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**Department of Information Technology**

**Cloud Computing Step Material**

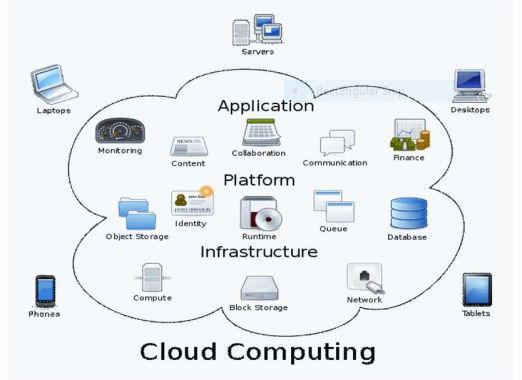
**Unit -I**

**1. What is cloud computing? What are the Advantages and Disadvantages of Cloud computing?**

The computing trend moved toward cloud from the concept of grid computing, particularly when large computing resources are required to solve a single problem, using the ideas of computing power as a utility and other allied concepts.

However, the potential difference between grid and cloud is that grid computing supports leveraging several computers in parallel to solve a particular application, while cloud computing supports leveraging multiple resources, including computing resources, to deliver a unified service to the end user.

In cloud computing, the IT and business resources, such as servers, storage, network, applications, and processes, can be dynamically provisioned to the user needs and workload. In addition, while a cloud can provision and support a grid, a cloud can also support non grid environments, such as a three-tier web architecture running on traditional or Web 2.0 applications.



Advantages:

1. Back-up and restore data: Once the data is stored in the cloud, it is easier to get back-up and restore that data using the cloud.

### Improved collaboration: loud applications improve collaboration by allowing groups of people to quickly and easily share information in the cloud via shared storage.

### Excellent accessibility: Cloud allows us to quickly and easily access store information anywhere, anytime in the whole world, using an internet connection. An internet cloud infrastructure increases organization productivity and efficiency by ensuring that our data is always accessible.

### Low maintenance cost: Cloud computing reduces both hardware and software maintenance costs for organizations.

### Mobility:Cloud computing allows us to easily access all cloud data via mobile.

### IServices in the pay-per-use model: Cloud computing offers Application Programming Interfaces (APIs) to the users for access services on the cloud and pays the charges as per the usage of service.

### Unlimited storage capacity: Cloud offers us a huge amount of storing capacity for storing our important data such as documents, images, audio, video, etc. in one place.

### Data security: Data security is one of the biggest advantages of cloud computing. Cloud offers many advanced features related to security and ensures that data is securely stored and handled.

## Disadvantages of Cloud Computing

### 1) Internet Connectivity: As you know, in cloud computing, every data (image, audio, video, etc.) is stored on the cloud, and we access these data through the cloud by using the internet connection. If you do not have good internet connectivity, you cannot access these data. However, we have no any other way to access data from the cloud.

### 2) Vendor lock-in: Vendor lock-in is the biggest disadvantage of cloud computing. Organizations may face problems when transferring their services from one vendor to another. As different vendors provide different platforms, that can cause difficulty moving from one cloud to another.

### 3) Limited Control: As we know, cloud infrastructure is completely owned, managed, and monitored by the service provider, so the cloud users have less control over the function and execution of services within a cloud infrastructure.

### 4) Security: Although cloud service providers implement the best security standards to store important information. But, before adopting cloud technology, you should be aware that you will be sending all your organization's sensitive information to a third party, i.e., a cloud computing service provider. While sending the data on the cloud, there may be a chance that your organization's information is hacked by Hackers.

**2. Outline the similarities and differences between grid computing and cloud computing?**

Similarities and Contrast between Grid Computing and Cloud Computing

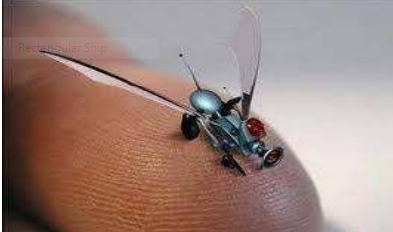
|  |  |  |
| --- | --- | --- |
| Feature | Grid Computing | Cloud Computing |
| Goal | Collaborative sharing of resources | Use of service |
| Principle | Grid needs processing from you | cloud does the processing for you |
| Workflow management | In one physical node | In EC2 instance (Amazon EC2+S3) |
| Functioning | Grid Computing divides everything | Cloud Computing Assimilates everything into one place |
| Level of abstraction | Low (more details) | High (eliminate details) |
| Critical object | Computer resource | Service |
| Multitask | Yes | Yes |
| Dependency | A grid is not necessarily a cloud or part of a cloud | A cloud would usually use a grid Transparency |
| Transparency | Low | High |
| Security | Low (grid certificate service) | High (Virtualization) |
| Ownership | Multiple | Single |
| Interconnection network | Mostly internet with latency and low bandwidth | Dedicated, high-end with low latency and high bandwidth |
| Resource Sharing | Collaboration (VOs, fair share) | Assigned resources are not shared. |
| Resource management | Distributed | Centralized/Distributed |
| Allocation /Scheduling | Decentralized | Both centralized/decentralized |
| Type of service | CPU, network, memory, bandwidth, device, storage, etc | IaaS, PaaS, SaaS, Everything as a service |
| Uses | Grids are used as computing/storage platform. | Cloud computing offers services. We can say that cloud computing is higher-level grid |
| Example of real world | SETI, BOINC, Folding@home, GIMPS | Amazon Web Service (AWS), Google apps |
| Standardization | Standardization and interoperability | Lack of standards for Clouds interoperability |

1. **Discuss in detail about Nano computing and Optical Computing?**

* Nanocomputing refers to computing systems that are constructed from nanoscale components.

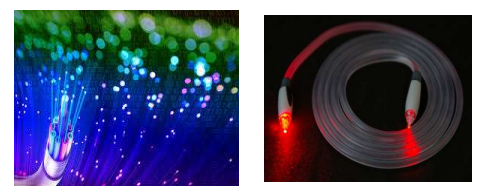
The silicon transistors in traditional computers may be replaced by transistors based on carbon nanotubes.

* The successful realization of nanocomputers relates to the scale and integration of these nanotubes or components.
* The issues of scale relate to the dimensions of the components; they are, at most, a few nanometers in at least two dimensions.
* The issues of integration of the components are twofold: first, the manufacture of complex arbitrary patterns may be economically infeasible, and second, nanocomputers may include massive quantities of devices.
* Researchers are working on all these issues to bring nanocomputing a reality



Optical Computing

* Optical computing system uses the photons in visible light or infrared beams, rather than electric current, to perform digital computations.
* An electric current flows at only about 10% of the speed of light. This limits the rate at which data can be exchanged over long distances and is one of the factors that led to the evolution of optical fiber.
* By applying some of the advantages of visible and/or IR networks at the device and component scale, a computer can be developed that can perform operations 10 or more times faster than a conventional electronic computer.



Optical Cable

1. **Discuss in detail about Grid computing and Quantum Computing?**

Grid Computing

* The computing resources in most of the organizations are underutilized but are necessary for certain operations.
* The idea of grid computing is to make use of such nonutilized computing power by the needy organizations, and thereby the return on investment (ROI) on computing investments can be increased.
* Thus, grid computing is a network of computing or processor machines managed with a kind of software such as middleware, in order to access and use the resources remotely.
* The managing activity of grid resources through the middleware is called grid services.
* Grid services provide access control, security, access to data including digital libraries and databases, and access to large-scale interactive and long-term storage facilities.

**Quantum Computing**

* Manufacturers of computing systems say that there is a limit for cramming(overfill) more and more transistors into smaller and smaller spaces of integrated circuits (ICs) and thereby doubling the processing power about every 18 months.
* This problem will have to be overcome by a new quantum computing–based solution, Quantum computers are millions of times faster than even our most powerful supercomputers today.
* Since quantum computing works differently on the most fundamental level than the current technology, and although there are working prototypes, these systems have not so far proved to be alternatives to today’s silicon-based machines.

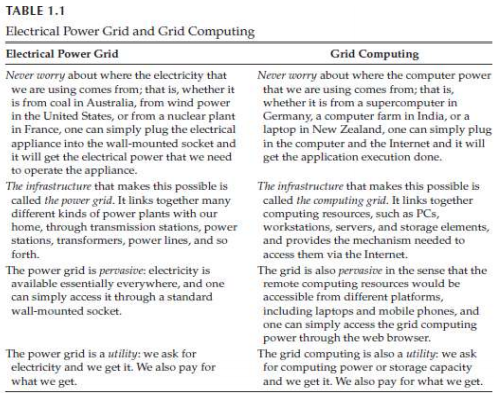
1. **Define grid computing and why it is popular?**

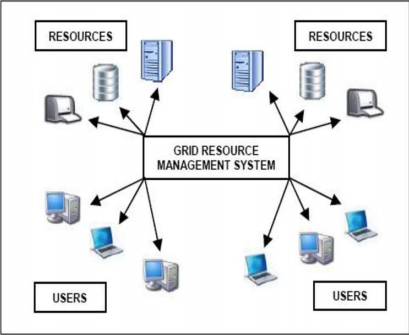
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Grid computing is more popular due to the following reasons:

Its ability to make use of unused computing power, and thus, it is a costeffective solution (reducing investments, only recurring costs) As a way to solve problems in line with any HPC-based application Enables heterogeneous resources of computers to work cooperatively and collaboratively to solve a scientific problem.





1. **Compare Distributed computing with parallel computing and Network computing?**

[**Parallel Computing**](https://www.geeksforgeeks.org/introduction-to-parallel-computing/)**:**

In parallel computing multiple processors performs multiple tasks assigned to them simultaneously. Memory in parallel systems can either be shared or distributed. Parallel computing provides concurrency and saves time and money.

[**Distributed Computing**](https://www.geeksforgeeks.org/distributed-database-system/)**:**

In distributed computing we have multiple autonomous computers which seems to the user as single system. In distributed systems there is no shared memory and computers communicate with each other through message passing. In distributed computing a single task is divided among different computers.

**Difference between Parallel Computing and Distributed Computing:**

|  |  |  |
| --- | --- | --- |
| S.NO | Parallel Computing | Distributed Computing |
| 1. | Many operations are performed simultaneously | System components are located at different locations |
| 2. | Single computer is required | Uses multiple computers |
| 3. | Multiple processors perform multiple operations | Multiple computers perform multiple operations |
| 4. | It may have shared or distributed memory | It have only distributed memory |
| 5. | Processors communicate with each other through bus | Computer communicate with each other through message passing. |
| 6. | Improves the system performance | Improves system scalability, fault tolerance and resource sharing capabilities |

**7. “Quantum computers are millions of times faster than most powerful supercomputers today”, Justify your answer.**

Quantum Computing:

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**Unit –II**

1. **Explain public cloud and community cloud in detail and its characteristics and issue?**

**Public cloud:** The cloud infrastructure is provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them. It exists on the premises of the cloud provider.

**Characteristics**

1. Highly scalable: The public cloud is highly scalable. The resources in the public cloud are large in number and the service providers make sure that all the requests are granted. Hence, the public cloud is con-sidered to be scalable.

2. Affordable: The public cloud is offered to the public on a pay-as-you-go basis; hence, the user has to pay only for what he or she is using(usually on a per-hour basis). And, this does not involve any cost related to the deployment.

3. Less secure: The public cloud is less secure out of all the four deployment models. This is because the public cloud is offered by a thirdparty and they have full control over the cloud. Though the SLAs ensure privacy, still there is a high risk of data being leaked.

4. Highly available: The public cloud is highly available because any-body from any part of the world can access the public cloud with proper permission, and this is not possible in other models as geo-graphical or other access restrictions might be there.

5. Stringent SLAs: SLA is very stringent in the case of the public cloud.As the service provider’s business reputation and customer strength are totally dependent on the cloud services, they follow the SLA strictly and violations are avoided. These SLAs are very competitive.

**Issues**

Several issues pertaining to the public cloud are as follows:

1. SLA: Unlike the private cloud, here the number of users is more and so are the numbers of service agreements. The service provider is answerable to all the users.
2. Network: The network plays a major role in the public cloud. Each and every user getting the services of the cloud gets it through the Internet. The services are accessed through the Internet by all the users, and hence, the service delivery wholly depends on the net-work.
3. Performance: As mentioned, the performance of a cloud delivery model primarily depends on the network and the resources. The service provider has to adequately manage the resources and the network. As the number of users increases, it is a challenging task for the service providers to give good performance.
4. Multitenancy: The resources are shared, that is, multiple users share the resources, hence the term multitenant. Due to this property, there is a high risk of data being leaked or a possible unprivileged access.
5. Location: The location of the public cloud is an issue. As the public cloud is fragmented and is located in different regions, the access to these clouds involves a lot of data transfers through the Internet. There are several issues related to the location.
6. Security and data privacy: Security and data privacy are the biggest challenges in the public cloud. As data are stored in different places around the globe, data security is a very big issue.
7. Laws and conflicts: The data are stored in different places of the world in different countries. Hence, data centers are bound to laws of the country in which they are located. This creates many conflicts and problems for the service providers and the users.
8. Cloud management: Here, the number of users is more, and so the management is difficult. The jobs here are time critical, and as the number of users increases, it becomes more difficult. Inefficient management of resources will lead to resource shortage, and user service might be affected. It has a direct impact on SLA and may cause SLA violation.
9. Maintenance: Maintaining the whole cloud is another task. This involves continuous check of the resources, network, and other such parameters for long-lasting efficient delivery of the service.

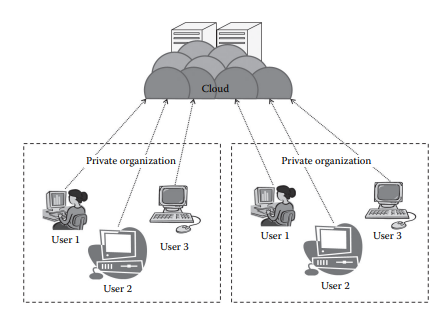
**Community cloud:** The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be managed by the organizations or a third party and may exist on premise or off premise.

**Characteristics:**

1. Collaborative and distributive maintenance: The community cloud is wholly collaborative, and usually no single party has full control over the whole cloud (in some cases, it may be controlled by one party). This is usually distributive, and hence, better cooperation gives better results.

2. Partially secure: Partially secure refers to the property of the community cloud where few organizations share the cloud, so there is a possibility that the data can be leaked from one organization to another, though it is safe from the outside world.

3. Cost effective: The community cloud is cost effective as the whole cloud is being shared by several organizations or a community. Usually, not only cost but every other sharable responsibilities are also shared or divided among the groups.



1. SLA: Here, SLA is a little more stringent than the private cloud but is less stringent than the public cloud. As more than one organization is involved, SLA has to be there to have a fair play among the users of the cloud and among the organizations themselves.

2. Network: The private cloud can be there in any location as this cloud is being shared by more than one organization. Here, each organization will have a separate network, and they will connect to the cloud. It is the responsibility of each organization to take care of their own network. The service provider is not responsible for the network issues in the organization. The network is not big and complex as in the public cloud.

3. Performance: In this type of deployment, more than one organization coordinate together and provide the cloud service. Thus, it is on the maintenance and management team that the performance depends.

4. Multitenancy: There is a moderate risk due to multitenancy. As this cloud is meant for several organizations, the unprivileged access into interorganizational data may lead to several problems.

5. Location: The location of the cloud is very important in this case. Usually, the cloud is deployed at any one of the organizations or is maintained off site by any third party. In either case, the organizations have to access the cloud from another location.

6. Security and privacy: Security and privacy are issues in the community cloud since several organizations are involved in it. The privacy between the organizations needs to be maintained. As the data are collectively stored, the situation is more like that of a public cloud with less users. The organizations should have complete trust on the service provider, and as all other cloud models, this becomes the bottleneck.

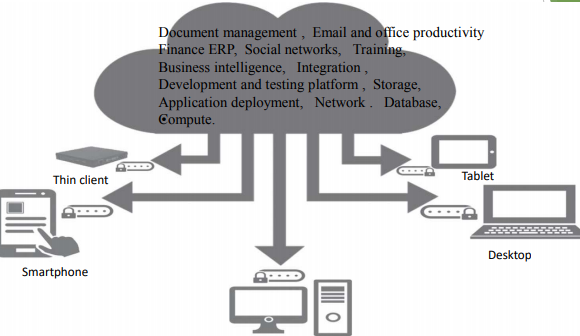
7. Laws and conflicts: This applies if organizations are located in different countries. If the organizations are located in the same country, then there is no issue, but if these organizations are located elsewhere, that is, in different countries, then they have to abide by the rules of the country in which the cloud infrastructure is present, thus making the process a bit more complex.

8. Cloud management: Cloud management is done by the service provider, here in this case by the organizations collectively. The organizations will have a management team specifically for this cloud and that is responsible for all the cloud management–related operations.

9. Cloud maintenance: Cloud maintenance is done by the organizations collectively. The maintenance team collectively maintains all the resources. It is responsible for continuous replacement of resources. In the community cloud, the number of resources is less than the public cloud but usually more than the private cloud.

1. **Explain briefly motivation for cloud computing?**

* The users who are in need of computing are expected to invest money on computing resources such as hardware, software, networking, and storage; this investment naturally costs a bulk currency to the users as they have to buy these computing resources, keep these in their premises, and maintain and make it operational—all these tasks would add cost.
* And, this is a particularly true and huge expenditure to the enterprises that require enormous computing power and resources, compared with classical academics and individuals.
* As one can easily assess the huge lump sum required for capital expenditure (whole investment and maintenance for computing infrastructure) and compare it with the moderate or smaller lump sum required for the hiring or getting the computing infrastructure only to the tune of required time, and rest of the time free from that.
* Therefore, cloud computing is a mechanism of bringing–hiring or getting the services of the computing power or infrastructure to an organizational or individual level to the extent required and paying only for the consumed services.
* One. can compare this situation with the usage of electricity (its services) from its producer-cum-distributor (in India, it is the state-/governmentowned electricity boards that give electricity supply to all residences and organizations) to houses or organizations; here, we do not generate electricity (comparable with electricity production–related tasks); rather, we use it only to tune up our requirements in our premises, such as for our lighting and usage of other electrical appliances, and pay as per the electricity meter reading value.
* Therefore, cloud computing is needed in getting the services of computing resources. Thus, one can say as a one-line answer to the need for cloud computing that it eliminates a large computing investment without compromising the use of computing at the user level at an operational cost.
* Cloud computing is very economical and saves a lot of money. A blind benefit of this computing is that even if we lose our laptop or due to some crisis our personal computer—and the desktop system—gets damaged, still our data and files will stay safe and secured as these are not in our local machine (but remotely located at the provider’s place— machine).
* one can think to add security while accessing these remote computing resources as depicted in below Figure.



Above Figure shows several cloud computing applications.

* The cloud represents the Internet-based computing resources, and the accessibility is through some secure support of connectivity.
* It is a computing solution growing in popularity, especially among individuals and small- and medium-sized companies (SMEs).
* In the cloud computing model, an organization’s core computer power resides offsite and is essentially subscribed to rather than owned.

1. **Differentiate between SaaS and PaaS and IaaS with example?**

**1. Cloud SaaS:** The capability provided to the consumer is to use the provider’ s applications running on a cloud infrastructure, including network, servers, operating systems, storage, and even individual application capabilities, with the possible exception of limited user-specific application configuration settings. The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g., web-based e-mail), or a program interface. The consumer does not manage or control the underlying cloud infrastructure. Typical applications offered as a service include customer relationship management (CRM), business intelligence analytics, and online accounting software.

**2. Cloud PaaS:** The capability provided to the consumer is to deploy onto the cloud infrastructure consumer-created or acquired applications created using programming languages, libraries, services, and tools supported by the provider. The consumer does not manage or control the underlying cloud infrastructure but has control over the deployed applications and possibly configuration settings for the application-hosting environment. In other words, it is a packaged and ready-to-run development or operating framework. The PaaS vendor provides the networks, servers, and storage and manages the levels of scalability and maintenance. The client typically pays for services used. Examples of PaaS providers include Google App Engine and Microsoft Azure Services.

**3. Cloud IaaS:** The capability provided to the consumer is to provision processing, storage, networks, and other fundamental computing resources on a pay-per-use basis where he or she is able to deploy and run arbitrary software, which can include operating systems and applications. The consumer does not manage or control the underlying cloud infrastructure but has control over the operating systems, storage, and deployed applications and possibly limited control of select networking components (e.g., host firewalls). The service provider owns the equipment and is responsible for housing, cooling operation, and maintenance. Amazon Web Services (AWS) is a popular example of a large IaaS provider.

The major difference between PaaS and IaaS is the amount of control that users have. In essence, PaaS allows vendors to manage everything, while IaaS requires more management from the customer side.

Generally speaking, organizations that already have a software package or application for a specific purpose and want to install and run it in the cloud should opt to use IaaS instead of PaaS.

1. **Describe various deployment models in cloud and its characteristics?**

Deployment models describe the ways with which the cloud services can be deployed or made available to its customers, depending on the organizationalstructure and the provisioning location. One can understand it in this manner too: cloud (Internet)-based computing resources—that is, the locations where data and services are acquired and provisioned to its customers—can take various forms. Four deployment models are usually distinguished, namely, 1.public 2.Private 3.Community 4.hybrid cloud service usage.

**1. Private cloud:** The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers (e.g., business units). It may be owned, managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises.

**2. Public cloud:** The cloud infrastructure is provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them. It exists on the premises of the cloud provider.

**3. Community cloud:** The cloud infrastructure is shared by several organizations and supports a specific community that has shared concerns (e.g., mission, security requirements, policy, and compliance considerations). It may be managed by the organizations or a third party and may exist on premise or off premise.

**4. Hybrid cloud:** The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities but are bound together by standardized or proprietary technology that enables data and application portability (e.g., cloud bursting for load balancing between clouds).

1. **Why cloud is called is a service and is a platform? Explain briefly.**

**Cloud Computing Is a Service**

* The simplest thing that any computer does is allow us to store and retrieve information.
* We can store our family photographs, our favorite songs, or even save movies on it, which is also the most basic service offered by cloud computing.
* Let us look at the example of a popular application called Flickr to illustrate the meaning of this section.
* While Flickr started with an emphasis on sharing photos and images, it has emerged as a great place to store those images. In many ways, it is superior to storing the images on your computer

1.. First, Flickr allows us to easily access our images no matter where we are or what type of device we are using. While we might upload the photos of our vacation from our home computer, later, we can easily access them from our laptop at the office.

2. Second, Flickr lets us share the images. There is no need to burn them to a CD or save them on a flash drive. We can just send someone our Flickr address to share these photos or images.

3. Third, Flickr provides data security. By uploading the images to Flickr, we are providing ourselves with data security by creating a backup on the web. And, while it is always best to keep a local copy— either on a computer, a CD, or a flash drive—the truth is that we are far more likely to lose the images that we store locally than Flickr is of losing our images.

**Cloud Computing Is a Platform**

* The World Wide Web (WWW) can be considered as the operating system for all our Internet-based applications. However, one has to understand that we will always need a local operating system in our computer to access web-based applications.
* The basic meaning of the term platform is that it is the support on which applications run or give results to the users. For example, Microsoft Windows is a platform. But, a platform does not have to be an operating system.
* Java is a platform even though it is not an operating system. Through cloud computing, the web is becoming a platform. With trends (applications) such as Office 2.0, more and more applications that were originally available on desktop computers are now being converted into.
* Through cloud computing, the web is becoming a platform. With trends (applications) such as Office 2.0, more and more applications that were originally available on desktop computers are now being converted into web–cloud applications.
* Word processors like Buzzword and office suites like Google Docs are now available in the cloud as their desktop counterparts.
* All these kinds of trends in providing applications via the cloud are turning cloud computing into a platform or to act as a platform.

1. **Explain the principles of cloud computing?**

Principles of Cloud computing

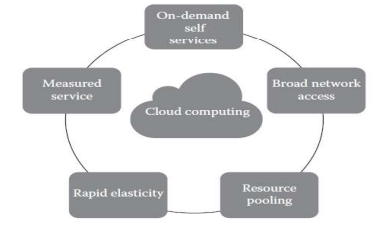
The 5-4-3 principles put forth by NIST describe

(a) the five essential characteristic features that promote cloud computing,

(b) the four deployment models that are used to narrate the cloud computing opportunities for customers while looking at architectural models, and

(c) the three important and basic service offering models of cloud computing

Cloud computing has five essential characteristics, which are shown in below Figure. Readers can note the word essential, which means that if any of these characteristics is missing, then it is not cloud computing



**Five Essential Characteristics:**

1. . On-demand self-service: A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service’ s provider.

2. Broad network access: Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, laptops, and personal digital assistants [PDAs]).

3. Elastic resource pooling: The provider’s computing resources are pooled to serve multiple consumers using a multitenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand.

4. . Rapid elasticity: Capabilities can be rapidly and elastically provisioned, in some cases automatically, to quickly scale out and rapidly released to quickly scale in. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be purchased in any quantity at any time.

5. Measured service: Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth, and active user accounts). Resource usage can be monitored, controlled, and reported providing transparency for both the provider and consumer of the utilized service.

**Four Cloud Deployment Models:**

Deployment . models describe the ways with which the cloud services can be deployed or made available to its customers, depending on the organizationalstructure and the provisioning location.

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**Three Service Offering Models:**

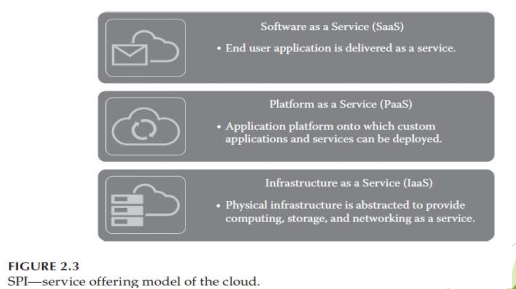
The three kinds of services with which the cloud-based computing resources are available to end customers are as follows:

1. Software as a Service (SaaS)

2. Platform as a Service (PaaS)

3. Infrastructure as a Service (IaaS).

It is also known as the service–platform–infrastructure (SPI) model of the cloud and is shown in Figure.



SaaS is a software distribution model in which applications (software, which is one of the most important computing resources) are hosted by a vendor or service provider and made available to customers over a network, typically the Internet.

PaaS is a paradigm for delivering operating systems and associated services (e.g., computer aided software engineering [CASE] tools, integrated development environments [IDEs] for developing software solutions) over the Internet without downloads or installation.

IaaS involves outsourcing the equipment used to support operations, including storage, hardware, servers, and networking components.

**7.What is cloud computing? Give a formal definition as per NIST?**

In the simplest terms, cloud computing means storing and accessing data and programs over the Internet from a remote location or computer instead of our computer’s hard drive. This so called remote location has several properties such as scalability, elasticity etc., which is significantly different from a simple remote machine.

The cloud is just a metaphor for the Internet. When we store data on or run a program from the local computer’s hard drive, that is called local storage and computing. For it to be considered cloud computing, we need to access our data or programs over the Internet. The end result is the same; however, with an online connection, cloud computing can be done anywhere, anytime, and by any device.

**NIST Definition of Cloud Computing :**

The formal definition of cloud computing comes from the National Institute of Standards and Technology (NIST):

“Cloud computing is a model for enabling ubiquitous, convenient, ondemand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.

This cloud model is composed of five essential characteristics, three service models, and four deployment models.

It means that the computing resource or infrastructure—be it server hardware, storage, network, or application software—all available from the cloud vendor or provider’s site/premises, can be accessible over the Internet from any remote location and by any local computing device.

In addition, the usage or accessibility is to cost only to the level of usage to the customers based on their needs and demands, also known as the pay-asyou-go or pay-as-per-use model. If the need is more, more quantum computing resources are made available (provisioning with elasticity) by the provider.

Minimal management effort implies that at the customer’ s side, the maintenance of computing systems is very minimal as they will have to look at these tasks only for their local computing devices used for accessing cloud-based resources, not for those computing resources managed at the provider’ s side.

Many . vendors, pundits, and experts refer to NIST, and both the International Standards Organization (ISO) and the Institute of Electrical and Electronics Engineers (IEEE) back the NIST definition.

Now, let us try to define and understand cloud computing from two other perspectives—as a service and a platform—in the following sections.

**8. Elaborate the term” software as service” related to cloud computing?**

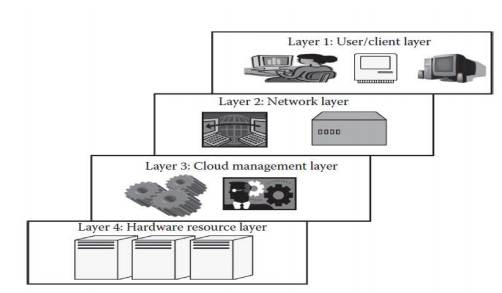
**Cloud SaaS:**

* The capability provided to the consumer is to use the provider’ s applications running on a cloud infrastructure, including network, servers, operating systems, storage, and even individual application capabilities, with the possible exception of limited user-specific application configuration settings.
* The applications are accessible from various client devices through either a thin client interface, such as a web browser (e.g., web-based e-mail), or a program interface.
* The consumer does not manage or control the underlying cloud infrastructure. Typical applications offered as a service include customer relationship management (CRM), business intelligence analytics, and online accounting software.

**Unit -III**

**1.Draw and explain architecture of cloud computing?**

* Any technological model consists of an architecture based on which the model functions, which is a hierarchical view of describing the technology.
* The cloud also has an architecture that describes its working mechanism. It includes the dependencies on which it works and the components that work over it.
* The cloud is a recent technology that is completely dependent on the Internet for its functioning.
* The cloud architecture can be divided into four layers based on the access of the cloud by the user. They are as follows.



Cloud Architecture

***Layer 1 (User/Client Layer)***

* This layer is the lowest layer in the cloud architecture. All the users or client belong to this layer. This is the place where the client/user initiates the connection to the cloud.
* The client can be any device such as a thin client, thick client, or mobile or any handheld device that would support basic functionalities to access a web application.
* The thin client here refers to a device that is completely dependent on some other system for its complete functionality. In simple terms, they have very low processing capability.
* Similarly, thick clients are general computers that have adequate processing capability.
* They have sufficient capability for independent work. Usually, a cloud application can be accessed in the same way as a web application. But internally, the properties of cloud applications are significantly different.

***Layer 2 (Network Layer)***

* This layer allows the users to connect to the cloud. The whole cloud infrastructure is dependent on this connection where the services are offered to the customers.
* This is primarily the Internet in the case of a public cloud.
* The public cloud usually exists in a specific location and the user would not know the location as it is abstract. public cloud can be accessed all over the world.
* In the case of a private cloud, the connectivity may be provided by a local area network (LAN). Even in this case, the cloud completely depends on the network that is used.
* Usually, when accessing the public or private cloud, the users require minimum bandwidth, which is sometimes defined by the cloud providers.
* This layer does not come under the purview of service-level agreements (SLAs), that is, SLAs do not take into account the Internet connection between the user and cloud for quality of service (QoS).

***Layer 3 (Cloud Management Layer)***

* This layer consists of softwares that are used in managing the cloud. The softwares can be a cloud operating system (OS), a software that acts as an interface between the data center (actual resources) and the user, or a management software that allows managing resources.
* These softwares usually allow resource management (scheduling, provisioning, etc.), optimization (server consolidation, storage workload consolidation), and internal cloud governance. This layer comes under the purview of SLAs, that is, the operations taking place in this layer would affect the SLAs that are being decided upon between the users and the service providers.
* Any delay in processing or any discrepancy in service provisioning may lead to an SLA violation. As per rules, any SLA violation would result in a penalty to be given by the service provider.
* These SLAs are for both private and public clouds Popular service providers are Amazon Web Services (AWS) and Microsoft Azure for public cloud.
* Similarly, OpenStack and Eucalyptus allow private cloud creation, deployment, and management.

***Layer 4 (Hardware Resource Layer)***

* Layer 4 consists of provisions for actual hardware resources. Usually, in the case of a public cloud, a data center is used in the back end.
* Similarly, in a private cloud, it can be a data center, which is a huge collection of hardware resources interconnected to each other that is present in a specific location or a high configuration system.
* This layer comes under the purview of SLAs. This is the most important layer that governs the SLAs. This layer affects the SLAs most in the case of data centers.
* Whenever a user accesses the cloud, it should be available to the users as quickly as possible and should be within the time that is defined by the SLAs. As mentioned, if there is any discrepancy in provisioning the resources or Whenever a user accesses the cloud, it should be available to the users as quickly as possible and should be within the time that is defined by the SLAs.
* As mentioned, if there is any discrepancy in provisioning the resources or application, the service provider has to pay the penalty.
* Hence, the data center consists of a high-speed network connection and a highly efficient algorithm to transfer the data from the data center to the manager.
* There can be a number of data centers for a cloud, and similarly, a number of clouds can share a data center.
* The architecture of a cloud layering is strict, and for any cloud application, this is followed. There can be a little loose isolation between layer 3 and layer 4 depending on the way the cloud is deployed.

**2.Explain five components of the cloud and explain layers of cloud computing?**

Anatomy of the Cloud

1. Application: The upper layer is the application layer. In this layer, any applications are executed.

2. Platform: This component consists of platforms that are responsible for the execution of the application. This platform is between the infrastructure and the application.

3. Infrastructure: The infrastructure consists of resources over which the other components work. This provides computational capability to the user.

4. Virtualization: Virtualization is the process of making logical components of resources over the existing physical resources. The logical components are isolated and independent, which form the infrastructure .

5. Physical hardware: The physical hardware is provided by server and storage units.

layers of cloud computing from above answer.

**3.Describe several approaches of cloud migration?/ Explain the phases and approaches of cloud migration?**

Cloud migration encompasses moving one or more enterprise applications and their IT environments from the traditional hosting type to the cloud environment, either public, private, or hybrid.

Cloud migration presents an opportunity to significantly reduce costs incurred on applications.

This activity comprises, of different phases like evaluation, migration strategy, prototyping, provisioning, and testing.

**Phases of Cloud Migration:**

**Evaluation:** Evaluation is carried out for all the components like current infrastructure and application architecture, environment in terms of compute, storage, monitoring, and management, SLAs, operational processes, financial considerations, risk, security, compliance, and licensing needs are identified to build a business case for moving to the cloud.

**Migration strategy:** Based on the evaluation, a migration strategy is drawn—a hotplug strategy is used where the applications and their data and interface dependencies are isolated and these applications can be operationalized all at once. A fusion strategy is used where the applications can be partially migrated; but for a portion of it, there are dependencies based on existing licenses, specialized server requirements like mainframes, or extensive interconnections with other applications.

**Prototyping:** Migration activity is preceded by a prototyping activity to validate and ensure that a small portion of the applications are tested on the cloud environment with test data setup.

**Provisioning:** Premigration optimizations identified are implemented. Cloud servers are provisioned for all the identified environments, necessary platform softwares and applications are deployed, configurations are tuned to match the new environment sizing, and databases and files are replicated.

All internal and external integration points are properly configured. Web services, batch jobs, and operation and management software are set up in the new environments

**Testing:** Postmigration tests are conducted to ensure that migration has been successful. Performance and load testing, failure and recovery testing, and scale-out testing are conducted against the expected traffic load and resource utilization levels.

**Approaches for Cloud Migration:**

The following are the four broad approaches for cloud migration that have been adopted effectively by vendors:

**1. Migrate existing applications:** Rebuild or rearchitect some or all the applications, taking advantage of some of the virtualization technologies around to accelerate the work. But, it requires top engineers to develop new functionality. This can be achieved over the course of several releases with the timing determined by customer demand.

**2. Start from scratch:** Rather than cannibalize sales, confuse customers with choice, and tie up engineers trying to rebuild existing application, it may be easier to start again. Many of the R&D decisions will be different now, and with some of the more sophisticated development environments, one can achieve more even with a small focused working team.

**3. Separate company:** One may want to create a whole new company with separate brand, management, R&D, and sales. The investment and internet protocol (IP) may come from the existing company, but many of the conflicts disappear once a new born in the cloud company is established. The separate company may even be a subsidiary of the existing company. What is important is that the new company can act, operate, and behave like a cloud-based start-up.

**4. Buy an existing cloud vendor:** For a large established vendor, buying a cloud-based competitor achieves two things. Firstly, it removes a competitor, and secondly, it enables the vendor to hit the ground running in the cloud space. The risk of course is that the innovation, drive, and operational approach of the cloud-based company are destroyed as it is merged into the larger acquirer.

**4. How does cloud architecture overcome the difficulties faced by traditional Architecture?**

Cloud computing is far more abstract as a virtual hosting solution. Instead of being accessible via physical hardware, all servers, software and networks are hosted in the cloud, off premises. It’s a real-time virtual environment hosted between several different servers at the same time. So rather than investing money into purchasing physical servers in-house, you can rent the data storage space from cloud computing providers on a more cost effective pay-per-use basis.

The main differences between cloud hosting and traditional web hosting are:

**Flexibility and Scalability**

Cloud hosting offers an enhanced level of flexibility and scalability in comparison to traditional data centres. The on-demand virtual space of cloud computing has unlimited storage space and more server resources. Cloud servers can scale up or down depending on the level of traffic your website receives, and you will have full control to install any software as and when you need to. This provides more flexibility for your business to grow.

With traditional IT infrastructure, you can only use the resources that are already available to you. If you run out of storage space, the only solution is to purchase or rent another server.If you hire more employees, you will need to pay for additional software licences and have these manually uploaded on your office hardware. This can be a costly venture, especially if your business is growing quite rapidly.

### Automation

A key difference between cloud computing and traditional IT infrastructure is how they are managed. Cloud hosting is managed by the storage provider who takes care of all the necessary hardware, ensures security measures are in place, and keeps it running smoothly. Traditional data centres require heavy administration in-house, which can be costly and time consuming for your business. Fully trained IT personnel may be needed to ensure regular monitoring and maintenance of your servers – such as upgrades, configuration problems, threat protection and installations.

### Running Costs

Cloud computing is more cost effective than traditional IT infrastructure due to methods of payment for the data storage services. With cloud based services, you only pay for what is used – similarly to how you pay for utilities such as electricity. Furthermore, the decreased likelihood of downtime means improved workplace performance and increased profits in the long run.

With traditional IT infrastructure, you will need to purchase equipment and additional server space upfront to adapt to business growth. If this slows, you will end up paying for resources you don’t use. Furthermore, the value of physical servers decreases year on year, so the return on investment of investing money in traditional IT infrastructure is quite low.

### Security

Cloud computing is an external form of data storage and software delivery, which can make it seem less secure than local data hosting. Anyone with access to the server can view and use the stored data and applications in the cloud, wherever internet connection is available. Choosing a cloud service provider that is completely transparent in its hosting of cloud platforms and ensures optimum security measures are in place is crucial when transitioning to the cloud.

With traditional IT infrastructure, you are responsible for the protection of your data, and it is easier to ensure that only approved personnel can access stored applications and data. Physically connected to your local network, data centres can be managed by in-house IT departments on a round-the-clock basis, but a significant amount of time and money is needed to ensure the right security strategies are implemented and data recovery systems are in place.

**5.Describe the role of Network connectivity in cloud computing?**

Cloud computing is a technique of resource sharing where servers, storage, and other computing infrastructure in multiple locations are connected by networks.

In the cloud, when an application is submitted for its execution, needy and suitable resources are allocated from this collection of resources.

These resources are connected via the Internet, the users get their required results. For many cloud computing applications, network performance will be the key issue to cloud computing performance.

Since cloud computing has various deployment options, we now consider the important aspects related to the cloud deployment models and their accessibility from the viewpoint of network connectivity.

**Public Cloud Access Networking**

* In this option, the connectivity is often through the Internet, though some cloud providers may be able to support virtual private networks (VPNs) for customers.
* Accessing public cloud services will always create issues related to security, which in turn is related to performance.
* One of the possible approaches toward the support of security is to promote connectivity through encrypted tunnels, so that the information may be sent via secure pipes on the Internet.
* This procedure will be an overhead in the connectivity, and using it will certainly increase delay and may impact performance.
* If we want to reduce the delay without compromising security, then we have to select a suitable routing method.
* such as the one reducing the delay by minimizing transit hops in the endto-end connectivity between the cloud provider and cloud consumer.
* Since the end-to-end connectivity support is via the Internet, which is a complex federation of interconnected providers (known as Internet service providers [ISPs]), one has to look at the options of selecting the path.

**Private Cloud Access Networking**

* In the private cloud deployment model, since the cloud is part of an organizational network, the technology and approaches are local to the in-house network structure.
* This may include an Internet VPN or VPN service from a network operator.
* If the application access was properly done with an organizational network—connectivity in a precloud configuration—transition to private cloud computing will not affect the access performance.

**6. Explain how to attain QOS by managing by managing cloud?**

**Managing the Cloud:**

Cloud management is aimed at efficiently managing the cloud so as to maintain the QoS. It is one of the prime jobs to be considered. The whole cloud is dependent on the way it is managed. Cloud management can be divided into two parts:

1. Managing the infrastructure of the cloud

2. Managing the cloud application

**Managing the Cloud Infrastructure**

* The infrastructure of the cloud is considered to be the backbone of the cloud. This component is mainly responsible for the QoS factor.
* If the infrastructure is not properly managed, then the whole cloud can fail and QoS would be adversely affected. The core of cloud management is resource management.
* Resource management involves several internal tasks such as resource scheduling, provisioning, and load balancing.
* These tasks are mainly managed by the cloud service provider’s core software capabilities such as the cloud OS that is responsible for providing services to the cloud and that internally controls the cloud.
* Performance is the most important aspect of the cloud, because everything in the cloud is dependent on the SLAs and the SLAs can be satisfied only if performance is good.
* The cost is a very important criterion as far as the business prospects of the cloud are concerned. On the part of the service providers, if they incur less cost for managing the cloud, then they would try to reduce the cost so as to get a strong user base.
* Load fluctuation is the point where the workload of the system changes continuously Load fluctuation can be divided into two types:
* predictable and unpredictable. Predictable load fluctuations are easy to handle. The cloud can be preconfigured for handling such kind of fluctuations.
* Whereas unpredictable load fluctuations are difficult to handle, ironically this is one of the reasons why cloud is preferred by several users.

**Managing the Cloud Application**

* Business companies are increasingly looking to move or build their corporate applications on cloud platforms to improve agility or to meet dynamic requirements that exist in the globalization of businesses and responsiveness to market demands.
* But, this shift or moving the applications to the cloud environment brings new complexities. Applications become more composite and complex, which requires leveraging not only capabilities like storage and database offered by the cloud providers.
* But also third-party SaaS capabilities like e-mail and messaging. So, understanding the availability of an application requires inspecting the infrastructure, the services it consumes, and the upkeep of the application.
* The composite nature of cloud applications requires visibility into all the services to determine the overall availability and uptime.
* Cloud application management is to address these issues and propose solutions to make it possible to have insight into the application that runs in the cloud, as well as implement or enforce enterprise policies like governance and auditing and environment management while the application is deployed in the cloud.
* These cloud-based monitoring and management services can collect a multitude of events, analyze them, and identify critical information that requires additional remedial actions like adjusting capacity or provisioning new services.
* Additionally, application management has to be supported with tools and processes required for managing other environments that might coexist, enabling efficient operations.

1. **Write short notes on end user and service provider responsibilities of cloud service models with a Suitable diagram.**

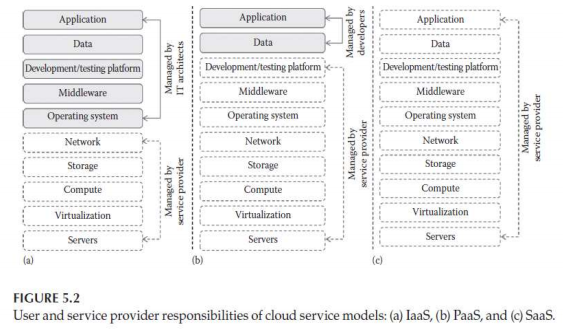
The different cloud service models target different audiences.

For example, the IaaS model targets the information technology (IT) architects,

PaaS targets the developers, and SaaS targets the end users.

Based on the services subscribed, the responsibility of the targeted audience may

vary as shown in below Figure



In IaaS, the end users are responsible for maintaining the development platform

and the application running on top of the underlying infrastructure. The IaaS

providers are responsible for maintaining the underlying hardware as shown in

Figure 5.2a.

In PaaS, the end users are responsible for managing the application that they have

developed. The underlying infrastructure will be maintained by the infrastructure

provider as shown in Figure 5.2b.

In SaaS, the end user is free from maintaining the infrastructure, development

platform, and application that they are using. All the maintenance will be carried

out by the SaaS providers as shown Figure 5.2c.

1. **What are the drawbacks of a web application?**

* The web application is not elastic and cannot handle very heavy loads, that is, it cannot serve highly varying loads.
* The web application is not multitenant.
* The web application does not provide a quantitative measurement of the services that are given to the users, though they can monitor the user.
* The web applications are usually in one particular platform.
* The web applications are not provided on a pay-as-you-go basis; thus, a particular service is given to the user for permanent or trial use and usually the timings of user access cannot be monitored.
* Due to its nonelastic nature, peak load transactions cannot be handled.

**Unit- IV**

1. **What are the pros and cons of IaaS, PaaS, SaaS?**

**Pros and Cons of IaaS**

Being one of the important service models of cloud computing, IaaS provides lot of benefits to the IT users. The following are the benefits provided by IaaS:

**1. Pay-as-you-use model:** The IaaS services are provided to the customers on a pay-per-use basis. This ensures that the customers are required to pay for what they have used. This model eliminates the unnecessary spending on buying. hardware .

**2. Reduced TCO:** Since IaaS providers allow the IT users to rent the computing resources, they need not buy physical hardware for running their business. The IT users can rent the IT infrastructure rather than buy it by spending large amount. IaaS reduces the need for buying hardware resources and thus reduces the TCO.

**3.Elastic resources:** IaaS provides resources based on the current needs. IT users can scale up or scale down the resources whenever they want. This dynamic scaling is done automatically using some load balancers. This load balancer transfers the additional resource request to the new server and improves application efficiency.

**4. Better resource utilization:** Resource utilization is the most important criteria to succeed in the IT business. The purchased infrastructure should be utilized properly to increase the ROI. IaaS ensures better resource utilization and provides high ROI for IaaS providers.

**5. Supports Green IT:** In traditional IT infrastructure, dedicated servers are used for different business needs. Since many servers are used, the power consumption will be high. This does not result in Green IT. In IaaS, the need of buying dedicated servers is eliminated as single infrastructure is shared between multiple customers, thus reducing the number of servers to be purchased and hence the power consumption that results in Green IT.

Even though IaaS provides cost-related benefits to small-scale industries, it lacks in providing security to the data. The following are the **drawbacks of IaaS:**

1**. Security issues:** Since IaaS uses virtualization as the enabling technology, hypervisors play an important role. There are many attacks that target the hypervisors to compromise it. If hypervisors get compromised, then any VMs can be attacked easily. Most of the IaaS providers are not able to provide 100% security to the VMs and the data stored on the VMs.

**2. Interoperability issues:** There are no common standards followed among the different IaaS providers. It is very difficult to migrate any VM from one IaaS provider to the other. Sometimes, the customers might face the vendor lock-in problem.

**3. Performance issues:** IaaS is nothing but the consolidation of available resources from the distributed cloud servers.

**Pros and Cons of PaaS**

The main advantage of using PaaS is that it hides the complexity of maintaining the platform and underlying infrastructure.

This allows the developers to work more on implementing the important functionalities of the application. Apart from this, the PaaS has the following benefits:

**1. Quick development and deployment:** PaaS provides all the required development and testing tools to develop, test, and deploy the software in one place. Most of the PaaS services automate the testing and deployment process as soon as the developer completes the development. This speeds up application development and deployment than traditional development platforms

**2. Reduces TCO:** The developers need not buy licensed development and testing tools if PaaS services are selected.

**3. Supports agile software development:** Nowadays, most of the new-generation applications are developed using agile methodologies.

**4. Different teams can work together:** The traditional development platform does not have extensive support for collaborative development. PaaS services support developers from different places to work together on the same project. This is possible because of the online common development platform provided by PaaS providers.

**5. Ease of use:** The traditional development platform uses any one of CLI- or IDEbased interfaces for development.

**6. Less maintenance overhead:** In on-premise applications, the development company or software vendor is responsible for maintaining the underlying hardware. They need to recruit skilled administrators to maintain the servers. This overhead is eliminated by the PaaS services as the underlying infrastructure is maintained by the infrastructure providers. This gives freedom to developers to work on the application development.

**7. Produces scalable applications:** Most of the applications developed using PaaS services are web application or SaaS application. These applications require better scalability on the extra load. For handling extra load, the software vendors need to maintain an additional server. It is very difficult for a new start-up company to provide extra servers based on the additional load. But, PaaS services are providing built-in scalability to the application that is developed using the PaaS platform.

**PaaS** provides a lot of benefits to developers when compared to the traditional development environment. On the other hand, it contains **drawbacks**, which are described in the following:

1. **Vendor lock-in:** The major drawback with PaaS providers are vendor lock-in. The main reason for vendor lock-in is lack of standards. There are no common standards followed among the different PaaS providers. The other reason for vendor lock-in is proprietary technologies used by PaaS providers.
2. **Security issues:** Like in the other cloud services, security is one of the major issues in PaaS services. Since data are stored in off-premise third-party servers, many developers are afraid to go for PaaS services.
3. **Less flexibility:** PaaS providers do not give much freedom for the developers to define their own application stack. Most of the PaaS providers provide many programming languages, databases, and other development tools. But, it is not extensive and does not satisfy all developer needs.
4. **Depends on Internet connection:** Since the PaaS services are delivered over the Internet, the developers should depend on Internet connectivity for developing the application.

**Pros and Cons of SaaS**

SaaS applications are used by a wide range of individuals and start-up industries for its cost-related benefits. Apart from the cost-related benefits, SaaS services provide the following benefits:

**1. No client-side installation:** SaaS services do not require client-side installation of the software. The end users can access the services directly from the service provider data center without any installation. There is no need of high-end hardware to consume SaaS services. It can be accessed from thin clients or any handheld devices, thus reducing the initial expenditure on buying high-end hardware.

**2. Cost savings:** Since SaaS services follow the utility-based billing or payas-you-go billing, it demands the end users to pay for what they have used. Most of the SaaS providers offer different subscription plans to benefit different customers. Sometimes, the generic SaaS services such as word processors are given for free to the end users.

**3. Less maintenance:** SaaS services eliminate the additional overhead of maintaining the software from the client side. For example, in the traditional software, the end user is responsible for performing bulk updates. But in SaaS, the service provider itself maintains the automatic updates, monitoring, and other maintenance activities of the applications.

**4. Ease of access:** SaaS services can be accessed from any devices if it is connected to the Internet. Accessibility of SaaS services is not restricted to any particular devices. It is adaptable to all the devices as it uses the responsive web UI.

**5. Dynamic scaling:** SaaS services are popularly known for elastic dynamic scaling. It is very difficult for on-premise software to provide dynamic scaling capability as it requires additional hardware. Since the SaaS services leverage elastic resources provided by cloud computing, it can handle any type of varying loads without disrupting the normal behavior of the application.

**6. Disaster recovery:** With proper backup and recovery mechanisms, replicas are maintained for every SaaS services. The replicas are distributed across many servers. If any server fails, the end user can access the SaaS from other servers. It eliminates the problem of single point of failure. It also ensures the high availability of the application.

7. **Multitenancy:** Multitenancy is the ability given to the end users to share a single instance of the application. Multitenancy increases resource utilization from the service provider side.

Even though SaaS services are used by many individuals and start-up industries, the adoption from the large industries is very low. The major problem with SaaS services is security to the data. All companies are worried about the security of their data that are hosted in the service provider data center. The following are the **major problems** with SaaS services:

1. **Security**: Security is the major concern in migrating to SaaS application. Since the SaaS application is shared between many end users, there is a possibility of data leakage. Here, the data are stored in the service provider data center. We cannot simply trust some third-party service provider to store our company-sensitive and confidential data. The end user should be careful while selecting the SaaS provider to avoid unnecessary data loss.
2. **Connectivity requirements:** SaaS applications require Internet connectivity for accessing it. Sometimes, the end user’s Internet connectivity might be very slow. In such situations, the user cannot access the services with ease. The dependency on high-speed Internet connection is a major problem in SaaS applications.
3. **Loss of control:** Since the data are stored in a third-party and off-premise location, the end user does not have any control over the data. The degree of control over the SaaS application and data is lesser than the on-premise application.
4. **What are the Suitable conditions of IaaS, PaaS, SaaS? Discuss briefly.**

**Suitability of IaaS**

IaaS reduces the total cost of ownership (TCO) and increases the return on investment (ROI) for start-up companies that cannot invest more in buying infrastructure.

IaaS can be used in the following situations:

* Unpredictable spikes in usage
* Limited capital investment
* Infrastructure on demand

Unpredictable spikes in usage: When there is a significant spike in usage of computing resources, IaaS is the best option for IT industries.

When demand is very volatile, we cannot predict the spikes and troughs in terms of demand of the infrastructure. In this situation, we cannot add or remove infrastructure immediately according to the demand in a traditional infrastructure.

If there is an unpredictable demand of infrastructure, then it is recommended to use IaaS services.

**Limited capital investment:** New start-up companies cannot invest more on buying infrastructure for their business needs. And so by using IaaS, start-up companies can reduce the capital investment on hardware. IaaS is the suitable option for start-up companies with less capital investment on hardware.

**Infrastructure on demand:** Some organizations may require large infrastructure for a short period of time. For this purpose, an organization cannot afford to buy more on-premise resources. Instead, they can rent the required infrastructure for a specific period of time.

IaaS best suits the organizations that look for infrastructure on demand or for a short time period.

**Suitability of PaaS**

Most of the start-up SaaS development companies and independent software vendors (ISVs) widely use PaaS in developing an application. PaaS technology is getting attention from other traditional software development companies also. PaaS is a suitable option for the following situations:

1. **Collaborative development:** To increase the time to market and development efficiency, there is a need for a common place where the development team and other stakeholders of the application can collaborate with each other.
2. **Automated testing and deployment:** Automated testing and building of an application are very useful while developing applications at a very short time frame. The automated testing tools reduce the time spent in manual testing tools.
3. **Time to market:** The PaaS services follow the iterative and incremental development methodologies that ensure that the application is in the market as per the time frame given.

**Suitability of SaaS**

SaaS is popular among individuals and start-up companies because of the benefits it provides. Most of the traditional software users are looking for SaaS versions of the software as SaaS has several advantages over traditional applications. SaaS applications are the best option for the following:

1. **On-demand software:** The licensing-based software model requires buying full packaged software and increases the spending on buying software. Some of the occasionally used software does not give any ROI. Because of this, many end users are looking for a software that they can use as and when they needed. If the end users are looking for on-demand software rather than the licensing-based full-term software, then the SaaS model is the best option.
2. **Software for start-up companies:** When using any traditional software, the end user should buy devices with minimum requirements specified by the software vendor. This increases the investment on buying hardware for start-up companies. Since SaaS services do not require high-end infrastructure for accessing, it is a suitable option for start-up companies that can reduce the initial expenditure on buying high-end hardware.
3. **Software compatible with multiple devices:** Some of the applications like word processors or mail services need better accessibility from different devices. The SaaS applications are adaptable with almost all the devices.
4. **Software with varying loads:** We cannot predict the load on popular applications such as social networking sites. The user may connect or disconnect from applications anytime. It is very difficult to handle varying loads with the traditional infrastructure. With the dynamic scaling capabilities, SaaS applications can handle varying loads efficiently without disrupting the normal behavior of the application

**3.What are the services provided by and used by IaaS, PaaS, SaaS? Discuss in detail with examples**.

* **IaaS:** The ability given to the infrastructure architects to deploy or run any software on the computing resources provided by the service provider.
* Here, the underlying infrastructures such as compute, network, and storage are managed by the service provider. Thus, the infrastructure architects are exempted from maintaining the data center or underlying infrastructure.
* The end users are responsible for managing applications that are running on top of the service provider cloud infrastucture.
* Generally, the IaaS services are provided from the service provider cloud data center. The end users can access the services from their devices through web command line interface (CLI) or application programming interfaces (APIs) provided by the service providers.
* Some of the popular IaaS providers include Amazon Web Services (AWS), Google Compute Engine, OpenStack, and Eucalyptus.
* **PaaS:** The ability given to developers to develop and deploy an application on the development platform provided by the service provider.
* Thus, the developers are exempted from managing the development platform and underlying infrastructure.
* Here, the developers are responsible for managing the deployed application and configuring the development environment.
* Generally, PaaS services are provided by the service provider on an on-premise or dedicated or hosted cloud infrastructure.
* The developers can access the development platform over the Internet through web CLI, web user interface (UI), and integrated development environments (IDEs).
* Some of the popular PaaS providers include Google App Engine, Force.com, Red Hat OpenShift, Heroku, and Engine Yard.
* **SaaS:** The ability given to the end users to access an application over the Internet that is hosted and managed by the service provider.
* Thus, the end users are exempted from managing or controlling an application, the development platform, and the underlying infrastructure.
* Generally, SaaS services are hosted in service provider–managed or service provider–hosted cloud infrastructure. The end users can access the services from any thin clients or web browsers.
* Some of the popular SaaS providers include Saleforce.com, Google Apps, and Microsoft office 365.

1. What are the characteristics of IaaS, PaaS, and SaaS. Explain briefly?

**Characteristics of IaaS**

IaaS providers offer virtual computing resources to the consumers on a pay-asyou-go basis.

IaaS contains the characteristics of cloud computing such as on-demand selfservice, broad network access, resource pooling, rapid elasticity, and measured service.

Apart from all these, IaaS has its own unique characteristics as follows:

1. Web access to the resources: The IaaS model enables the IT users to access infrastructure resources over the Internet. When accessing a huge computing power, the IT user need not get physical access to the servers. Through any web browsers or management console, the users can access the required infrastructure.

2. Centralized management: Even though the physical resources are distributed, the management will be from a single place. The resources distributed across different parts can be controlled from any management console. This ensures effective resource management and effective resource utilization.

3. Elasticity and dynamic scaling: IaaS provides elastic services where the usage of resources can be increased or decreased according to the requirements. The infrastructure need depends on the load on the application.

4. Shared infrastructure: IaaS follows a one-to-many delivery model and allows multiple IT users to share the same physical infrastructure. The different IT users will be given different VMs. IaaS ensures high resource utilization.

5. Preconfigured VMs: IaaS providers offer preconfigured VMs with operating systems (OSs), network configuration, etc.

6. Metered services: IaaS allows the IT users to rent the computing resources instead of buying it.

**Characteristics of SaaS**

SaaS services are different and give more benefits to end users than the traditionalsoftware. The following are the essential characteristics of SaaS services that make it unique from traditional software:

* One to many
* Web access
* Centralized managemen
* Multidevice support
* Better scalability
* High availability
* API integration

1. One to many: SaaS services are delivered as a one-to-many model where a single instance of the application can be shared by multiple tenants or customers.

2. Web access: SaaS services provide web access to the software. It allows the end user to access the application from any location if the device is connected to the Internet.

3. Centralized management: Since SaaS services are hosted and managed from the central location, management of the SaaS application becomes easier. Normally, the SaaS providers will perform the automatic updates that ensure that each tenant is accessing the most recent version of the application without any user-side updates.

4. Multidevice support: SaaS services can be accessed from any end user devices such as desktops, laptops, tablets, smartphones, and thin clients.

5. Better scalability: Since most of the SaaS services leverage PaaS and IaaS for its development and deployment, it ensures a better scalability than the traditional software. The dynamic scaling of underlying cloud resources makes SaaS applications work efficiently even with varying loads.

6. High availability: SaaS services ensure the 99.99% availability of user data as proper backup and recovery mechanisms are implemented at the back end.

7. API integration: SaaS services have the capability of integrating with other software or service through standard APIs

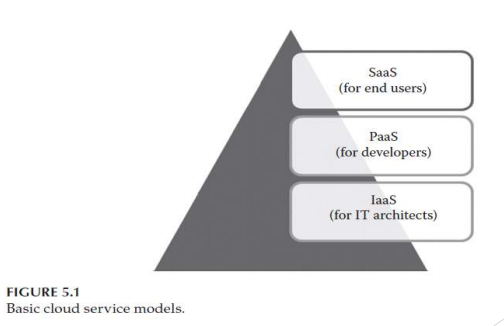
**Characteristics of PaaS**

PaaS development platforms are different from the traditional application development platforms. The following are the essential characteristics that make PaaS unique from traditional development platforms:

1. **All in one:** Most of the PaaS providers offer services to develop, test, deploy, host, and maintain applications in the same IDE.

Additionally, many service providers provide all the programming languages, frameworks, databases, and other development-related services that make developers choose from a wide variety of development platforms.

1. **Web access to the development platform:** A typical development platform uses any IDEs for developing applications.
2. **Offline access:** A developer may not be able to connect to the Internet for a whole day to access the PaaS services. When there is no Internet connectivity, the developers should be allowed to work offline. To enable offline development, some of the PaaS providers allow the developer to synchronize their local IDE with the PaaS services. The developers can develop an application locally and deploy it online whenever they are connected to the Internet.
3. **Built-in scalability:** Scalability is an important requirement for the newgeneration web or SaaS applications. It is very difficult to enable the dynamic scalability for any application developed using traditional development platforms. But, PaaS services provide built-in scalability to an application that is developed using any particular PaaS. This ensures that the application is capable of handling varying loads efficiently.
4. **Collaborative platform:** Nowadays, the development team consists of developers who are working from different places. There is a need for a common platform where the developers can collaboratively work together on the same project. Most of the PaaS services provide support for collaborative development. To enable collaboration among developers, most of the PaaS providers provide tools for project planning and communication.
5. **Diverse client tools:** To make the development easier, PaaS providers provide a wide variety of client tools to help the developer. The client tools include CLI, web CLI, web UI, REST API, and IDE. The developers can choose any tools of their choice. These client tools are also capable of handling billing and subscription management.
6. **Explain in detail about the overview of IaaS, PaaS, and SaaS with suitable diagrams.**

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The NIST definition of the three basic service models is given as follows:

**1. IaaS:** The ability given to the infrastructure architects to deploy or run anysoftware on the computing resources provided by the service provider. Here, the underlying infrastructures such as compute, network, and storage are managed by the service provider.

Thus, the infrastructure architects are exempted from maintaining the datacenter or underlying infrastructure.

The end users are responsible for managing applications that are running on top of the service provider cloud infrastructure.

Generally, the IaaS services are provided from the service provider cloud data center. The end users can access the services from their devices through web command line interface (CLI) or application programming interfaces (APIs) provided by the service providers.

Some of the popular IaaS providers include Amazon Web Services (AWS), Google Compute Engine, Open Stack, and Eucalyptus.

**2. PaaS:** The ability given to developers to develop and deploy an application on thed evelopment platform provided by the service provider.Thus, the developers are exempted from managing the development platform and underlying infrastructure. Here, the developers are responsible for managing the deployed application and configuring the development environment.

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The developers can access the development platform over the Internet through web CLI, web user interface (UI), and integrated development environments (IDEs). Some of the popular PaaS providers include Google App Engine, Force.com, Red Hat OpenShift, Heroku, and Engine Yard.

**3. SaaS:** The ability given to the end users to access an application over the Internetthat is hosted and managed by the service provider. Thus, the end users are exempted from managing or controlling an application, the development platform, and the underlying infrastructure.

Generally, SaaS services are hosted in service provider–managed or service provider–hosted cloud infrastructure. The end users can access the services from any thin clients or web browsers.

Some of the popular SaaS providers include Saleforce.com, Google Apps, andMicrosoft office 365.

**6.Give the drawbacks of cloud computing paradigm?**

**1. No longer in control**. When moving services to the cloud, you are handing over your data and information. For companies who have an in-house IT staff, they will be unable to handle issues on their own. However, Stratosphere Networks has a 24/7 live help desk that can rectify any problems immediately.

**2. May not get all the features.** Not all cloud services are the same. Some cloud providers tend to offer limited versions and enable the most popular features only, so you may not receive every feature or customization you want. Before signing up, make sure you know what your cloud service provider offers.

**3. Doesn't mean you should do away with servers.** You may have fewer servers to handle which means less for your IT staff to handle, but that doesn't mean you can let go of all your servers and staff. While it may seem costly to have data centers and a cloud infrastructure, redundancy is key for backup and recovery.

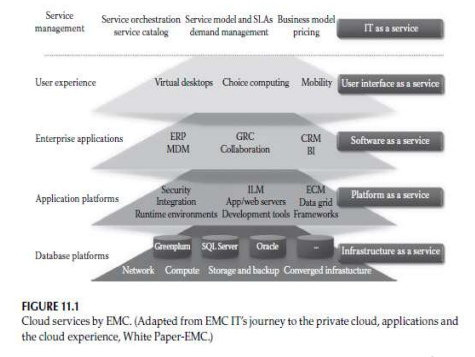
**4. No Redundancy.** A cloud server is not redundant nor is it backed up. As technology may fail here and there, avoid getting burned by purchasing a redundancy plan. Although it is an extra cost, in most cases it will be well worth it.

**5. Bandwidth issues.** For ideal performance, clients have to plan accordingly and not pack large amounts of servers and storage devices into a small set of data centers.

**Unit –V**

**1.Explain EMC IT and what are the services provided by EMC IT.**

* EMC is one of the leading global enterprises that require dynamic scalability and infrastructure agility to meet changing applications as well as business needs.
* EMC chose cloud computing as the ideal solution to reduce the complexity and optimize the infrastructure.
* Offering Information Technology as a Service (ITaaS) reduces the energy consumption through resource sharing.
* Virtualization is the main concept behind the success of EMC IT.
* By virtualizing the infrastructure, allocation of the resources on demand is possible. This also helps to increase efficiency and resource utilization.
* EMC IT provides its business process units with IaaS, PaaS, and SaaS.

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1.IaaS offers EMC business units the ability to provision infrastructure components such as network, storage, computing, and operating systems individually or as integrated services.

2. PaaS provides the secure application and information frameworks on top of application server, web server, database, unstructured content management, and security components as a service to business units from which to develop solutions.

EMC IT offers database platforms (Oracle Database as a Service, SQL Server as a Service, Greenplum as a Service) and application platforms (application development, Enterprise Content Management as a Service, Information Cycle Management as a Service, Security PaaS, Integration as a Service) for the purpose of development.

3.SaaS provides applications and tools in a service model for business enablement. EMC IT brought together several existing business solutions under the unified architecture named as Business Intelligence as a Service. It also offers Enterprise Resource Planning (ERP) and Customer Relationship Management (CRM) as a Service.

4. User Interface as a Service (UIaaS) provisions user and interface experience, rather than provisioning the actual device used.

**Captiva Cloud Toolkit:**

EMC offers a tool called Captiva Cloud Toolkit to help in the development of softwares.

EMC Captiva Cloud Toolkit is a Software Development Kit (SDK) comprised of modules that help web application developers to quickly add scanning and imaging functionality directly to their web-based business applications.

Using Captiva Cloud Toolkit, developers can quickly create a working scanenabled web-based business application in as early as 1 week.

As a result, time to market is shortened and development, testing, and support costs are greatly reduced.

Also, the enterprise’s return on investment is quickly achieved, and its ability to compete in an increasingly competitive distributed document capture market is accelerated.

There are a few modules that are commonly used in most of the process development. These are basic modules that import images from various sources like fax, e-mail, or scanner or from any repository.

**1. Scan:** Scanning is importing activity of documents into Captiva from a scanner. Basically, scanning happens at page level to bring images page by page into Captiva. (intelligent Capture) Scanning is the entry point to Captiva where one can import any kind of document like pdf, tiff, and jpg.

**2. MDW:** Multi Directory Watch is another entry point to Captiva. MDW can be pointed to any folder/repository from where Captiva could import documents directly. MDW is very useful if business is getting documents in the form of a soft copy, for example, as an attached file in an e-mail. MDW also acts as a scan module except it does not interlock with the scanner.

**3. IE:** Image enhancement is a kind of filter or repairing tool for images that are not clear. It enhances the image quality, so it could be processed easily through Captiva. One can configure IE as per business requirement and images being received. The functionalities of IE are deskew, noise removal, etc.

**4. Index:** Indexing is a data capturing activity in Captiva through which one can capture key data from various fields. For example, if bank form is being processed, the A/C no. and sort code could be the indexing field. Indexing could be added as per requirement of business. A validation field could be added to avoid unwanted data entry while indexing any document.

**5. Export:** Export is the exit point of Captiva where images/data are sent to various repositories like file, net, document, or data. The exported data are used for business requirements of various business divisions. For example, if we are capturing the A/C no. and sort code for a bank application, this could be mapped to any department where it is needed.

**6. Multi:** Multi is the last process in Captiva to delete batches that have gone through all modules and exported value successfully. Multi could be configured as per need of business. In the case when it is required to take a backup of batches, this module could be avoided.

The previously mentioned modules are very basic modules of Captiva for indexing and exporting. But for more flexibility and automation, dispatcher is used, which is more accurate to capture data.

**2.List out the cloud services provided by Google and explain in brief.**

* Google is one among the leading cloud providers that offer secure storage of user’s data.
* It provides cloud platform, app engine, cloud print, cloud connect, and many more features that are scalable, reliable, as well as secure.
* Google offers many of these services for free or at a minimum cost making it user friendly.

**Cloud Platform**

* Google Cloud Platform enables developers to build, test, and deploy applications on Google’s highly scalable and reliable infrastructure.
* Software infrastructures such as MapReduce, BigTable, and Dremel are the innovations for industrial development.
* Google Cloud Platform includes virtual machines, block storage, NoSQL datastore, and big data analytics.
* It provides a range of storage services that allow easy maintenance and quick access of user’s data.
* The cloud platform offers a fully managed platform as well as flexible virtual machines allowing the user to choose as per the requirements.
* Google also provides easy integration of user’s application within the cloud platform.
* Applications hosted on the cloud platform can automatically scale up to handle the most demanding workloads and scale down when traffic subsides. The cloud platform is designed to scale like Google’s own products, even when there is a huge traffic spike.
* Managed services such as App Engine or Cloud Data store provide auto scaling that enables application to grow with the users. The user has to pay only for what he or she uses.

**Cloud Storage**

* Google Cloud Storage is a RESTful online file storage web service for storing and accessing one’s data on Google’s infrastructure.
* Representational state transfer (REST) is an architectural style consisting of a coordinated set of architectural constraints applied to components, connectors, and data elements within a distributed system.
* The service combines the performance and scalability of Google’s cloud with advanced security and sharing capabilities.
* Google Cloud Storage is safe and secure. Data are protected through redundant storage at multiple physical locations.
* The following are the few tools for Google Cloud Storage:
* Google Developers Console is a web application where one can perform simple storage management tasks on the Google Cloud Storage system.
* gsutil is a Python application that lets the user access Google Cloud Storage from the command line.

**Google Cloud Connect**

* Google Cloud Connect is a feature provided by Google Cloud by integrating cloud and the application programming interface (API) for Microsoft Office.
* After installing a plug-in for the Microsoft Office suite of programs, one can save files to the cloud.
* The cloud copy of the file becomes the master document that everyone uses.
* Google Cloud Connect assigns each file a unique URL that can be shared to let others view the document.
* If changes are made to the document, those changes will show up for everyone else viewing it.
* When multiple people make changes to the same section of a document, Cloud Connect gives chance to the user to choose which set of changes to keep.
* When the user uploads a document to Google Cloud Connect, the service inserts some metadata into the file. Metadata is information about other information.
* In this case, the metadata identifies the file so that changes will track across all copies.
* The back end is similar to the Google File System and relies on the Google Docs infrastructure. As the documents sync to the master file, Google Cloud Connect sends the updated data out to all downloaded copies of the document using the metadata to guide updates to the right files.

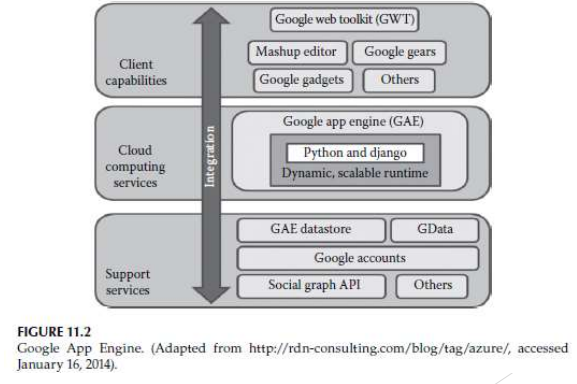
**Google Cloud Print**

* Google Cloud Print is a service that extends the printer’s function to any device that can connect to the Internet.
* To use Google Cloud Print, the user needs to have a free Google profile, an app, a program, or a website that incorporates the Google Cloud Print feature, a cloud-ready printer or printer connected to a computer logged on to the Internet.
* When Google Cloud Print is used through an app or website, the print request goes through the Google servers.
* Google routes the request to the appropriate printer associated with the user’s Google account.
* Assuming the respective printer is on and has an active Internet connection, paper, and ink, the print job should execute on the machine.
* The printer can be shared with other people for receiving documents through Google Cloud Print.
* Because most printers are not cloud ready, most Google Cloud Print users will need to have a computer act as a liaison(cooperation).
* Google Cloud Print is an extension built into the Google Chrome Browser, but it should be enabled explicitly. Once enabled, the service activates a small piece of code called a connector.
* The connector’s job is to interface between the printer and the outside world. The connector uses the user’s computer printer software to send commands to the printer.
* If one has a cloud-ready printer, one can connect the printer to the Internet directly without the need for a dedicated computer.
* The cloud printer has to be registered with Google Cloud Print to take advantage of its capabilities. Because Google allows app and website developers to incorporate
* Google Cloud Print into their products as they see fit, there is no standard approach to executing a print job.
* Google Cloud Print depends on developers incorporating the feature into their products.
* Not every app or site will have Google Cloud Print built into it, which limits its functionality.
* Naturally, Google builds the service into its own products, but many people rely on services from multiple sources and may find Google Cloud Print does not have a wide enough adoption to meet all their needs.

**Google App Engine**

* Google App Engine lets the user run web applications on Google’s infrastructure. App Engine applications are easy to build, easy to maintain, and easy to scale as traffic and data storage needs grow.
* With App Engine, there are no servers to maintain: Just upload theapplication, and it is ready to serve users.
* The app can be served from the user’s own domain name (such as http://www.example.com/) using Google Apps. Otherwise, it can be served using a free name on the appspot.com domain.
* An application can be shared with the world or limit access to members of an organization.

Figure 11.2 shows the different modules in Google App Engine. Integration of cloud computing services with support services and client capabilities

* Google App Engine supports apps written in several programming languages. With App Engine’s Java runtime environment, one can build one’s app using standard Java technologies, including the JVM, the Java servlets, and the Java programming language—or any other language.
* App Engine also features a Python runtime environment, which includes a fast Python interpreter and the Python standard library.
* App Engine also features a PHP runtime, with native support for Google Cloud SQL and Google Cloud Storage that works just like using a local MySQL instance and doing local file writes.
* Finally, App Engine provides a Go runtime environment that runs natively compiled Go code. These runtime environments are built to ensure that your application runs quickly, securely, and without interference from other apps on the system.
* With App Engine also, the user has to only pay for what he or she uses. There are no setup costs and no recurring fees.
* The resources used by the application such as storage and bandwidth are measured in gigabyte and billed at competitive rates.
* App Engine costs nothing to get started. All applications can use up to 1GB of storage and enough CPU and bandwidth to support an efficient app serving around five million page views a month, absolutely free.
* When billing is enabled for the application, free limits are raised, and one has to only pay for resources one uses above the free levels.

**3.What is Google Cloud Print? What are its advantages?**

**Google Cloud Print**

* Google Cloud Print is a service that extends the printer’s function to any device that can connect to the Internet.
* To use Google Cloud Print, the user needs to have a free Google profile, an app, a program, or a website that incorporates the Google Cloud Print feature, a cloud-ready printer or printer connected to a computer logged on to the Internet.
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Google Cloud Print into their products as they see fit, there is no standard approach to executing a print job.

Google Cloud Print depends on developers incorporating the feature into their products.

Not every app or site will have Google Cloud Print built into it, which limits its functionality.

Naturally, Google builds the service into its own products, but many people rely on services from multiple sources and may find Google Cloud Print does not have a wide enough adoption to meet all their needs.

**4.List out and brief the features of Amazon Simple Queue Service?**

**Amazon Simple Queue Service**

* Another service of AWS is Amazon SQS. It is a fast, reliable, scalable, fully managed message queuing service.SQS makes it simple and cost effective to decouple the components of a cloud application.
* SQS can be used to transmit any volume of data, at any level of throughput, without losing messages or requiring other services to be always available.
* A queue is a temporary repository for messages that are waiting to be processed. Amazon SQS offers various features like allowing multiple readers and writers at the same time, providing access control facilities, guaranteeing high availability of sending, and retrieving messages due to redundant infrastructure.
* It also gives provision for having variable length messages as well as configurable settings for each queue.

**5.Explain the Amazon Elastic Compute Cloud (EC2) ?**

**Amazon Elastic Compute Cloud**

* Amazon EC2 is an IaaS offered by AWS and is the leading provider of IaaS in the current market. Powered by a huge infrastructure that the company has built to run its retail business, Amazon EC2 provides a true virtual computing environment.
* By providing a variety of virtual machine or instance types, operating systems, and software packages to choose from, Amazon EC2 enables the user to instantiate virtual machines of his choice through a web service interface.
* The user can change the capacity and characteristics of the virtual machine by using the web service interfaces, hence named elastic.
* Computing capacity is provided in the form of virtual machines or server instances by booting Amazon Machine Images (AMI), which can be instantiated by the user
* An AMI contains all the necessary information needed to create an instance.
* The primary Graphical User Interface (GUI) interface is the AWS Management Console (point and click) and a web service API that supports both Simple Object Access Protocol and Query Requests.
* The API provides programming libraries and resources for Java, PHP, Python, Ruby, Windows, and .Net.

The infrastructure is virtualized by using Xen hypervisor, and different instance types are provided as follows:

Standard instances—suitable for most applications

Micro instances—suitable for low-throughput applications

High-memory instances—suitable for high-throughput applications

High-CPU instances—suitable for compute-intensive applications

Cluster compute instances—suitable for high-performance computing (HPC) applications

* The instances can be obtained on demand on an hourly basis, thus eliminating the need of forecasting computing needs earlier.
* Instances can be reserved earlier, and a discounted rate is charged for such instances.
* Users can also bid on unused Amazon EC2 computing capacity and obtain instances. Such instances are called as Spot Instances. The Spot Price is varying and is decided by the company.
* Instances can be placed in multiple locations, which are defined by regions and availability zones.
* Availability zones are distinct locations that are engineered to be insulated from failures in other availability zones and provide inexpensive, low-latency network connectivity to other availability zones in the same region.
* The Amazon EC2 instances can be monitored and controlled by the AWS Management Console and the web service API.
* However, AWS provides Amazon Cloud Watch, a web service that provides monitoring for AWS cloud resources, starting with Amazon EC2.
* It provides customers with visibility into resource utilization, operational performance, and overall demand patterns—including metrics such as CPU utilization, disk reads and writes, and network traffic.
* Instances are authenticated using a signature-based protocol, which uses key pairs. Another important feature provided is the Amazon Virtual Private Cloud(Amazon VPC).
* The existing IT infrastructure can be connected to Amazon EC2 via a virtualprivate network (VPN). Isolated computing resources are provided in Amazon VPC, and the existing management capabilities such as security services, firewalls, and intrusion detection systems can be extended to isolated resources of Amazon EC2.
* Elastic load balancing (ELB) enables the user to automatically distribute and balance the incoming application’s traffic among the running instances based on metrics such as request count and request latency.
* Fault tolerance and automatic scaling can be performed by configuring the ELB as per the specific needs.
* ELB monitors the health of the instances running and routes traffic away from a failing instance.
* An instance is stored as long as it is operational and is removed on termination. Persistent storage can be enabled by using either Elastic Block Storage (EBS) or Amazon Simple Storage Service (S3).
* EBS provides a highly reliable and secure storage, and the storage volumes can be used to boot an Amazon EC2 instance or be attached to an instance as a standard block device.
* Amazon S3 provides a highly durable storage infrastructure designed for mission-critical and primary data storage.
* Storage is based on units called objects whose size can vary from one byte to five gigabytes of data. These objects are stored in a bucket and retrieved via a unique, developer-assigned key.

**6. Explain the cloud services provided by Windows Azure?**

**OR**

**List the tools/services provided by Microsoft and explain them in brief?**

* Cloud computing provides a new way of looking at IT at Microsoft called Microsoft IT (MSIT).
* Cloud computing is now the preferred and default environment for new and migrated applications at Microsoft.
* MSIT has developed a methodology and a set of the best practices for analyzing their current application portfolio for possible candidates to migrate to cloud computing.
* This analysis enables MSIT to select the ideal cloud computing–based environment for each application. MSIT has captured these best practices and documented them for other Microsoft customers who wish to migrate their organizations to cloud computing.
* Windows Azure Cloud Services (web and worker roles/PaaS) allow developers to easily deploy and manage application services.
* It delegates the management of underlying role instances and operating system to the Windows Azure platform.
* The Migration Assessment Tool (MAT) for Windows Azure encapsulates all the information to be aware of before attempting the application migration to Windows Azure.
* Based on the response to a series of simple binary questions, the tool generates a report that outlines the amount of development effort involved to migrate the application, or the architecture considerations for a new application.
* The Windows Azure Pricing Calculator analyzes an application’s potential public cloud requirements against the cost of the application’s existing infrastructure.
* This tool can help to compare current operational costs for an application, against what the operating costs would be on Windows Azure and SQL Azure.
* Windows Azure Pack for Windows Server is a collection of Windows Azure technologies available to Microsoft customers at no additional cost for installation into their data center

**Microsoft Assessment and Planning Toolkit**

* The Microsoft Assessment and Planning Toolkit (MAP) is an agentless, automated, multiproduct planning and assessment tool for cloud migration.
* MAP provides detailed readiness assessment reports, executive proposals, and hardware and software information.
* It also provides recommendations to help organizations accelerate the application migration process for both private and public cloud planning assessments.
* MAP analyzes server utilization data for server virtualization and also server consolidation with Hyper-V.

**SharePoint**

* Microsoft offers its own online collaboration tool called SharePoint. Microsoft SharePoint is a web application platform that comprises a multipurpose set of web technologies backed by a common technical infrastructure.
* By default, SharePoint has a Microsoft Office–like interface, and it is closely integrated with the Office suite.
* The web tools are designed to be usable by nontechnical users. SharePoint can be used to provide intranet portals, document and file management, collaboration, social networks, extranets, websites, enterprise search, and business intelligence.
* It also has system integration, process integration, and workflow automation capabilities. Unlike Google Cloud Connect, Microsoft SharePoint is not a free tool. But it has additional features that cannot be matched by Google or any other companies.

**7.Briefly explains the architecture of IBM smart cloud with a neat architectural diagram?**

* IBM SmartCloud is a branded ecosystem of cloud computing products and solutions from IBM.
* It includes IaaS, SaaS, and PaaS offered through public, private, and hybrid cloud delivery models.

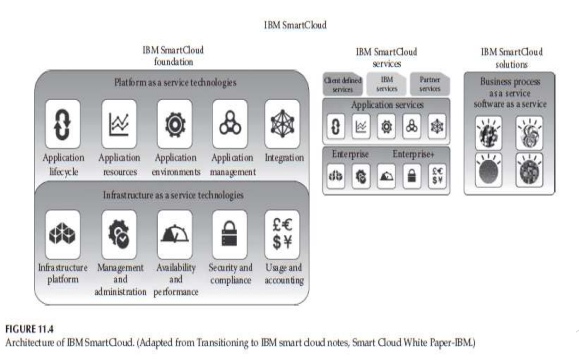
IBM places these offerings under three umbrellas

SmartCloud Foundation

SmartCloud Services

SmartCloud Solutions.

Figure 11.4 briefly explains the architecture of IBM SmartCloud.



* SmartCloud Foundation consists of the infrastructure, hardware, provisioning, management, integration, and security that serve as the underpinnings of a private or hybrid cloud.
* Built using those foundational components, PaaS, IaaS, and backup services make up SmartCloud Services.
* Running on this cloud platform and infrastructure, SmartCloud Solutions consist of a number of collaboration, analytics, and marketing SaaS applications. Along with IaaS, PaaS, and SaaS, IBM also offers Business Process as a Service (BPaaS).
* Infrastructure cloud services provide the consumer the provision of processing, storage, networks, and other fundamental computing resources where the consumer is able to deploy and run arbitrary software, which can include operating systems and applications.
* In platform cloud services, a consumer can deploy consumer-created or consumer acquired applications onto the cloud infrastructure created using programming languages and tools supported by the provider .
* Application cloud services allow consumers to use the provider’s applications running on a cloud infrastructure.
* The applications are accessible from various client devices through a thin client interface such as a web browser (e.g., web-based e-mail).
* Business process cloud services are any business process (horizontal or vertical) delivered through the cloud service model via the Internet with access via web-centric interfaces and exploiting web-oriented cloud architecture.
* The BPaaS provider is responsible for the related business functions.

**8. Give a brief summary on various cloud services offered by sales force?**

**OR**

**What do you mean by Knowledge as a Service? Which company provides this service? Explain?**

**OR**

**What is vCloud? Explain in brief.**

* Salesforce.com is a cloud computing and social enterprise SaaS provider based in San Francisco.
* Of its cloud platforms and applications, the company is best known for its Salesforce CRM product, which is composed of Sales Cloud, Service Cloud, Marketing Cloud, Force.com, Chatter, and Work.com.
* In addition to its products and platforms, Salesforce.com created AppExchange, a custom application building and sharing platform.
* The company also has consulting, deployment, and training services.
* Sales Cloud refers to the sales module in Salesforce.com.
* It includes Leads, Accounts, Contacts, Contracts, Opportunities, Products, Pricebooks, Quotes, and Campaigns (limits apply).
* It includes features such as web-to-lead to support online lead capture, with autoresponse rules. It is designed to be a start-to-end setup for the entire sales process.
* Sales Cloud manages contact information and integrates social media and real-time customer collaboration through Chatter.
* The Sales Cloud gives a platform to connect with customers from complete, up-to-date account information to social insights, all in one place and available anytime, anywhere.
* Salesforce.com created the Sales Cloud to be as easy to use as a consumer website like Amazon and built it in the cloud to eliminate the risk and expense associated with traditional software.
* With its open architecture and automatic updates, the Sales Cloud does away with the hidden costs and drawn-out implementations of traditional CRM software.
* By continuing to innovate and embrace technologies like mobile, collaboration, and social intelligence, the Sales Cloud has continued to pull ahead of the competition.

**Service Cloud: Knowledge as a Service**

* Service Cloud refers to the service (as in customer service) module in Salesforce.com.
* It includes Accounts, Contacts, Cases, and Solutions.
* It also encompasses features such as the public knowledge base, web-to-case, call center, and self-service portal, as well as customer service automation.
* Service Cloud includes a call center–like case tracking feature and a social networking plug-in for conversation and analytics.
* The Service Cloud delivers the world’s first enterprise-grade knowledge base to run entirely on an advanced, multitenant cloud platform.
* That means one can get all the cloud computing benefits that Salesforce.com is known for delivering without expensive data centers or software.
* Just powerful knowledge management, without the hassle of on-premises software, is provided.
* Unlike stand-alone applications, this knowledge base is fully integrated with everything else.
* Service Cloud has to offer all the tools one needs to run the entire service operation.
* When the consumer’s knowledge base is a core part of CRM solution, knowledge as a process can be managed.
* One can continually create, review, deliver, analyze, and improve the knowledge.
* And, because it is delivered by the Service Cloud, user’s knowledge is available wherever other customers need it.
* Agents have the right answers at their fingertips to communicate over the phone, send out through an e-mail, or share via a chat client.
* The same knowledge base serves up answers to the service website is a part of company’s public site.
* If one wants to take advantage of social channels like Twitter or Facebook, one can easily share knowledge that is tapped into the wisdom of the crowd to capture new ideas or answers. All this is done securely.
* The Service Cloud gives the tools that are needed to manage knowledge at enterprise scale.
* But it also delivers the same great ease of use that Salesforce.com is known for.
* That means user will benefit no matter what size or how complex the business is.

**Rackspace**

* Rackspace Cloud, a part of Rackspace, is another player in the cloud computing market.
* Offering IaaS to clients, it has been used by a large number of enterprises.
* Rackspace Cloud offers three cloud computing solutions—

•Cloud Servers

•Cloud Files

•Cloud Sites

* Cloud Servers provide computational power on demand in minutes; Cloud Sites are for robust and scalable web hosting, and Cloud Files are for elastic online file storage and content delivery.
* Cloud Servers is an implementation of IaaS where the computing capacity is provided as virtual machines that run in the Cloud Servers systems.
* The virtual machine instances are configured with different amounts of capacities.
* The instances come in different flavors and images. A flavor is an available hardware configuration for a server.
* Each flavor has a unique combination of disk space, memory capacity, and priority for CPU time. A varied set of instances are available for the user to choose from.
* These virtual machines are instantiated using images. An image is a collection of files used to create or rebuild a server.
* A variety of prebuilt operating system images are provided by Rackspace Cloud (64-bit Linux distributions—Ubuntu, Debian, Gentoo, CentOS, Fedora, Arch, and Red Hat Enterprise Linux) or Windows Images (Windows Server 2008 and Windows Server 2003).
* These images can be customized to the user’s choice to create custom images.
* The Cloud Servers systems are virtualized using the Xen Hypervisor for Linux and Xen Server for Windows.
* The virtual machines that are generated come in different sizes and measured based on the amount of physical memory reserved. Currently, the physical memory can vary from 256 MB to 15.5 GB.
* In the event of availability of extra CPU power, Rackspace Cloud claims to provide extra processing power to the running workloads, free of cost.
* Backup schedules can be created to define when to create server images.
* This is a useful feature, which enables the user to continue work in the event of failures by using the backup images. Custom images are helpful in creating backup schedules.
* A type of images, referred to as gold server images, can be produced if the servers of that configuration are to be instantiated frequently.
* Cloud Servers can be run through the Rackspace Cloud Control Panel(GUI) or programmatically via the Cloud Server API using a RESTful interface.
* The control panel provides billing and reporting functions and provides access to support materials including developer resources, a knowledge base, forums, and live chat.
* The Cloud Servers API was open sourced under the Creative Commons Attribution 3.0 license.
* Language bindings via high-level languages like C++, Java, Python, or Ruby that adhere to the Rackspace specification will be considered as Rackspace-approved bindings.
* The virtual machine instances are authenticated in the API by a token-based protocol that uses the HTTP x-Header. Private/public keys are used to ensure Secured Shell Access.
* Cloud Servers scale automatically to balance load.
* This process is automated and initiated from either the Rackspace Cloud Control Panel or the Cloud Server API.
* The amount to scale is specified; the Cloud Server is momentarily taken offline; the RAM, disk space, and CPU allotment are adjusted; and the server is restarted.
* A Cloud Server can be made to act as a load balancer using simple readily available packages from any of the distribution repositories.
* Rackspace Cloud is working on beta version of the Cloud Load Balancing product, which provides a complete load balancing solution.
* Cloud Servers are provided persistent storage through RAID10 disk storage; thus, data persistency is enabled leading to better functioning.

**VMware**

* VMware, a leader in virtualization technology, has come up with enterprise cloud computing solutions.
* VMware is currently providing a range of products for the development of private and public clouds and for leveraging the services offered by both as a hybrid cloud, such as VMware vCloud Director, VMware vCloud Datacenter Services, VMware vSphere, and VMware vShield to name a few.
* VMware’s private cloud offering provides greater standardization, rapid provisioning, and self-service for all applications and unparalleled cost savings by consolidating their physical infrastructures.
* VMware’s modular technology enables the user to select from a variety of hardware, software, and certified service providers to result in efficient cloud computing.
* Private clouds can be created by using the VMware vSphere and VMware vCloud Director.
* VMware vSphere is a robust virtualization platform used to transform IT infrastructures into virtual storage, compute, and network resources and provide them as a service within the organization.
* VMware vSphere provides services at both the infrastructure and application levels.
* At the infrastructure level, it provides options to perform efficient operation and management of the compute, storage, and network resources.
* At the application level, service-level controls are provided for the applications running on the underlying infrastructures, leading to available, secure, and scalable applications.
* The VMware vCloud Director, coupled with VMware vSphere, is a software solution that enables enterprises to build secure, multitenant private clouds by pooling infrastructure resources into virtual datacenters and exposing them to users through web-based portals and programmatic interfaces as fully automated, catalog-based services.
* VMware vCloud Director abstracts the virtual computing environment from the underlying resources and provides a multitenant architecture that features isolated virtual resources, independent authentication, specific policy controls, and unique catalogs.
* VMware vShield technologies are used to provide security to these environments by using services like perimeter protection, port-level firewall, NAT and DHCP services, site-to-site VPN, network isolation, and web load balancing.
* Public and hybrid cloud solutions are provided by VMware by partnering with other companies, certified as service providers.
* VMware vCloud Datacenter Services and VMware vCloud Express offer efficient solutions for utilizing IaaS either as a public cloud or a hybrid cloud. vCloud Datacenter Services provides a scalable environment, where internal resources are augmented with the external resources.
* vCloud Datacenter Services are built on the same technology and foundations as VMware vCloud Director and VMware vSphere to enable interoperability between cloud environments.
* Thus, the user is free to burst his private cloud into public cloud of his preferred service provider.
* vCloud Express is an IaaS offering delivered by leading VMware service provider partners.
* It is a cobranded service that provides reliable, on-demand, pay-as-you-go infrastructure.
* The VMware vCloud Express providers are Virtacore vCloud Express, Hosting.com, Melbourne IT, and Terremark’s vCloud Express. Instance types, load balancing, storage options, and pricing vary between service providers.

1. **Explain in detail about virtualization services provided by SAP?**

**Virtualization Services Provided by SAP**

* ERP virtualization increases a project’s return on investment by maximizing hardware utilization.
* The business benefits of virtualization of ERP applications are shorter development cycles, reduction in IT costs, improved availability, and energy saving.
* A joint service from SAP and VMware helps in transition to a more open and flexible private cloud platform based on proven virtualization technology.

1. **Explain in detail about SAP HANA?**

* SAP HANA Cloud Platform is an open-standard, Eclipse-based, modular PaaS.
* In SAP HANA Cloud Platform, applications are deployed via command-line tools to the cloud as web application archive (WAR) files or OSGi bundles.
* OSGi bundles are normal jar components with extra manifest headers.
* The applications run within the Java-based SAP HANA Cloud Platform runtime environment.
* It is powered by SAP HANA and can be maintained using web-based management tools.
* The main features of SAP HANA Cloud Platform are as follows:

Enterprise platform built for developers

Native integration with SAP and non-SAP software

In-memory persistence

Secure data platform

Lightweight, modular runtime container for applications

* SAP HANA Cloud Platform lets the users quickly build and deploy business and consumer applications that deliver critical new functionality to meet emerging business needs.
* It also helps connect users with customers in more engaging experiences. It provides connectivity based on the cloud connectivity service.
* As a result, the platform streamlines the integration of new applications at the lowest possible total cost of ownership.
* Support for open programming standards provides a low barrier entry for developers.
* This makes them productive from the start in building enterprise applications that can integrate with any SAP or non-SAP solution.
* No new coding skills are required to work with SAP HANA

1. **Explain the importance and features of Aneka cloud?**

Aneka provides a set of services that make enterprise cloud construction and development of applications as easy as possible without sacrificing flexibility, scalability, reliability, and extensibility.

The key features supported by Aneka are as follows:

1. A configurable and flexible execution platform (container) enabling pluggable services and security implementations. Multiple authentication/authorization mechanisms such as role-based security and Windows domain–based authentication are considered for this purpose.

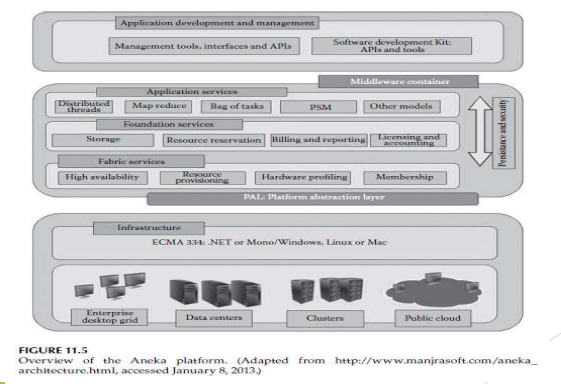
2. Multiple persistence options including Relational Database Management System (RDBMS), Structured Query Language (SQL) Express, MySQL, and flat files.

3. Software development kit (SDK) supporting multiple programming models including object-oriented thread model, task model for legacy applications, and MapReduce model for data-intensive applications.

4. Custom tools such as Design Explorer for parameter sweep studies.

5. Easy to use management tool for SLA and Quality of Service (QoS) negotiation and dynamic resource allocation.

6. Supports deployment of applications on private or public clouds in addition to their seamless integration.



Aneka allows servers and desktop PCs to be linked together to form a very powerful computing infrastructure.

This allows companies to become energy efficient and save money without investing in a number of computers to run their complex applications.

Each Aneka node consists of a configurable container that includes information and indexing, scheduling, execution, and storage services.

Aneka supports multiple programming models, security, persistence, and communications protocols.

1. **What are the support services offered by Amazon Web Services? Explain?**

Amazon SQS and AmazonS3 are support services.

**Amazon Simple Storage Service**

* Amazon Simple Storage Service known as Amazon S3, is the storage for the Internet. It is designed to make web-scale computing easier for developers.
* Amazon S3 provides a simple web service interface that can be used to store and retrieve any amount of data, at any time, from anywhere on the web.
* It gives any developer access to the same highly scalable, reliable, secure, fast, inexpensive infrastructure that Amazon uses to run its own global network of websites.
* The service aims to maximize benefits of scale and to pass those benefits on to developers.
* Along with its simplicity, it also takes care of other features like security, scalability, reliability, performance, and cost.
* Thus, Amazon S3 is a highly scalable, reliable, inexpensive, fast, and also easy to use service that meets design requirements and expectations.
* Amazon S3 provides a highly durable and available store for a variety of content, ranging from web applications to media files.
* It allows users to offload storage where one can take advantage of scalability and pay-as-you-go pricing
* For sharing content that is either easily reproduced or where one needs to store an original copy elsewhere, Amazon S3’s Reduced Redundancy Storage(RRS) feature provides a compelling solution.
* It also provides a better solution in the case of storage for data analytics.
* Amazon S3 is an ideal solution for storing pharmaceutical data for analysis, financial data for computation, and images for resizing.
* Later this content can be sent to Amazon EC2 for computation, resizing, or other large-scale analytics without incurring any data transfer charges for moving the data between the services.
* Amazon S3 offers a scalable, secure, and highly durable solution for backup and archiving critical data.
* For data of significant size, the AWS Import/Export feature can be used to move large amounts of data into and out of AWS with physical storage devices.
* This is ideal for moving large quantities of data for periodic backups, or quickly retrieving data for disaster recovery scenarios.
* Another feature offered by Amazon S3 is its Static Website Hosting, which is ideal for websites with static content, including html files, images, videos, and client-side scripts such as JavaScript.

**Amazon Simple Queue Service**

* Another service of AWS is Amazon SQS. It is a fast, reliable, scalable, fully managed message queuing service.
* SQS makes it simple and cost effective to decouple the components of a cloud application.
* SQS can be used to transmit any volume of data, at any level of throughput, without losing messages or requiring other services to be always available.
* A queue is a temporary repository for messages that are waiting to be processed.
* Amazon SQS offers various features like allowing multiple readers and writers at the same time, providing access control facilities, guaranteeing high availability of sending, and retrieving messages due to redundant infrastructure.
* It also gives provision for having variable length messages as well as configurable settings for each queue.

1. **What do you mean by cloud service provider? Which are the major cloud service providers?**

* Cloud computing is one of the most popular buzzwords used these days.
* It is the upcoming technology provisioning resources to the consumers in the form of different services like software, infrastructure, platform, and security.
* Services are 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-premise servers.
* Cloud services are designed to provide easy, scalable access to applications, resources, and services and are fully managed by a cloud service provider.
* A cloud service can dynamically scale to meet the needs of its users, and because the service provider supplies the hardware and software necessary for the service, there is no need for a company to provision or deploy its own resources or allocate information technology (IT) staff to manage the service.
* Examples of cloud services include online data storage and backup solutions, web-based e-mail services, hosted office suites and document collaboration services, database processing, and managed technical support services.

Cloud services can be broadly classified into three types:

Software as a Service (SaaS)

Platform as a Service (PaaS)

Infrastructure as a Service (IaaS).

With growing technologies, many more services are emerging in this field, such as

Security as a Service (SeaaS)

Knowledge as a Service

Data Analytics as a Service.

* Many companies have come forward to adapt the cloud environment and ensure that the users as well as the companies benefit from this.
* Amazon, Microsoft, Google, Yahoo, EMC, Salesforce, Oracle, IBM, and many more companies provide various tools and services in order to give cloud support for their customers.