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PART-B

ESSAY QUESTIONS WITH SOLUTIONS

1.1 HIGH-PERFORMANCE COMPUTING, PARALLEL COMPUTING, DISTRIBUTED COMPUTING

Q7. Discuss in detail about High-Performance computing.

Answer :

High-Performance Computing

HPC stands for High-Performance Computing which improves the performance of computing by increasing its speed. The main motivation behind such kind of computing is improvements in various fields such as engineering, scientific etc., which made the speed measured over Pflops from Gflops. Modern computing usually involve desktop (or) PCs are connected over LANs and WANs where computing must provide efficient ways to make the servers transparent along with faster access.

The high-performance computing systems are typically a set of processors which could be processor machines or CPUs. These systems are connected together through devices like memory unit, storage unit and input or output devices. Consecutively, the entire setup of connected components is run using the software which is employed.

The HPC can include both same type of processor machines or different types of processor machines. Since, they attribute high-performance. So, they are sometimes called as super computers and are difficult to replace. They also include computing paradigms.

Some of the examples of HPC could be, small cluster of desktop computers, Personal Computers (PCs) and fastest super computers. HPC systems are predominantly used in applications which include scientific problem solving. In essence, these problems demands appropriate simulation study which can easily be accomplished through HPC. Typical scientific problems include protein folding in molecular biology, research and study on developing models and applications depending on nuclear fusion.

Q8. Write about parallel computing.

Answer :

The computing wherein a single program is executed by multiple processors simultaneously is referred to as parallel computing. The major advantage of parallel computing is that, the execution of a program is done at very high speed. However, the difficulty of such computing lies in dividing a single program among multiple processors without interfering with one another. This sort of computing is generally performed on a computer that contain more than one process. However, it can also be performed by connecting computers into a network. This computing is specially used in areas such as weather forecasting and semiconductor design. Beside this, parallel computing is also used to solve such problem which cannot be solved by single computer.

It is one of the aspect of HPC. This computing collectively solves a computational problem through systems which are of same type (i.e., same type of CPUs). In a way similar to HPC, parallel computing too includes super computers consisting of hundreds and thousands of processors connected to other resources.

The main difference between serial (or sequential computers) and parallel computing are discussed below,

The former one runs on single computer which utilizes only single CPU. It disintegrates the problem into different series of instructions. Here, the execution of instructions is done in sequential manner. While the latter one use many processors at the same time using multiple CPUs. Here, the problem is disintegrated into different portions and can be solved at the same time. And also, every portion is further divided into sequence of instructions, which undergo concurrent execution on multiple processors.
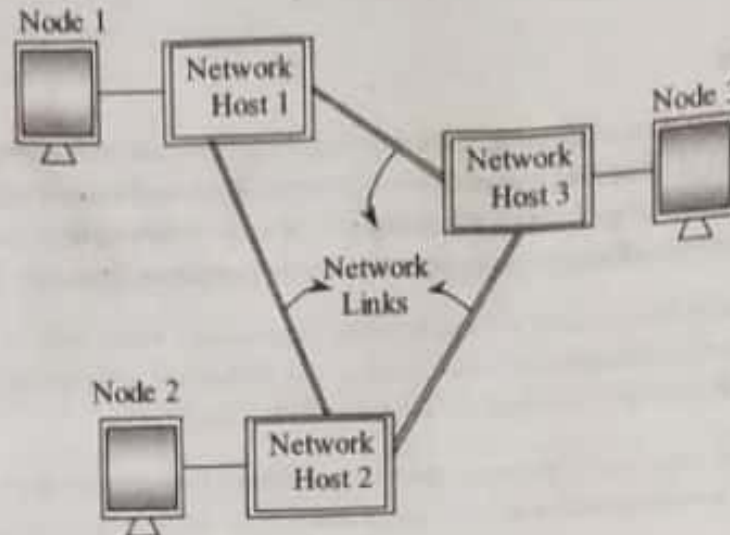
Q9. Discuss in brief about distributed computing.

Answer :

Distributed Computing

In the distributed computing model, the processing is done in multiple computers that are connected in the same network. Each of these computers have their own processors in addition to other resources. The overall structure of a distributed computing model is as shown in figure.

Figure: Distributed Computing Model

All the workstations, i.e., nodes have a complete access on the resources of local computer to which it is connected. When there is an interaction between local computers and remote computers, the users will be able to access the resources of remote computers as well.

A best example of distributed computing is the 'World Wide Web'. To visit a website, a user makes use of a browser for example Internet Explorer, Mozilla Firefox or Netscape Navigator etc., They will run on local system of the user. They will also interact with another program running on a remote system to search for a required file. This file may reside on any other remote system.

The distributed computing network consists of either same system or different systems. But irrespective of this, it runs on single system. The CPUs in this network could physically be close together or can be connected through local network. It is also possible that, the CPUs can geographically be kept at some distance and connected through wide area network. Due to the inclusion of heterogeneity (i.e., different systems), the distributed computing network sustains any number of possible configurations with in the processor machines. These processor machines could be mainframes, PCs, workstations and minicomputers. Thus, making the entire set-up as single computer.

The distributed systems substantiates many characteristic features in comparison to centralized systems. Some of them are,

1. **Scalability**

The distributed systems are highly scalable and can be expanded by including more machines and vice-versa. Also, the addition of the machines does not disturbs the existing set-up.

2. **Redundancy or Replication**

The distributed systems support the feature of redundancy where in many computers provide same services. This feature allows the system to function even if any of the computer fails. This is because of the availability of other similar computing supports.

1.2 CLUSTER COMPUTING, GRID COMPUTING, CLOUD COMPUTING

Q10. Write about the following.

    (i)   Cluster Computing

    (ii) Grid Computing.

Answer :

(i)   Cluster Computing

Cluster is a term referring to a collection of computers connected over a local network and work together as a single unified resource. Cluster computing is a mechanism of combining these multiple computers together to work as a single high-performance computer. A cluster computer can be used as an alternative to super computer because it provides improved performance in terms of speed on a wide range of high-performance computing applications.

These clusters consist of identical set of processor machines well connected through dedicated network infrastructure. These processor machines permits the programs to be run across all nodes concurrently. This is possible, because processor machines shares resources such as common home directory and holds a software called Message Passing Interface (MPI) implementation to substantiate it.

Ideally, cluster computing is also one of the aspect of HPC category. Here, all individual nodes operates together through meaningful communication with each other so as to solve complex problems.

Advantages

❖   It incurs low cost when compared with supercomputers.

❖   As multiple computers (or) components work together as a single computer, it can be easily managed.

❖   It uses replicas of various parts of the system which makes the resources highly available.

❖   It can be extended easily if additional computational power is required.

Disadvantages

❖   It does not provide the feature of resource sharing among participants of different clusters.

❖   Resources belonging to different software background might generate issues while combining.

❖   As there exist replicas of various components, finding faulty component is a tedious task.

(ii) Grid Computing

A computational grid is typically referred to a group of computing resources that belong to individual, heterogeneous (having different operating systems) and geographically different computers that carry out a common goal. These computers are loosely coupled through a network and usually shares their idle CPU cycles with each other. The cycles from all participants of a grid together forms a 'Virtual Super Computers'.

Here, a large task is divided into multiple smaller tasks and distributed among all the computers of a grid. This distribution is typically carried out with the help of middleware. The maximum size of a grid might be equal to the total number of computer participating in a grid.

The term grid was generally used to refer electric power grid but in computing terms, it was first used as power grid metaphor in the beginning of 1990s. Ian Foster, Steve Tuecke and Calrl Kesselmen are referred to as fathers of grid because they included features like distributed computing, web services and object oriented programming in the computational grid. They introduced Globus toolkit that was considered as a major solution to many of the computing problems.

Many computing resources of organizations are underutilized and kept idle mostly. They are necessary for certain operations. So, the concept of grid computing was brought into focus to utilize such underutilized computing power and supply it to the needy organizations. This can eventually leads to increase in the ReturnOnInvestment (ROI) on computing investments.

Furthermore, the software required is middleware which allows the remote access of resources. Each activity of grid resources managed through middleware is called grid services. Some of its services include access control, security, data access which includes digital libraries and databases. It also provides access to large-scale interactive and long-term storage facilities.

The grid computing is highly popular because of its ability to utilize unused computing power. It is also a cost-effective solution to many computing problems. It holds many options to alleviate problems in regard to any HPC based application.

It also allow heterogeneous resources to operate cooperatively and collaboratively for solving any complicated scientific problem.

Advantages

❖ Availability of high computational power.

❖ Provide access to certain additional resources other than processor and storage.

❖ Large storage capacity.

❖ As the resources are distributed geographically, failure of one resource will not effect the functionality of others.

❖ Resources can be distributed based on CPU utilization of nodes.

Disadvantages

❖ It does not provide stable standards.

❖ Combining resources from geographically distributed sites require high speed internet connectivity.

❖ Efficient tools such as opsware are needed to perform operations like synchronization.

Q11. Discuss in detail about cloud computing and its history.

Answer :

Cloud Computing

The term cloud is usually used to represent the Internet but it is not just restricted to Internet. It is a virtual storage where the data is stored in third-party data centers. Storing, managing and accessing data present in the cloud is typically referred to as cloud computing. It is a model for distributing information technology inorder to gain access to the resources from Internet without depending on direct connection with the server. It uses various web-based tools and applications to easily retrieve resources.

Accessing resources over the Internet makes these resources available anytime and anywhere thereby allowing the users to work remotely. In general, cloud computing is nothing but the use of computing resources such as hardware and software that are distributed as services across the network. It centralizes the data storage, processing and bandwidth which in turn provides efficient computing to the user. The services are made available by a cloud vendor based on pay-per-use.

In order to serve large computing resources for solving single problem, the concept of computing escalated from grid computing to cloud computing. This computing make use of potential ideas of computing power in the form of utility. The main difference between grid and cloud is that, the former one substantiate the use of multiple computers concurrently for solving a specific application. On the other hand, the cloud computing substantiates the use of multiple resources which includes computing resources inorder to serve unified service to the end user.

Typically, the cloud computing holds IT and business resources including servers storage, network, applications and processes. It provides the user needs and workload dynamically. Apart from supporting grid, the cloud also supports non-grid environments including three tier web architecture.

History of Cloud Computing

In 1977, the figure of cloud was used in ARPANET to represent network of equipments associated with it. A few years later, it was used to represent platforms associated with distributed systems. In 2006, it became popular as Amazon released EC2 (Elastic Computer Cloud) as a commercial web service.

Practically, the cloud computing has evolved through various phases among which grid and utility computing holds much of its significance. The history of cloud computing is discussed below.

1970s

In 1970s, most of the systems were based on time-sharing terminologies among which, the popular one was Remote Job Entry (RJE). In 1972, IBM introduced its first virtual machine operating system that makes use of various virtual machines to provide a time-sharing operational services.

1990s

With introduction of the concept of virtual machines, most of the organizations that used to have point-to-point data circuits started using VPNs (Virtual Private Networks) which incurs low cost. Moreover, they were able to manage the network traffic more efficiently. At this point, telecommunication organizations started using cloud symbol to represent interface between customer premises equipment (such as wiring) and service provider equipment. However, cloud computing is much more beyond this boundary and includes all types of servers.

In 1999, the introduction of salesforce.com lead to the concept of providing services and applications over various websites.

2000

In 2002, Amazon started providing web services such as storage, computations etc., with the introduction of Amazon Mechanical Turk. A few years later, in 2006, Amazon introduced a much more effective mechanism of providing commercial webservices on rental basis with the use of Amazon EC2 (Elastic Computer Cloud).

In 2008, NASA introduced the first-open source software capable of supporting both hybrid and private cloud but lacks in providing quality of service. In the same year, microsoft introduced "Azure" which was included in the top 500 supercomputers.

In 2011, IBM introduced IBM smart cloud which is a framework used to provide assistance in smarter planet. Later on in 2012, Oracle developed oracle cloud which is capable of providing interesting cloud services such as SaaS (Software as a Service), PaaS (Platform as a Service) and IaaS (Infrastructure as a Service).

Q12. State the basic principles of cloud computing.

Answer :   Model Paper-II, Q3(a)

The following are the basic principles of cloud computing.

1. **Federation**

   A cloud computing environment must be capable of providing federated service providers which means that, these providers must be capable of collaborating and resource sharing at any point irrespective of their type. This is usually needed when an organization extends its computing paradigm from private to public cloud. Moreover, this federation must be kept transparent so that the virtual application can be used on all the sites. This makes the application to be handled remotely and allows it to migrate from one site to another. Apart from this, federation must be carried out in a secure and independent way.

2. **Independence**

   The user of cloud computing services must be independent of the providers specific tool and the type of service. According to this principle, a user must be allocated with required virtual resource irrespective of the type of provider. Moreover, it is the responsibility of service providers to handle cloud infrastructure while hiding the confidential information.

3. **Isolation**

   According to this principle, a service provider must ensure the user with respect to the isolation of their data from others. Even the data in the same cloud must be separated from different users and therefore should not be accessed.

4. **Elasticity**

   The users of cloud computing must be providing with ease of accessing and releasing the resources as required. This typically referred to as elasticity. The rules associated with elasticity must be included within the contract made between consumers and service providers.

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5. **Business Orientation**

To develop a more efficient computing environment, an efficient platform must be developed before the applications are included into the cloud. This typically ensure the quality of service and assist SLAs (Service-Level Agreements).

6. **Trust**

To build a successful cloud computing environment, one of the major factor is trust between consumers and service providers. Therefore, effective mechanism must be included to develop trust worthy computing environment.

Q13. List the features of cloud computing.

Answer :

The key features of cloud computing are as follows,

1. **Low Capital**

It offers services to specific consumers and small business because these services help them to minimize their capital expenditure.

2. **Convenience**

It allows the customer to access the cloud computing services regardless of their locations or type of devices.

3. **Resource Sharing**

It employs multitendancy concept that allows sharing of resources and cost among large number of users. Due to this, the efficiency of under utilize systems increases along with the peak load capacity.

4. **Reliability**

It provides high reliability because service providers make use of multiple sites.

5. **Scalability**

It offers high scalability depending upon the fluctuating demands of the users.

6. **Security**

(i) It provides high level of security to the customer resources and infrastructure which is maintained by service providers.

(ii) It employs dedicated security staff and protection policies inorder to keep the customer data safe and secure.

7. **Authorization**

It employs data protection policies and access to data is provided only to authenticated users. However, the security mechanisms used for audit log are extreme which does not general many customers to access it.

Q14. List the challenges of cloud computing.

Answer :

The challenges faced by the companies that are implementing cloud computing are as follows,

1. Secured data storage

2. High speed internet access

3. Standardization.

4. Availability, fault tolerance and disaster recovery

5. Resources management and efficiency.

1. **Secured Data Storage**

(Organizations stores their large amount of confidential data outside the corporate firewalls at centralised locations. The data could be corresponding to user privacy, identity and application specific preferences) But the data protection mechanisms across these locations is likely to be compromised by Hackers and various attacks. Due to which the overall system performance decreases. This may in turn create various doubts/confusions regarding the legal frame work that the cloud computing has adopted.

2. High Speed Internet Access

The organizations can exercise cloud computing provided if it has constant access to high speed internet. Although, the organizations perform cost cutting over hardware, they have to spend significant amount for data intensive applications as they require sufficient bandwidth. Another important concern is the fact that, the internet broad-band service in United States is very poor in comparison to other European and Asian countries. Therefore, cloud computing and its services cannot be pursuit unless the organization has access to high-speed internet. So, these challenges must be overcome for the betterment of the organization.

3. Standardization

An organization in order to exercise cloud computing, must adopt high-level of technical standards. These technical standards is necessary for implementing various computer systems and applications. However, these standards has still not been defined nor introduced in public and not even approved by external body. Hence, these hurdles inhibits the growth of an organization.

Apart from these challenges, the cloud computing also faces the challenge of reliability. The organization even though uses the computing services, often get confused regarding the reliability of the services, as there is a threat of data being stolen, power failures, viruses, hackers. The cloud computing services are also not robust in nature due to which the performance may degrade.

4. Availability, Fault Tolerance and Disaster Recovery

The users of cloud services expect that their services and resources must be available any time and anywhere even if errors (faults) exist in the system. Moreover, the system must include the feature of recovering from disasters that might occur for any reason.

5. Resources Management and Efficiency

As the resources such as CPU cores, disk space etc are distributed and shared among multiple machines/networks, managing these resources is considered as a major challenge. Moreover, operations like load balancing, backup and recovery must be performed without degrading the performance of the system.

1.3 BIO COMPUTING, MOBILE COMPUTING, QUANTUM COMPUTING, OPTICAL COMPUTING, NANO COMPUTING

Q15. Briefly discuss about biocomputing.

Answer :

The biocomputing systems operate on the idea of biologically derived or simulated molecules. This is necessary for carryingout computational processes for solving problems. Moreover, the biologically derived models assist in structuring the computer programs to include in the application.

The biocomputing not just caters theoretical background but also caters practical tools. This is helpful for scientists for carryingout research work in protein patterns and DNA. In simple terms, the DNA and proteins can be regarded as building blocks and its functionality is highly dependant on the order of these blocks.

Therefore, the biocomputing scientist operates on inventing the order needed for various application. This entails better comprehension of life and molecular causes of diseases.

Q16. Write a short note on mobile computing.

Answer :

Mobile Computing

The term 'Mobile' is the ability to be on the move. Mobile computing systems are the computing systems that may be easily moved while they are being moved. Examples of mobile computing systems are laptops, PDA's and mobile phones.

There are two distinct types of mobility.

(i) User Mobility

(ii) Device portability.

1.   **User Mobility**

In user mobility, the user is mobile and services follow him. i.e., user can point to same or identical telecommunication services at distinct places. Techniques that sustain user mobility are call forwarding facility from telephone or desktops supporting roaming.

2.   **Device Portability**

In device portability, the communication device moves with or without the help of user. Several techniques in the network guarantees that communication is even possible while the device is being moved. Example for device portability is mobile phones where the system automatically directs the device from one base station to the succeeding one, if the signal turns into weak signal.

The mobile computing supports wireless media communication where in devices are small mostly handheld devices. On the other hand, the mobile communication concerning voice applications such as cellular phones has widely set platform across the world. It has a huge growth in all aspects and holds large number of subscribers in various cellular networks. When this technology is upgraded it gives rise to another level where in small devices such as smartphones are implemented to transmit and receive data across multiple cellular networks. Subsequently, the technology substantiates various applications such as video call or conferencing.

Therefore, mobile computing-based applications exhibits various upgraded technologies.

Q17. Write short notes on,

   (i)   Quantum computing

   (ii)   Optical computing

   (iii) Nano computing.

Answer :

(i)   Quantum Computing

The quantum computing came into existence inorder to solve the problem of manufacturers of computing systems. The problem is embedding of more and more transistors into tiny spaces of integrated circuits. This addition demands equivalent processing power i.e., the processing power should be doubled in every 18 months. So, the new quantum computing based solution comes into picture where the entire focus is made on quantum information.

Typically, the quantum computers are way faster in opposed to most powerful super computers in present. The functionality of these quantum computing is different at basic level in comparison to the present technology. They have some specific set of rules (prototypes). Although, they serve in solving many computing problems but couldn't replace the present day silicon-based machines.

(ii)   Optical Computing

The Optical computing carries out digital computation through photons in visible light or infrared beams in oppose to electric current. This is due to the fact that, electric current propagates at about 10% of light speed. Thus, confining the flow of data rate across long distance. As a consequence, optical fiber came into existence.

The benefits of visible and IR networks can be applied at the device and component scale inorder to develop a computer which can carryout operations 10 times faster than the traditional computer systems.

(iii)   Nano Computing

The nano computing can be defined as a computing systems developed using nanoscale components. Here, the transistor are used based on carbon nanotubes rather than silicon transistors.

The nanocomputers includes the scale and integration of nanotubes or components. In doing so, the problems of scale can be concerned with the dimensions of components which comes up to the few nanometer in two dimensions. On the other hand the problems concerned with the integration of components include twofold. Here, at first the developer of complex arbitrary patterns can stay economically infeasible. And secondly, the nanocomputer holds huge quantities of devices which eventually brings problems. However, this field of study is still under research.

PART-B

ESSAY QUESTIONS WITH SOLUTIONS

2.1 MOTIVATION FOR CLOUD COMPUTING, THE NEED FOR CLOUD COMPUTING, DEFINING CLOUD COMPUTING, DEFINITION OF CLOUD COMPUTING

Q7. Briefly give the motivation for cloud computing.

Model Paper-I, Q4

Answer :

Motivation for Cloud Computing

It is necessary to know the computing inorder to understand the availability of cloud computing. For this, consider those users who require computing and are ready to invest money on computing resources which includes hardware, software, networking and storage. The additional expenditure incurred in regard to this is, the maintenance, keeping it in premises and operating it. In particular the enterprises has to deal with huge expenditure which supports high computing power and resources.

It is also possible to acquire necessary computing power and resources through any provider or supplier. The advantage of this option is that, the user has to pay only for that usage. Thereby, incurring just cost effective investment rather than huge investments for purchasing the complete computing infrastructure. Basically, this occurrence can be taken as capital expenditure versus operational expenditure. This will help in analyzing total capital expenditure necessary for infrastructure in opposed to the moderate expenditure incurred in hiring the computing infrastructure for limited time and then it is left unused. This problem can be addressed through mechanism called cloud computing. This mechanism brings, hires and gets the services of the computing power or infrastructure to an organizational or individual level. And also provides required services just by paying the charges for consumed services.

This situation can be compared with electricity usage taking from producer-cum-distribute. Here, the electricity is not generated, but utilized to address requirements in the premises which includes lighting and use of other electrical appliances. As a consequence the user has to pay only for the electricity meter reading value.

The requirement of the cloud computing is mainly concern with acquiring the services of computing resources (in essence, the cloud computing successfully removes the large computing investments. At the same time it doesn't let the user to ignore the use of computing at operational cost. Some of the significant feature of cloud computing is that, it is very cost effective and saves users money. And, in case of fire accident or damage if the laptop or desktop gets destroyed the data is still secure because it is stored in cloud not in local machines.
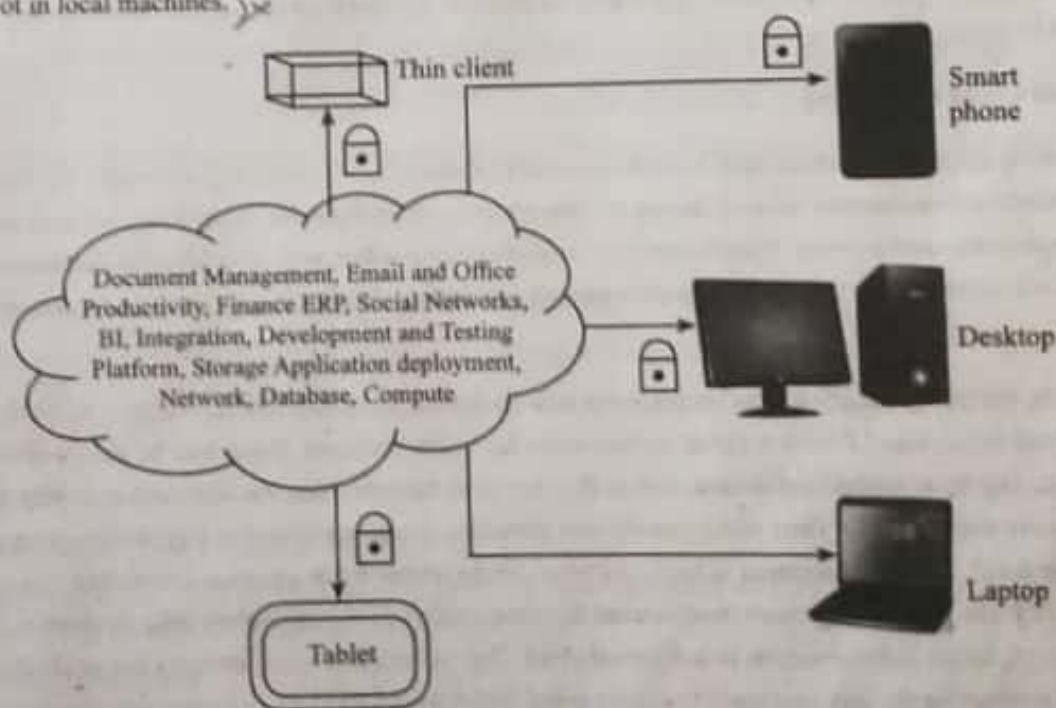

Figure: Cloud Computing

(In the above figure, the cloud is the Internet-based computing resources which can be accessed through a certain support of connectivity. This computing solution is fastly becoming popular in small-medium sized companies. Every organization in cloud computing model has its core computer power situated offline. Therefore, the cloud computing is much demanded only when the user thinks what is required for computing resources and information technology solution. So, increasing the capacity without the need in investing new infrastructure. It mainly focuses on pay-per-user service model by catering computing resources to end users across the Internet.)

Q8. Give the need for cloud computing.

Answer :

The cloud computing is preferred mostly because it is very convenient and reliable. The conventional methods for saving a file were storing the file into USB flash drive, external hard drive or CD and then taking it into a different place for accessing. But with cloud computing, the user can easily save the file into the cloud. This allows them to access the file from anywhere, from any computer using Internet connection. Also, the sharing of files with friends, collaborating over the web becomes easier.

Moreover, the data stored in cloud is less likely to be lost. The only threat is that, since the data is online there are chances that any intruder can gain access to the data. So, authentication mechanism becomes necessary along with any privacy setting for cloud service which is in use.

Q9. Define in brief about cloud computing and NIST definition of cloud computing.

Answer :

Cloud Computing

The cloud computing can be viewed as the source for storing and accessing data, programs across the Internet. The access can be made from any remote location or computer rather than there own computer hard drive. This set up is referred to as remote location and it holds multiple properties like scalability, elasticity. It is not related to simple remote machine.

The term cloud is considered as a metaphor for Internet. So, when the user stores the data or runs a program through local Internet hard drive it is viewed as local storage and computing. But, if it is considered as cloud computing, the user needs to get access of these files over the Internet. Thus, with online connection the cloud computing can be performed from anywhere, anytime through any device.

NIST Definition of Cloud Computing

The National Institute of Standards and Technology (NIST) defines cloud computing as a model for allowing universal availability, convenient and on-demand network access to a shared group of configurable computing resources such as networks, servers, storage, applications and services. These resources can be provided at adhoc and can be released with less management and service provider involvement. Ideally, the cloud model consist of 5 important characteristics, 3 service models and 4 deployment models.

This signifies the computing resource or infrastructure including server hardware, storage, network or application software. They all can be accessed from the cloud vendor, provider's site, premises. It can also be accessed from any remote location and through any local computing device. But as the user uses the resources; the cost is charge only to the extend of usage to the customers depending on their requirements and demands. These are called as pay-as-you-go or pay-as-per-use model. On the other hand, if the requirement is high, the provider generates more quantum computing resources which are scalable. Subsequently, the less management involvement or efforts refers to the customers side. In essence, the computing system maintenance customer side comes up to a minimal level. This is because, the customers has to check these task just for respective local computing devices necessary to access cloud-based resources. This does not include computing resources operated at providers side.

2.2 CLOUD COMPUTING IS A SERVICE, CLOUD COMPUTING IS A PLATFORM

Q10. Discuss the following.

    (i)   Cloud computing is a service

    (ii) Cloud computing is a platform.

Answer : *Model Paper-II, Q5*

(i)   **Cloud Computing is a Service**

The basic functionality of every computer is to store and retrieve information for the user. The information could be any family photographs, songs, movies which is also serviced by cloud computing. This could be better understood by considering a popular application called Flickr.

Using Flickr, users can share photos and images which has proved to be a great location for storing images. Also, it is much better than storing the images on the computer.

At first, it is important to note that, Flickr is independent of location and the user can upload the images from any device while on vacation and can access then later through home computer or laptop.

Secondly, the Flickr surpasses the traditional method of saving the images on CD by burning them or saving them on Flash drive. So, with Flickr the user can simply send image by sharing the Flickr address.

Thirdly, the Flickr provides high data security. The user just has to upload the images on Flickr and the images not only becomes secured but also get backup on the web. At the same time, it is important to keep a local copy on the computer CD or flash drive.

(ii)   **Cloud Computing is a Platform**

The World Wide Web (WWW) behaves as an operating system for Internet based applications. But inorder to access or understand the web-based applications, the user needs to have local operating system.

In general the platform meaning is that, it gives support for running the applications and executing the results. For instance, Microsoft windows serves as a platform while such platform need not be only operating system. Moreover, Java is also a platform not an operating system. With the use of cloud computing the web is considered as platform.

The desktop applications such as office 2.0 and other applications are converted into web-cloud applications. Therefore, word processors including Buzzword and office suites such as google docs are present in cloud in the form of desktop equivalents.

Thus, these applications running through cloud are transforming the cloud computing into a platform or serves as a platform.

2.3 PRINCIPLES OF CLOUD COMPUTING, FIVE ESSENTIAL CHARACTERISTICS, FOUR CLOUD DEPLOYMENT MODELS

Q11. Explain 5-4-3 principles of cloud computing and five essential characteristics of cloud computing.

Answer : *Model Paper-III, Q4*

5-4-3 Principles of Cloud Computing

The NIST introduced 5-4-3 principles to describe the following.

(i)   Promoting cloud computing by putting down five essential characteristic features.

(ii) Narrating cloud computing opportunities to the customers by putting down four deployment models with respect to architectural models.

(iii) Specifying three important and fundamental service which provides the cloud computing models.

Five Essential Characteristics of Cloud Computing

The following are the five essential characteristics. The term essential is necessary because if any of the characteristic is missing, then the whole cloud computing system will be incomplete.

(i)   **Self-service On-demand**

The consumer can alone supply computing capabilities including server time, network storage automatically. This is done without the involvement of human interaction with every service provider.

(ii)   Access of Network in Broad Sense

The network can offer multiple capabilities and access to services using standard mechanisms. This promotes the use of heterogeneous thin or thick client platforms such as mobile phones, laptops, Personal Digital Assistants PDAs.

(iii)   Elastic Resource Pooling

The provider's computing resources are in abundance so as to serve numerous consumers by utilizing multitenant model. This model is use with different physical and virtual resources. These resources assigned and reassigned dynamically based on the demand of the consumer. It also provides location independence, in essence the customer stay unaware of the exact location of the given resources. However, the lower level remains location dependent while the higher level abstraction carries location. Some of the resources include storage, processing, memory and network bandwidth.
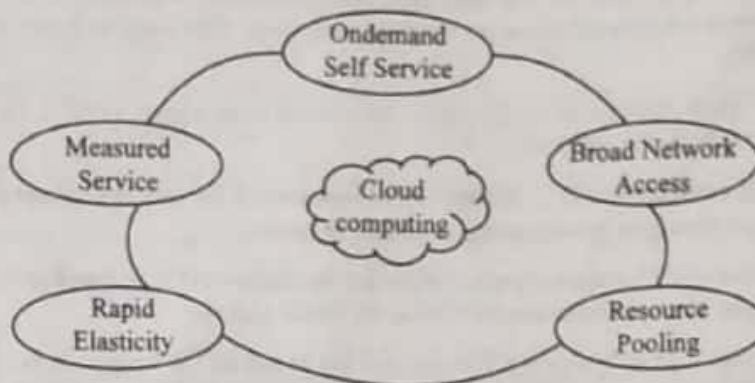

Figure: Essential Characteristics of Cloud Computing

(iv)   Rapid Elasticity

The rapid elasticity is concern with the quick supply of services. This is necessary for automatic and quick scaling out and rapid releasing to quick scaling in the capabilities.

Here the capabilities present for provisioning stay unlimited and the consumer has to buy them in abundance.

(v)   Guaged Service

The resources in cloud systems can be control automatically and can get optimize. This is done by purchasing metering capability at certain level of abstraction suitable to the type of service offered. The services cloud be storage, processing, bandwidth and active user accounts.

If there is transparency then resource usage can easily be monitored, controlled and reported not just for provider but also for consumer who is utilizing the service.

Q12.   Write about the four cloud deployment models.

Answer :   (Model Paper-I, Q5(a) | Model Paper-II, Q4(b))

Four Cloud Deployment Models

The deployment models specifies a path with which the cloud services gets enabled and the customers can easily access to them. Typically, the availability entirely depends upon the structure of the organization and location.

Another definition could be the cloud which is nothing but, Internet-based computing resources consist of locations. These location typically have data and services and they are facilitated to the customers. These services take various forms such as four deployment models including namely public, private, community and hybrid cloud service usage.

(i)   Private Cloud

This type of cloud infrastructure is selectively dedicated to a single organization holding multiple consumers such as business units. The complete set up can be managed, owned and operated by organization or third party or both of them. It is also possible that, it exist ON or OFF premises.

(ii)   Public Cloud

This type of cloud infrastructure is facilitated for general public. The complete set up is managed owned and operated by business, academic or may be government organization or any combination of them. It is located on the premises of cloud provider.

(iii) Community Cloud

This type of cloud infrastructure is adopted and shared by many organizations. The motive behind is to sustain a particular community which holds same concerns like mission, security requirements, policy and compliance considerations. It is possible that, its management can be taken care by organizations or third party. It can be located on premise or off premise.

(iv) Hybrid Cloud

This type of cloud infrastructure is composed of multiple distinct cloud infrastructures such as private, community or public. They all behave as a unique entities. But, they are group together through a standardized or proprietary technology. This allows the portability of data and application, such as cloud bursting for load balancing between the clouds.

Q13. Write briefly about three service offering models.

Answer :

Three Service Offering Models

The cloud-based computing resources make use of three kinds of services which are available to end users. These services include,

(i) Software as a Service (SaaS)

(ii) Platform as a Service (PaaS)

(iii) Infrastructure as a Service (IaaS).

This is mostly referred to as Service Platform Infrastructure (SPI) model of cloud. On the otherhand, SaaS can be viewed as software distribution model where in applications are provided by vendor or a service provider, which are then given to the customer across the network.

The PaaS is the paradigm for providing operating systems and its respective services such as Computer Aided Software Engineering (CASE) tools, integrated development environments for generating software solutions. This is done over the internet and the user doesn't have to download or install. Subsequently, the IaaS is associated with outsourcing the equipments for substantiating the operations such as storage, hardware, servers and networking components.

(i) Cloud SaaS

The consumers is provided with capabilities for the full utilization of applications offered by the provider. These applications are stored in cloud infrastructure such as network, servers, operating system, storage, individual application capabilities. These capabilities has exception where in it offers limited for configuration settings user-specific application. The user or client can access these applications through devices using thin client interface which include web browser such as web based e-mail or program interface.

Also, it is important to note that, the consumer is not involved in managing and controlling the operating cloud infrastructure. Some of the related applications are included in the form of services are Customer Relationship Management (CRM), Business Intelligence Analysis and online accounting software.

(ii) Cloud PaaS

The consumer is provided with capability to bring into action the cloud infrastructure consumer-created. This is not just enough, it is concern with the acquired applications developed with the help of programming languages, libraries, services and tools given by the provider.

Here, the consumer is least concern with the charge of managing and controlling the basic cloud infrastructure. Although, it has control upon the deployed applications and also the configuration setting related to application-hosting environment. So, in simple terms, it is ready-to-run development of operating framework package. Moreover, the PaaS vender facilitates networks, servers and storage and manages the levels of scalability and maintenance. Here, the client only has to pay the amount for used services.

Examples

PaaS providers are Google App Engine and Microsoft Azure Services.

(iii)   Cloud IaaS

The consumer is provided with the capability to carryout processing, storage, networks and other related basic computing resources which run on pay-per-use basis. Here, the consumer will be able to bring into the action and run the arbitrary software that also involves operating systems and applications. In a way similar to PaaS, cloud consumer is least concerned with the charge of managing and controlling the given cloud infrastructure. Although, it has full control over the operating systems, storage and deployed applications, but has less control on selected networking components such as host firewalls.
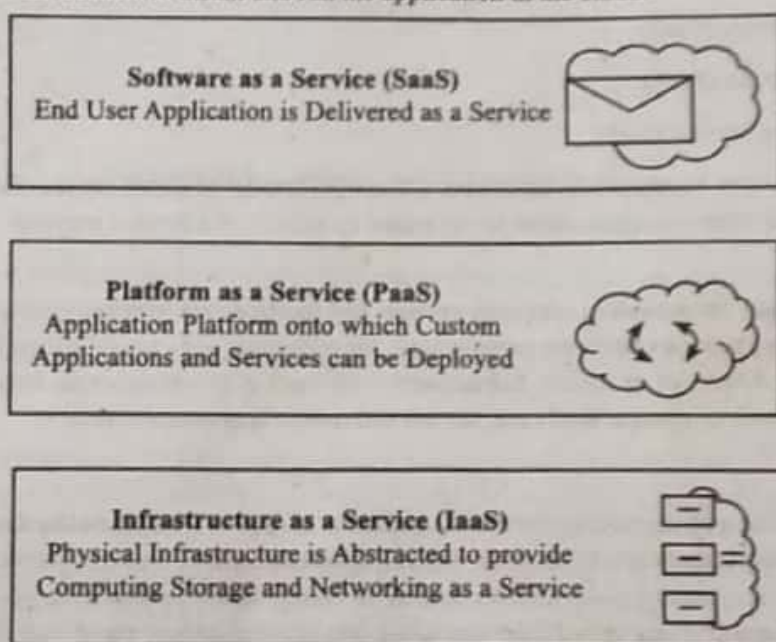
Thus, the service provider provides the requirement and holds itself responsible for housing, cooling, operation and maintenance.

Example

Amazon Web Services (AWS) is a large IaaS provider.

The main point of difference between PaaS and IaaS is the control offered to its users. That is, the PaaS permits the vendors to control everything and on the other hand, the IaaS demands more contribution from the customer side.

So, those organizations that hold software packages or application dedicated for a particular purpose should prefer IaaS instead of PaaS. This allows them to install and run the application in the cloud.

Software as a Service (SaaS)
End User Application is Delivered as a Service

Platform as a Service (PaaS)
Application Platform onto which Custom
Applications and Services can be Deployed

Infrastructure as a Service (IaaS)
Physical Infrastructure is Abstracted to provide
Computing Storage and Networking as a Service

Figure: SPI Service Offering Model of Cloud

PART-B

ESSAY QUESTIONS WITH SOLUTIONS

3.1 CLOUD ARCHITECTURE, LAYER, ANATOMY OF THE CLOUD, NETWORK CONNECTIVITY IN CLOUD COMPUTING

Q11. Draw and explain the architecture of cloud.

Answer :

Cloud Architecture

The architecture of any technological model depends on how the model works which is nothing but a hierarchical view in describing the technology. Similarly, the cloud also has its own architecture which shows its working mechanisms. These mechanisms operate upon the components and the dependencies present in it. So, it is confirm that the operation of cloud is absolutely based on the Internet.

Ideally, the architecture of the cloud can be categorized into 4 layers depending upon how the user uses the cloud. They are,

1. Layer 1 (User/Client Layer)

2. Layer 2 (Network Layer)

3. Layer 3 (Cloud Management Layer)

4. Layer 4 (Hardware Resource Layer).

1. Layer 1 (User/Client Layer)

The user/client layer is the first layer in the cloud architecture. This layer holds all users and clients. Here, only both users and clients starts the connection to the cloud. In particular, the client device could be thin client, thick client, mobile or any handheld device. These clients provide rudimentary functionalities so as to form access to the web application.

The thin clients can be described as those devices which entirely depends on other system for its operations. In essence, they hold very low processing capability, thats why thy depends upon other systems. On the other hand, the thick clients are very general computers which holds adequate processing capability. They can sustain independent operations through their adequate processing capability.

It can be said that, the access of cloud application can be done in the same manner as that of web application. However, the internal properties differ highly in cloud applications. Therefore, offering only client devices in this layer.

2. Layer 2 (Network Layer)

In this layer, the user forms connection to the cloud. The entire infrastructure of the cloud is based on the connection. Through this connection, the customers acquire the services. This capability serves as Internet in public cloud, which is located in a specific location. The location is however made abstract and user would be unaware of the location. But, its accessibility can be done from any where across the world.

On the other hand, the connectivity in private cloud can be offered by local area network (LAN). In a way similar to the others, here also the cloud is entirely based on the network which is being used. Regardless of the public or private cloud, the users need least band width which is offered by cloud providers. Therefore, the network layer does not fall under the scope or range of service-level agreements (SLAs). In simple terms, the SLA dose not considers, the internet connection happening between the users and cloud to maintain the quality of service (QoS).

3. Layer 3 (Cloud Management Layer)

The cloud management layer comprises of softwares implemented in managing the cloud. In particular, the softwares are cloud operating system (OS). This software serves as an interface between data center which consists of actual resources and the user. Additionally, it also contains management software for managing the resources. Basically, these softwares are meant for resource management i.e., scheduling and provisioning etc., optimization which includes server consolidation, storage workload consolidation. And then, the software holds internal cloud governance. Unlike layer 2, the network layer falls under the scope of SLAs, this is mostly set by users and service providers together.

However, it is reported as the violation of SLA if they make any delay while processing the service or leading to inconsistency in service. In doing so, the service provider has to pay the penalty led by the protocols. The SLAs are meant not just to private cloud, but also for public clouds. Some of the famous service providers are Amazon Web Services (AWS) and microsoft azure for public cloud. In case of private cloud creation, deployment and management open stack and eucalyptus are very famous.

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

The hardware resource layer comprises provisions with respect to hardware resources. Unlike other layers, here the public cloud holds data center at the back end. But, incase of private cloud the data center has a huge collection of hardware resources. They are interconnected to each other situated in a particular location or a high configuration system. Also, this layer falls under the scope of SLAs and is considered as the most important layer which controls the SLAs. Subsequently, it gives a great impact on the data centers present in SLAs. The motive here is to grant the service, the moment user accesses the cloud. It is also important that it should fall within the time anticipated by the SLAs. So, similar to the above layers, any inconsistencies in providing the service may entail penalty of the service provider. Inorder to avoid this, the layer's data centers operates on high-speed network connection and also uses highly efficient algorithms. This supports in the transmission on data from center to the manager. Here the number of data centers could be unlimited and numerous clouds can share those data centers.

This is the complete architecture of the cloud where in each layer is rigid and it is functional for any cloud applications.
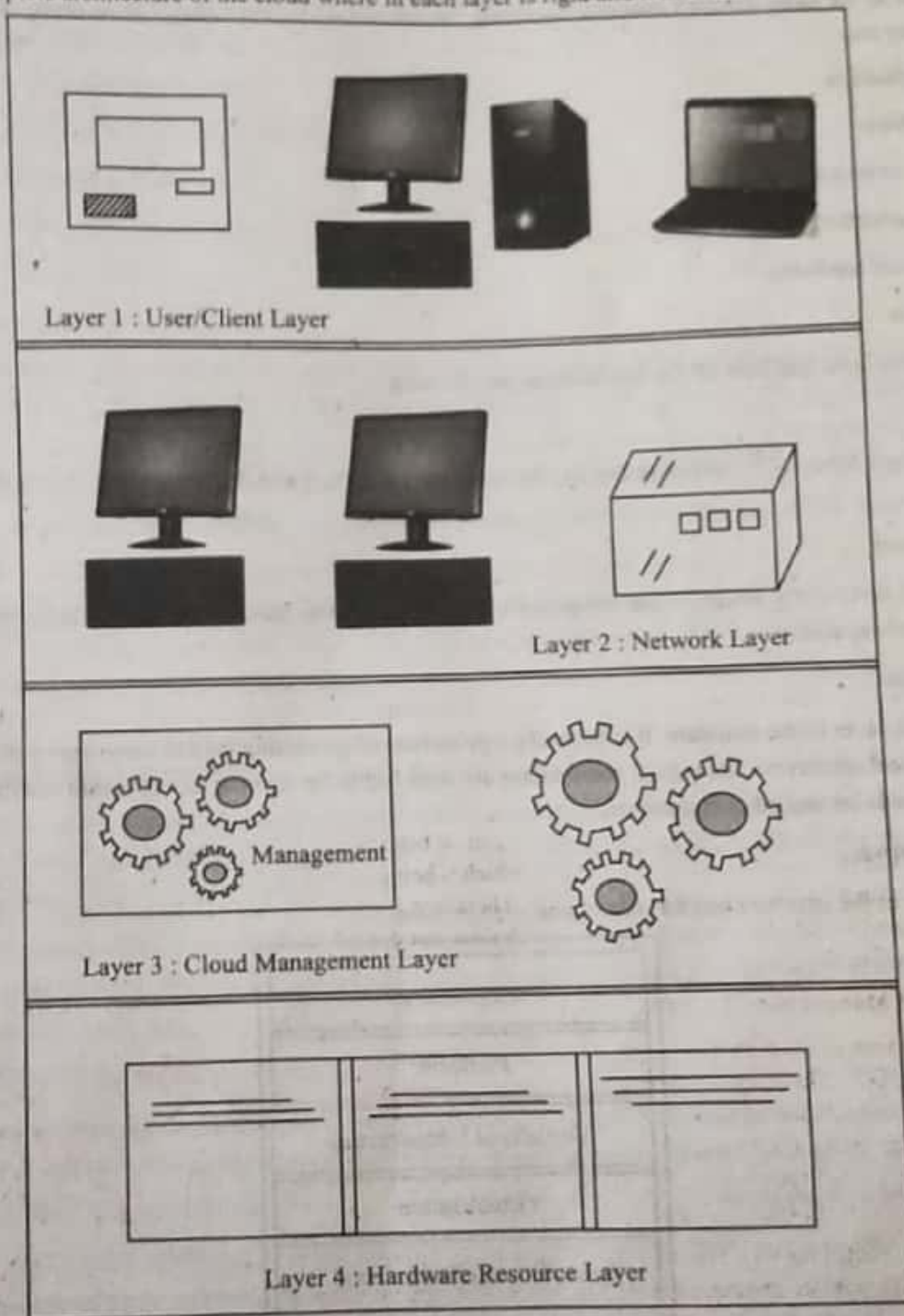

Layer 1 : User/Client Layer

Layer 2 : Network Layer

Management

Layer 3 : Cloud Management Layer

Layer 4 : Hardware Resource Layer

Figure: Cloud Architecture

Q12. Discuss in detail the anatomy of the cloud.

Answer :

Anatomy of the Cloud

The anatomy of the cloud is nothing but the structure of the cloud. Unlike cloud architecture, the cloud anatomy also has unique features which does not match with cloud architecture. The cloud anatomy is independent of any platform and has its own dedicated technology to carryout operations. On the other hand, the architecture truely specifies the technology upon which it works.

Ideally, the architecture can be specified as structural view which is largely concern with the technology upon which it is dependent and with which it operates. It is also concern with those technologies which are dependent on it. It can be said that, anatomy is one of the part of architecture. The figure given below is a basic structure of cloud. It can be further enhanced and can be illustrated as the most standard anatomy becoming the foundation for the cloud. The anatomy of cloud comprises five components. They are,

1. Application
2. Platform
3. Infrastructure
4. Virtualization
5. Physical hardware.

1.   Application

It is the upper layer and here all the applications are executed.

2.   Platform

It is the second layer in the structure and lies between the infrastrure and the application. It is meant for executing the application.

3.   Infrastructure

It is the third layer in the structure and comprises of resources used by other components. This layer enhances the users computational capability.

4.   Virtualization

It is the fourth layer in the structure. It is basically a procedure of generating logical components of resources across the existing physical resources. The logical components are responsible for forming infrastructure and they are separated and does not depends on any other component.

5.   Physical Hardware

It is fifth layer in the structure and has server and storage units.
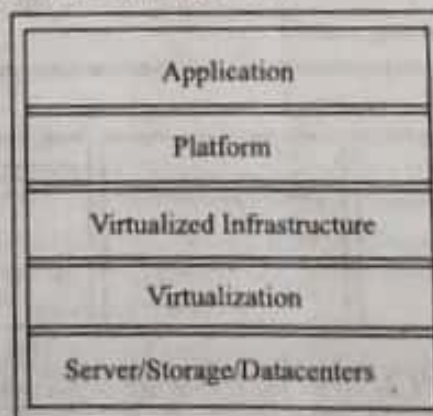
Figure: Cloud Structure

Q13. Explain in detail the network connectivity in cloud computing.

Answer :

Cloud computing can be viewed as a technique pertaining to resource sharing. Here, servers, storage and various other computing infrastructure situated at various locations forms connection through the network. Each time the application is submitted in the cloud for execution, necessary and suitable resources are taken from the storage of resources. After this, it is allocated to the applications. Since, these resources are connected through internet the result which are generated are according to the users. The network performance in cloud computing applications is considered as one of the major concerns effecting entire computing performance.

Ideally, the cloud computing operates on various deployment options. The significance aspect concern with cloud deployment models and its respective accessibilities is illustrated in the following network connectivity options.

1. Public cloud access networking
2. Private cloud access networking
3. Intracloud networking for public cloud services
4. Private intracloud networking
5. New facets in private networks
6. Path for Internet traffic.

1. Public Cloud Access Networking

In public cloud access networking, the devices forms connection via internet using certain cloud providers. These providers substantiates Virtual Private Networks (VPNs) for the customers. The security while accessing the public cloud services is likely to get compromise which eventually effects the performance. This problem can be addressed by promoting the connectivity using encrypted tunnels. These tunnels transmits the information through a secure pipes using internet. Subsequently after some use, this solution failed as it started giving overheads, delays in the connectivity which effected the performance.

So, the software engineers designed a suitable routing method which not just minimizes the delay but also provide security. It operates by minimizing the delay through reducing transit hops occurring in the end-to-end connectivity between cloud provider and cloud consumer. In particular, end-to-end connectivity is a complex federation with respect to interconnected providers. This connectivity gains support through internet. Therefore, due to these reasons, it is important to examine the options prior to selecting the paths.

2. Private Cloud Access Networking

In private cloud deployment option, the technology and approaches stay local to the in-house network structure. This is due to the fact that cloud is one of the part of organizational network. Ideally, the structure holds Internet VPN or VPN service taken through network operator.

Here, the performance will not get affected if the application access is executed correctly. This execution should be done within the organizational network, which is nothing but precloud configuration. In simple terms, the change or transition to private cloud computing does not compromise the performance.

3. Intracloud Networking for Public Cloud Services

The intracloud networking consideration in cloud computing is concern with public cloud services. The cloud provider holds certain resources and the services the cloud to the customer highly depends upon those dements which are geographically placed far from each other. Although, the distance does not impacts this, they stay connected through internet.

In particular, the visibility of the public cloud computing networks is internet to service provider. The user and customers can not see them. Despite of such measures, security of connection and access mechanisms of resources are significant issue. Apart from this, QoS also presents certain issues while connecting the resources across the world. Therefore, the problems related to performance and violations are solved at commercial level by SLAs.

4. Private Intracloud Networking

The private intracloud networking is one of the most complex option for networking and connectivity with in the cloud computing. This is due to the fact that, it is entirely based upon the quantity of the intracloud connections. These connections are associated with those applications that are executed with in the environment. In particular, this type of networking is sustained by connection between the huge data center sites run by the companies.

In doing so, at least case all the cloud implementations with respect is cloud computing depends upon intracloud networking. This assist them in connecting the users to their respective resource suitable for their assigned applications. At moment, resources are allocated the extent of utilization of intracloud networking highly depends upon the segregation application into small portions.

Now, this segregation may or may not be done based upon the service oriented architecture (SOA) between the many systems. However, if the SOA is run according to its principle then, it can make the traffic travel between components of applications and also between application can user. In doing so, the performance of cloud computing is highly compromised. This impact is caused due to the difference occuring among the current application and the relationship of the network with the application.)

5. New Facets in Private Networks

The traditional private networks are developed for on-premise applications and to acquire atmost internet security. Here, the applications including e-mail, file sharing and Enterprise Resource Planning (ERP) system are given to on-premise based servers located at every single corporate data center. In particular software vendors, as an alternative offers Software-as-a-Service (SaaS) to corporate offices. This alternative serves as an software support to them. However, this becomes more challenging while accessing and using the software mechanisms from data center servers and the problems also pool in from network architectures.

The global enterprises architecture could not optimize the performance with respect to cloud applications because the design was too old. On the other hand, applications such as mission critical applications travel from on-premise base to cloud based. Here, the availability and accessibility to the network stays as critical and the businesses does not run if applications such as ERP and e-mails becomes inaccessible.

6. Path for Internet Traffic

The internet traffic has a conventional path setup and consists of less number of internet gateways. As a consequence, the end users may face performance and availability issues while accessing cloud-based applications. However, the problem can be alleviated by implementing more widely distributed internet gateway infrastructure and connectivity. This establishes an efficient gateways for accessing applications and also provides lower latency access to the applications.

Once the traffic to cloud applications increases, the total amount of legacy network's capacity with respect to the traffic also increases. This occurs at regional gateways. Some of the applications which generates more bandwidth are video conferencing. On the other hand, other applications such as mission-critical applications (like ERP) will consume less bandwidth.

This rises the need for netizens to plan accurate connectivity and path between providers and consumers.

3.2 APPLICATIONS ON THE CLOUD, MANAGING THE CLOUD, MANAGING THE CLOUD INFRASTRUCTURE, MANAGING THE CLOUD APPLICATION

Q14. How the power of computer is realized through applications? Explain.

Answer :

Model Paper-II, Q5(b)

Applications on the Cloud

The applications are said to be the power of computer. In simple terms, the power of computer can be estimated through the application. Among many types of applications, the first type of application is said to be stand-alone application. It is meant to be run on a single system and it is independent of the network i.e., its functioning does not depend on the network. In particular, they make use of the same machine upon which it is installed. They entirely depend upon the resources and features present in the system and independent of data or processing power of other systems. In short it can be said as self-sustaining. However, with the increases requirements of users in terms of applications, the web applications came into picture.

There was a huge difference between web applications and stand-alone application and stand-alone applications in various aspects. The most important difference was the client-server architecture itself and these web applications were totally dependent upon the network for the functioning. So consequently, it consists of two main components one is called client and the other one is called server. The latter one is a high-end machine consisting of installed web applications which can be accessed through other client systems. On the other hand, the former one is location independent and can be placed anywhere in the network, which helps them to access the web applications. This turned out to be very useful and has become an extensive part of the day-to-day life. however, despite of its full utilization there are many drawbacks connected to it. They are,

1. The web applications fail to manage heavy loads and varying loads. It is inelastic in nature.

2. They do not support multitenancy.

3. They fail to estimate the quantitative measurement of services despite of the fact that they can easily monitor the user.

4. They only substantiate themselves on one specific platform.

5. They do not operates on pay-as-you go basis. As a consequence, any particular service provided to the user is certainly permanent or trial use. They does not monitor the timings also.

6. They can not handle highly loaded transaction because of its non-elastic nature.
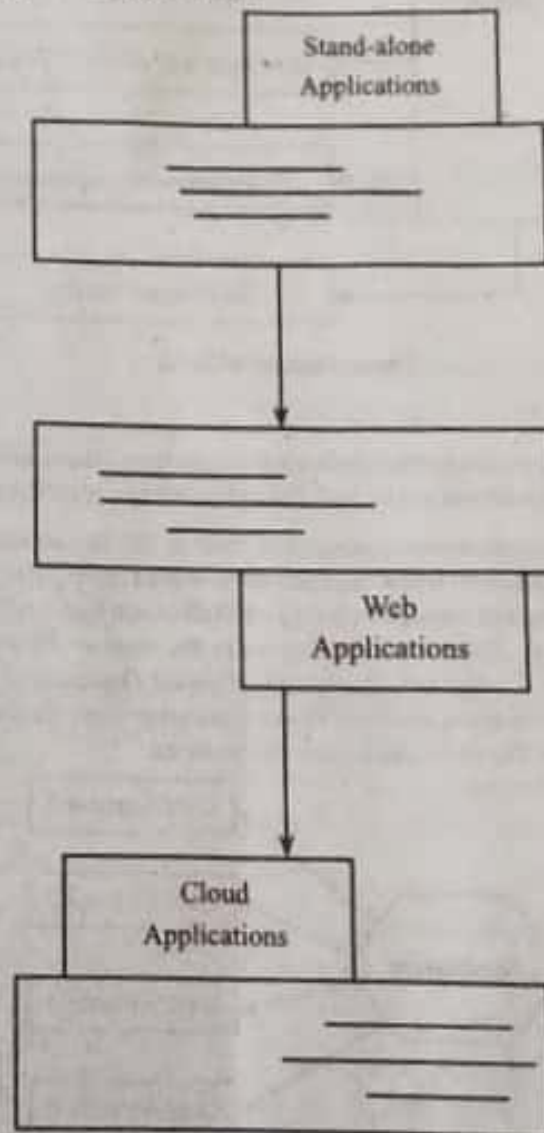
These issues can be solved through cloud applications.

Figure: Computer Application Evolution

3.10

Q15. What are the various features of cloud applications?

Answer :

Features of Cloud Application

The cloud application has unique features and does not share any properties with other applications. It can be accessed as a web application but with different properties. Based on the studies made by NIST, some of the properties which distinguishes cloud application from web application includes,

1. Multitenancy
2. Elasticity
3. Heterogeneous cloud platform
4. Quantitative measurement
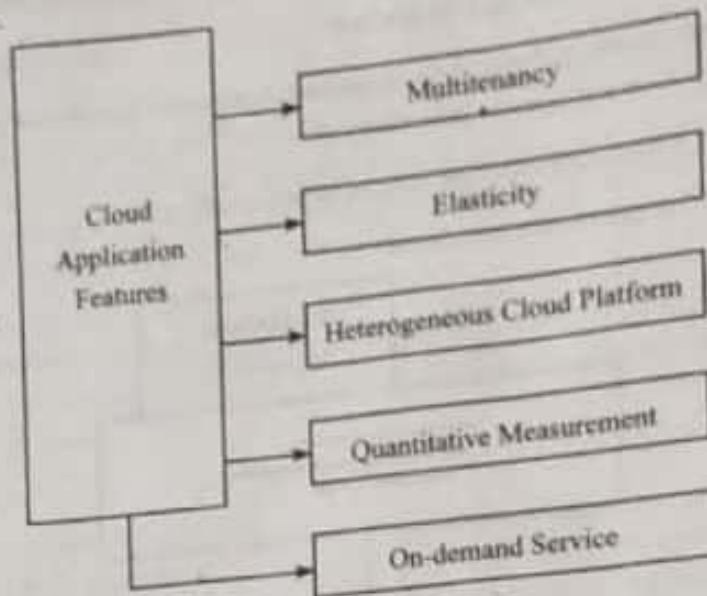5. On-demand service.

Figure: Features of Cloud

1. Multitenancy

This is one of the unique properties of cloud which makes it different from other applications. In these applications, software is used by multiple users independently. In simple terms, here the independence is concern with the logical independence.

It operates by employing separate applications instance and ensures that any modification made in one application is not reflected to the other application. But, in physical terms the software is shared among the applications and it is not independent. And, it is also important to note that the physical separation is very negligible and high emphasis is made on logical independence. It substantiates any number of application. There is no limitations in the number. However, to some extent logical isolation providings is highly dependent on physical isolations. In essence, physical closeness of any application entails difficulties in acquiring multitenancy. It is known that web application and cloud application share similarities because the users implements it in same manner. In the figure given below, the users share same applications.
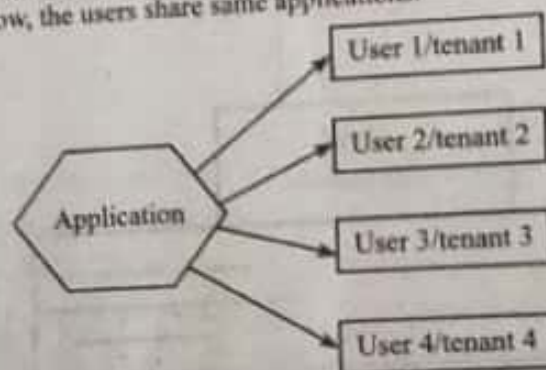

Figure: Multitenancy

2.   Elasticity

It is one of the unique properties of cloud which helps it for efficient functioning. Typically, elasticity can be described as the ability of a system to stay extendible so as to adapt to variations occurring in the workload. It sustains this ability by allocating and deallocating the resources automatically. As a result, at each point in time, the resources present meets the current demand accurately.

This property also allows the efficient management of number of users i.e., from one user to several users at a time. Apart from this, quick changes in load is also taken care due to this property i.e., increase and decrease of users and their related work is sustained.

3.   Heterogeneous Cloud Platform

This type of feature permits the cloud to support heterogeneity. In simple terms, the user can deploy any type of application in the cloud. This property leaves the cloud flexible for the users and developers can easily deploy it. So, using web-browsers, the users can access the deployed applications.

4.   Quantitative Measurement

This property measurement is unique to cloud and is not available in web application. This property allows the quantitative measurement or assessment of services. These services are acquired based on certain charges and the user has to pay the provider. In simple terms, the application or resources serves as a utility on pay-per-use basis. This implies that the usage is not just monitored but also measured. Apart from this, other measurable parameters include, other services, usage of link and also many other parameters supporting cloud applications.

5.   On-demand Service

This property provides on-demand service to the user. It is location independent and the user can utilize it regardless of its location. So, the user can seamlessly access web-application without any limitations of time duration and the device used.

Q16. Discuss in detail two components of managing the cloud.

Answer :   Model Paper-II, Q7

Managing the Cloud

The cloud management is crucial because it is implemented so as to maintain the quality of service and it is given top most priority. The cloud is entirely based upon the manner in which it is managed. So, it is categorized into two components namely,

1.   Managing the cloud infrastructure

2.   Managing the cloud application.

1.   Managing the Cloud Infrastructure

The infrastructure of the cloud is the main support system of the cloud. And it is used for gauging the Qos factor. In particular, failure in managing the infrastructure can lead to the breakdown of the complete cloud. Subsequently, this can present bad impacts on the QoS. The cloud management mainly operates upon the resource management which consists of multiple internal tasks such as resource scheduling, provisioning and load balancing. Now, cloud service provider's core software capabilities are implemented to manage these tasks. The capabilities include cloud OS that facilitates services to the cloud which inturn controls the internal structure of the cloud. Technically, the infrastructure of the cloud is very complicated system and compresses many resources which are mostly shared by multiple users.

Management of resources in an inefficient manner may entails several adversaries i.e., effecting the performance, functionality of the system. Also, mismanagement of resources can bring down the complete system. Thus, making the performance as basic aspect of cloud as every part in the cloud depends upon the SLAs. Ideally, the SLAs is directly related to the performance. In simple terms, the SLAs can be at optimum rate if and only if performance is good. On the other hand, the cloud functionality is always provided and taken into account at any cost. But, any incosistency in facilitating the functionality can effect the entire purpose of cloud management. And subsequently, if the cloud is functioning partially, then also the SLAs won't give the correct output.

The cost was one of the important criterias in the development of the cloud which includes the business prospects. If the cost at service providers end is less in cloud management then the provider will minimize the price, this is necessary to attract strong user base. It makes the users to use the service for improving the profit margin. On the other hand, when resource management cost is high then eventually, the accessing cost of resource also becomes high. This never keeps the business in loss and the service provider never bear the cost which means that the user has to make heavy payments. As a consequence, the service provider bear provider never bear the cost which means that the user has to make heavy payments. As a consequence, the service provider bear adverse impact due to high cost. Then, the user may not use the service and the provider looses the wide user base. Thus leading to a minimal growth in the industry and this presents big problem while dealing with the competitors. So, it is necessary to employ efficient management which offers less to cost.

Apart from these issues, when the cloud operates at higher level, it invites more issues related to resource management. These issues could be power consumption and optimization of multiple objectives for minimizing the cost. However, some of the approaches such as consolidation of server and storage workloads can efficiently accomplishes these tasks. The role of consolidation is to minimize the consumption of energy which eventually results in the performance increase of the cloud in certain cases. Ideally, the consolidation of server is nothing but efficient utilization of computer server resources. The aim is to minimize the total number of servers or its location required by the organizations.

Moreover, different service delivery models follows different management methods. These management methods are based on load fluctuation. Ideally, load fluctuation can be defined as a point where in the workload with respect to the system varies frequently. This is considered as an important criteria for cloud applications.

Load fluctuation can further be categorized into two types,

(a) Predictable

(b) Unpredictable.

(a) **Predictable**

These fluctuations can be handled in an easy manner. The preconfiguration of the cloud is necessary so as to handle the fluctuations.

(b) **Unpredictable**

These fluctuations are difficult to handle. Despite of this, cloud is preferred by many users across the world.

2. **Managing the Cloud Application**

Many business companies are transferring their corporate applications on cloud platforms. This enhances the quickness and easiness so as to meet up with huge requirements prevailing in the globalization of business. It also assists in generating responsiveness towards the market demands. However, such transfer of applications can come up with its own complexities. In simple terms, the application structure becomes highly composite and complex. They demand maximum utilization of capabilities such as storage and database given by cloud providers. It also takes into account the capabilities of third party SaaS such as email and messaging.

Once the companies understand the availability of application, they can easily examine the infrastructure, the required services it uses and the updation of application. Therefore, the complex structure of cloud application shows the need of visibility with in the services so as to estimate complete availability and updation.

Now, the role of the cloud application management is to alleviate these issues and generate a potential solution. This solution should allow the user to have deep examination in the application for executing it in the cloud. Apart from this, it should also design enterprise policies such as governance, auditing and environment management. This should be done at the time of application deployment. Such cloud based monitoring as well as management services have certain benefits such as collecting multiple of events, analysing them and determining the crucial information necessary to perform additional remedial actions. These actions include adjusting capacity or provisioning new services. Apart from this, application management requires tools necessary to manage the other environments.

3.3 MIGRATING APPLICATION TO CLOUD, PHASES OF CLOUD MIGRATION APPROACHES FOR CLOUD MIGRATION

Q17. Write in short about migrating application to cloud. Also, discuss the phases of cloud migrating.

Answer :

Migrating Application to Cloud

The cloud migration can be viewed as the process of transferring the multiple enterprise application and their corresponding IT environments. These environments are originally placed on traditional hosting type and the transfer is done to the cloud environment which could be public, private or hybrid.

With cloud migration, the user can get the opportunity to minimize the expenses incurred on applications (In doing so, the user has to undergo different phases such as, evaluation, migration strategy, prototyping, provisioning and testing.)

Phases of Cloud Migration

1. Evaluation

In this phase, all the components are evaluated. These components include current infrastructure, application architecture and environment. They are evaluated with respect to certain factors like compute, storage, monitory and management, SLAs, operational processes, risk, security, financial considerations compliance. Apart from this, licensing needs are determined for developing business. Thus, it is required for moving the cloud.

2. Migration Strategy

In this phase, strategy is developed depending upon the reports generated after evaluation. The strategy employed is hotplug strategy Here, the application and their corresponding data interface dependencies are kept separate. Also, these applications can be utilized or operationalized all at one time.

Apart from this, another strategy called fusion strategy is used so as to migrate some of the applications. For rest of the applications, dependencies exist based on existing licenses, specialized server requirements which could be mainframes, highly sophisticated interconnections with other applications.

3. Prototyping

In this phase, the activities initiates only after the accomplishment of migration strategy. Here, validation is necessary so as to ensure that small part of the applications are put to test on the cloud environment along with test data setup.

4. Provisioning

In this phase, premigration optimizations are determined and then implemented. To accomplish this, cloud servers are provided corresponding to all environments which are determined. Apart from this, necessary platform softwares and applications are put into work. This alerts the necessity of configuration which are tuned so as to match the newly generated environment sizing.

At this point, files and databases also gets replicated. This step also ensures that internal and external integration points are configured correctly. This leads to the support of web services, batch jobs operation and management software within the new environments.

5. Testing

In this phase, tests such as postmigration are performed so as to confirm that migration is accurately done.

In addition to this, performance and load testing, failure and recovery testing, scale out testing are carried out. These testing do not support certain elements, so it is done against traffic load and resource utilization levels.

Q18. Discuss various approaches for cloud migration.

Answer :

Approaches for Cloud Migration

The vendors adopt following four broad approaches for implementing cloud migration. They are,

1. Migrate existing applications.
2. Initiate from scratch
3. Separate company
4. Buy an existing cloud vendor.

1. Migrate Existing Applications

In this approach, some of the applications are redeveloped and restructured. Here, advantages of certain virtualization technologies are atmost utilized to speed-up the work process. However, for new functionalities, the organizations have to hire top engineers. This task is accomplished after releasing many applications with respect to the timings set by the demand of the customer.

2. Initiate from Scratch

In this approach, the engineers rebuild or restructure the existing application instead of using other systems. As a consequence, the R & D decisions changes in this regards. But if the team is small, then using complex development environments, the approach can be successful?

3. Separate Company

In this approach, an individual new company is established which has a separate brand, management R & D and sales. Some of the benefits which include use of internet protocol (IP) and investment from the existing company. Thus, minimizing many prevailing conflicts with the establishment of new company in cloud.

This separated company acts as a subsidiary to the already existing company. And one of the important factors is that, the new company can act, function and operate just like a cloud based start-up

4. Buy an Existing Cloud Vendor

In this approach, large vendor buying cloud based competitor so as to attain two things.

1. At first, it eliminates competitor.
2. Secondly, it makes the vendor capable to hit the ground operating in the cloud space.

Since, this is kind of merging the potential risk associated with it is innovation, drive subsequently the operational approach of cloud-based company is likely to get compromise.

PART-B
ESSAY QUESTIONS WITH SOLUTIONS
4.1 INFRASTRUCTURE AS A SERVICE

Q9. Discuss in brief about the basic cloud service models.
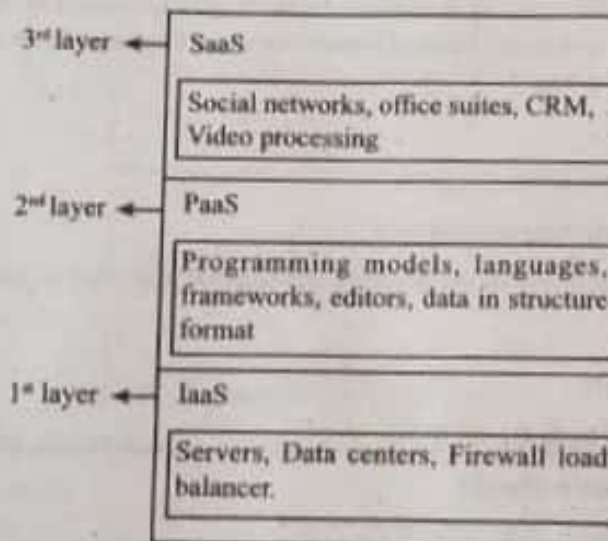
Answer :

Model Paper-4, Q9(a)

Cloud computing supports IT services and delivers them through network which is basically the internet. It can be realized through layers considering the entire stack. The following figure shows the architecture of cloud computing.

The cloud resources layer is implemented by a data center that constitutes innumerable nodes stored together. The "Computing/horse power" provides services by employing various cloud resources. The nature of cloud infrastructure is heterogeneous since resources like cluster, and networked PCs can be built upon it. The core middleware manages the physical infrastructure. It provides a runtime environmental for applications and to utilize the resources. The virtualization technologies guarantees the runtime environment customization, application isolation, sand boxing and quality of service. Usually, hardware virtualization technique is used for these purposes. This technology partitions the hardware resources like CPU, memory and vitualizes devices as per the needs of users and application core middleware is responsible for infrastructure management. It supports functionalities like negotiation of Quality of Service (QoS), admission control, execution management and monitoring, accounting and billing.

Layers of Cloud Computing Services

The services offered by cloud computing can be divided into three layers (or) classes namely,

(a) Infrastructure-as-a-Service (IaaS)

(b) Platform-as-a-Service (PaaS)

(c) Software-as-a-Service (SaaS).

3rd layer ←	**SaaS**
	Social networks, office suites, CRM, Video processing
2nd layer ←	**PaaS**
	Programming models, languages, frameworks, editors, data in structure format
1st layer ←	**IaaS**
	Servers, Data centers, Firewall load balancer.

Figure: Layered Architecture of Services

1. Infrastructure-as-a-Service (IaaS)

This service of the cloud computing forms the first layer in the layered architecture. This service provides the user with all the infrastructure for developing and deploying the applications. The infrastructure provided includes servers, data centers for storing data, firewall and load balancer. All the equipment will be provisioned to the user on demand. It offers users the activities to start, access, manage, customize the applications. All these activities will be managed by a virtual infrastructure manager present inside the infrastructure itself. Hence this service basically creates a cloud infrastructure for computing applications.

2. **Platform-as-a-Service (PaaS)**

This forms the second layer of the layered architecture. By utilizing this service the programmers will be able to program the cloud that is already having the infrastructure. In order make the cloud programmable it offers various programming models, languages and frameworks. The advantage of the service is that the developers can develop and deploy the applications without having to know about the underlying features of the platform. The underlying features include information regarding the amount of space used on the cloud, the number of processors needed for deploying the application etc. The best example of PaaS is the GoogleApp engine. They provide an development environment.

3. **Software-as-a-Service (SaaS)**

This forms the third and last layer of the architecture. This service enables the delivery of the built applications to the end users. The applications are accessed by the end users through a web browser. As it delivers the applications on-line many users are shifting to it from local computer programs that are specific to only that system. Social networking sites are best examples of SaaS as they can be accessed from anywhere in the world.

Q10. Explain in detail about public clouds.

Answer :

Public Clouds

Public clouds offer services that can be accessible to anyone from anywhere at point of time. The structural view of public cloud represents a distributed system containing one or more datacenters which are interconnected together. Services offered by the cloud are implemented on the top of datacenters. Users can use these service by signing -in with the cloud provider and entering their personal and billing details. On the other hand, the architectural view of pubic clouds represent a distributed system which can be of any type. It contains one or more data centers upon which the cloud services are implemented and delivered to the users.

Pubic cloud offers solutions that helps in reducing the costs related to IT infrastructure. They handle heavy loads on the local infrastructure. They can either grow or shrink depending upon the requirement of business. They offer Iaas, PaaS and SaaS services. Amazon EC2 is an IaaS, Google AppEngine is a PaaS and Salesforce .com is a SaaS.

The architecture of public cloud is designed to support wide range of users that handles heavy loads. The datacenters of public clouds can be distributed geographically so as to minimize the burden of loads. For example, the datacenters of Amazon Web Services are installed in US and in Europe. Their customers have the freedom of selecting the services from either of the three regions-us-west-1, us-east-1 or eu-west-1.

Features of Public Clouds

1. Serves a wide range of customers across the globe

2. Provides an isolated virtual computing environment

3. Provides effective monitoring, guaranteed performance and negotiable Quality of Service.

4. Stores the history of usage

5. Provides complete accountability.

6. Ability to scale on demand and sustain peak foods.

Q11. Explain in detail about private clouds.

Answer :

Private Clouds

Private clouds are virtual distributed systems whose resource provisioning model is restricted upto certain boundaries. These boundaries are set by its company. Private clouds are dependent upon private infrastructure and stores the business operations in house (ie., under their own organization). They offer high security since all the private information exists within the organization. The billing system bills each and every department of the organization based on their usage. It tests the applications and systems at lower costs. It provides QoS which performs operations like clustering and fail over, monitoring and maintenance, disaster recovery, data replication and uptime services corresponding to the application. Private clouds allow the users to adopt specific procedures during the deployment and execution phase of applications. This operation is necessary if the organization is following the standards of some third-party organization.

Features of Private Clouds

Private clouds provide the following features.

1. **Security of Customer Information**

   Customer information is secured by maintaining the data in-house.

2. **Infrastructure that Guarantees Service Level Agreements (SLAs)**

   Quality of service is guaranteed with the following operations like replication of data clustering and fail over monitoring and maintenance of system, recovery from disaster and uptime services that are equivalent to the requirements of application.

3. **Compliance with Typical Methods and Operations**

   Organizations which conform to third-party standards must have to use their own procedures while deploying and executing applications.

Private clouds can be implemented on Heterogeneous hardware (i.e., data centers, clusters, Desktop Grids). They depend upon the IT infrastructure that is already deployed on private environment like a datacenter, a cluster or desktop grids. The following figure shows the implementation of private clouds.
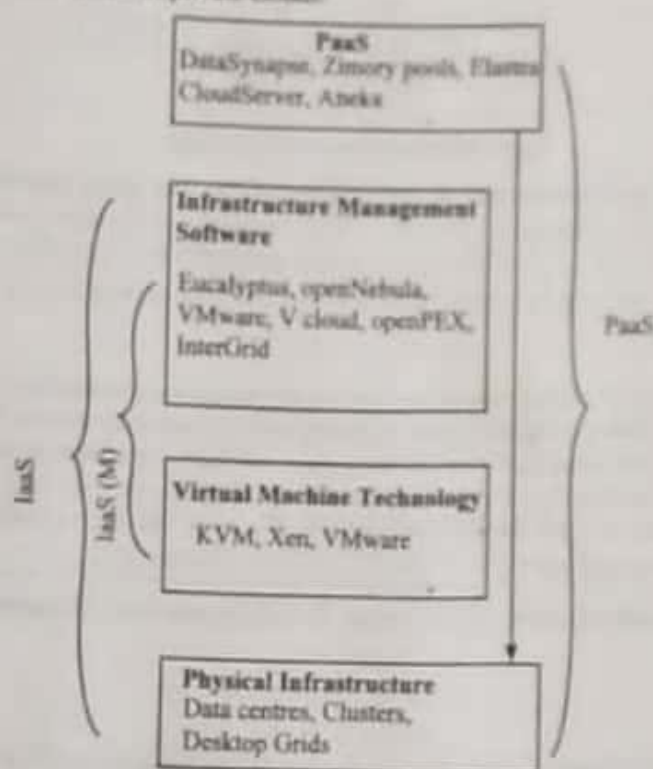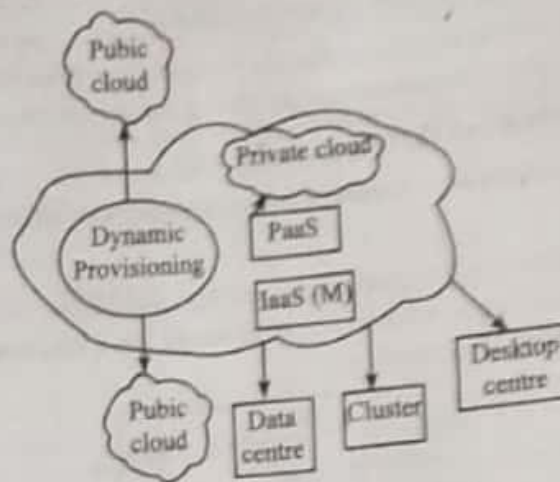

Figure: Implementation of Private Clouds

1. In the bottom layer, Xen, KVM and VMware technologies act as foundations of the cloud. They are responsible for integrating third-party IaaS providers.

2. VMware, VCloud, Eucalyptus and OpenNebula technologies manage the virtual infrastructure thereby providing IaaS solutions. Eucalyptus provides a compatible environment with Amazon web services interfaces and supports Xen, KVM and VMware.

3. OpenPEX is a web-based system that reserves the virtual machine instances and supports various back-ends. Intergrid also reserves virtual machine instance. In addition, it manages a multi-administrative domains clouds.

4. Private deployment of clouds is possible through dataSynapse, zimory pools, (Elastra, and Aneka. DataSynapse provides application virtualization software globally, Elastra allows configuring and deploying of distributed application infrastructures on clouds. Zimory automates the usage of resources pools based on Xen, KVM and VMware. Aneka deploys cloud infrastructure on the top of heterogeneous hardware.

4.6

Q12. Explain in detail about hybrid clouds.

Answer :

Hybrid clouds are a heterogeneous distributed system formed from a private cloud that combines resources or services from pubic clouds. They maintain private information within their in-house. They grow and shrink automatically by supplying the external resources and releasing them whenever required. The following figure shows the implementation of hybrid clouds.

Figure: Implementation of Hybrid clouds

Dynamic provisioning plays an important role in this implementation. The issues related to scalability are resolved by leveraging the external resources to meet the capacity demands. These resources will be rented out temporarily and released later. This process in known as "cloud-bursting". Hybrid clouds are mostly applicable to IT infrastructure. From IaaS point of view, dynamic provisioning is a method of gaining the virtual machines to increase the performance of resulting distributed system. It then releases those virtual machines.

Deployment and management of hybrid clouds is done by infrastructure management software and PaaS solutions. Infrastructure management software like openNebula opens up the abilities of integrating resources from public clouds. The virtual machine that is obtained manages all the virtual machine instances on a local basis. OpenNebula integrates the advanced schedules (like Harizea) to provide cost-based scheduling. Dynamic provisioning is implemented in PaaS solutions with a guarantee that the execution of applications are under the QoS satisfied and agreed by the users. The Aneka PaaS solutions provide provisioning services capable of leveraging various IaaS provides for scaling the cloud infrastructure.

Q13. What is a community cloud? Explain the various candidate sectors of community clouds.

Answer :

Community Cloud

Community clouds are the distributed systems that are formed by the integration of various cloud services. They serve various sectors like an industry, a community, a business, government or private enterprises, research organization, public virtual infrastructure provider etc. The infrastructure of community cloud is shared by various organizations that support a particular community. The community cloud is implemented on various administrative domains.

Candidate Sectors of Community Clouds

The various candidate sectors of community clouds are as follows,

1. **Public Sector**

   Public sector includes government processes like institutions and agencies that provide solutions at local, national and international level. These processes include operations like public hearing, infrastructure planning and invoice approval. Community cloud provides a distributed environment that builds a communication platform to perform these operations.

2. **Media Industry**

   The industries based on media prefer low-cost and simple solutions to produce an efficient content. Community clouds provide a shared environment that serves business-to-business collaboration and computing based on aggregate bandwidth, CPU and storage. These three factors are necessary for efficient media production.

3. **Healthcare Industry**

In the healthcare industry, community clouds provide a global platform where private knowledge and data can be shared and maintained within a private infrastructure.

4. **Energy and Other Essential Industries**

This sector includes industries comprising of various vendors, providers and organizations. Community cloud provides type of infrastructure that is perfectly suitable to build an open, good and satisfactory market.

5. **Scientific Research**

Science clouds are an example of community clouds. Scientific computing enables sharing of huge distributed infrastructure among different organizations. Community clouds eliminate the dependency on cloud vendors. Its scalable nature allows the infrastructure to grow by increasing its base. There is no chance of failure and differences between convenience and control. It grows and shrinks based on the community's demand. This property is sustainable.

Q14. What is Infrastructure/hardware as a Service (IaaS)? Explain its implementation.

Answer :

Model Paper-I, Q9(a)

Infrastructure/ Hardware as a service (IaaS) delivers customizable infrastructure as per requirements. It includes single sever to huge infrastructures that constitutes network devices, load balancers, database and web servers.

The IT architects or end users will utilize the infrastructure resources in the form of virtual machines as follows,
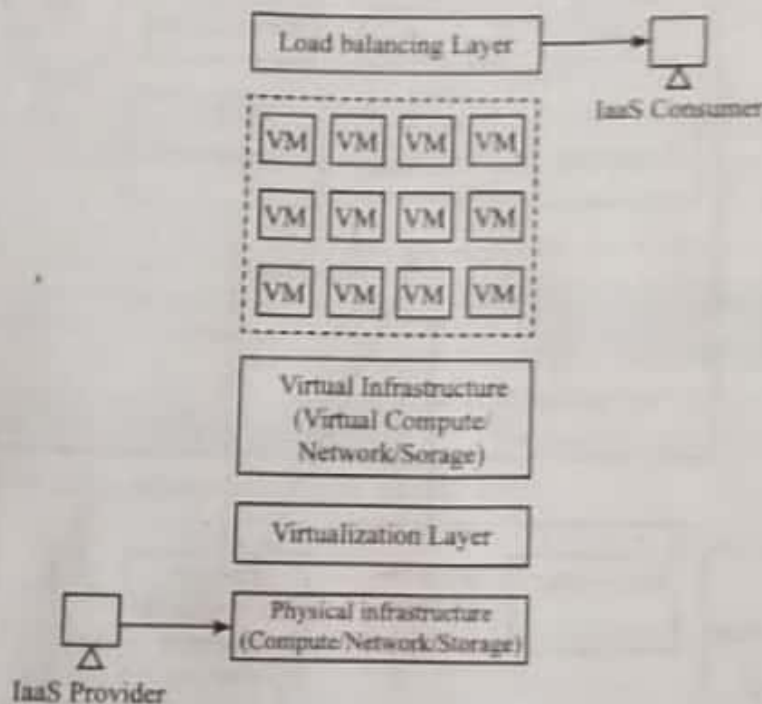
Figure: Overview of IaaS

IaaS mainly aims at IT architect. Depending on the requirements, an IT architect can develop virtual infrastructure, network, load balancers and so on. It eliminates the need of maintaining the physical servers since they are maintained by the service providers themselves. Moreover, an IaaS provider provides various services which are as follows,

(i) **Compute**

This service includes virtual main memory and virtual central processing units for the virtual machines that are supplied to the end users.

(ii) **Storage**

This service is responsible for providing back-end storage for the virtual machine images. In addition to this, few of the IaaS providers also provides the back end for saving the files.

It performs hardware virtualization by configuring and interconnecting virtual machines. This forms a distributed system upon which the applications are installed and deployed, the virtual machines comprise of atomic components whose deployment and pricing depends upon the features of virtual hardware. Virtual hardware comprises of memory, processors and disk storage. The following figure shows the implementation of IaaS.

(iii) **Network**

This service is responsible for providing various components of virtual networking like virtual routers, switch and bridge of virtual machines.

(iv) **Load Balancers**

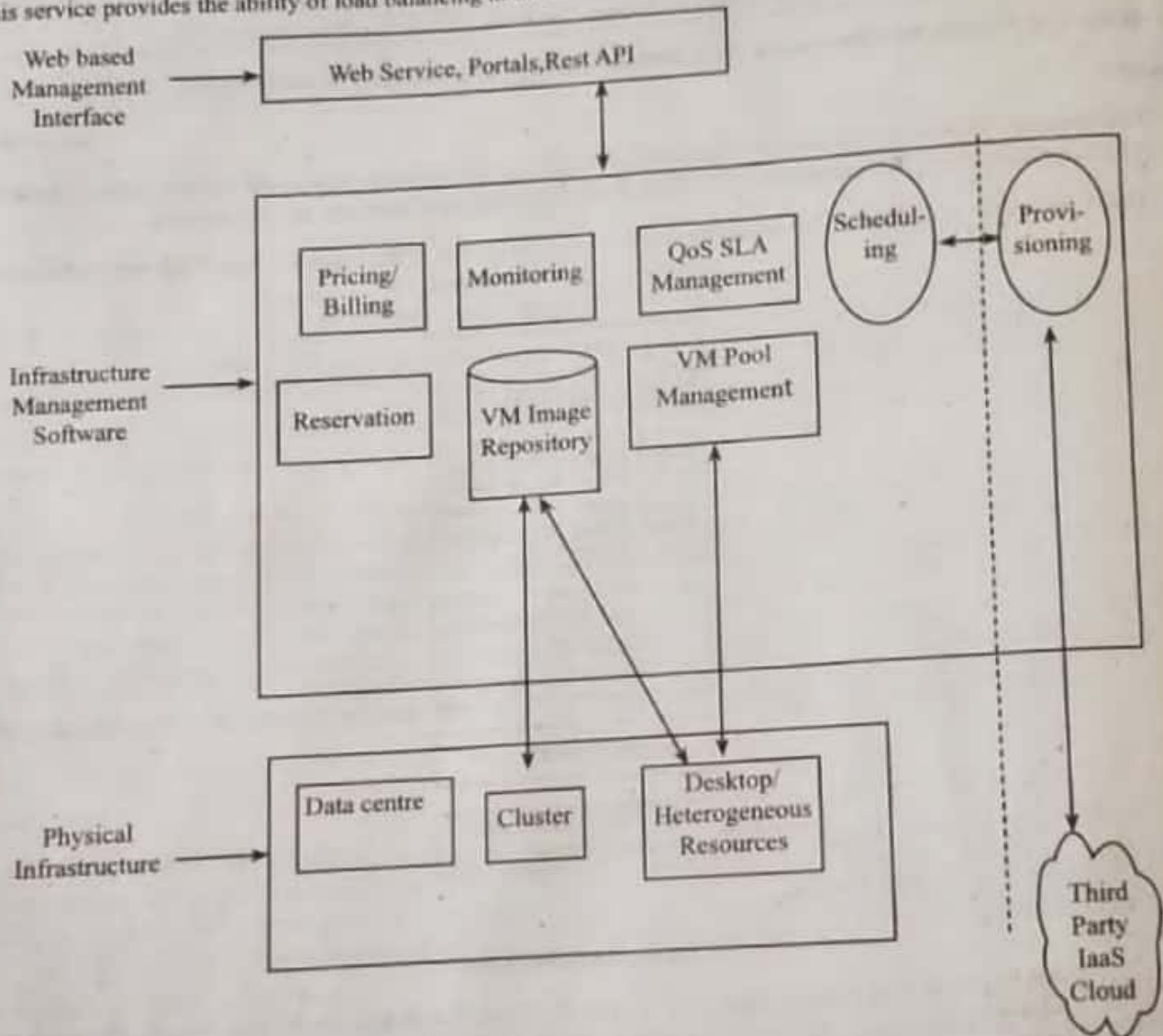This service provides the ability of load balancing at the infrastructure layer.

Figure: Implementation of IaaS

This implementation constitutes three major layers- physical infrastructure, infrastructure management software and web based management interface. The web based management interface is the user interface which provides access to the services that are given by the infrastructure management software layer. These services include web services, RESTful API sand mashups. The infrastructure management software layer is responsible for the management of virtual machines. The schedule plays on important role in the execution of virtual machines. It communicates with other components that perform various tasks. Following are those components and their tasks.

1. Pricing/Billing Component

It maintains the execution cost of virtual machine instances and maintains data for which the user is charged.

2. Monitoring Component

It tracks the execution of virtual machine instances and maintains the data used for analyzing the system performance.

3. Reservation Component

It stores the data of virtual machine instances.

4. QoS/ SLA Management Component

It maintains a repository of SLAs agreed by the users and ensures the execution of virtual machine instances with complete QoS.

5. VM Repository Component

It provides a catalog of virtual machine images which can be used by users for uploading three images. It also allows the users to create virtual instances.

6. VM Pool Manager Component

It tracks the live instances.

7. Provisioning Component

It communicates with the scheduler to provide a virtual machine instance outside the local physical infrastructure.

The bottom layer i.e., physical infrastructure has heterogeneous environment constituting PCs, workstations and clusters. The desktop grids evolve from this layer. Here, the computing resources are employed to provide huge computing power.

4.2 CHARACTERISTICS OF IaaS

Q15. Discuss in brief about characteristics of IaaS.

Answer :

Model Paper-II, Q9(a)

The following are the various characteristics that are possessed by IaaS.

(i) Web Access to the Resources

The model of IaaS allows the IT users to access infrastructure resources over the internet. An IT user need not gain access to the servers physically while utilizing the huge computing power. The users can gain access to the required infrastructure by means of any web browser or management console.

(ii) Centralized Management

Although the physical resources are distributed, they are managed from single location only. It ensures effective management and utilization of resources by controlling the resources that are resources by controlling the resources that are distributed across different parts from any management console.

(iii) Elasticity and Dynamic Scaling

IaaS provides elastic services wherein the resource utilization can be increased or decreased with respect to the requirements. The need of the infrastructure is based on the load on the application. In other words, resources are supplied by the IaaS services according to the load.

(iv) Shared Infrastructure

Since IaaS employs one-to-many delivery model, it enables several IT users to share single physical infrastructure. Each IT user will be provided with a separate virtual machine. Thus, it ensures high utilization of resource.

(v) Preconfigured Virtual Machines

IaaS providers provide preconfigured virtual machines along with operating systems, network configuration and so on. Among these VMs the IT users can opt for any virtual machine. Moreover, the users can start using the machine the moment they subscribe the services.

(vi) Metered Services

IaaS facilitates the IT users by supplying them computing resources on rent rather than selling them. It measures the number of services utilized by the IT users and then charges the users depending on the amount of their usage.

4.3 SUITABILITY OF IaaS, PROS AND CONS OF IaaS

Q16. Describe the various situations where IaaS can be used and must be avoided.

Answer :

Model Paper-III, Q8(b)

The following are the various situations wherein IaaS can be utilized,

(i) Unpredictable Spikes in Usage

When a notable increase occur in usage of computing resources then IaaS serves as the best choice for IT industries. But, when there exists volatile demand for the infrastructure one cannot predict the spikes and troughs. Due to this fact, infrastructure cannot be added or removed immediately with respect to the demand in conventional infrastructure. So, it is suggested to use the services of IaaS only when the demand of infrastructure is unpredictable.

(ii) Limited Capital Investment

Since it is not possible for the newly established companies to spend more on purchasing infrastructure for their business requirements, they use IaaS for reducing the capital investment on hardware.

(iii)   Infrastructure on Demand

At times, few of the organizations need huge infrastructure for a very short time period. But, they may not afford to purchase many on premise resources. So, they opt for IaaS as it allows the IT users to rent the computing resources rather than buying them.

Apart from being a suitable option, there are few situations wherein IaaS may not serve as the best option. The following are the various situations during which IaaS must be avoided by IT users.

(i)   When Regulatory Compliance does not Permit off Premise Hosting

The regulation of IaaS for few companies restricts the application and data from being hosted on third-party off premise infrastructure.

(ii)   When there is Minimum Usage

When the usage computing resources is less and the underlying on-premise infrastructure possess the ability to meet its requirements then users must avoid using IaaS.

(iii)   When better Performance is Needed

Since, access to IaaS services is made through the internet, the performance may become poor due to network latency.

(iv)   When more Control is Required on Physical Infrastructure

Since IaaS services are derived as virtual resources, one cannot get more control on current physical infrastructure. So, IaaS may not be the suitable option.

Q17. Mention the Pros and Cons of IaaS.

Answer :

Pros (Benefits) of IaaS

The various benefits that are provided by IaaS are as follows,

(i)   Pay-as-you-use Model

The IaaS provides services to the users depending on pay per usage condition. It ensures that users pay only for the resources that they have utilized. It reduces the overhead of the customer on spending money for purchasing the hardware resources.

(ii)   Minimized TCO

The IT users need not purchase physical hardware in order to run their business as they can take them on rent from the IaaS providers. So, this reduces the TCO.

(iii)   Elastic Resources

The IaaS provides supply resources depending on the current requirements of the IT users. The IT users can use load balancers and perform dynamic scaling of resources depending on their requirement. This load balancer sends the newly added resource request to the new server and thus improves the efficiency of the application.

(iv)   Better Utilization of Resource

To achieve success in IT business, utilization of resource is the major criteria. Inorder to increase the ROI, the infrastructure purchased must be used properly. IaaS ensure better utilization of resource and offers high ROI for IaaS providers.

(v)   Supports Green IT

IaaS eliminates the need of purchasing dedicated servers since it shares single infrastructure between multiple customers. Therefore, this minimizes the number of servers to be purchased and also reduces the amount of power consumed thereby resulting in Green IT.

Cons (Drawbacks) of IaaS

The drawbacks of IaaS are as follows,

(i)   Security Issues

Hypervisors play a vital role in IaaS since it employs virtualization as its enabling technology. There are several attacks that target hypervisors and if they get compromised then they can attack any virtual machine easily. Many of the IaaS providers are incapable of providing 100% security to the virtual machines and data stored in them.

(ii) Interoperability Issues

IaaS providers does not follow any common standard. Due to this fact, it becomes difficult to move any virtual machine from one IaaS provider to the other. Sometimes, this may also result in vendor lock-in problem.

(iii) Performance Issues

In IaaS, all the distributed servers are connected over the network. Since network latency plays a vital role in performance, if there occurs any issue in the latency then the performance of virtual machine may also get affected.

4.4 SUMMARY OF IaaS PROVIDERS

Q18. Give the summary of IaaS providers.

Answer :

Model Paper-III, Q9(a)

Depending on the license, deployment model and supported host OS, guest OS and hypervisors, the IaaS providers are classified into various categories. The IaaS provider is selected by an end user based on their requirements. There are various public and private IaaS providers available in the market who offers infrastructure services to the end user. The consumers of public IaaS does not depend on host OS since it is managed by the service provider whereas the users of private IaaS rely on the supported host OS. The following table describes the summary of popular IaaS providers.

Provider	Amazon web services	Google Compute engine	MS Windows Azure	Eucalyptus	Apache cloudstack	Open Nebula	Openstack
License	Proprietary	Proprietary	Proprietary	GPLV3	Apache 2	Apache 2	Apache 2
Deployment Model	Public	Public	Public	Private & hybrid	Private	Private, Public & hybrid	Private & public
Host OS	Not available	Not available	Not available	Linux	Linux	Cent OS, Debian, and Open SUSE	Cent OS, Debian Fedora, RHEL OpenSUSE, and Ubunter
Guest OS	Red Hat Linux, Windows server, SUSE Linux, Ubunter, Fedora, Debian, Centos, Gentoo Linux and Free BSD	Debian 7 Wheezy, Centos 6, Red Hat Enterprise Linux, Suse, Windows Server, Co-reOS, FreeBSD & SELinux	Windows Server, Centos, FreeBSD, OpenSUSE Linux and Oracle Enterprise Linux	Linux and Windows	Windows, Linux and Various Versions of BSD	MS Windows and Linux	Cent OS, Ubunter, Microsoft Windows and FreeBSD
Supported Hypervisor	Xen	KVM	Windows Azure hyper-visor	Xen, KVM VMware	KVM, VSphere, XenServer/ SCP	Xen, KVM, VMware	Libvirt, Hyper-V, VMware, XenServer 6.2, Barem-etal docker, Xen, LXV Via Libvirt

Figure: Summary of IaaS Providers

4.5 PLATFORM AS A SERVICE, CHARACTERISTICS OF PaaS

Q19. Explain about Platform-as-a-Service (PaaS) along with its characteristics.

Answer :

Platform-as-a-Service (PaaS)

In Platform-as-a-Service, a platform, group of software, product development, database tools are introduced which results in easy development and running of applications across a cloud platform. Therefore, user does not need to buy and maintain of these tools in the organization. Hence, developers code the applications on the providers platform across the Internet. But Interpretability and data portability does not follow specific standards (However, few users do not allow to shift their software in different cloud service infrastructure) For instance, force.com and Google Apps are the two commonly used PaaS applications.

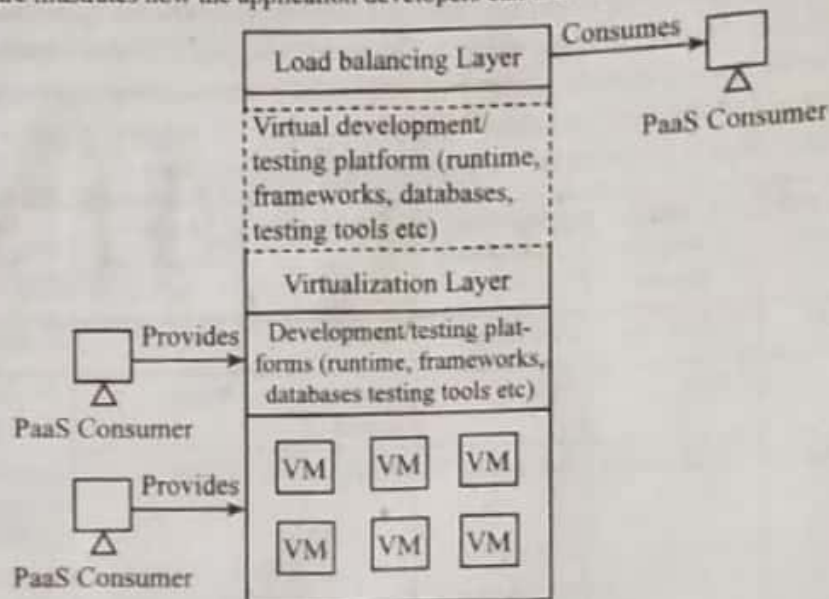The following figure illustrates how the application developers can use the PaaS services over the internet,

Figure: Overview of PaaS

PaaS supports online application development and enables the developers to deploy application on the same platform. Additionally, it minimizes the overhead of buying and managing various tools for application development.

The typical providers of PaaS provide various services like,

(i) Programming Languages

The providers of PaaS supply various programming languages for developing applications to the application developers. Java, Perl, PHP, Python, Ruby, Scala, Clojure and Go are some of the programming languages that are provided by PaaS.

(ii) Application Frameworks

PaaS vendors make development of application easy by providing application framework to the developers. Node.js, Rails, Drupal, Joomla, WordPress and so on are few of the frameworks supported by PaaS.

(iii) Database

As it is necessary for every application to interact with the database, it is an essential tool for each application. PaaS providers provide databases along with their platforms. ClearDB, PostgreSQL cloudant, Membase, MongoDB and Redis are the popular databases supported by PaaS vendors.

(iv) Other Tools

The PaaS providers provide all the tools that are necessary for developing, testing and deploying an application.
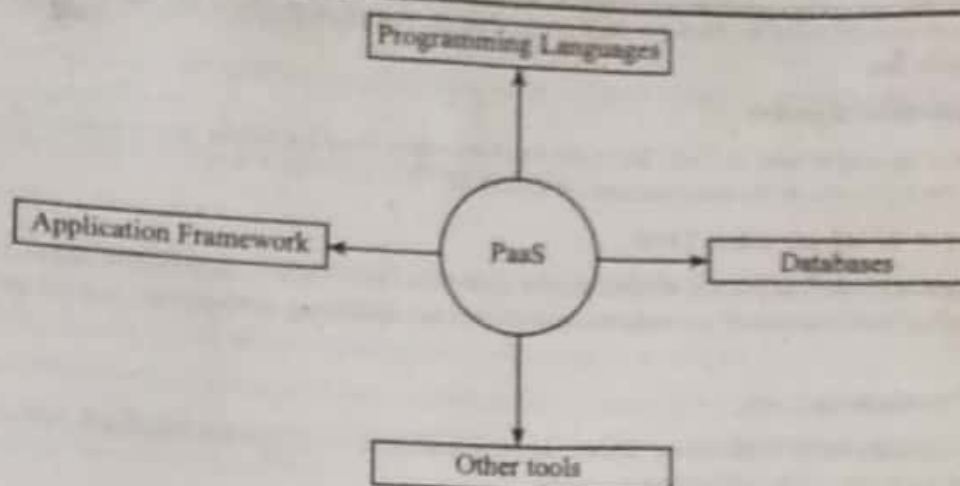
Figure: Services Offered by PaaS Providers

Characteristics of PaaS

1. It has the ability of providing services that are responsible for developing, testing, deploying as well as managing web application so as to support the application development life cycle.

2. It comprises web based user interface creation tools which are usually used for simplifying the process of creating user interfaces that are basically dependent on standards like HTML and JAVA script.

3. It supports multitenant architecture due to which the developer need not worry about concurrent image of some application.

4. It support services for,

    (i) Carrying out concurrency management

    (ii) Ensuring scalability and security.

5. It supports SOAP and other interfaces which allow integration of web servicing and databases. This integration enhances the productivity of Paas offering by creating and sharing the code with adhoc predefning or distributed team. In addition to this, the integrated Paas offering even enables the developer to have much knowledge about the actual works of application as well as behavior of the users.

4.6 SUITABILITY OF PaaS

Q20. Write about the situations where PaaS can be suitable option and may not be a suitable option.

Answer :

Model Paper-II, Q8(b)

The following are the various situations where PaaS is a suitable option,

(i) Collaborative Development

Inorder to acquire more details about the market and gain development efficiency it is necessary for the application development team and state holders to work together with one another. Therefore, as PaaS supports a collaborative environment it is suitable for the applications that require collaborative development.

(ii) Automated Testing and Deployment

When application development is required to be carried in short period of time then automated testing and deployment capabilities play a vital role. This is because automated tools consumes very less amount of time when compared to manual testing tools. Since, PaaS supports automated testing and application deployment it serves as a best option when applications

(iii) Time to Market

The services provided by PaaS employ iterative incremental development methodologies to make sure that the application is available in the market within the time provided. Thus, PaaS service serves as the suitable option when an application vendor wants their application to beat the earliest in the market.

Although the services provided by PaaS are used immensely in various application development process, it may not be suitable in few situations like,

(i) Frequent Application Migration

Vendor lock-in is the major issue in PaaS. Since the PaaS providers does not follow any common rules, migration of an application from one PaaS provider to the other becomes tedious task.

(ii) Customization at the Infrastructure Level

Some of the application development platforms require customization of underlying infrastructure or configuration at the hardware level. But, since PaaS does not hold complete control over the underlying infrastructure it is not best option to go for PaaS.

(iii) Flexibility at the Platform Level

PaaS supports template-based applications wherein several databases, programming languages and message queues are predefined. Thus, PaaS suits only if the application is generic.

(iv) Integrating with On-premise Application

Sometimes, a company may employ PaaS services for a few set of applications and on-premise platforms for rest of the applications. But, since PaaS uses its own proprietary methodologies for defining an application stack it might not match with the on-premise application stack. As a result, it becomes difficult to integrate on-premise platform and PaaS platform. So, PaaS is not suitable in such situations.

4.7 PROS AND CONS OF PaaS

Q21. List out the Pros and Cons of PaaS.

Model Paper-I, Q9(b)

Answer :

Pros and Cons of PaaS

The PaaS is preferred by many organization. This is because it helps in easy maintenance of Platform and underlying infrastructure without rising any complexities in this regard. Due to this feature, the developer started implementing important functionalities of an application through PaaS. Some of the benefits of PaaS are as follows,

1. Easy Development and Deployment

The PaaS substantiates the development and provides testing tools to carryout testing, deployment of software and designing at one place.

Once the designing process is set the PaaS services automate the process of testing and deployment. In comparision to traditional development platform, this PaaS increases the speed of application development and deployment.

2. Miniming the TCO

The PaaS services rules out the requirement of licensed development and testing tools when developers prefers PaaS.

The traditional development platforms increases the TCO of application development company because it operates on sophisticated infrastructure. But in contrast to this, with PaaS the developers can rent the software, development platforms and testing tools. This assist them for development, building and deploying the applications. So, PaaS don't need any sophisticated infrastructure for the application development.

Thereby, it minimizes the TCO of development company.

3. Sustaining Agile Software Development

The PaaS services offers agile methodologies so as to design the new generation applications. This designing was adopted by various ISVs and SaaS development compromises to develop the application.

The PaaS incorporated this feature as most of the new-generation applications are designed by implementing the agile methodologies.

4. **Collaboration of Different Teams for Work**

The PaaS services being together developers to work collaboratively on same project. But, such facility is not provided in traditional development platforms.

The PaaS encompasses online common development platform.

5. **Easy in Use**

The PaaS services facilitates wide variety of client tools which includes CLI, Web CLI, Web UI, APIs and IDEs. Also, it gives the opportunity to the developers to select client tools based upon their requirements. In particular, web UI-based PaaS services enhances the usability of development platform for many types of developers.

On the other hand, the traditional development platform implements either CLI or IDE-based interface for carrying out development. Here, few developers stay unaware of the interfaces used by the application development platform. As a consequence the task of development becomes complicated.

6. **Low Maintenance Overhead**

The PaaS services are responsible for eliminating the overhead. The development company or software vendors corresponding to on-premise applications has to maintain the hardware which is functional. This rises the requirement for hiring highly skilled administrators for server maintenance. Thus creating an overhead in the development. So, PaaS services operate on it, same as underlying infrastructure is maintained using infrastructure providers. Due to this step, the developers can seamlessly work on development of application.

7. **Generates Scalable Applications**

PaaS services mostly develop applications such as web application or SaaS application. They are scalable in nature and handle extra load. This feature is maintained by implementing additional servers.

But his step presents difficulties in maintaining additional servers for new-startup companies. Through PaaS services, these companies can incorporate scalability because PaaS provides built-in scalability feature to the application developed using PaaS Platform.

Despite of having so many benefits the PaaS services has few drawbacks. They are,

1. The PaaS services do not provide standards to which the problem of vendor lock-in arises. The different PaaS providers follow different standards, there is no common standard followed. Apart from this, another reason for vendor lock-in is proprietary technologies implemented by PaaS providers. The proprietary technology used by one PaaS vendor is not compatible with other PaaS providers.

    Due to vendor lock in problem, the application fails to migrate from provider to other.

2. The PaaS services does not provide security in the cloud. This is due to the fact that the data is stored in off-premise third-party servers and the developers never prefer such platform.

    Many PaaS providers do offer security to their data, but it does not cover the safety of on-premise deployment this issue can partially be addressed, if developer selects a proper PaaS provider and the provider should be reviewed prior to the selection. The developer using their own security requirements must look into certain factors like regulatory, compliance and security policies of PaaS provider. If this is ignored then the developers and also the user are under the threat of security breach.

3. The PaaS service providers does not facilitates high flexibility. In simple terms, it does not permits the developers to define their own application stack. Although, many PaaS providers offer various programming languages, databases and other development tools. But they are not extensive and fails to meet all developers requirements.

    Moreover, few PaaS providers permit the developers to extend their PaaS tools by incorporating new programming languages.

4. The PaaS services are highly dependent on internet and delivers services over the internet. So, for this the developers must have Internet connection while developing the application. Many PaaS providers does not support offline access.

    Thus, the slow Internet connection, the usability and efficiency of PaaS platform does not meet the developer requirements.

4.8 SUMMARY OF PaaS PROVIDERS

Q22. Give the summary of PaaS providers.

Answer :

Summary of PaaS Providers

The PaaS providers operates in both IT market for public and for private clouds also. The summary for both private and public PaaS providers includes,

Summary of Popular PaaS Providers

1.
Provider	–	Cloud foundry.
License	–	Open source and proprietary
Deployment Model	–	Public
Supported Languages	–	Python, PHP, Java, Groovy, Scala and Ruby
Supported Frameworks	–	Spring, Grails, Play, Node.js, Lift, Rails, Sinatra and Rack
Support Databases	–	MySQL, PostgreSQL, MongoDB and Redis
Client Tool	–	cf. CLI, IDEs, and build tools.

2.
Provider	–	Google App Engine
License	–	Proprietary
Deployment Model	–	Public
Supported Languages	–	Python, Java, Groovy, JRuby, Scala, CLojure, Go and PHP.
Supported Frameworks	–	Django, CherryPy, Pyramid, Flask, Web2py, Webapp2
Supported Databases	–	Google Cloud SQL, Datastore, BigTable, Blobstore
Client Tools	–	APIs

3.
Provider	–	Heroku
License	–	Proprietary
Deployment Model	–	Public
Supported Languages	–	Ruby, Java, Scal, CLojure, Python, PHP and Perl
Supported Frameworks	–	Rails, Play, Django, Node.js
Supported Databases	–	Clear DB, PostgreSQL, Cloudant, Membase, MangoDB, Redis
Client Tools	–	CLI and RESTful API

4.
Provider	–	Microsft Windows Azure
License	–	Proprietary
Deployment Model	–	Public
Supported Languages	–	.Net, PHp, Python, Ruby and Java
Supported Frameworks	–	Django, Rails, Deupal, Joomla, WordPress, DotNetNuke and Node.js.
Supported Databases	–	SQL Azure, MySQL, MongoDB and CouchDB
Client Tools	–	RESTful API and IDEs

5. Provider   – Red Hat OpenShift Online
    License   – Proprietary
    Deployment Model   – Public
    Supported Languages   – Java, Ruby, Python, PHP and Perl
    Supported Frameworks   – Node.js, Rails, Drupal, Joomla, WordPress, Django, EE6, Spring, Play, Sinatra, Rack and Zend
    Supported Databases   – MySQL, PostgreSQL and MongoDB
    Client Tools   – Web OI, APIs, CLI and IDEs

6. Provider   – Active State Stackato
    License   – Proprietary
    Deployment Model   – Private
    Supported Languages   – java, Perl, PHP, Python, Ruby, Scala, CLojure and Go.
    Supported Frameworks   – Spring, Node.js, Drupal, Joomla, WordPress, Django, Rails and Sinatra
    Supported Databases   – MySQL, PostgreSQL, MangoDB and Redis
    Client Tools   – CLI and IDEs

7. Provider   – Apprenda
    License   – Proprietary
    Deployment Model   – Private
    Supported Languages   – .Net and Java
    Supported Framework   – .Net
    Supported Databases   – SQL server
    Client Tools   – REST APIs

8. Provider   – Cloud Bees
    License   – Proprietary
    Deployment Model   – Private
    Supported Languages   – Java, Groovy and Scala
    Supported Frameworks   – Spring and Geails, jRails, jRuby
    Supported Databases   – MySQL, PostgreSQL, MangoDB and CouchDB
    Client Tools   – API, SDK and IDEs

9. Provider   – Cumulogic
    License   – Proprietary
    Deployment Model   – Private
    Supported Languages   – Java, PHP and Python
    Supported Frameworks   – Spring and Geails
    Supported Databases   – MySQL, MongoDB and Couchbase
    Client Tools   – RESTful API

10.	Provider	–	Gigasspaces cloudify
	License	–	Open Source
	Deployment Model	–	Private
	Supported Languages	–	All programming languages defined by recipe
	Supported Frameworks	–	Rails, Play and other
	Supported Databases	–	MySQL, MongoDB, Couchbase, Cassandra
	Client Tools	–	CLI, Web UI and Rest API

4.9 SOFTWARE AS A SERVICE, CHARACTERISTICS OF SaaS

Q23. Give the overview of SaaS.

Answer :

Software as a Service (SaaS)

The traditional method of delivering the software was strictly license-based. That is, the license base product should be installed at end-user device so as to get the software. So, it can be said that SaaS is delivered as on-demand service across the Internet. In simple terms, the developer i.e., end user's device does not need to install the software. Due to this fact, the services of SaaS is accessible at any time and based upon the needs the end user can disconnect the services. Also, the accessibility of SaaS services can be made any light weighted web browser running upon devices like laptops, tablets and smartphone.

The thin-client which does not hold storage space and also cannot run software like how traditional desktop PCs can run, highly support the SaaS services. The benefits of running the SaaS services on thin-clients include,

1. Low vulnerability to attack
2. Longer life cycle
3. Consumes less power
4. Less expensive.

Ideally, the SaaS provider offers the following services.

(i) Business services

(ii) Social networks

(iii) Document management

(iv) Mail services.

(i) Business Services

Many start-up companies were benefitted with the implementation of SaaS services. This is because, they provided variety of business services which includes ERP, CRM, billing, sales and human resources.

(ii) Social Networks

Many social networking sites implements SaaS services because it shows high sustainability. As social networking site is extremely used by general public and their use is increasingly exponential, the cloud computing is highly recommended for managing the variations in load.

(iii) Document Management

Many SaaS providers offer services like creating, managing and tracking electronic documents. Due to this capability many enterprises operating on electronic documents prefers SaaS services.

(iv) **Mail Services**

Many people uses E-mail services and its unpredictable number of users and load on servers can be handled by SaaS services seamlessly.
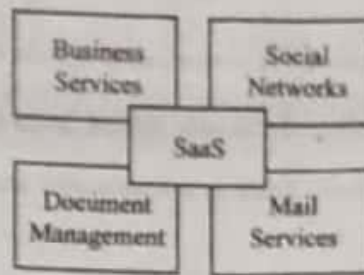

Figure: Services of SaaS Providers

Q24. Discuss the characteristics of SaaS.

Answer :

Characteristics of SaaS

In comparision to traditional software SaaS services are highly beneficial to the users and developers. Some of the characteristics given below makes it unique from others,

(i) One-to-many

(ii) Web access

(iii) Centralized management

(iv) Multi-device support

(v) Better scalability

(vi) High availability

(vii) API integration.

(i) **One-to-many**

It supports one-to-many model. Here, single application is shared by one or many customers.

(ii) **Web Access**

It supports web access to the software. In simple terms with this, the end users can easily get access to application. Also, it is independent of the user location provided if the device is connected to the location.

(iii) **Centralized Management**

It supports the management and host development of the services from central location. This makes the management of SaaS application easy.

It ensures automatic updates with which every single tenant can access the updated version of application without the support of user-side updates.

(iv) **Multidevice Support**

It supports the access from any end-user devices such as desktops, laptops, tablets, smart phones and thin client.

(v) **Better Scalability**

It supports operations even under varying loads. With dynamic scaling of underlying cloud resources, the SaaS applications works even more efficient.

Therefore, in comparision to PaaS and IaaS adopted for development and deployment, SaaS encompasses high scalability,

(vi)   High Availability

It supports proper backup and recovery mechanisms, thus making user data 99.99% available for the developers.

(vii)   API Integration

It supports the integration with various software or services using standard APIs.

4.10   SUITABILITY OF SaaS, PROS AND CONS OF SaaS

Q25. Describe the various situations where SaaS is suitable and also the situations where it may not be suitable.

Answer :

Suitability of SaaS

The benefits provided by SaaS makes it suitable for individuals and start-up companies. The users of traditional software are now transforming to SaaS versions of software for better efficiency.

SaaS applications are preferred for the following reasons,

(i)   On-demand Software

The licensing-based software model is applicable provider if the developer buys complete packaged software. This increases the spending of software purchase. Also, software used rarely does not offer any ROI. Due to which many developers are opting for an option (software) which they can use when needed. This makes, the on demand software most preferred one, in comparision to licensing-based full term software. Therefore, SaaS model offers this facility seamlessly.

(ii)   Software for Start-up Companies

The use of traditional software makes the developers to buy devices having least requirements given by the vendors. So, for start-up companies this becomes an expenditure for buying hardware.

This problem can be solved by implementing SaaS services which provides suitable option for start-up companies, rather than providing high-end infrastructure. Therefore, minimizing the initial expenditure on purchasing the high-end hardware.

(iii)   Software Compatible with Multiple Devices

The applications such as word processors and mail services demands better accessibility on different devices. So, SaaS applications are best suited with every device.

(iv)   Software with Changing Loads

The quantity of load given on applications such as social networking cannot be measured. Also, the user has the authority to connect or disconnect from application.

The variation in loads presents lots of difficulties in traditional infrastructure. This problem can be solved with SaaS applications having dynamic scaling capabilities. They manages the varying loads effectively and at the same time without disturbing the normal functioning of the application.

Disadvantages

It is known fact that traditional software vendors are transforming to SaaS business because it is fastly emerging software delivery model. So, the users are highly attracted to this.

Situations Where SaaS is not be Suitable

Also, it is important to known that SaaS is not a best option for the following reasons,

1.   Real-time Applications

The SaaS applications do not work well with low speed Internet because it is an Internet based application. On top of this, if the end-user is situated far away form the stored data then latency issues may arise and can delay the data retrieval timings.

The SaaS applications do not support real-time applications as they demand fast processing of data. This is due to the fact that it depends on high-speed Internet connectivity and latency issues.

2. **Applications with Confidential Data**

The SaaS applications barely provides data security, data governance and data compliance. This is because the data is stored with third-party service providers, so no security is provided to the data.

But, in case if the stored confidential data is lost then it is impossible for the organization to retrieve it. This is in situation if the organization has SaaS applications.

3. **Better On-premise Application**

The SaaS model may not be helpful in situation when on-premise applications fulfills all the requirements of the organization.

Q26. Mention the Pros and Cons of SaaS.

Answer :

Pros (Benefits) of SaaS

The SaaS applications are highly cost-effective and are preferred by many individuals and start-up companies. In addition to this, the SaaS offers the following more benefits,

1. **No Client-side Installation**

The SaaS services rule out the need of client-side installation of the software. This is because the end-user has direct access to the services from the service provider data center. This does not need any installation.

Also, the SaaS services operates on simple and cost-effective hardware. So, its accessibility becomes easy through clients or any handheld devices. Thus, minimizing the initial expenditure made on high-end hardware.

2. **Cost Saving**

The SaaS services operate on utility-based billing or pay-as-you-go billing basis. With this, the user has to pay for the service they are utilizing.

The SaaS providers has different subscription plans with which different customers can take advantage. It is also possible that the word-processors which is generic SaaS services is provided free for the users.

3. **Low Maintenance**

The SaaS services removes the problem of additional overload in maintaining the software at client-side. For instance, end-user operating in traditional software performs huge number of updates. On the other hand, the service provider in SaaS performs auto updation, monitoring and various other maintenance activities in applications.

4. **Ease of Access**

The SaaS services are accessible from any devices. The internet connection is necessary and the accessibility can be made through any device.

5. **Dynamic Scaling**

The SaaS services are highly elastic, dynamically scaling in nature. In contrast to this, the on premise software lacks dynamic scaling capability due to the additional requirements of hardware.

The SaaS services offers elastic resources given by cloud computing for handling load variation. This property of elasticity can be carried out without distributing the normal operation of application.

6. **Disaster Recovery**

The SaaS services performs backups and recovery mechanisms. Also, replicas are made for every single SaaS services. These replicas are segregated among various servers. This is helpful in situation of server failure where in the end user makes use of SaaS from other servers.

Thus, removing the problem of single point of failure. Subsequently, it assures high availability of application.

7.   Multitenancy

The SaaS service offers multitenancy to the end-users, where one instance of application is shared among the many end-users. It improves resource utilization at service provider side.

Cons (Drawbacks) of SaaS

The main drawback of SaaS services is lack of security. Due to this, SaaS preference by many industries is very less. Some of the issues with SaaS services are,

1.   Security

The migration of data to SaaS application compromises the security. This is because, the application is shared among multiple end users and there is high risk of data leakage. As the data is stored in service provider data center, serious trust issues from third-party service provider arises.

There is likelihood that company's sensitive and confidential data can be stolen. So, it is responsibility of end user to carefully choose the SaaS provider inorder to avoid loss of data.

2.   Connectivity Requirements

SaaS applications are highly internet dependent. End-user need to have internet connection in order to access applications. But if the connection is slow, the user cannot access the services easily. This causes lots of problems.

3.   Loss of Control

SaaS services are stored in third-party and off-premise location. So, if the location is far away from user, then he or she may not have control over the data.

In comparision to on-premise application, the extent of control over SaaS application data is less.

4.11 SUMMARY OF SaaS PROVIDERS

Q27. Give the summary of SaaS providers.

Answer :

Summary of SaaS Providers

SaaS services are provided by many SaaS providers such as ERP, CRM, billing, document management and mail services.

The summary of SaaS vendors in the market includes,

	Providers	Services Provided
1.	Salseforce.com	On-demand CRM solutions.
2.	Google Apps	Google Calender, Talk, Docs, sites and Gamil.
3.	Microsoft Office 356	Software, plus services, on line office suite.
4.	Netsuite	ERP, accounting, inventory, order management, CRM, Professional Services Automation (PSA) and e-commerce applications.
5.	Concur	Integrated travel and expense management solutions.
6.	GoTo meeting	Desktop sharing, online meeting and video-conferencing software.
7.	Constant contact	Social-media marketing, E-mail marketing, online survey, event marketing, digital store-fronts and local deals tools.
8.	Workday, Inc	Payroll, Human capital management, financial management.
9.	Oracle CRM	CRM applications.
10.	Intacct	Financial management and accounting software solution.

4.12 OTHER CLOUD SERVICE MODELS

Q28. Discuss in detail about other cloud service models.

Answer :

The start up companies and individual companies implement basic cloud services such as IaaS, PaaS and SaaS. This makes the cloud computing most dominant technology in the IT world.

The basic cloud services are highly utilized and the end users get awareness of these benefits in the form of services such as network, storage and database. Ideally, the basic cloud service model consist of unified models which offers multiple services in it. With the transformation of user's expectations, the individual services are acquired through service providers. As a result, many service provider prefers individual services which fulfill their requirements. So, most of the services providers have already initiated the task of offering separate services including network, desktop, database and storage on demand. This is given as follows,

1. NaaS

NaaS can be specified as the ability of the end-users to get access of virtual network services. These services are offered by service provides. In a way similar to other cloud service models, NaaS is a complete business model meant to deliver the virtual network service across the Internet. This service is done on pay-per-use basis. On the other hand, in on-premise data center, large amount of money is spent by IT-industries to get access or purchase network hardware for operating in-house networks. Although, if this is done the cloud computing changes the networking services into utility-based service.

With NaaS, the architects and developers can develop virtual networks, virtual Network Interface Cards (NICs), virtual routers, virtual switches and networking components. In addition to this, it permits the architects to enforce custom routing protocols and also enabling the design of efficient in network services. These services include data aggregation, stream processing and caching.

Other services offered by NaaS are virtual private network (VPN), Bandwidth on Demand (BoD) and mobile network virtualization.

2. Desktop as a Service (DEaaS)

DEaaS can be specified as an ability of the end-users to access desktop virtualization. They have this facility face of cost and does not have to manage or buy the infrastructure. Ideally, DEaaS is a pay-per-use cloud service delivery model. Here, the service provider controls the back-end responsibilities which includes data storage, backup, security and updation.

Moreover, the end users are allowed to manage their own desktop images, applications and security. The virtual desktop access provided by DEaaS can be independent of device, location and network.

The services provided by the DEaaS are easy to enforce, highly secure and give better experience on all devices.

3. STaaS

STaaS can be specified as the ability of the end-users to store the data on the storage services given by the service provider. In particular, the role of the STaaS is to permit the end-users to use the files at any where irrespective of the time.

The STaaS provider facilitates the virtual storage taken from physical storage of any cloud data center. As STaaS is also considered as cloud business model which is used in the form of utility. The STaaS is referred as backup storage, effective at the time of disaster recovery. Due to this fact, the customers or users can rent the storage from STaaS provider.

4. DBaaS

DBaaS can be specified as the ability of the end-user to use the database services. This eliminates the need of installation and maintenance of the database.

In this particular, the task of installation and maintenance is undertaken by service providers. Subsequently, the end-users have direct access to the services and the respective payment is made based upon the usage.

The entire process of database administration is simplified and automated by DBaaS. Using any API or web UIs given in the service provider, the end users can get access to the services seamlessly.

Examples

It includes simpleDB, DynamoDB, MongoDB as a Service, GAE datastore and ScaleDB.

5. Data as a Service (DaaS)

DaaS can be specified as the ability of the end users to attain access to the data. This data is facilitated by the service provider on the Internet. Similar to SaaS, the DaaS also works by providing data on demand. This data can be text, images, sounds and videos.

Due to its similarities with SaaS and STaaS, the DaaS can be collaborated with SaaS or STaaS so as to offer a composite service. Some of the benefits of DaaS include its agile nature, cost-effectiveness and data quality.

6. SECaaS

It can be specified as an ability of end users to attain access to security services. These services are facilitated by service provider on pay-per-use basis. Here, the SECaaS benefits the end users by combining their security services.

In particular, the SECaaS encompasses authentication, antivirus, antimalware/spyware, intrusion detection and security event management. Here, the services are used for securing the on-premise or in-house infrastructure and applications.

Example

The SECaaS includes Ciso, MCAfee, Panda Software, Symantec, Trend Micro and Verisign.

7. IDaaS

The IDaaS can be specified as the ability of the end-users to attain access to authentication infrastructure controlled by the third-party service provider. Here, the end-user corresponding to IDaaS is an organization or enterprise.

Moreover, with IDaaS services, the organization can seamlessly manage employees identity. This task does not given any additional overhead. Task which comes under IDaaS are, directory services, federated services, registration, authentication services, risk and event monitoring, single-sign-on services, identity and profile management.