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Cloud Computing

By

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Introduction

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PART-1

Introduction to Cloud Computing, Definition of Cloud, Evolution of Cloud Computing.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 1.1. **What do you mean by cloud computing ? Also, give its properties.**

Answer

1. Cloud computing is the means of delivering all IT from computer applications, software, business processes, messaging, and collaboration to end users as a service wherever and whenever they need it.
2. Cloud computing is a paradigm for delivering IT where rapid provisioning is an important characteristic for computing resources, data applications and IT.
3. Cloud computing helps us to face the challenges such as :
   i. Decreasing the capex and opex cost.
   ii. Enhancing the service quality.
   iii. Maintaining the desired and right level of security, compliances, regulations, and policies across the different functions of enterprise.
   iv. Rapid provisioning, agility, and business transparency for consistent self-service delivery.
4. Thus, cloud computing is the service and deployment model using large resource pool based provisioning of virtual or physical resources in a service model using the internet (public cloud) or intranet (private cloud).

Properties of cloud computing are :

1. **User centric :** This means once a user is connected to cloud any data, such as images, videos, applications, becomes his property. Not only the data but the devices connected to it and the user can share it with other users.
2. **Task centric :** Cloud computing focus on what one need and how application can do it. Here documents are given more priority than the applications which create them.

3. **Self healing :** In self healing, backups are available for every document in the cloud. Hence, if one document crashes there will be its duplicate ready to run.

4. **Multi-tenancy and intelligence :** Multi-tenancy refers to sharing of data and costs across a large pool of users. As various data are stored in cloud, data mining and analysis are necessary for accessing information in an intelligent manner.

5. **Programmable :** Many processes in cloud computing shall be automate such as backing up crashed data with its duplicate. Hence, programming is associated with cloud computing.

6. **Flexible :** Flexible as the users may be of different varieties and hence it has to match with their needs.

Que 1.2. **What are the advantages and disadvantages of cloud computing ?**

Answer

Advantages of cloud computing :

1. **Cost saving :** It helps us to save substantial capital cost as it does not need any physical hardware investments.

2. **Strategic edge :** Cloud computing helps us to access the latest applications any time without spending our time and money on installations.

3. **High speed :** Cloud computing allows us to deploy our service quickly in fewer clicks. This faster deployment allows us to get the resources required for our system within fewer minutes.

4. **Reliability :** Through cloud computing we can always get instantly updated about the changes.

5. **Mobility :** Employees who are working on the premises or at the remote locations can easily access all the cloud services. All they need is internet connectivity.

6. **Unlimited storage capacity :** Cloud computing offers limitless storage capacity.

Disadvantages of cloud computing :

1. **Performance can vary :** When we are working in a cloud environment, our application is running on the server which simultaneously provides resources to other businesses that can affect the performance of our shared resource.

2. **Technical issues :** Cloud technology is always prone to an outage and other technical issues.

3. **Security threat in the cloud :** Before adopting cloud technology, we should be well aware of the fact that we will be sharing all our company's sensitive information to a third-party cloud computing service provider. Hackers might access this information.

4. **Internet connectivity :** Good internet connectivity is must in cloud computing. We cannot access cloud without an internet connection.

5. **Lack of support :** Cloud computing companies fail to provide proper support to the customers. Moreover, they want their user to depend on FAQs or online help, which can be a tedious job for non-technical persons.

Que 1.3. **Explain vision of cloud computing.**

Answer

1. Cloud computing provides the facility to provision virtual hardware, runtime environment and services to a person having money.

2. These all things can be used as long as they are needed by the user.

3. The whole collection of computing system is transformed into collection of utilities, which can be provisioned and composed together to deploy systems in hours rather than days, with no maintenance costs.

4. The long term vision of a cloud computing is that IT services are traded as utilities in an open market without technological and legal barriers.

5. In the future, we can imagine that it will be possible to find the solution that matches with our requirements by simply entering out request in a global digital market that trades with cloud computing services.

6. The existence of such market will enable the automation of discovery process and its integration into its existing software systems.

7. Due to the existence of a global platform for trading cloud services will also help service providers to potentially increase their revenue.

8. A cloud provider can also become a consumer of a competition service in order to fulfill its promises to customers.

Que 1.4. **List the major categories of parallel computing systems.**

Answer

Categories of parallel computing systems :

i. **Bit level parallelism :** It is a form of parallelism which is based on increasing processors word size. It shortens the number of instructions that the system must run in order to perform a task on variables which are greater in size.

ii. **Instruction level parallelism :** It is a form of parallel computing in which we can calculate the amount of operation carried out by an operating system at same time. For example :

1. Instruction pipelining
2. Out of order execution
3. Register renaming
4. Speculative execution
5. Branch prediction

Que 1.5. **Discuss the issues related to cloud computing.**

Answer

Several issues related to cloud computing are :

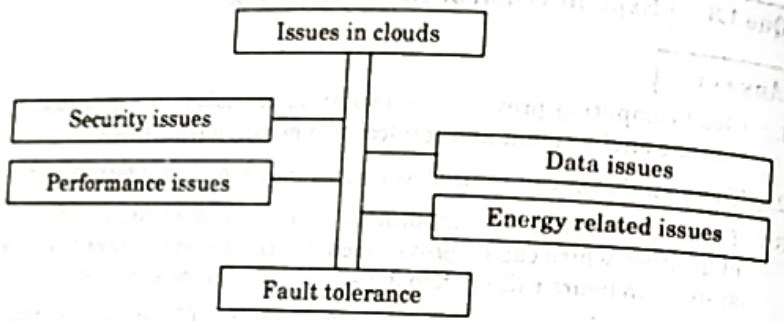

Fig. 1.5.1.

Security issues : Some of the security problems which are faced by the cloud computing are as follows :

1. **Data integrity :** When a data is on a cloud, anyone from any location can access those data from the cloud. Cloud does not differentiate between a sensitive data from a common data thus enabling anyone to access those sensitive data. Thus there is a lack of data integrity in cloud computing.
2. **Data theft :** Most of the cloud vendors instead of acquiring a server try to lease a server from other service providers because they are cost effective and flexible for operation.
3. **Security on vendor level :** Vendor should make sure that the server is well secured from all the external threats it may come across. A cloud is good only when there is good security provided by the vendor to the customers.
4. **Security on user level :** Even though the vendor has provided good security layer for the customer, the customer should make sure that because of its own action, there should not be any loss of data or tampering of data for other users who are using the same cloud.
5. **Information security :** Security related to the information exchanged between different hosts or between hosts and user. This issues pertaining

to secure communication, authentication, issues concerning single sign on and delegation.

Data issues : Various data issues in cloud computing are as follows :

1. **Data loss :** If the vendor closes due to financial or legal problems there will be a loss of data for the customers. The customers will not be able to access those data because data is no more available for the customer as the vendor shut down.
2. **Data location :** When it comes to location of the data nothing is transparent even the customers do not know where his own data are located. The vendor does not reveal where all the data are stored. The data will not even be in the same country of the customer, it might be located anywhere in the world.
3. **Data lock-in :** Software stacks have improved interoperability among platforms, but the APIs for cloud computing itself are still essentially proprietary, or at least have not been the subject of active standardisation. Thus, customers cannot easily extract their data and programs from one site to run on another.
4. **Data segregation :** Data in the cloud is typically stored in a shared environment whereby one customer's data is stored alongside another customer's data, hence it is difficult to assure data segregation.
5. **Data confidentiality and auditability :** Current cloud offerings are essentially public (rather than private) networks, exposing the system to more attacks. Auditability could be added as an additional saver beyond the reach of the virtualized guest OS providing facilities arguably more secure than those built into the applications themselves and centralizing the software responsibilities related to confidentiality and auditability to a single logical layer.
6. **Data integrity :** One of the biggest concerns with cloud data storage is the verification of data integrity at untrusted servers, and how to deal with sensitive data. It is not an easy task to maintain customer's most sensitive cloud data securely, which is needed in many applications for clients.
7. **Deletion of data :** Data that has to be deleted by the user because he or she no longer needs it or many no longer process it for another reason is also deleted by the provider and no more copies of data are available. This can lead to problems, particular in connection with backups.
8. **Service level agreements :** According to the purpose for which the data is processed, it is important to agree on binding service levels for availability and data recovery and if necessary, safe guarded by supporting fixed penalties in the event of non-compliance with the agreed service levels.

Various performance issues in cloud computing are :

1. **Poor application performance or application hang-ups :** Usually the application is starved for RAM or CPU cycles, and faster processors or more RAM is added.
2. **Slow access to applications and data :** Bandwidth is usually the cause, and the most common solution is to add faster network connections.
3. **Horizontal and vertical scalability :**
   i. **Vertical scaling :** Vertical scaling (up) entails adding more resources to the same computing pool.
   ii. **Horizontal scaling :** Horizontal scaling (out) requires the addition of more machines devices to the computing platform to handle the increased demand. Sustained increases in demand, however, require horizontal scaling and load balancing to restore and maintain peak performance.

Energy related issues : Various energy related issues are as follows :

1. Cloud computing is rapidly growing in importance as increasing numbers of enterprises and individuals are shifting their workload to cloud service providers.
2. The electricity costs involved in operating a large cloud infrastructure of multiple data centres can be enormous. In fact, cloud service providers often must pay for the peak power they draw, as well as the energy they consume.
3. Lowering these high operating costs is one of the challenges facing cloud service providers.
4. Insufficient or malfunctioning cooling system can lead to overheating of the resources reducing system reliability and devices lifetime.
5. High power consumption by the infrastructure leads to substantial carbon dioxide (CO_2) emission contributing to the greenhouse effect.

Fault tolerance :

1. Fault tolerance is one of the key issues of cloud computing. Fault tolerance is concerned with all the techniques necessary to enable a system to tolerate software faults.
2. These software faults may or may not manifest themselves during systems operations, but when they do, software fault tolerant techniques should provide the necessary mechanisms of the software system to prevent system failure occurrences.
3. Fault tolerance techniques are employed during the procurement, or development, of the software. When a fault occurs, these techniques provide mechanisms to the software system to prevent system failure from occurring.

Que 1.6. **What are the hurdles in cloud computing ?**

Answer

Hurdles in cloud computing :

1. **Security :**
   i. As the services are opened and delivered over the network between the cloud service provider and the consumer, the security in this model is perceived at higher levels.
   ii. Other inhibitors can be location-independent resource pooling where consumer does not know where his services are running or where his data is stored.
   iii. Limited service management and monitoring capabilities in the public cloud model also added to the complexities.
2. **Regulation and compliances :**
   i. There is a need of data governance models to be established in the enterprises and federating data privacy.
   ii. In large organizations, IT delivery is taken with the concerns of reliability, performance, and availability.
   iii. There are different levels of maturities for organizations seeking different levels of Service Level Agreements (SLA) but cloud service providers are not equipped to deliver the services.
   iv. There is a need of stringent Recovery Point Objective (RPO) and the Recovery Time Objective (RTO) with the agreed number of mins/hours down-time.
3. **Cloud migration :**
   i. This requires the property of powerful interoperability of platforms that should identify the appropriate application that can be migrated to the cloud.
   ii. It is important to identify the interdependencies and integration points with standards and interfaces that are lacking among service providers.
   iii. Cloud migration becomes more complex if the service bundles are integrated from multiple cloud service providers. This can also become the deal breaker or the reason for downgraded performance.
4. **Workload suitability for cloud :**
   i. Not all the applications are suitable candidates for the cloud.
   ii. It depends on the function of the business, enterprise policies, application architecture, scalability, suitability, usage patterns according to pay-per-use-model, or infrastructure requirements in the service model.

Que 1.7. **Explain briefly the term cloud.**

Answer

1. Cloud is an extension of the internet with some level of inherent discipline and ethics.
2. Cloud can be thought of unification of information technology with business intelligence.
3. Technology merges virtualization, grid functionalities and web standards as a single utility model which is delivered to the customers over the internet, whereas the business intelligence defines the best cost schemes leading to win-win situation for both the cloud service provider as well as the cloud service consumer.
4. Cloud brokers negotiate the best deals and relationships between the cloud consumers and cloud providers.
5. They can use specialized tools to identify the most appropriate cloud resource and map the requirements of the application to it.
6. Cloud broker services are mainly categorized into three group :
   a. Service intermediation broker provides a service to a consumer that enhances a given service by adding some value on top to increase some specific capability.
   b. Service aggregation brokerage service combines and integrates into one or more services and ensures that data are modelled across all component services and movement, security of data between the service consumer and multiple providers.
   c. Service arbitrage is similar to cloud service aggregation but services being aggregated are not fixed. In addition, these services provide flexibility and opportunity for the service aggregator.

Que 1.8. **What are the components of cloud ?**

Answer

Components of cloud :

1. **Cloud service consumer (or end user) :**
   i. Cloud service consumers are the end users known as clients, which interact with the system and demand for services as per their requirement.
   ii. The client can be categorized into the following three categories :
      a. **Mobile clients :** Mobile clients run the application from laptops, PDAs and smart phones. This category of clients demands for higher speed and high level of security.

      b. **Thin clients :** Thin clients neither have hard drives nor have DVD ROM drives, and largely depend on the server.
      c. **Thick clients :** Thick clients are self-sufficient in terms of accessories.
2. **Cloud service provider :**
   i. Cloud service providers are the agents which host the servers in the cloud and deliver service to the end users.
   ii. The major cloud providers are Google, Amazon, Sales Force, IBM, Microsoft and Rackspace.
3. **Internet medium :** Internet medium is the communication channel between the consumer and provider where services are redirected.
4. **Datacentre :**
   i. Datacentre is the collection of servers where the applications subscribed are housed.
   ii. It consists of storage, network, and server.

Que 1.9. **Give the characteristics of cloud.**

Answer

Characteristics of cloud are :

1. **Self-service on-demand :** As a cloud consumer, users are privileged to request and provision computing capabilities bundled with services with or without approval process powered by automation and workflows.
2. **Ubiquitous network access :** This is the characteristic by which end user and server computing devices can be accessed over the network even using the next generation heterogeneous devices such as smartphone, tablets, thin and thick clients.
3. **Resource pooling :**
   i. This characteristic refers to the pooling of resources across multiple datacenters.
   ii. These pooled virtual datacenters are then divided into multiple pools to provide their services to various consumers in a multi-tenant model.
   iii. These pools can have both physical and virtual resources.
   iv. The devices provided by this pool give the notion of location-independent compute (storage, servers, processing, network bandwidth, virtual machines, etc.), where the consumer does not have control or visibility about the service location and its geography.
4. **Rapid elasticity :**
   i. This characteristic makes the provisioning rapid and elastic.

ii. This provisioning can be automatic and can flex-up and flex-down on the basis of spikes of utilization.

iii. The consumer can view the infinite capacity available as a service, which can be bought at any point of time.

Que 1.10. **What are the challenges in cloud ?**

Answer

Challenges in cloud :

1. **Lack of control :** In case of lack of control, by delegating the IT management to a third party, the service consumer loses the ability to directly control and monitor the execution of the submitted workload.
2. **Security :** For security, trusting a third party to store enterprises confidential data is a source of potential concern and needs to be effectively addressed by the cloud service provider.
3. **Interoperability among multiple service providers :** This leads to avoid vendor lock-in, it is desirable to be able to run the same virtualized application on clouds provided by multiple vendors. Appropriate standards need to be in place for addressing this concern.
4. **Resource management :** The management of computing, storage and other resources in a distributed system is recognized as a 'hard' problem.

Que 1.11. **Explain cloud services.**

Answer

On the basis of user requirements, the cloud infrastructure has given various servicing schemes in order to deliver the utility to the consumers or clients or end users :

a. **Infrastructure-as-a-Service (IaaS) :**

i. Infrastructure-as-a-Service (IaaS) model allows the customer to provision processing, storage, network and other important software such as operating system and applications.

ii. The consumer does not have control over the underlying infrastructure but has control over the operating systems, storage and deployed applications.

b. **Platform-as-a-Service (PaaS) :**

i. Platform-as-a-Service (PaaS) model provides capacity to the customer to deploy the customer-created applications into the cloud infrastructure using the programming language or tools supported by the cloud provider.

ii. The consumer does not manage the underlying cloud infrastructure such as network, storage, etc., but has control over the deployed applications.

iii. It also provides solutions for integrating cloud computing into existing application, services, and infrastructure with a market-oriented approach.

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

i. Software-as-a-Service (SaaS) model enables the customer to use the provided application hosted on the cloud infrastructure.

ii. In this model, the customer does not have any control over the cloud infrastructure but has a little control over the application configuration settings.

iii. The applications are accessible from the client devices such as thin client or web browser interface.

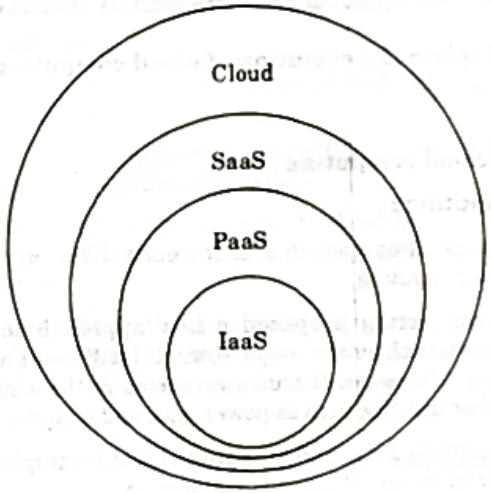

Fig. 1.11.1. Cloud services.

Que 1.12. **List the benefits of cloud.**

Answer

Benefits of cloud :

1. Increased agility on the IT datacenter resources and innovation.
2. Enabling of self-service portal and thus ensure Virtual Machines (VMs) in less lead-times.
3. Adherence of SLAs as the VM lead-times and down-times are significantly reduced.

4. Trial and error configuration tests can be done at ease.
5. Complete control over cloud usage for administrators is possible.
6. Scalability and flexibility allow the IaaS cloud to almost deliver the promise of unlimited IT services on demand.
7. Usage-based payment and not getting billed when the utilization decreases.
8. Significant reduction in the costs for IT datacenter.
9. Dynamic sharing of the resources available in IT datacenter through private cloud so that demands can be met cost effectively.
10. Considerable increase in the utilization of resources of IT datacenter.
11. Increase in the operational efficiency of the resources in the IT datacenter.
12. Achieve a greener datacenter.
13. Support for heterogeneous hardware vendors. Avoids vendor locking.

Que 1.13. Explain the evolution of cloud computing.

Answer

Evolution of cloud computing :

1. **Grid computing :**
   i. Grid computing appeared in the early 1990s as an evolution of cluster computing.
   ii. Grid computing proposed a new approach to access large computational power, huge storage facilities, and a variety of services. Users can consume resources in the same way as they use other utilities such as power, gas, and water.
   iii. Grids initially developed as aggregation of geographically dispersed cluster by means of internet connection.
   iv. These clusters belonged to different organizations and arrangements were made among them to share the computational power.
   v. Different from a large cluster, a computing grid was a dynamic aggregation of heterogeneous computing nodes, and its scale was nationwide or even worldwide.
2. **Utility computing :**
   i. Utility computing is a vision of computing, defining a service provisioning model for computing services in which resources such as storage, compute power, applications, and infrastructure are packaged and offered on a pay-use basis.

   ii. The business model introduced with utility computing brought new requirements and led to an improvement of mainframe technology, additional features such as operating systems, process control and user metering facilities.
   iii. The idea of computing as utility remained and extended from the business domain to the academia with the advent of cluster computing.
3. **Software-as-a-Service :** Refer Q. 1.11, Page 1–11E, Unit-1.
4. **Cloud computing :** Refer Q. 1.1, Page 1–2E, Unit-1.

Que 1.14. Discuss the architecture of cloud computing.

Answer

Cloud computing architecture refers to the components and subcomponents required for cloud computing. These components consist of :

1. **Front end platform :**
   i. Cloud computing architecture consists of front end platforms called clients or cloud clients.
   ii. These clients comprise servers, fat (or thick) clients, thin clients, zero clients, tablets and mobile devices.
   iii. These client platforms interact with the cloud data storage through an application (middleware), through a web browser, or through a virtual session.
   iv. The front end refers to the client part of cloud computing system. It consists of interfaces and applications that are required to access the cloud computing platforms like web browser.
2. **Back end platform :**
   i. The back end refers to the cloud itself. It consists of all the resources required to provide cloud computing services.
   ii. It comprises of huge data storage, virtual machines, security mechanism, services, deployment models, servers, etc.
   iii. It is online network storage where data is stored and accessible to multiple clients.
3. **Cloud based delivery :** These include the following :
   i. **Software-as-a-Service (SaaS) :** Refer Q. 1.11, Page 1–11E, Unit-1.
   ii. **Development-as-a-Service (DaaS) :** Development as a service is web-based, community shared development tools. This is equivalent to locally installed development tools in the traditional (non-cloud computing) delivery of development tools.

iii. **Platform-as-a-Service (PaaS) :** Refer Q. 1.11, Page 1–11E, Unit-1.

iv. **Infrastructure-as-a-Service (IaaS) :** Refer Q. 1.11, Page 1–11E, Unit-1.

4. **Network :** The cloud network layer offers :

   i. **High bandwidth (low latency) :** Allowing users to have uninterrupted access to their data and applications.

   ii. **Agile network :** On-demand access to resources requires the ability to move quickly and efficiently between servers and possibly even clouds.

   iii. **Network security :** Security is always important, but when dealing with multi-tenancy, it becomes much more important because we are dealing with segregating multiple customers.

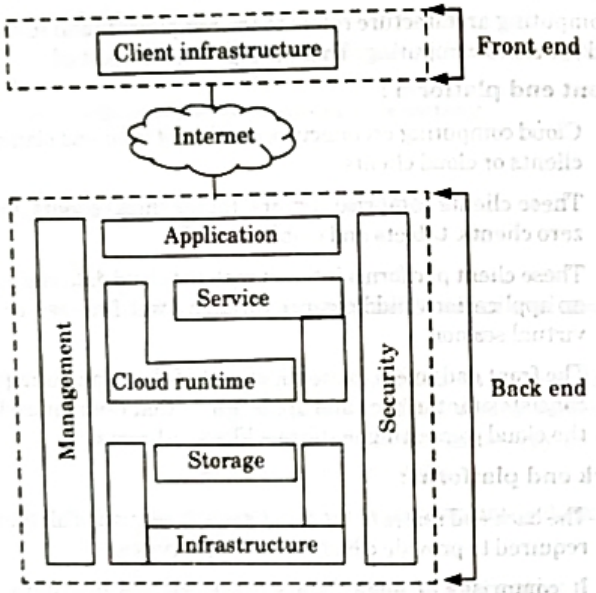

Fig. 1.14.1. Cloud computing architecture.

Que 1.15. **Write some applications of cloud computing.**

Answer

Applications of cloud computing :

1. **Big data analytics :** From fraud recognition to statistical investigation, big data exist universally. Analyse how Hadoop and great presentation computing clusters can be set-up in both public and private clouds.

2. **Develop and test :** Build and test applications in on-requirement platforms using constantly configured resources, lower expenditure, and decreased release cycles.

3. **Disaster recovery :** Public and private clouds facilitate commercial solutions to maintain highly accessible applications with flexible multiple datacentres and provider architectures, and reduce down-time and data loss.

4. **Gaming applications :** Distribute flexible capacity to assemble random traffic actions and to lower expenditure for the ongoing life cycle management by public and private clouds.

5. **Web and mobile applications :** Deploy mobile applications and web applications that are extremely scalable and accessible across a range of verified architectures, technologies and clouds.

Que 1.16. **Give limitations of cloud computing.**

Answer

Limitations of cloud computing :

1. **Data protection :**

   i. Data security is a crucial element that warrants scrutiny.

   ii. Enterprises are reluctant to buy an assurance of business data security from vendors.

   iii. They fear losing data to competition and the data confidentiality of consumers.

   iv. In many instances, the actual storage location is not disclosed, adding onto the security concerns of enterprises.

   v. In the existing models, firewalls across datacentres (owned by enterprises) protect this sensitive information.

   vi. In the cloud model, service providers are responsible for maintaining data security and enterprises would have to rely on them.

2. **Data recovery and availability :**

   i. All business applications have service level agreements that are stringently followed.

   ii. Operational teams play a key role in management of service level agreements and runtime governance of applications.

   iii. In production environments, operational teams support :

      a. Appropriate clustering and fail over

      b. Data replication

      c. System monitoring (transactions monitoring, logs monitoring and others)

      d. Maintenance (runtime governance)

      e. Disaster recovery

      f. Capacity and performance management.

3. **Management capabilities :**
   i. Despite there being multiple cloud providers, the management of platform and infrastructure is still in its infancy.
   ii. For example, features like Auto-scaling are a crucial requirement for many enterprises.
   iii. There is huge potential to improve on the scalability and load balancing features provided today.
4. **Regulatory and compliance restrictions :**
   i. In some of the European countries, government regulations do not allow customer's personal information and other sensitive information to be physically located outside the state or country.
   ii. In order to meet such requirements, cloud providers need to set-up a datacentre or a storage site exclusively within the country to comply with regulations.
   iii. Having such an infrastructure may not always be feasible and is a big challenge for cloud providers.

PART-2

Underlying Principles of Parallel and Distributed Computing, Cloud Characteristics, Elasticity in Cloud, On-Demand Provisioning.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 1.17. **Write a short note on parallel computing. Write the advantages of parallel computing over serial computing.**

Answer

1. Parallel computing is a computation type in which multiple processors execute multiple tasks simultaneously.
2. Problems are broken down into instructions and are solved concurrently.
3. The main reason for parallel programming is to execute code efficiently, since parallel programming saves time, allowing the execution of applications in a shorter time.
4. Advantages of parallel computing over serial computing are :

   i. It saves time and money as many resources working together will reduce the time and cut potential costs.
   ii. It can be impractical to solve larger problems on serial computing.
   iii. It can take advantage of non-local resources when the local resources are finite.
   iv. Serial computing wastes the potential computing power, thus parallel computing makes better work of hardware.

Que 1.18. **Describe briefly the components of parallel computing.**

Answer

Components of parallel computing :

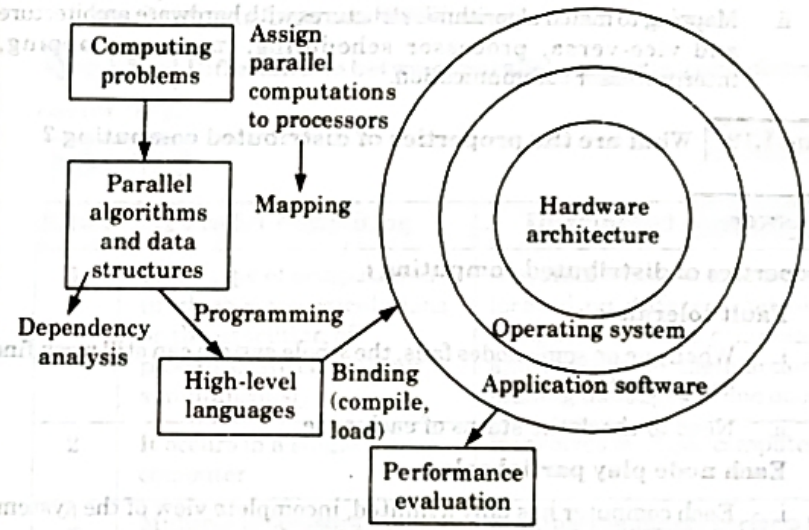

Fig. 1.18.1.

1. **Computing problems :**
   i. **Numerical computing :** Science and engineering numerical problems demand intensive integer and floating point computations.
   ii. **Logical reasoning :** Artificial Intelligence (AI) demands logic inferences and symbolic manipulations and large space searches.
2. **Parallel algorithms and data structures :**
   i. Special algorithms and data structures are needed to specify the computations and communication present in computing problems (from dependency analysis).
   ii. Most numerical algorithms are deterministic using regular data structures.

iii. Symbolic processing may use heuristics or non-deterministic searches.

iv. Parallel algorithm development requires interdisciplinary interaction.

3. **Hardware resources :**

i. Processors, memory, and peripheral devices (processing nodes) form the hardware core of a computer system.

ii. Processor connectivity (system interconnects, network), memory organization, influence the system architecture.

4. **Operating systems :**

i. Manages the allocation of resources to running processes.

ii. Mapping to match algorithmic structures with hardware architecture and vice-versa, processor scheduling, memory mapping, interprocessor communication.

Que 1.19. **What are the properties of distributed computing ?**

Answer

Properties of distributed computing :

1. **Fault tolerance :**

i. When one on some nodes fails, the whole system can still work fine except performance.

ii. Need to check the status of each node.

2. **Each node play partial role :**

i. Each computer has only a limited, incomplete view of the system.

ii. Each computer may know only one part of the input.

3. **Resource sharing :** Each user can share the computing power and storage resource in the system with other users.

4. **Load sharing :** Dispatching several tasks to each node can help share loading to the whole system.

5. **Easy to expand :** We expect to use few time when adding nodes. Hope to spend no time if possible.

6. **Performance :** Parallel computing can be considered a subset of distributed computing.

Que 1.20. **Write a short note on distributed computing.**

Answer

1. Distributed computing is a model in which components of a software system are shared among multiple computers to improve efficiency and performance.

2. In distributed computing, each processor has its own private memory (distributed memory). Information is exchanged by passing messages between the processors.

3. A distributed system allows resource sharing, including software by systems connected to the network.

4. The goal of distributed computing is to make network as a single computer.

5. Examples of distributed systems / applications of distributed computing are : Intranets, Internet, WWW, email.

Que 1.21. **Differentiate between parallel computing and distributed computing.**

Answer

S. No.	Parallel computing	Distributed computing
1.	It is a type of computation in which many calculations or the execution of processes are carried out simultaneously.	A system whose components are located on different networked computers, which communicate and coordinate their actions by passing messages to one another.
2.	It occurs in a single computer.	It involves multiple computers.
3.	Multiple processors execute multiple tasks at the same time.	Multiple computers perform tasks at the same time.
4.	Computer can have shared memory or distributed memory.	Each computer has its own memory.
5.	Processors communicate with each other using a bus.	Computers communicate with each other through the network.
6.	Increase the performance of the system.	Allows scalability sharing resources and helps to perform computation tasks efficiently.

Que 1.22. **Explain briefly the architecture of distributed computing.**

Answer

Architecture of distributed computing :

1. **Data-centered architecture :**
   i. These architectures identify the data as the fundamental element of the software system and access to shared data is the core characteristic of the data-centered architectures.
   ii. Therefore, especially within the context of distributed and parallel computing system, integrity of data is the overall goal for such systems.
   iii. The repository architectural style is the most relevant reference model in this category.
   iv. It is characterized by two main components; the central data structure, which represents the current state of the system, and a collection of independent components, which operate on the central data.
   v. The ways in which the independent components interact with the central data structure can be very heterogeneous.
2. **Data-flow architecture :**
   i. In the case of data-flow architectures, it is the availability of data that controls the computation.
   ii. With respect to the data-centered styles, where the access to data is the core feature, data-flow styles explicitly incorporate the pattern of data flow, since their design is determined by an orderly motion of data from component to component, which is the form of communication between them.
   iii. Data-flow architectures are optimal when the system to be designed embodies a multi-stage process, which can be clearly identified into a collection of separate components that need to be orchestrated together.
3. **Virtual machine architecture :**
   i. This class of architectural styles is characterized by the presence of an abstract execution environment that simulates features that are not available in the hardware of software.
   ii. Applications and system are implemented and become portable over different hardware and software environment as long as there is an implementation of the virtual machine they interface with constitutes its execution.

4. **Call and return architecture :**
   i. This category identifies all the systems that are composed by components mostly connected together by method calls.
   ii. The activity of systems modeled in this way is characterized by a chain of method calls whose overall execution and composition identify the execution of one or more operations.
   iii. The internal organization of components and their connections may vary.
5. **Architectural styles based on independent components :**
   i. This class of architectural styles model systems in term of independent components having their own life cycle, which interact to each other in order to perform their activities.
   ii. There are two major categories within this class, which differentiate in the way the interaction among components is managed :
      a. **Communicating processes :** In this architectural style, components are represented by independent processes that leverage Inter-Process Communication (IPC) facilities for coordinate management.
      b. **Event systems :** In this architectural style, the components of the system are loosely coupled and connected. In addition to exposing operation for data and state manipulation, each component also publishes (or announces) a collection of events that other components can register with.

Que 1.23. **What do you mean by dynamic cloud infrastructure ?**

Answer

1. Cloud computing clients can access standardized IT resources to deploy new applications, services, or computing resources rapidly without re-engineering their entire infrastructure, thus making it dynamic.
2. Cloud dynamic infrastructure is based on an architecture that combines the following initiatives :
   a. **Service management :** Offers business transparency and automation across the pillars of business for consistent delivery.
   b. **Asset management :** Maximizes the value of critical business and IT assets over their life cycle with industry-tailored asset management solutions.
   c. **Virtualization and consolidation :** Reduce operating costs, improve responsiveness, and fully utilize the resources.
   d. **Information infrastructure :** Helps businesses achieve information compliance, availability, retention, and security

objectives.

e. **Energy efficiency :** Offers green and sustainable energy solutions for business.

f. **Security :** Provides end-to-end industry customized governance, risk management, and compliance for businesses.

g. **Elasticity :** Maintains continuous business and IT operations while rapidly adapting and responding to risks and opportunities.

Que 1.24. **Explain technologies used for distributed computing.**

Answer

Technologies used for distributed computing are :

1. **Remote procedure call :**

   i. Remote Procedure Call (RPC) is the fundamental abstraction enabling the execution of procedures on client's request.

   ii. It allows extending the concept of procedure call beyond the boundaries of a processor and a single memory address space.

   iii. The called procedure and calling procedure may be on the same system, or they may be on different systems in a network.

   iv. The system is based on a client server model.

   v. The server process maintains a registry of all the available procedures that can be remote invoked, and listens for requests from clients that specify which procedure to invoke together with the values of the parameters required by the procedure.

   vi. RPC maintains the synchronous pattern that is natural in process procedure and function calls.

2. **Distributed object frameworks :**

   i. Distributed object frameworks extend the object-oriented programming systems by allowing objects to be distributed across a heterogeneous network and provide facilities so that they can coherently act as if they were in the same address space.

   ii. Distributed object frameworks leverage the basic mechanism introduced with RPC, and extend it to enable the remote invocation of object methods and to keep track of references to object made available through a network connection.

   iii. Distributed objects frameworks give the illusion of interaction with a local instance while invoking remote methods. This is done by a mechanism called proxy-skeleton.

   iv. Proxy and skeleton always constitute a pair, the server process maintain the skeleton component, which is in charge of executing the method remotely invoked, while the clients maintain the proxy component allowing its hosting environment to remotely invoke methods through the proxy interface.

Que 1.25. **What are the characteristics of cloud computing ?**

Answer

Characteristics of cloud computing are :

1. **On demand self-service :** Resources can automatically be provisioned without the need of human interaction as and when needed.

2. **Compatibility :** Cloud services allow access to the data from any location and on any device. Employees can work from anywhere.

3. **Elasticity :** Cloud services are scalable. Consumers can add resources they need and discard resources they do not want.

4. **Reliability :** Cloud runs on multiple servers and is automated to run even if one server fails. Resources are drawn from the other servers to ensure continuity without any interruption.

5. **Disaster recovery :** With replication and storing across multiple servers, cloud allows easy cost-effective solutions at times of data loss due to some theft or calamity.

6. **Updates :** Consumers need not worry about software updates and technical issues. The cloud servers are located in different places away from our business premises. The providers do all the updates and patches.

7. **Security :** Cloud services offers enhanced security. We can access our data from any system even if we lose our personal device.

Que 1.26. **Write a short note on elasticity in cloud.**

Answer

1. In cloud computing, elasticity is defined as "the degree to which a system is able to adapt to workload changes by provisioning and de-provisioning resources in an autonomic manner, such that at each point in time the available resources match the current demand as closely as possible".

2. Elasticity is a defining characteristic that differentiates cloud computing from previously proposed computing paradigms, such as grid computing.

3. The dynamic adaptation of capacity, by altering the use of computing resources, to meet a varying workload is called elastic computing.

4. Elasticity aims at matching the amount of resource allocated to a service with the amount of resource it actually requires, avoiding over-provisioning or under-provisioning.

5. Over-provisioning, *i.e.*, allocating more resources than required, should be avoided as the service provider often has to pay for the resources that are allocated to the service.
6. Under-provisioning, *i.e.*, allocating fewer resources than required, must be avoided, otherwise the service cannot serve its users with a good service.

Que 1.27. What are the advantages of elastic cloud computing ?

Answer

Advantages of elastic cloud computing :

1. **Cost efficiency :**
   i. Cloud is available at much cheaper rates than traditional approaches and can significantly lower the overall IT expenses.
   ii. By using cloud solution companies can save licensing fees as well as eliminate overhead charges such as the cost of data storage, software updates, management etc.
2. **Convenience and continuous availability :** Cloud makes easier access of shared documents and files with view and modify choice. Public clouds also offer services that are available wherever the end user might be looted Moreover it guaranteed continuous availability of resources and in use of system failure, alternative instances are automatically spawned on other machines
3. **Backup and recovery :** The process of backing up and recovering data is easy as information is residing on cloud and not on a physical device. The various cloud providers offer reliable and flexible backup/recovery solutions.
4. **Cloud is environment friendly :** The cloud is more efficient than the typical IT infrastructure and it takes fewer resources to compute, thus saving energy.
5. **Scalability and performance :** Scalability is a built-in feature for cloud deployments. Cloud instances are deployed automatically only when needed and as a result enhance performance with excellent speed of computations.

Que 1.28. What are the disadvantages of elastic cloud computing ?

Answer

Disadvantages of elastic cloud computing :

1. **Security and privacy in the cloud :** Security is the biggest concern in cloud computing. Companies essentially hide their private data and information over cloud as remote based cloud infrastructure is used, it is

then up to the cloud service provider to manage, protect and retain data confidential.
2. **Limited control :** Since the applications and services are running remotely companies, users and third party virtual environments have limited control over the function and execution of the hardware and software.
3. **Dependency and vendor lock-in :** One of the major drawbacks of cloud computing is the implicit dependency on the provider. It is also called "vendor lock-in". As it becomes difficult to migrate vast data from old provider to new. So, it is advisable to select vendor very carefully.
4. **Increased vulnerability :** Cloud based solutions are exposed on the public internet therefore are more vulnerable target for malicious users and hackers.

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2 UNIT

Cloud Enabling Technologies

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PART-1

Service Oriented Architecture.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 2.1. **Briefly describe the Service Oriented Architecture (SOA).**

Answer

1. Service Oriented Architecture (SOA) is an architectural approach in which applications make use of services available in the network.
2. Service Oriented Architecture (SOA) is a style of software design where services are provided to the other components by application components through a communication protocol over a network.
3. SOA allows users to combine a large number of facilities from existing services to form applications.
4. SOA encompasses a set of design principles that structures the system development and provide means for integrating components into a coherent and decentralized system.
5. SOA based computing packages functionalities into a set of interoperable services, which can be integrated into different software systems belonging to separate business domains.
6. SOA provides a translation and management layer within the cloud architecture that removes the barrier for cloud clients obtaining desired services.

Que 2.2. **Explain the major roles of Service Oriented Architecture (SOA).**

Answer

There are two major roles of Service Oriented Architecture (SOA) :

1. **Service provider :**
   a. The service provider is the maintainer of the service and the organization that makes available one or more services for others to use.
   b. To advertise services, the provider can publish them in a registry, together with a service contract that specifies the nature of the service, how to use it, the requirements for the service, and the fees charged.

2. **Service consumer :**

   a. The service consumer can locate the service metadata in the registry and develop the required client components to bind and use the service.

   b. Services aggregate information and data retrieved from other services or create workflows of services to satisfy the request of a given service consumer.

Que 2.3. **Describe the guiding principles of SOA.**

Answer

Guiding principles of SOA :

1. **Standardized service contract :** Services adhere to a given communication agreement which is specified through one or more service description documents.
2. **Loose coupling :** Services are designed as self-contained components, maintain relationship that minimizes dependencies on other services.
3. **Abstraction :** A service is completely defined by service contracts and description documents. They hide their logic, which is encapsulated within their implementation.
4. **Reusability :** Being designed as components, services can be reused more effectively, thus reducing the development time and the associated costs. It allows for a more agile design and cost effective system implementation and deployment.
5. **Lack of state :** By providing a stateless interaction pattern, service increase the chance of being reused and aggregated, especially in a scenario where a single service is used by multiple consumers belonging to different administrative and business domains.
6. **Discoverability :** Services are defined by description documents that constitute supplemental metadata through which they can be effectively discovered. Service discovery provides an effective means for utilizing third-party resources.
7. **Composability :** By using services as building blocks, sophisticated and complex operations can be implemented. Service orchestration and choreography provide a solid support for composing services and achieving the business goals.

Que 2.4. **What are the advantages and disadvantages of SOA ?**

Answer

Advantages of SOA :

1. **Service reusability :** In SOA, applications are made from existing services. Thus, services can be reused to make many applications.

2. **Easy maintenance :** As services are independent of each other they can be updated and modified easily without affecting other services.
3. **Platform independent :** SOA allows making a complex application by combining services picked from different sources and are independent of the platform.
4. **Availability :** SOA facilities are easily available to anyone on request.
5. **Reliability :** SOA applications are more reliable because it is easy to debug small codes rather than huge codes.
6. **Scalability :** Services can run on different servers within an environment, this increases scalability.

Disadvantages of SOA :

1. **High overhead :** A validation of input parameters of services is done whenever services interact, which decreases performance as it increases load and response time.
2. **High investment :** A huge initial investment is required for SOA.
3. **Complex service management :** When services interact they exchange messages to tasks. The number of messages may go in millions. It becomes a cumbersome task to handle a large number of messages.

Que 2.5. **Explain the application areas of SOA.**

Answer

Application areas of SOA are :

1. SOA infrastructure is used by many armies and airforce to deploy situational awareness systems.
2. SOA is used to improve the healthcare delivery.
3. SOA is used in mobile solutions apps such as games and they use inbuilt functions to run.
4. SOA helps to maintain museums a virtualized storage pool for their information and content.

Que 2.6. **What are the benefits of using SOA ?**

Answer

Benefits of using SOA :

1. **Language neutral integration :** Regardless of the developing language used, the system offers and invoke services through a common mechanism. Programming language neutralization is one of the key benefits of SOA's integration approach.

2. **Component reuse :** Once an organization built an application component, and offered it as a service, the rest of the organization can utilize that service.
3. **Organizational agility :** SOA defines building blocks of capabilities provided by software and it offers some services that meet some organizational requirement which can be recombined and integrated rapidly.
4. **Leveraging existing system :** This is one of the major use of SOA which is to classify elements or functions of existing applications and make them available to the organizations or enterprise.

Que 2.7. **Explain horizontal layer of SOA architecture.**

Answer

SOA architecture is viewed as five horizontal layers :

1. **Consumer interface layer :** These are GUI based apps for end users accessing the applications.
2. **Business process layer :** These are business-use cases in terms of application.
3. **Services layer :** These are whole-enterprise, in service inventory.
4. **Service component layer :** They are used to build the services, such as functional and technical libraries.
5. **Operational systems layer :** It contains the data model.

Que 2.8. **Explain vertical layers of SOA architecture.**

Answer

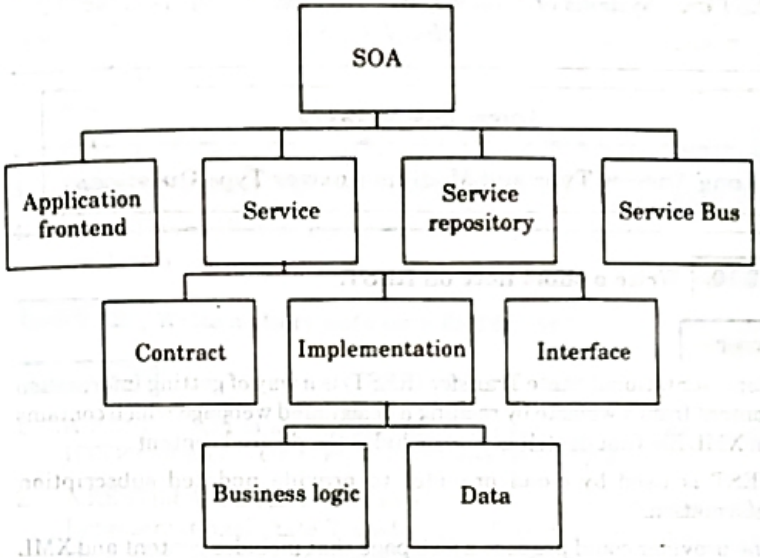
Vertical layers of SOA architecture :

1. **Integration layer :** Starts with platform integration (protocols support), data integration, service integration, application integration, leading to enterprise application integration supporting B2B and B2C.
2. **Quality of service layer :** Security, availability, performance etc., constitute the quality of service parameters which are configured based on required SLAs, OLAs.
3. **Informational layer :** Provide business information.
4. **Governance layer :** IT strategy is governed to each horizontal layer to achieve required operating and capability model.

Que 2.9. **Explain the elements of SOA.**

Answer

Elements of Service Oriented Architecture (SOA) :



1. **Application frontend :**
   a. Application frontends are active elements of the SOA, delivering the value of SOA to the end users.
   b. They initiate and control all activity of the enterprise system.
2. **Service :** It is a software component that encapsulates a high level business concept.
3. **Contract :** It provides a specification of the purpose, functionality, constraints, and usage of services.
4. **Interface :** Functionality of the service exposed by the service to the clients that are connected to the service.
5. **Implementation :** The service implementation provides the required business logic and appropriate data. It contains one or more of the artifacts : programs, configuration, data and databases.
6. **Business logic :** Business process represented by the service.
7. **Data :** Data represented in the service used by the service.
8. **Service repository :** It registers the services and their attributes to facilitate the discovery of services, operation, access rights, owner, qualities, etc.
9. **Service bus :** A flexible infrastructure for integrating applications and services by : routing messages, transforming protocols between requestor and service, handling business events and delivering them, providing QoS, security, and managing the interaction among services.

PART-2

REST and Systems of Systems, Web Services, Publish-Subscribe Model.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 2.10. **Write a short note on REST.**

Answer

1. Representational State Transfer (REST) is a way of getting information content from a website by reading a designated webpage which contains an XML file that describes and includes the desired content.
2. REST is used by cloud provider to provide updated subscription information.
3. The provider could prepare a web page that includes content and XML statements that are described in the code.
4. Subscribers only need to know the Uniform Resource Locator (URL) for the page where the XML file is located, read it with a web browser, understand the content using XML information, and display it appropriately.
5. REST uses the same publishing approach that many sites use with RDF Site Summary (RSS). RSS uses the Resource Description Framework (RDF), which is a standard way to describe a website.

REST offers the following benefits :

1. It gives better response time and reduced server load due to its support for the caching of representations.
2. Server scalability is improved by reducing the need to maintain session state.
3. A single browser can access any application and any resource, so less client-side software needs to be written.
4. A separate resource discovery mechanism is not needed, due to the use of hyperlinks in representations.
5. It has better long-term compatibility and evolvability characteristics.

Que 2.11. **What are HTTP methods used by REST architecture ?**

Answer

The REST architecture makes use of four HTTP methods. These are :

1. **GET method :** This method helps in offering read-only access for the resources.
2. **POST method :** This method is implemented for creating a new resource.
3. **DELETE method :** This method is implemented for removing a resource.
4. **PUT :** This method is implemented for updating an existing resource or creating a new one.

Que 2.12. **Write a short note on RESTful API.**

Answer

1. A RESTful API is an Application Program Interface (API) that uses HTTP requests to GET, PUT, POST and DELETE data.
2. A RESTful API is referred to as a RESTful web service that is based on Representational State Transfer (REST) technology, an architectural style and approach to communications often used in web services development.
3. REST technology is generally preferred to the more robust Simple Object Access Protocol (SOAP) technology because REST leverages less bandwidth, making it more suitable for internet usage.
4. An API for website is a code that allows two software programs to communicate with each other.
5. REST is a logical choice for building APIs that allow users to connect and interact with cloud services.
6. RESTful APIs are used by sites such as Amazon, Google, LinkedIn and Twitter.
7. A RESTful API breaks down a transaction to create a series of small modules. Each module addresses a particular underlying part of the transaction. This modularity provides developers with a lot of flexibility.

Que 2.13. **Differentiate between RESTful web service and RESTless web service.**

Answer

S. No.	RESTful web service	RESTless web service
1.	An application that provides interoperability between computer systems on the internet.	An application that is not based on the principle of REST.
2.	Use REST.	Use SOAP.
3.	Support various data format such as HTML, JSON, etc.	Support XML format.
4.	Use URL to expose business logic.	Use the service interface to expose business logic.
5.	Easier and flexible.	Not easy and flexible.
6.	Inherits security measures from the underlying transport protocols.	Defines its own security layer and is more secure.
7.	Consume less bandwidth and resources.	Consume more bandwidth and resources.

Que 2.14. **What are the advantages of REST ?**

Answer

The advantages of REST are :

1. **Separation between the client and the server :**
   a. The REST protocol totally separates the user interface from the server and the data storage.
   b. For example, it improves the portability of the interface to other types of platforms, it increases the scalability of the projects, and allows the different components of the developments to be evolved independently.
2. **Visibility, reliability and scalability :**
   a. The separation between client and server has one evident advantage, that each development team can scale the product without problem.
   b. They can migrate to other servers or make all kinds of changes in the database, provided that the data from each request is sent correctly.

   c. The separation makes it easier to have the front and the back on different servers, and this makes the apps more flexible to work with.
3. **The REST API is always independent of the type of platform or languages :**
   a. The REST API always adapts to the type of syntax or platforms being used, which gives considerable freedom when changing or testing new environments within the development.
   b. With a REST API we can have PHP, Java, Python Servers.

Que 2.15. **Write a short note on web services.**

Answer

1. A web service is a software package that is used for communicating between two devices or web entities lying on the network.
2. They involve a service provider along with a service requester, *i.e.*, the client.
3. Since web services are advantageous as they are language transparent, so there is no issue whether the fundamental system is providing the service developed in Java, PHP or any other language while the client application is written in Python, Ruby, Perl or JavaScript.
4. Task performed by web services :
   i. Web services are searched for over the network as well as call upon accordingly.
   ii. As a web service is called, it would be capable of providing operation for the client that has invoked the web service.

Que 2.16. **What are types of web services ?**

Answer

Two types of web services :

1. **SOAP web services :**
   i. The abbreviation of SOAP is Service Oriented Architecture Protocol.
   ii. It is an XML based protocol having the main benefit of implementing the SOAP web service as its security.
   iii. SOAP offers a wrapper for sending a web service based messages over the Internet by the help of HTTP protocol. All its messages are usually in XML format.

iv. The SOAP message consists of :

a. SOAP document has a root element termed as the <Envelope> element. This element is the initial element used in an XML document.

b. Then next the "Envelope" which is categorized into two parts. The former is the 'header,' and the later is the 'body.'

c. The header includes the routing data that is essentially the information telling the XML document to whom or for which the client needs to be sent to.

d. Lastly, the body includes the actual message.

2. **REST (Representational State Transfer) web services :**

i. REST service is not a collection of paradigm or specific rules, it is instead the style architecture for software.

ii. Those apps that are designed using this architecture are collectively termed as RESTful web services.

iii. It establishes the resources through the use of URL as well as depends on the nature of the transport protocol (like HTTP's: GET, PUT, POST, DELETE, etc.) used to perform the resources.

iv. Allocation of resources in REST depends on the URL. It is more like conventions based application.

Que 2.17. **Explain architectural constraints of web services.**

Answer

Architectural constraints of web service are :

1. **Uniform interface :**

i. It is a key constraint that differentiates between a REST API and Non-REST API.

ii. It suggests that there should be a uniform way of interacting with a given server irrespective of device or type of application (website, mobile app).

iii. There are four guidelines principle of uniform interface :

a. **Resource-based :** Individual resources are identified in requests.

b. **Manipulation of resources through representations :** Client has representation of resource and it contains enough information to modify or delete the resource on the server, provided that it has permission to do so.

c. **Self-descriptive messages :** Each message includes enough information to describe how to process the message so that server can easily analyse the request.

d. **Hypermedia As The Engine of Application State (HATEOAS) :** It need to include links for each response so that client can discover other resources easily.

2. **Stateless :**

i. It means that the necessary state used to handle the request is contained within the request itself and server would not store anything related to the session.

ii. In REST, the client must include all information for the server to fulfill the request whether as a part of headers or URI.

3. **Cacheable :**

i. Every response should include whether the response is cacheable or not and for how much duration responses can be cached at the client side.

ii. Client will return the data from its cache for any subsequent request and there would be no need to send the request again to the server.

4. **Client-Server :**

i. REST application should have client-server architecture.

ii. A client is someone who is requesting resources and are not concerned with data storage, which remains internal to each server, and server is someone who holds the resources and are not concerned with the user interface or user state.

5. **Layered system :**

i. An application architecture needs to be composed of multiple layers.

ii. Each layer does not know anything about any layer other than that of immediate layer and there can be lot of intermediate servers between client and the end server.

iii. Intermediary servers may improve system availability by enabling load-balancing and by providing shared caches.

6. **Code on demand :**

i. It is an optional feature. According to this, servers can also provide executable code to the client.

Que 2.18. **Differentiate between REST and SOAP.**

Answer

S. No.	REST	SOAP
1.	REST is Representational State Transfer.	SOAP is Service Oriented Architecture Protocol.
2.	It is an architecture style.	It is a protocol.
3.	It uses simple HTTP protocol.	It uses SOAP envelop and then HTTP to transfer the data.
4.	It supports many different data format like JSON, XML, YAML etc.	It supports only XML format.
5.	Performance, scalability, and caching is high.	Slower performance and scalability is bit complex, caching not possible.
6.	It is used widely and frequently.	It is used where REST is not possible.

Que 2.19. **Explain briefly publish-subscribe model.**

Answer

1. In software architecture, publish-subscribe pattern is a message pattern, a network oriented architectural pattern, which describes how two different parts of a message passing system connect and communicate with each other.
2. In modern cloud architecture, applications are decoupled into smaller, independent building blocks that are easier to develop, deploy and maintain.
3. Publish/Subscribe (Pub/Sub) messaging provides instant event notifications for these distributed applications.
4. The publish-subscribe model allows messages to be broadcast to different parts of a system.
5. Publish-subscribe is a sibling of the message queue paradigm, and is one part of a larger message-oriented middleware system.
6. Messaging systems support both the pub/sub and message queue models in their API. For example, Java Message Service (JMS).
7. This pattern provides greater network scalability and a dynamic network topology, with a resulting decreased flexibility to modify the publisher and the structure of the published data.

Que 2.20. **Explain how publish-subscribe model works.**

Answer

Working of publish-subscribe model :

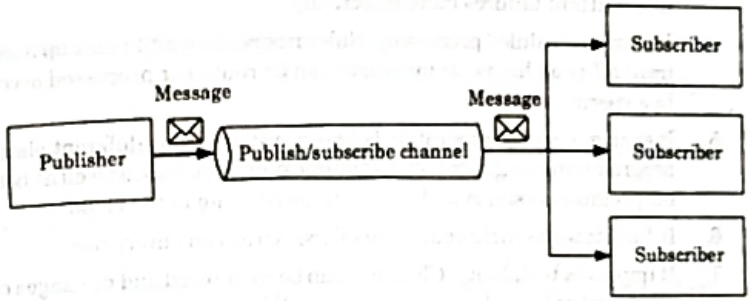


Fig. 2.20.1.

1. **Publisher :** Publishes messages to the communication infrastructure.
2. **Subscriber :** Subscribes to a category of messages.
3. **Communication infrastructure (channel, classes) :** Receives messages from publishers and maintains subscriber subscription.
4. The publisher will categorize published messages into classes where subscribers will receive the message.
5. A publisher has one input channel that splits into multiple output channels, one for each subscriber.
6. Subscribers can express interest in one or more classes and only receive interested message.
7. In pub/sub model the publisher and subscriber are unaware of each other. The publisher sends messages to subscribers, without knowing about subscriber.
8. Subscriber receives messages, without having knowledge of the publishers. If there are no subscribers around to receive the topic-based information, the message is dropped.

Que 2.21. **What are the benefits of publish-subscribe model ?**

Answer

Following are the benefits of publish-subscribe model :

1. It decouples subsystems that need to communicate. Subsystems can be managed independently, and messages can be properly managed even if one or more receivers are offline.
2. It increases scalability and improves responsiveness of the sender. The sender can quickly send a single message to the input channel, then

return to its core processing responsibilities. The messaging infrastructure is responsible for ensuring messages delivered to interested subscribers.

3. It improves reliability. Asynchronous messaging helps applications to continuously run smoothly under increased loads and handle intermittent failures more effectively.
4. It allows scheduled processing. Subscribers can wait to pick up messages until off-peak hours, or messages can be routed or processed according to a specific schedule.
5. It enables simpler integration between systems using different platforms, programming languages, or communication protocols, as well as between on-premises systems and applications running in the cloud.
6. It facilitates asynchronous workflows across an enterprise.
7. It improves testability. Channels can be monitored and messages can be inspected or logged as part of an overall integration test strategy.

PART-3

Basics of Virtualization, Types of Virtualization, Implementation Levels of Virtualization.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 2.22. **Define virtualization. Why it is needed ?**

Answer

1. Virtualization is an abstraction layer (hypervisor) that decouples the physical hardware from the Operating System (OS) to deliver greater IT resource utilization and flexibility.
2. The virtualization platform provides the isolation of platform and allows multiple businesses to run multiple virtual machines on the same physical machine.
3. Following are the benefits provided by virtualization :

   i. **Money saving :**

      a. With virtualization technology, the number of physical servers can be reduced.

      b. Therefore, the ongoing procurement, maintenance, and ongoing operational costs will also be reduced.

   ii. **Dramatic increase in control :**

      a. Virtualization provides a flexible foundation to provide capacity according to the demand for an organization.

      b. New servers can be quickly deployed. Therefore, services can be provided within minutes.

      c. It is also easy to ship the infrastructure when it is deployed using virtualization techniques.

   iii. **Simplified disaster recovery :**

      a. More efficient and cost effective disaster recovery solutions can be realized with virtualization technologies.

      b. Servers and online business can be transferred to an alternate site within minutes with the help of virtualization.

   iv. **Business readiness assessment :**

      a. Virtualization introduces a shared computing model to an enterprise and it is easy to understand infrastructure requirements in a virtualized environment.

Virtualization can help to :

1. Reduce the cost of the existing infrastructure by reducing operational and systems management cost while maintaining the needed capacity.
2. Reduce the complexity of adding to the infrastructure.
3. Gather information and collaboration across the organization to increase both the utilization of information and its effective use.
4. Deliver on-Service Level Agreement (SLA) response time during spikes in production and test scenarios.
5. Build a heterogeneous infrastructure across the organization that is more responsive to the organization's needs.

Que 2.23. **Explain various current virtualization initiatives.**

Answer

Various current virtualization initiatives are :

1. **Virtual CPU and memory :**

   i. Physical CPUs and RAM can be dedicated or dynamically allocated to virtual machines.

   ii. As there is no OS dependency on the physical hardware, with the CPU checking off, virtual machines can be migrated to different hosts, with background changes to the physical CPU and memory resources being transparent to the guest OSs running on virtual machines.

2. **Virtual networking :**
   i. This creates a virtual 'network in a box' solution that allows the hypervisor to manage virtual machine network traffic through the physical Network Interface Controller (NIC) and allows each of the virtual machines to have a unique identity on the network from the physical host.
3. **Virtual disk :**
   i. Storage Area Network (SAN) based storage is presented as storage targets to the physical host, which in turn used to host virtual machine's vdisks (virtual disks).
4. **Consolidated management :**
   i. The performance and health of virtual machines and guest OSs can be monitored and console access to all of the servers can be obtained via single console.
5. **Virtual machine :**
   i. Active virtual machines can be transparently transferred across physical hosts with no down-time and no loss of service availability or performance.
   ii. The virtual machine's execution state, active memory, network identity, and active network connections are preserved across the source and destination hosts so that the guest OS and running applications are unaware of the migration.
6. **Storage virtual machine :**
   i. Vdisks of active virtual machines can be seamlessly and transparently transferred across data stores, while the execution state, active memory, and active network connections remain on the same physical host.
7. **Dynamic load balancing :**
   i. Dynamically load balances virtual machines across the most optimal physical hosts to ensure that pre-defined performance levels are met.
   ii. Virtual machines can be automatically and seamlessly transferred to a less busy host if a particular host in a resource pool is in a high utilization state.
   iii. Different resource pools can be defined for different business needs.
   iv. For instance, production pools can be defined with more demanding service level requirements, while development pools can be used with more relaxed service level requirements.
8. **Logical Partitions (LPARs) :**
   i. LPARs result in hardware layer logical partitioning to create two or more isolated computing domains, each with its own CPU, memory address space and I/O interface, with each domain capable of housing a separate OS environment on single physical server.

   ii. LPARs can share CPUs or have dedicated physical CPUs.
   iii. Likewise, an LPAR can be a dedicated physical memory address space or memory addresses can be dynamically allocated among LPARs as needed.
9. **Logical Domains (LDOMs) :**
   i. Operating systems running in each logical domain can be independently managed, that is, stopped, started, and rebooted without impacting other LDOMs running on the host.
   ii. A Type 1 'bare-metal' hypervisor isolates computing environments from physical resources.
   iii. For example, domains across distinct threads can be separated using the multithreading technology, because the hypervisor is dynamically managing and encapsulating the allocation of physical resources.
10. **Zones :**
   i. Zone is an OS-level virtualization solution rather than a hardware-level hypervisor solution.
   ii. Each zone is an encapsulated virtual server environment running within a single OS instance.
   iii. As such, zones share a common kernel, through a global zone, although 'non-native' zones can emulate an OS environment other than that of the host's native OS.

Que 2.24. **What are the advantages and disadvantages of virtualization ?**

Answer

Advantages :
1. Virtualization software reduces VMM complexity.
2. Improves functionality.
3. Increase performance.
4. Provides server consolidation, testing and development, the provision of dynamic load balancing and the disaster recovery and also improves the system reliability and security.
5. Conservation of energy, maintenance of legacy application and supporting a cross-platform office.

Disadvantages :
1. High risk in the physical fault.
2. It is also not easy, quite complicated.
3. Not supported by all applications.

4. It has single point of failure, demands power machines, visualization may lead to lower performance.
5. Application is identified to be always not possible.

Que 2.25. Write a short note on server virtualization.

Answer

1. Server virtualization works as a masking of the server computer that comprises the count and identity of resources with servers, storage, processors and OS from the end user.
2. Administrators divide the physical server into multiple isolated VMs talking to same resource pools.
3. Virtualization of servers provides an abstraction of the physical server by maintaining resource pools for server users (Fig. 2.25.1).

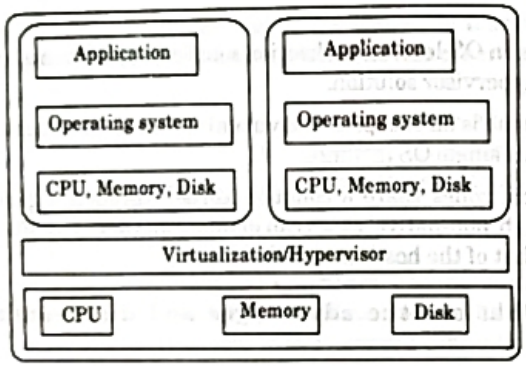


Fig. 2.25.1. Server virtualization.

Virtual machine :

1. Virtual machine can be termed as a virtual environment, partition, or container.
2. In a server environment, a server that does not physically exist but is created on a different server is called 'guest'.
3. The instance where a virtual machine runs is termed as 'host'.
4. These hosts can have multiple VMs running on the physical server.
5. All VMs assigned to a pool of resources can be dynamically assigned to pool-based available resources.
6. When a user talks to this VM, he/she is privileged to use his/her VM as a physical server with all functionalities such as accessing the OSs, CPU, memory, and hard disk from the common pool.
7. The hypervisor virtualizes multiple virtual servers based on supported architecture.
8. Each virtual machine is bundled with an OS, CPU, hard disk, and memory.

Virtualization technologies : Two major types of technologies are employed in server virtualization :

a. **Hardware virtualization :**
   i. Hardware virtualization is also known as hypervisor-based virtualization, bare-metal hypervisor, type 1 virtualization, or simply hypervisor.
   ii. This virtualization technology has a virtualization layer running immediately on the hardware which divides the server machine into several , virtual machines or partitions, with a guest OS running in each of these machines.
   iii. The binary transparency is provided by a virtualized approach and products enable the transparency for OSs, middleware, and applications.

b. **OS virtualization :**
   i. This type of server virtualization is also known as OS-based virtualization, OS-level virtualization, or type 2 virtualization.
   ii. OS virtualization creates virtualization environments within a single instance of an OS.
   iii. Virtual environments created by OS virtualization are often called 'containers'.
   iv. Because all virtualization environments must share resources of a single OS while having a private virtual OS environment, a particular implementation of the technology may alter the file system orientation and often introduce access restrictions to global system configuration or settings.

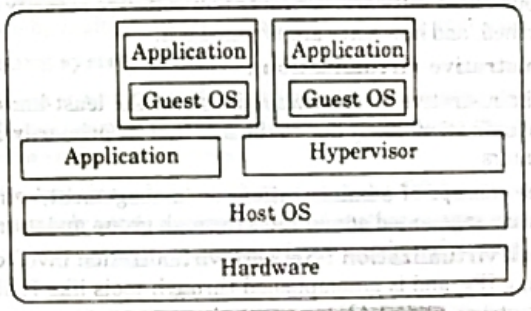


Fig. 2.25.2. OS virtualization.

Que 2.26. What are the types of virtualization ?

Answer

Types of virtualization :

1. **OS virtualization :**
   i. Virtualizing an operating system environment is the most common form of virtualization.

ii. It involves putting a second instance or multiple instances of an operating system, like Windows, on a single machine.

iii. This empowers businesses to reduce the amount of physical hardware required to run their software by cutting down the number of actual machines.

iv. It saves companies cash on energy, cabling, hardware, rack space, and more, while still allowing them to run the same quantity of applications.

2. **Application-server virtualization :**

i. Application-server virtualization is also referred to as 'advanced load balancing,' as it spreads applications across servers and servers across applications.

ii. This enables IT departments to balance the workload of specific software in an agile way that does not overload a specific server or underload a specific application in the event of a large project or change.

iii. It also allows for easier management of servers and applications, since we can manage them as a single instance.

3. **Application virtualization :**

i. Application virtualization operates application on computers as if they reside naturally on the hard drive, but instead are running on a server.

ii. The ability to use RAM and CPU to run the programs while storing them on a server, like through Microsoft terminal services and cloud-based software, improves how software security updates are pushed, and how software is rolled out.

4. **Administrative virtualization :**

i. Administrative virtualization is one of the least-known forms of virtualization, likely due to the fact that its primarily used in data centers.

ii. The concept of administration, or 'management,' virtualization means segmented admin roles through group and user policies.

5. **Network virtualization :** Network virtualization involves virtually managing IPs, and is accomplished through tools like routing tables, NICs, switches, and VLAN tags.

6. **Hardware virtualization :** Refer Q. 2.25, Page 2–19E, Unit-2.

7. **Storage virtualization :**

i. Storage virtualization is an array of servers that are managed by a virtual storage system.

ii. The servers are not aware of exactly where their data is stored.

Que 2.27. **Explain the implementation level of virtualization.**

Answer

Various implementation level of virtualization :

1. **Instruction Set Architecture (ISA) level :**

i. At the ISA level, virtualization is performed by emulating a given ISA by the ISA of the host machine.

ii. The basic emulation method is through code interpretation.

iii. An interpreter program interprets the source instructions to target instructions one by one.

iv. One source instruction may require tens or hundreds of native target instructions to perform its function. This process is relatively slow.

v. For better performance, dynamic binary translation is desired.

vi. This approach translates basic blocks of dynamic source instructions to target instructions.

vii. The basic blocks can also be extended to program traces or super blocks to increase translation efficiency.

viii. A Virtual Instruction Set Architecture (V-ISA) thus requires adding a processor-specific software translation layer to the compiler.

2. **Hardware abstraction level :**

i. It is performed right on top of the bare hardware and generates a virtual hardware environment for a VM.

ii. The idea is to virtualize a computer's resources, such as its processors, memory, and I/O devices so as hardware utilization rate by multiple users concurrently may be upgraded.

3. **Operating system level :**

i. OS-level virtualization creates isolated containers on a single physical server and the OS instances to utilize the hardware and software in data centers.

ii. The containers behave like real servers. OS-level virtualization is commonly used in creating virtual hosting environments to allocate hardware resources among a large number of mutually distrusting users.

iii. Library Support Level Virtualization with library interfaces is possible by controlling the communication link between applications and the rest of a system through API hooks.

4. **Library support level :**

i. Virtualization with library interfaces is possible by controlling the communication link between applications and the rest of a system through API hooks.

ii. The software tool WINE has implemented this approach to support Windows applications on top of UNIX hosts.

5. **User-application level :**
   i. Virtualization at the application level virtualizes an application as a VM.
   ii. On a traditional OS, an application often runs as a process.
   iii. Therefore, application-level virtualization is also known as process-level virtualization. The most popular approach is to deploy High Level Language (HLL).

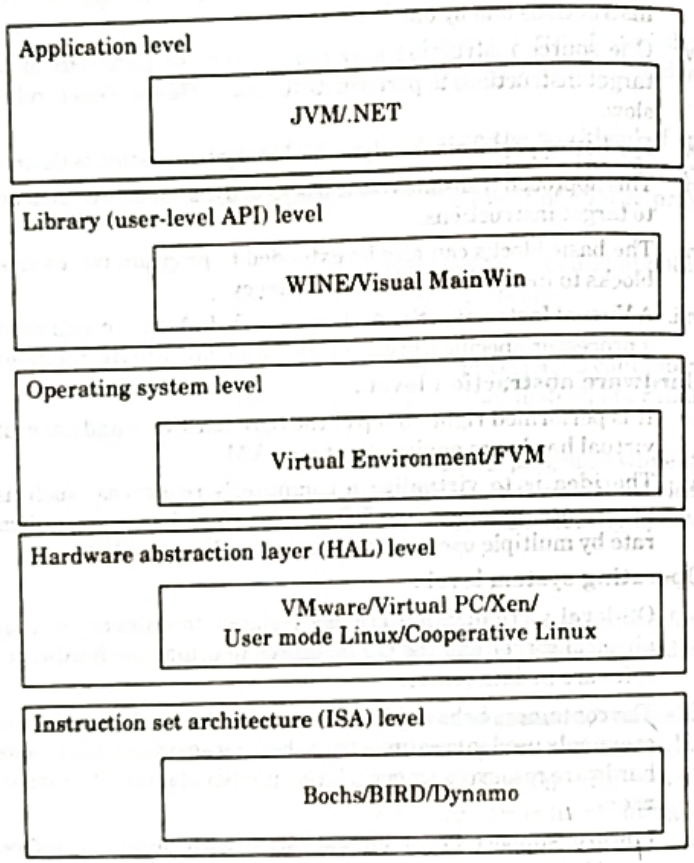


Fig. 2.27.1.

PART-4

Virtualization Structure, Tools and Mechanism, Virtualization of CPU, Memory, I/O Devices, Virtualization Support and Disaster Recovery.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 2.28. **Describe virtualization structure.**

Answer

1. In virtualization structure, the operating system manages the hardware.
2. A virtualization layer is inserted between the hardware and the operating system. The virtualization layer is responsible for converting portions of the real hardware into virtual hardware.
3. Therefore, different operating systems such as Linux and Windows can run on the same physical machine, simultaneously.
4. Depending on the position of the virtualization layer, there are several classes of VM architectures :
   i. Hypervisor (Virtual Machine Monitor) architecture
   ii. Para-virtualization
   iii. Host-based virtualization

Que 2.29. **Describe hypervisor architecture and Xen architecture.**

Answer

Hypervisor architecture :

1. The hypervisor supports hardware-level virtualization on bare-metal devices like CPU, memory, disk and network interfaces.
2. The hypervisor software sits directly between the physical hardware and its OS.
3. This virtualization layer is referred to as either the VMM or the hypervisor. The hypervisor provides hypercalls for the guest OS and applications.
4. Depending on the functionality, a hypervisor can assume a microkernel architecture like the Microsoft Hyper-V, or it can assume a monolithic hypervisor architecture like the VMware ESX for server virtualization.
5. A microkernel hypervisor includes only the basic and unchanging functions (such as physical memory management and processor scheduling). The device drivers and other changeable components are outside the hypervisor.
6. A monolithic hypervisor implements all the mentioned functions, including those of the device drivers.

The Xen architecture :

1. Xen is a microkernel hypervisor, which separates the policy from the mechanism.
2. The Xen hypervisor implements all the mechanisms, leaving the policy to be handled by Domain 0.
3. Xen does not include any device drivers natively. It just provides a mechanism by which a guest OS can
4. Xen provides a virtual environment located between the hardware and the OS.
5. The core components of a Xen system are the hypervisor, kernel, and applications.
6. Like other virtualization systems, many guest OS can run on top of the hypervisor.
7. The guest OS, which has control ability, is called Domain 0, and the others are called Domain U.
8. Domain 0 is a privileged guest OS of Xen. Domain 0 is designed to access hardware directly and manage devices.
9. The responsibilities of Domain 0 is to allocate and map hardware resources for the guest domains (the Domain U domains).

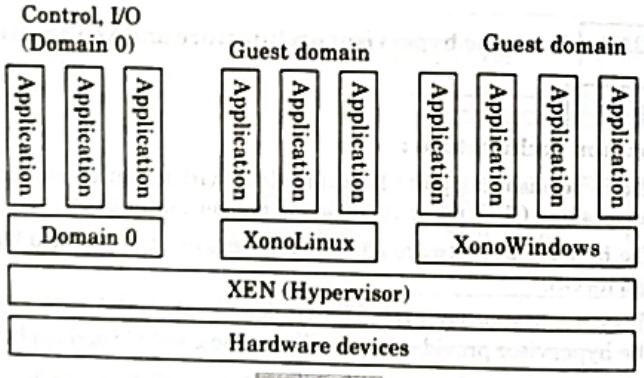


Fig. 2.29.1.

Que 2.30. **Write a short note on binary translation with full virtualization.**

OR

Describe host-based virtualization.

Answer

Binary translation with full virtualization :

1. **Full virtualization :**
   i. With full virtualization, non-critical instructions run on the hardware directly while critical instructions are discovered and replaced with traps into the VMM to be emulated by software.
   ii. Both the hypervisor and VMM approaches are considered full virtualization.
   iii. Critical instructions are trapped into the VMM because binary translation can incur a large performance overhead.
   iv. Non-critical instructions do not control hardware or threaten the security of the system, but critical instructions do.
   v. Therefore, running non-critical instructions on hardware not only can promote efficiency, but also can ensure system security.
2. **Binary translation of guest OS requests using a VMM :**
   i. VMware puts the VMM at Ring 0 and the guest OS at Ring 1.
   ii. The VMM scans the instruction stream and identifies the privileged, control and behaviour sensitive instructions.
   iii. When these instructions are identified, they are trapped into the VMM, which emulates the behaviour of these instructions. The method used in this emulation is called binary translation.
   iv. Full virtualization combines binary translation and direct execution. The guest OS is completely decoupled from the underlying hardware. Consequently, the guest OS is unaware that it is being virtualized.

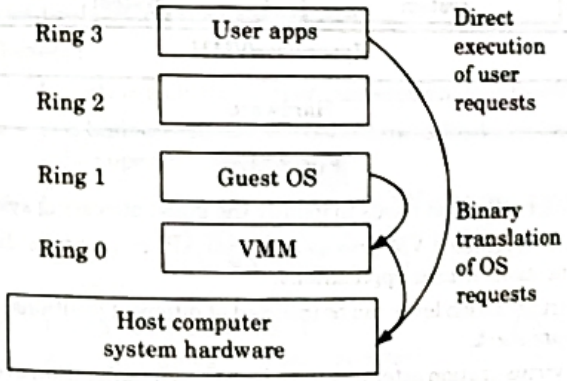


Fig. 2.30.1.

3. **Host-based virtualization :**
   i. An alternative VM architecture is to install a virtualization layer on top of the host OS. This host OS is still responsible for managing the hardware.
   ii. The guest OS are installed and run on top of the virtualization layer.
   iii. Dedicated applications may run on the VMs. Certainly, some other applications can also run with the host OS directly.
   iv. Advantages of host-based architecture :
      a. The user can install the VM architecture without modifying the host OS. The virtualizing software can rely on the host OS to provide device drivers and other low-level services. This will simplify the VM design and ease its deployment.
      b. The host-based approach appeals to many host machine configurations. Compared to the hypervisor/VMM architecture, the performance of the host-based architecture may also be low.

Que 2.31. **Describe para-virtualization.**

Answer

Para-virtualization :

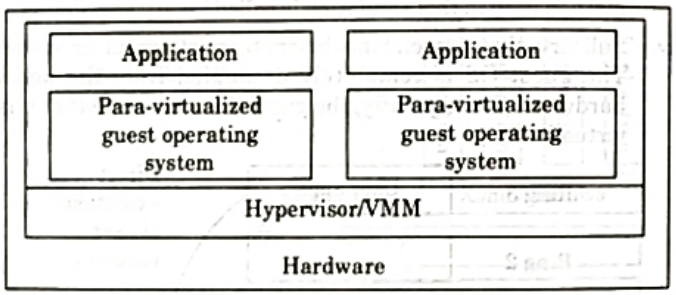


Fig. 2.31.1.

1. Para-virtualization needs to modify the guest operating systems.
2. A para-virtualized VM provides special API requiring substantial OS modifications in user applications.
3. The virtualization layer can be inserted at different positions in a machine software stack.
4. Para-virtualization attempts to reduce the virtualization overhead, and thus improve performance by modifying only the guest OS kernel.
5. The guest operating systems are para-virtualized. They are assisted by an intelligent compiler to replace the non-virtualizable OS instructions by hypercalls.

6. The traditional X86 processor offers four instruction execution rings: Rings 0, 1, 2, and 3.
7. The lower the ring number, the higher the privilege of instruction being executed.
8. The OS is responsible for managing the hardware and the privileged instructions to execute at Ring 0, while user-level applications run at Ring 3.

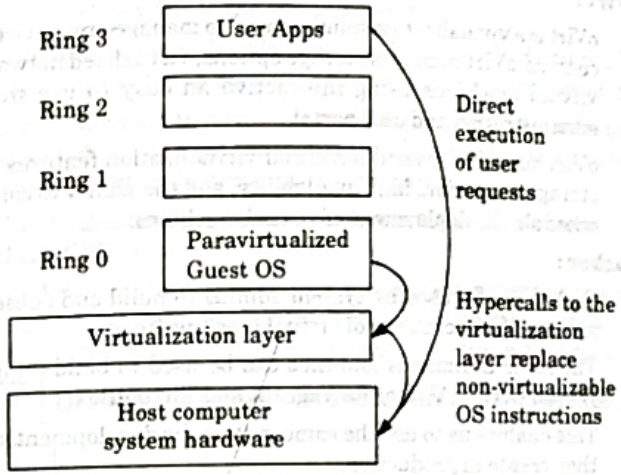


Fig. 2.31.1.

Que 2.32. **What are the various tools of virtualization ?**

Answer

Various tools of virtualization are :

1. **Ganeti :**
   i. Ganeti is a cluster server management tool developed by Google.
   ii. It is built on existing virtualization technologies like KVM, Xen and other open-source software.
   iii. Ganeti was initially started as a VMware alternative for managing networks, storage, and virtual machines and not as a cloud platform, meaning it lacks several of the features that come with larger open cloud projects.
   iv. It was designed to handle cluster management of virtual servers and offer quick and easy recovery after physical failures using commodity software.
2. **KVM (Kernel-based Virtual Machine) :**
   i. KVM is an open-source virtualization tool for Linux and contains virtualization extensions (AMD-V or Intel VT).

ii. It can either be operated in emulation or hardware mode. However, without the CPU extensions, the overall performance will be poor.

iii. It was designed for command line.

iv. KVM has a decent management interface that enable users to perform actions like launching and stopping virtual machines or taking screen shots with ease.

3. **oVirt :**

i. oVirt is a virtualization solution used to manage/create virtual data centers. oVirt manages storage options, virtualized networks, and virtual machines using interactive an easy to use web-based administration and user portal.

ii. oVirt supports several advanced virtualization features like live storage migration, high availability, and the ability to control and schedule the deployment of virtual machines.

4. **Packer :**

i. Packer can be used by system admins to build and subsequently manage the operations of virtual machine images.

ii. The same commands and files can be used to build an image on Digital Ocean, AWS or for vagrant and VirtualBox.

iii. This enables us to use the same system for development which we then create in production.

5. **Vagrant :**

i. Vagrant is a command-line tool that provides a framework and configuration format for creating, managing and distributing virtualized development environments.

ii. Vagrant enables users to share their running vagrant environment via the internet.

6. **Xen :**

i. Xen is a best Linux hypervisors.

ii. The Xen hypervisor is inserted between the server's hardware and the operating system.

iii. This creates an abstraction layer that allows multiple guest operating systems to be concurrently executed on a single physical server.

iv. Xen is included with most popular Linux distributions like Fedora, RHEL, CentOS, Ubuntu, and Debian.

Que 2.33. **Write a short note on CPU virtualization.**

Answer

1. CPU virtualization is a hardware feature that allows a single processor to act as if it was multiple individual CPUs.

2. This allows an operating system to effectively & efficiently utilize the CPU power in the computer.

3. CPU virtualization goes by different names depending on the CPU manufacturer.

4. For Intel CPUs, this feature is called Intel Virtualization Technology, or Intel VT, and with AMD CPUs it is called AMD-V. Regardless of what it is called, each virtualization technology provides generally the same features and benefits to the operating system.

5. CPU virtualization is disabled by default in the BIOS and needs to be enabled in order for an operating system to take advantage of it.

6. CPU virtualization involves a single CPU acting as if it were multiple separate CPUs. The most common reason for doing this is to run multiple different operating systems on one machine.

7. CPU virtualization emphasizes performance and runs directly on the available CPUs whenever possible.

8. The underlying physical resources are used whenever possible and the virtualization layer runs instructions only as needed to make virtual machines operate as if they were running directly on a physical machine.

Que 2.34. **Describe memory virtualization in cloud computing.**

Answer

1. Memory virtualization decouples volatile Random Access Memory (RAM) resources from individual systems in the data center, and then aggregates those resources into a virtualized memory pool available to any computer in the cluster.

2. The memory pool is accessed by the operating system or applications running on top of the operating system.

3. The distributed memory pool can then be utilized as a high-speed cache, a messaging layer, or a large shared memory resource for a CPU.

4. Memory virtualization allows networked and distributed, servers to share a pool of memory to overcome physical memory limitations, a common bottleneck in software performance.

5. With this capability integrated into the network, applications can take advantage of a very large amount of memory to improve overall performance, system utilization, increase memory usage efficiency, and enable new use cases.

6. Memory virtualization implementations are distinguished from shared memory systems.

7. Shared memory systems do not permit abstraction of memory resources, thus requiring implementation with a single operating system instance (*i.e.*, not within a clustered application environment).

8. Memory virtualization is different from storage based on flash memory such as Solid-State Drives (SSDs) - SSDs and other similar technologies replace hard-drives (networked or otherwise), while memory virtualization replaces or complements traditional RAM.

Que 2.35. Write a short note on I/O virtualization.

Answer

1. I/O Virtualization (IOV), or input/output virtualization, is technology that uses software to abstract upper-layer protocols from physical connections or physical transports.
2. This technique takes a single physical component and presents it to devices as multiple components.
3. Because it separates logical resource from physical resources. IOV is considered an enabling data center technology that aggregates IT infrastructure as a shared pool, including computing, networking and storage.
4. Recent Peripheral Component Interconnect express (PCIe) virtualization standards include single root I/O virtualization (SR-IOV) and multi-root I/O virtualization (MR-IOV).
5. SR-IOV converts a hardware component into multiple logical partitions that can simultaneously share access to a PCIe device.
6. MR-IOV devices reside externally from the host and are shared across multiple hardware domains.

Que 2.36 How I/O virtualization works.

Answer

1. In I/O virtualization, a virtual device is substituted for its physical equivalent, such as a Network Interface Card (NIC) or Host Bus Adapter (HBA).
2. Aside from simplifying server configurations, I/O virtualization setup has cost implications by reducing the electric power drawn by I/O devices.
3. Virtualization and blade server technologies cram dense computing power into a small form factor. With the advent of virtualization, data centers started using commodity hardware to support functions such as burst computing, load balancing and multi-tenant networked storage.
4. I/O virtualization is based on a one-to-many approach. The path between a physical server and nearby peripherals is virtualized, allowing a single IT resource to be shared among Virtual Machines (VMs).
5. The virtualized devices interoperate with commonly used applications, operating systems and hypervisors.

6. This technique can be applied to any server component, including disk-based RAID controllers, Ethernet NICs, Fibre Channel HBAs, graphics cards and internally mounted Solid-State Drives (SSDs). For example, a single physical NIC is presented as a series of multiple virtual NICs.

Que 2.37 Describe virtualization support.

Answer

1. With the help of VM technology, a new computing mode known as cloud computing is emerging. Cloud computing is transforming the computing landscape by sharing the hardware and costs of managing a computational center to third parties, just like banks.
2. Cloud computing has atleast two challenges :
   i. The ability to use a variable number of physical machines and VM instances depending on the needs of a problem. For example, a task may need only a single CPU during some phases of execution but may need hundreds of CPUs at other times ?
   ii. The slow operation of instantiating new VMs. Currently, new VMs originate either as fresh boots or as replicates of a template VM, unaware of the current application state. Therefore, to support cloud computing, a large amount of research and development is to be done.

Que 2.38 Explain Disaster Recovery (DR) in cloud computing.

Answer

1. Disaster Recovery (DR) is one of the important factors for cloud deployments.
2. DR defines the factors to ensure service availability and trust, and help to develop credibility for the cloud vendor.
3. DR has been treated as separate disciplines that focused on planning and recovering business operations having following catastrophic disruptions :
   i Site/facility destruction, hurricanes, tornados, floods and fire.
   ii. Often long duration (days to weeks).
   iii. Often involves shifting work (and people) to alternate facilities for some period of time.
4. The objective of the DR plan is to provide critical IT service within a stated period of time following the declaration of a disaster and perform the following activities :
   i. Protect and maintain currency of vital records.
   ii. Select a site or vendor that is capable of supporting the requirements of the critical application workload.

iii. Provide a provision for the restoration of all IT services when possible.

5. A DR plan includes procedures that will ensure the optimum availability of the critical business function and the protection of vital records necessary to restore all services to normal.

6. When DR plans fail, the failures primarily result from lack of HA (High Availability) planning, preparation, and maintenance prior to the occurrence of the disaster.

7. An infrastructure supporting high availability (HA) is essential for a rapid DR. The system and application designs must be built to support HA and rapid DR.

8. To prevent gaps in DR plans, recovery procedures, technology platforms, and DR vendors, contracts must be updated concurrently with changes.

☺☺☺

3 UNIT

Cloud Architecture, Services and Storage

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PART-1

Layered Cloud Architecture Design, NIST Cloud Computing Reference Architecture.

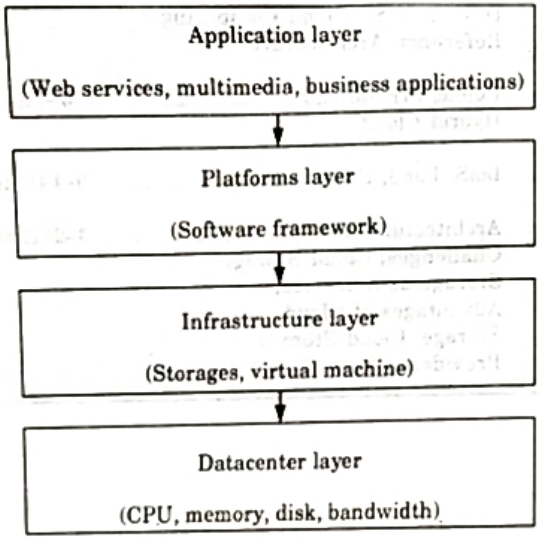
Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 3.1. **Explain the layered architecture of a cloud.**

Answer

Layered architecture of a cloud :



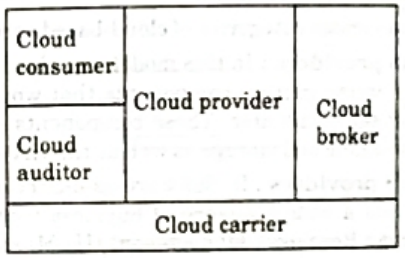
1. **Application layer :**
   a. This layer consists of different cloud services which are used by cloud users.
   b. These applications provide services to the end user as per their requirements.
2. **Platform layer :**
   a. This layer consists of application software and operating system.
   b. The objective of this layer is to deploy applications directly on the virtual machines.

3. **Infrastructure layer :**
   a. It is a virtualization layer where physical resources are partitioned into set of virtual resources through different virtualization technologies such as Xen, KVM and VMware.
   b. This layer is the core of the cloud environment where cloud resources are dynamically provisioned using different virtualization technologies.
4. **Datacenter layer :**
   a. This layer is accountable for managing physical resources such as servers, switches, routers, power supply, and cooling system etc., in the datacenter of the cloud environment.
   b. All the resources are available and managed in datacenters to provide services to the end user.
   c. The datacenter consists of physical servers, connected through high speed devices such as router and switches.

Que 3.2. **Describe briefly NIST cloud computing reference architecture.**

Answer

NIST cloud computing architecture :



1. **Cloud consumer :**
   i. A cloud consumer is the end user who browses or utilizes the services provided by Cloud Service Providers (CSP), sets up service contracts with the cloud provider.
   ii. In this, set of organizations having mutual regulatory constraints performs a security and risk assessment for each use case of cloud migrations and deployments.
   iii. Cloud consumers use Service-Level Agreement (SLAs) to specify the technical performance requirements to be fulfilled by a cloud provider.
   iv. SLAs can cover terms concerning the quality of service, security, and remedies for performance failures.

2. **Cloud auditor :**
   i. Cloud auditor is an entity that can conduct independent assessment of cloud services, security, performance and information system operations of the cloud implementations.
   ii. The services that are provided by Cloud Service Providers (CSP) can be evaluated by service auditors in terms of privacy impact, security control and performance, etc.
   iii. Cloud Auditor can make assessment of the security controls in the information system to determine the extent to which the controls are implemented correctly, operating as planned and constructing the desired outcome with respect to meeting the security necessities for the system.
   iv. There are three major roles of cloud auditor :
      a. Security audit
      b. Privacy impact audit
      c. Performance audit
3. **Cloud service providers :**
   i. It is a group or object that delivers cloud services to cloud consumers or end users.
   ii. It offers consumers to purchase a growing variety of cloud services from cloud service providers.
   iii. There are various categories of cloud-based services :
      a. **IaaS providers :** In this model, the cloud service providers offer infrastructure components that would exist in an on-premises datacenter. These components consist of servers, networking and storage as well as the virtualization layer.
      b. **SaaS providers :** In Software-as-a-Service (SaaS), vendors provide a wide sequence of business technologies, such as Human Resources Management (HRM) software, Customer Relationship Management (CRM) software, all of which the SaaS vendor hosts and provide services through internet.
      c. **PaaS providers :** In Platform-as-a-Service (PaaS), vendors offer cloud infrastructure and services that can access to perform many functions. In PaaS, services and products are mostly utilized in software development. PaaS providers offer more services than IaaS providers. PaaS providers provide operating system and middleware along with application stack, to the underlying infrastructure.
4. **Cloud broker :**
   i. An organization or a unit that manages the performance, use and delivery of cloud services by enhancing specific capability and offers the value-added services to cloud consumers.
   ii. It combines and integrates various services into one or more new services.

   iii. They provide service arbitrage which allows flexibility and opportunistic choices.
   iv. There are major three services offered by a cloud broker :
      a. Service intermediation
      b. Service aggregation
      c. Service arbitrage
5. **Cloud carrier :**
   i. The mediator who offer connectivity and transport of cloud services within cloud service providers and cloud consumers.
   ii. It allows access to the services of cloud through Internet network, telecommunication, and other access devices.

Que 3.3. **Discuss the scope between provider and consumer of NIST cloud computing reference architecture.**

Answer

1. The cloud provider and cloud consumer share the control of resources in a cloud system.
2. This analysis of description of controls over the application stack helps to understand the responsibilities of parties involved in managing the cloud application.

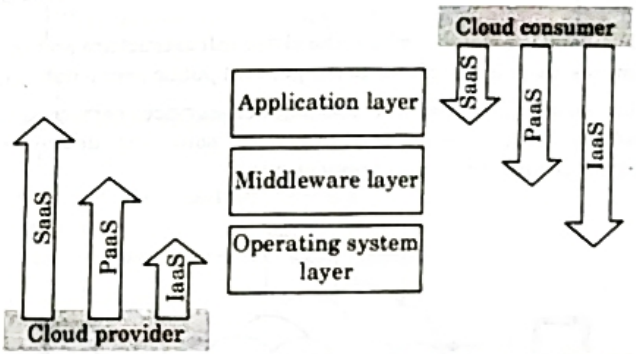


Fig. 3.3.1. Scope of controls between provider and consumer.

3. The application layer includes software applications targeted at end users or programs.
4. The applications are used by SaaS consumers, or installed/managed/maintained by PaaS consumers, IaaS consumers, and SaaS providers.
5. The middleware layer provides software building blocks (for example, libraries, database, and Java Virtual Machine) for developing application software in the cloud. The middleware is used by PaaS consumers, installed/managed/maintained by IaaS consumers or PaaS providers, and hidden from SaaS consumers.

6. The OS layer includes operating system and drivers, and is hidden from SaaS consumers and PaaS consumers.
7. An IaaS cloud allows one or multiple guest OS's to run virtualized on a single physical host.
8. Generally, consumers have broad freedom to choose which OS to be hosted among all the OS's that could be supported by the cloud provider.
9. The IaaS consumers should assume full responsibility for the guest OS's, while the IaaS provider controls the host OS.

PART-2

Public, Private and Hybrid Clouds.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 3.4. **Write a short note on public cloud.**

Answer

1. Public cloud is a cloud in which the cloud infrastructure and computing resources are made available to the general public over a public network.
2. Public cloud offers resource pooling, self-service, service accounting, elasticity, multi-tenancy to manage the solutions, deployment, and securing the resources and applications.

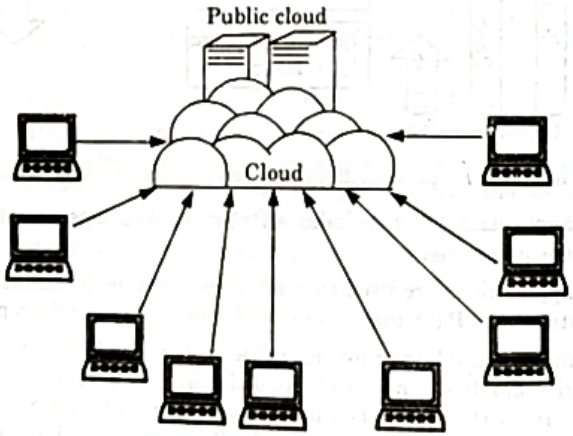


Fig. 3.4.1. Public cloud.

4. Enterprises are able to offload commodity applications to third-party service providers (hosters).
5. The term 'public' does not mean :
   a. That it is free, even though it can be free or fairly inexpensive to use.
   b. That a user's data is publicly visible - public cloud vendors typically provide an access control mechanism for their users.
6. Following are the examples of public cloud application :
   a. Public facing web pages
   b. Public Wiki's and blogs
   c. Jobs resembling batch processing with lower security constraints.
   d. Data intensive workloads
7. The services consumed from a public cloud are as follows :
   i. Security and data privacy
   ii. Ease of access
   iii. Discovery of services
   iv. RESTful interface support
   v. Lower cost
   vi. Speed and availability

Que 3.5. **Discuss security in a public cloud.**

Answer

Security in a public cloud :

1. **Multi-tenancy :**
   i. As long as the cloud provider builds its security to meet the higher-risk client requirements, all of the lower-risk clients get better security than they would have normally.
   ii. A bandage manufacturer may have a low risk of being a direct target of malfeasance, but a music label that is currently using file sharers could have a high risk of being targeted by malfeasance.
   iii. When both the bandage manufacturer and the music label use the same cloud (multi-tenancy), it is possible that attacks directed at the music label could affect the bandage manufacturer's infrastructure as well.
   iv. So, the cloud provider must design the security to meet the needs of the music label and the bandage manufacturer gets the benefits.
2. **Security review :**
   i. As the time passes, organizations become lenient with their security policies.

ii. In order to tackle security review, cloud service provider should conduct regular audits, review, and assessments for the security.

iii. This should be done by security specialists who are able to identify the issues and fix them.

iv. The report should be provided to each client immediately after the assessment is performed so that the clients know the current state of the overall cloud's security.

3. **Mutual risk :**

i. There can be a situation where the cloud service provider may not be the cloud operator, but providing a value-added service on top of another cloud provider's service.

ii. Like somebody wants to offer the SaaS-based services, it is good to lease the infrastructure of an IaaS provider and offer the SaaS based services instead of building the infrastructure from the scratch.

iii. In this way, the tiers of IaaS and SaaS are developed on top of each other.

iv. In this setup, there is a risk associated to each operator and service provider and it is shared among them.

v. They share the security risks at different levels.

vi. Therefore, a holistic risk mitigation plan should be devised to suit the architecture of the cloud provider.

4. **Employee physical screening :**

i. In this outsourcing world, it is common for the organizations to hire the contract services. Same thing works for the cloud service providers.

ii. Like regular employees, contract employee background verification should be done by a third party for cloud service provider.

iii. Service provider should publish its policy to all type of employees and report should be generated for the employees once the background verification is accomplished.

iv. This screening establishes the trust between the user and the service provider.

5. **Multi-geographical datacenters :**

i. Disasters, whether man-made or natural, are part of life.

ii. They can be storm, earthquakes, fire, or cable cuts. In practice, the cloud is a reliable model as it is not based on single or one location based datacenter. Cloud datacenters are distributed and hence, less prone to disasters.

iii. But sometimes organizations sign up the public cloud services for one location only.

iv. In this case, it is more important for the providers to test their disaster recovery option as they are heavily tied with SLAB and penalties.

v. At the same time, organization as a consumer should also check and test the disaster recovery options with mock drills of fail over.

6. **Physical security :** Physical threats are also important to be analyzed when opting for cloud services from a provider. There are various points to be analyzed :

i. Whether all the facilities of the cloud provider have the same level of security ?

ii. Is it possible that only one site is secured and there is no information available for the data residency ?

iii. Whether datacenter is having all the necessary physical security components such as biometric access, surveillance cameras, logbook, escorts, and automatic alarms ?

7. **Regulations :**

i. If any of the service provider says that they never had a security issue, it means they are either misleading or not aware of the consequences of the incidents.

ii. So, all cloud service providers should have a special task force for any incident response based on the policies and regulations.

iii. These policies should be shared with the end customers also.

8. **Programming conventions :**

i. Whether it is IaaS, SaaS, or PaaS, cloud providers still use their own software that may be prone to security threats and bugs.

ii. It is recommended to the cloud providers to use the secure coding and programming practices. It should be based on standards that are well documented, reviewed, accepted, and adhered.

9. **Data control :**

i. Today in the security domain, an organization's greatest risk is data and information control.

ii. All governments and corporate organizations have laid down compliances and regulations to handle the situation.

iii. Therefore, the cloud service provider should be able to adhere to the guidelines laid by the region or agency.

iv. The cloud provider should own the policies to meet the regulation and compliances.

v. There should be strong encryption mechanism for the in-flight data.

Que 3.6. **Write down the advantages and disadvantages of public cloud.**

Answer

Advantages of public cloud :

1. Flexible
2. Reliable
3. High scalable
4. Low cost
5. Place independence

Disadvantages of public cloud :

1. Less secured
2. Poor customizable

Que 3.7. **What do you mean by private cloud ?**

Answer

1. Private clouds are deployments made inside the company's firewall (on-premise datacenters) and traditionally run by on-site servers.
2. Private clouds offer some of the benefits of a public cloud computing environment; such as elastic on-demand capacity, self-service provisioning, and service-based access.
3. Private cloud is suitable when the traditional requirements, such as control, security, and resiliency, are more emphasized by an organization with the restricted and designated user access and authorization.

Services in private cloud :

1. Virtualization
2. Government and management
3. Multi-tenancy
4. Consistent deployment
5. Chargeback and pricing
6. Security and access control

Benefits of using private clouds :

1. **Eliminating capital expenses and operating costs :**
   i. Ownership of the hardware or software eliminates the pay-per-use potential, as these must be upfront purchases.
   ii. The full cost of operations must be shouldered as there is no elasticity.
   iii. If the private cloud hardware is sized for peak loads, there will be inefficient excess capacity.
   iv. Otherwise, the owner will face complex procurement cycles.

2. **Removing undifferentiated heavy lifting by offloading data center operations :**
   i. Utility pricing (for lower capital expenses and operating expenses) usually implies an outside vendor offering on-demand services.
   ii. It relies on the economies of multiple tenants sharing a larger pool of resources.
   iii. These higher costs might be justified if the benefits of quicker and easier self-service provisioning and service-oriented access are large.

Que 3.8. **What are the types of private cloud ?**

Answer

Types of private cloud :

1. **Shared private cloud :**
   a. This is a shared compute capacity with variable usage-based pricing to business units that are based on service offerings, accounts data centers.
   b. It requires an internal profit center to take over or buy infrastructure made available through account consolidations.
2. **Dedicated private cloud :**
   a. Dedicated private cloud has IT service catalog with dynamic provisioning.
   b. It depends on standardized Service-Oriented Architecture (SOA) assets that can be broadly deployed into new and existing accounts and is a lower-cost model.
3. **Dynamic private cloud :**
   a. Dynamic private cloud allows client workloads to dynamically migrate from and to the compute cloud as needed.
   b. This model can be shared and dedicated.
   c. It delivers the ultimate value of clouds.
   d. This is a very low-management model with reliable SLAs and scalability.

Que 3.9. **Write down the advantages and disadvantages of private cloud.**

Answer

Advantages of private cloud :

1. **Highly private and secured :** Private cloud resource sharing is highly secured.

2. **Control oriented :** Private clouds provide more control over its resources than public cloud as it can be accessed within the organization's boundary.

Disadvantages of private cloud :

1. **Poor scalability :** Private type of clouds is scaled within internal limited hosted resources.
2. **Costly :** It provides secured and more features, so it's more expensive than a public cloud.
3. **Pricing :** It is inflexible *i.e.*, purchasing new hardware for up-gradation is more costly.
4. **Restriction :** It can be accessed locally within an organization and is difficult to expose globally.

Que 3.10. **Explain hybrid cloud.**

Answer

1. A hybrid cloud is a combination of an interoperating public and private cloud.
2. This is the model where consumer takes the non-critical application or information and compute requirements to the public cloud while keeping all the critical information and application data in control.
3. The hybrid model is used by both public and private clouds simultaneously.
4. It is an intermediate step in the evolution process, providing businesses on-ramp from their current IT environment into the cloud.
5. It offers the best of both cloud worlds - the scale and convenience of a public cloud and the control and reliability of on-premises software and infrastructure - and let them move fluidly between the two on the basis of their needs.
6. This model allows the following :
   a. Elasticity is the ability to scale capacity up or down within minutes, without owning the capital expense of the hardware or datacenter.
   b. Pay-as-you-go pricing.
   c. Network isolation and secure connectivity as if all the resources were in a privately owned datacenter.
   d. Gradually move to the public cloud configuration, replicate an entire datacenter, or move anywhere in between.

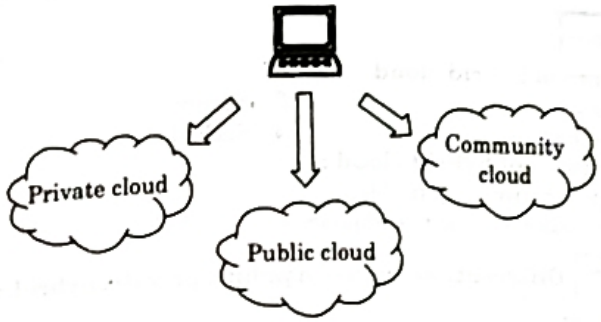


Fig. 3.10.1. Hybrid cloud.

Que 3.11. **How can we manage hybrid cloud ? Explain.**

Answer

1. A management strategy for hybrid cloud should define what we need to manage and how best to do that.
2. Hybrid cloud consists of an internal private cloud and contracts with one or more public cloud providers.
3. Hybrid cloud administrators are responsible for managing computing, networking and storage resources in multiple domains.
4. Over the time, combination of domains will change, but our management strategy and tools should remain the same.
5. In a hybrid cloud, the management system should provide the means for the user to make submissions without the need to choose or indicate the localization of the computational resources to be used.
6. The hybrid cloud management system must implement means to deploy interfaces with each public cloud to be used, as well as with the private cloud resources.
7. The workload management system is tightly coupled to the resource management system. Besides the submission interface, which interacts with users, two other main actors appear to manage the workload execution in hybrid cloud : the dispatcher/scheduler and the application.
8. Configuration and installment management policies should specify rules governing the creation, deployment, patching and rebuilding of images.
   a. Access control policies should be in place when sensitive data and restricted applications, such as programs containing high-value intellectual property, are being used in the private or a public cloud.
   b. Budget management and reporting policies should specify how cloud users will receive information regarding costs and use.

Que 3.12. **Write down the advantages and disadvantages of hybrid cloud.**

Answer

Advantages of hybrid cloud :

1. Flexible
2. Secure
3. Cost effective
4. Scalable

Disadvantages of hybrid cloud :

1. Complex networking problem
2. Organization's security compliance

Que 3.13. **Differentiate between public, private, hybrid cloud.**

Answer

S. No.	Public cloud	Private cloud	Hybrid cloud
1.	A deployment model that operates for a single organization.	A deployment model that renders services over a network for public use.	A composition of private and public cloud that offer benefits of multiple deployment models.
2.	It offers more security.	It is less secure.	It is more secure than public cloud.
3.	It offers services to an organization.	It offers services to the general public.	It offers services of both private and public cloud as it is a combination of both.
4.	Not very scalable because it can be scaled only with the capacity of internal hosted resources.	It is highly scalable as it can be scaled up or down depending on the requirement.	It provides scalability according to the public cloud scalability and private cloud scalability in it.
5.	More expensive.	Requires a minimum cost.	Cost effective than private cloud.

PART-3

IaaS, PaaS, SaaS.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 3.14. **Explain Infrastructure-as-a-Service (IaaS).**

Answer

1. In Infrastructure-as-a-Service (IaaS), an organization outsources the infrastructure related to the storage, hardware, servers and networking components to the service provider.
2. IaaS is also referred to as Hardware-as-a-Service (HaaS). Deployment of applications requires huge initial investment for setting up hardware, storage devices and networking components in addition to the maintenance of the hardware and storage devices, a large amount of electricity is also needed to power the servers as well as to keep the data center cool.
3. In case of IaaS, the client typically pays on a per-use basis to the service provider. Common characteristics and components of IaaS include utility computing service, billing model, automation of administrative tasks, dynamic scaling, virtualization, policy-based services and network connectivity.
4. The billing is usually on an hourly, daily or monthly basis based on the actual consumption of the resources.
5. It is not like the conventional services in which we pay a fixed amount whether we use the resources or not.

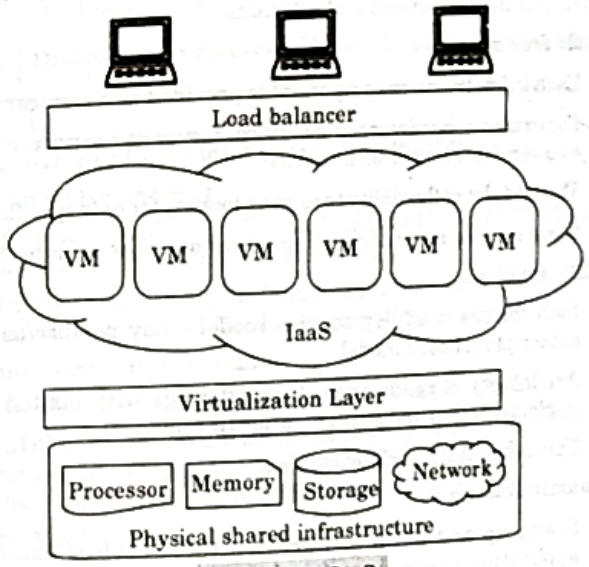


Fig. 3.14.1. IaaS.

6. Use of IaaS is quite rational as it is cost effective and makes us free from huge investment on hardware.

7. With IaaS, one can configure the required resources as per the requirement and the user can increase or decrease capacity within minutes.
8. We can ask for one, hundreds or even thousands of server instances simultaneously as per our computing need. Good service provider ensures 99.99% availability of the service within a region over a trailing 365 day period.
9. The IaaS service provider ensures that the infrastructural needs of the virtual machine are continuously met. With the quick availability of IaaS and infrastructure delivered as a service, it frees the organization to focus their time and resources in bringing innovations in applications and solutions.
10. However, it is the responsibility of the user to invest on the operating system and application software.

Que 3.15. What are the advantages and disadvantages of IaaS ?

Answer

Advantages of IaaS :

1. **Allows IT to shift focus :** With the quick availability of IaaS services, infrastructure delivered as a service (ready to consume), it frees an organization to leverage and focus their time and resources in bringing innovations in applications and solutions.
2. **Hassle free service :**
   i. Each infrastructure component is provided as a service.
   ii. For example, hardware as a service, server as a service, computing as a service, storage as a service.
   iii. This adds lot of flexibility to anyone looking for only specific services.
   iv. Some require more computing power and others more storage.
3. **Utility service :**
   i. IaaS follows a utility service model - pay per-use/pay per-go subscription based model.
   ii. Availability of ready to go IaaS offerings with limited time for implementation and customization (if provided).
   iii. This is hallmark of cloud services.
4. **Dynamic scaling :**
   i. Scales up and down of infrastructure services based on the application usage, best for the applications where there are significant spikes and troughs on the usage of infrastructures.
   ii. This again is one of the pillars of cloud computing services.

5. **Multiple tenants :** Service provisioning includes multiple users accessing same piece of infrastructure.
6. **Investment cap :**
   i. More beneficial for companies with limited capital to invest in hardware and infrastructure.
   ii. Most small and medium businesses cannot afford the upfront cost of their IT infrastructure as they want to focus more on their product offering/core business.

Disadvantages of IaaS :

1. **Security :** The enterprise does not have any control over cloud security in an IaaS environment. They need to review the cloud service provider's Service Level Agreement (SLA) to help them understand its security obligations and thereby identifying gaps in their security coverage.
2. **Lack of flexibility :** Service providers maintain the software, but they do not upgrade the software for some of the businesses.
3. **Technical problems :** Organizations faces some down-time with IaaS, and it will restrict their access to applications and data.
4. **Over dependency :** Having IaaS in our organization means have a full dependency on the provider or third party for our data.
5. **Upgrade and maintenance :** The organization is solely responsible for any upgrades of software and maintenance of tools or data system.
6. **Virtualization services and user-privacy :** IaaS depends on virtualization services. Also, restricts user-privacy and customization.

Que 3.16. Discuss the vendors of IaaS cloud computing platform.

Answer

Vendors providing IaaS cloud computing platform :

1. **Amazon web services :**
   i. Its solution are Elastic, Elastic Compute Cloud (EC2), MapReduce, Route S3, Virtual Private Cloud, etc.
   ii. The cloud computing platform pioneer, Amazon offers auto scaling, cloud monitoring, and load balancing features as part of its portfolio.
2. **Reliance communications :**
   i. Its solution is Reliance Internet Data Center (RIDC).
   ii. RIDC supports both traditional hosting and cloud services, with datacenters in Mumbai, Bangalore, Hyderabad, and Chennai. The cloud services offered by RIDC include IaaS and SaaS.
3. **Sify technologies :**
   i. Its solution is Sify IaaS.
   ii. Sify's cloud computing platform is powered by HP's converged infrastructure. The vendor offers all three types of cloud services: IaaS, PaaS, and SaaS.

4. **Tata communications :**
   i. Its solution is InstaCompute.
   ii. InstaCompute is Tata Communications IaaS offering. InstaCompute datacenters are located in Hyderabad and Singapore, with operations in both countries.

Que 3.17. **Explain Platform-as-a-Service (PaaS) in brief.**

Answer

1. Platform-as-a-Service (PaaS) is a category of cloud computing services that provides a platform allowing customers to develop, run, and manage applications without the complexity of building and maintaining the infrastructure typically associated with developing and launching an app.
2. PaaS can be delivered in two ways :
   i. As a public cloud service from a provider, where the consumer controls software deployment with minimal configuration options, and the provider provides the networks, servers, storage, OS, 'middleware' (*i.e.*, java runtime, .net runtime, integration, etc.), database and other services to host the consumer's application.
   ii. As a private service (software) inside the firewall, or as software deployed on a public infrastructure as a service.

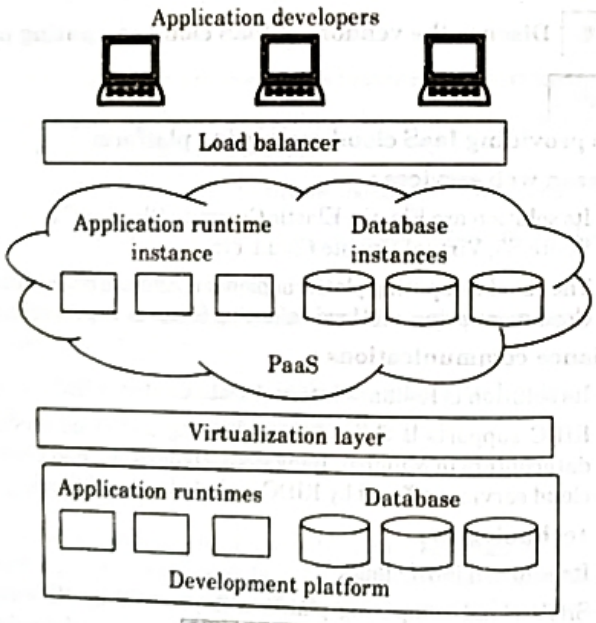


Fig. 3.17.1. PaaS.

3. Features of PaaS :
   i. Operating system
   ii. Server-side scripting environment
   iii. Database management system
   iv. Server software
   v. Support
   vi. Storage
   vii. Network access
   viii. Tools for design and development
   ix. Hosting

Que 3.18. **What are the advantages and disadvantages of PaaS ?**

Answer

Advantages of PaaS :

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

Disadvantages of PaaS :

1. Developers may not be able to use a full range of conventional tools (for example, relational databases with unrestricted joins).
2. It locked into a certain platform. However, most PaaS are relatively lock-in free.

Que 3.19. **Give characteristics of PaaS.**

Answer

The main characteristics of PaaS are :

1. **Runtime framework :**
   a. This is the "software stack" aspect of PaaS, and perhaps the aspect that comes first to mind for most people.

b. The PaaS runtime framework executes end user code according to policies set by the application owner and cloud provider.

c. PaaS runtime frameworks come in many flavours, some based on traditional application runtimes, others based on 4GL and visual programming concepts, and some with pluggable support for multiple application runtimes.

2. **Abstraction :**

a. Platform-oriented cloud platforms are distinguished by the higher level of abstraction they provide.

b. With IaaS, the focus is on delivering to user raw access to physical or virtual infrastructure.

c. In contrast with PaaS, the focus is on the applications that the cloud must support.

d. Whereas an IaaS cloud gives the user a bunch of virtual machines that must be configured and to which application components must be deployed, a PaaS cloud provides the user a way to deploy the applications into a seemingly limitless pool of computing resources, eliminating the complexity of deployment and infrastructure configuration.

3. **Automation :** PaaS environments automate the process of deploying applications to infrastructure, configuring application components, provisioning and configuring supporting technology like load balancers and databases, and managing system change based on policies set by the user.

4. **Cloud services :**

a. PaaS provide developers and architects with services and APIs that help to simplify the job of delivering elastically scalable, highly available cloud applications.

b. These cloud services provide a wide variety of capabilities key differentiators among competing PaaS offerings.

Que 3.20. **Write down the vendors of PaaS cloud computing platform.**

Answer

Vendors providing PaaS cloud computing platform :

1. Google Apps Engine (GAE)
2. SalesForce.com
3. Windows Azure
4. AppFog
5. Openshift
6. Cloud foundry from VMware

Que 3.21. **What do you mean by cloud platform ?**

Answer

1. Cloud platform lets developers to write applications that run in the cloud, or use services provided from the cloud, or both. Cloud platform is also known as on-demand platform and Platform-as-a-Service (PaaS).
2. When a development team creates an on-premises application (*i.e.*, one that will run within an organization), much of what that application needs already exists.
3. An operating system provides basic support for executing the application, interacting with storage, and more, while other computers in the environment offer services such as remote storage.
4. If the creators of every on-premises application first had to build all of these basics, we have many fewer applications today.
5. Similarly, if every development team that wishes to create a cloud application must first build its own cloud platform, we would not see many cloud applications.
6. Vendors are rising to this challenge, and a number of cloud platform technologies are available today.
7. The goal is to categorize and briefly describe those technologies as they are seen by someone who creates enterprise applications.
8. To get a grip on cloud platforms, it is useful to start by looking at cloud services in general.
9. Three broad categories of services in cloud :

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

i. A SaaS application runs entirely in the cloud (*i.e.*, on servers at an internet-accessible service provider).

ii. The on-premises client is typically a browser or some other simple client. For example, salesforce.com.

b. **Attached services :**

i. Every on-premises application provides useful functions on its own. An application can sometimes enhance application-specific services provided in the cloud.

ii. Because these services are usable only by this particular application, they can be thought of as attached to it. For example, Apple's iTunes.

iii. The desktop application is useful for playing music and more, while an attached service allows buying new audio and video content.

iv. Microsoft's exchange hosted services provides an enterprise example, adding cloud-based spam filtering, archiving, and other services to an on-premises exchange server.

c. **Cloud platforms :**

i. A cloud platform provides cloud-based services for creating applications. Rather than building their own custom foundation, for example, the creators of a new SaaS application could instead build on a cloud platform.

ii. In Fig. 3.21.1, the direct users of a cloud platform are developers, not end users.

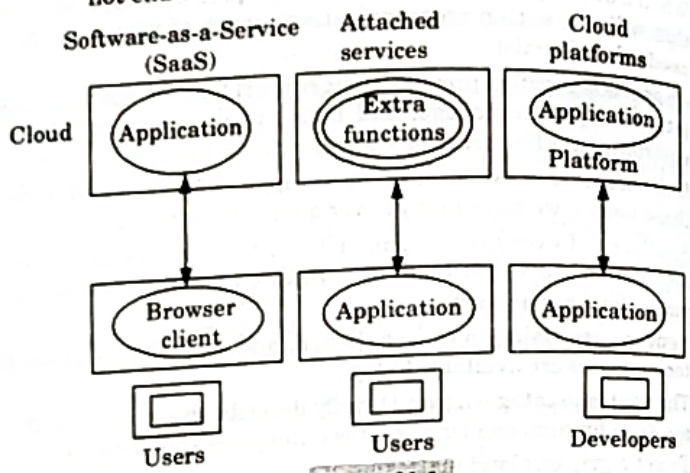


Fig. 3.21.1.

Que 3.22. **Explain Software-as-a-Service (SaaS) in brief.**

Answer

1. SaaS (Software-as-a-Service) is an application hosted on a remote server and accessed through the internet.
2. SaaS is the web-based e-mail service offered by companies such as Microsoft (Hotmail), Google (Gmail), and Yahoo! (Yahoo Mail).
3. Each mail service meets the basic criteria, the vendor (Microsoft, Yahoo, and so on) hosts all of the programs and data in a central location, providing end users with access to the data and software, which is accessed across the World Wide Web.

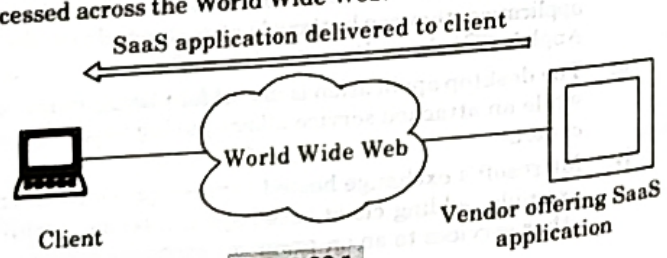


Fig. 3.22.1.

5. Two major categories of SaaS :

a. **Line of business services :**

i. These are business solutions offered to companies and enterprises.

ii. They are sold through a subscription service.

iii. Applications covered under this category include business processes, like supply chain management applications, customer relations applications, and similar business-oriented tools.

b. **Customer-oriented services :**

i. These services are offered to the general public on a subscription basis.

ii. They are offered for free and supported by advertising.

iii. For example, web mail services, online gaming, and consumer banking, among others.

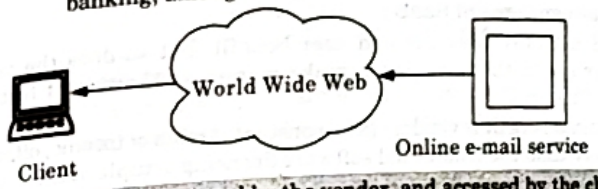


Fig. 3.22.2. E-mail is stored by the vendor, and accessed by the client.

Que 3.23. **What are the advantages of SaaS ?**

Answer

Advantages of SaaS :

1. There is a faster time to value and improved productivity, when compared to the long implementation cycles and failure rate of enterprise software.
2. SaaS offerings feature the biggest cost savings over installed software by eliminating the need for enterprises to install and maintain hardware, pay labour costs, and maintain the applications.
3. SaaS can be used to avoid the custom development cycles to get applications to the organization quickly.
4. SaaS vendors typically have very accurate security audits.

Que 3.24. **Explain software considerations in SaaS.**

Answer

1. Using the existing software paradigm, the user purchases a software package and license by paying a one time fee. The software then becomes the property of the user who bought it.
2. Support and updates are provided by the vendor under the terms of the license agreement. This can be costly if we are installing a new application on hundreds or thousands of computers.

3. SaaS, has no licensing. Rather than buying the application, we pay for it through the use of a subscription, and we only pay for what we use. If we stop using the application, we stop paying.

Fig. 3.24.1.

Que 3.25. **Give vendor advantages and limitations of SaaS.**

Answer

Vendor advantages of SaaS :

1. SaaS not only does the end user benefit, but so does the vendor. (They are in the business to make money, so there is at least that benefit.)
2. Financial benefit is vendors get a constant stream of income, often what is more than the traditional software licensing setup.
3. Vendors can fond off piracy concerns and unlicensed use of software.
4. Vendors also benefit more as more subscribers come online.
5. They have a huge investment in physical space, hardware, technology staff, and process development.
6. The more resources are used to capacity, the more the provider can clear as margin.

Limitations of SaaS :

1. Technical obstacles to SaaS have included an effective, multi-tenant architecture. This has become less and less of a problem due to virtualization, but designing an application to efficiently deliver it to thousands of customers via the internet is hard work.
2. Software companies are being asked to become service companies, and the two do not necessarily mesh well.
3. They tend to have a corporate culture that is dominated by engineering innovation and a license-sales mindset. These are fine traits to have if we are writing programs and applications, but it is not the best when we are called upon for customer service.
4. Further, a business model that is built on selling licensed software does not easily transform into a subscription model very cleanly. Not only does the vendor face challenges, but so does the customer.
5. While some applications are ideal for SaaS, others are not good to use employing an SaaS model.

Que 3.26. **Write a short note on driving forces of SaaS.**

Answer

Driving forces of SaaS are :

1. **Popularity :**
   i. SaaS has become big buzz in the already buzzy issue of cloud computing.
   ii. SaaS is becoming trendy, because of its a number of factors. But there are solid reasons other than type that make it so popular.
2. **Plenty of SaaS platforms :**
   i. There are many SaaS platforms which grow each rapidly.
   ii. For example, Oracle is developing its own SaaS platform while Microsoft is working to make their own applications SaaS ready.
   iii. As SaaS becomes more and more popular, more vendors are going to be forced to make their platforms SaaS-friendly for SaaS-based applications.
   iv. Another reason SaaS platforms will continue to grow is because of the interest in Green IT and the efforts to move toward virtualized infrastructure.
   v. That means clients are likely to move toward SaaS platforms so they can reduce the number of servers.
3. **Virtualization benefits :**
   i. Virtualization makes it easy to move to a SaaS system.
   ii. It is easier for Independent Software Vendors (ISVs) to adopt SaaS is the growth of virtualization.
   iii. The growing popularity of some SaaS vendors using Amazon's EC2 cloud platform and the overall popularity of virtualized platforms help with the development of SaaS.
4. **SaaS and SOA :**
   i. A Service-Oriented Architecture (SOA) is one in which IT supports the business processes that cover current and emerging requirements to run the business end-to-end.
   ii. This ranges from Electronic Data Interchange (EDI) to online auctions. By updating older technologies like Internet-enabling EDI-based systems companies can make their IT systems available to internal or external customers.
   iii. SOA unifies business processes by structuring large applications as a collection of smaller modules known as services.
   iv. SOA presents a design framework for realizing rapid and low-cost system development and improving total system quality. SaaS and SOA are quite similar; what they have in common is that they use a service model.
5. **Economic impact :**
   i. Many industry observers think conventional ISVs will have a tougher time than SaaS vendors.

ii. The subscription-based payment model of SaaS makes it more appealing in these tough times.

iii. The ability to quickly and easily turn on new applications with a significantly lower initial cost of ownership makes SaaS an attractive offering for small and mid-sized businesses, significantly expanding the market for software applications.

iv. The benefits are likely to be key in a slower economic environment where purchasers of software may be increasingly skeptical of significant upfront investments which we anticipate to characterize.

Que 3.27. **Differentiate between IaaS, PaaS, SaaS.**

Answer

S. No.	IaaS	PaaS	SaaS
1.	Infrastructure-as-a-Service.	Platform-as-a-Service.	Software-as-a-Service.
2.	A service model in cloud computing that provides virtualized computing resources.	A cloud computing model that delivers tools necessary for application development over the internet.	A service model in cloud computing that hosts software and makes them available for clients over the internet.
3.	It provides access to resources such a virtual machines, virtual storage etc.	It provides runtime environments development and deployment tools for applications.	It provides software as services to the end users.
4.	It is used by network architects.	It is used by developers.	It is used by end users.

PART-4

Architectural Design Challenges, Cloud Storage, Storage-as-a-Service, Advantages of Cloud Storage, Cloud Storage Providers-S3.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 3.28. **Write short note on the architectural design challenges in cloud.**

Answer

Cloud architectural design challenges :

1. Service availability and data lock-in problem.
2. Data privacy and security concerns.
3. Unpredictable performance and bottlenecks.
4. Distributed storage and widespread software bugs.
5. Cloud scalability, interoperability, and standardization.
6. Software licensing and reputation sharing.

Que 3.29. **Write a short note on storage.**

Answer

1. The necessary storage is provided and configured in much the same way as the computing resources. IP-based storage systems are deployed.
2. To reduce hardware configuration effort, the computing systems use direct-attached storage. Using Fiber-Channel (FC) cards in the servers and deploying an FC network increases overall system complexity substantially. The IP storage systems are linked via Giga-bit Ethernet.

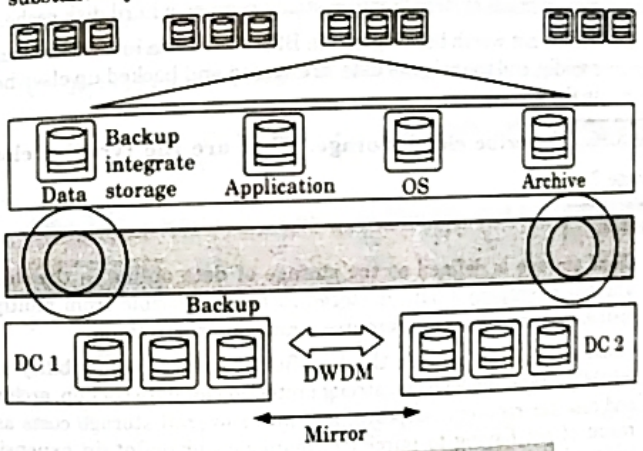


Fig. 3.29.1. Storage resource : backup-integrated, read-only and archive storage.

3. Storage is automatically allocated to the server systems that require it. Storage resources are located in different fire zones as well as in different datacenters, preventing data loss in the event of a disaster.

4. The storage system handles replication of data between datacenters and fire zones. So, computing resources are not needed for this purpose.
5. In addition to storage resources, backups are necessary to safeguard against data loss. For this reason, and in the interests of automation, the Dynamic Data Center model directly couples backup to storage; in other words, Backup-Integrated Storage (BIS) is provided, along with full management functionality.
6. To accelerate backup and reduce the volume of data transferred, data are backed up on hard disks within the storage system by means of snap shooting.
7. This simplifies the structure of the computing systems and minimizes the potential for temporal bottlenecks. Storage systems normally provide for 35-day storage period. Usually, the last three days are accessible on-line, with the rest being accessible from a remote site.
8. **Archive and other storage :**
   a. Archive systems are also available for long term data storage. Like BIS, these are hard disk-based and linked via IP to the respective systems. Data for archiving is replicated within the archive system and in a separate fire zone, as well as at a remote datacenter.
   b. Replication is handled by the archive system itself.
   c. Archiving can be initiated either from the applications themselves, which then handle administration of all data, or via a document management system. Some systems require a hard disk cache.
   d. This is not worth backing up via BIS, since data in a cache change rapidly, and the original data are stored and backed up elsewhere in the system.

Que 3.30. **Describe cloud storage. What are the types of cloud storage ?**

Answer

1. Cloud storage is defined as the storage of data online in the cloud, wherein a company's data is stored in and accessible from multiple distributed and connected resources that comprise a cloud.
2. Cloud storage can provide the benefits of greater accessibility and reliability, rapid deployment, strong protection for data backup, archival and disaster recovery purposes, and lower overall storage costs as a result of not having to purchase, manage and maintain expensive hardware.
3. Cloud storage does have the potential for security and compliance concerns that are not associated with traditional storage systems.

Types of cloud storage :

1. **Personal cloud storage :**
   i. It is also known as mobile cloud storage. Personal cloud storage is a subset of public cloud storage that applies to storing an individual's data in the cloud and providing the individual with access to the data from anywhere.
   ii. It provides data syncing and sharing capabilities across multiple devices. Apple's iCloud is an example of personal cloud storage.
2. **Public cloud storage :**
   i. Public cloud storage is where the enterprise and storage service provider are separate and there aren't any cloud resources stored in the enterprise's datacenter.
   ii. The cloud storage provider fully manages the enterprise's public cloud storage.
3. **Private cloud storage :**
   i. A form of cloud storage where the enterprise and cloud storage provider are integrated in the enterprise's datacenter.
   ii. In private cloud storage, the storage provider has infrastructure in the enterprise's datacenter that is typically managed by the storage provider.
   iii. Private cloud storage helps to resolve the potential for security and performance concerns while still offering the advantages of cloud storage.
4. **Hybrid cloud storage :** Hybrid cloud storage is a combination of public and private cloud storage where some critical data resides in the enterprise's private cloud while other data is stored and accessible from a public cloud storage provider.

Que 3.31. **Write short note on Storage-as-a Service (SaaS).**

Answer

1. Storage-as-a Service (SaaS) is a business model in which a large company rents space in their storage infrastructure to a smaller company or individual.
2. In the enterprise, SaaS vendors are targeting secondary storage applications by promoting SaaS as a convenient way to manage backups.
3. The key advantage to SaaS in the enterprise is in cost savings, in personnel, in hardware and in physical storage space.
4. Storage-as-a-Service is generally seen as a good alternative for a small or mid-sized business that lacks the capital budget and/or technical personnel to implement and maintain their own storage infrastructure.

5. SaaS is also being promoted as a way for all businesses to mitigate risks in disaster recovery, provide long-term retention for records and enhance both business continuity and availability.

Que 3.32. **What are the advantages and disadvantages of cloud storage ?**

Answer

Advantages of cloud storage :

1. **Usability :** All cloud storage services have desktop folders for Mac's and PCs. This allows users to drag and drop files between the cloud storage and their local storage.
2. **Bandwidth :** Avoid emailing files to people and send an internet link to recipients through email.
3. **Accessibility :** Stored files can be retrieved from anywhere via Internet connection.
4. **Disaster recovery :** It is highly suggested that businesses have an emergency backup plan ready in the case of a crisis. It can be used as a backup plan by companies by providing a second backup of important files. These records are saved at a remote location and may be obtained through an online connection.
5. **Price savings :** Businesses and organizations may frequently lower annual operating costs by using cloud storage. Users may observe extra cost savings because it does not require internal ability to store information remotely.

Disadvantages of cloud storage :

1. **Usability :** Be careful when using drag/drop to transfer a file to the cloud storage folder. This may permanently move our record from its original folder to the cloud storage place. Do a backup and paste instead of drag/drop if we want to retain the record's unique location in addition to transferring a backup on the folder.
2. **Bandwidth :** Many storage services have a particular bandwidth allowance. When an organization exceeds the specified allowance, further charges could be important. But some suppliers allow unlimited bandwidth. This is a factor that firms should consider when looking at a cloud storage supplier.
3. **Access :** If we have no internet connection, we have no access to our information.
4. **Data security :** There are concerns with the security and privacy of all important data stored remotely. The possibility of personal information commingling with other businesses makes some companies uncomfortable.

Que 3.33. **Explain cloud storage providers.**

Answer

1. A cloud storage provider, also known as a Managed Service Provider (MSP), is a company that offers organizations and individuals the ability to place and retain data in an off-site storage system. Customers can lease cloud storage capacity per month or on demand.
2. A cloud storage provider hosts a customer's data in its own datacenter, providing fee-based computing, networking and storage infrastructure.
3. Both individual and corporate customers can get unlimited storage capacity on a provider's servers at a low per-gigabyte price.
4. Rather than store data on local storage devices, such as a hard disk drive, flash storage or tape, customers choose a cloud storage provider to host data on a system in a remote datacenter. Users can then access those files using an internet connection.
5. The delivery of IT services via the internet is broadly defined as cloud computing or utility computing. This business model first hit mainstream enterprises with the rise of application service providers.
6. A cloud storage provider also sells non-storage services for a fee.
7. Enterprises purchase compute, software, storage and related IT components as discrete cloud services with a pay-as-you-go license.
8. For example, customers can opt to lease infrastructure-as-a-service, platform-as-a-service, or security, software and storage-as-a-service.

Que 3.34. **What are the challenges faced by cloud service providers ?**

Answer

Challenges faced by the cloud service providers :

1. **Data corruption :** Cloud services which host consumer data are usually burdened with the responsibility of ensuring the integrity and availability of these data, depending on the subscribed service level.
2. **Logical security :** In terms of information security, an appropriate control of logical security should be adopted by the producer to ensure adequate confidentiality (*i.e.*, data and transactions are open only to those who are authorized to view or access them).
3. **Data interoperability :** Producer should follow the interoperability standards in order for the consumers to be able to combine any of the cloud services into their solutions.
4. **Software vulnerability and breaches :** There are occasions when the public community discovers vulnerabilities of specific software, middleware, web services, or other network services components in the

software components. The producer should ensure that a proper strategy and processes are in placed to address such vulnerabilities and fixed to prevent breaches.

Que 3.35. **Describe the two charging models of cloud service provider.**

Answer

Two charging models of cloud service provider are :

1. **Utility model :**
   i. Pay-per-use model where consumer is charged on the quantity of cloud services usage and utilization. This model is similar to traditional electricity charges.
   ii. For example, a consumer uses secured storage to support its private work documentation. The consumer is charged yearly fee for every 10 gigabytes of storage that is used. This model provides a lower startup cost option for a customer in translating TCO to actual utilization.
2. **Subscription model :**
   i. Here the consumer is charged based on time-based cloud services usage.
   ii. For example, the consumer is charged yearly fee for a dedicated storage of 10 gigabytes to host the company website. This model provides predictable cost outlay and provides a steady stream of revenue for the services provider.

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4 UNIT Resource Management and Security in Cloud

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PART-1

Inter Cloud Resource Management.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 4.1. **Write a short note on inter cloud.**

Answer

1. Inter cloud is the concept of connected cloud networks, including public, private, and hybrid clouds.
2. It incorporates a number of technology efforts that are put together to improve interoperability and portability among cloud networks.
3. The goal was to improve interoperability of cloud networks. The terms inter cloud computing and intercloud were used to address this concept.
4. Inter cloud is used to connect different cloud computing platforms and allows the data and applications to be ported between datacenters or cloud services.
5. The main focus is on direct interoperability between public cloud service providers.
6. To provide cloud services as utility successfully, interconnected clouds are required and interoperability and portability are important factors in inter cloud.
7. The limitations of cloud are that they have limited physical resource.

Que 4.2. **Explain the types of inter cloud resource management.**

Answer

Types of inter cloud resource management are :

1. **Federation clouds :**
   i. A federation cloud is an inter cloud where a set of cloud providers willingly interconnect their cloud infrastructures in order to share resources among each other.
   ii. The cloud providers in the federation voluntarily collaborate to exchange resources.
   iii. This type of inter cloud is suitable for collaboration of governmental clouds (Clouds owned and utilized by non-profit institution or government) or private cloud portfolios (Cloud is a part of a portfolio of clouds where the clouds belong to the same organization).

   iv. This types of federation clouds are Peer-to-Peer and Centralized clouds.
2. **Multi-Cloud :**
   i. In a multi-cloud, a client or service uses multiple independent clouds.
   ii. A multi-cloud environment has no volunteer interconnection and sharing of the cloud service provider infrastructures.
   iii. Managing resource provisioning and scheduling is the responsibility of client or their representatives.
   iv. This approach is used to utilize resources from both governmental clouds and private cloud portfolios.
   v. This types of multi-cloud are services and libraries.

Que 4.3. **Describe the challenges faced in federation of cloud infrastructure.**

Answer

The following are the challenges faced in federation of cloud infrastructures :

1. **Application service behaviour prediction :**
   i. It is important that the system should be able to predict the demands and the behaviour of the services.
   ii. Only when it can predict, it can take decisions intelligently to dynamically scale up and down.
   iii. Prediction and forecasting models must be built.
   iv. The challenge is to build such models that accurately learn and fit statistical functions suitable to different behaviours. It is more challenging to correlate between different behaviours of a service.
2. **Flexible mapping of services to resources :**
   i. It is important to maximize the efficiency, cost-effectiveness and utilization because of high operating costs and energy requirements.
   ii. The system has to compute the best software and hardware configurations which result in a complex process of mapping services to cloud resources.
   iii. Mapping of services must guarantee that QoS targets are satisfied along with maximum system efficiency and utilization.
3. **Economic models driven optimization techniques :**
   i. Combinatorial optimization problem is a market driven decision making strategy which searches the optimal combinations of services and deployment plans.
   ii. Optimization models must be developed which optimize both resource-centric and user-centric QoS targets.

4. **Integration and interoperability :**
   i. Sensitive data in an enterprise also may not be migrated to the cloud for security reasons and privacy.
   ii. A need related to integration and interoperability arises between assets on premises and the cloud services. Issues related to identity management, data management, and business process orchestration need to be resolved.
5. **Scalable monitoring of system components :**
   i. The components in a federated system are distributed but the techniques employed for system monitoring and managing use centralized approaches.
   ii. Due to concerns of scalability, performance and reliability arising from the management of multiple service queues and large volume of service requests, centralized approaches are not suitable and architectures using service monitoring and management services based on decentralized messaging and indexing models are needed.

Que 4.4. **Describe the topologies used in inter cloud architecture.**

Answer

Topologies used in inter cloud architectures :

1. **Peer-to-peer inter cloud federation :**
   i. Clouds collaborate directly with each other but may use distributed entities for directories or brokering.
   ii. Clouds communicate with each other and negotiate directly without mediators.
   iii. The inter cloud projects that use Peer-to-Peer federation are RESERVOIR (Resources and Services Virtualization without Barriers Project).
2. **Centralized inter cloud federation :**
   i. Clouds use a central entity to perform or facilitate resource sharing.
   ii. The central entity acts as a storehouse where the available cloud resources are registered.
   iii. The inter cloud projects that use centralized inter cloud federation are inter cloud, Dynamic Cloud Collaboration (DCC) and federated cloud management.
3. **Multi-cloud service :**
   i. Clients access multiple clouds through a service.
   ii. A service is hosted by the cloud client either externally or in-house.
   iii. The services contain broker components.

   iv. The inter cloud projects that use multi-cloud services are OPTIMIS, contrail, MOSAIC, STRATOS and commercial cloud management systems.
4. **Multi-cloud libraries :**
   i. Clients develop their own brokers by using a unified cloud API as a library.
   ii. Inter clouds that use libraries facilitate the usage of clouds in a uniform way.
   iii. Examples of Several Multi-cloud Libraries are Java library J-clouds, Python library Apache Lib-Clouds, Ruby library Apache Delta-Cloud.

Que 4.5. **Explain the extended cloud computing services.**

Answer

1. Fig. 4.5.1 shows six layers of cloud services ranging from hardware, network, and collocation to infrastructure, platform, and software applications.

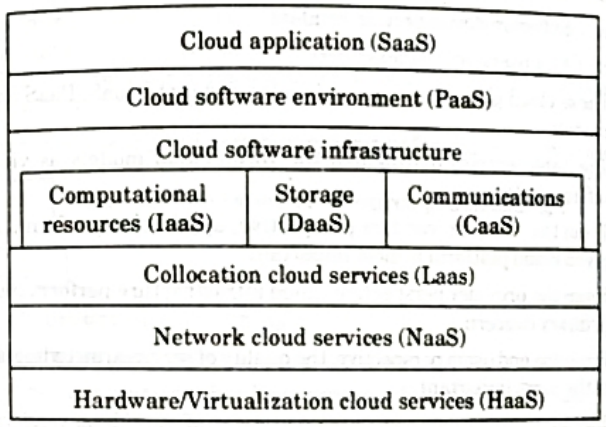

Fig. 4.5.1. A stack of six layers of cloud services and their providers.

2. The top three service layers are SaaS, PaaS, and IaaS.
3. The cloud platform provides PaaS, Which sits on top of the IaaS infrastructure.
4. The top layer offers SaaS. These must be implemented on the cloud platforms provided. Although the three basic models are dissimilar in usage, they are built one on top of another.
5. The implication is that one cannot launch Sass applications with a cloud platform. The cloud platform cannot be built if compute and storage infrastructures are not there.

6. The bottom three layers are more related to physical requirements. The bottom most layer provides Hardware-as-a-Service (HaaS).
7. The next layer is for interconnecting all the hardware components, and is simply called Network-as-a-Service (NaaS). Virtual LANs fall within the scope of NaaS.
8. The next layer up offers Location-as-a-Service (LaaS), which provides a collocation service to house, power, and secure all the physical hardware and network resources.
9. The cloud infrastructure layer can be further subdivided as Data-as-a-Service (DaaS) and Communication-as-a-Service (CaaS).

Que 4.6. Give the cloud difference in perspectives of providers, vendors and users.

Answer

1. Table 4.6.1, shows that cloud players are divided into three classes :
   a. Cloud service providers and IT administrators.
   b. Software developers or vendors.
   c. End users or business users.
2. These cloud players vary in their roles under the IaaS, PaaS and SaaS models.
3. The table entries distinguish the three cloud models as viewed by different players.
4. From the software vendors perspective, application performance on a given cloud platform is most important.
5. From the provider perspective, cloud infrastructure performance is the primary concern.
6. From the end users perspective, the quality of services, including security, is the most important.

Table 4.6.1. Cloud difference in perspectives of providers, vendors and users.

Cloud Players	IaaS	PaaS	SaaS
IT administration/ cloud providers	Monitor SLAs	Monitor SLAs and enable service platforms	Monitor SLAs and deploy software
Software developers (vendors)	To deploy and store data	Enabling platforms via configurators and APIs	Develop and deploy software
End users or business users	To deploy and store data	To develop and test web software	Use business software

PART-2

Resource Provisioning and Resource Provisioning Methods.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 4.7. Explain resource provisioning.

Answer

1. Resource provisioning means the selection, deployment, and run-time management of software (for example, database management servers, load balancers) and hardware resources (for example, CPU, storage, and network) for ensuring guaranteed performance for applications.
2. This resource provisioning takes Service Level Agreement (SLA) into consideration for providing service to the cloud users.
3. This is an initial agreement between the cloud users and cloud service providers which ensures Quality of Service (QoS) parameters like performance, availability, reliability, response time etc.
4. Based on the application needs static provisioning dynamic provisioning and static/dynamic allocation of resources have to be made in order to efficiently make use of the resources without violating SLA and meeting these QoS parameters.
5. Over provisioning and under provisioning of resources must be avoided.

Que 4.8. What are the types of resource provisioning ?

Answer

Types of resource provisioning :

1. **Static provisioning :**
   i. For applications that have predictable and generally unchanging demands workloads we use static provisioning effectively.
   ii. With advance provisioning, the customer contracts with the provider for services and the provider prepares the appropriate resources in advance of start of service.
   iii. The customer is charged a flat fee or is billed on a monthly basis.
2. **Dynamic provisioning :**
   i. In cases where demand by applications may change or vary, dynamic provisioning techniques have been suggested whereby VTIs may be migrated on-the-fly to new compute nodes within the cloud.
   ii. With dynamic provisioning, the provider allocates more resources as they are needed and removes them when they are not. The customer is billed on a pay-per-use basis. When dynamic

provisioning is used to create a hybrid cloud, it is sometimes referred to as cloud bursting.

3. **User self-provisioning :**
   i. With user self-provisioning (also known as cloud self-service), the customer purchases resources from the cloud provider through a web form, creating a customer account and paying for resources with a credit card.

Que 4.9. **Describe briefly parameters used for resource provisioning.**

Answer

Parameters used for resource provisioning are :

i. **Response time :** The resource provisioning algorithm designed must take minimal time to respond when executing the task.

ii. **Minimize cost :** From the cloud user point of view cost should be minimized.

iii. **Revenue maximization :** This is to be achieved from the cloud service provider's view.

iv. **Fault tolerance :** The algorithm should continue to provide service in spite of failure of nodes.

v. **Reduced SLA violation :** The algorithm designed must be able to reduce SLA violation.

vi. **Reduced power consumption :** VM placement and migration techniques must have lower power consumption.

Que 4.10. **Describe the resource provisioning methods.**

Answer

Resource provisioning methods are :

1. **Demand-driven resource provisioning :**
   i. This method adds or removes computing instances based on the current utilization level of the allocated resources.
   ii. The demand-driven method automatically allocates two Xeon processors for the user application, when the user was using one Xeon processor more than (A) percent of the time for an extended period.
   iii. In general, when a resource has surpassed a threshold for a certain amount of time, the scheme increases that resource based on demand.
   iv. When a resource is below a threshold for a certain amount of time, that resource could be decreased accordingly.

   v. Amazon implements such an auto-scale feature in its EC2 platform.
   vi. This method is easy to implement. The scheme does not work out right if the workload changes abruptly.

2. **Event-driven resource provisioning :**
   i. This scheme adds or removes machine instances based on a specific time event.
   ii. The scheme works better for seasonal or predicted events.
   iii. During events, the number of users grows before the event period and then decreases during the event period.
   iv. This scheme anticipates peak traffic before it happens.
   v. The method results in a minimal loss of QoS if the event is predicted correctly.
   vi. Otherwise, wasted resources are even greater due to events that do not follow a fixed pattern.

3. **Popularity-driven resource provisioning :**
   i. In this method the Internet searches for popularity of certain applications and creates the instances by popularity demand.
   ii. The scheme anticipates increased traffic with popularity.
   iii. The scheme has a minimal loss of QoS, if the predicted popularity is correct. Resources may be wasted if traffic does not occur as expected.

PART-3

Global Exchange of Cloud Resources.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 4.11. **Write a short note on global exchange of cloud resources.**

Answer

1. Enterprises employ cloud services in order to improve the scalability of their services and to deal with bursts in resource demands.
2. However, at present, service providers have inflexible pricing, generally limited to flat rates or tariffs based on usage thresholds, and consumers are restricted to offerings from a single provider at a time.
3. For cloud computing to mature, it is required that the services follow standard interfaces.

4. This would enable services to be commoditised and thus, would pave the way for the creation of a market infrastructure for trading in services.
5. The market directory allows participants to locate providers or consumers with the right offers.
6. The banking system ensures that financial transactions pertaining to agreements between participants are carried out.

Que 4.12. **What are the market-oriented techniques ?**

Answer

Various market-oriented techniques are :

1. **Aneka :**
   i. Aneka is implied in Platform-as-a-Service type and offers platform in cloud computing to its users making it convenient for them to create and deploy applications.
   ii. Its unique feature is its flexible design and customization capability that allows it to target different application scenarios.
2. **Workflow engine :**
   i. The Workflow Management System (WMS) assists users in representing their applications as a workflow.
   ii. It then executes these workflows on the cloud platform from higher level of abstraction.
   iii. The WMS provisions an easy to use workflow editor that allows for application composition.
3. **MetaCDN :**
   i. MetaCDN creates an integrated overlay network at a very low cost by exploiting storage cloud resources being offered by multiple IaaS vendors.
   ii. It eradicates the difficulty arose due to dealing with multiple storage providers.
4. **CloudSim :**
   i. The CloudSim toolkit offers an environment to the users that enable them to model and simulate extensible clouds.
   ii. They offers platform where user can get their applications executed.
   iii. It is a complete customizable tool that allows extension and description of policies in the software stack.
5. **Resource management :**
   i. Resource management in cloud computing is considered as an important aspect as it leads to proper utilization of available resources for making a cloud as an optimum computing environment.
   ii. The taxonomy of resource management falls under various categories such as energy-aware, SLA-aware, market-oriented, load balanced, hybrid cloud and mobile cloud computing.

PART-4

Security Overview, Cloud Security Challenges.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 4.13. **Give a schematic diagram of various cloud security challenges ?**

Answer

1. Fig. 4.13.1 represents the schematic diagram showing the hierarchy of the cloud computing, with security challenges on both the cloud computing models, deployment and service models and also the issues related to networks.

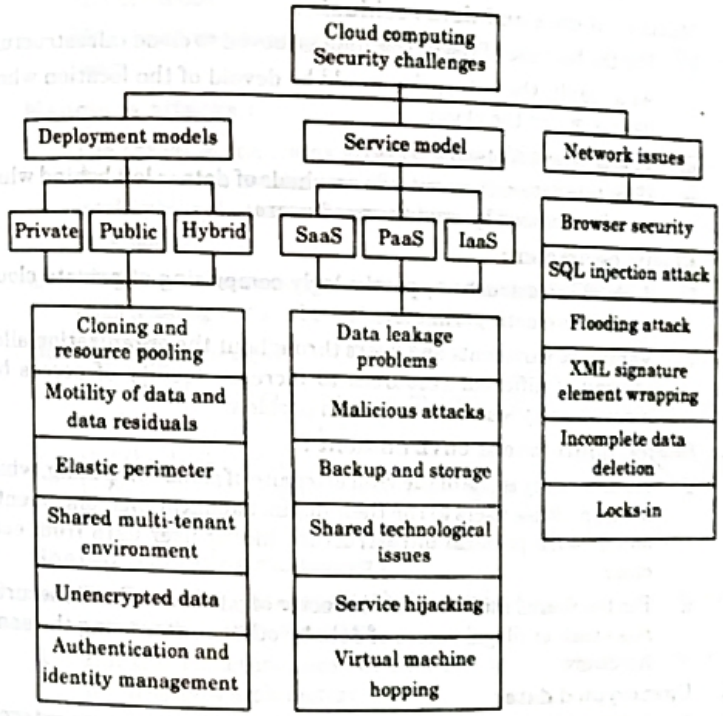

Fig. 4.13.1. Classification of security challenge.

2. The classification shown in Fig. 4.13.1 reveals various common challenges under cloud computing. The deployment model is classified further as private, public and hybrid cloud and the security issues of the same have been exposed in common.

3. The service model is classified into the SaaS, PaaS and IaaS briefing its security challenges in common. The security challenges with respect to network are also known as for any internet based service. Network is considered as the backbone for cloud computing.

Que 4.14. Explain various security challenges related to deployment models.

Answer

Various security challenges related to deployment model :

1. **Cloning and resource pooling :**
   i. Cloning deals with replicating or duplicating the data.
   ii. Cloning leads to data leakage problems revealing the machine's authenticity.
2. **Motility of data and data residuals :**
   i. For the best use of resources, data is moved to cloud infrastructure.
   ii. As a result, the enterprise would be devoid of the location where data is put on the cloud.
   iii. This is true with public cloud.
   iv. With this data movement, the residuals of data is left behind which may be accessed by unauthorized users.
3. **Elastic perimeter :**
   i. A cloud infrastructure, particularly comprising of private cloud, creates an elastic perimeter.
   ii. Various departments and users throughout the organization allow sharing of different resources to increase facility of access but unfortunately lead to data breach problem.
4. **Shared multi-tenant environment :**
   i. Multi-tenancy is one of the vital attribute of cloud computing, which allows multiple users to run their distinct applications concurrently on the same physical infrastructure hiding user data from each other.
   ii. But the shared multi-tenant character of public cloud adds security risks such as illegal access of data by other renter using the same hardware.
5. **Unencrypted data :**
   i. Data encryption is a process that helps to address various external and malicious threats.

   ii. Unencrypted data is vulnerable for susceptible data, as it does not provide any security mechanism.
   iii. These unencrypted data can easily be accessed by unauthorized users.
6. **Authentication and identity management :**
   i. With the help of cloud, a user is facilitated to access its private data and make it available to various services across the network.
   ii. Identity management helps in authenticating the users through their credentials.

Que 4.15. Discuss security challenges related with the service models.

Answer

Various security challenges related with the service models :

1. **Data leakage and consequent problem :**
   i. Data deletion or alteration without backup leads to certain drastic data related problems like security, integrity, locality, segregation and breaches.
   ii. This would lead to sensitive data being accessed by the unauthorized users.
2. **Malicious attacks :**
   i. The threat of malicious attackers is augmented for customers of cloud services by the use of various IT services which lacks the intelligibility between the procedure and process relating to service providers.
   ii. Malicious users may gain access to certain confidential data and thus leading to data breaches.
3. **Backup and storage :**
   i. The cloud vendor must ensure that regular backup of data is implemented with all measures.
   ii. But this backup data is generally found in unencrypted form leading to misuse of the data by unauthorized parties.
   iii. Thus, data backups lead to various security threats.
4. **Shared technological issues :**
   i. IaaS vendors transport their services in a scalable way by contributing infrastructure.
   ii. But this structure does not offer strong isolation properties for a multi-tenant architecture.
   iii. Hence, in order to address this gap, a virtualization hypervisor intercede the access between guest operating systems and the physical compute resources.

5. **Service hijacking :**
   i. Service hijacking is associated with gaining an illegal control on certain authorized services by various unauthorized users.
   ii. It accounts for various techniques like phishing, exploitation of software and fraud.
   iii. This is considered as one of top most threats.
6. **VM hopping :**
   i. With VM hopping, an attacker on one VM gains rights to use another victim VM's.
   ii. The attacker can check the victim VM's resource procedure, alter its configurations and can even delete stored data, thus, putting it in danger the VM's confidentiality, integrity and availability.
   iii. A requirement for this attack is that the two VM's must be operating on the same host, and the attacker must recognize the victim VM's IP address.
7. **VM mobility :**
   i. The contents of VM's virtual disks are saved as files such that VM's can be copied from one host to another over the system or via moveable storage devices with no physically stealing a hard drive.
   ii. VM mobility might offer quick use but could show the way to security problems likewise, the rapid spread of susceptible configurations that an attacker could make use of, to endanger the security of a novel host.
8. **VM denial of service :**
   i. Virtualization lets numerous VM's split physical resources like CPU, network bandwidth and memory or disk.
   ii. A Denial-of-Service (DoS) attack in virtualization takes place when one VM occupies all the obtainable physical resources such that the hypervisor cannot hold-up more VM's and accessibility is endangered.
   iii. The most excellent move towards preventing a DoS attack is to bound resource allocation using correct configurations.

Que 4.16. **What are cloud security controls ?**

Answer

Cloud security controls are :

1. **Detective control :** This type of control is used to detect and react instantly and appropriately to any incident.
2. **Preventive control :** It strengthen the system against any incident or attack by actually eliminating the vulnerabilities.

3. **Deterrent control :** This type of control is used is meant to reduce attack on cloud system. It reduces the threat level by giving a warning sign.
4. **Corrective control :** It reduces the consequences of an incident by controlling the damage. Restoring system backup is an example of such type.

PART-5

Software-as-a-Service Security, Security Governance, Virtual Machine Security, IAM, Security Standards.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 4.17. **What is cloud security governance ? Describe its challenges.**

Answer

i. Cloud security governance refers to the management model that facilitates effective and efficient security management and operations in the cloud environment so that an enterprise's business targets are achieved.

ii. This model incorporates a hierarchy of executive mandates, performance expectations, operational practices, structures, and metrics that when implemented, result in the optimization of business value for an enterprise.

Cloud security governance challenges :

1. **Lack of senior management participation and buy-in :**
   i. The lack of a senior management influenced and initial security policy is one of the common challenges faced by cloud customers.
   ii. An enterprise security policy is intended to set the executive tone, principles and expectations for security management and operations in the cloud.
   iii. The result of this situation is the ineffective definition and communication of executive tone and expectations for security in the cloud.
   iv. To resolve this challenge, it is essential to engage enterprise executives in the discussion and definition of tone and expectations for security that will feed a formal enterprise security policy.

2. **Lack of embedded management operational controls :**
   i. Controls are interpreted as an auditor's checklist or repackaged as procedures, and as a result, are not effectively embedded into security operational processes and procedures as they should be, for purposes of optimizing value and reducing day-to-day operational risks.
   ii. This lack of embedded controls may result in operational risks that may not be apparent to the enterprise.
3. **Lack of operating model, roles, and responsibilities :**
   i. Many enterprises moving into the cloud environment tend to lack a formal operating model for security, or do not have strategic and tactical roles and responsibilities properly defined and operationalized.
   ii. This situation stifles the effectiveness of a security management and operational function/organization to support security in the cloud.
   iii. Establishing a hierarchy help an enterprise to better manage and control security in the cloud, and protect associated investments in accordance with enterprise business goals.
   iv. This hierarchy can be employed as in-sourced, out-sourced, or co-sourced model depending on the culture, norms, and risk tolerance of the enterprise.
4. **Lack of metrics for measuring performance and risk :**
   i. Another major challenge for cloud customers is the lack of defined metrics to measure security performance and risks. A problem that also stifles executive visibility into the real security risks in the cloud.

Que 4.18. **What are objectives of cloud security governance ?**

Answer

Objectives of cloud security governance :

1. **Strategic alignment :** Enterprises should mandate that security investments, services, and projects in the cloud are executed to achieve established business goals (For example, market competitiveness, financial, or operational performance).
2. **Value delivery :** Enterprises should define, operationalize, and maintain an appropriate security function/organization with appropriate strategic and tactical representation, and charged with the responsibility to maximize the business value (Key Goal Indicators, RGI) from the pursuit of security initiatives in the cloud.
3. **Risk mitigation :** Security initiatives in the cloud should subject to measurements that gauge effectiveness in mitigating risk to the enterprise (Key Risk Indicators). These initiatives should also yield results that progressively demonstrate a reduction in these risks over time.
4. **Effective use of resources :** It is important for enterprises to establish a practical operating model for managing and performing security operations in the cloud, including the proper definition and operationalization of due processes, the institution of appropriate roles and responsibilities, and use of relevant tools for overall efficiency and effectiveness.
5. **Sustained performance :** Security initiatives in the cloud should be measurable in terms of performance, value and risk to the enterprise (Key Performance Indicators, Key Risk Indicators), and yield results that demonstrate attainment of desired targets (Key Goal Indicators) over time.

Que 4.19. **Write down properties and characteristics of VM.**

Answer

Virtual machine is open-source software that runs an operating system and application. It is comprised of a set of specification and configuration files and is backed by the physical resource of a host.

Virtual machine properties :

1. **Dispatcher :** Hypervisor starting point to decide which module to call for the given trap.
2. **Allocator :** It has to decide what system resources are to be provided.
3. **Interpreter :** It needs one interpreter routine per privileged instruction, each routine has to simulate the effect of the instruction which is trapped.

Characteristics of VM :

1. A virtual machine (VM) is a special program, which must meet the following three characteristics :
   a. The efficiency property
   b. The resource control property
   c. The equivalence property
2. The virtual machine can run any program in its virtual environment.
3. The efficiency property requires that the large portion of the program instructions will be executed directly on the physical processor, without any changes or interventions from the virtual machine monitor.
4. This requirement is not only set for performance reasons, but also to exclude emulators or simulators from the virtual machine definition.

Que 4.20. **Discuss implementations of virtual machines.**

Answer

There are two main implementations of Virtual Machines (VMs) :

i. **Process virtual machines :**

1. A process VM is a virtual machine capable of supporting an individual process as long as the process is alive. Fig. 4.20.1(a) demonstrates process VMs.

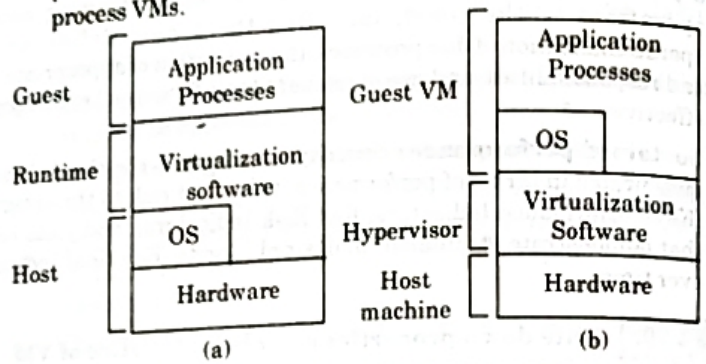

Fig. 4.20.1. Virtual machine types (a) Process virtual machines, and (b) System virtual machines.

2. A process VM terminates when the hosted process ceases. From a process VM perspective, a machine consists of a virtual memory address space, user-level registers and instructions assigned to a single process so as to execute a user program.
3. A regular process in a general-purpose OS can also be deemed a machine. However, a process in an OS can only support user program binaries compiled for the ISA of the host machine. In other words, executing binaries compiled for an ISA different than that of the host machine cannot be ensued with regular processes.
4. Conversely, a process VM allows emulation. As shown in Fig. 4.20.2, emulation is the process of allowing the interfaces and functionalities of one system (the source) to be employed on a system with different interfaces and functionalities (the target).

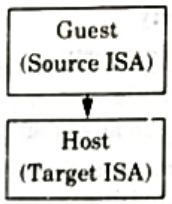

Fig. 4.20.2. Emulation process.

5. The abstraction of the process VM is provided by a piece of virtualizing software called the runtime as shown in Fig. 4.20.1(a). The runtime is placed at the Application Binary Interface (ABI), on top of the host OS, and the underlying hardware. It is this runtime that emulates the VM instructions and system calls when guest and host ISAs are different.

6. A process VM may not directly correspond to any physical platform but employed mainly to offer cross-platform portability. Such kinds of process VMs are known as High Level Language Virtual Machines (HLL VMs).
7. An HLL VM abstracts away details of the underlying hardware resources and the OS and allows programs to run in the same way on any platform. Java VM (JVM) and Microsoft Common Language Infrastructure (CLI) are examples of HLL VMs.
8. A process VM is similar to a regular process running on an OS. However, a process VM allows, through emulation, the execution of an application compiled for an ISA different than that of the host machine.

ii. **System virtual machines :**

1. A system VM is a virtual machine capable of virtualizing a full set of hardware resources including processors, memories, and IO devices, thus providing a complete system environment.
2. A system VM can support an OS along with its associated processes as long as the system environment is alive. Fig. 4.20.1(b) illustrates system VMs. The hypervisor (or the Virtual Machine Monitor (VMM) is a piece of software that provides abstraction for the system VM.
3. It can be placed at the ISA level directly on top of the raw hardware and below system images (for example, OSs). The hardware resources of the host platform can be shared among multiple guest VMs. The hypervisor manages the allocation of, and access to, the hardware resources to/by the guest VMs.
4. The hypervisor provides an elegant way to logically isolate multiple guest VMs sharing a single physical infrastructure (for example, the cloud datacentres). Each guest VM is given the illusion of acquiring the hardware resources of the underlying physical machine.
5. There are different classes of system VMs as shown in Fig. 4.20.3.

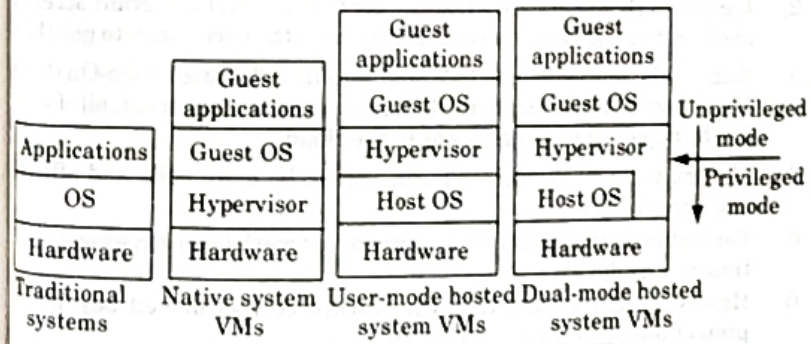

Fig. 4.20.3. Different system VM classes.

6. In a conventional time-shared system, the OS runs in privileged mode (system mode) while the applications associated with it run in unprivileged mode (user mode).
7. With system virtualization, however, the guest OS(s) will run unprivileged mode while the hypervisor can operate in privileged mode. Such a system is denoted as native system VM. In native system VM, every privileged instruction issued by a user program at any guest OS has to trap to the hypervisor.
8. The hypervisor needs to specify and implement every function required for managing hardware resources. In contrary, if the hypervisor operates in unprivileged mode on top of a host OS, the guest OS(s) will also operate in unprivileged mode.
9. This system is called user-mode hosted system VM. In this case, privileged instructions from guest OS(s) still need to trap to the hypervisor. In return, the hypervisor also needs to trap to the host OS.
10. Clearly, this increases the overhead by adding one more trap per every privileged instruction. The hypervisor can utilize the functions already available on the host OS to manage hardware resources.
11. Finally, the hypervisor can operate partly in privileged mode and partly in user-mode in a system referred to as dual-mode hosted system VM. This way, the hypervisor can make use of the host OS's resource management functions and also preclude the one more trap per each privileged instruction incurred in user-mode hosted system VMs.

Que 4.21. **Write a short note on IAM.**

Answer

1. Identity and Access Management (IAM) is a system that secures, stores, and manages user identities and access privileges.
2. It ensures that users are who they say they are and will grant access to applications and resources only if they have the permission to use them.
3. Some of the most common IAM solutions include Single Sign-On (SSO), Multi-Factor Authentication (MFA), and access management, all of which can be deployed on-premises or in the cloud.
4. Modern technology enables businesses to be more agile and efficient than ever before.
5. For instance, the cloud lets the employees work from anywhere at any time on any device.
6. However, this means that the workforce has moved beyond the protections of on-premise security.

Que 4.22. **Describe the benefits of IAM.**

Answer

Benefits of IAM are :

1. **Improving user experiences :**
   i. SSO eliminates the need for users to remember and input multiple passwords to access different areas of the system.
   ii. All vendors offer a variety of user authentication schemes ranging from more strict multi-factor authentication to federated solutions that leverage existing user security profiles.
2. **Enhancing security profiles :**
   i. IAM systems can authenticate and authorize users based on the access level indicated in their directory profiles.
   ii. IAM system can also automatically control user access using other factors to specific functions of our system.
3. **Simplifies auditing and reporting :**
   i. Consolidating user identities and passwords with SSO makes it easier for IT departments to audit where and how these user credentials are used.
   ii. In the event that user credentials are compromised, IAM systems make it easier for IT departments to identify which user was compromised and which data was accessed during the breach.
4. **Allows easy access no matter where we are :**
   i. IAM/SSO allows users to access to all interconnected systems, regardless of where the user is physically located.
   ii. This can be especially useful for large companies doing business globally, providing ease of access to employees, partners and clients alike.
5. **Increases productivity and reduces IT costs :**
   i. The original benefit of SSO for IT departments was to eliminate the cost of internal help desks helping users locked out of their application accounts.
   ii. IAM leverage in already existing identity stores such as Active Director. IAM allows to extend what we have into the future.
   iii. Cloud-based and mobile-based IAM tools not only allow users to authenticate from anywhere anytime, they also provide the extensive audit trails, analytics, access rules and policies to truly automate identity access and management across the enterprise.

Que 4.23. **What are the advantage and disadvantages of IAM ?**

Answer

Advantages of IAM are :

1. Users have fewer accounts and passwords to manage.
2. Less password fatigue related to managing multiple passwords.
3. Less user time needed to log separately into different systems.
4. Fewer support requests for password resets.
5. Provides a central location for administrative management of accounts.

Disadvantages of IAM are :

1. The primary concern with SSO systems is that it creates a single point of failure if the authentication server fails. This forces the added burden of multiple authentication servers to provide redundancy.
2. This single point also creates a single breach point. If a user account is breached, an attacker can gain access to all protected systems that the compromised user account has access to.

Que 4.24. **Explain the architecture of IAM.**

Answer

Architecture of IAM are :

i. **Cloud-based and multi-tenant architecture :**

a. A multi-tenant architecture provides lots of benefit such as the vendor can issue updates, security fixtures, and improves performance.

b. It also modifies the capability to manage access provision and governance effectively.

ii. **Security, management architecture :**

a. The most important need of IAM is identity and access management.

b. IAM in Cloud computing offer features like multi-factor authentication, digital access cards, and biometrics.

c. These features help to easily retrieve the information in a secure manner.

iii. **Single Sign-On (SSO) and federation :**

a. SSO enhances the experience of the end user while maintaining security and availability of the network to users as intended.

b. The user can use the safest password combination without working hard to remember, which is used to access services on regular basis.

c. It also benefits in another way, as it helps to manage secure authentication for third-party cloud services.

iv. **Analytics and intelligence :**

a. Analytics and intelligence capabilities are used to report the use of access privileges in the context of multifaceted relationships.

b. This relationship is between users, their roles and responsibilities, job function, and data usage.

c. This information allows the organization to identify anomalies for former employee's awesome specific type of workforce segment.

v. **Governance, risk, and compliance :**

a. The governance, risk and compliance are supported by modifying the automation and intelligence capabilities of an identity as a service system.

b. This IAM function helps an organization to define and automate the application specific processes, which will get familiar with the access and usage patterns.

Que 4.25. **Discuss the cloud security standards.**

Answer

Following are the cloud security standards :

1. **Information Technology Infrastructure Library (ITIL) :**

i. It is a set of best practices and guidelines that define an integrated, process-based approach for managing information technology services.

ii. ITIL helps to make sure that proper security measures are taken at all important levels, namely strategic, tactical, and operational level.

iii. Many IT organizations employ security management framework-Information Technology Infrastructure Library (ITIL)

iv. This industry standard management framework provides guidance for planning and implementing a governance program with sustaining management processes that protect information assets and thus provide security.

v. Hence, it provides a framework with continuous improvement that is necessary to align and realign IT services to changing business needs.

2. **Open Virtualization Format (OVF) :**

i. Open Virtualization Format (OVF) is a standard pertaining to portability concern. OVF provides the ability for an efficient, flexible and secure distribution of enterprise software over the cloud.

ii. OVF thus provides customers, vendor and platform independence as it facilitates mobility of virtual machines.

iii. Across the cloud OVF plays a major role in providing cross-platform portability. It also helps to provide simplified deployment over multiple platforms.

iv. An OVF format virtual machine can be deployed easily by customers. They can do so on the platform of their choice. It helps to enhance customer experience as it provides customers with portability, platform independence, verification, signing, versioning, and licensing terms.

3. **ITU-T X.1601 :**

i. The ITU standard presents a sketch of issues pertaining to cloud computing and proposes a framework for cloud security.

ii. It talks in detail about various security challenges and ways to reduce these security risks in cloud computing. It also discusses a framework that provides an insight into what security capabilities are required for making the cloud secure and facing security challenges.

iii. ITU-T X.1601 starts by listing down major security threats that the cloud can encounter.

iv. The standard discusses the security challenges based on the nature of the role that an individual or an organization plays in the cloud computing paradigm.

v. The standard divides the roles of an individual or an organization into following three categories :

a. **Cloud Service Provider (CSP) :** An individual or an organization responsible for making cloud services available.

b. **Cloud Service Customer (CSC) :** An individual or an organization that uses cloud services.

c. **Cloud Service Partner (CSN) :** A partner that helps support the CSPs or the CSCs.

4. **PCI DSS :**

i. Payment Card Industry Data Security Standard (PCI DSS) was released by PCI security standards council.

ii. PCI's main objective is to provide security guidelines for credit card usage and address CSP's and CSC's.

iii. Cloud security is a shared responsibility between the CSP and its clients

iv. The division of responsibilities between the client and the CSP for managing PCI DSS controls is influenced by multiple factors, which are :

a. The client uses the cloud service for what purpose.

b. What scope of PCI DSS requirements is the client outsourcing to the CSP ?

c. The CSP validates which service and system components within its own operations.

d. The service option that the client has selected to engage the CSP (IaaS, PaaS or SaaS).

e. The scope of any additional services the CSP is providing to pro-actively manage the client's compliance.

5. **ISO/IEC 27017 Code of practice for information security controls :**

i. This standard is yet to be launched in the market.

ii. It aims to provide further guidance in the information security domain of cloud computing.

iii. It is aimed at supplementing the guidance in ISO/IEC 27002 and various other ISO27k standards including ISO/IEC 27018 on the privacy aspects of cloud computing, ISO/IEC 27031 on business continuity, and ISO/IEC 27036-4 on relationship management, as well as all the other ISO27k standards.

iv. The scope and purpose :

a. It aims is to provide an advancement to ISO/IEC 27002 in terms of adding value to its practices of control implementation

b. Additionally, the standard will provide further security advice for both: clients and service providers. It will do that by offering advice for both side-by-side in each section.

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5 UNIT

Cloud Technologies and Advancements

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PART-1

Hadoop, MapReduce, Virtualbox.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 5.1. **Describe briefly the term Hadoop ?**

Answer

1. Hadoop is an open-source software framework used for storing data and running applications on clusters of commodity hardware.
2. It provides massive storage for any kind of data, enormous processing power and the ability to handle virtually limitless concurrent tasks or jobs.
3. The Hadoop ecosystem is a framework of various types of complex and evolving tools and components. Some of these elements are very different from each other in terms of their architecture however, what keeps them all together under a single roof is that they all derive their functionalities from the scalability and power of Hadoop.
4. Hadoop ecosystem can be defined as a comprehensive collection of tools and technologies that can be effectively implemented and deployed to provide big data solutions in a cost-effective manner.
5. MapReduce and Hadoop Distributed File System (HDFS) are two core components of the Hadoop ecosystem that is used to manage big data. However, they are not sufficient to deal with the big data challenges.
6. Along with these two, the Hadoop ecosystem provides a collection of various elements to support the complete development and deployment of big data solutions.

Que 5.2. **Why do we use Hadoop ?**

Answer

Use of Hadoop :

1. Ability to store and process huge amounts of any kind of data quickly.
2. **Computing power :** Hadoop's distributed computing model processes big data fast.

3. **Fault tolerance :** Data and application processing are protected against hardware failure. If a node goes down, jobs are automatically redirected to other nodes to make sure that distributed computing does not fail. Multiple copies of all data are stored automatically.

4. **Flexibility :** Unlike traditional relational databases, we do not have to preprocess data before storing it. We can store as much data as we want and decide how to use it later. That includes unstructured data like text, images and videos.

5. **Low cost :** The open-source framework is free and uses commodity hardware to store large quantities of data.

6. **Scalability :** We can easily grow our system to handle more data simply by adding nodes.

Que 5.3. **Explain features of Hadoop.**

Answer

Features of Hadoop :

1. **Suitable for big data analysis :**
   i. As big data tends to be distributed and unstructured in nature, Hadoop clusters are best suited for analysis of big data.
   ii. Since it is processing logic (not the actual data) that flows to the computing nodes, less network bandwidth is consumed.
   iii. This concept is called as data locality concept which helps to increase the efficiency of Hadoop based applications.
2. **Scalability :**
   i. Hadoop clusters can easily be scaled to any extent by adding additional cluster nodes and thus allows for the growth of big data.
   ii. Scaling does not require modifications to application logic.
3. **Fault tolerance :**
   i. Hadoop ecosystem has a provision to replicate the input data on to other cluster nodes.
   ii. In case of a cluster node failure, data processing can still proceed by using data stored on another cluster node.

Que 5.4. **Write a short note on modules of Hadoop.**

Answer

Modules of Hadoop :

1. **HDFS (Hadoop Distributed File System) :** It states that the files will be broken into blocks and stored in nodes over the distributed architecture.
2. **YARN (Yet Another Resource Negotiator) :** It is used for job scheduling and managing the cluster.
3. **MapReduce :**
   i. This is a framework which helps Java programs to do the parallel computation on data using key value pair.
   ii. The Map task takes input data and converts it into a data set which can be computed in key value pair.
   ii. The output of Map task is consumed by reduce task and then the reducer gives the desired result.
4. **Hadoop common :** These Java libraries are used to start Hadoop and are used by other Hadoop modules.

Que 5.5. **What are the advantages of Hadoop ?**

Answer

Advantages of Hadoop :

1. **Fast :** In HDFS, the data distributed over the cluster helps in faster retrieval. As tools are present on the same server, reducing the processing time. It is able to process terabytes of data in minutes and peta bytes in hours.
2. **Scalable :** Hadoop cluster can be extended by just adding nodes in the cluster.
3. **Cost effective :** Hadoop is open-source that uses commodity hardware to store data so it is cost effective as compared to traditional relational database management system.
4. **Resilient to failure :** HDFS has the property with which it can replicate data over the network, so if one node is down or some other network failure happens, then Hadoop takes the other copy of data and use it. Normally, data are replicated thrice but the replication factor is configurable.

Que 5.6. **Explain the architecture of Hadoop.**

Answer

Architecture of Hadoop :

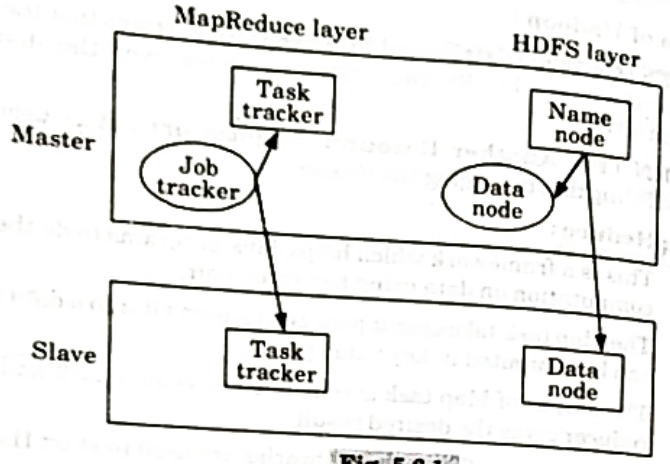

Fig. 5.6.1.

NameNode :

i. It is a single master server that exists in the HDFS cluster.

ii. As it is a single node, it may become the reason of single point failure.

iii. It manages the file system namespace by executing an operation like the opening, renaming and closing the files.

iv. It simplifies the architecture of the system.

DataNode :

i. The HDFS cluster contains multiple DataNodes.

ii. Each DataNode contains multiple data blocks.

iii. These data blocks are used to store data.

iv. It is the responsibility of DataNode to read and write requests from the file system's clients.

v. It performs block creation, deletion, and replication upon instruction from the NameNode.

Job tracker :

i. The role of job tracker is to accept the MapReduce jobs from client and process the data by using NameNode.

ii. In response, NameNode provides metadata to job tracker.

Task tracker :

i. It works as a slave node for job tracker.

ii. It receives task and code from job tracker and applies that code on the file. This process can also be called as a Mapper.

Que 5.7. **Differentiate between cloud computing and Hadoop.**

Answer

S. No.	Cloud computing	Hadoop
1.	Storing of data, applications and software are in cloud servers accessible through the internet on-demand basis.	Hadoop process and store large volume data sets in a distributed GDFS computing environment across clusters and data nodes.
2.	Cloud computing reduces the cost of managing and maintaining IT systems, instead of purchasing expensive systems and equipment for the business.	Business can apply Hadoop to analyze a variety of business problems such as product recommendation, fraud detection, and sentiment analysis.
3.	Cloud computing offers a reliable, secure and consistent Quality of Service (QoS) management as decided in service level agreements.	Hadoop HDFS provides appropriate response times and increased system availability.
4.	Cloud management console provides a complete analysis of cloud usage as reports and graphs.	Hadoop database can be connected to many data reporting tools like Microstrategy, and, data meter.
5.	Computing behaviour like performance, scalability, availability, and security is analyzed.	Big data with a large volume of data is processed and analyzed using Hadoop.
6.	Cloud computing focus on system performance, network performance, data security, and availability. Cost is focused on delivering Software-as-a-Service in the cloud.	Hadoop focuses on manipulating large data sets with structured and unstructured data.

Que 5.8. **Write a short note on MapReduce.**

Answer

1. MapReduce is based on the parallel programming framework to process large amounts of data dispersed across different system.
2. The process is initiated when a user request is received to execute the MapReduce program and terminated once the results are written back to the HDFS (Hadoop Distributed File System).
3. MapReduce facilitate the processing and analyzing of both unstructured and sem-structured data collected from different sources, which may not be analyzed effectively by other traditional tools.
4. MapReduce enables computational processing of data stored in a file system without the requirement of loading the data initially into a database.
5. It primarily supports two operations, map and reduce.
6. These operations execute in parallel on a set of worker nodes.
7. MapReduce works on a master working approach in which the master process controls and directs the entire activity, such as collecting, segregating, and delegating the data among different working.

Que 5.9. **Explain the working and phases of MapReduce.**

Answer

1. The MapReduce algorithm contains two important tasks, namely Map and Reduce :
   i. The Map task takes a set of data and converts it into another set of data, where individual elements are broken down into tuples (key-value pairs).
   ii. The Reduce task takes the output from the Map as an input and combines those data tuples (key-value pairs) into a smaller set of tuples.
2. The reduce task is always performed after the map task.

Phases of MapReduce :

1. **Input phase :** Here we have a record reader that translates each record in an input file and sends the parsed data to the mapper in the form of key-value pairs.
2. **Map :** Map is a user-defined function, which takes a series of key-value pairs and processes each one of them to generate zero or more key-value pairs.
3. **Intermediate keys :** They key-value pairs generated by the mapper are known as intermediate keys.

4. **Combiner :**
   i. A combiner is a type of local reducer that groups similar data from the map phase into identifiable sets.
   ii. It takes the intermediate keys from the mapper as input and applies a user-defined code to aggregate the values in a small scope of one mapper.
   iii. It is not a part of the main MapReduce algorithm; it is optional.
5. **Shuffle and sort :**
   i. The Reducer task starts with the shuffle and sort step.
   ii. It downloads the grouped key-value pairs onto the local machine, where the reducer is running.
   iii. The individual key-value pairs are sorted by key into a larger data list.
   iv. The data list groups the equivalent keys together so that their values can be iterated easily in the reducer task.
6. **Reducer :**
   i. The reducer takes the grouped key-value paired data as input and runs a reducer function on each one of them.
   ii. Here, the data can be aggregated, filtered, and combined in a number of ways, and it requires a wide range of processing.
   iii. Once the execution is over, it gives zero or more key-value pairs to the final step.
7. **Output phase :**
   i. In the output phase, we have an output formatter that translates the final key-value pairs from the reducer function and writes them onto a file using a record writer.

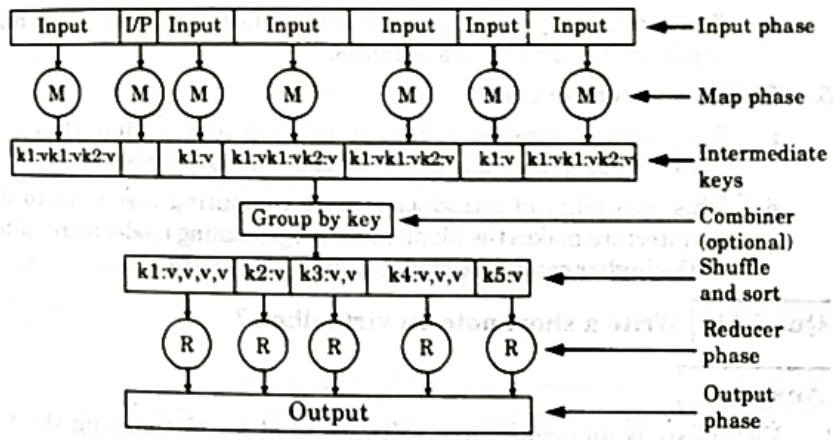

Fig. 5.9.1.

Que 5.10. **Explain the features of MapReduce.**

Answer

Features of MapReduce :

1. **Scheduling :**
   i. MapReduce involves two operations : map and reduce, which are executed by dividing large problems into smaller chunks are run in parallel by different computing resources.
   ii. The operation of breaking tasks into subtasks and running these subtasks independently in parallel is called mapping, which is performed ahead of the reduce operation.
2. **Synchronization :**
   i. Execution of several concurrent processes requires synchronization.
   ii. The MapReduce program execution framework is aware of the mapping and reducing operations that are taking place in the program.
3. **Co-location of code/data (Data locality) :**
   i. The effectiveness of a data processing mechanism depends on the location of the code and the data required for the code to execute.
   ii. The best result is obtained when both code and data reside on the same machine.
   iii. This means that the co-location of the code and data produces the most effective processing outcome.
4. **Handling of errors/faults :**
   i. MapReduce engines provide a high level of fault tolerance and robustness in handling errors.
   ii. The reason for providing robustness to these engines is their high tendency to make errors or faults.
5. **Scale-out architecture :**
   i. MapReduce engines are built in such a way that they can accommodate more machines, as and when required.
   ii. This possibility of introducing more computing resources to the architecture makes the MapReduce programming model more suited to the higher computational demands of big data.

Que 5.11. **Write a short note on virtualbox ?**

Answer

1. Virtualbox is an open-source software used for virtualizing the x86 computing architecture.

2. It acts as a hypervisor, creating a VM (Virtual Machine) in which the user can run another OS (Operating System).
3. The operating system in which virtualbox runs is called the host OS.
4. The operating system running in the VM is called the guest OS. Virtualbox supports Windows, Linux, or MacOS as its host OS.
5. When configuring a virtual machine, the user can specify how many CPU cores, and how much RAM and disk space should be devoted to the VM.
6. When the VM is running, it can be paused (system execution is frozen at that moment in time), and resumed later when the user wishes to continue.

Que 5.12. **Describe the working of MapReduce algorithm.**

Answer

Working of MapReduce algorithm :

1. Take a large dataset or set of records.
2. Perform iteration over the data.
3. Extract some interesting patterns to prepare an output list by using the map function.
4. Arrange the output list properly to enable optimization for further processing.
5. Compute a set of results by using the reduce function.
6. Provide the final output.

PART-2

Google App Engine, Programming Environment for Google App Engine.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 5.13. **Write a short note on Google App Engine (GAE).**

Answer

1. Google App Engine (GAE) is a Platform-as-a-Service (PaaS) product that provides web app developers and enterprises with access to Google's scalable hosting and tier-1 Internet service.

2. The App Engine requires that apps written in Java or Python, store data in Google BigTable and use the Google query language. Non-compliant applications require modification to use App Engine.
3. Google App Engine provides more infrastructure than other scalable hosting services such as Amazon Elastic Compute Cloud (EC2).
4. The App Engine also eliminates some system administration and developmental tasks to make it easier to write scalable applications.
5. Google App Engine is free up to a certain amount of resource usage.
6. Users exceeding the per-day or per-minute usage rates for CPU resources, storage, number of API calls or requests and concurrent requests can pay for more of these resources.

Que 5.14. **What are the advantage and disadvantages of GAE ?**

Answer

Advantages of Google App Engine (GAE) :

1. GAE do not scale however, even after we empower billing, the whole system is augmented to support only 500 requests per second. If we want more, we can reach Google's disposal to increase our thresholds, so we can have millions of users, but more than 500 requests per second.
2. GAE feature set is good enough to build a decent website and we do not need to do the maintenance work.
3. It does not require any server administration. It has free usage allocation and provides scalability. GAE has better access to Google user accounts and deployment process is very easy.
4. GAE has the highest admin load, but once it is set up, deploying and re-deploying is quick.
5. We can get any feature from the store with GAE.

Disadvantages of GAE :

1. GAE is not stable enough and the budget would increase much when the website becomes bulky.
2. Without native file system read/write access, it is hard to process some data transform with existing library, and it do not support some native file system base library as well.
3. It does not provide full text search API.
4. SDK (Software Development Kit) Java is unfavorable with GAE as it is unsatisfactory to accomplish lots of external libraries.

5. The SDK/Java depth rest on IDE, and the default project directory structure is different from normal web app.
6. It is not easy to process unit test. It cannot fix the root cause and does not support add SSL to website.
7. The GAE may be the development for future web application, but it is not equipped for building a modern web site.
8. It suffers from the inability to weak server software. The file system and many standard library modules are inaccessible. Only Python and a few runs of Java Virtual Machine are accessible.

Que 5.15. **What are the features of Google App Engine ?**

Answer

Features of Google App Engine :

i. Persistent storage with queries, sorting and transactions.
ii. Automatic scaling and load balancing.
iii. APIs for authenticating users and sending email using Google accounts.
iv. Task queues for performing work outside of the scope of a web request.
v. Scheduled tasks for triggering events at specified times and regular intervals.
vi. Dynamic web serving, with full support for common web technologies.

Que 5.16. **Explain the services provided by Google App Engine.**

Answer

Services provided by Google App Engine :

1. **Data store :**
   i. App engine provides a powerful distributed data storage service that features query engine and transactions. Data store entities are schemaless.
   ii. The structure of data entities is provided and enforced by application code. The Java interfaces and the Python data store interface include features for applying and enforcing structure within app.
   iii. The data store is strongly consistent and uses optimistic concurrency control. An update of an entity occurs in a transaction that retried a fixed number of times if other processes are trying to update the same entity simultaneously.
   iv. The application can execute multiple data store operations in a single transaction which either all succeed or all fail ensuring the integrity of our data.

2. **Google accounts :**
   i. App Engine supports integrating an app with Google accounts for user authentication. Our application can allow a user to sign in with a Google account, and access the email address and displayable name associated with the account.
   ii. It also saves the effort of implementing a user account system just for the application.
   iii. If the application is running under Google apps, it can use the same features with members of the organization and Google apps accounts.
   iv. The users API can also tell the application whether the current user is a registered administrator for the application. This makes it easy to implement admin-only areas of the site.
3. **URL fetch :** Applications can access resources on the Internet, such as web services or other data using App Engine's. URL fetch service retrieves web resources using the same high-speed Google infrastructure that retrieves web pages for many other Google products.
4. **Mail :** Applications can send email messages using App Engine's mail service. The mail service uses Google infrastructure to send email messages.
5. **Image manipulation :** The image service lets the application manipulate images. With this API, we can resize, crop, rotate and flip images in JPEG and PNG formats.
6. **Memcache :**
   i. The memcache service provides application with a high performance in memory key value cache that is accessible by multiple instances of the application.
   ii. Memcache is useful for data that do not need the persistence and transactional features of the data store, such as temporary data or data copied from the data store to the cache for high speed access.
7. **Scheduled tasks and task queues :**
   i. An application can perform tasks outside of responding to web requests.
   ii. The application can perform these tasks on a schedule, such as on a daily or hourly basis.
   iii. The application can perform tasks added to a queue by the application itself, such as a background task created while handling a request.

Que 5.17. **Describe briefly the supported environments for Google App Engine.**

Answer

Supported environments for Google App Engine :

1. **Java Runtime Environment :**
   i. Develop application using common java web development tools and API standards.
   ii. It includes java Runtime Environment 6, platform and libraries.
   iii. App interacts with the environment using Java Servlet standard and can use common web application techniques such as Java Server pages.
2. **Python Runtime Environment :**
   i. Implement app using the Python runtime environment, and run it on an optimized Python interpreter.
   ii. App engine includes rich data modelling APIs and tools for managing and accessing app's data.
   iii. Uses Python version 2.5.2, in future being considered Python 3.
   iv. Provides rich APIs for the data store, Google accounts, URL fetch, and email services.
   v. It provides simple Python web application framework called web app to make it easy to start building applications.

PART-3

Openstack, Federation in the Cloud, Four Levels of Federation, Federated Services and Applications, Future of Federation.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 5.18. **Explain openstack.**

Answer

1. Openstack is an open-source software that allows the deployment and management of a cloud Infrastructure-as-a-Service (IaaS) platform.
2. Openstack supports both private and public cloud deployments.
3. It fulfills two main requirements of the cloud, massive scalability and simplicity of implementation.
4. Openstack is highly configurable as user can choose whether or not to implement several services offered by the software.

5. The configuration of each component is also up to the user and is easily made through the Application Programming Interface (API).
6. Therefore, there are many different ways to use openstack, which makes it a flexible tool that is able to work along with other software.
7. Another reason to adopt openstack is that it supports different hypervisors (Xen, VMware or Kernel-based Virtual Machine [KVM]) and several virtualization technologies (such as bare-metal or high-performance computing).

Que 5.19. **What are the components of openstack ?**

Answer

Components of openstack : Openstack has open nature, anyone can add additional components to openstack to help it to meet their needs. But the openstack community has collaboratively identified nine key components that are a part of the core of openstack, officially maintained by the openstack community :

1. **Nova :**
   i. It is the primary computing engine behind openstack.
   ii. It is used for deploying and managing large numbers of virtual machines and other instances to handle computing tasks.
2. **Swift :**
   i. It is a storage system for objects and files.
   ii. It allows the system, rather than the developer, to make sure that data is backed up in case of the failure of a machine or network connection.
3. **Cinder :**
   i. It is a block storage component, which is more analogous to the traditional notion of a computer being able to access specific locations on a disk drive.
   ii. This more traditional way of accessing files might be important in scenarios in which data access speed is the most important consideration.
4. **Neutron :**
   i. It provides the networking capability for openstack.
   ii. It helps to ensure that each of the components of an openstack deployment can communicate with one another quickly and efficiently.
5. **Horizon :**
   i. It is the dashboard behind openstack.
   ii. Developers can access all of the components of openstack individually through an Application Programming Interface (API), but the dashboard provides system administrators a look at what is going on in the cloud, and how to manage it.

Keystone :

i. It provides identity services for openstack.
ii. It is essentially a central list of all of the users of the openstack cloud, mapped against all of the services provided by the cloud, which they have permission to use.
iii. It provides multiple means of access, so that, developers can easily map their existing user access methods against keystone.

Glance :

i. It provides image services to openstack.
ii. In this case, images refers to images (or virtual copies) of hard disks.
iii. Glance allows these images to be used as templates when deploying new virtual machine instances.

Ceilometer :

i. It provides telemetry services, which allow the cloud to provide billing services to individual users of the cloud.
ii. It also keeps a verifiable count of each user's system usage of each of the various components of an openstack cloud.

Heat :

i. It is the orchestration component of openstack, which allows developers to store the requirements of a cloud application in a file that defines what resources are necessary for that application.
ii. In this way, it helps to manage the infrastructure needed for a cloud service to run.

ue 5.20. **Write down the benefits of using openstack ?**

nswer

nefits of using openstack :

Enables rapid innovation :

i. Openstack's orchestration and self-service capabilities offers developers and IT staff with faster and better access to IT resources.
ii. Because developers can provision machines rapidly and on-demand, they can significantly reduce development and testing periods and have more freedom to experiment with new ideas.

Cuts down time-to-market :

i. Faster deployment of IT resources also means end users and business units no longer have to wait days or weeks to start using the network services and applications they need.

ii. In turn, they would be more capable of rolling out and completing projects earlier than before.

3. **Boosts scalability and resource utilization :**

i. Although not as scalable as public clouds, openstack private clouds still offer a significant degree of scalability. We can still spin up and spin down servers on demand.

4. **Eases regulatory compliance :**

i. Because openstack enables the construction of private, on-premise clouds, it can help in regulatory compliance endeavors.

ii. If our cloud is in our own datacenter, we will have more control of access privileges, security measures, and security policies.

iii. We can personally take charge of ensuring that policies for securing personal data, financial data, and other confidential and regulated information are actually enforced and not just printed on a piece of paper.

Que 5.21. **Write a short note on cloud federation.**

Answer

1. Cloud federation refers to the unionization of software, infrastructure and platform services from disparate networks that can be accessed by a client through the internet.
2. The federation of cloud resources is facilitated through network gateways that connect public or external clouds, private or internal clouds (owned by a single entity) and/or community clouds (owned by several cooperating entities); creating a hybrid cloud computing environment.
3. The federated cloud computing services rely on the existence of physical datacenters.
4. Two approaches of cloud federation are :

a. **Centralized federation model :** This is the approach taken by several identity federation standards. It distinguishes two operational roles in transaction :

i. The identity provider

ii. The service provider

b. **Claim-based model :** This approach addresses the problem of user authentication from a different perspective and requires users to provide claims answering who they are and what they can do in order to access content or complete a transaction.

Que 5.22. **What are the benefits of cloud federation ?**

Answer

Benefits of cloud federation are :

1. The federation of cloud resources allows client to optimize enterprise IT service delivery.
2. The federation of cloud resources allows a client to choose best cloud service providers in terms of flexibility cost and availability of services to reach particular business or technological need within their organization.
3. Federation across different cloud resources pools allows applications to run in the most appropriate infrastructure environments.
4. The federation of cloud resources also allows an enterprise to distribute workloads around the globe, move data between disparate networks and implement innovative security models for user access to cloud resources.

Que 5.23. **What are the levels of federation ?**

Answer

Levels of federation are :

1. **Permissive federation :**

i. Permissive federation occurs when a server accepts a connection from a peer network server without verifying its identity using DNS lookups or certificate checking.

ii. The lack of verification or authentication may lead to domain spoofing (the unauthorized use of a third-party domain name in an email message in order to pretend to be someone else), which opens the door to widespread spam and other abuses.

2. **Verified federation :**

i. This type of federation occurs when a server accepts a connection from a peer after the identity of the peer has been verified.

ii. It uses information obtained via DNS and by means of domain-specific keys exchanged beforehand.

iii. The connection is not encrypted, and the use of identity verification effectively prevents domain spoofing.

iv. To make this work, federation requires proper ITS setup, and that is still subject to DNS poisoning attacks.

v. Verified federation has been the default service policy on the open XMPP since the release of the open-source jabberd 1.2 server.

3. **Encrypted federation :**

i. In this mode, a server accepts a connection from a peer if and only if the peer supports Transport Layer Security (TLS).

ii. The peer must present a digital certificate. The certificate may be self-signed, but this prevents using mutual authentication.

iii. If this is the case, both parties proceed to weakly verify identity using Server Dialback. XEP-0220 defines the server dialback protocol, which is used to provide identity verification.

iv. Server dialback uses the DNS as the basis for verifying identity, the basic approach is that when a receiving server receives a server-to-server connection request from an originating server, it does not accept the request until it has verified a key with an authoritative server for the domain asserted by the originating server.

v. Although server dialback does not provide strong authentication or trusted federation, and although it has effectively prevented most instances of address spoofing on the XMPP network since its release in 2000.

vi. This results in an encrypted connection with weak identity verification.

4. **Trusted federation :**

i. Here, a server accepts a connection from a peer only under the condition that the peer supports TLS and the peer can present a digital certificate issued by a root Certification Authority (CA) that is trusted by the authenticating server.

ii. The list of trusted root CAs may be determined by one or more factors, such as the operating system, XMPP server software, or local service policy.

iii. In trusted federation, the use of digital certificates results not only in a channel encryption but also in strong authentication.

iv. The use of trusted domain certificates effectively prevents DNS poisoning attacks but makes federation more difficult, since such certificates have traditionally not been easy to obtain.

Que 5.24. **What are the advantages provided by cloud federation ?**

Answer

Advantages provided by cloud federation :

i. **Performance guarantees :** By lending resources, it is possible to maintain the necessary levels of performance to the rendered services.

ii. **Availability guarantees :** Location diversity for data and services allows migration of services. For example, disaster-prone areas, maintaining higher availability to the client.

iii. **Convenience :** Federation provides convenience to the client in relation to contracted services, allowing a unified view from services of different providers.

iv. **Dynamic workload distribution :** Geographic distribution allows to scatter load according to the client location.

Que 5.25. **What are the approaches used to model cloud federation ?**

Answer

Approaches used to model cloud federation are :

1. **Semantics based :**

i. A theoretical federation model based on semantics and Infrastructure-as-a-Service (IaaS) is proposed.

ii. The authors utilize ontology to provide interoperability between autonomous clouds in a resource sharing environment.

iii. The use of ontologies is justified by the difficulties offering interoperability, which is a critical aspect in a federated cloud.

iv. The difficulties in providing interoperability include different implementation schemes for the same type of entity or components on each cloud, where ontologies are utilised to understand and model such differences.

2. **Market-oriented :**

i. The federation model oriented to computation services was proposed.

ii. It focuses on the commercialization of infrastructure resources in a structure that resembles a services market.

iii. To support this model, four components are utilized as the core of the cloud federation :

a. **Clouds :** Where resources are located and the services will be offered to the clients.

b. **Application broker :** Interface responsible for intermediating operations between client and federation.

c. **Cloud coordinator :** Component located in each cloud and responsible for maintaining the integrity of the federation.

d. **Concentrator :** Acts as the market of resources and services.

3. **Reservoir :**

i. The reservoir is a project leaded by IBM and developed with the objective to provide a cloud federation environment that offers software-as-a-service to providers.

ii. The reservoir modelling is focused in loose coupling, and also in avoiding limitations shown by isolated clouds, such as :

a. Difficulties small providers have in providing scalability.

b. Lack of interoperability.

c. Lack of support to Business Service Management (BSM).

iii. The official documentation highlights four functional requirements : rapid installation of applications and services, dynamic elasticity, semantic and continuous optimization, and independence of virtualization technologies.

☺☺☺

1 UNIT

Introduction (2 Marks Questions)

1.1. Define the term cloud.

Ans. The cloud refers to a group of hardware computing devices, software, storage devices, and application programming interfaces (APIs) that integrate and interface with each other to deliver the characteristics of cloud computing in a service model.

1.2. What do you understand by cloud computing ?

Ans. Cloud computing is a computing paradigm, where a large pool of systems are connected in private or public networks, to provide dynamically scalable infrastructure for application, data and file storage.

1.3. What are the features of cloud computing ?

Ans. Features of cloud computing are :

1. On-demand self-service
2. Compatibility
3. Reliability
4. Disaster recovery

1.4. What are the advantages of using cloud computing ?

Ans. Advantages of using cloud computing are :

1. Cost saving
2. Excellent accessibility
3. High speed
4. Unlimited storage capacity

1.5. What are benefits of cloud computing ?

Ans. Benefits of cloud computing are :

1. High availability
2. High productivity
3. Easy to manage
4. Increased mobility
5. Less development time

1.6. What are disadvantages of cloud computing ?

Ans. Disadvantages of cloud computing are :
1. Technical issues
2. Performance can vary
3. Internet connectivity
4. Vulnerability to attacks
5. Lack of support

1.7. What are the service models of cloud computing ?
Ans. Service models of cloud computing are :
1. Infrastructure-as-a-Service
2. Platform-as-a-Service
3. Software-as-a-Service

1.8. Mention platforms which are used for large scale cloud computing.
Ans. The platforms that are used for cloud computing are :
1. Apache Hadoop
2. MapReduce

1.9. List some visions of cloud computing.
Ans. Visions of cloud computing are :
1. Cloud computing provides the facility to provision virtual hardware, runtime environment and services to a person having money.
2. These all things can be used as long as they are needed by the user, there is no requirement for the upfront commitment.
3. A cloud provider can also become a consumer of a competitor service in order to fulfill its promises to customers.

1.10. Write the components of cloud.
Ans. Components of cloud computing are :
1. Cloud service consumer
2. Cloud service provider
3. Internet medium
4. Data centre

1.11. What are the challenges of cloud computing ?
Ans. Challenges of cloud computing are :
1. Data protection
2. Data recovery and availability
3. Management capabilities
4. Regulatory and compliance restrictions

1.12. Define parallel computing.
Ans. Parallel computing is a type of combination in which many calculations or the execution of processes are carried out simultaneously.

1.13. Define distributed computing.
Ans. Distributed computing is a computation type in which networked computers communicate and coordinate the work through message passing to achieve a common goal.

1.14. What are the advantages of distributed computing ?
Ans. Advantages of distributed computing are :
1. Reliability
2. Incremental growth
3. Sharing of resource
4. Flexibility
5. Speed

1.15. What are the disadvantages of distributed computing ?
Ans. Disadvantages of distributed computing are :
1. Less software support
2. Loss of message
3. Data security
4. Trouble shooting and diagnosing

1.16. Name the technologies used for distributed computing.
Ans. Technologies used for distributed computing are :
1. Remote procedure call
2. Distributed object framework

1.17. What are the categories of parallel computing systems ?
Ans. Categories of parallel computing system :
1. Bit level parallelism
2. Instruction level parallelism

1.18. Define the challenges in cloud.
Ans. Challenges in cloud are :
1. Lack of control
2. Interoperability
3. Resource management

1.19. List the components in architecture of cloud computing.
Ans. Components in architecture of cloud computing :
1. Front end platform
2. Back end platform
3. Cloud based delivery
4. Network

1.20. What are the various cloud computing technologies ?
Ans. Various cloud computing technologies are :
1. Amazon Web Service (AWS)

2. Microsoft Azure
3. Force.com and salesforce.com

1.21. What are the issues in cloud computing ?

Ans. Issues in cloud computing are :

1. Security issues
2. Data issues
3. Performance issues
4. Energy related issues
5. Fault tolerant

1.22. What are the advantages of parallel computing ?

Ans. Advantages of parallel computing are :

1. Save time and money
2. Solve larger problems
3. Provide concurrency
4. Multiple execution units

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2 UNIT

Cloud Enabling Technologies (2 Marks Questions)

2.1. Define SOA.

Ans. Service Oriented Architecture (SOA) is an architectural approach in which applications make use of services available in the network. It is a style of software design where services are provided to the other components by application components through a communication protocol over a network.

2.2. What are the major roles of SOA ?

Ans. Major roles of SOA are :

1. Service provider
2. Service consumer

2.3. What are the guiding principles of SOA ?

Ans. Guiding principles of SOA are :

1. Standardized service contract
2. Loose coupling
3. Abstraction
4. Reusability
5. Autonomy
6. Lack of state
7. Discoverability
8. Composability

2.4. What are the advantages of SOA ?

Ans. Advantages of SOA are :

1. Service reusability
2. Easy maintenance
3. Platform independent
4. Availability
5. Reliability
6. Scalability

2.5. What are the disadvantages of SOA ?

Ans. Disadvantages of SOA are :

1. High overhead

2. High investment
3. Complex service management

2.6. What do you understand by REST ?

Ans. Representational State Transfer (REST) is a way of getting information content from a website by reading a designated web page that contains an XML file and describes the desired content.

2.7. What are the architectural constraints of web services ?

Ans. Architectural constraints of web services are :

1. Uniform interface
2. Stateless
3. Cacheable
4. Client-Server
5. Layered system
6. Code on demand

2.8. What is RESTful API ?

Ans. A RESTful API is an Application Program Interface (API) that uses HTTP requests to GET, PUT, POST and DELETE data.

2.9. Define virtualization.

Ans. Virtualization is an abstraction layer that decouples the physical hardware from the Operating System (OS) to deliver greater IT resource utilization and flexibility.

2.10. What are the benefits provided by virtualization ?

Ans. Benefits provided by virtualization are :

1. Cost saving
2. Dramatic increase in control
3. Simplified disaster recovery
4. Business readiness assessment

2.11. What are the types of virtualization ?

Ans. Types of virtualization are :

1. OS virtualization
2. Application-server virtualization
3. Application virtualization
4. Administrative virtualization
5. Network virtualization
6. Hardware virtualization
7. Storage virtualization

2.12. What are the characteristics of virtualization ?

Ans. Characteristics of virtualization are :

1. Partitioning

2. Isolation
3. Encapsulation

2.13. What are the implementation levels of virtualization ?

Ans. Various implementation levels of virtualization are :

1. Instruction set architecture level
2. Hardware abstraction level
3. Operating system level
4. Library support level
5. User-application level

2.14. What are the tools of virtualization ?

Ans. Tools of virtualization are :

1. Ganeti
2. KVM (Kernel-based Virtual Machine)
3. oVirt
4. Packer
5. Vagrant
6. Xen

2.15. What are the mechanisms used for virtualization of the system ?

Ans. Mechanisms used for virtualization of the system are :

1. Binary translation
2. Hardware assist
3. Para virtualization

2.16. What are the benefits of using SOA ?

Ans. Benefits of using SOA :

1. Language neutral integration
2. Component reuse
3. Organizational agility
4. Leveraging existing system

2.17. What are the four HTTP methods used by REST architecture ?

Ans. Four HTTP methods are :

1. GET method
2. PUT method
3. DELETE method
4. POST method

2.18. Define the types of web services.

Ans. Two types of web services are :

1. SOAP web service
2. REST web service

2.19. What are the application areas of SOA ?

Ans. Application areas of SOA :

1. Armies and airforce
2. Healthcare delivery
3. Mobile solution apps

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3 UNIT

Cloud Architecture, Services and Storage (2 Marks Questions)

3.1. What are various cloud deployment model ?

Ans. Various deployment models are :

1. Public cloud
2. Private cloud
3. Hybrid cloud
4. Community cloud

3.2. Define public cloud.

Ans. Public cloud is a computing service that offers resource pooling, self-service, service accounting, elasticity, multi-tenancy to manage the solutions, deployment, and securing the resources and applications.

3.3. Define private cloud.

Ans. Private cloud is a cloud computing model where services are provisioned over private infrastructure for the dedicated use of a single organization.

3.4. Define hybrid cloud.

Ans. A hybrid cloud is a combination of an interoperating public and private cloud. This is the model where consumer takes the non-critical application or information and compute requirements to the public cloud while keeping all the critical information and application data in control.

3.5. Define community cloud.

Ans. Community cloud is a cloud computing model which is created and controlled by the group of organization who have shared same internet and they are all having same security policies.

3.6. What are the types of private cloud ?

Ans. Types of private cloud are :

1. Shared private cloud
2. Dedicated private cloud
3. Dynamic private cloud

3.7. Define Infrastructure-as-a-Service.

Ans. Infrastructure-as-a-Service is a model that allocates virtualized computing resources to the user through the internet.

3.8. What are the advantages of IaaS ?

Ans. Advantages of IaaS are :

1. Cost saving
2. Flexibility
3. Utility service
4. Dynamic scaling
5. Multiple tenants

3.9. What is Platform-as-a-Service ?

Ans. Platform-as-a-Service (PaaS) is a category of cloud computing services that provides a platform allowing customers to develop, run, and manage applications without the complexity of building and maintaining the infrastructure.

3.10. What are the advantages of PaaS ?

Ans. Advantages of PaaS are :

1. Simple and convenient for users
2. Cost effective
3. Efficiently managing the lifecycle
4. Efficiency

3.11. What are the disadvantages of PaaS ?

Ans. Disadvantages of PaaS are :

1. Developers may not be able to use a full range of conventional tools.
2. Migration from one PaaS vendor's application to another PaaS vendor will create some problem.

3.12. What are the characteristics of PaaS ?

Ans. Characteristics of PaaS are :

1. Runtime framework
2. Abstraction
3. Automation
4. Cloud services

3.13. What is Software-as-a-Service ?

Ans. SaaS (Software-as-a-Service) is an application hosted on a remote server and accessed through the internet. SaaS is the web-based e-mail service offered by an organization.

3.14. What are the advantages of SaaS ?

Ans. Advantages of SaaS are :

1. Improve productivity
2. Require low maintenance
3. Easy to buy

3.15. What are the challenges in cloud design ?

Ans. Cloud architectural design challenges are :

1. Service availability and data lock-in problem.
2. Data privacy and security concerns.
3. Unpredictable performance and bottlenecks.
4. Distributed storage and widespread software bugs.
5. Cloud scalability, interoperability, and standardization.

3.16. Define storage.

Ans. Storage is a mechanism through which data is saved within a data storage device by means of computing technology.

3.17. What are the types of storage devices ?

Ans. There are two types of storage devices :

1. **Block storage devices :** It offers raw storage to the clients. This raw storage is partition to create volumes.
2. **File storage devices :** It offers storage to clients in the form of files maintaining its own file systems.

3.18. Define cloud storage.

Ans. Cloud storage means the storage of data online in cloud wherein a combine data is stored and accessible from multiple distributed and connected resources that comprise a cloud.

3.19. What are the types of cloud storage ?

Ans. There are two types of cloud storage :

1. Unmanaged cloud storage
2. Managed cloud storage

3.20. Define unmanaged cloud storage.

Ans. Unmanaged cloud storage means the storage is preconfigured from the customer.

3.21. Define managed cloud storage.

Ans. Managed cloud storage offers online storage space on demand. This system appears to the user to be a raw disk that the user can partition and format.

3.22. Define Storage-as-a-Service.

Ans. Storage-as-a-Service is a business model in which a large company rents space in their storage infrastructure to a smaller company or individual.

3.23. What are the advantages of cloud storage ?

Ans. Advantages of cloud storage :

1. Usability
2. Bandwidth
3. Accessibility
4. Disaster recovery
5. Price savings

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4 UNIT Resource Management and Security in Cloud (2 Marks Questions)

4.1. What is inter-cloud ?

Ans. Inter-cloud is the concept of connected cloud networks, including public, private, and hybrid clouds. It incorporates a number of technologies to improve interoperability and portability among cloud networks.

4.2. What are the types of inter-cloud resource management ?

Ans. Types of inter-cloud resource management are :

1. **Federation cloud :** A federation cloud is an inter-cloud where a set of cloud providers willingly interconnect their cloud infrastructures in order to share resources among each other.
2. **Multi-cloud :** In a multi-cloud, a client or service uses multiple independent clouds. A multi-cloud environment has no volunteer interconnection and sharing of the cloud service provider infrastructures.

4.3. What are the topologies used in inter-cloud architecture ?

Ans. Topologies used in inter-cloud architectures are :

1. Peer to peer inter-cloud federation
2. Centralized inter-cloud federation
3. Multi-cloud Service
4. Multi-cloud Libraries

4.4. What is resource provisioning ?

Ans. Resource provisioning means the selection, deployment, and run-time management of software and hardware resources for ensuring guaranteed performance for applications.

4.5. What are the types of resource provisioning ?

Ans. Types of resource provisioning are :

1. **Static provisioning :** For applications that have predictable and generally unchanging demands workloads, static provisioning is used.
2. **Dynamic provisioning :** In cases where demand by applications may change or vary, dynamic provisioning technique is used.

3. **User self-provisioning :** With user self-provisioning (also known as cloud self-service), the customer purchases resources from the cloud provider through a web form, creating a customer account and paying for resources with a credit card.

4.6. What are the parameters used for resource provisioning ?

Ans. Parameters used for resource provisioning are :

1. Response time
2. Minimize cost
3. Revenue maximization
4. Fault tolerant
5. Reduced SLA violation
6. Reduced power consumption

4.7. What are market-oriented techniques ?

Ans. Various market-oriented techniques are :

1. Aneka
2. Workflow engine
3. MetaCDN
4. CloudSim
5. Resource management

4.8. What are security challenges related to deployment models ?

Ans. Security challenges related to deployment models are :

1. Cloning and resource pooling
2. Motility of data and data residuals
3. Elastic perimeter
4. Shared multi-tenant environment
5. Unencrypted data
6. Authentication and identity management

4.9. What are the security challenges related with service models ?

Ans. Security challenges with the service models are :

1. Data leakage and consequent problem
2. Malicious attacks
3. Backup and storage
4. Shared technological issues
5. Service hijacking
6. VM hopping
7. VM mobility
8. VM denial of service

4.10. What are the properties of virtual machines ?

Ans. Properties of virtual machines are :

1. Efficiency
2. Resource control

3. Equivalence

4.11. How can we implement virtual machines ?

Ans. We can implement virtual machines in two ways :

1. Process virtual machines
2. System virtual machines

4.12. Define IAM.

Ans. Identity and Access Management (IAM) is a system that secures, stores, and manages user identities and access privileges. It ensures that the users can only get access to applications and resources only if they have the permission to use them.

4.13. What are the benefits of IAM ?

Ans. Benefits of IAM are :

1. Improving user experiences
2. Enhancing security profiles
3. Simplifies auditing and reporting
4. Allows easy access
5. Increases productivity and reduces IT costs

4.14. Define the resource provisioning methods.

Ans. Resource provisioning methods :

1. Demand driven resource provisioning
2. Event driven resource provisioning
3. Popularity driven resource provisioning

4.15. What are cloud security controls ?

Ans. Cloud security controls :

1. Detective control
2. Preventive control
3. Deterrent control
4. Corrective control

4.16. Define the objectives of cloud security governance.

Ans. Objectives of cloud security governance :

1. Strategic alignment
2. Value delivery
3. Risk mitigation
4. Effective use of resources
5. Sustained performance

4.17. Write down the cloud security standards.

Ans. Cloud security standards :

1. Information Technology Infrastructure Library (ITIL)
2. Open Virtualization Format (OVF)
3. ITU-TX.1601
4. Payment Card Industry Data Security Standard (PCIDSS)
5. ISO/IEC 27017 Code of practice for information security controls

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5 UNIT

Cloud Technologies and Advancements (2 Marks Questions)

5.1. Define hadoop.

Ans. Hadoop is an open-source software framework for storing data and running applications on clusters of commodity hardware.

5.2. Why do we use hadoop ?

Ans. We use hadoop for :

1. Computing power
2. Fault tolerance
3. Flexibility
4. Low cost
5. Scalability

5.3. What are the features of hadoop ?

Ans. Features of hadoop are :

1. Suitable for Big Data Analysis
2. Scalability
3. Fault Tolerance

5.4. What are the modules of hadoop ?

Ans. Modules of hadoop are :

1. HDFS
2. Yarn
3. MapReduce
4. Hadoop common

5.5. What are the advantages of hadoop ?

Ans. Advantages of hadoop are :

1. Fast
2. Scalable

3. Cost effective
4. Resilient to failure

5.6. Define Google App Engine.

Ans. Google App Engine is a Platform-as-a Service (PaaS) product that provides Web app developers and enterprises with access to Google's scalable hosting and tier-1 Internet service.

5.7. What are the services provided by Google app engine ?

Ans. Services provided by Google app engine are :

1. Datastore
2. Google accounts
3. URL Fetch
4. Mail
5. Image manipulation
6. Memcache
7. Scheduled tasks and task queues

5.8. What are the environments supported by Google app engine ?

Ans. Environments supported by Google app engine are :

1. Java runtime environment
2. Python runtime environment

5.9. What is openstack ?

Ans. Openstack is open source software that allows for the deployment and management of a cloud infrastructure-as-a service (IaaS) platform.

5.10. What is cloud federation ?

Ans. Cloud federation refers to the unionization of software, infrastructure and platform services from disparate networks that can be accessed by a client via the internet.

5.11. Define virtualbox.

Ans. Virtualbox is open-source software for virtualizing the X86 computing architecture. It acts as a hypervisor creating a VM in which the user can run another operating system.

5.12. What are the features of virtualbox ?

Ans. Features of virtualbox are :

1. Running multiple operating systems simultaneously
2. Easier software installations
3. Testing and disaster recovery
4. Infrastructure consolidation

5.13. What are the advantages of GAE ?

Ans. Advantages of Google App Engine (GAE) are :

1. Cost saving
2. Platform independent
3. Performance and reliability
4. Easy to use
5. Scalability

5.14. What are the components of openstack ?

Ans. Components of openstack are :

1. Nova
2. Swift
3. Cinder
4. Neutron
5. Horizon
6. Keystone
7. Glance
8. Ceilometer
9. Heat

5.15. What are the benefits of openstack ?

Ans. Benefits of openstack :

1. Enable rapid innovation
2. Cuts down time to market
3. Boots scalability
4. Resource utilization

5.16. What are the challenges of openstack ?

Ans. Challenges of openstack :

1. Scarcity of talent
2. Longer to implement

5.17. What are the features of openstack ?

Ans. Features of openstack are :

1. Web frontend dashboard
2. Database-as-a-Service
3. Messaging service
4. Backups and restore
5. Disaster recovery

5.18. What are the four levels of cloud federation ?

Ans. Four levels of cloud federation are :

1. Permissive
2. Verified
3. Encrypted
4. Trusted

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B. Tech.
(SEM. VII) ODD SEMESTER THEORY EXAMINATION, 2019-20
CLOUD COMPUTING

Time : 3 Hours **Max. Marks : 70**

Note : Attempt **all** sections. If require any missing data; then choose suitably.

SECTION-A

1. Attempt **all** questions in brief. **(2 × 7 = 14)**

a. What is cloud ecosystem ?

Ans.

1. Ecosystem is a term used to describe the complex system of interdependent components that work together to enable services.
2. In terms of cloud computing that complex system includes not only traditional elements of cloud computing such as software and infrastructure but also consultants, integrators, partners, third parties and anything in their environments that has bearing on the other components.
3. The cloud is an ecosystem that has an interconnected array of resources, services and applications which provide value for businesses and consumers.

b. Differentiate between distributed computing and cloud computing.

Ans.

S. No.	Distributed computing	Cloud computing
1.	A computing technique that allows multiple computers to communicate and coordinate work by passing messages through the network to achieve a common task.	A computing technique that delivers hosted services over the internet.
2.	Helps to achieve computational tasks faster than using a single computer.	Provides services such as hardware, software resources through the internet.

c. Explain grid computing.

Ans. Grid computing is a processor architecture that combines computer resources from various domains to reach a main objective. In grid computing, the computers on the network can work on a task together, thus functioning as a supercomputer.

d. Explain hybrid cloud.

Ans. Refer Q. 3.4, Page SQ–9E, Unit-3, Two Marks Questions.

e. Differentiate between public and private cloud.

Ans. Refer Q. 3.13, Page 3–14E, Unit-3.

f. What do you mean by full virtualization ?

Ans. Refer Q. 2.30, Page 2–25E, Unit-2.

g. What are the major challenges faced in cloud ?

Ans. Refer Q. 1.10, Page 1–11E, Unit-1.

SECTION-B

2. Attempt any **three** of the following : (7 × 3 = 21)

a. Illustrate the cloud adoption discussing its several policies.

Ans.

1. Cloud adoption is a strategic move by organizations of reducing cost, mitigating risk and achieving scalability of data base capabilities.
2. Cloud adoption may be up to various degrees in an organization, depending on the depth of adoption.
3. In fact the depth of adoption yields insight into the maturity of best practices, enterprise-ready cloud services availability.
4. Organisations that go ahead with the strategic decision of adopting cloud based technologies have to identify potential security thefts and controls, required to keep the data and applications in the cloud secured.
5. Hence there is a need for compliance assessment during cloud adoption.

Following are the policies of cloud adoption :

1. **Evaluation :** The investigation will present the ultimate guidance for estimating the advantages and disadvantages of Cloud implementation. The following are analysed during evaluation :
   a. Judge the cloud consumption challenges, prospects in the market.
   b. Find out the business value.
   c. Assess and manuscript the success stories, risks and obstacles involved in cloud adoption.
   d. Evaluate the cloud vendors for cloud association.
2. **Plan :** It is significant for an organization to build up an adapted Cloud strategy. The following are analysed during planning :
   a. It will recognize applications that are rapid to the market and significant to business in terms of income and customer fulfillment.
   b. For premature adoptors, it is a valuable strategy to decide applications that are stand-alone anti straight forward to migrate.
   c. It is significant to identify the appropriateness of public, private or hybrid Clouds and cloud models such as SaaS, Infrastructure as a Service (IaaS) and Platform as a Service (PaaS).

   d. Consider recognizing and manuscripting what is sketched to distribute to the client Quality of Service (QoS). This will assist to extend a Cloud strategy for a victorious and well supervised Cloud deployment.
3. **Adoption :** The following are then analysed during adoption :
   a. Control the cloud deployment architectures that were sophisticated, lit the planning phase and extend application migration approaches, and use cases ford scripts.
   b. Recognize the servers and the data stores alum with the software to understand navigation road mars.
4. **Optimize :** Developing business process and software licenses that will assist the consumer to understand the advantages of enhanced organizational capabilities to offer improved value to the organizational and the customer are as follows :
   a. Presenting lessons and or on educated session after every cloud deployment and purify the procedures and methods consequently.
   b. Develop required skill roadmaps and unite skilled resources prior to deployment.

b. What is a Hypervisor ? Explain in detail with necessary illustrations.

Ans. **Hypervisor :** Refer Q. 2.29, Page 2–24E, Unit-2.

Hypervisor reference model :

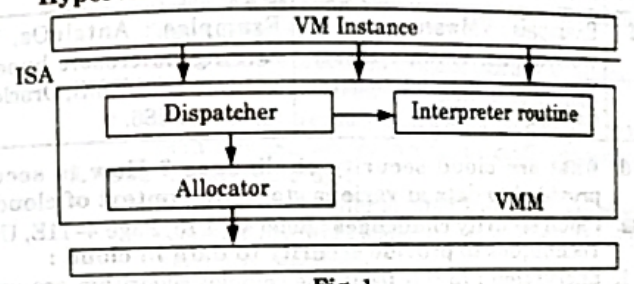


Fig. 1.

There are three main modules coordinate in order to follow the underlying hardware :

1. **Dispatcher :** The dispatcher behaves like the entry point of the monitor and reroutes the instructions of the virtual machine instance to one of the other two modules.
2. **Allocator :** The allocator is responsible for deciding the system resources to be provided to the virtual machine instance. It means whenever virtual machine tries to execute an instruction that results in changing the machine resources associated with the virtual machine, the allocator is invoked by the dispatcher.
3. **Interpreter :** The interpreter module consists of interpreter routines. These are executed, whenever virtual machine executes a privileged instruction.

c. What is the difference between process virtual machines, host VMMs and native VMMs.

Ans. Process virtual machines :

1. Constructed at ABI level.
2. Runtime manages guest process.
3. Not persistent.
4. Guest processes may intermingle with host processes.
5. As a practical matter, guest and host OSes are often the same.
6. Dynamic optimizers are special case.
7. Examples : IA-32 EL, FX!23, Dynamo.

S. No.	Native VMMs	Host VMMs
1.	A hypervisor that runs on conventional operating system just as other computer programs do.	A hypervisor that runs directly one the host's hardware to control the hardware and to manage guest operating systems.
2.	Called a Host OS Hypervisor.	Called a native or Bare metal hypervisor.
3.	Runs on an operating system similar to other computer programs.	Runs directly on the host's hardware.
4.	Examples : VMware Workstation, VMware Player, VirtualBox, Parallel Desktop for Mac.	Examples : AntsleOs, Xen, XCP-ng, Microsoft hyper V, VMware ESX/ESXi, Oracle VM server for x86.

d. What are cloud security challenges ? How is security provided to data at various stages in context of cloud ?

Ans. Cloud security challenges : Refer Q. 4.13, Page 4–11E, Unit-4.

Techniques to provide security to data in cloud :

1. **Encryption :** In this technique complex algorithm are used to hide the original information with the help of encryption key. The data is converted into unreadable form called cipher text and then stored on remote server storage.
2. **Authentication processes :** In this process, a login mechanism is used to verify that the only authenticated user is accessing the cloud data. It requires creating a user name and password.
3. **Authorization practices :** A list of authorized client is used to identify, who can access data stored on cloud system.

e. Explain the characteristics and type of virtualization in cloud computing.

Ans. Characteristics of virtualization in cloud computing are :

1. **Increased security :** The ability to control the execution of a guest programs in a completely transparent manner opens new

possibilities for delivering a secure, controlled execution environment.
2. **Sharing :** Virtualization allows the creation of a separate computing environment within the same host. This basic feature is used to reduce the number of active servers and limit power consumption.
3. **Aggregation :** In aggregation, a group of separate hosts can be tied together and represented to guests as a single virtual host.
4. **Emulation :** Guest programs are executed within an environment that is controlled by the virtualization layer, which ultimately is a program.
5. **Isolation :** Virtualization allows providing guests whether they are operating systems, applications, or other entities with a completely separate environment, in which they are executed.

Types of virtualization : Refer Q. 2.26, Page 2–20E, Unit-2.

SECTION-C

3. Attempt any one part of the following : (7 × 1 = 7)

a. How cloud computing provides scalability and fault tolerance ?

Ans. Ways to provide scalability in cloud computing :

1. **Employ auto scaling :**
   a. Many cloud providers offer auto scaling, which can even further help to manage resources and allocate load balances appropriately.
   b. Auto scaling is defined as automatically scaling capacity either up or down based on user-defined conditions.
   c. It allows us to ensure that we always have the precise number of instances available in order to handle our application's load.
2. **Use load balancing :**
   a. Load balancers offer another automatic way of scaling up by distributing workloads across various nodes in order to maximize resources.
   b. A load balancer will accept all incoming application traffic and then acts as an user to find the best instance for each incoming request that will best utilize the resources on hand.
3. **Employ containers with container orchestration :**
   a. Containers and container orchestration systems is a popular way to create more scalable and portable infrastructure.
   b. Containers share a single kernel and require fewer resources and offer more flexibility than virtual machines because they can share things like operating systems and other components.
   c. This allows containers to function the same way across platforms, and thus can be easily and rapidly moved between nodes.

Ways to provide fault tolerance in cloud computing :

1. **Reactive fault tolerance :**

a. Reactive fault tolerance policies reduce the effect of failures on application execution when the failure effectively occurs.

b. Various techniques based on this policy are :

i. **Check pointing/restart :** When a task fails, it is allowed to be restarted from recently checked pointed state rather than from the beginning.

ii. **Replication :** Replication means copy. Various tasks are replicated and they are run on different resources, for the successful execution and for getting the desired result.

iii. **Retry :** It is the simplest technique that retries the failed task on the same resource.

iv. **Rescue workflow :** It allows the system to keep functioning after failure of any task until it will not be able to proceed without rectifying the fault.

2. **Proactive fault tolerance :**

a. It refers to avoiding failures, errors and faults by predicting them in advance and replaces the suspected components by other working components thus avoiding recovery from faults and errors.

b. Some of the techniques which are based on these policies are :

i. **Self-healing :** When multiple instances of an application are running on multiple virtual machines, it automatically handles failure of application instances. A big task can be divided into parts. This division is done for better performance.

ii. **Pre-emptive migration :** In this technique an application is constantly observed and analyzed. It relies on a feedback-loop control mechanism where application is constantly monitored and analyzed.

iii. **Software rejuvenation :** The system is planned for periodic reboots and every time the system starts with a new state.

b. Explain Virtual LAN (VLAN) and Virtual SAN (VSAN) in cloud computing.

Ans. **Virtual LAN :**

1. A VLAN (virtual LAN) is a subnetwork which can group together collections of devices on separate physical Local Area Networks (LANs).
2. A LAN is a group of computers and devices that share a communications line or wireless link to a server within the same geographical area.
3. VLANs make it easy for network administrators to partition a single switched network to match the functional and security requirements of their systems without having to run new cables or make major changes in their current network infrastructure.
4. VLANs are often set up by larger businesses to re-partition devices for better traffic management.

5. VLANs are important because they can help to improve the overall performance of a network by grouping together devices that communicate most frequently.
6. VLANs also provide security on larger networks by allowing a higher degree of control over which devices have access to each other.
7. VLANs tend to be flexible because they are based on logical connections, rather than physical.

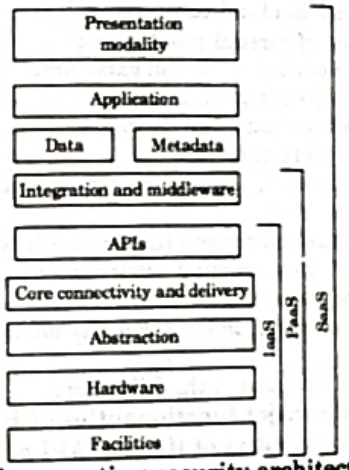
Virtual SAN :

1. Virtual SAN is a software-defined storage offering from VMware that enables enterprises to pool their storage capabilities and to instantly and automatically provision virtual machine storage via simple policies that are driven by the virtual machine.
2. VMware's virtual Storage Area Networking (SAN) solution also provides the ability to dynamically scale storage capacity and performance as needed, and exposes the underlying physical storage to the virtual machines through a policy-driven control pane.

4. Attempt any **one** part of the following : (7 x 1 = 7)

a. Explain the Cloud Computing security architecture using suitable block diagram.

Ans. Cloud security architecture based on the type of cloud model as software-as-a-service (SaaS), infrastructure-as-a-service (IaaS), or platform-as-a-service model (PaaS).



IaaS cloud computing security architecture :

1. This infrastructure provides the storage and networking components to cloud networking.
2. It relies heavily on application programming interfaces (APIs) to allow enterprises to manage and interact with the cloud.
3. The Cloud Service Provider (CSP) handles the security of the infrastructure and the abstraction layers. The enterprise's security obligations include the rest of the stack, including the applications.

4. IaaS cloud computing service models require these additional security features :
   a. Virtual web application firewalls placed in front of a website to protect against malware.
   b. Virtual network-based firewalls located at the cloud network's edge that guards the perimeter.
   c. Virtual routers.
   d. Intrusion Detection Systems and Intrusion Prevention Systems (IDS/IPS).
   e. Network segmentation.

SaaS cloud computing security architecture :

1. SaaS centrally hosts software and data that are accessible via a browser.
2. Security features for the SaaS cloud environment include :
   a. Logging b. IP restrictions c. API gateways

PaaS cloud computing security architecture :

1. It is defined as the deployment of applications without the cost and complexity of buying and managing the underlying hardware and software and provisioning hosting capabilities.
2. The CSP secures a majority of a PaaS cloud service model.
3. The essential components to secure the PaaS cloud include :
   a. Logging b. IP restrictions
   c. Cloud access security brokers.

b. What is the importance of a virtual machine ? What role do they play in cloud computing ?

Ans. Importance of virtual machines :

1. Multiple OS environments can exist simultaneously on the same machine, isolated from each other.
2. Virtual machine can offer an instruction set architecture that differs from real computers.
3. Easy maintenance, application provisioning, availability and convenient recovery.

Role of virtual machine : Its purpose is to provide a platform-independent programming environment that abstracts away details of the underlying hardware or operating system, and allows a program to execute in the same way on any platform.

5. Attempt any **one** part of the following : **(7 × 1 = 7)**

a. What are the major functionalities of Hadoop API ?

Ans. Major functionalities of Hadoop API are :

1. The mapping operation :

a. In order for the Hadoop framework to recognize mapper and reducer implementation, the Hadoop API offers a base class for them: org.apache.hadoop.mapred.MapReduceBase.

b. The mapper class also needs to implement the Mapper<K1,V1,K2,V2> interface and provide functionality for mapping input key-value pairs of type K1,V1 to intermediary key-value pairs of type K2,V2.

c. Input pairs are generated by an input formatter, originating from the InputFormat base class.

d. Each entry given by the formatter, called InputSplit, generates one set of input key-value pairs.

e. For each of these input pairs, the framework automatically calls the map(K1,V1, OutputCollector<K2,V2>,Reporter) method. Each input pair can generate one or several intermediary pairs that are collected in the OutputCollector <K2,V2> instance.

f. The Reporter instance is a utility that helps in keeping track of job progress.

2. The reduction operation :

a. The reducer must implement the Reducer<K2,V2,K3,V3> interface.

b. Its role is to transform a set of intermediary key-value pairs of type K2,V2 to a smaller set of key-value pairs of type K3,V3. All intermediary value that shares the same key is grouped into a collection.

c. For each of these groups, the reduce (K2,Iterator<V2>,OutputCollector <K3,V3>,Reporter) method is automatically called.

d. The reducer can also report its progress by means of the Reporter instance.

3. The job configuration :

a. To manage jobs execution, the Hadoop routine needs to know some configuration parameter.

b. The most basic of these parameters are the classes that implement the mapper and reducer functionalities and what formatter the runtime should use for parsing the input.

b. Explain the cloud management and services creation tools ?

Ans. Cloud management and services creation tools :

1. Cloud management and service creation tools are responsible for managing physical and virtual infrastructures.
2. These tools automate consumer requests, processing, and creation of cloud services.
3. These tools enable consumers to request cloud services and allow operators to provide cloud services based on consumer request.
4. They also provide administrators a single management interface to manage distributed resources.
5. Cloud management tools are classified in three categories :

a. First is the virtual infrastructure management software which enables the management of the both the physical and virtual infrastructure resources.

b. Second, there is the unified management software which is employed for the creation of cloud services.

c. Third, there is the user access management software which enables consumers to issue requests for the cloud services that they require.

6. These various software components interact to automate the overall provisioning of cloud services.

6. Attempt any one part of the following : (7 × 1 = 7)

a. What do you understand by Service Oriented Architecture (SOA) ? How does it support cloud computing ?

Ans. **Service oriented architecture :** Refer Q. 2.1, Page 2–2E, Unit-2.

Support cloud computing :

1. SOA binds both the deliver and leverage cloud-based services.
2. Cloud computing relies on service orientation to loosely couple the applications with the under laying infrastructure model for using web services.
3. SOA works as a foundation for the cloud. It embraces all the characteristics of the cloud – such as self-service, shared and dynamic infrastructure, and virtualization.
4. Cloud share and leverage the characteristics of SO with flexibility and agility. Applications and services and reused in new and dynamic ways and so rapid deployment happens in SOA-based cloud implementation.
5. Clouds enable the deployment of cloud services, and SOA is the most sophisticated architectural approach for building and delivery of services.
6. SOA helps to break an application framework into discrete service components so they can be reused as common services between different applications.

b. Draw the architecture and explain the importance of workflow management systems in cloud.

Ans.

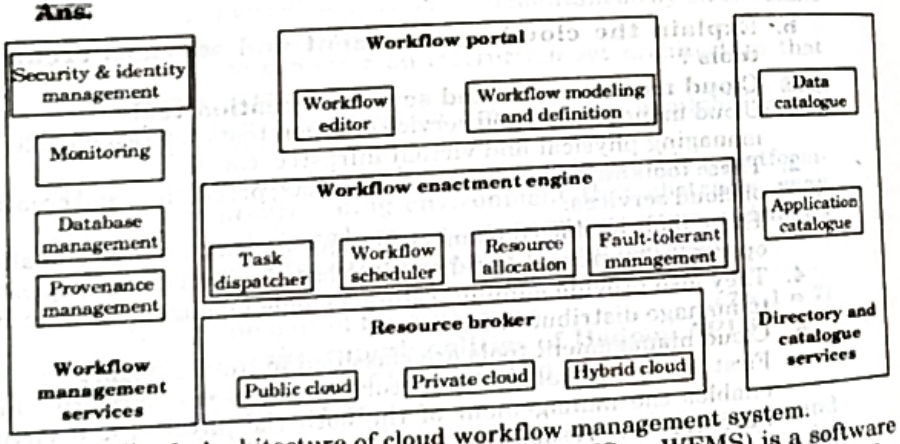


Fig. 1. Architecture of cloud workflow management system.

1. A workflow management system (WMS or WFMS) is a software tool designed to help streamline routine business processes for optimal efficiency.

2. Workflow management systems involve creating a form to hold data and setting a sequential path of tasks for the data to follow until it is fully processed.
3. Workflow Management Systems (WFMS) enable automated and seamless execution of workflows.
4. It allows users to define and model workflows, set their deadline and budget limitations, and the environments in which they wish to execute. The WFMS then evaluates these inputs and executes them within the defined constraints.

Components of a cloud WFMS are :

1. **Workflow portal :** The workflow portal is used to model and define abstract workflows, *i.e.*, tasks and their dependencies.
2. **Workflow enactment engine :** The workflow enactment engine takes the abstract workflows and parses them using a language parser. It also handles the fault-tolerance of the workflow. It also contains a resource allocation component which allocates resources to the tasks through the resource broker.
3. **Resource broker :** The resource broker interfaces with the infrastructure layer and provides a unified view to the enactment engine. The resource broker communicates with compute services to provide the desired resource.
4. **Directory and catalogue services :** The directory and catalogue services house information about data objects, the application and the computes resources. This information is used by the enactment engine, and the resource broker to make critical decisions.
5. **Workflow management services :**
   a. It provides important services that are essential for the working of a WFMS.
   b. Security and identify services ensure authentication and secure access to the WFMS.
   c. Monitoring tools constantly monitor vital components of the WFMS and raise alarms at appropriate times.
   d. Database management component provides a reliable storage for intermediate and final data results of the workflows.
   e. Provenance management services capture important information such as, dynamics of control flows and data and their progressions.

Importance of WFMS :

1. It converts manual processes to web-based digital workflows
2. It eliminates paper forms and manual data entry.
3. Improve the efficiency of workflows
4. Lower cost

7. Attempt any one part of the following : (7 × 1 = 7)

a. Identify NIST cloud computing reference architecture with a neat schematic diagram.

Ans. Refer Q. 3.2, Page 3–3E, Unit-3.

b. Explain the migration of memory, files and network resources in detail.

Ans. Memory migration :

1. This is one of the most important aspects of VM migration.
2. Moving the memory instance of a VM from one physical host to another can be approached in any number of ways.
3. The techniques employed for this purpose depend upon the characteristics of application/workloads supported by the guest OS.
4. Memory migration can be in a range of hundreds of megabytes to a few gigabytes in a typical system today, and it needs to be done in an efficient manner.
5. The Internet Suspend-Resume (ISR) technique exploits temporal locality as memory states are likely to have considerable overlap in the suspended and the resumed instances of a VM.
6. To exploit temporal locality, each file in the file system is represented as a tree of small sub files. A copy of this tree exists in both the suspended and resumed VM instances.

File migration :

1. To support VM migration, a system must provide each VM with a consistent, location-independent view of the file system that is available on all hosts.
2. A simple way to achieve this is to provide each VM with its own virtual disk which the file system is mapped to and transport the contents of this virtual disk along with the other states of the VM.
3. Another way is to have a global file system across all machines where a VM could be located.
4. This way removes the need to copy files from one machine to another because all files are network-accessible.
5. The actual file systems themselves are not mapped onto the distributed file system. Instead, the VMM only accesses its local file system.
6. The relevant VM files are explicitly copied into the local file system for a resume operation and taken out of the local file system for a suspend operation.

Network migration :

1. A migrating VM should maintain all open network connections without relying on forwarding mechanisms on the original host.
2. To enable remote systems to locate and communicate with a VM, each VM must be assigned a virtual IP address known to other entities.
3. This address can be distinct from the IP address of the host machine where the VM is currently located.
4. Each VM can also have its own distinct virtual MAC address.
5. The VMM maintains a mapping of the virtual IP and MAC addresses to their corresponding VMs.
6. In general, a migrating VM includes all the protocol states and carries its IP address with it.

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