"Cloud Computing" Prepared by **Dr.P.Sumathi**

Year	Subject Title	Sem	Sub. Code
2018-19 Onwards	**CLOUD COMPUTING**	**III**	**18MIT34C**

UNIT-I: Introduction – Essentials – Benefits – Why cloud – Business and IT perspective – cloud and virtualization – cloud service requirements – dynamic cloud infrastructure – cloud computing characteristics – cloud adoption – cloud rudiments. **Cloud deployment models:** introduction – cloud characteristics – measured service accounting – cloud deployment models – security in a public cloud – public versus private clouds – cloud infrastructure self-service. (Chap 1,2)

UNIT-II: Cloud as a service: introduction – gamut of cloud solutions – principal technologies- cloud strategy – cloud design and implementation using SOA – conceptual cloud model – cloud service defined. **Cloud solutions**: introduction – cloud ecosystem – cloud business process management – cloud service management – on premise cloud orchestration and provisioning engine – computing on demand. (Chap 3,4)

UNIT-III: Cloud offerings: Introduction – introduction storage, retrieval archive and protection-cloud analytics – testing under cloud – information security – virtual desktop infrastructure-storage cloud. **Cloud Management:** Introduction – resiliency – provisioning – asset management-cloud governance – high availability and disaster recovery – charging models – usage reporting, and metering. **Cloud Virtualization Technology:** Introduction – virtualization demand – virtualization benefits – server virtualization – virtualization for x86 architecture – hypervisor management software – virtual infrastructure requirements. (Chap 5,6,7)

UNIT-IV: Cloud Infrastructure: Introduction – storage virtualization – storage area networks-network-attached storage – cloud server virtualization – networking essential to the cloud. **Cloud and SOA:** Introduction – SOA Journey to Infrastructure – SOA and the cloud – SOA Defined – SOA and infrastructure as a service – SOA based cloud infrastructure steps – SOA Business and IT services. (Chap 8,9)

UNIT-V: Cloud Mobility: Introduction – the business problem – mobile enterprise application platforms – mobile application architecture overview. **Cloud Governance**: Introduction – service level agreement and compliance – data privacy and protection risks – enterprise governance – risk management – third party management – information management. (Chap 10,11)

TEXT BOOK

1. Dr. Kumar Saurabh "Cloud Computing-Unleashing Next Gen Infrastructure to Application", 3rd Edition, Wiley India Pvt Ltd, 2014.

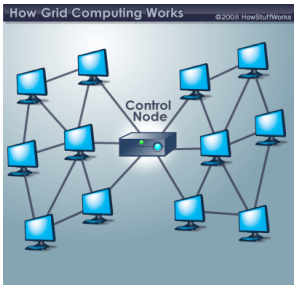
UNIT-I: Chapter 1: First Drive

- 1.1 Introduction
- 1.2 Essentials
- 1.3 Benefits
- 1.4 Why cloud?
- 1.5 Business and IT Perspective
- 1.6 Cloud and Virtualization
- 1.7 Cloud Services Requirements
- 1.8 Dynamic Cloud Infrastructure
- 1.9 Cloud Computing Characteristics
- 1.10 Cloud Adoption
- 1.11 Cloud Rudiments

History of Cloud Computing

- Before emerging the cloud computing, there was **Client/Server computing which is basically a centralized storage** in which all the software applications, all the data and all the controls are resided on the server side.
- If a single user wants to access specific data or run a program, he/she need to connect to the server and then gain appropriate access, and then he/she can do his/her business.
- Then after, distributed computing came into picture, where all the computers are networked together and share their resources when needed.
- On the basis of above computing, there was emerged of cloud computing concepts that later implemented.
- At around in **1961, John MacCharty suggested in a speech at MIT that computing can be sold like a utility,** just like a water or electricity. It was a brilliant idea, but like all brilliant ideas, it was ahead if its time, as for the next few decades, despite interest in the model, the technology simply was not ready for it.
- But ofcourse time has passed and the technology caught that idea and after few years we mentioned that:
- **In 1999, Salesforce.com started delivering of applications to users using a simple website.** The applications were delivered to enterprises over the Internet, and this way the dream of computing sold as utility were true.
- **In 2002, Amazon started Amazon Web Services**, providing services like storage, computation and even human intelligence. However, only starting with the launch of the Elastic Compute Cloud in 2006 a truly commercial service open to everybody existed.
- **In 2009, Google Apps also started to provide cloud computing** enterprise applications.
- **In 2009, Microsoft launched Windows Azure,** and companies like Oracle and HP have all joined the game. This proves that today, cloud computing has become mainstream.

Grid Computing



- **Grid computing is also called as "distributed computing." It links multiple computing resources (PC's, workstations, servers, and storage elements) together and provides a mechanism to access them.** (or)
- **Collection of computer resources from multiple locations to reach a common goal.**
- The main advantages of grid computing are that it increases user productivity by providing transparent access to resources, and work can be completed more quickly.
- In a basic grid computing system, every computer can access the resources of every other computer belonging to the network.

A Grid is made up of a number of resources and layers with different levels of implementation.

- **1. Information grids:** These are aimed to provide and efficient and simple access to data without worries about platforms, location, and performance.
- **2. Compute grids:** These exploit the processing power from a distributed collection of systems.
- **3. Services grids:** They provide scalability and reliability across different servers with the establishment of simulated instance of grid services.
- 4. **A mix of them:** Each of these has specific sets of characteristics that are peculiar of the hybrid characteristic of compute and service grid.

Conceptually, we can imagine the following three layers:

- **1.Lower layer:** This is a physical layer where we have servers, storage devices, and interconnecting network.
- **2. Middle layer:** This layer represents different operating systems mapped one-to-one with servers.
- **3. Upper layer:** This is an application layer in which we map different applications supporting enterprise business processes.

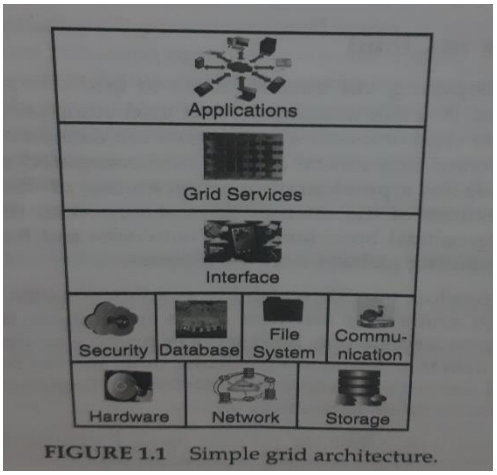


FIGURE 1.1 Simple grid architecture.

Standard Grid Architecture

- 1. Storage/data/information: It provides logical views of data without having to understand where the data is located or whether it is replicated.
- 2. System management: It defines, controls, configures, removes components and/or services (could be physical) on a grid using automated or physical methods.
- 3. Metering billing, and software (SW) licensing: It provides tools to monitor and distribute the number of licenses while using licensed software. It also provides metering and billing techniques, such as utility – like services, so that the owners of the resources made available are accurately compensated for providing the resources.
- 4. Security
    - *Authentication:* The grid has to 'be aware' of the identity of the users who interact with it.
    - *Authorization:* This grid has to restrict access to its resources to the users who are eligible to access it.
    - *Integrity:* Data exchanged among grid nodes should not be subject to tampering.

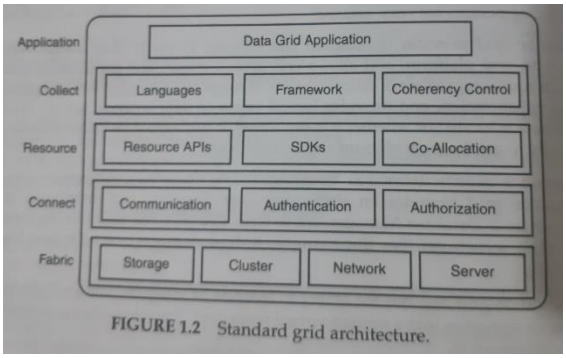


FIGURE 1.2 Standard grid architecture.

Cloud Computing

- Cloud computing uses a client-server architecture to deliver computing resources such as servers, storage, databases, and software over the cloud (Internet) with pay-as-you-go pricing.
- Cloud computing becomes a very popular option for organizations by providing various advantages, including cost-saving, increased productivity, efficiency, performance, data back-ups, disaster recovery, and security.
- The term cloud refers to a network or the internet. It is a technology that uses remote servers on the internet to store, manage, and access data online rather than local drives. The data can be anything such as files, images, documents, audio, video, and more.

Difference between cloud computing and grid computing

Cloud Computing	Grid Computing
Cloud Computing follows client-server computing architecture.	Grid computing follows a distributed computing architecture.
Scalability is high.	Scalability is normal.
Cloud Computing is more flexible than grid computing.	Grid Computing is less flexible than cloud computing.
Cloud operates as a centralized management system.	Grid operates as a decentralized management system.
In cloud computing, cloud servers are owned by infrastructure providers.	In Grid computing, grids are owned and managed by the organization.
Cloud computing uses services like Iaas, PaaS, and SaaS.	Grid computing uses systems like distributed computing, distributed information, and distributed pervasive.
Cloud Computing is Service-oriented.	Grid Computing is Application-oriented.
It is accessible through standard web protocols.	It is accessible through grid middleware.

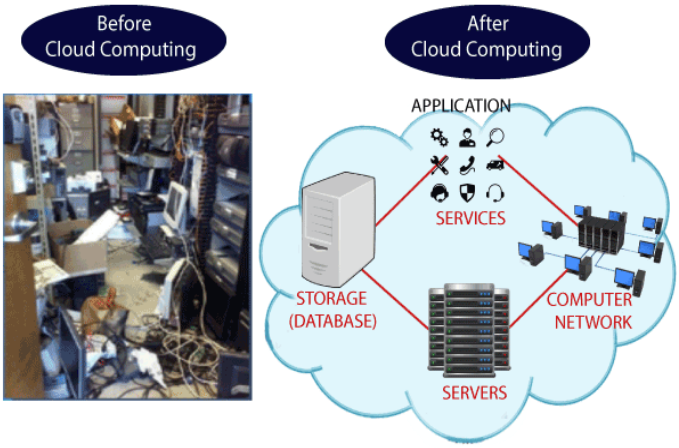
There are the following operations that we can do using cloud computing:

- Developing new applications and services
- Storage, back up, and recovery of data
- Hosting blogs and websites
- Delivery of software on demand
- Analysis of data
- Streaming videos and audios

1.2 Essentials

Small as well as large IT companies, follow the traditional methods to provide the IT infrastructure. That means for any IT company, we need a Server Room that is the basic need of IT companies.

- In that server room, there should be a database server, mail server, networking, firewalls, routers, modem, switches, QPS (Query Per Second means how much queries or load will be handled by the server), configurable system, high net speed, and the maintenance engineers.
- To establish such IT infrastructure, we need to spend lots of money. To overcome all these problems and to reduce the IT infrastructure cost, Cloud Computing comes into existence.



Benefits

- Helps to use applications without installations.
- Access the personal files at any computer with internet access.
- This technology allows much more efficient computation by centralizing storage, memory, processing and band width.

Why cloud?

- The cloud typically contains a significant pool of resources, which could be reallocated to different purpose within short time frames, and allows the cloud owner to benefit significantly from economies of scale as well as from statistical multiplexing (Fig.1.3). The entire process of requesting and receiving resources its typically automated and is completed in minutes.
- Cloud services today are delivered in a user – friendly manner and offered on an unprecedented. The payment model is pay-as-you-go and pay-for-what-you use, eliminating the need for and up-front investment or a long-term contract. This presents a less disruptiveness opportunity for businesses with spiky or unpredictable IT demands, as they are able to easily provision massive amounts of resources on a moment's notice and release them back into the cloud just as quickly.

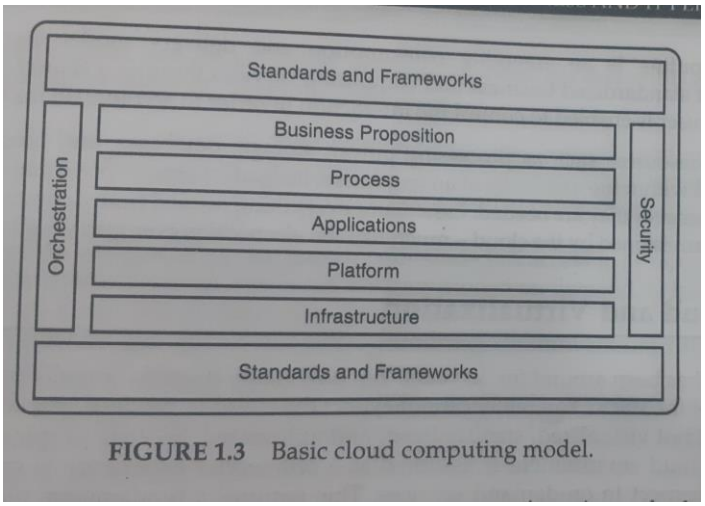


FIGURE 1.3 Basic cloud computing model.

Different reasons for adopting the cloud as follows:

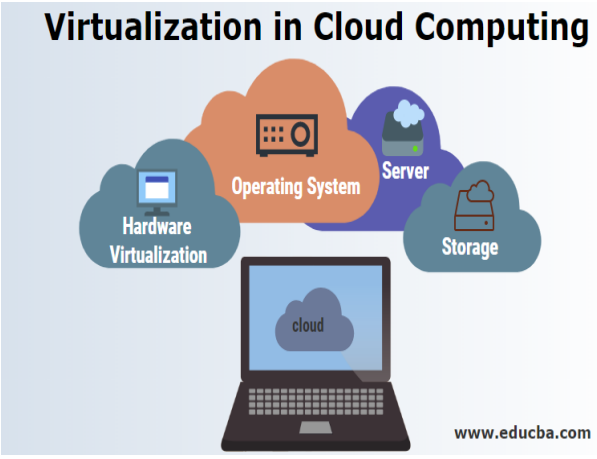
- 1. Very big, Web – Scale infrastructure that is abstracted.
- 2. Dynamic allocation, scaling, movement of applications.
- 3. Pay – per – use.
- 4. No Long – term commitments.
- 5. Operating system(OS), application architecture independent.
- 6. No hardware or software to install.

This results in the following business and IT aligned benefits:

- 1. More emphasis on innovation to launch new offerings.
- 2. IT as an enabler for innovation and rapid deployment.
- 3. Use of self – service based consistent delivery model.
- 4. Higher service quality and increased agility, ubiquitous computing.
- 5. Uniqueness via service models and competitive in the ecosystem.
- 6. Anytime anywhere computing for consumers over the internet to deliver next generation technologies.
- 7. Reduced IT obstacles enabling launch of new offerings.
- 8. Building and integration of modular services – in record time – by leveraging 'rentable' IT services capabilities, pay only for what you use.

Cloud and Virtualization

- Virtualization is the "creation of a virtual (rather than actual) version of something, such as a server, a desktop, a storage device, an operating system or network resources".
- In other words, Virtualization is a technique, which allows to share a single physical instance of a resource or an application among multiple customers and organizations. It does by assigning a logical name to a physical storage and providing a pointer to that physical resource when demanded.
- Mainly Virtualization means, running multiple operating systems on a single machine but sharing all the hardware resources. And it helps us to provide the pool of IT resources so that we can share these IT resources in order to get benefits in the business.



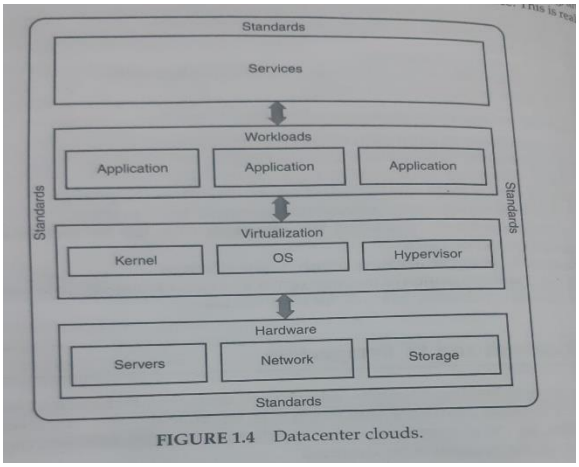


FIGURE 1.4 Datacenter clouds.

1.6 Cloud and Virtualization

- These results include:
- 1. Server / Storage: IT resources from servers to storage, network, and applications are pooled and visualized to help provide an implementation-independent, efficient infrastructure, with elastic scaling – environment that can scale up and sown by large factors as demand changes.
- 2. Automation using self-service portal: Point-and-click access to IT resources.
- 3. Automated provisioning: Resources are provisioned on demand, helping in reducing IT resource setup and configuration cycle times.
- 4. Standardization through service catalog ordering: Uniform offerings are readily available from a service catalog on a meted basis.
- 5. Flexible pricing: Utility pricing, variable payments, pay-by-consumption with metering and subscription models help make pricing of IT services more flexible.

1.7 Cloud Services Requirements

- When building out a cloud strategy, there are several in-depth steps that must be taken to ensure a robust infrastructure.
- **Requirement 1: Service and Resource Management**
  A cloud infrastructure virtualizes all components of a data center. Service management is a measured package of applications and services that end users can easily deploy and manage via a public and/or private cloud vendor. And a simplified tool to outline and gauge services is vital for cloud administrators to market functionality.
  Service management needs to contain resource maintenance, resource guarantees, billing cycles, and measured regulations. Once deployed, management services should help create policies for data and workflows to make sure it's fully efficient and processes are delivered to systems in the cloud.
- **Requirement 2: Data Center Management Tools Integration**
  Most data centers utilize a variety of IT tools for systems management, security, provisioning, customer care, billing, and directories, among others. And these work with cloud management services and open APIs to integrate existing operation, administration, maintenance, and provisioning (OAM&P) systems.
  A modern cloud service should support a data center's existing infrastructure as well as leveraging modern software, hardware, and virtualization, and other technology.
- **Requirement 3: Reporting, Visibility, Reliability, a Security**
  Data centers need high levels of real-time reporting and visibility capabilities in cloud environments to guarantee compliance, SLAs, security, billing, and chargebacks. Without robust reporting and visibility, managing system performance, customer service, and other processes are nearly impossible. And to be wholly reliable, cloud infrastructures must operate regardless of one or more failing components. For to safeguard the cloud, services must ensure data and apps are secure while providing access to those who are authorized.
- **Requirement 4: Interfaces for Users, Admins, and Developers**
  Automated deployment and self-service interfaces ease complex cloud services for end users, helping lower operating costs and deliver adoption. Self-service interfaces offer customers the ability to effectively launch a cloud service by managing their own data centers virtually, designing and driving templates, maintaining virtual storage, networking resources, and utilizing libraries. Administrator interfaces present better visibility to all resources, virtual machines, templates,

service offers, and various cloud users. And all of these structures integrate by way of APIs for developers.

1.8 Dynamic Cloud Infrastructure

Cloud dynamic infrastructure is based on an architecture that combines the following initiatives:

- 1. Service managements: Offers business transparency and automation across the pillars of business for consistent delivery.
- 2. Asset management: Maximizes the value of critical business and IT assets over their lifecycle with industry – tailored asset management solutions.
- 3. Virtualization and consolidation: Reduce operating costs, improve responsiveness, and fully utilize the resources.
- 4. Information infrastructure: Helps businesses achieve information compliance, availability, retention, utilize the resources.
- 5. Energy efficiency: Offers green and sustainable energy solutions for business.
- 6. Security: Provides end-to-end industry customized governance, risk management, and compliance for businesses.
- 7. Elasticity: Maintains continuous business and IT operations while rapidly adapting and responding to risks and opportunities.

Cloud Computing Characteristics

1. On-Demand Self-Service

It is one of the important and valuable features of cloud computing as the user can continuously monitor the server uptime, capabilities, and allotted network storage. With this feature, the user can also monitor the computing capabilities.

2. Broad Network Access

The user can access the data of the cloud or upload the data to the cloud from anywhere just with the help of a device and an internet connection. These capabilities are available all over the network and accessed with the help of internet.

3. Multi-tenancy and Resource Pooling

Cloud computing resources are designed to support a multi-tenant model. Multi-tenancy allows multiple customers to share the same applications or the same physical infrastructure while retaining privacy and security over their information.

Resource pooling means that the Cloud provider pulled the computing resources to provide services to multiple customers with the help of a multi-tenant model. There are different physical and virtual resources assigned and reassigned which depends on the demand of the customer. The customer generally has no control or information over the location of the provided resources but is able to specify location at a higher level of abstraction.

4. Rapid elasticity and scalability

One of the great things about cloud computing is the ability to quickly provision resources in the cloud as manufacturing organizations need them. And then to remove them when they don't need them. Cloud computing resources can scale up or down rapidly and, in some cases, automatically, in response to business demands. It is a key feature of cloud computing. The usage, capacity, and therefore cost, can be scaled up or down with no additional contract or penalties.

5. Pay as you go (or) Measured Service

In cloud computing, the user has to pay only for the service or the space they have utilized. There is no hidden or extra charge which is to be paid. The service is economical and most of the time

some space is allotted for free. This means that the resource usages which can be either virtual server instances that are running in the cloud are getting monitored measured and reported by the service provider. The model pay as you go is variable based on actual consumption of the manufacturing organization.

6. Security

Cloud Security, is one of the best features of cloud computing. It creates a snapshot of the data stored so that the data may not get lost even if one of the servers gets damaged. The data is stored within the storage devices, which cannot be hacked and utilized by any other person. The storage service is quick and reliable.

7.Economical

It is the one-time investment as the company (host) has to buy the storage and a small part of it can provide to the many companies which save the host from monthly or yearly costs only the amount which spends on the basic maintenance and few more expenses.

Cloud computing hurdles

- Cloud computing is expected to be a part of all business IT by 2020; however, it faces several key challenges that need to be tackled before it becomes omnipresent.

1. Cloud security

- Researchers in cybersecurity are even more worried about the new protection in the cloud. we are even worried about confidentiality data loss and leakage, hacks, and data privacy.
- Since cutting back on remote access and remote archiving is usually not a feasible option for organizations, it will continue to be of paramount importance to protect device connections to the network and will become more challenging.
- Because of these challenges, all companies will need to make use of professional expertise in software consulting and support, as well as operations-and mobility-based specialists to allow businesses to reach the required level of safety.

2. **Lack of expertise and resources**

- Based on a market survey, the lack of skilled resources was classified as a challenge by nearly 75% of the respondent, with 23% claiming it was a significant challenge.
- While many of the IT staff have taken various steps to improve their knowledge in potential cloud computing forecasts, companies continue to find it challenging to find the skills they need to find workers. And it seems likely that even future cloud computing trends will continue.

3. Power of governance

- One of the most significant advantages of cloud computing in 2020–the speed and ease of deployment of new computing resources–can be so much potential downturn. Many of the organizations lack visibility in their employees ' "shadow IT" and governance in hybrid cloud and multi-cloud environments according to the challenges.
- Some of the experts reported that some of these cloud computing management issues were alleviated by the organizations calling through the following best practices, including compliance and policy-making. And multiple companies offer technology for cloud management to simplify and automate the operation.

4. Managing multi-cloud environments

- Nowadays, most organizations are not only working on one cloud. According to a survey, about 89 percent of companies follow a multi-cloud strategy, and 52 percent adopt a hybrid

cloud strategy that is mixed together with the private and public cloud. Also, five separate private and public clouds are used by businesses.

- A long-term forecast for the future of cloud computing provides the IT infrastructure teams with much more complexity. To address this challenge, experts also suggest best practices such as training staff, rethinking procedures, conducting research, actively managing supplier relationships, and tooling.

5. Compliance

- The recent flurry of cloud computing risk activity with the General Data Protection Regulation has now returned to the forefront for many of the organization's IT teams in accordance with compliance.
- Also, one aspect of the GDPR law may, in the near future, make many compliances more comfortable. Even many organizations are required by law to appoint a data protection officer to oversee data security and privacy. Assuming that most of these people are well versed in the compliance needs of the organizations where they work, centralizing compliance responsibilities should even help companies to fulfill any legal obligations.

Cloud Adoption

Cloud Adoption is a strategic move by organisations of reducing cost, mitigating risk and achieving scalability of data base capabilities. Cloud adoption may be upto various degrees in an organisation, depending on the depth of adoption.

Cloud adoption is a strategy used by enterprises to improve the scalability of Internet-based database capabilities while reducing cost and risk.

Business function that suits cloud adoption can be low-priority business applications:

1.Business Intelligence against large database

2. Partner facing project sites

3. Low priority services

Cloud favours traditional web applications and interactive applications that comprise two or more data sources and services.

Services with low availability requirements and short life spans

Who Needs Cloud Adoption – and Why?

A variety of industries benefit from cloud adoption, including healthcare, marketing and advertising, retail, finance, and education. Benefits include:

- **Healthcare:** Fueled by digital and social consumer behaviors and the need for secure and accessible electronic health records (EHRs), hospitals, clinics, and other medical organizations are using cloud computing for document storage, marketing, and human resources.
- **Marketing and Advertising:** In an industry dependent on social media, as well as the quick creation and publishing of customer-relevant content, agencies are using hybrid cloud adoption strategies to deliver critical client messages to their local and worldwide audiences.
- **Retail:** A successful e-commerce strategy requires a sound Internet strategy. With the help of cloud adoption, Internet-based retail is able to effectively market to customers and save their product data for less money.
- **Finance:** Efficient expense management, human resources, and customer communications are three of the most important business needs of today’s finance organizations. For these

reasons, financial services institutions are now placing their email platforms and marketing tools in the cloud.

- **Education:** Internet-based education opportunities are now more popular than ever. The cloud allows universities, private institutions, and K-12 public schools to provide learning, homework, and grading systems online.
- Additional industries benefiting from cloud adoption include construction, real estate, and not-for-profit.

Cloud Adoption not suitable to

- Mission critical and core business applications, transaction processing and application that depend on sensitive data normally restricted to organization requiring high level of accountability and auditability.

Cloud Rudiments

- Cost

Cloud computing itself is affordable, but tuning the platform according to the company's needs can be expensive. Furthermore, the expense of transferring the data to public clouds can prove to be a problem for short-lived and small-scale projects.

Companies can save some money on system maintenance, management, and acquisitions. But they also have to invest in additional bandwidth, and the absence of routine control in an infinitely scalable computing platform can increase costs.

- Service Provider Reliability

The capacity and capability of a technical service provider are as important as price. The service provider must be available when you need them. The main concern should be the service provider's sustainability and reputation. Make sure you comprehend the techniques via which a provider observes its services and defends dependability claims.

- CLOUD SECURITY

Researchers in cybersecurity are even more worried about the new protection in the cloud. Roughly 90 percent of security professionals are concerned about cloud security, according to a survey in 2019. Much more importantly, we are even worried about confidentiality data loss and leakage, hacks, and data privacy.

Since cutting back on remote access and remote archiving is usually not a feasible option for organizations, it will continue to be of paramount importance to protect device connections to the network and will become more challenging.

Because of these challenges, all companies will need to make use of professional expertise in software consulting and support, as well as operations-and mobility-based specialists to allow businesses to reach the required level of safety.

- LACK OF EXPERTISE AND RESOURCES

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Chapter 2: Cloud Deployment Models

2.1 Introduction
2.2 Cloud Characteristics
2.3 Measured Service Accounting
2.4 Cloud Deployment models
2.5 Security in a Public cloud
2.6 Public Versus Private clouds
2.7 Cloud Infrastructure Self-service

2.1 Cloud Computing Characteristics

1. On-Demand Self-Service

It is one of the important and valuable features of cloud computing as the user can continuously monitor the server uptime, capabilities, and allotted network storage. With this feature, the user can also monitor the computing capabilities.

2. Broad Network Access

The user can access the data of the cloud or upload the data to the cloud from anywhere just with the help of a device and an internet connection. These capabilities are available all over the network and accessed with the help of internet.

3. Multi-tenancy and Resource Pooling

Cloud computing resources are designed to support a multi-tenant model. Multi-tenancy allows multiple customers to share the same applications or the same physical infrastructure while retaining privacy and security over their information.

Resource pooling means that the Cloud provider pulled the computing resources to provide services to multiple customers with the help of a multi-tenant model. There are different physical and virtual resources assigned and reassigned which depends on the demand of the customer. The customer generally has no control or information over the location of the provided resources but is able to specify location at a higher level of abstraction.

4. Rapid elasticity and scalability

One of the great things about cloud computing is the ability to quickly provision resources in the cloud as manufacturing organizations need them. And then to remove them when they don't need them. Cloud computing resources can scale up or down rapidly and, in some cases, automatically, in response to business demands. It is a key feature of cloud computing. The usage, capacity, and therefore cost, can be scaled up or down with no additional contract or penalties.

5. Pay as you go (or) Measured Service

In cloud computing, the user has to pay only for the service or the space they have utilized. There is no hidden or extra charge which is to be paid. The service is economical and most of the time some space is allotted for free. This means that the resource usages which can be either virtual server instances that are running in the cloud are getting monitored measured and reported by the service provider. The model pay as you go is variable based on actual consumption of the manufacturing organization.

6. Security

Cloud Security, is one of the best features of cloud computing. It creates a snapshot of the data stored so that the data may not get lost even if one of the servers gets damaged. The data is stored within the storage devices, which cannot be hacked and utilized by any other person. The storage service is quick and reliable.

7.Economical

It is the one-time investment as the company (host) has to buy the storage and a small part of it can provide to the many companies which save the host from monthly or yearly costs only the amount which spends on the basic maintenance and few more expenses.

2.3 Measured Service Accounting

- Cost Factor
- Benefits

- Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts).
- Resource usage can be monitored, controlled, and reported, charged, billed and invoiced on actual from provider to consumers
- The measured service is directly proportional to standardization and to the economies of scale for operating expenses. The more the virtualization is practiced in the environment, the more it helps to achieve optimization.
- Both standardization and virtualization help to reduce the cost investments while maintaining the required resources to meet the dynamic need of the infrastructure.

Now organizations are migrating to cloud computing to

1. Derive the greatest flexibility and cost-reduction benefits from their cloud computing investments.
2. Avoid vulnerability to costly problems and delays arising from a trial-and-error method of migrating workloads.
3. Augment limited in-house resource or experience to rapidly develop an optimization roadmap and smoothly migrate workloads to a cloud computing environment.

Cloud vendors can address client's challenges by

1. Prioritizing workloads for cloud adoption on the basis of business impact and risk.
2. Maximizing business return by identifying applications that are well suited for cloud computing and high business impact.
3. Addressing problematic workloads to improve their propensity for cloud computing.
4. Avoiding costly implementation issues by identifying and addressing potential difficulties during the migration.
5. Mitigating the risk of costly implementation delays by identifying potential problems and addressing them before the migration.
6. Avoiding inadequate performance of highly complex and integrated workloads.
7. Leveraging the expertise to deliver an actionable roadmap to successfully migrate application to a cloud computing environment.
8. Accelerating the cloud initiatives.

2.3.2 Benefits

We can enjoy many benefits by adopting the cloud:

1. **Self-service capability:**

When somebody deploys the cloud services, he becomes capable of self-service. Now testing tams do not have to buy computing services as they can enjoy the same services over the cloud. It also reduces the procurement process.

2. **Resource availability:**

It is one of the most common benefits facilitated by the virtualization. It also helps to track and leverage the resource pool under the same umbrella of resource units.

3. **Operational efficiency:** Sometimes conventions and configurations followed by the test and operation teams may differ from those followed by the development teams. This difference may cause the application behavior to the different from what was intended as well as result in delayed services. The template-based approach, with its solution stacks of hardware, configurable applications, and operating systems, is more transparent and can help the teams to understand the environments better.

4. Hosted tools: In cloud computing, the developers and testers need not to install, configure, run, or maintain tools on their systems as they can log into the network maintaining these tools from any machine.

2.4 Cloud Deployment models

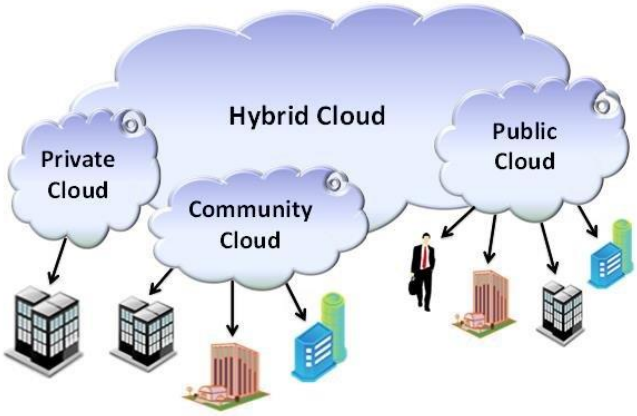
A cloud deployment model is a specific configuration of environment parameters such as the accessibility and proprietorship of the deployment infrastructure and storage size. It means that deployment types vary depending on who controls the infrastructure and where it resides.

To make the most use of this computing type, a company should opt for a model that suits it the most. To choose one, consider computing, networking and storage requirements, available resources and business goals, as well as the pros and cons of cloud deployment models.

Cloud delivery models can be briefly classified into the following three types:

- Public:
- Private:
- Hybrid:

Additionally, there are also community clouds, Shared Private cloud, Dedicated Private cloud, Dynamic Private cloud



2.4.1.**Public cloud:** As the name suggests, this type of cloud deployment model supports all users who want to make use of a computing resource, such as hardware (OS, CPU, memory, storage) or software (application server, database) on a subscription basis. Most common uses of public clouds are for application development and testing, non-mission-critical tasks such as file-sharing, and e-mail service.

The following excerpt has been taken from the book 'Cloud Analytics with Google Cloud Platform' written by Sanket Thodge.

- Major public cloud service providers include:
- Google Cloud Platform: https://cloud.google.com
- Amazon Web Services: https://aws.amazon.com
- IBM: https://www.ibm.com/cloud
- Microsoft Azure: https://azure.microsoft.com
- Rackspace: https://www.rackspace.com/cloud

When to use the public cloud

- The public cloud is most suitable for situations with these needs:
- Predictable computing needs, such as communication services for a specific number of users
- Apps and services necessary to perform IT and business operations
- Additional resource requirements to address varying peak demands
- Software development and test environments

Advantages of public cloud

- No investments required to deploy and maintain the IT infrastructure
- High scalability and flexibility to meet unpredictable workload demands
- Reduced complexity and requirements on IT expertise as the cloud vendor is responsible to manage the infrastructure
- Flexible pricing options based on different SLA offerings
- The cost agility allows organizations to follow lean growth strategies and focus their investments on innovation projects

Limitations of public cloud

- The total cost of ownership (TCO) can rise exponentially for large-scale usage, specifically for midsize to large enterprises
- Not the most viable solution for security and availability sensitive mission-critical IT workloads
- Low visibility and control into the infrastructure, which may not suffice to meet regulatory compliance

2.4.2.Private cloud: private cloud is typically infrastructure used by a single organization. Such infrastructure may be managed by the organization itself to support various user groups, or it could be managed by a service provider that takes care of it either on-site or off-site. Private clouds are more expensive than public clouds due to the capital expenditure involved in acquiring and maintaining them. However, private clouds are better able to address the security and privacy concerns of organizations today.

Common private cloud technologies and vendors include the following:

- VMware: https://cloud.vmware.com
- OpenStack: https://www.openstack.org
- Citrix: https://www.citrix.co.in/products/citrix-cloud
- CloudStack: https://cloudstack.apache.org
- Go Grid: https://www.datapipe.com/gogrid

When to use the private cloud

- The private cloud is often suitable for:
- Highly-regulated industries and government agencies
- Technology companies that require strong control and security over their IT workloads and the underlying infrastructure
- Large enterprises that require advanced data center technologies to operate efficiently and cost-effectively
- Organizations that can afford to invest in high performance and availability technologies

Advantages of private cloud

- Dedicated and secure environments that cannot be accessed by other organizations
- Compliance to stringent regulations as organizations can run protocols, configurations and measures to customize security based on unique workload requirements
- High scalability and efficiency to meet unpredictable demands without compromising on security and performance
- High SLA performance and efficiency
- Flexibility to transform the infrastructure based on ever-changing business and IT needs of the organization

Limitations of private cloud

- Expensive solution with a relatively high total cost of ownership as compared to public cloud alternatives for short-term use cases
- Mobile users may have limited access to the private cloud considering the high security measures in place
- The infrastructure may not offer high scalability to meet unpredictable demands if the cloud data center is limited to on-premise computing resources

2.4.3. Hybrid cloud: In a hybrid cloud, an organization makes use of interconnected private and public cloud infrastructure. Many organizations make use of this model when they need to scale up their IT infrastructure rapidly, such as when leveraging public clouds to supplement the capacity available within a private cloud. For example, if an online retailer needs more computing resources to run its Web applications during the holiday season it may attain those resources via public clouds.

Some common hybrid cloud examples include:

- Hitachi hybrid cloud: https://www.hitachivantara.com/en-us/solutions/hybrid-cloud.html
- Rackspace: https://www.rackspace.com/en-in/cloud/hybrid
- IBM: https://www.ibm.com/it-infrastructure/z/capabilities/hybrid-cloud
- AWS: https://aws.amazon.com/enterprise/hybrid

When to use the hybrid cloud

- Here's who the hybrid cloud might suit best:
- Organizations serving multiple verticals facing different IT security, regulatory and performance requirements
- Optimizing cloud investments without compromising on the value proposition of either public or private cloud technologies
- Improving security on existing cloud solutions such as SaaS offerings that must be delivered via secure private networks
- Strategically approaching cloud investments to continuously switch and tradeoff between the best cloud service delivery model available in the market

Advantages of hybrid cloud

- Flexible policy-driven deployment to distribute workloads across public and private infrastructure environments based on security, performance and cost requirements
- Scalability of public cloud environments is achieved without exposing sensitive IT workloads to the inherent security risks
- High reliability as the services are distributed across multiple data centers across public and private data centers
- Improved security posture as sensitive IT workloads run on dedicated resources in private clouds while regular workloads are spread across inexpensive public cloud infrastructure to tradeoff for cost investments

Limitations of hybrid cloud

- It can get expensive
- Strong compatibility and integration is required between cloud infrastructure spanning different locations and categories. This is a limitation with public cloud deployments, for which organizations lack direct control over the infrastructure
- Additional infrastructure complexity is introduced as organizations operate and manage an evolving mix of private and public cloud architecture

2.4.4 Community clouds

- This is the cloud managed by groups of people, communities, and agencies especially government to have the common interests – such as maintaining the compliance, regulation and security parameters – working on the same mission.
- The members of the community share access to the data and applications in the cloud.

2.4.5 Shared Private Cloud

- This is a shared compute capacity with variable usage-based pricing to business units that are based on service offerings, accounts datacenters.
- It requires an internal profit center to take over or buy infrastructure made available through account consolidations.

2.4.6 Dedicated Private Cloud

- Dedicated private cloud has IT Service Catalog with dynamic provisioning.
- It depends on standardized Service-Oriented Architecture (SOA) architectural assets that can be broadly deployed into new and existing accounts and is a lower-cost model.

2.4.7 Dynamic Private Cloud

- Dynamic private cloud allows client workloads to dynamically migrate to and from the compute cloud as needed.
- This model can be shard and dedicated.
- It delivers on the ultimate value of clouds.
- This is a very low-management model with reliable SLAs and scalability.

2.4.8 Cloud Models Impact

Clouds will transform the IT industry and profoundly affect how we live and how businessess operate.

Cloud computing

- 1. Offers the scalable compute mode to be accessed from anywhere.
- 2. Simplifies service delivery.
- 3. Provides rapid innovation.
- 4. Provides dynamic platform for next generation datacenters.

Some say it is grid or utility computing of Software-as-a-Service, but it is all of those combined.

Internal Private Clouds – Cost Savings

- Reduce It Labor by 50% in configuration, operations, management and monitoring
- Improve Utilization by 75%
- Lower administrative cost 50%
- Reduce end-user IT support cost by 40%
- Reduce provisioning cycle from weeks to minutes
- Benefits of cloud economics with security within firewall
- Provide consistency of application environment

2.4.9 Savings and Cost Metrics

- Virtualization leads to consolidation – hence reduces hardware costs
- Labour saving –
- Automation of IT
- Environment provisioning further reduces the cost
- Total savings substantially offset he small incremental increase in software costs required for initialization and service management

2.4.10 Commoditization in Cloud

- A Company needs certain amount of UNIQUE IT to runs its Business (say Google search infrastructure)
- It also needs a huge amount of Commodity IT to run its basic operations.
- Cost of commodity It set up may be high and hence be delegated or outsourced

2.5 Security in a Public Cloud

- Security is a deep concern in Cloud Computing.
- Here are few security concerns to be considered:
- Multi-Tenancy
- Security Assessment

- Shared Risk
- Staff Security Screening
- Distributed Datacenters
- Physical Security
- Policies
- Coding
- Data Leakage

2.5.1 Multi-Tenancy

- As long as cloud provider builds its security to meet high-risk client, all the lower-risk clients get better security
- Ex: A bandage manufacturer may have a low-risk of being a target of malfeasance.
- A music label that is currently suing file sharers could have a high risk of being targeted by malfeasance
- Hence, Cloud designer must design security to meet the needs of the music label ad bandage manufacturer gets the benefits

2.5.2. Security Assessment

- Over time, enterprises tend to relax their security posture.
- To combat a relaxation of security, the cloud provider should perform regular security assessments.
- The assessments should be done by someone who is experienced and able to identify issues and fix them.
- The report should be provided to each client immediately after the assessment is performed so that the clients know the current state of the cloud's overall security.

2.5.3 Shared Risk

- Often cloud service provider may not be the cloud operator.
- For example, a SaaS provider may use services of an IaaS
- This may have security implications.
- In this multi-tier service provider arrangement, each provider shares the risk of security.
- The service provider must be aware of cloud architecture used by cloud provider and factor that into overall risk mitigation plan

2.5.4 Staff Security Screening

Both regular and contract employees must be subjected to all security procedures, background checks etc

2.5.5 Distributed Data Centers

- Disasters include – hurricanes, tornadoes, landslides, earthquakes, and even fiber-cuts
- Geographically distributed data centers provide better data security ad disaster management and recovery possibilities

This includes:

- Card or biometric access
- Mantrap

- Surveillance
- On-site guard
- Escorting the guests
- Automatic Alarms

2.5.7. Policies

Cloud computing companies need to have incident response policies ad they need to have procedures for every client that feed into their overall incident response plan

2.5.8 Coding

Every cloud company must follow secure coding practices.
All code must be documented and should be demonstrated to clients.

2.5.9 Data Leakage

- Data leakage is a security risk and challenge.
- At minimum, the data that falls under legislative mandates, or contractual obligation, should be encrypted while in flight and at rest.

2.6 Public versus Private Cloud

- A public cloud is a shared cloud computing infrastructure that anyone can access.
- It provides hardware and virtualization layers that are owned by the vendor and are shared between all customers.
- It is connected to the public internet and presents an illusion of infinitely elastic resource
- For consumption based pricing, the user pays for resources used, allowing for capacity fluctuations over time
- Provisioning is applied through simple web interface for self – service provisioning of infrastructure capacity.

2.6 Public versus Private Cloud

- Operating costs for the cloud are absorbed in the usage based pricing.
- Users have no say in SLA or contractual terms and conditions.

2.6 Public versus Private Cloud

- A private cloud is a cloud computing infrastructure owned by a single party.
- It provides hardware and virtualization layers that are owned by, and reserved for the business.
- All data and secure information remains behind the corporate firewall.
- It provides an elastic but finite resource and may not be connected to the public internet
- Private clouds can be designed for specific operating system, applications and use cases business.

2.7 Cloud infrastructure Self – Service

- The cloud infrastructure has to be provisioned and paid-up front in private clouds
- Self-service is possible up to a point.

2.7.1 Infrastructure Strategy and Planning Features

The cloud computing strategy and planning has the following 3 major steps

- Assessment of current environment to determine strengths, gaps and readiness
- Development of the value proposition for cloud computing in the enterprise
- Strategy, planning and roadmaps to successfully implement the selected cloud delivery model

2.7.2 The Path to Cloud Computing

The path from simple virtualization to cloud computing occurs in five distinct stages:

- Stage 1: Server Virtualization – Consolidation attempt
- Stage 2: Distributed Virtualization – Elasticity, Rapidity
- Stage 3: Private Cloud
- Stage 4: Hybrid Cloud
- Stage 5: Public Cloud

Difference	Private	Public	Hybrid
Tenancy	Single tenancy: there's only the data of a single organization stored in the cloud.	Multi-tenancy: the data of multiple organizations in stored in a shared environment.	The data stored in the public cloud is usually multi-tenant, which means the data from multiple organizations is stored in a shared environment. The data stored in private cloud is kept private by the organization.
Exposed to the Public	No: only the organization itself can use the private cloud services.	Yes: anyone can use the public cloud services.	The services running on a private cloud can be accessed only the organization's users, while the services running on public cloud can be accessed by anyone.
Data Center Location	Inside the organization's network.	Anywhere on the Internet where the cloud service provider's services are located.	Inside the organization's network for private cloud services as well as anywhere on the Internet for public cloud services.
Cloud Service Management	The organization must have their own administrators managing their private cloud services.	The cloud service provider manages the services, where the organization merely uses them.	The organization itself must manage the private cloud, while the public cloud is managed by the CSP.
Hardware Components	Must be provided by the organization itself, which has to buy physical servers to build the private cloud on.	The CSP provides all the hardware and ensures it's working at all times.	The organization must provide hardware for the private cloud, while the hardware of CSP is used for public cloud services.
Expenses	Can be quite expensive, since the hardware, applications and network have to be provided and managed by the organization itself.	The CSP has to provide the hardware, set-up the application and provide the network accessibility according to the SLA.	The private cloud services must be provided by the organization, including the hardware, applications and network, while the CSP manages the public cloud services.

Unit 1 : Chap 2: Cloud (Deployment) Models

1. List and explain 4 cloud computing characteristics.
2. What is measured service? What are its benefits?
3. List 3 reasons for which business organizations are migrating to cloud computing?
4. What are the different ways in which cloud vendors can promote cloud computing within organization?
5. How does cloud computing help reduce costs for business?
6. What are the four benefits of adopting cloud computing?
7. Why does testing too long in traditional computing environment? How does cloud computing overcomes that challenge?
8. Name 3 cloud computing deployment models?
9. What is a public cloud? What are different meanings of "public?
10. Name 8 workloads suitable for public clouds
11. Name 6 workloads that not suitable for public clouds.
12. What is a private cloud? Name 6 services provided by private clouds
13. Name different services consumed by public cloud.
14. Write a short notes on high "cost of privacy"
15. Private clouds provide more control. Justify
16. What is a hybrid cloud? What are the features allowed by hybrid cloud?
17. Describe the following in 2 or 3 sentences

a. Community cloud b. Shared private cloud
c. Dedicated private cloud d. Dynamic private cloud

18. How does a cloud model affect our life and business?
19. List different benefits of public cloud
20. How does internal private cloud help reduce cost?
21. Write a short note on cloud savings and cost metrics
22. Explain commoditization in cloud computing
23. List and explain 9 cloud computing security concerns.
24. Compare and contrast public and private clouds
25. Write a short note on cloud infrastructure self-service
26. Name 3 major features of infrastructure strategy and planning
27. Name and explain 5 stages in the path to cloud computing
