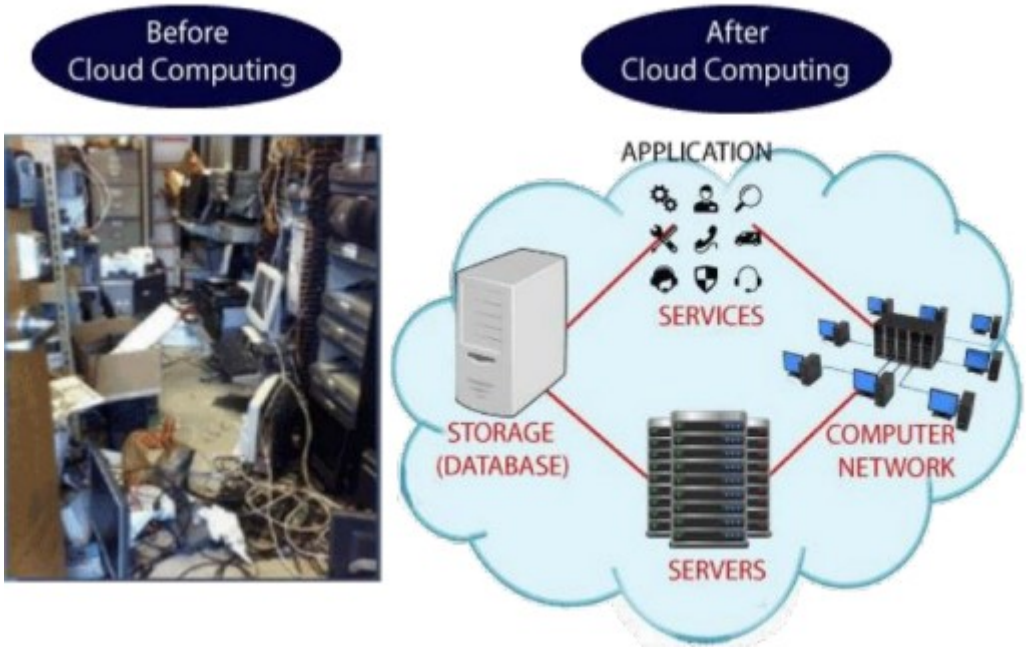
Why Cloud Computing?

Here are the top reasons why to switch to Cloud Computing instead of owning a database server.

1. Reduces cost: The cost-cutting ability of businesses that utilize cloud computing over time is one of the main advantages of this technology. On average 15% of the total cost can be saved by companies if they migrate to the cloud. By the use of cloud servers businesses will save and reduce costs with no need to employ a staff of technical support personnel to address server issues. There are many great business modules regarding the cost-cutting benefits of cloud servers such as the **Coca-Cola** and **Pinterest** case studies.

2. More storage: For software and applications to execute as quickly and efficiently as possible, it provides more servers, storage space, and computing power. Many tools are available for cloud storage such as Dropbox, Onedrive, Google Drive, iCloud Drive, etc.

3. Employees using cloud computing have better work-life balance: Direct connections between cloud computing benefits, and the work and personal lives of an enterprise's workers can both improve because of cloud computing. Even on holidays, the employees have to work with the server for its security, maintenance, and proper functionality. But with cloud storage the thing is not the same, employees get ample of time for their personal life and the workload is even less comparatively.

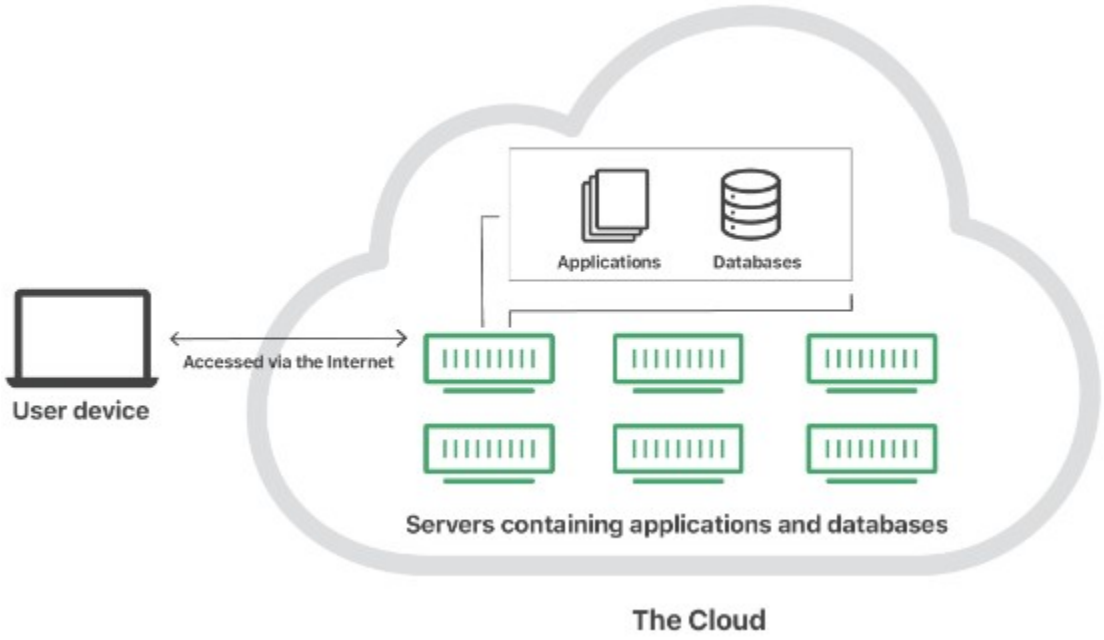


Basic Concepts & Terminology

Clouds

In cloud computing, the term "cloud" refers to the internet itself and the abstract representation of the infrastructure, platforms, and software that deliver various computing services over the internet.

The cloud enables users to access the same files and applications from almost any device, because the computing and storage takes place on servers in a data center, instead of locally on the user device.



IT Resource

An IT resource is a physical or virtual IT-related artifact that can be either software based, such as a virtual server or a custom software program, or hardware-based, such as a physical server or a network device (Figure below).

Examples of common IT resources and their corresponding symbols.

Cloud Consumers and Cloud Providers

The party that provides cloud-based IT resources is the cloud provider. The party that uses cloud-based IT resources is the cloud consumer.

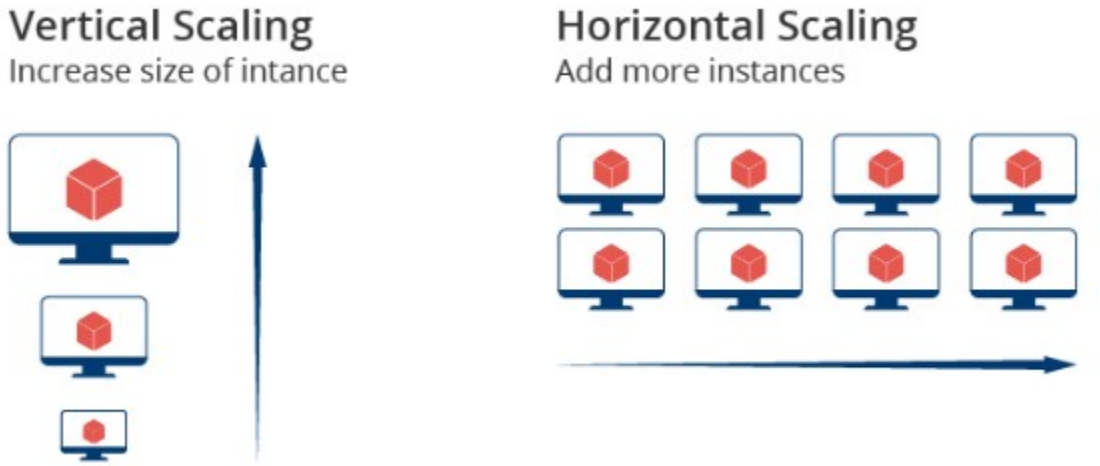
Scaling

Scaling is the ability of the IT resource to handle increased or decreased usage demands.
There are two types of scaling:

- Horizontal Scaling – scaling out and scaling in
- Vertical Scaling - scaling up and scaling down

(i)- Horizontal Scaling: The allocating or releasing of IT resources that are of the same type is referred to as horizontal scaling. The horizontal allocation of resources is referred to as scaling out and the horizontal releasing of resources is referred to as scaling in. Horizontal scaling is a common form of scaling within cloud environments.

(ii)- Vertical Scaling: Vertical scaling implies adding resources to an existing server or replacing a server with a more powerful one. The process of vertical scaling is also known as scaling up and down. Vertical scaling is less common in cloud environments due to the downtime required while the replacement is taking place.



Cloud Service

Cloud services are application and infrastructure resources that exist on the Internet. Third-party providers contract with subscribers for these services, allowing customers to leverage powerful computing resources without having to purchase or maintain hardware and software.

Evolution of Cloud Computing

The concept of cloud computing has a history that spans several decades, evolving alongside advancements in technology and computing paradigms:

- **1960s-1970s:** The early roots of cloud computing trace back to the development of mainframe computers, where multiple users accessed a centralized system. The concept of "time-sharing" allowed users to share computing resources remotely.
- **1980s-1990s:** Telecommunications companies began offering Virtual Private Network (VPN) services, allowing remote access to centralized computing resources. The development of the internet laid the groundwork for more distributed computing models.
- **1990s:** Internet Service Providers (ISPs) began offering web hosting services, enabling businesses to host their websites on remote servers. Meanwhile, the term "grid computing" emerged, referring to the pooling of resources across multiple locations.
- **Early 2000s:** Salesforce introduced Software as a Service (SaaS) in 1999, delivering enterprise applications over the internet. Amazon Web Services (AWS) launched in 2006, introducing Elastic Compute Cloud (EC2) and providing scalable computing resources.
- **Mid-2000s:** Google launched Google Apps (now G Suite) in 2006, offering cloud-based office productivity tools. Microsoft launched Azure in 2010, entering the cloud computing market.
- **Late 2000s-2010s:** Cloud computing gained significant traction, with more providers offering Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). Cloud adoption increased due to scalability, cost-efficiency, and flexibility.
- **2010s-2020s:** The cloud became an integral part of IT strategies for businesses globally. Major providers like AWS, Microsoft Azure, and Google Cloud expanded their services, offering a wide array of solutions from storage and computing to AI/ML and serverless computing.

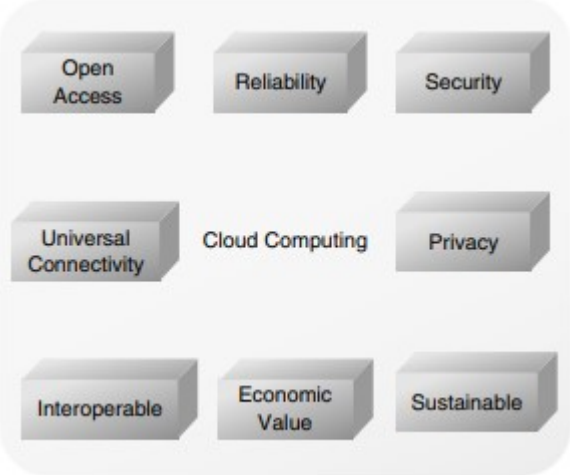
Throughout this evolution, cloud computing transitioned from a concept into a dominant model for delivering computing resources over the internet. It has revolutionized how businesses and individuals access, store, and process data, enabling scalability, flexibility, and cost-effectiveness in managing IT infrastructure and applications. The continuous advancements in cloud technology continue to shape the digital landscape, driving innovation and reshaping the way we approach computing and data management.

Basic Components of Cloud Computing

IT professionals recognized that there are eight basic components that are very important in enabling the cloud computing concept for the cloud to work in the public or private sector, they are as follows:

1. World wide connectivity: users should have near-ubiquitous access to the Internet.
2. Open access: Users should have fair, open-minded access to the Internet.
3. Reliability: The cloud's performance should equal to or better than recent standalone systems.

4. Interoperability and user choice: Users must be able to progress among different clouds.
5. Security: It should ensure that data of users are safe.
6. Privacy: Users' rights must be clearly defined and allow access based on rights.
7. Economic value: The cloud must provide substantial savings and benefits.
8. Sustainability: The cloud must increase power effectiveness and reduce environmental impact.



Basic Components of Cloud Computing

Significance of Cloud Computing

- The applications are made available to everyone through the cloud as and when they are available.
- The IT costs have been reduced due to the reduction in the number of servers, software cost, and the staff.
- The investment costs have become more flexible as compared to traditional methods.
- Increased reliability as anyone could get connected anytime.
- The data and the applications are mobile and easily made available to the employees across the globe.
- The increased collaboration has reduced the time to market and product enhancement.
- The facility could be turned up, down or off as per the demand and the circumstances.
- The cloud computing delivers an appreciable integration with Mergers and Acquisitions [M&A] activity.
- The cloud computing has increased the 'green' credentials as the solutions have the lesser environmental impact.

Importance of Cloud Computing

Cloud computing is of immense importance in today's technological landscape due to several key reasons:

1. **Flexibility:** With cloud computing, managing resources is easier than ever. Simply pay for the resources you are using each month, and nothing more. Cloud storage and cloud VPS providers offer flexible packages, where you can easily add or decrease the amount of storage and bandwidth you are paying to use.
2. **Scalability:** Businesses can easily scale their resources up or down based on demand, allowing for flexibility and cost-efficiency without the need for extensive physical infrastructure.
3. **Data Recovery:** Recovering data from damaged physical servers and hard drives can be fairly problematic. If the physical device is badly damaged, recovery may not be possible. These issues can result in businesses losing vital data, especially when it is not adequately backed up. With cloud computing, these issues are not as relevant.
4. **Cost-Effectiveness:** Cloud services operate on a pay-as-you-go model, reducing upfront costs for hardware and maintenance. This model allows businesses to optimize spending by paying only for the resources they use.
5. **Accessibility and Flexibility:** Cloud computing enables users to access data, applications, and services from anywhere with an internet connection, fostering remote work, collaboration, and innovation.
6. **Rapid Innovation:** Cloud services facilitate quick deployment of resources, enabling faster development, testing, and deployment of applications and services. This speed fosters innovation and agility within businesses.
7. **Reliability and Redundancy:** Cloud providers typically offer robust backup, disaster recovery, and redundancy options, ensuring data availability and minimizing the risk of data loss in case of hardware failures or disasters.
8. **Advanced Security Measures:** Cloud providers invest heavily in security measures, offering advanced security features, encryption, and compliance certifications, often surpassing what individual organizations can manage or afford.
9. **Data Analytics and AI:** Cloud platforms provide powerful tools and resources for data analytics, machine learning, and artificial intelligence, allowing businesses to derive valuable insights from large datasets and implement AI-driven solutions.
10. **Environmental Impact:** Cloud computing can be more environmentally friendly compared to traditional on-premises data centers, as cloud providers often optimize energy usage and resource allocation across massive infrastructure.

Overall, cloud computing has transformed the way businesses operate by offering cost-effective, scalable, and accessible computing resources. It fosters innovation, enhances collaboration, improves efficiency, and allows organizations to focus more on their core business objectives rather than managing complex infrastructure.

Characteristics of Cloud Computing

There are many characteristics of Cloud Computing here are few of them:

1. **On-demand self-services:** The Cloud computing services does not require any human administrators, user themselves are able to provision, monitor and manage computing resources as needed.
2. **Broad network access:** The Computing services are generally provided over standard networks and heterogeneous devices.
3. **Rapid elasticity:** The Computing services should have IT resources that are able to scale out and in quickly and on as needed basis. Whenever the user requires services it is provided to him and it is scale out as soon as its requirement gets over.
4. **Resource pooling:** The IT resource (e.g., networks, servers, storage, applications, and services) present are shared across multiple applications and occupant in an uncommitted manner. Multiple clients are provided service from a same physical resource.
5. **Measured service:** The resource utilization is tracked for each application and occupant, it will provide both the user and the resource provider with an account of what has been used. This is done for various reasons like monitoring billing and effective use of resource.
6. **Multi-tenancy:** Cloud computing providers can support multiple tenants (users or organizations) on a single set of shared resources.
7. **Virtualization:** Cloud computing providers use virtualization technology to abstract underlying hardware resources and present them as logical resources to users.
8. **Resilient computing:** Cloud computing services are typically designed with redundancy and fault tolerance in mind, which ensures high availability and reliability.
9. **Flexible pricing models:** Cloud providers offer a variety of pricing models, including pay-per-use, subscription-based, and spot pricing, allowing users to choose the option that best suits their needs.
10. **Security:** Cloud providers invest heavily in security measures to protect their users' data and ensure the privacy of sensitive information.
11. **Automation:** Cloud computing services are often highly automated, allowing users to deploy and manage resources with minimal manual intervention.
12. **Sustainability:** Cloud providers are increasingly focused on sustainable practices, such as energy-efficient data centers and the use of renewable energy sources, to reduce their environmental impact.

Pros and Cons of Cloud Computing

Absolutely, cloud computing comes with numerous advantages and a few challenges:

Pros:

1. **Scalability:** Easily scale resources up or down based on demand, allowing flexibility without heavy investment in physical infrastructure.

2. **Cost Efficiency:** Pay-as-you-go models reduce upfront costs, and businesses pay only for the resources they use, potentially saving money compared to traditional on-premises setups.
3. **Accessibility:** Users can access data, applications, and services from anywhere with an internet connection, fostering collaboration and remote work.
4. **Rapid Deployment:** Quick deployment of resources enables faster innovation, development, and deployment of applications and services.
5. **Reliability:** Cloud providers often offer robust backup, disaster recovery, and redundancy options, ensuring data availability and minimizing downtime.
6. **Security:** Cloud services often have advanced security measures, encryption, and compliance certifications, providing secure environments for data storage and processing.

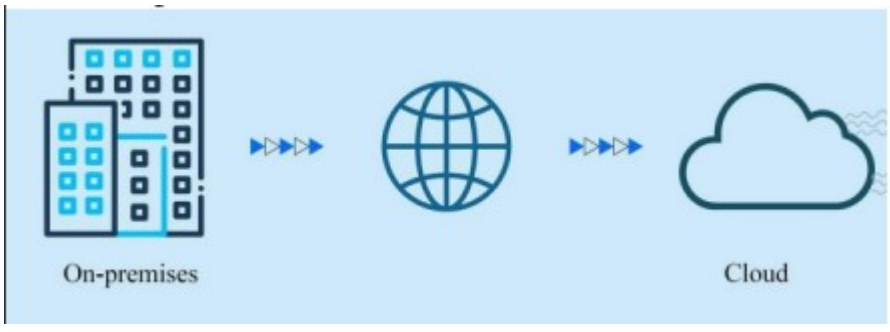
Cons:

1. **Downtime:** Dependence on internet connectivity means potential service disruptions if there are network issues or outages.
2. **Security Concerns:** While cloud providers offer robust security, storing data off-site raises concerns about data security and privacy, especially for sensitive information.
3. **Vendor Lock-In:** Switching between cloud providers might be challenging due to differences in technologies and proprietary features, potentially leading to vendor lock-in.
4. **Cost Management:** While pay-as-you-go models are cost-effective, inefficient resource management or unexpected spikes in usage can lead to higher costs.
5. **Limited Control:** Organizations might have limited control over their data and applications as they rely on the cloud provider's infrastructure and policies.
6. **Compliance Challenges:** Meeting specific regulatory compliance requirements can be challenging due to the shared responsibility model between cloud providers and users.

While cloud computing offers numerous advantages, organizations need to assess their specific needs and weigh these against the potential challenges to make informed decisions about adopting cloud services.

Migrating into Cloud

A cloud migration is when a company moves some or all of its data center capabilities into the cloud, usually to run on the cloud-based infrastructure provided by a cloud service provider such as AWS, Google Cloud, or Azure.



Cloud migration is sort of like a physical move, except it involves moving data, applications, and IT processes from some data centers to other data centers, instead of packing up and moving physical goods. Much like a move from a smaller office to a larger one, cloud migration requires quite a lot of preparation and advance work, but usually it ends up being worth the effort, resulting in cost savings and greater flexibility.

Benefits of Migrating into Cloud

1. **Scalability:** Cloud computing can scale up to support larger workloads and greater numbers of users far more easily than on-premises infrastructure, which requires companies to purchase and set up additional physical servers, networking equipment, or software licenses.
2. **Cost:** Companies that move to the cloud often vastly reduce the amount they spend on IT operations, since the cloud providers handle maintenance and upgrades. Instead of keeping things up and running, companies can focus more resources on their biggest business needs – developing new products of improving existing ones.
3. **Performance:** For some businesses, moving to the cloud can enable them to improve performance and the overall user experience for their customers. If their application or website is hosted in cloud data centers instead of in various on premises servers, then data will not have to travel as far to reach the users, reducing latency.
4. **Flexibility:** Users, whether they're employees or customers, can access the cloud services and data they need from anywhere. This makes it easier for a business to expand into new territories, offer their services to international audiences, and let their employees work flexibly.

Challenges of Migrating into Cloud

1. **Migrating large databases:** Often, databases will need to move to a different platform altogether in order to function in the cloud. Moving a database is difficult, especially if there are large amounts of data involved. Some cloud providers actually offer physical data transfer methods, such as loading data onto a hardware appliance and then shipping the appliance to the cloud provider, for massive databases that would take too long to transfer via the Internet. Data can also be transferred over the Internet. Regardless of the method, data migration often takes significant time.
2. **Data integrity:** After data is transferred, the next step is making sure data is intact and secure, and is not leaked during the process.
3. **Continued operation:** A business needs to ensure that its current systems remain operational and available throughout the migration. They will need to have some overlap between on-premises and cloud to ensure continuous service; for instance, it's necessary to make a copy of all data in the cloud before shutting down an existing database. Businesses typically need to move a little bit at a time instead of all at once.

4. **Security:** Security is an obvious threshold question, if the cloud is not secure, enterprises will not consider migrating to it fearing their sensitive data will be tampered. Users must ensure that they understand the underlying infrastructure of the cloud to which they migrate from their clients and must also advise clients to include security in their cloud SLAs and terms of service.

Strategies of Migrating into Cloud

Migrating to a cloud can be a good investment for our business. We might be admiring where to start like several companies.

Gartner specified some options that are widely called "the six Rs of migration", defined as follows:

1. **Rehost -** Rehosting can be thought of as "the same thing, but on cloud servers". Companies that choose this strategy will select an IaaS (Infrastructure as-a-Service) provider and recreate their application architecture on the infrastructure.
2. **Refactor -** Companies that choose to refactor will reuse already existing code and frameworks, but run their applications on a PaaS (Platform-as-a-Service) provider's platform – instead of on IaaS, as in rehosting.
3. **Revise -** This strategy involves partially rewriting or expanding the code base, then deploying it by either rehosting or refactoring.
4. **Rebuild -** To "rebuild" means rewriting and re-architecting the application from the ground up on a PaaS provider's platform. This can be a labor intensive process, but it also enables developers to take advantage of modern feature from PaaS vendors.
5. **Replace -** Businesses can also opt to discard their old applications all together and switch to already-built SaaS (Software-as-a-Service) applications from third-party vendors.

7 Steps of Migrating Model in Cloud

Migrating a model to a cloud can help in several ways, such as improving scalability, flexibility, and accessibility. There are seven steps to follow when migrating a model to the cloud:

Step 1: Choose the right cloud provider (Assessment step)

The first step in migrating your model to the cloud is to choose a cloud provider that aligns with your needs, budget, and model requirement. Consider the factors such as compliance, privacy, and security.

Step 2: Prepare your data (Isolation step)

Before migrating to your cloud, you need to prepare your data. For that ensure your data is clean and well organized, and in a format that is compatible with your chosen cloud provider.

Step 3: Choose your cloud storage (Mapping step)

Once your data is prepared, you need to choose your cloud storage. This is where your data is stored in the cloud. There are many cloud storage services such as GCP Cloud Storage, AWS S3, or Azure Blob Storage.

Step 4: Set up your cloud computing resources and deploy your model (Re- architect step)
If you want to run a model in the cloud, you will need to set up your cloud computing resources. This includes selecting the appropriate instance type and setting up a virtual machine (VM) or container for your model. After setting up your computing resource, it is time to deploy your model to the cloud. This includes packaging your model into a container or virtual machine image and deploying it to your cloud computing resource. and while deploying it may be possible that some functionality gets lost so due to this some parts of the application need to be re-architect.

Step-5: Augmentation step
It is the most important step for our business for which we migrate to the cloud in this step by taking leverage of the internal features of cloud computing service we augment our enterprise.

Step 6: Test your Model
Once your model is deployed, we need to test it to ensure that it is working or not. That involves running test data through your model and comparing the results with your expected output.

Step 7: Monitor and maintain your Model
After the model is deployed and tested, it is important to monitor and maintain it. That includes monitoring the performance, updating the model as needed, and need to ensure your data stays up-to-date. Migrating your machine learning model to the cloud can be a complex process, but above 7 steps, you can help ensure a smooth and successful migration, ensuring that your model is scalable and accessible.

Throughout these steps, communication among stakeholders, risk mitigation strategies, and a phased approach to migration can significantly contribute to a successful transition. Additionally, regular reviews and adjustments based on feedback and evolving business needs are crucial for long-term success in the cloud.

Trends in Computing

IT Maturity Analysis
The technologies are compared based on two parameters—the current investment rate and the current adoption rate. This assessment provides the success rate of the technology and its deployment and also the organizations that will find this technology beneficial. Thus, these

factors provide insight into how developed a technology is related to other technologies and how rapidly it will expand in the market.

Cloud computing technology changed its focus from industry to real-world problems. The major trends that emerged in cloud computing technology are:

- Small, medium business and micro-business
- Supply chains management, media and digital content, and legacy systems
- On-the-fly access
- Hybrid cloud model
- Growth in stack-as-a-service

Technology Trends to Watch

1. **Virtualization:** Infrastructure, applications, server, desktop, storage, network and hardware compose virtualization. Virtualization can supply extra power on demand and is compatible with today's environmental measures. For small and medium business (SMBs), virtualization affords incredibly easy migration.
2. **Data Growth:** Data growth is expected to increase more in the next fi ve years and 80% will remain unstructured. Due to this trend in the IT, the complexity will also increase, despite continued budget constraints. More access will lead to more data, resulting in increased compliance, backup, audit and security. To keep up with the tide, companies must virtualize storage quickly, preparation of reduplication, calculate all data inputs, keep up the needs, segments and prioritize data. Thin provisioning, data reduplication, automated tiering, HSM (heterogeneous storage management) principles and virtual tapes are included in the key technologies to manage the data growth.
3. **Energy and Green IT:** In Green IT, performance and its effectiveness will play a vital role. Corporate social responsibility will become a primary concern as the power issue moves up the food chain.
4. **Complex Resource Tracking:** Complex resource tracking monitors energy consumption made by resources and automatically optimizes it by moving workloads dynamically. Organizations will have to manage new KPI (knowledge power infrastructures) based on power and there will be a growing demand for new vendors and skills.
5. **Consumerization and Social Software:** Social collaboration (wikis, blogs, Facebook, Twitter), social media (content sharing and aggregation) and social validation (social ratings, rankings and commentary) will continue to be a major force in shaping consumerization and the software, compelling organizations to focus on early pattern detection and 'collectiveness'.

Cloud Service Models

Cloud Computing can be defined as the practice of using a network of remote servers hosted on the Internet to store, manage, and process data, rather than a local server or a personal computer.

Cloud service is any service made available to users on demand via the Internet from a cloud computing provider's servers as opposed to being provided from a company's own on-premises servers.

Cloud services are designed to provide easy, scalable access to applications, resources and services, and are fully managed by a cloud services provider.

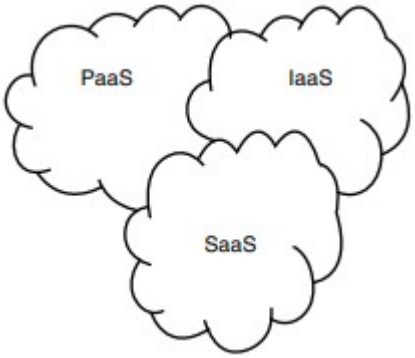
A cloud service can exist as a simple web-based software program with a technical interface invoked via the use of a messaging protocol, or as a remote access point for administrative tools or larger environments and other IT resources.

Companies offering such kinds of cloud computing services are called cloud providers and typically charge for cloud computing services based on usage. Grids and clusters are the foundations for cloud computing.

Service models describe the type of service that the service provider is offering. The best known service models are Software as a Service, Platform as a Service, and Infrastructure as a Service.

The service models build on one another and define what a vendor must manage and what the client's responsibility is.

Figure below shows the various cloud service models such as software, platform and infrastructure. Service models are types of services that are required by customers. Models are based on the kind of operation and requirement of the business.



Cloud Service Model

These are sometimes called the cloud computing stack because they are built on top of one another. Knowing what they are and how they are different, makes it easier to accomplish your goals. These abstraction layers can also be viewed as a layered architecture where services of a higher layer can be composed of services of the underlying layer i.e, SaaS can provide Infrastructure.

The various Service Models are

- **SaaS (Software as a Service)** applications are designed for end-users, delivered over the web.
- **PaaS (Platform as a Service)** is the set of tools and services designed to make coding and deploying those applications quick and efficient.
- **IaaS (Infrastructure as a Service)** is the hardware and software that powers it all – servers, storage, networks, operating systems.

SaaS

SaaS (sometimes called cloud application services) is cloud-hosted, ready-to-use application software. The application and the entire infrastructure required to deliver it - servers, storage, networking, middleware, application software, and data storage - are hosted and managed by the SaaS vendor.

Software-as-a-Service (SaaS) is a way of delivering services and applications over the Internet. Instead of installing and maintaining software, we simply access it via the Internet, freeing ourselves from the complex software and hardware management. It removes the need to install and run applications on our own computers or in the data centers eliminating the expenses of hardware as well as software maintenance.

SaaS provides a complete software solution that you purchase on a pay-as-you-go basis from a cloud service provider. Most SaaS applications can be run directly from a web browser without any downloads or installations required. The SaaS applications are sometimes called Web-based software, on-demand software, or hosted software.

The vendor manages all upgrades and patches to the software, usually invisibly to customers. Typically, the vendor ensures a level of availability, performance and security as part of a service level agreement (SLA). Customers can add more users and data storage on demand at additional cost.

Today, anyone who uses a or mobile phone almost certainly uses some form of SaaS. Email, social media, and cloud file storage solutions (such as Dropbox or Box) are examples of SaaS applications people use every day in their personal lives.

Popular business or enterprise SaaS solutions include Salesforce (customer relationship management software), HubSpot (marketing software), Trello (workflow management), Slack (collaboration and messaging), and Canva (graphics). Many applications designed originally for the desktop (e.g., Adobe Creative Suite) are now available as SaaS (e.g., Adobe Creative Cloud).

Characteristics of SaaS:

1. Software applications or services are stored remotely.
2. A user can then access these services or software applications via the Internet.
3. In most cases, a user does not have to install anything onto their host machine, all they requires is a web browser to access these service and in some cases, a browser may require additional plug-in/add-on for certain services.
4. Network-based management and access to commercially available software from central locations rather than at each customer's site, enabling customers to access applications remotely via the Internet.
5. Application delivery from one-to-many model, as opposed to a traditional one-to-one model.

Advantages of SaaS

1. **Cost-Effective:** Pay only for what you use.
2. **Reduced time:** Users can run most SaaS apps directly from their web browser without needing to download and install any software. This reduces the time spent in installation and configuration and can reduce the issues that can get in the way of the software deployment.
3. **Accessibility:** We can Access app data from anywhere.
4. **Automatic updates:** Rather than purchasing new software, customers rely on a SaaS provider to automatically perform the updates.
5. **Scalability:** It allows the users to access the services and features on-demand.

Disadvantages of Saas :

1. **Limited customization:** SaaS solutions are typically not as customizable as on-premises software, meaning that users may have to work within the constraints of the SaaS provider's platform and may not be able to tailor the software to their specific needs.
2. **Dependence on internet connectivity:** SaaS solutions are typically cloud-based, which means that they require a stable internet connection to function properly. This can be problematic for users in areas with poor connectivity or for those who need to access the software in offline environments.
3. **Security concerns:** SaaS providers are responsible for maintaining the security of the data stored on their servers, but there is still a risk of data breaches or other security incidents.
4. **Limited control over data:** SaaS providers may have access to a user's data, which can be a concern for organizations that need to maintain strict control over their data for regulatory or other reasons.

PaaS

PaaS is a category of cloud computing that provides a platform and environment to allow developers to build applications and services over the internet. PaaS services are hosted in the cloud and accessed by users simply via their web browser.

A PaaS provider hosts the hardware and software on its own infrastructure. As a result, PaaS frees users from having to install in-house hardware and software to develop or run a new application. Thus, the development and deployment of the application take place independent of the hardware.

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. To make it simple, take the example of an annual day function, you will have two options either to create a venue or to rent a venue but the function is the same.

The various companies providing *Platform as a service* are Amazon Web services Elastic Beanstalk, Salesforce, Windows Azure, Google App Engine, cloud Bees and IBM smart cloud.

Characteristics of PaaS:
There are the following characteristics of PaaS:

1. Builds on virtualization technology, so computing resources can easily be scaled up (Auto-scale) or down according to the organization's needs.
2. Support multiple programming languages and frameworks.
3. Integrates with web services and databases.

Advantages of PaaS:

1. **Simple and convenient for users:** It provides much of the infrastructure and other IT services, which users can access anywhere via a web browser.
2. **Cost-Effective:** It charges for the services provided on a per-use basis thus eliminating the expenses one may have for on-premises hardware and software.
3. **Efficiently managing the lifecycle:** It is designed to support the complete web application lifecycle: building, testing, deploying, managing, and updating.
4. **Efficiency:** It allows for higher-level programming with reduced complexity thus, the overall development of the application can be more effective.

Disadvantages of Paas:

1. **Limited control over infrastructure:** PaaS providers typically manage the underlying infrastructure and take care of maintenance and updates, but this can also mean that users have less control over the environment and may not be able to make certain customizations.
2. **Dependence on the provider**: Users are dependent on the PaaS provider for the availability, scalability, and reliability of the platform, which can be a risk if the provider experiences outages or other issues.
3. **Limited flexibility:** PaaS solutions may not be able to accommodate certain types of workloads or applications, which can limit the value of the solution for certain organizations.

IaaS

Infrastructure as a service (IaaS) is a service model that delivers computer infrastructure on an outsourced basis to support various operations. Typically IaaS is a service where infrastructure is provided as outsourcing to enterprises such as networking equipment, devices, database, and web servers.
IaaS is on-demand access to cloud-hosted computing infrastructure - servers, storage capacity and networking resources - that customers can provision, configure and use in much the same

way as they use on-premises hardware. The difference is that the cloud service provider hosts, manages and maintains the hardware and computing resources in its own data centers. IaaS customers use the hardware via an internet connection, and pay for that use on a subscription or pay-as-you-go basis.

Typically IaaS customers can choose between virtual machines (VMs) hosted on shared physical hardware (the cloud service provider manages virtualization) or bare metal servers on dedicated (unshared) physical hardware. Customers can provision, configure and operate the servers and infrastructure resources via a graphical dashboard, or programmatically through application programming interfaces (APIs).

It simply provides the underlying operating systems, security, networking, and servers for developing such applications, and services, and deploying development tools, databases, etc.

IaaS can be thought of as the original 'as a service' offering: Every major cloud service provider - Amazon Web Services, Google Cloud, IBM Cloud, Microsoft Azure - began by offering some form of IaaS.

Characteristics of IaaS:

There are the following characteristics of IaaS:

1. Resources are available as a service
2. Services are highly scalable
3. Dynamic and flexible Cloud Service Model
4. GUI and API-based access
5. Automate the administrative tasks

Advantages of IaaS:

1. **Cost-Effective:** Eliminates capital expense and reduces ongoing cost and IaaS customers pay on a per-user basis, typically by the hour, week, or month.
2. **Website hosting:** Running websites using IaaS can be less expensive than traditional web hosting.
3. **Security:** The IaaS Cloud Provider may provide better security than your existing software.
4. **Maintenance:** There is no need to manage the underlying data center or the introduction of new releases of the development or underlying software. This is all handled by the IaaS Cloud Provider.

Disadvantages of laaS :

1. **Limited control over infrastructure:** IaaS providers typically manage the underlying infrastructure and take care of maintenance and updates, but this can also mean that users have less control over the environment and may not be able to make certain customizations.

2. **Security concerns**: Users are responsible for securing their own data and applications, which can be a significant undertaking.
3. **Limited access:** Cloud computing may not be accessible in certain regions and countries due to legal policies.

Difference between IaaS, PaaS and SaaS:

Basis Of	IAAS	PAAS	SAAS
Stands for	Infrastructure as a service.	Platform as a service.	Software as a service.
Uses	IAAS is used by network architects.	PAAS is used by developers.	SAAS is used by the end user.
Access	IAAS gives access to the resources like virtual machines and virtual storage.	PAAS gives access to run time environment to deployment and development tools for application.	SAAS gives access to the end user.
Model	It is a service model that provides virtualized computing resources over the internet.	It is a cloud computing model that delivers tools that are used for the development of applications.	It is a service model in cloud computing that hosts software to make it available to clients.
Technical understanding.	It requires technical knowledge.	Some knowledge is required for the basic setup.	There is no requirement about technicalities company handles everything.
Popularity	It is popular among developers and researchers.	It is popular among developers who focus on the development of apps and scripts.	It is popular among consumers and companies, such as file sharing, email, and networking.

Basis Of	IAAS	PAAS	SAAS
Percentage rise	It has around a 12% increment.	It has around 32% increment.	It has about a 27 % rise in the cloud computing model.
Usage	Used by the skilled developer to develop unique applications.	Used by mid-level developers to build applications.	Used among the users of entertainment.
Cloud services.	Amazon Web Services, sun, vCloud Express.	Facebook, and Google search engine.	MS Office web, Facebook and Google Apps.
Enterprise services.	AWS virtual private cloud.	Microsoft Azure.	IBM cloud analysis.
Outsourced cloud services.	Salesforce	Force.com, Gigaspaces.	AWS, Terremark
User Controls	Operating System, Runtime, Middleware, and Application data	Data of the application	Nothing
Others	It is highly scalable and flexible.	It is highly scalable to suit the different businesses according to resources.	It is highly scalable to suit the small, mid and enterprise level business

Cloud Computing Logical Architecture

Cloud computing system can be divided into two parts: front end and back end. The interconnection between them is done via the Internet. Front end is used by the customers and back end refers to the service providers.

The front end contains customer's devices comprising of computers and a network and applications for accessing the back end system, that is, the cloud systems. Front end refers to the interface through which a customer can make use of the services rendered by the cloud computing system.

Back end contains physical devices or peripherals. It also contains various computer resources such as CPU and data storage systems. A combination of these resources is termed as cloud computing system. A dedicated server is used for administration purpose. It monitors the consumer's demands, traffics, etc.

A provider who renders service may have multiple consumers requiring large storage space. When we adopt cloud computing, the size of storage has to be increased, as it tries to store all the information about the clients. Cloud computing is no more a new technology due to its multifarious nature it has gained popularity among small- and medium-sized enterprises.

In cloud computing, all of the consumer's data are not stored in his premises, but in the service providers storage premises. When the consumer is in need of any data, he can retrieve it via the Internet.

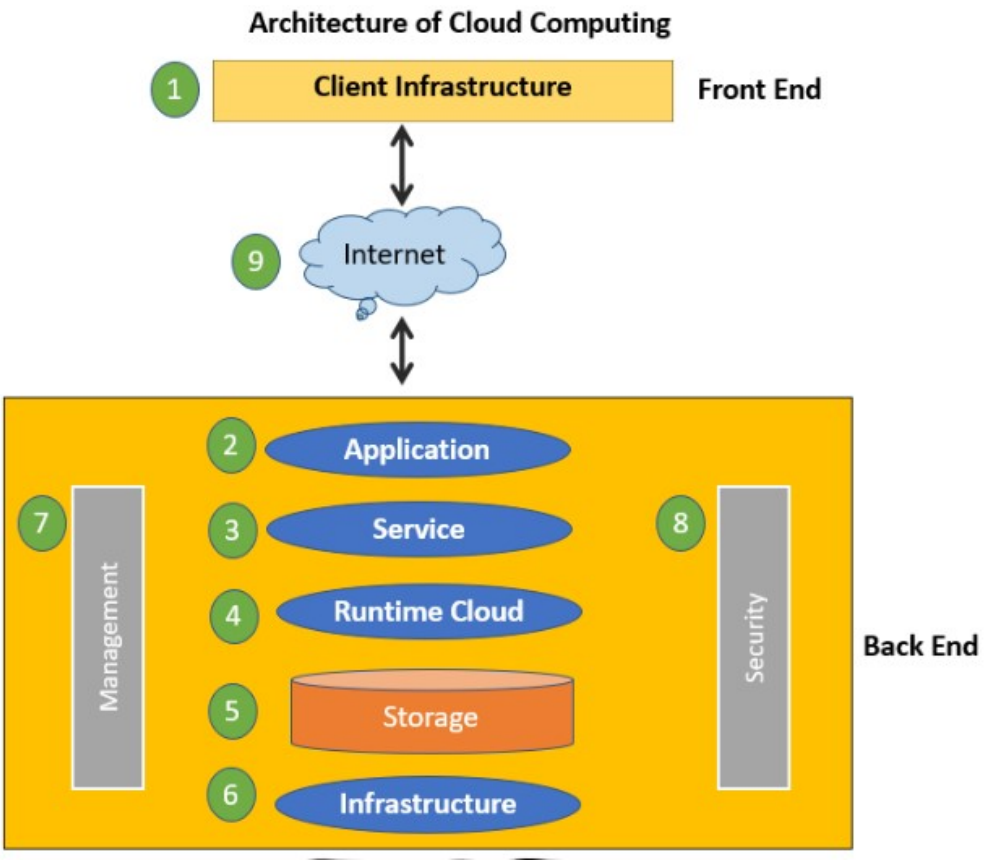
The Architecture of Cloud computing contains many different components. It includes Client infrastructure, applications, services, runtime clouds, storage spaces, management, and security. These are all the parts of a Cloud computing architecture.

Front End:

The client uses the front end, which contains a client-side interface and application. Both of these components are important to access the Cloud computing platform. The front end includes web servers (Chrome, Firefox, Opera, etc.), clients, and mobile devices.

Back End:

The backend part helps you manage all the resources needed to provide Cloud computing services. This Cloud architecture part includes a security mechanism, a large amount of data storage, servers, virtual machines, traffic control mechanisms, etc.



Important Components of Cloud Computing Architecture
Here are some important components of Cloud computing architecture:

1. Client Infrastructure
Client Infrastructure is a front-end component that provides a GUI. It helps users to interact with the Cloud.

2. Application
The application can be any software or platform which a client wants to access. Depending upon the client requirement, the application provides the result to the end-user (with resources) in the back end.

3. Service
Service is an essential component in cloud architecture. Its responsibility is to provide utility in the architecture. In a Cloud, few widely used services among the end-users are storage application development environments and web services. The service component manages which type of service you can access according to the client's requirements.
Three Cloud computing services are:

- Software as a Service (SaaS)
- Platform as a Service (PaaS)
- Infrastructure as a Service (IaaS)

4. Runtime Cloud
Runtime cloud offers the execution and runtime environment to the virtual machines.

5. Storage
Storage is another important Cloud computing architecture component. It provides a large amount of storage capacity in the Cloud to store and manage data.

- Some of the popular examples of storage services are below:
    - Amazon S3
    - Oracle Cloud-Storage
    - Microsoft Azure Storage
- Its capacity varies depending upon the service providers available in the market

6. Infrastructure
It offers services on the host level, network level, and application level. Cloud infrastructure includes hardware and software components like servers, storage, network devices, virtualization software, and various other storage resources that are needed to support the cloud computing model.

7. Management
Its task is to allot specific resources to a specific task, it simultaneously performs various functions of the cloud environment. This component manages components like application, service, runtime cloud, storage, infrastructure, and other security matters in the backend. It also establishes coordination between them. In simple terms, it establishes coordination among the cloud resources.

8. Security
Security in the backend refers to implementing different security mechanisms for secure Cloud systems, resources, files, and infrastructure to the end-user. Also, it implements security management to the cloud server with virtual firewalls which results in preventing data loss.

9. Internet
Internet connection acts as the bridge or medium between frontend and backend. It allows you to establish the interaction and communication between the frontend and backend.

Developing Holistic Cloud Computing Reference Model

The term 'cloud' in cloud computing refers to a combined set of hardware, storage, networks, services and interfaces.

Consumer cloud computing services are widely used in the Internet. Examples are e-mails and social networking sites. Usage of cloud computing by the IT organizations sector is low, because of security risks in terms of privacy of data.

While adapting to the cloud services, documentation of data is essential and the same should be shared with the consumers. The documents should cover governance, compliance and risk factors.

Complete View of Cloud Management

Cloud computing has not yet reached its full potential. Obstacles for cloud adoption lie in the confusion among different delivery models and deployment methods. Other concerns on risking outsourcing of cloud management are data legislation issues, inability to assess service providers, etc. In addition to cloud environment as a concept, it also has technological obstacles, making service provisioning a complicated process.

The five top level research areas for analysing obstacles in cloud computing are as follows:

1. Optimization in deployment and construction of cloud services.
2. Self-preservation in resource management.
3. Self-management for various cloud services and decision making.
4. Support for service deployment.
5. Market and legislative issues.

Cloud Computing Reference Model

The cloud computing reference model (CC-RM) facilitates the process of modeling cloud architecture and planning the deployment activities. It also establishes a foundation for modeling cloud and its architecture, from which an IT organization can plan, architect, model and deploy to address business and technical challenges. Cloud is not a problem-solving architecture; it is a collection of services, which can be used to solve problems.

The cloud reference model consists of the following four elements/models:

1. **Cloud enablement model:** This model describes the various layers of cloud and its advantages for business operations. This model comprises of various cloud computing technologies and solutions for the consumers.
2. **Cloud deployment model:** The cloud deployment model (CDM) describes the various cloud models such as private, public, hybrid and community clouds.
3. **Cloud governance and operations model:** The cloud governance and operations model defines the requirements for cloud computing such as governance, privacy, security operations, management, support and monitoring.
4. **Cloud ecosystem model:** The cloud ecosystem takes cares of development and sustenance. It consists of cloud providers, consumers, intermediaries and networks.

The cloud computing reference model has four sub-models, they are as follows:

1. **Cloud virtualization tier:** Cloud virtualization tier focuses on the tools that provide hardware and infrastructure virtualization, computing, storage, network and security virtualization.
2. **Cloud operating system tier:** Cloud operating system tier focuses on the technologies that enable virtualization of resources as cloud-enabled capabilities. Cloud OS tier provides provisioning, billing and metering, load balancing, resource management, monitoring and management, workflow and orchestration of cloud-enabled resources.
3. **Cloud platform tier:** It focuses on enabling the PaaS oriented services and includes SOA and Web services concepts.
4. **Cloud business tier:** Cloud business tier focuses on the various range of business capabilities and business solutions, that are designed and provisioned to consumers as services via the cloud.

Cloud Deployment Model (CDM)

The CDM provides an open framework for identifying the necessities and differences of various cloud deployment environments. The CDM l and the CEM are key decisions that determine aspects such as security, architectural and management challenges. The various CDM scenarios are private internal cloud, public external cloud, hybrid integrated cloud and community cloud. The CDM and CEM are central necessities of the cloud computing reference model.

Cloud Governance and Operations Model

This model helps in making choices in cloud enablement approaches in terms of cloud deployment model. The primary elements of the cloud governance and operations model are cloud governance, security and privacy, management and monitoring and operations and support.

Cloud Ecosystem Model

The last model in CC-RM is the CEM. Cloud ecosystem is the physical, logical and virtual environment in which the cloud providers, consumers, solution and technology providers help cloud computing to run smooth and legitimate business and technology trend. The key elements of the cloud ecosystem model are cloud network/dial tone, cloud ecosystem enablement and cloud consumers and cloud providers.

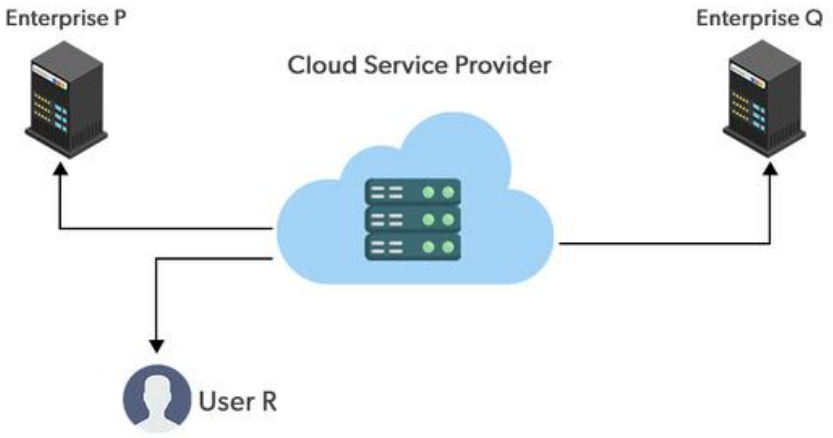
Cloud Deployment Model

Cloud deployment models are refers to the location and management of the cloud's infrastructure.

The cloud deployment model identifies the specific type of cloud environment based on ownership, scale, and access, as well as the cloud's nature and purpose. The location of the servers you're utilizing and who controls them are defined by a cloud deployment model. It specifies how your cloud infrastructure will look, what you can change, and whether you will be given services or will have to create everything yourself. Relationships between the infrastructure and your users are also defined by cloud deployment types. Different types of cloud computing deployment models are described below.

Public Cloud

The public cloud makes it possible for anybody to access systems and services. The public cloud may be less secure as it is open to everyone. The public cloud is one in which cloud infrastructure services are provided over the internet to the general people or major industry groups. The infrastructure in this cloud model is owned by the entity that delivers the cloud services, not by the consumer. It is a type of cloud hosting that allows customers and users to easily access systems and services. This form of cloud computing is an excellent example of cloud hosting, in which service providers supply services to a variety of customers. In this arrangement, storage backup and retrieval services are given for free, as a subscription, or on a per-user basis. For example, Google App Engine etc.



Advantages of the Public Cloud Model

- **Minimal Investment:** Because it is a pay-per-use service, there is no substantial upfront fee, making it excellent for enterprises that require immediate access to resources.
- **No setup cost:** The entire infrastructure is fully subsidized by the cloud service providers, thus there is no need to set up any hardware.
- **Infrastructure Management is not required:** Using the public cloud does not necessitate infrastructure management.

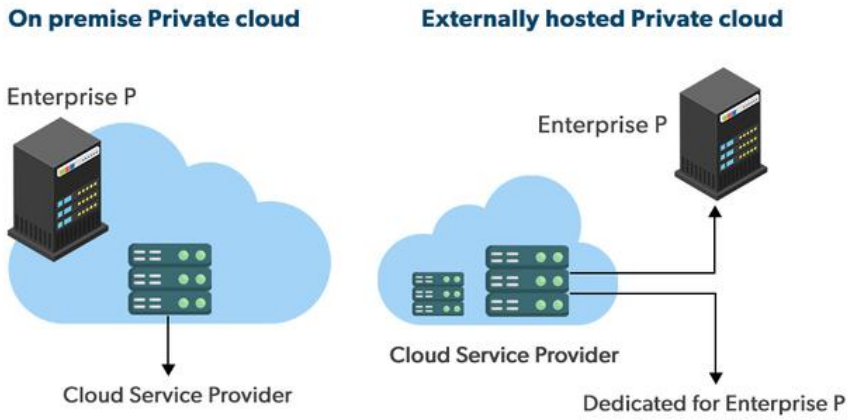
- **No maintenance:** The maintenance work is done by the service provider (not users).
- **Dynamic Scalability:** To fulfill your company's needs, on-demand resources are accessible.

Disadvantages of the Public Cloud Model

- **Less secure:** Public cloud is less secure as resources are public so there is no guarantee of high-level security.
- **Low customization:** It is accessed by many public so it can't be customized according to personal requirements.

Private Cloud

The private cloud deployment model is the exact opposite of the public cloud deployment model. It's a one-on-one environment for a single user (customer). There is no need to share your hardware with anyone else. The distinction between private and public clouds is in how you handle all of the hardware. It is also called the "internal cloud" & it refers to the ability to access systems and services within a given border or organization. The cloud platform is implemented in a cloud-based secure environment that is protected by powerful firewalls and under the supervision of an organization's IT department. The private cloud gives greater flexibility of control over cloud resources.



Advantages of the Private Cloud Model

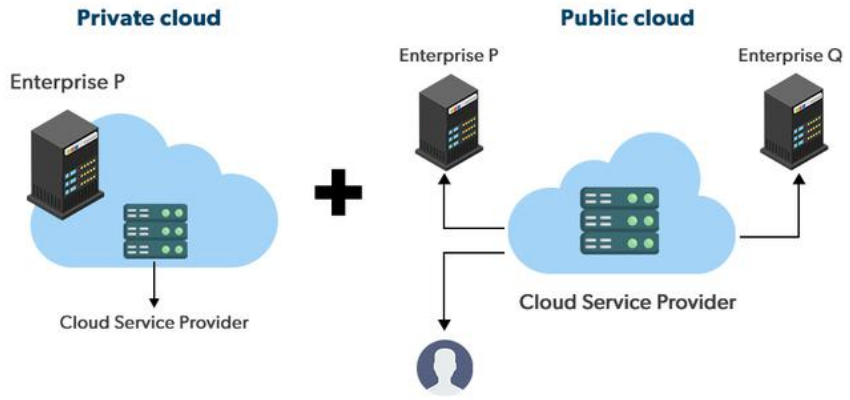
- **Better Control:** You are the sole owner of the property. You gain complete command over service integration, IT operations, policies, and user behavior.
- **Data Security and Privacy:** It's suitable for storing corporate information to which only authorized staff have access. By segmenting resources within the same infrastructure, improved access and security can be achieved.
- **Supports Legacy Systems:** This approach is designed to work with legacy systems that are unable to access the public cloud.
- **Customization:** Unlike a public cloud deployment, a private cloud allows a company to tailor its solution to meet its specific needs.

Disadvantages of the Private Cloud Model

- **Less scalable:** Private clouds are scaled within a certain range as there is less number of clients.
- **Costly:** Private clouds are more costly as they provide personalized facilities.

Hybrid Cloud

By bridging the public and private worlds with a layer of proprietary software, hybrid cloud computing gives the best of both worlds. With a hybrid solution, you may host the app in a safe environment while taking advantage of the public cloud's cost savings. Organizations can move data and applications between different clouds using a combination of two or more cloud deployment methods, depending on their needs.



Hybrid Cloud

Advantages of the Hybrid Cloud Model

- **Flexibility and control:** Businesses with more flexibility can design personalized solutions that meet their particular needs.
- **Cost:** Because public clouds provide scalability, you'll only be responsible for paying for the extra capacity if you require it.
- **Security:** Because data is properly separated, the chances of data theft by attackers are considerably reduced.

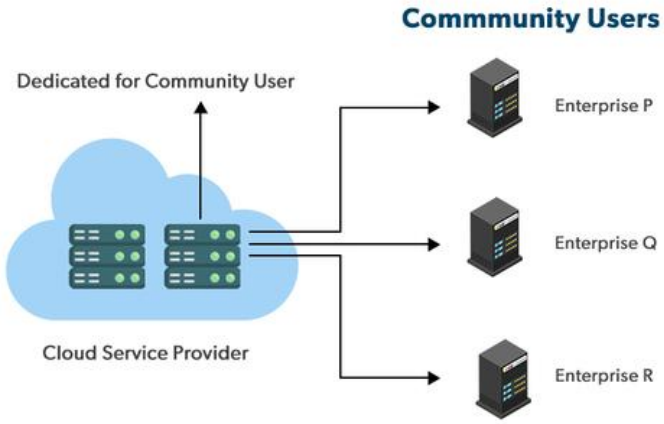
Disadvantages of the Hybrid Cloud Model

- **Difficult to manage:** Hybrid clouds are difficult to manage as it is a combination of both public and private cloud. So, it is complex.
- **Slow data transmission:** Data transmission in the hybrid cloud takes place through the public cloud so latency occurs.

Community Cloud

It allows systems and services to be accessible by a group of organizations. It is a distributed system that is created by integrating the services of different clouds to address the specific needs of a community, industry, or business. The infrastructure of the community could be shared

between the organization which has shared concerns or tasks. It is generally managed by a third party or by the combination of one or more organizations in the community.



Community Cloud

Advantages of the Community Cloud Model

- **Cost Effective:** It is cost-effective because the cloud is shared by multiple organizations or communities.
- **Security:** Community cloud provides better security.
- **Shared resources:** It allows you to share resources, infrastructure, etc. with multiple organizations.
- **Collaboration and data sharing:** It is suitable for both collaboration and data sharing.

Disadvantages of the Community Cloud Model

- **Limited Scalability:** Community cloud is relatively less scalable as many organizations share the same resources according to their collaborative interests.
- **Rigid in customization:** As the data and resources are shared among different organizations according to their mutual interests if an organization wants some changes according to their needs they cannot do so because it will have an impact on other organizations.

Difference between Private Cloud, Public Cloud and Hybrid Cloud

The various cloud deployment models and highlights its characteristics.

Factors	Public Cloud	Private Cloud	Community Cloud	Hybrid Cloud
Initial Setup	Easy	Complex, requires a professional team to setup	Complex, requires a professional team to setup	Complex, requires a professional team to setup

Factors	Public Cloud	Private Cloud	Community Cloud	Hybrid Cloud
Scalability and Flexibility	High	High	Fixed	High
Cost-Comparison	Cost-Effective	Costly	Distributed cost among members	Between public and private cloud
Reliability	Low	Low	High	High
Data Security	Low	High	High	High
Data Privacy	Low	High	High	High

On Premises VS on Cloud

On Premises: In on-premises, from use to the running of the course of action, everything is done inside; whereby backup, privacy, and updates moreover should be managed in-house. At the point when the item is gotten, it is then installed on your servers; requiring additional power laborers, database programming software and operating systems to be purchased. With no prior commitment, you anticipate complete ownership.

On Cloud: Cloud refers to the delivery of on-demand computing services over the internet on "Pay As U Use "services, in simple words rather than managing files and Services on the local storage device you can do the same over the Internet in a cost-efficient manner. With a Cloud-based enrolment model, there is no convincing motivation to purchase any additional establishment or licenses.

Difference between On-Premises and On Cloud:

1. **Scalability –**
   When it comes to scalability we pay more for on-premises set up and get lesser option too and once you scale up it is difficult to scale down and turn into heavy loss like infrastructure and maintenance cost while on the other hand Cloud allows you to pay only how much you use with much easier and faster for scaling upper and down.
2. **Server Storage –**

On-premises need a lot of space, power, and maintenance to store while on the other hand cloud solution are offered by the provider and maintain the server which saves your money and space.

3. **Data Security –**
   On promises offers less security and for security, we need physical and traditional IT security measures whereas the cloud offers much better security, and I avoiding all other physical and other security options.
4. **Data Loss or Recovery –**
   If data loss occurs recovery in on-premises is very least while cloud offers you the backup for easier and faster data recovery.
5. **Maintenance –**
   On promises require an extra team for maintenance which increases the cost while the cloud is maintained by the provider.

	On Premises	**On Cloud**
1.	Control of user is more.	Control of user is less as third parties are involved.
2.	Infrastructure is not easy to scale.	Infrastructure is easy to scale.
3.	Internet connectivity is not need all the time.	Internet is must for the services of the cloud.
4.	These services run within the enterprise only.	The services of cloud depends on the third parties so these are not only accessed within the enterprise.
5.	These services are not quite flexible.	The services of cloud are highly flexible.
6.	Not available on a subscription basis.	Services are available for purchase.
7.	For hardware and software updates, enterprise is responsible.	For hardware and software updates, third party is responsible.
8.	Cost is fixed.	Cost is not fixed, as additional services comes with additional charges.

	On Premises	On Cloud
9.	Data is easily portable.	Data is not easily portable.
10.	The deployment happens in the local environment.	The deployment happens on the internet.
11.	Security is more.	Security is less as all the information is stored in the cloud.
12.	These services are used in large companies.	These services are used in small and mid sized companies.
13.	Implementation time is more.	Implementation time is less.

Cloud Lifecycle Model

Cloud computing technology is capable of significantly transforming IT and also enhances responsiveness towards business requirements concurrently providing cost-effective infrastructure, platforms and applications.

On one hand, the IT sector is dependent on virtual machines, and on the other, there is rapid progress in lively infrastructure, which implies that the IT sectors must take vital decisions on supported platforms, degrees of flexibility and scalability using a unified management strategy.

The lifecycle should have the ability to consider the requirements of the business providing elasticity to deliver user-configured, multi tiered cloud services.

The lifecycle management of cloud is so efficient that the IT sector can easily achieve the primary goals of a cloud environment such as agility, cost savings and optimal use of resources. Currently, many know-how associations are trying to adopt cloud computing for applying virtualization in their data centers.

Cloud lifecycle management provides:

- Ease in administrating cloud and service portal
- Manageable service
- Established multi-tenancy
- Include performance and capacity management
- Support heterogeneity

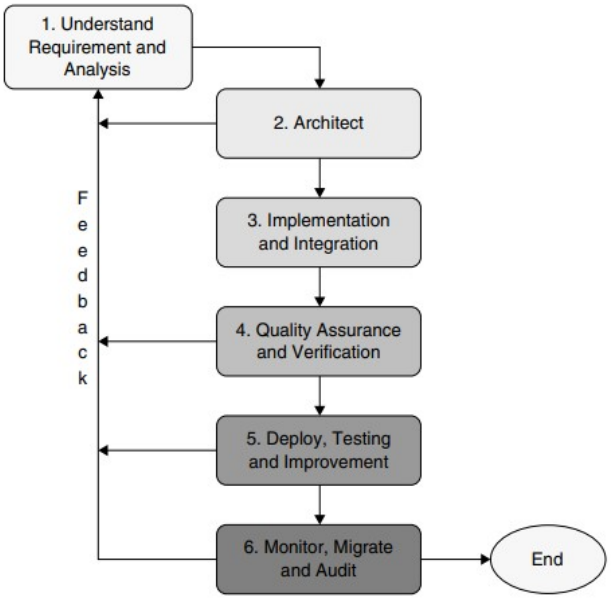
Cloud lifecycle working group documents the observations for effective modelling and thereby helps in understanding the dynamical and thermo dynamical processes of the clouds in climate and weather analyses models. The objectives of this working group are as follows:

- To identify questions related to cloud lifecycles.
- To maximize the efforts of the investigator by answering the questions.
- To make understanding easy for cloud lifecycle process by prioritizing the strategies and observational data.

The Cloud Life Cycle (CDLC) is the repeated life cycle model for growth, deployment and delivery of cloud.

Phases of CDLC

In this lifecycle model, feedback is used in which a phase gives the necessary information to the preferred upper phase.



1. Requirement and Analysis

Requirement and analysis method is used to evaluate and understand the requirements of an end user. This is done by taking up the significant complaints from the user, network solution, management and customers of the present system. Once these complaints are thoroughly studied, a tentative cloud computing solution is arrived, which minimizes the deficiencies and meets one's requirements. Solution such as computing cost, scalability, organizational agility and benefits can be accessed through this phase.

2. Architect

The structural behaviour of the cloud architecture gives solution to the cloud system which comprises of on-premise resource, cloud resources, cloud services, cloud middleware, software components, data server location and externally visible properties of data server location.

3. Implementation and Integration

Third phase of CDLC is the actual formation and enablement of the private, public, community, hybrid, inter and hosted cloud solutions to a computing problem.

Implementation: Events such as privacy, protection, regular, legality, mentality, inter-machine message and privacy theory are addressed within the implementation phase. Two components of cloud computing are implemented in this phase. The implementation of file system is the first case. The implementation of map-reduce system is the second case.

Integration: Integration is intermediate between the source and target systems for extracting data, mediating and publishing it. In the present economy, businesses and enterprises are shifting to cloud technology due to the low costs, scalability and independent IT constrained resources.

4. Quality Assurance and Verification

In this phase, cloud auditing is done to ensure the quality of the cloud network. It also confirms the performance, reliability, availability, elasticity and safety of cloud network at the service level.

5. Deploy, Testing and Improvement

Different platform service providers drastically reduce the deployment cost of the application by pre-building and pre-configuring a stack of application infrastructure in this phase.

6. Monitor, Migrate and Audit

This phase is marked by periodically monitoring the cloud environment and measuring the performance of the system. The extra cost and worth that a client incurs moving to cloud from the traditional SOA method and furthermore integration with the existing methods are considered in this phase.

Applications of Cloud computing in real-world

Cloud Service Providers (CSP) are providing many types of cloud services and now if we will cloud computing has touched every sector by providing various cloud applications. Sharing and managing resources is easy in cloud computing that's why it is one of the dominant fields of computing. These properties have made it an active component in many fields. Now let's know some of the real-world applications of cloud computing.

1. **Online Data Storage:** Cloud computing allows storing data like files, images, audios, and videos, etc on the cloud storage. The organization need not set physical storage systems to store a huge volume of business data which costs so high nowadays. As they are growing technologically, data generation is also growing with respect to time, and storing that becoming problem. In that situation, Cloud storage is providing this service to store and access data any time as per requirement.

2. **Backup and Recovery:** Cloud vendors provide security from their side by storing safe to the data as well as providing a backup facility to the data. They offer various recovery application for retrieving the lost data. In the traditional way backup of data is a very complex problem and also it is very difficult sometimes impossible to recover the lost data. But cloud computing has made backup and recovery applications very easy where there is no fear of running out of backup media or loss of data.
3. **Bigdata Analysis:** We know the volume of big data is so high where storing that in traditional data management system for an organization is impossible. But cloud computing has resolved that problem by allowing the organizations to store their large volume of data in cloud storage without worrying about physical storage. Next comes analyzing the raw data and finding out insights or useful information from it is a big challenge as it requires high-quality tools for data analytics. Cloud computing provides the biggest facility to organizations in terms of storing and analyzing big data.
4. **Testing and development:** Setting up the platform for development and finally performing different types of testing to check the readiness of the product before delivery requires different types of IT resources and infrastructure. But Cloud computing provides the easiest approach for development as well as testing even if deployment by using their IT resources with minimal expenses. Organizations find it more helpful as they got scalable and flexible cloud services for product development, testing, and deployment.
5. **Anti-Virus Applications:** Previously, organizations were installing antivirus software within their system even if we will see we personally also keep antivirus software in our system for safety from outside cyber threats. But nowadays cloud computing provides cloud antivirus software which means the software is stored in the cloud and monitors your system/organization's system remotely. This antivirus software identifies the security risks and fixes them. Sometimes also they give a feature to download the software.
6. **E-commerce Application:** Cloud-based e-commerce allows responding quickly to the opportunities which are emerging. Users respond quickly to the market opportunities as well as the traditional e-commerce responds to the challenges quickly. Cloud-based e-commerce gives a new approach to doing business with the minimum amount as well as minimum time possible. Customer data, product data, and other operational systems are managed in cloud environments.
7. **Cloud computing in education:** Cloud computing in the education sector brings an unbelievable change in learning by providing e-learning, online distance learning platforms, and student information portals to the students. It is a new trend in education that provides an attractive environment for learning, teaching, experimenting, etc to students, faculty members, and researchers. Everyone associated with the field can connect to the cloud of their organization and access data and information from there.
8. **E-Governance Application:** Cloud computing can provide its services to multiple activities conducted by the government. It can support the government to move from the

traditional ways of management and service providers to an advanced way of everything by expanding the availability of the environment, making the environment more scalable and customized. It can help the government to reduce the unnecessary cost in managing, installing, and upgrading applications and doing all these with help of could computing and utilizing that money public service.

9. **Cloud Computing in Medical Fields:** In the medical field also nowadays cloud computing is used for storing and accessing the data as it allows to store data and access it through the internet without worrying about any physical setup. It facilitates easier access and distribution of information among the various medical professional and the individual patients. Similarly, with help of cloud computing offsite buildings and treatment facilities like labs, doctors making emergency house calls and ambulances information, etc can be easily accessed and updated remotely instead of having to wait until they can access a hospital computer.
10. **Entertainment Applications:** Many people get entertainment from the internet, in that case, cloud computing is the perfect place for reaching to a varied consumer base. Therefore different types of entertainment industries reach near the target audience by adopting a multi-cloud strategy. Cloud-based entertainment provides various entertainment applications such as online music/video, online games and video conferencing, streaming services, etc and it can reach any device be it TV, mobile, set-top box, or any other form. It is a new form of entertainment called On-Demand Entertainment (ODE). With respect to this as a cloud, the market is growing rapidly and it is providing various services day by day. So other application of cloud computing includes social applications, management application, business applications, art application, and many more. So in the future cloud computing is going to touch many more sectors by providing more applications and services.