Credit System Scheme

SAVITRIBAI PHULE PUNE UNIVERSITY - 2015 SYLLABUS

B.E. (COMP) Semester - II (Elective - IV)

CLOUD COMPUTING

Iresh A. Dhotre

M.E. (Information Technology)
Ex-Faculty, Sinhgad college of Engineering
Pune.

▶ Written by Popular Authors of Text Books of Technical Publications

▶ Covers Entire Syllabus

▶ Question Answer Format

▶ Exact Answers and Solutions

▶ Important Points to Remember

▶ Memory Map

SOLVED SPPU QUESTION PAPERS

- **May   - 2016** (End Sem)   • **Dec. - 2016** (End Sem)
- **April - 2017** (In Sem)   • **May   - 2017** (End Sem)
- **Oct. - 2017** (End Sem)   • **Dec. - 2017** (End Sem)
- **April - 2018** (In Sem)   • **May   - 2018** (End Sem)
- **Oct. - 2018** (End Sem)   • **April - 2019** (In Sem)
- **May   - 2019** (End Sem)   • **Dec. - 2019** (End Sem)

DECODE ®

A Guide For Engineering Students

DECODE ®

A Guide For Engineering Students

CLOUD COMPUTING

SUBJECT CODE : 410253(C)

B.E. (Computer Engineering) Semester - II (Elective - IV)

SPPU 15

SYLLABUS
CLOUD COMPUTING (410253(C))

Credits	Examination Scheme :
03	In-Sem Paper : 30 Marks
	End-Sem Paper : 70 Marks

Unit - I Basics of Cloud Computing

Overview, Applications, Intranets and the Cloud. Your Organization and Cloud Computing- Benefits, Limitations, Security Concerns. Software as a Service (SaaS)- Understanding the Multitenant Nature of SaaS Solutions, Understanding SOA. Platform as a Service (PaaS)-IT Evolution Leading to the Cloud, Benefits of Paas Solutions, Disadvantages of PaaS Solutions. Infrastructure as a Service (IaaS)-Understanding IaaS, Improving Performance through Load Balancing, System and Storage Redundancy, Utilizing Cloud-Based NAS Devices, Advantages, Server Types. Identity as a Service (IDaaS). **(Chapter - 1)**

Unit - II Data Storage and Security in Cloud

Cloud file systems: GFS and HDFS, BigTable, HBase and Dynamo Cloud data stores: Datastore and Simple DB Gautam Shrauf, Cloud Storage-Overview, Cloud Storage Providers. [Anthony T. Velte]3 Securing the Cloud- General Security Advantages of Cloud-Based Solutions, Introducing Business Continuity and Disaster Recovery. Disaster Recovery- Understanding the Threats. **(Chapter - 2)**

Unit - III Virtualization

Implementation Levels of Virtualization, Virtualization Structures/Tools and Mechanisms, Types of Hypervisors, Virtualization of CPU, Memory, and I/O Devices, Virtual Clusters and Resource Management, Virtualization for Data-Center Automation. Common Standards: The Open Cloud Consortium, Open Virtualization Format, Standards for Application Developers: Browsers (Ajax), Data (XML, JSON), Solution Stacks (LAMP and LAPP),Syndication (Atom, Atom Publishing Protocol, and RSS), Standards for Security. **(Chapter - 3)**

Unit - IV Amazon Web Services

Services offered by Amazon Hands-on Amazon, EC2 - Configuring a server, Virtual Amazon Cloud, AWS Storage and Content Delivery Identify key AWS storage options Describe Amazon EBS Creating an Elastic Block Store Volume Adding an EBS Volume to an Instance Snap shotting an EBS Volume and Increasing Performance Create an Amazon S3 bucket and manage associated objects. AWS Load Balancing Service Introduction Elastic Load Balancer Creating and Verifying Elastic Load Balancer. **(Chapter - 4)**

Unit - V Ubiquitous Clouds and the Internet of Things

Cloud Trends in Supporting Ubiquitous Computing, Performance of Distributed Systems and the Cloud, Enabling Technologies for the Internet of Things (RFID, Sensor Networks and ZigBee Technology, GPS), Innovative Applications of the Internet of Things (Smart Buildings and Smart Power Grid, Retailing and Supply-Chain Management, Cyber-Physical System), Online Social and Professional Networking. **(Chapter - 5)**

Unit - VI Future of Cloud Computing

How the Cloud Will Change Operating Systems, Location-Aware Applications, Intelligent Fabrics, Paints, and More, The Future of Cloud TV, Future of Cloud-Based Smart Devices, Faster Time to Market for Software Applications, Home-Based Cloud Computing, Mobile Cloud, Autonomic Cloud Engine, Multimedia Cloud, Energy Aware Cloud Computing, Jungle Computing. Docker at a Glance: Process Simplification, Broad Support and Adoption, Architecture, Getting the Most from Docker, The Docker Workflow. **(Chapter - 6)**

TABLE OF CONTENTS

Unit - I

Unit - II

Unit - III

Unit - IV

Unit - V

Unit - VI

Chapter - 6   Future of Cloud Computing   (6 - 1) to (6 - 25)

Memory Map

Basic of cloud computing

- Historical development
- Cloud computing reference model
- Cloud and dynamic infrastructure
- Cloud applications
- Service and deployment models

Data storage and security in cloud

- Cloud file system: GFS and HDFS
- BigTable
- HBase and dynamo
- Cloud storage
- Security

Virtualization

- Virtualization and its types
- Virtualization tools
- Virtualization of CPU, memory and I/O device
- Open cloud consortium
- Standard for application developers

Amazon web services

- Amazon services
- Elastic compute cloud
- Virtual private cloud
- Elastic block store and elastic file system
- Amazon S3
- Elastic load balancing

Ubiquitous cloud and the internet of things

- Relation between ubiquitous computing and cloud computing
- DS and cloud
- IoT and RFID
- Sensor network and zigbee
- GPS
- Social networks

Future of cloud computing

- JeOS
- Locations-aware application
- Cloud TV
- Mobil cloud
- Multimedie cloud
- Jungle computing and docker

1 Basics of Cloud Computing

Important Points to Remember

- Cloud computing is a technology that delivers many kinds of resources as services, mainly over the internet

- Cluster computing is a group of linked computers, working together closely thus in many respects forming a single computer

- SOA define as a loosely-coupled architecture designed to meet the business needs of the organization

- Five essential characteristics of Cloud Computing are on demand self-service, Broad network access, Resource pooling, Rapid Elasticity and Measured service

- NIST five essential characteristics of Cloud Computing are as On demand self-service, Broad network access, Resource pooling, Rapid Elasticity and Measured service

- SaaS provider dispose the applied software unified on their server, the user can subscribe applied software service from the manufacturer through Internet

- PaaS takes develop environment as a service to supply. This layer provides a platform for creating applications.

- Cloud enabling technologies are Broadband networks and internet architecture, Data center technology, Virtualization technology, Web technology and Multitenant technology

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

- Dynamic infrastructure platform is a system that provides computing resources, particularly servers, storage, and networking, in a way that they can be programmatically allocated and managed.

- Cloud Adoption is a strategic move by organisations of reducing cost, mitigating risk and achieving scalability of data base capabilities

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

- cloud computing reference model is an abstract model that characterizes and standardizes the functions of a cloud computing environment by partitioning it into abstraction layers and cross-layer functions

- Cloud application interoperability addresses the application components, whether they are deployed as IaaS, PaaS, or SaaS.

- Vendor lock-in is a situation in which a customer using a product or service cannot easily transition to a competitor's product or service.

- Public cloud is built over the Internet and can be accessed by any user who has paid for the service

- A private cloud is built within the domain of an intranet owned by a single organization.

1.1 Overview of Cloud Computing

Q.1 Discuss brief history of cloud computing.

Ans. : • Idea of cloud computing was introduced by computer scientist John McCarthy publicly in 1961.

- Then in 1969, Leonard Kleinrock, a chief scientist of the ARPANET project comments about Internet.

- The general public has been leveraging forms of Internet-based computer utilities since the mid-1990s through various incarnations of search engines, e-mail services, open publishing platforms and other types of social media.

- Though consumer-centric, these services popularized and validated core concepts that form the basis of modern-day cloud computing.

- The Salesforce.com provides remote service from 1990 to organization. Amazon launched its web services in 2002 and it provides services to organization for storage and remote computing.

- Cloud computing definition as per Gartner "a style of computing in which scalable and elastic IT-enabled capabilities are delivered as a service to external customers using Internet technologies".

- In 2008, Gartner's original definition of cloud was changed. In the definition, "massively scalable" was used instead of "scalable and elastic."

- **NIST definition of cloud :** Cloud computing is a pay-per-use model for enabling available, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, services) that can be rapidly provisioned and released with minimal management effort or service-provider interaction.

- The above cloud definition was published by NIST in 2009,followed by a revised version after further review and industry input that was published in September of 2011.

- Cloud computing refer to a variety of services available over the Internet that deliver compute functionality on the service provider's infrastructure.

- Its environment (infrastructure) may actually be hosted on either a grid or utility computing environment, but that doesn't matter to a service user.

Q.2 Define NIST definition of cloud computing.

Ans. : NIST definition of cloud : Cloud computing is a pay-per-use model for enabling available, convenient, on-demand network access to a shared pool of configurable computing resources (e.g.,

networks, servers, storage, applications, services) that can be rapidly provisioned and released with minimal management effort or service-provider interaction.

Q.3 Differentiate between Distributed computing and cloud computing.

Ans. : • Cloud computing is a technology that delivers many kinds of resources as services, mainly over the internet, while distributed computing is the concept of using a distributed system consisting of many self-governed nodes to solve a very large problem.

• Cloud computing is basically a sales and distribution model for various types of resources over the internet, while distributed computing can be identified as a type of computing, which uses a group of machines to work as a single unit to solve a large scale problem.

• Distributed computing achieves this by breaking the problem up to simpler tasks, and assigning these tasks to individual nodes.

Q.4 What is cloud ? Explain IT resources used in cloud computing.

Ans. : • Cloud computing refer to a variety of services available over the Internet that deliver compute functionality on the service provider's infrastructure.

• Its environment (infrastructure) may actually be hosted on either a grid or utility computing environment, but that doesn't matter to a service user.

• Cloud computing is a general term used to describe a new class of network based computing that takes place over the Internet, basically a step on from utility computing.

• In other words, this is a collection/group of integrated and networked hardware, software and internet infrastructure (called a platform).

• Fig. Q.4.1 shows cloud symbol. It denotes cloud boundary.

• Using the Internet for communication and transport provides hardware, software and networking services to clients.

- These platforms hide the complexity and details of the underlying infrastructure from users and applications by providing very simple graphical interface or API.

Fig.Q.4.1 : cloud symbol

- In addition, the platform provides on demand services that are always on anywhere, anytime and anyplace. Pay for use and as needed, elastic.

- The hardware and software services are available to the general public, enterprises, corporations and business markets.
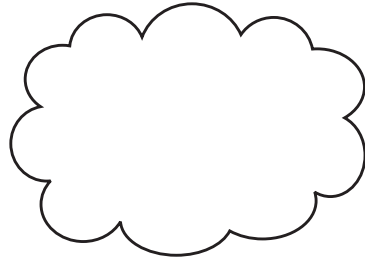
IT Resources :

- IT resources are of two types : Software based and hardware based.

- Software based resources are virtual server, custom software program and hardware based means physical server and networking devices.

- IT resources include server, virtual server, storage device, networking device, services and software programs.

- An on-premise IT resource can access and interact with a cloud-based IT resource.

- An on-premise IT resource can be moved to a cloud, thereby changing it to a cloud-based IT resource

Q.5 List the components of cloud ? Explain in details.

Ans. : • Cloud computing solutions are made up of several elements. Fig. Q.5.1 shows cloud components.

1. **Clients :** Mobile, terminals or regular computers.

2. **Benefits :** Lower hardware costs, lower IT costs, security, data security, less power consumption, ease of repair or replacement, less noise.
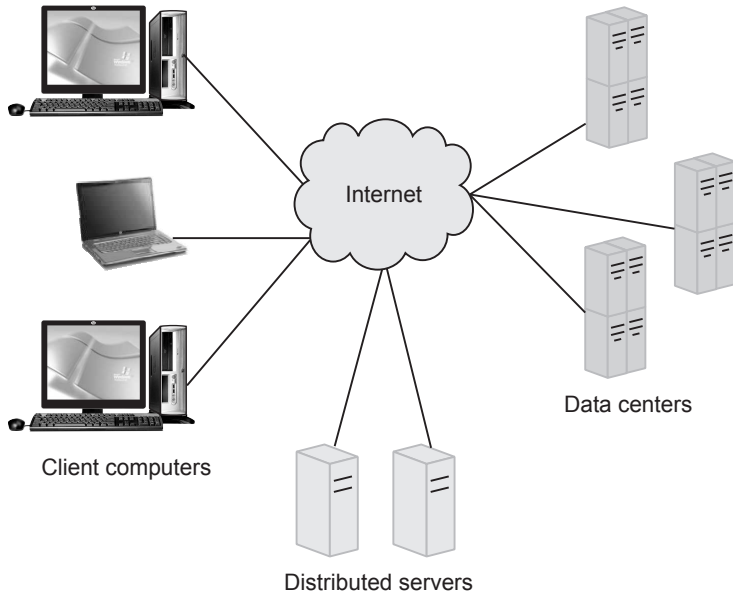
Fig. Q.5.1 : Cloud components

3. **Data centers :** Collection of servers where the application to subscribe is housed. It could be a large room in the basement of your building or a room full of servers on the other side of the world

4. **Virtualizing servers :** Software can be installed allowing multiple instances of virtual servers to be used and a dozen virtual servers can run on one physical server.

5. **Distributed servers :** Servers don't all have to be housed in the same location. It can be in geographically disparate locations. If something were to happen at one site, causing a failure, the service would still be accessed through another site. If the cloud needs more hardware, they can add them at another site.

Q.6 Explain cloud computing reference model.
☞ **[SPPU : April-18, end sem, Marks 5, Dec.-16, End Sem, Marks 4]**

Ans. : • Fig. Q.6.1 shows architectural framework of cloud computing.

Fig. Q.6.1 Architectural framework

1. **Users/Brokers :** They submit their service requests from anywhere in the world to the cloud.

2. **SLA resource allocator :** It is a kind of interface between users and cloud service provider which enable the SLA-oriented resource management.
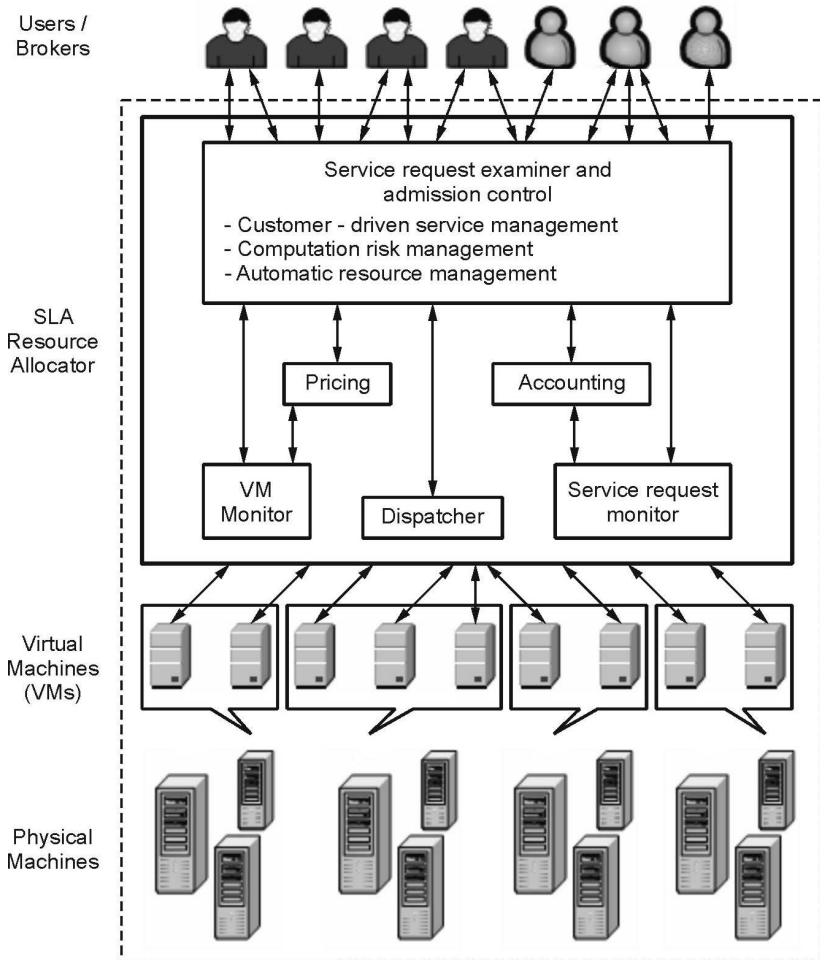
3. **Service request examiner and admission control :** It interprets the submitted request for QoS requirements before determining

whether to accept or reject the request. Based on resource availability in the cloud and other parameters decide.

4. **Pricing :** It is in charge of billing based on the resource utilization and some factors. Some factors are request time, type etc.

5. **Accounting :** Maintains the actual usage of resources by request so that the final cost can be charged to the users.

6. **VM monitor :** Keeps tracks on the availability of VMs and their resources.

7. **Dispatcher :** The dispatcher mechanism starts the execution of admitted requests on allocated VMs.

8. **Service request monitor :** The request monitor mechanism keeps track on execution of request in order to be in tune with SLA.

Q.7 Define and explain any five characteristics of cloud computing.

☞ **[SPPU : Oct-17, End Sem, Marks 5]**

OR Elaborate characteristics of cloud computing.

☞ **[SPPU : Dec-16, Marks 6, Dec.-18, end sem, Marks 4]**

Ans. : Essential characteristics of cloud computing :

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

2. **Ubiquitous network access :** Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms.

3. **Location-independent resource pooling :** The provider's computing resources are pooled to serve all consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand.

4. **Rapid elasticity :** Capabilities can be rapidly and elastically provisioned to quickly scale up, and rapidly released to quickly scale down.

5. **Pay per use :** Capabilities are charged using a metered, fee-for-service, or advertising-based billing model to promote optimization of resource use.

Q.8 Discuss the advantages and disadvantages of cloud computing.

Ans. : Advantages of cloud computing

1. **Lower computer costs :** Since applications run in the cloud, not on the desktop PC, your desktop PC does not need the processing power or hard disk space demanded by traditional desktop software.

2. **Improved performance :** Computers in a cloud computing system boot and run faster because they have fewer programs and processes loaded into memory.

3. **Reduced software costs :** Instead of purchasing expensive software applications, you can get most of what you need for free.

4. **Instant software updates :** When you access a web-based application, you get the latest version - without needing to pay for or download an upgrade.

5. **Improved document format compatibility :** You do not have to worry about the documents you create on your machine being compatible with other user's applications or operating systems.

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

7. **Increased data reliability :** Unlike desktop computing, in which if a hard disk crashes and destroy all your valuable data, a computer crashing in the cloud should not affect the storage of your data.

8. **Universal document access :** All your documents are instantly available from wherever you are.

9. **Latest version availability :** The cloud always hosts the latest version of your documents; as long as you are connected, you are not in danger of having an outdated version.

10. **Easier group collaboration :** Sharing documents leads directly to better collaboration.

11. **Device independence :** Move to a portable device and your applications and documents are still available.

Disadvantages of cloud computing

1. It requires a constant Internet connection : Cloud computing is impossible if you cannot connect to the Internet.

2. Features might be limited.

3. Stored data might not be secure : With cloud computing, all your data is stored on the cloud.

4. Does not work well with low-speed connections.

Q.9 Explain Google application using cloud.

Ans. : Google Application using Cloud

1. Gmail :

• Google provides electronic mail services to organization. It is straightforward and efficient. It provides 25 GB of storage capacity per client.

• User can filter their mails.

• A Google account gives you access to Gmail in addition to other Google services including Google Drive, Calendar, YouTube, Google+, and more.

• Spam filtering happens automatically. Gmail flags messages that it thinks are spam and places them in the Spam folder

• Gmail suggests archiving all your email instead of deleting anything.

- The search feature in Gmail is incredibly powerful. Just typing a keyword search in the search box usually gets you what you need, but there are many more advanced search options.

2. Google Docs :

- Google Docs is Google's web-based office suite. Google Docs offers free access, free online storage, and a number of collaborative features.

- It allows you to share documents for viewing and editing, and allows multiple users to collaborate simultaneously on a project over the web.

- It provides 1 GB of free storage space; you can purchase extra storage space

- Google Docs, Sheets and Slides are available as web applications for Google Chrome, Mozilla Firefox, Internet Explorer, Microsoft Edge, and Apple Safari web browsers.

3. Google Group :

- A Google Group is a user-owned group created using the Google Groups service.

- Google Groups not only allows you to manage and archive your mailing list, but also provides a method for true communication and collaboration with group members.

- Unlike other free mailing list services, Google Groups offers generous storage limits, customizable pages, and unique management options. As always, Google Groups displays only relevant text ads.

4. Google Video :

- Google Videos, part of Google's peripheral Web properties, is a great way to view multimedia content from YouTube, and other video search sites. This service was started in 2005.

- Google Videos is a simple search tool that retrieves videos from YouTube and other relevant video sites.

• If you're looking for a very simple way to find videos, Google Videos is a good choice.

1.2 : Intranets and the Cloud

Q.10 Explain the role and boundaries of following :

Ans. : a. Cloud Provider   b. Cloud Consumer

      c. Cloud Service Owner   d. Cloud Resource Administrator

a. Cloud Provider : A person, organization, or entity responsible for making a service available to interested parties. When assuming the role of cloud provider, an organization is responsible for making cloud services available to cloud consumers, as per agreed upon Service Level Agreement (SLA) guarantees. Cloud provider have their own IT resources.

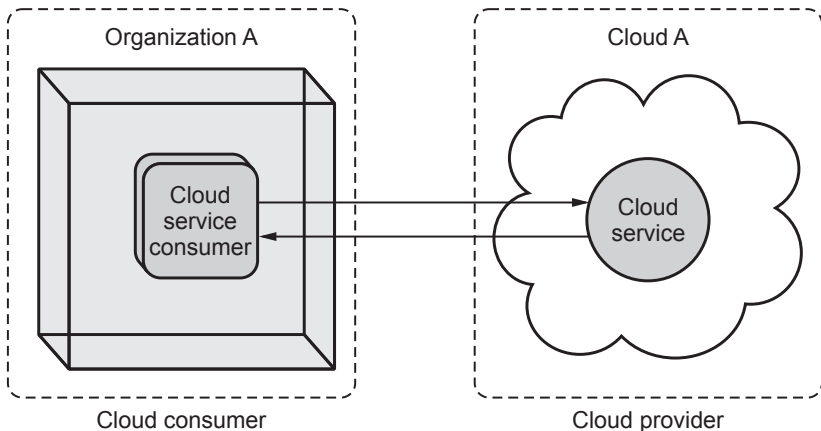**Fig.Q.10.1 Cloud service and cloud service consumer**

b. Cloud Consumer : A person or organization that maintains a business relationship with, and uses service from, Cloud Providers. The cloud consumer uses a cloud service consumer to access a cloud service.

c. Cloud Service Owner : The person or organization that legally owns a cloud service is called a cloud service owner. The cloud

service owner can be the cloud consumer, or the cloud provider that owns the cloud within which the cloud service resides.
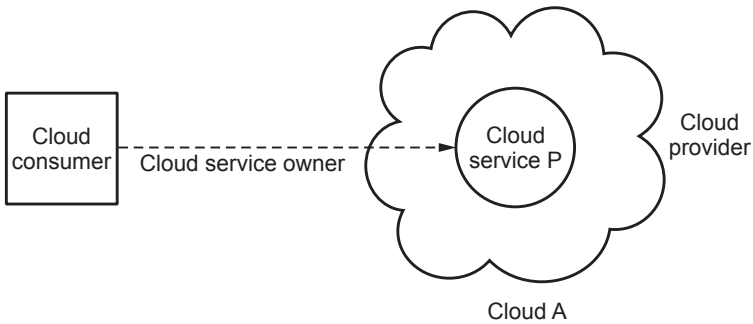
Fig. Q.10.2

4. **Resource Administrator :** Cloud resource administrator is the person or organization responsible for administering a cloud-based IT resource. The cloud consumer or cloud provider , or even third-party organization could be a cloud resource administrator.

Q.11 Explain relation between Intranet with cloud computing.

Ans. : Intranets and the Cloud

• Services in cloud computing are served via Internet. All clouds must be connected to a network. Internet's largest backbone networks, established and deployed by ISPs, are interconnected by core routers.

• Cloud consumers have the option of accessing the cloud using only private and dedicated network links in LANs, although most clouds are Internet-enabled.

• Cloud platform generally growth with Internet connectivity and service quality.

   1. Internet Service Providers (ISPs)

   2. Connectionless Packet Switching (Datagram Networks)

   3. Router-Based Interconnectivity

   4. Technical and Business Considerations

- An ISP is a company that provides its customers access to the internet and other web services. In addition to maintaining a direct line to the internet, the company usually maintains web servers.

- Almost all ISPs offer email and web browsing capabilities. They also offer varying degrees of user support, usually in the form of an email address or customer support hotline.

- Fig. Q.11.1 shows client/server computing in cloud.
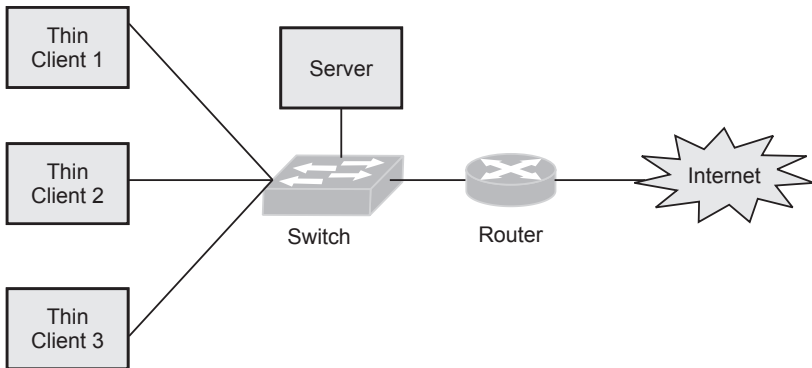
Fig. Q.11.1 Shows client / server computing in cloud

- Thin client uses application program to communicate with application server.

- The communication links and routers of the Internet and ISP networks are IT resources that are distributed among countless traffic generation paths.

- Two fundamental components used to construct the internetworking architecture are connectionless packet switching (datagram networks) and router-based interconnectivity.

- **Connectionless Packet Switching (Datagram Networks) :** Data flow between end to end is through limited size packet. It passed through network switches and routers, then queued and forwarded from one intermediary node to the next.

- Each packet carries the information, such as the Internet Protocol (IP) or Media Access Control (MAC) address, to be processed and routed at every source, intermediary, and destination node.

- A router is a networking device that is connected to multiple networks through which it forwards packets.

- Router maintains the information like network topology, source address and destination address and other information. Using this information, it forwards the packet.

- Routers also manage network traffic and select the most efficient hop for packet delivery.

- The communication path that connects a cloud consumer with its cloud provider may involve multiple ISP networks.

- The Internet's mesh structure connects Internet hosts (endpoint systems) using multiple alternative network routes that are determined at runtime.

> ## 1.3 : Cloud Delivery Models and Cloud Deployment Models

Q.12 Elaborate IaaS, Paas and SaaS. ☞ **[SPPU : Oct-17, end sem, Marks 6]**

OR Explain various service models in cloud computing.
☞ **[April-17, In sem, Marks 5, May-16, End Sem, Marks 6]**

Ans. : • It is collection of services consisting the following levels :

1. Software as a Service (SaaS)

- Model in which an application is hosted as a service to customers who access it via the internet.

- The provider does all the patching and upgrades as well as keeping the infrastructure running.

- The traditional model of software distribution, in which software is purchased for and installed on personal computers, is referred to as

Characteristics

1. Software applications or services are stored remotely.

2. A user can then access these services or software applications via the internet.

3. In most cases, a user does not have to install anything onto their host machine, all they require is a web browser to access these services and in some cases, a browser may require additional plug-in/add-on for certain services.

4. Network-based management and access to commercially available software from central locations rather than at each customer's site, enabling customers to access applications remotely via the internet.

5. Application delivery from a one-to-many model, as opposed to a traditional one-to-one model.

Benefits of SaaS

- Streamlined administration

- Automated update and patch management services

- Data compatibility

- Facilitated, enterprise-wide collaboration

- Global accessibility

- Familiarity with the WWW

- Smaller staff IT

- Customization

- Better marketing

- Web reliability

- Security secure sockets layer

- More bandwidth.

2. Platform as a Service (PaaS)

- Platform as a service is another application delivery model and also known as cloud-ware. Supplies all the resources required to build applications and services completely from the internet, without having to download or install software.

- Services include : Application design, development, testing, deployment, and hosting, team collaboration, web service integration, database integration, security, scalability, storage, state management, and versioning.

- PaaS is closely related to SaaS but delivers a platform from which to work rather than an application to work with.

3. Infrastructure as a Service (IaaS or HaaS)

- SaaS and PaaS are providing apples to customers, HaaS doesn't. It offers the hardware so that your organization can put whatever they want onto it. Rather than purchase servers, software, racks, and having to pay for the datacenter space for them, the service provider rents those resources :

  1. Server space   2. Network equipment 3. Memory
  4. CPU cycles   5. Storage space

- Examples : Amazon EC2, Rackspace Mosso, GoGrid

Q.13 What is multitenant technology ? What is role of tenants ? Explain benefit of multitenant technology.

Ans. : • A multi-tenant cloud is a cloud computing architecture that allows customers to share computing resources in a public or private cloud. Each tenant's data is isolated and remains invisible to other tenants.

- It allows multiple users to work in a software environment at the same time, each with their own separate user interface, resources and services.

- The multitenant application design was created to enable multiple users (tenants) to access the same application logic simultaneously.

- Tenants can individually customize features of the application, such as :

  1. **User Interface :** Tenants can define a specialized look for their application interface.

  2. **Business Process :** Tenants can customize the rules, logic, and workflows of the business processes that are implemented in the application.

  Open shared application and one shared database

  Fig. Q.13.1 Multi-tenant technology

  3. **Data Model :** Tenants can extend the data schema of the application to include, exclude, or rename fields in the application data structures.

  4. **Access Control :** Tenants can independently control the access rights for users and groups.

- **Benefits of a Multitenancy technology :**

  1. Costs savings : It yields tremendous economy of scale for the provider so he can offer the service at a lower cost to customers.

  2. Improved quality, user satisfaction, and customer retention: a multitenant application is one large community hosted by the provider which can gather operational information from the collective user population and make frequent, incremental improvements to the service that benefit the entire user community at once.

  3. Improved security : most current enterprise security models are perimeter-based, making them vulnerable to inside attacks

Q.14 List and explain common characteristics of multitenant applications.

Ans. : • Common characteristics of multitenant applications are as follows :

1. Usage Isolation - The usage behavior of one tenant does not affect the application availability and performance of other tenants.

2. Data Security - Tenants cannot access data that belongs to other tenants.

3. Recovery - Backup and restore procedures are separately executed for the data of each tenant.

4. Application Upgrade - Tenants are not negatively affected by the synchronous upgrading of shared software artifacts.

5. Scalability - The application can scale to accommodate increases in usage by existing tenants and/or increases in the number of tenants.

6. Metered Usage - Tenants are charged only for the application processing and features that are actually consumed.

7. Data Tier Isolation - Tenants can have individual databases, tables, and schemas isolated from other tenants.

Q.15 What is difference between multitenancy and virtualization ?

Ans. : • With multitenancy : A physical or virtual server hosting an application is designed to allow usage by multiple different users. Each user feels as though they have exclusive usage of the application.

• With virtualization : Multiple virtual copies of the server environment can be hosted by a single physical server. Each copy can be provided to different users, can be configured independently, and can contain its own operating systems and applications.

Q.16 Explain difference between IaaS, PaaS and SaaS.

Ans. : Difference between IaaS, PaaS and SaaS

IaaS	PaaS	SaaS
IaaS gives users automated and scalable environments	PaaS provides a framework for quickly developing and deploying applications	SaaS makes applications available through the internet.

Amazon Web Services, for example, offers IaaS through the Elastic Compute Cloud, or EC2	Google Cloud Platform provides another PaaS option in App Engine	SaaS applications such as Gmail, Dropbox, Salesforce, or Netflix
In Iaas, infrastructure as a service.	In Paas, platform as a service	In SaaS, software as a service
Virtual platform on which required operating environment and application deployed	Operating environment included	Operating environment largely irrelevant, fully functional application provided
IaaS is a cloud service that provides basic computing infrastructure: servers, storage, and networking resources. In other words, IaaS is a virtual data center	PaaS refers to cloud platforms that provide runtime environments for developing, testing, and managing applications	SaaS allows people to use cloud-based web applications.
Major IaaS providers include Amazon Web Services, Microsoft Azure, and Google Compute Engine.	Examples of PaaS services are Heroku and Google App Engine.	email services such as Gmail and Hotmail are examples of cloud-based SaaS services.
IaaS services are available on a pay-for-what-you-use model	PaaS solutions are available with a pay-as-you-go pricing model.	SaaS services are usually available with a pay-as-you-go pricing model
Used by IT administrator	Used by software developers	Used by end user

1.4 : System and Storage Redundancy

Q.17 Write short note on SAN and NAS.

☞ **[SPPU : Oct-17, End Sem, Marks 5]**

Ans. : • Networked storage devices usually fall into one of the following categories :

1. Storage Area Network (SAN) :

- Physical data storage media are connected through a dedicated network and provide block-level data storage access using industry standard protocols, such as the Small Computer System Interface (SCSI).

- The purpose of the SAN is to allow multiple servers access to a pool of storage in which any server can potentially access any storage unit.

- SAN is a network designed to transfer data from servers to targets, and it is alternative to directly attached target architecture, or to a DAS architecture, where the storage is connected to the servers on general purpose networks.

- SAN consists of a communication infrastructure, which provides physical connections; and a management layer, which organizes the connections, storage elements, and computer systems so that data transfer is secure and robust.

- SAN consists of three main components : Servers, network infrastructure and storage.

2. Network-Attached Storage (NAS)

- Hard drive arrays are contained and managed by this dedicated device, which connects through a network and facilitates access to data using file-centric data access protocols like the Network File System (NFS) or Server Message Block (SMB).

- NAS is storage that sits on the ordinary network and is accessible by devices attached to that LAN. NAS devices provide access to file systems and as such are effectively file server appliances.

- NAS allows more hard disk storage space to be added to a network that already utilizes servers without shutting them down for maintenance and upgrades.

- NAS device does not need to be located within the server but can exist anywhere in a LAN and can be made up of multiple networked NAS devices.

- NAS systems usually contain one or more hard disks, often arranged into logical, redundant storage containers or RAID arrays.

Q.18 Differentiate between SAN and NAS.

☞ **[SPPU : May-16, End Sem, Marks 4]**

Ans. : Difference between NAS and SAN

NAS	SAN
Machine connected with LAN may utilize NFS, CIFS or HTTP protocol to connect to a NAS	Server class devices that are equipped with SCSI and Fibre Channel adapters connect to a SAN.
File system is managed by the NAS head unit	The SAN servers manage the file system
Backups and mirrors are generated on files, not blocks	Backups and mirrors require a block by block copy operation.
A NAS identifies the data by file name and byte offset, transfers file data or metadata	SAN addresses the data by logical block numbers, and transfers the data in disk blocks.
NAS uses TCP/IP Networks	SAN uses Fibre Channel

Q.19 Explain role of VSAN in cloud storage and its benefits.

☞ **[SPPU : April-18, End Sem, Marks 5]**

Ans. : • A Virtual Storage Area Network (VSAN) is a logical partition in a physical Storage Area Network (SAN).

- VSANs allow traffic to be isolated within specific portions of a storage area network so that if a problem occurs in one logical partition, it can be handled with a minimum of disruption to the rest of the network

Benefits :

1. Simple Storage Management

2. Self-Tuning Storage and Dynamic Load Balancing

3. Resiliency Against Multiple Hardware Failures

4. Integrated data services

1.5 Identity as a Service

Q.20 Explain Identity as a Service in cloud computing. List its advantages.

Ans. : Identity as a Service (IDaaS)

- Identity as a Service (IDaaS) is cloud-based authentication operated by a third-party provider.

- Identity as a service (IDaaS) are SaaS-based identity and access management (IAM) offerings that allow organizations to use single sign-on (SSO using SAML or OIDC), authentication and access controls to provide secure access to their growing number of software and SaaS applications.

- Five key capabilities are required to make enterprise IDaaS solutions possible:

  1. **Single Sign-on (SSO) :** With single sign-on employees, partners and customers obtain easy, fast and secure access to all SaaS, mobile and enterprise applications with a single authentication using corporate credentials.

  2. **Multi-factor Authentication (MFA) :** MFA typically includes adaptive authentication methods-options to step up as risk increases based on situational changes, user behavior or application sensitivity.

  3. **Access Security :** Access security is policy-based access management for applications and APIs to enhance security beyond SSO.

  4. **Directory :** While most enterprises prefer to integrate IDaaS with their existing user stores, they may use a cloud directory, especially to support customers and/or partners.

  5. **Provisioning :** Through SCIM support and integration with on-premises provisioning, user data is synced with web and enterprise applications.

- IDaaS supplies cloud-based authentication or identity management to enterprises who subscribe. The goal is to ensure users are who they claim to be, and to give them the right kinds of access to software applications, files, or other resources at the

right times. If the infrastructure to make this happen is built on site, then the company has to figure out what to do every time a problem comes up.

Advantages of IDaaS :

1. Deliver access services efficiently and cost-effectively.

2. Protect against internal and external security threats

3. With IDaaS, costs drop to the subscription fee and the administration work

4. Your team has to keep up servers; purchase, upgrade, and install software; back up data regularly; pay hosting fees

1.6 : Cloud Computing Challenges

Q.21 List and explain primary challenges in cloud computing.
☞ **[SPPU : May-17, End Sem, Marks 5]**

Ans. : 1. Increased Security Vulnerabilities

2. Reduced Operational Governance Control

3. Limited Portability Between Cloud Providers

4. Multi-Regional Compliance and Legal Issues

• Use of cloud for business purpose means that the responsibility over data security becomes shared with the cloud provider. Organization extends their trust boundary to cloud consumer to external cloud.

• It is clear that the security issue has played the most important role in hindering cloud computing acceptance.

• Without doubt, putting your data, running your software on someone else's hard disk using someone else's CPU appears daunting to many.

• Well-known security issues such as data loss, phishing, pose serious threats to organization's data and software.

1.7 : Understanding SOA

Q.22 What do you understand by Service Oriented Architecture (SOA). How it support cloud computing ? Explain.

Ans. : • SOA define as a loosely-coupled architecture designed to meet the business needs of the organization.

• A service-oriented architecture is essentially a collection of services. These services communicate with each other. The communication can involve either simple data passing or it could involve two or more services coordinating some activity. Some means of connecting services to each other is needed.

• Fig. Q.22.1 shows a basic service-oriented architecture. It shows a service consumer at the right sending a service request message to a service provider at the left.
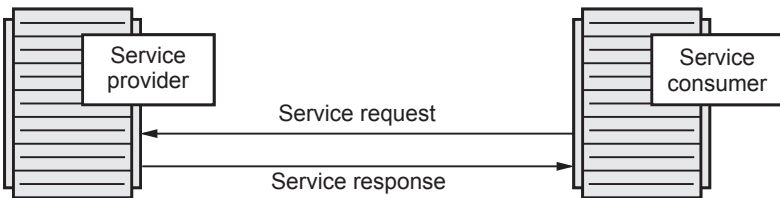
Fig. Q.22.1

• The service provider returns a response message to the service consumer. The request and subsequent response connections are defined in some way that is understandable to both the service consumer and service provider. A service provider can also be a service consumer

• Web services currently provide the main enabling technique for Service Oriented Architecture. The Web Service technique can function both as a middleware and a modeling and management tool for composed business processes.

• Web-based applications that dynamically interact with other Web applications using open standards that include XML, UDDI and SOAP.

- SOA and cloud computing are complementary activities, and both will play important roles in IT planning for senior leadership teams for years to come.

- Cloud computing and SOA can be pursued independently, or concurrently, where cloud computing platform and storage service offerings can provide a value-added underpinning for SOA efforts

Q.23 Explain key characteristics of SOA.

Ans. : Service-oriented architectures have the following key characteristics :

1. SOA services have self-describing interfaces in platform-independent XML documents. Web Services Description Language (WSDL) is the standard used to describe the services.

2. SOA services communicate with messages formally defined via XML schema. Communication among consumers and providers or services typically happens in heterogeneous environments, with little or no knowledge about the provider. Messages between services can be viewed as key business documents processed in an enterprise.

3. SOA services are maintained in the enterprise by a registry that acts as a directory listing. Applications can look up the services in the registry and invoke the service. Universal Description, Definition, and Integration is the standard used for service registry.

4. Each SOA service has a Quality of Service (QoS) associated with it. Some of the key QoS elements are security requirements, such as authentication and authorization, reliable messaging, and policies regarding who can invoke services.

5. Quality of service, security and performance are specified.

6. Software infrastructure is responsible for managing.

7. Services are cataloged and discoverable.

8. Data are cataloged and discoverable.

9. Protocols use only industry standards.

Q.24 Explain various SOA actors.

Ans. : Service Consumer

- Uses service providers to complete business processes.

- The service consumer is an application, service, or some other type of software module that requires a service.

- It is the entity that initiates the locating of the service in the registry, binding to the service over a transport, and executing the service function.

- The service consumer executes the service by sending it a request formatted according to the contract.

Service Provider

- Provides a stateless, location transparent business service.

- The service provider is the service, the network-addressable entity that accepts and executes requests from consumers. It can be a mainframe system, a component, or some other type of software system that executes the service request.

- The service provider publishes its contract in the registry for access by service consumers.

Service Registry

- Allows service consumers to locate service providers that meet required criteria.

- A service registry is a network-based directory that contains available services.

- It is an entity that accepts and stores contracts from service providers and provides those contracts to interested service consumers.

Service Contract

- A contract is a specification of the way a consumer of a service will interact with the provider of the service. It specifies the format of the request and response from the service.

- A service contract may require a set of preconditions and post-conditions.

- The preconditions and post-conditions specify the state that the service must be in to execute a particular function.

- The contract may also specify Quality of Service (QoS) levels. QoS levels are specifications for the nonfunctional aspects of the service. For instance, a quality of service attribute is the amount of time it takes to execute a service method.

END... ✍

2

Data Storage and Security in Cloud

Important Points to Remember

- Cloud computing ecosystem are business process, application services, platform services and Infrastructure services.

- Cloud analytics can refer to any data analytics or business intelligence process that is carried out in collaboration with a cloud service provider.

- Virtual Desktop Infrastructure is a term that refers to using a virtualized desktop that is hosted on a Virtual machine that lives on a server.

- Cloud provisioning is the allocation of a cloud provider's resources and services to a customer.

- MapReduce is a programming model that simultaneously processes and analyzes huge datasets logically into separate clusters.

- Disaster Recovery Plan is a plan designed to recover all the vital business processes during a disaster within a limited amount of time. This plan has all the procedures required to handle the emergency situations.

- RPO is the amount of time that passes that's "acceptable" to you during an emergency situation.

- RTO is the amount of time it takes you to restore regular business processes after a natural disaster or emergency situation.

- Cloud computing security consists of a set of policies, controls, procedures and technologies that work together to protect cloud-based systems, data and infrastructure.

- The data confidentiality, authentication, and access control issues in cloud computing could be addressed by increasing the cloud reliability and trustworthiness.
- Data integrity in the cloud system means preserving information integrity. The data should not be lost or modified by unauthorized users.
- Cloud Security Services are Authentication, Authorization, Auditing and Accountability.
- Cloud security design principles are Least Privilege , Separation of Duties, Defense in Depth, fail Safe, Economy of Mechanism and Complete Mediation.
- Cloud security is a shared responsibility of the cloud provider and customer.
- A multi-tenant cloud is a cloud computing architecture that allows customers to share computing resources in a public or private cloud.

2.1 : Cloud File Systems : GFS and HDFS

Q.1 How does cloud file system differ from normal file system ?
☞ **[SPPU : April-17, In Sem, Marks 5]**

Ans. : • Cloud file system that allows many clients to have access to data and supports operations (create, delete, modify, read, write) on that data. Each data file may be partitioned into several parts called chunks.

- Cloud file storage is a method for storing data in the cloud that provides servers and applications access to data through shared file systems. This compatibility makes cloud file storage ideal for workloads that rely on shared file systems and provides simple integration without code changes.

- A file system in the cloud is a hierarchical storage system that provides shared access to file data. Users can create, delete, modify, read, and write files and can organize them logically in directory trees for intuitive access.

Q.2 Explain benefits of cloud file system.

Ans. : Storing file data in the cloud delivers advantages in three key areas :

1. **Scalability :** Although not every cloud file storage solution can scale, leveraging all the capabilities of the cloud, the most advanced solutions provide the ability to start with the capacity and performance you need today and grow your capacity as needed. No more over provisioning to try and anticipate future needs.

2. **Interoperability :** Many existing applications require integration with shared file services that follow existing file system semantics. Cloud file storage solutions offer a distinct advantage as there is no new code to write to have secure, shared file access.

3. **Budget and Resources :** Operating file services on-premises requires budget for hardware, ongoing maintenance, power, cooling, and physical space. Cloud file storage enables organizations to redeploy technical resources to other projects that bring more value to the business.

Q.3 Write short note on Google file system.
☞ **[SPPU : May-17, End Sem, Marks 5]**

Ans. : • Google File System (GFS) is a proprietary distributed file system developed by Google to provide efficient, reliable access to data using large clusters of commodity hardware.

• GFS provides fault tolerance, reliability, scalability, availability and performance to large networks and connected nodes.

• GFS is made up of several storage systems built from low-cost commodity hardware components. It is optimized to accommodate Google's different data use and storage needs, such as its search engine, which generates huge amounts of data that must be stored.

• Google file system is "a scalable distributed file system for large distributed data-intensive applications" created by Google.

Initially used to store Google's search indexes and the crawling data, GFS is now mostly used to store user generated content.

- GFS was built primarily as the fundamental storage service for Google's search engine.

- GFS typically will hold a large number of huge files, each 100 MB or larger, with files that are multiple GB in size quite common. Thus, Google has chosen its file data block size to be 64 MB instead of the 4 KB in typical traditional file systems. The I/O pattern in the Google application is also special.

- Files are typically written once, and the write operations are often the appending data blocks to the end of files. Multiple appending operations might be concurrent. There will be a lot of large streaming reads and only a little random access.

- There is no data cache in GFS as large streaming reads and writes represent neither time nor space locality

Motivation behind GFS

- Fault tolerance and auto-recovery need to be built into the systems i.e. monitoring, error detection, fault tolerance, automatic recovery. Because problems are very often caused by application bugs, OS bugs, human errors, and the failure of disks, memory, connectors, networking, and power supplies.

- Standard I/O assumptions (e.g. block size) have to be re-examined.

- Record appends are the frequent form of writing and Google applications and GFS should be co-designed.

Q.4 Draw and explain architecture of Google file system.

Ans. : A GFS cluster consists of a single master and multiple chunk servers and is accessed by multiple clients.

Basic terms :

a. **Master :** Single, coordinates system-wide activities. Can have read-only 'Shadow' servers.

b. **Chunk :** 64 MB storage block representing a file or piece thereof.

c. **Chunkserver :** Many, stores chunks of data.

d. **Replica :** Either primary or secondary. A Chunkserver that replicates a given block.

e. **Client :** Runs tasks on data.

- It is easy to run both a chunkserver and a client on the same machine, as long as machine resources permit.

- Files are divided into fixed-size chunks. Each chunk is identified by an immutable and globally unique 64 bit chunk handle assigned by the master at the time of chunk creation.

- Chunkservers store chunks on local disks as Linux files and read or write chunk data specified by a chunk handle and byte range. For reliability, each chunk is replicated on multiple chunkservers.

- The master maintains all file system metadata. This includes the namespace, access control information, the mapping from files to chunks, and the current locations of chunks.

- Clients interact with the master for metadata operations, but all data-bearing communication goes directly to the chunkservers.

- Neither the client nor the chunkserver caches file data. Fig. Q.4.1 shows GFS architecture.
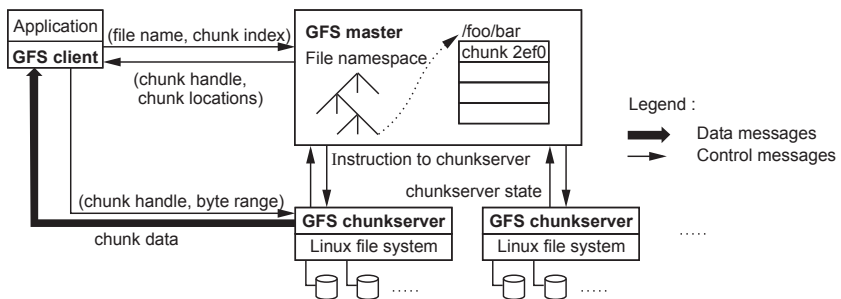

Fig. Q.4.1 GFS architecture

- Clients never read and write file data through the master. Instead, a client asks the master which chunkservers it should contact. It caches this information for a limited time and interacts with the chunkservers directly for many subsequent operations.

- First, using the fixed chunk size, the client translates the file name and byte offset specified by the application into a chunk index within the file. Then, it sends the master a request containing the file name and chunk index.

- The master replies with the corresponding chunk handle and locations of the replicas. The client caches this information using the file name and chunk index as the key. The client then sends a request to one of the replicas, most likely the closest one.

- The request specifies the chunk handle and a byte range within that chunk.

- Further reads of the same chunk require no more client-master interaction until the cached information expires or the file is reopened.

- In fact, the client typically asks for multiple chunks in the same request and the master can also include the information for chunks immediately following those requested. This extra information sidesteps several future client-master interactions at practically no extra cost

Q.5 Explain data mutation sequence in Google file system.

Ans. : Data Mutation Sequence in GFS : Here we discuss Write Control and Data Flow (data mutation) sequence of GFS.

- Fig. Q.5.1 shows process of control flow of a write through.

- The client asks the master which chunk server holds the current lease for the chunk and the locations of the other replicas. If no one has a lease, the master grants one to a replica it chooses.

- The master replies with the identity of the primary and the locations of the other (secondary) replicas. The client caches this data for future mutations. It needs to contact the master again
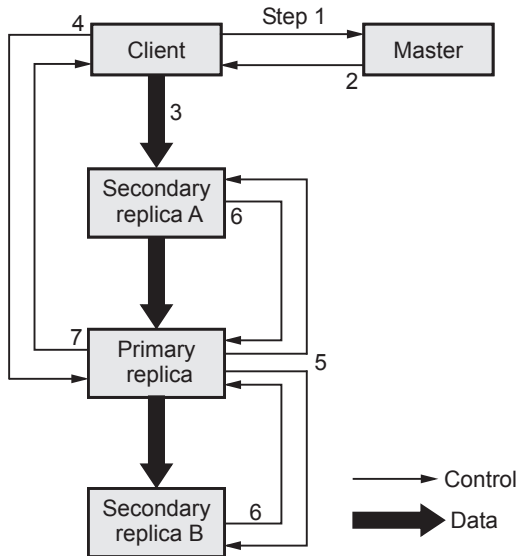
Fig. Q.5.1 Process of control flow of a write through

only when the primary becomes unreachable or replies that it no longer holds a lease.

- The client pushes the data to all the replicas. A client can do so in any order. Each chunk server will store the data in an internal LRU buffer cache until the data is used or aged out.

- Once all the replicas have acknowledged receiving the data, the client sends a write request to the primary.

- The primary forwards the write request to all secondary replicas. Each secondary replica applies mutations in the same serial number order assigned by the primary.

- The secondary's all reply to the primary indicating that they have completed the operation.

- The primary replies to the client. Any errors encountered at any of the replicas are reported to the client.

Q.6 Explain HDFS in details. ☞ **[SPPU : April-18, End Sem, Marks 5]**

OR Elaborate HDFS architecture in detail.
☞ **[SPPU : May-16, End Sem, Marks 6]**

Ans. : • Hadoop Distributed File System (HDFS) is a distributed file system inspired by GFS that organizes files and stores their data on a distributed computing system.

• The Hadoop core is divided into two fundamental layers : the MapReduce engine and HDFS.

• The MapReduce engine is the computation engine running on top of HDFS as its data storage manager.

• Hadoop is an open-source software framework that supports data-intensive distributed applications, licensed under the Apache v2 license. It provide software framework for distributed processing of large datasets in real-time applications.

• Hadoop provides the basic platform for big data processing. The hadoop architecture have mainly two parts: Hadoop distributed File System (HDFS) and the MapReduce engine.

• HDFS is Distributed Files system designed to run on commodity hardware, which is highly fault - tolerant and scalable. Fig. Q.6.1 shows HDFS architecture.
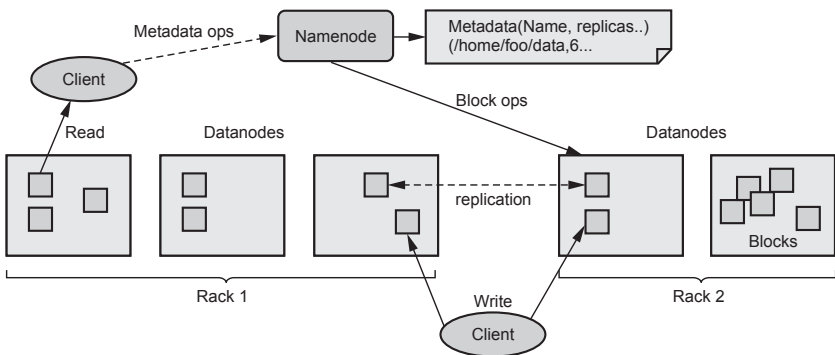

Fig. Q.6.1 Hadoop architecture

- Hadoop Distributed File System is a block-structured file system where each file is divided into blocks of a pre-determined size. These blocks are stored across a cluster of one or several machines.

- Apache Hadoop HDFS Architecture follows a Master/Slave Architecture, where a cluster comprises of a single NameNode (Master node) and all the other nodes are DataNodes (Slave nodes).

- To store a file in this architecture, HDFS splits the file into fixed-size blocks (e.g., 64 MB) and stores them on workers (DataNodes).

- HDFS can be deployed on a broad spectrum of machines that support Java. Though one can run several DataNodes on a single machine, but in the practical world, these DataNodes are spread across various machines.

- NameNode is the master node in the Hadoop HDFS Architecture that maintains and manages the blocks present on the DataNodes (slave nodes).

- NameNode is a very highly available server that manages the File System Namespace and controls access to files by clients.

- DataNodes are the slave nodes in HDFS. Unlike NameNode, DataNode is a commodity hardware, that is, a non-expensive system which is not of high quality or high-availability. The DataNode is a block server that stores the data in the local file ext3 or ext4.

- Journal is the modification log of image, which is available in local hosts native file system. Journal is updated for every client transaction.

- Checkpoint is persistent record of the image, which is also stored on local hosts native file system to enable recovery. NameNode is not allowed to update or modify Checkpoint file.

- Administrator or Checkpoint Node can demand to create new checkpoint file on startup, or restart.

Q.7 Explain block placement in Hadoop.

Ans. : • For a large cluster, it may not be practical to connect all nodes in a flat topology. A common practice is to spread the nodes across multiple racks.

- Nodes of a rack share a switch, and rack switches are connected by one or more core switches. Communication between two nodes in different racks has to go through multiple switches.

- In most cases, network bandwidth between nodes in the same rack is greater than network bandwidth between nodes in different racks.

- Fig. Q.7.1 shows cluster with two racks, each of which contains three nodes.
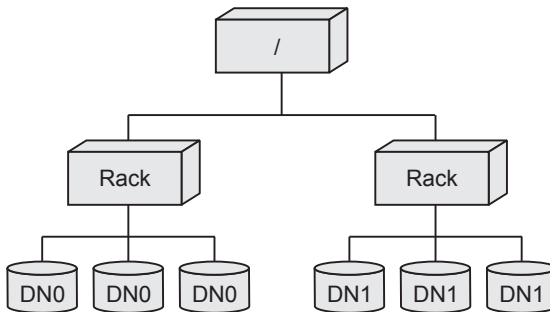
Fig. Q.7.1 Block placement

- HDFS estimates the network bandwidth between two nodes by their distance. The distance from a node to its parent node is assumed to be one.

- A distance between two nodes can be calculated by summing the distances to their closest common ancestor. A shorter distance between two nodes means greater bandwidth they can use to transfer data.

- HDFS allows an administrator to configure a script that returns a node's rack identification given a node's address.

- The NameNode is the central place that resolves the rack location of each DataNode. When a DataNode registers with the NameNode, the NameNode runs the configured script to decide which rack the node belongs to.

- If no such a script is configured, the NameNode assumes that all the nodes belong to a default single rack.

- The default HDFS block placement policy provides a tradeoff between minimizing the write cost, and maximizing data reliability, availability and aggregate read bandwidth.

- When a new block is created, HDFS places the first replica on the node where the writer is located. The second and the third replicas are placed on two different nodes in a different rack.

- The rest are placed on random nodes with restrictions that no more than one replica is placed at any one node and no more than two replicas are placed in the same rack, if possible.

- The choice to place the second and third replicas on a different rack better distributes the block replicas for a single file across the cluster. If the first two replicas were placed on the same rack, for any file, two-thirds of its block replicas would be on the same rack.

- After all target nodes are selected, nodes are organized as a pipeline in the order of their proximity to the first replica. Data are pushed to nodes in this order.

- For reading, the NameNode first checks if the client's host is located in the cluster. If yes, block locations are returned to the client in the order of its closeness to the reader. The block is read from DataNodes in this preference order.

Q.8 Define MapReduce ? List the characteristics of MapReduce ?

Ans. : MapReduce is a programming model and software framework first developed by Google. Intended to facilitate and simplify the processing of vast amounts of data in parallel on large clusters of commodity hardware in a reliable, fault-tolerant manner.

Characteristics of MapReduce :

1. Very large scale data: peta, exa bytes.

2. Write once and read many data. It allows for parallelism without mutexes.

3. Map and Reduce are the main operations: simple code.

4. All the map should be completed before reduce operation starts.

5. Map and reduce operations are typically performed by the same physical processor.

6. Number of map tasks and reduce tasks are configurable.

7. Operations are provisioned near the data.

8. Commodity hardware and storage.

Q.9 What are the limitations of Hadoop/MapReduce ?

Ans. : limitation of Hadoop/MapReduce

1. Cannot control the order in which the maps or reductions are run.

2. For maximum parallelism, you need Maps and Reduces do not depend on data generated in the same MapReduce job.

3. A database with an index will always be faster than a MapReduce job on unindexed data.

4. Reduce operations do not take place until all Maps are complete

5. General assumption that the output of Reduce is smaller than the input to Map; large data source used to generate smaller final values.

Q.10 Example with suitable example map reduce model.

Ans. : • Hadoop MapReduce is a software framework for easily writing applications which process vast amounts of data in-parallel on large clusters of commodity hardware in a reliable, fault-tolerant manner.

• A MapReduce job usually splits the input data-set into independent chunks which are processed by the map tasks in a completely parallel manner.

- The framework sorts the outputs of the maps, which are then input to the reduce tasks. Typically both the input and the output of the job are stored in a file-system.

- The framework takes care of scheduling tasks, monitoring them and re-executes the failed tasks.
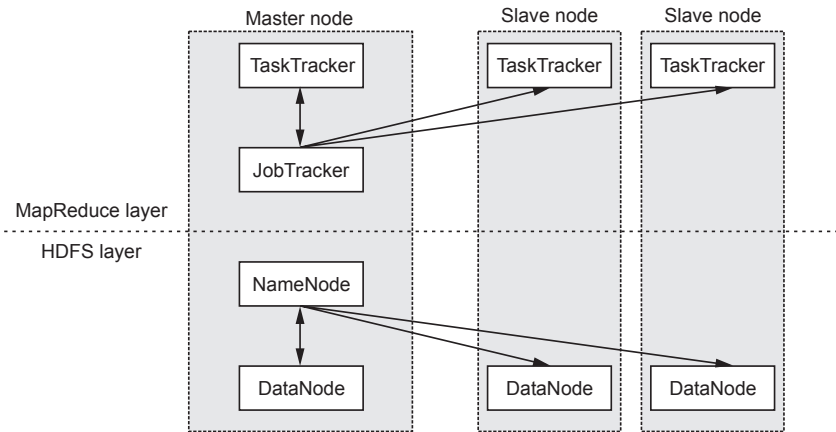
Fig. Q.10.1

- With HDFS, we are able to distribute the data so that data is stored on hundreds of nodes instead of a single large machine.

- Mapreduce provides the framework for highly parallel processing of data across clusters of commodity hardware. Fig. Q.10.1 shows MapReduce data processing.

- JobTracker splits up data into smaller tasks("Map") and sends it to the TaskTracker process in each node.

- TaskTracker reports back to the JobTracker node and reports on job progress, sends data ("Reduce") or requests new jobs.

- The execution of a MapReduce job begins when the client submits the job configuration to the Job Tracker that specifies the map, combine and reduce functions along with the location for input and output data.

- On receiving the job configuration, the job tracker identifies the number of splits based on the input path and select Task Trackers based on their network vicinity to the data sources. Job Tracker sends a request to the selected Task Trackers.

- The processing of the Map phase begins where the Task Tracker extracts the input data from the splits.

- Map function is invoked for each record parsed by the "InputFormat" which produces key-value pairs in the memory buffer.

- The memory buffer is then sorted to different reducer nodes by invoking the combine function. On completion of the map task, Task Tracker notifies the Job Tracker.

- When all Task Trackers are done, the Job Tracker notifies the selected Task Trackers to begin the reduce phase. Task Tracker reads the region files and sorts the key-value pairs for each key.

- The reduce function is then invoked which collects the aggregated values into the output file.

2.2 : Big Table

Q.11 What is BigTable ? Explain its features.

Ans. : • Bigtable is a distributed storage system that is used for managing and storing structured data at Google.

- Bigtable is designed to reliably scale to petabytes of data and thousands of machine. Bigtable has multiple goals like applicability, high availability, scalability, high performance.

- It is used by approximate sixty Google project or product like Google Analytic, Google Finance, Personalized search, Writely and Google Earth.

- Bigtable is built on Google file system for storing the data for scheduling large scale data processing. It stored data in form of

rows, columns and timestamp that means it maps with arbitrary string value like row key and column key as well as timestamp.

- It uses MapReduce. Bigtable maintains data in alphabetical order by row key. The row keys in a table are arbitrary strings

- Rows are the unit of transactional consistency. Several rows are grouped in tablets which are distributed and stored close to each other. Reads of short row ranges are efficient, typically require communication with only one or a few machines.

Features :

1. Bigtable is a distributed storage system for managing structured data.

2. Bigtable uses the distributed Google File System (GFS) to store log and data files.

3. A Bigtable cluster stores a number of tables. Each table consists of a set of tablets, and each tablet contains all data associated with a row range.

4. Bigtable use a highly available and persistent distributed lock services called Chubby

5. Bigtable supports single-row transactions.

Q.12 Explain row key, column key and timestamp with respect to Bigtable.

Ans. : • The map is indexed by a row key, column key and a timestamp; each value in the map is an un-interpreted array of bytes.

1. Row Key :

- The row keys in a table are arbitrary strings. Every read or write of data under a single row key is atomic.

- Bigtable maintains data in lexicographic order by row key . The row range for a table is dynamically partitioned.

- Each row range is called a tablet, which is the unit of distribution and load balancing.

2. Column key :

- Column keys are grouped into sets called column families, which form the basic unit of access control. All data stored in a column family is usually of the same type.

- A column family must be created before data can be stored under any column key in that family; after a family has been created, any column key within the family can be used.

- Syntax of column key is **family : qualifier**.

- Column family names must be print-able, but qualifiers may be arbitrary strings. An example column family for the Webtable is language, which stores the language in which a web page was written.

- The qualifier is the name of the referring site; the cell contents is the link text.

- Access control and both disk and memory account-ing are performed at the column-family level.

3. Timestamp

- For each column, bigtables use timestamp (64-bit integer) to track update of data cell. For sequential data, when new data wrote in, it adds an additional layer of data with new timestamp.

- Data structure can be viewed as 3D with third dimension. Timestamp is also convenient for defining garbage-collect which means certain data or only last versions of data will be kept.

Q.13 Explain Google big table in detail.

☞ **[SPPU : April-18, End Sem, Marks 5]**

Ans. : • **SSTable** is a file format to stored persistent, ordered immutable map from key to values. It contains block index and can be applied binary search to locate certain block. Client loaded SSTable loaded into memory.

- Fig. Q.13.1 shows Bigtable architecture.
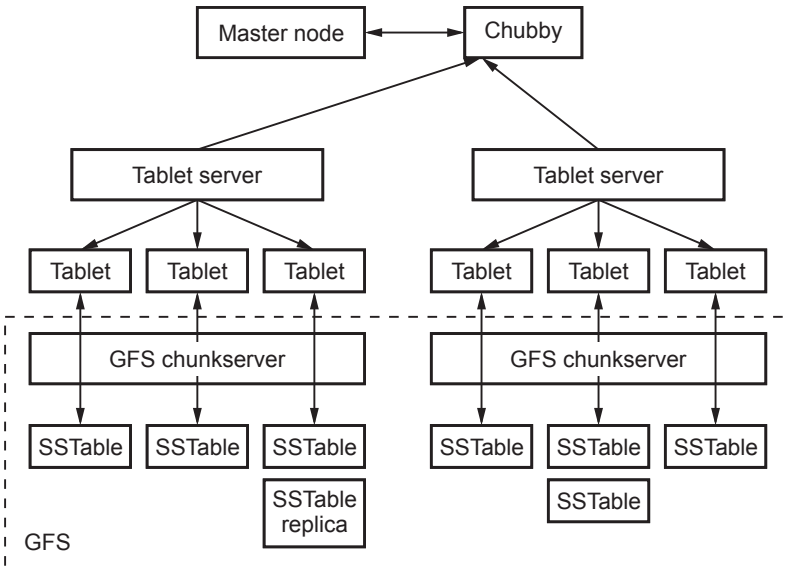
Fig. Q.13.1 Bigtable architecture

- Master node : The master is responsible for assigning tablets to tablet servers, detecting the addition and expiration of tablet servers, balancing tablet-server load, and garbage collection in GFS.

- Tablet server : Each tablet server manages a set of tablets. The tablet server handles read and write requests to the tablets that it has loaded, and also splits tablets that have grown too large.

- Bigtable uses Chubby to keep track of tablet servers. When a tablet server starts, it creates, and acquires an exclusive lock on, a uniquely named file in a specific Chubby directory.

- The master is responsible for detecting when a tablet server is no longer serving its tablets, and for reassigning those tablets as soon as possible.

- To detect when a tablet server is no longer serving its tablets, the master periodically asks each tablet server for the status of its lock.

- If a tablet server reports that it has lost its lock, or if the master was unable to reach a server during its last several attempts, the master attempts to acquire an exclusive lock on the server's .

- If the master is able to acquire the lock, then Chubby is live and the tablet server is either dead or having trouble reaching Chubby, so the master ensures that the tablet server can never serve again by deleting its server.

- Once a server's has been deleted, the master can move all the tablets that were previously assigned to that server into the set of unassigned tablets.

Q.14 Define Chubby ? What are the uses of Chubby ?

Ans. : • Bigtable relies on a highly-available and persistent distributed lock service called Chubby.

- In Bigtable, Chubby is used to :

    1. Ensure there is only one active master

    2. Store the bootstrap location of Bigtable data

    3. Discover tablet servers

    4. Store Bigtable schema information

    5. Store access control lists

- A Chubby service consists of five active replicas, one of which is elected to be the master and actively serve requests.

- The service is live when a majority of the replicas are running and can communicate with each other. Chubby uses the Paxos algorithm to keep its replicas consistent in the face of failure.

- Chubby provides a namespace that consists of directories and small files. Each directory or file can be used as a lock, and reads and writes to a file are atomic.

- The Chubby client library provides consistent caching of Chubby files. Each Chubby client maintains a session with a Chubby service.

- A client's session expires if it is unable to renew its session lease within the lease expiration time. When a client' s session expires, it loses any locks and open handles.

- Chubby clients can also register callbacks on Chubby files and directories for notification of changes or session expiration

2.3 : HBase

Q.15 Write short note on HBase.

☞ **[SPPU : May-16, End Sem, Marks 4]**

Ans. : • HBase is an open source, non-relational, distributed database modeled after Google's BigTable.

- It is a part of the Hadoop ecosystem that provides random real-time read/write access to data in the Hadoop File System.

- It runs on top of Hadoop and HDFS, providing BigTable-like capabilities for Hadoop.

- HBase supports massively parallelized processing via MapReduce for using HBase as both source and sink.

- HBase supports an easy to use Java API for programmatic access. It also supports Thrift and REST for non-Java front-ends

- Hbase is a column oriented distributed database in Hadoop environment. It can store massive amounts of data from terabytes to petabytes. Hbase is scalable, distributed big data storage on top of the Hadoop eco system.

- The HBase Physical Architecture consists of servers in a Master-Slave relationship. Typically, the HBase cluster has one Master node, called HMaster and multiple Region Servers called HRegionServer.

- Fig. Q.15.1 shows Hbase architecture.

- Zookeeper is a centralized monitoring server which maintains configuration information and provides distributed
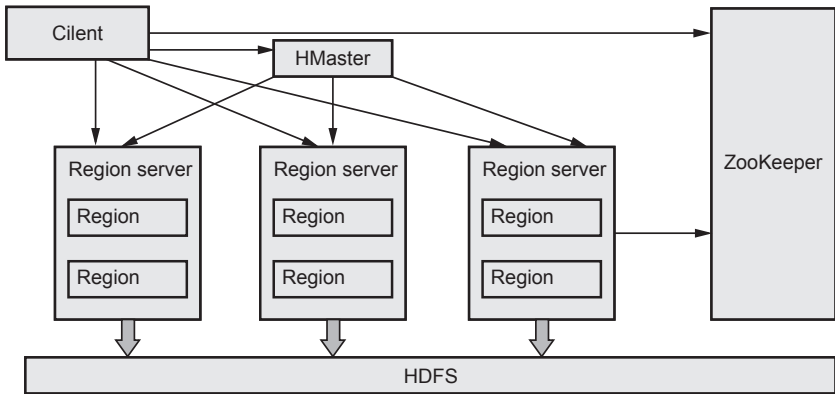
Fig. Q.15.1 Hbase architecture

synchronization. If the client wants to communicate with regions servers, client has to approach Zookeeper.

- HMaster in the master server of Hbase and it coordinates the HBase cluster. HMaster is responsible for the administrative operations of the cluster.

- **HRegions Servers :** It will perform the following functions in communication with HMaster and Zookeeper.

  1. Hosting and managing regions.

  2. Splitting regions automatically.

  3. Handling read and writes requests.

  4. Communicating with clients directly.

- **HRegions :** For each column family, HRegions maintain a store. Main components of HRegions are Memstore and Hfile

- Data Model in HBase is designed to accommodate semi-structured data that could vary in field size, data type and columns

Q.16 Explain Ecosystem of Hadoop.

Ans. : • The Hadoop ecosystem refers to the various components of the Apache Hadoop software library, as well as to the accessories and tools provided by the Apache Software Foundation for these types of software projects, and to the ways that they work together. Hadoop is a Java-based framework that is extremely popular for handling and analyzing large sets of data.

• The idea of a Hadoop ecosystem involves the use of different parts of the core Hadoop set such as MapReduce, a framework for handling vast amounts of data, and the Hadoop Distributed File System (HDFS), a sophisticated file-handling system. There is also YARN, a Hadoop resource manager.

• In addition to these core elements of Hadoop, Apache has also delivered other kinds of accessories or complementary tools for developers.

• These include Apache Hive, a data analysis tool; Apache Spark, a general engine for processing big data; Apache Pig, a data flow language; HBase, a database tool; and also Ambarl, which can be considered as a Hadoop ecosystem manager, as it helps to administer the use of these various Apache resources together.

• Fig. Q.16.1 shows Apache Hadoop ecosystem.

• **Hadoop HDFS -** Distributed storage layer for Hadoop.

• **Yarn Hadoop -** Resource management layer introduced in Hadoop 2.x.

• **Hadoop Map-Reduce -** Parallel processing layer for Hadoop.

• **HBase -** It is a column-oriented database that runs on top of HDFS. It is a NoSQL database which does not understand the structured query. For sparse data set, it suits well.

• **Hive -** Apache Hive is a data warehousing infrastructure based on Hadoop and it enables easy data summarization, using SQL queries.

- **Pig -** It is a top-level scripting language. As we use it with Hadoop. Pig enables writing complex data processing without Java programming.

Management and Monitoring (Ambari)						
Coordination (ZooKeeper)	Workflow and Scheduling (Oozie)	Scriping (Pig)	Machine Learning (Mahout)	Query (Hive)	NoSQL (HBase)	Data Integration
		Distributed Processing (MapReduce)				
		Distributed Storage (HDFS)				

Fig. Q.16.1 Apache Hadoop ecosystem

- **Oozie -** It is a Java Web application uses to schedule Apache Hadoop jobs. It combines multiple jobs sequentially into one logical unit of work.

- **Zookeeper -** A centralized service for maintaining configuration information, naming, providing distributed synchronization, and providing group services.

- **Mahout -** A library of scalable machine-learning algorithms, implemented on top of Apache Hadoop and using the MapReduce paradigm.

$$\boxed{\textbf{2.4 : Dynamo}}$$

Q.17 Write short note on : Dynamo.
☞**[SPPU : Oct-17, End Sem, Marks 5, Dec.-16, End Sem, Marks 4]**

Ans. : • Dynamo is propriety key value structured storage system.

- It can act as database and also distributed hash table.

- Dynamo dynamically partitions a set of keys over a set of storage nodes

- It is most powerful relational database available in WWW. Relational databases have been used a lot in retail sites, to make visitors browse and search for product easily.

• Fig. Q.17.1 shows dynamo architecture.
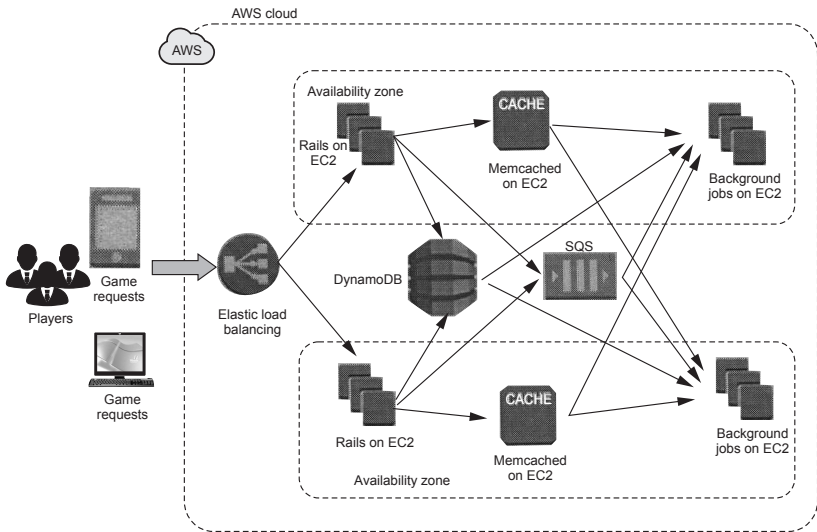
Fig. Q.17.1 Dynamo architecture

• Dynamo does not support replication.

• Dynamo is used to manage the state of services that have very high reliability requirements and need tight control over the tradeoffs between availability, consistency, cost-effectiveness and performance.

• There are many services on Amazon's platform that only need primary-key access to a data store. For many services, such as those that provide best seller lists, shopping carts, customer preferences, session management, sales rank, and product catalog, the common pattern of using a relational database would lead to inefficiencies and limit scale and availability. Dynamo provides a simple primary-key only interface to meet the requirements of these applications.

• Dynamo is a completely decentralized system with minimal need for manual administration. Storage nodes can be added and removed from Dynamo without requiring any manual partitioning or redistribution.

- Compared to Bigtable, Dynamo targets applications that require only key/value access with primary focus on high availability where updates are not rejected even in the wake of network partitions or server failures.

- Dynamo stores objects associated with a key through a simple interface; it exposes two operations : get() and put().

- Dynamo treats both the key and the object supplied by the caller as an opaque array of bytes. It applies a MD5 hash on the key to generate a 128-bit identifier, which is used to determine the storage nodes that are responsible for serving the key.

- Dynamo's partitioning scheme relies on consistent hashing to distribute the load across multiple storage hosts. In consistent hashing , the output range of a hash function is treated as a fixed circular space or "ring".

- Dynamo provides eventual consistency, which allows for updates to be propagated to all replicas asynchronously.

- Dynamo uses vector clocks in order to capture causality between different versions of the same object. A vector clock is effectively a list of (node, counter) pairs. One vector clock is associated with every version of every object.

- In Dynamo, when a client wishes to update an object, it must specify which version it is updating. This is done by passing the context it obtained from an earlier read operation, which contains the vector clock information.

- In Dynamo, each storage node has three main software components: request coordination, membership and failure detection, and a local persistence engine. All these components are implemented in Java.

2.5 : Cloud Storage and Storage Providers

Q.18 a) What do you mean cloud storage provides ? Explain different storage providers.

Ans. : • A cloud storage provider is an organization 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.

• A cloud storage provider hosts a customer's data in its own data center, providing fee-based computing, networking and storage infrastructure. Both individual and corporate customers can get unlimited storage capacity on a provider's servers at a low per-gigabyte price.

• Amazon S3 provides a simple web services interface that can be used to store and retrieve any amount of data, at any time, from anywhere on the web. It gives any developer access to the same highly scalable, reliable, fast, inexpensive data storage infrastructure that Amazon uses to run its own global network of web sites. The service aims to maximize benefits of scale and to pass those benefits on to developers.

• Amazon.com has played a vital role in the development of cloud computing. SaaS is a type of cloud computing that delivers applications through a browser to thousands of customers using a multi-user architecture. The focus for SaaS is on the end user as opposed to managed services.

• Salesforce.com is by far the best-known example of SaaS computing among enterprise applications. Salesforce.com was founded in 1999 by former Oracle executive Marc Benioff.

• Another example is Google Apps, which provides online access via a web browser to the most common office and business applications used today, all the while keeping the software and user data stored on Google servers.

Q.18 b) Explain the working of Google Data Store.
                                          ☞ **[SPPU : March-19, Marks 5]**

Ans. : • Cloud storage is a cloud computing model in which data is stored on remote servers accessed from the internet, or "cloud." It is maintained, operated and managed by a cloud storage service provider on a storage servers that are built on virtualization techniques.

• Cloud storage is part of cloud computing. All cloud storage services provide drag?and?drop accessing and syncing of folders and files between your desktop and mobile devices, and the cloud drive. They also all allow account users to collaborate with each other on documents.

• A cluster of interconnected server farms provided by the cloud storage service connects to the Internet which connects to your computer.

• Cloud storage can reduce costs, simplify IT management, improve user experience, and allow employees to work and collaborate from remote locations

• Cloud storage services may be accessed through a web service API, a cloud storage gateway or through a web-based user interface.

• Cloud storage is used in many different ways. For example : local data (such as on a desktop) can be backed up to cloud storage; a virtual disk can be "synched" to the cloud and distributed to other computers; and the cloud can be used as an archive to retain data for regulatory or other purposes.

Q.19 Explain the cloud deployment models.
                    ☞ **[SPPU : Oct-17, End Sem, Marks 4, Dec.-16, End Sem, Marks 6]**

OR Explain in detail cloud deployment models.
                              ☞ **[SPPU : April-17, In Sem, Marks 5]**

Ans. : • Deployment models (shared or dedicated, and whether internally hosted or externally hosted) are defined by the ownership and control of architectural design and the degree of available customization

• Cloud deployment models are private, public and community clouds. Fig. Q.19.1 shows these cloud models.
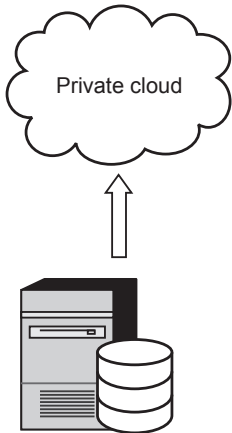

Fig. Q.19.1(a) : Private cloud   **Fig. Q.19.1(b) : Public cloud**
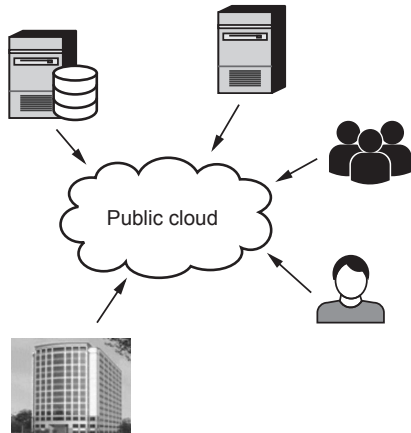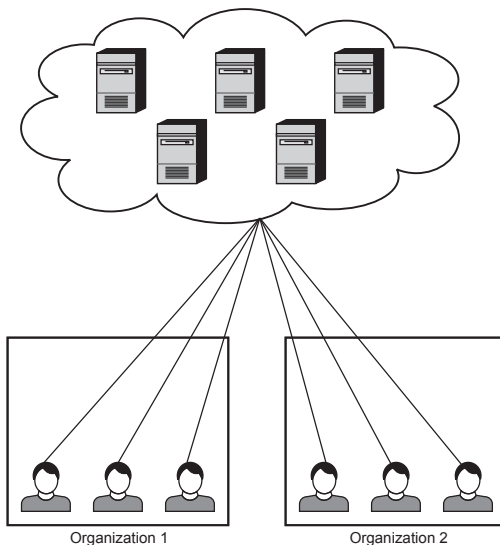
Fig. Q.19.1 (c) : Community cloud

1) **Public Cloud :** The cloud infrastructure is made available to the general public or a large industry group and is owned by an organization selling cloud services.

Public cloud benefits :

1. Low investment hurdle : Pay for what you use.

2. Good test/development environment for applications that scale to many servers.

Public cloud risks :

1. Security concerns : Multi-tenancy and transfers over the internet.

2. IT organization may react negatively to loss of control over data center function.

2) Private Cloud : The cloud infrastructure is operated solely for a single organization. It may be managed by the organization or a third party and may exist on-premises or off-premises.

Private cloud benefits :

1. Fewer security concerns as existing data center security stays in place.

2. IT organization retains control over data center.

Private cloud risks :

1. High investment hurdle in private cloud implementation, along with purchases of new hardware and software.

2. New operational processes are required; old processes not all suitable for private cloud.

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

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

Hybrid cloud benefits :

1. Operational flexibility : Run mission critical on private cloud, dev/test on public cloud.

2. Scalability : Run peak and bursty workloads on the public cloud.

Hybrid cloud risks :

1. Hybrid clouds are still being developed; not many in real use.

2. Control of security between private and public clouds, some of same concerns as in public cloud.

Q.20 Explain difference between public and private cloud.

Ans. :

Sr. No.	Public Cloud	Private Cloud
1.	Public cloud infrastructure is offered via web applications and also as web services over Internet to the public.	Private cloud infrastructure is dedicated to a single organization.
2.	Support multiple customer.	Support dedicated customer.
3.	Full utilization of infrastructure.	Does not utilize shared infrastructure.
4.	Security is low as compared to private cloud.	High level of security.
5.	Low cost.	High cost.
6.	Azure, Amazon Web Services, Google App Engine and Force.com are a few examples of public clouds.	An example of the Private Cloud is NIRIX's oneServer with dedicated servers.

2.6 : Securing the Clouds

Q.21 What is Single Sign-On (SSO) ?

Ans. : • A mechanism enabling one cloud service consumer to be authenticated by a **security broker** which establishes a security context that is persisted while the cloud service consumer accesses other cloud services or cloud-based IT resources in order for the

cloud service consumer not to **re-authenticate** itself with every subsequent request.

Implementation mechanisms

• Not a trivial job at all to propagate the authentication and authorization information for a cloud service consumer across multiple cloud services, especially with a numerous cloud services or cloud-based IT resources to be invoked as part of **the same overall runtime activity**.

• SSO (or **security broker**) mechanism to enable mutually independent cloud services and IT resources to generate and circulate **runtime authentication** and **authorization credentials (security token)** in order to allow the credentials provided by the cloud service consumer at its login time to be valid through out the duration of the same session.

• Security brokerage mechanism is especially useful when a cloud service consumer needs to access cloud services residing on different clouds.

• Not to counter security threats directly , but **to enhance** the usability of cloud-based environments for access and management of distributed IT resources and solutions without violating security policies.

Q.22 Explain cloud security threats.

Ans. : 1. Traffic eavesdropping :

• Data being passively intercepted by a malicious service agent for illegitimate information gathering purpose while being transferred to or within a cloud.

• Aim to discredit the confidentiality of data and the relationship between the cloud consumer and cloud provider.

• It is hard to detect for a long period of time because of passive nature of the attack.
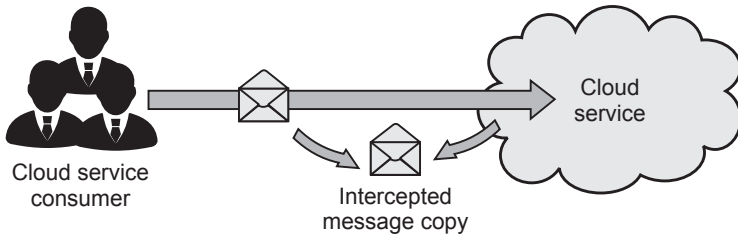
Fig. Q.22.1

2. Malicious intermediary

- Messages intercepted and altered by a malicious service agent discrediting the message's confidentiality and/or integrity

- Possible malicious contents insertion before forwarding it to its destination
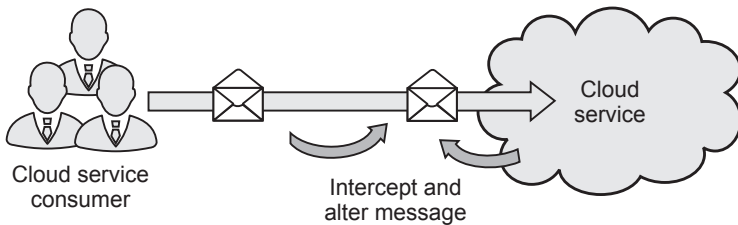
Fig. Q.22.2

3. Denial of Service (DoS)

- Intentional sabotage on shard physical IT resource by overloading it so that the IT resource can hardly be allocated to other consumers sharing the same IT resource.

- Typically intentional overloading shared IT resource by generating excessive messages, consuming full network bandwidth, or sending multiple requests that consume excessive CPU time and memory.

4. Insufficient authorization

- A case when access is granted to an attacker erroneously or too broadly, resulting in the attacker getting access to IT resources that are normally protected.

• Another case **(Weak Authentication)** when weak passwords or shared accounts are used to protect IT resources.

Fig. Q.22.3

5. Virtualization attack (Overlapping Trust Boundaries)

• Physical resources shared by multiple virtual users in virtualized environment by the nature of resource virtualization.

• Possible inherent risk that some cloud consumers could abuse their access right to attack the underlying physical IT resources.

Q.23 Explain digital identity and access management in cloud computing. ☞ **[SPPU : April-18, End Sem, Marks 8]**

Ans. : • Identity and access management (IAM) is all about the management of access of identities to data.

• IAM is a framework provided to business processes that will help with management of electric and digital identity. This framework is an equipped with required policies to manage all the digital identity.

• Major IAM functions that are essential for successful and effective management of identities in the cloud :

  1. Identity provisioning/de-provisioning
  2. Authentication and federation
  3. Authorization and user profile management
  4. Support for compliance.

• The components and policies necessary to control and track user identities and access privileges for IT resources, environments and systems.

- Comprised of **authentication, authorization, user management** and **credential management**.

Implementation mechanisms

- **Authentication :** Username and password pair : typical user authentication credentials managed by IAM. Additional mechanism : digital signature, digital certificates, biometric hardware (fingerprint leader), specialized software (voice recognition), locking user accounts to registered IP/MAC address, etc.

- **Authorization** : Access controls based on relationships between identities, access control rights and IT resource availability.

- User management : Administrative capabilities including creating new user identities & access group, resetting passwords, defining password policies and managing privileges.

- Credential management : Credential management including establishing identities and access control rules for defined user account which mitigates the threat of insufficient authorization.

Q.24 List few major challenges in securing cloud computing.

Ans. : Cloud computing security challenges fall into three broad categories :

1. Data Protection : Securing your data both at rest and in transit.
2. User Authentication : Limiting access to data and monitoring who accesses the data.
3. Disaster and Data Breach : Contingency Planning.

- Data Protection : Data needs to be encrypted at all times, with clearly defined roles when it comes to who will be managing the encryption keys.

- User Authentication : Data resting in the cloud needs to be accessible only by those authorized to do so, making it critical to both restrict and monitor who will be accessing the company's data through the cloud. In order to ensure the integrity of user authentication, companies need to be able to view data access

logs and audit trails to verify that only authorized users are accessing the data.

- Contingency Planning : With the cloud serving as a single centralized repository for a company's mission-critical data, the risks of having that data compromised due to a data breach or temporarily made unavailable due to a natural disaster are real concerns.

<div style="border:1px solid black; text-align:center;">

2.7 : Introducing Business Continuity and Disaster Recovery

</div>

Q.25 What Disaster recovery plan ? explain RTO and RPO. What happens if you ignore RTO and RPO ?

Ans. : • Disaster Recovery Plan is a plan designed to recover all the vital business processes during a disaster with in a limited amount of time. This plan has all the procedures required to handle the emergency situations.

- Recovery Point Objective (RPO) and Recovery Time Objective (RTO) are two of the most important parameters of a disaster recovery or data protection plan. These are objectives which can guide enterprises to choose an optimal data backup plan.

- Recovery Point Objective (RPO) describes the interval of time that might pass during a disruption before the quantity of data lost during that period exceeds the Business Continuity Plan's maximum allowable threshold or "tolerance."

- RPO is the amount of time that passes that's "acceptable" to you during an emergency situation. You should define this amount of time in your business continuity plan. If you exceed this period of time, you could jeopardize your business.

- RTO is the duration of time and a service level within which a business process must be restored after a disaster in order to avoid unacceptable consequences associated with a break in continuity.

- RTO is the amount of time it takes you to restore regular business processes after a natural disaster or emergency situation.

- If you ignore RTO, the amount of time it takes for you to get up and running again after a disaster and you won't be able to manage downtime properly in the future.

- If you ignore RPO, the amount of downtime that's acceptable during a disaster and you won't meet your business continuity objectives. That could jeopardize your business reputation. In fact, you could lose customers if you experience too much downtime. Consumers won't be able to purchase products from your online store or contact you with queries.

Q.26 Explain differences between disaster recovery and business continuity plan.

Ans. :

Disaster Recovery Plan	Business Continuity Plan
Main idea : Recover from disasters.	Main idea : Continue critical business operations.
Disaster recovery is data centric	Business continuity is business centric
DR plan can be built upon a strong business continuity plan.	The business continuity process has a series of DRPs.
Activities are pre-planned to react to disasters.	Planning on mitigating risk for the assets, business processes that will adversely impact company, if a disaster happens.
DR plan starts with IT, not because other aspects are not important, but because IT is easiest to recover, and impact is also more.	BC plan is not an IT process; it includes the complete business as a unit.
Disaster recovery is more reactive.	Business continuity is more proactive.

Q.27 What is business continuity plan ?

Ans. : • Business continuity refers to the activities required to keep the organization running during a period of displacement or interruption of normal operations.

• BCP helps in continuing the business even after a disaster occurs.

• Business has to stay active during the crisis; if it closes its operations even for a day or a week, they are many chances that the organization will experience losses and will have to shut down.

• Moreover, legal issues can arise if the critical services are not provided to clients. This can lead to bad reputation and many more legal problems for an organization in addition to having the pain of being in the state of disaster. Hence an efficient BCP plan can be used to actively run and maintain the business activities.

END...✍

3 Virtualization

Important Points to Remember

- Virtualization means running multiple machines on a single hardware.
- Storage virtualization is a system administration practice that allows decoupling the physical organization of the hardware from its logical representation.
- Hyper-V is an infrastructure virtualization solution.
- File level storage is seen and deployed in Network Attached Storage (NAS) systems.
- Block level storage is seen and deployed in Storage Area Network (SAN) storage.
- A Hypervisor Or Virtual Machine Monitor (VMM) is computer software, firmware or hardware that creates and runs virtual machines.
- A Virtual Storage Area Network (VSAN) is a logical partition in a physical Storage Area Network (SAN).
- A cloud storage provider is an organization 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.

3.1 : Introduction of Virtualization

Q.1 What is virtualization ?

Ans. : • Virtualization is an abstraction layer that decouples the physical hardware from the operating system to deliver greater IT resource utilization and flexibility. It allows multiple virtual machines, with heterogeneous operating systems to run in isolation, side-by-side on the same physical machine.

- Virtualization means running multiple machines on a single hardware. The "Real" hardware invisible to operating system. OS only sees an abstracted out picture. Only Virtual Machine Monitor (VMM) talks to hardware.

Q.2 Explain taxonomy of virtualization.
☞ **[SPPU : May-18, End Sem, Marks 5]**

OR Elaborate taxonomy of virtualization techniques.
☞ **[SPPU : Dec-17, End Sem, Marks 5]**

Ans. : Exploring Virtualization : • Virtualization is a broad term that refers to the abstraction of resources across many aspects of computing. For our purposes : One physical machine to support multiple virtual machines that run in parallel.

- Virtualization is a frame work or methodology of dividing the resources of computer into multiple execution environments.

- Virtualization is an abstraction layer that decouples the physical hardware from the operating system to deliver greater IT resource utilization and flexibility.

- It allows multiple virtual machines, with heterogeneous operating systems to run in isolation, side-by-side on the same physical machine.

- Fig. Q.2.1 shows before and after virtualization.

- Virtualization means running multiple machines on a single hardware. The "Real" hardware invisible to operating system. OS only sees an abstracted out picture. Only Virtual Machine Monitor (VMM) talks to hardware.

- It is "a technique for hiding the physical characteristics of computing resources from the way in which other systems, applications, or end users interact with those resources.

- This includes making a single physical resource appear to function as multiple logical resources; or it can include making multiple physical resources appear as a single logical resource."
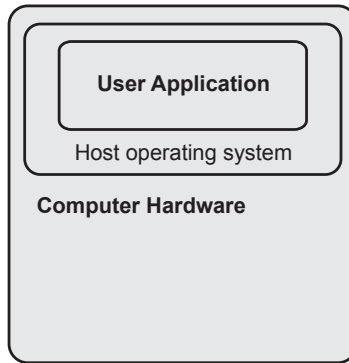
(a) : Before virtualization
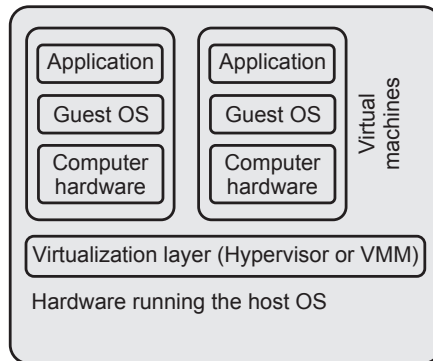
(b) After virtualization
Fig. Q.2.1

- It is divided into two main categories :

   1. Platform virtualization involves the simulation of virtual machines.

   2. Resource virtualization involves the simulation of combined, fragmented or simplified resources.

- Fig. Q.2.2 shows taxonomy of virtualization.

- Virtualization is mainly used to emulate execution environment, storage and network. Execution environment classified into two types : process level and system level.

- Process level is implemented on top of an existing operating system.
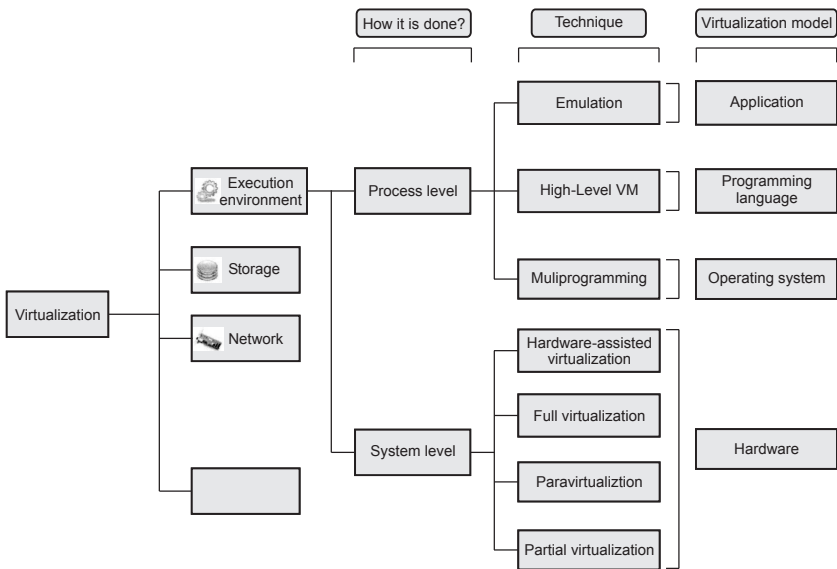
Fig. Q.2.2 Taxonomy of virtualization

• System level is implemented directly on hardware and do not or minimum requirement of existing operating system.

Q.3 Explain the characteristics of virtualized environment.

☞ **[SPPU : April-17, In Sem, Marks-5][Dec-16, End Sem, Marks 4]**

Ans. : • In a virtualized environment there are three major components : guest, host, and virtualization layer.

• Characteristics of virtualized environment are as follows :

  1. Increased security : The ability to control the execution of a guest in a completely transparent manner opens new possibilities for delivering a secure, controlled execution environment. The virtual machine represents an emulated environment in which the guest is executed. All the operations of the guest are performed against the virtual machine, which then translates and applies them to the host.

  2. Sharing : It allows the creation of a separate computing environments within the same host.

3. **Isolation :**   Virtualization allows providing guests whether they are operating systems,   applications, or other entities with a completely separate environment, in which they are executed.

4. **Emulation :** Guest programs are executed within an environment that is controlled by the virtualization layer, which ultimately is a program.

5. Portability allows having your own system always with you and ready to use as long as the required virtual machine manager is available.

Q.4 Enlist and explain pros and cons of virtualization.

☞ **[SPPU : May-18, End Sem, Marks 5]**

Ans. : Pros :

1. Data center and energy-efficiency savings : As companies reduce the size of their hardware and server footprint, they lower their energy consumption.

2. Operational expenditure savings : Once servers are virtualized, your IT staff can greatly reduce the ongoing administration and management of manual.

3. Reduced Costs : One of the biggest advantages associated with using virtualization in your IT infrastructure is the ability to cut costs.

4. Data does not leak across virtual machine.

5. Virtual machine is completed isolated from host machine and other virtual machine.

6. Simplifies resource management by pooling and sharing resources.

7. Significantly reduce downtime.

8. Improved performance of IT resources.

Cons :

• Virtualization can sometime lead to an inefficient use of the host.

- The Network : Virtualizing servers before making sure that the network infrastructure can handle it is a risky undertaking. After the process is complete the network will be under a lot more strain and making sure that it has what it takes to sustain the added traffic is critical.

- Performance degradation : Performance is definitely one of the major concerns in using virtualization technology. Since virtualization interposes an abstraction layer between the guest and the host, the guest can experience increased latencies.

- Security holes and new threats : Virtualization opens the door to a new and unexpected form of phishing. The capability of emulating a host in a completely transparent manner led the way to malicious programs that are designed to extract sensitive information from the guest.

- Misplacing Applications : A virtualized infrastructure is a more complex than a traditional one and with a number of applications deployed, losing track of applications is a distinct possibility. Within a physical server infrastructure keeping track of all the apps and the machines running them isn't a difficult task.

- Mismatching Servers : This aspect is commonly overlooked especially by smaller companies that don't invest sufficient funds in their IT infrastructure and prefer to build it from several bits and pieces. This usually leads to simultaneous virtualization of servers that come with different chip technology.

Q.5 Write short note on :
i) OS level virtualization ii) Application level virtualization.

☞ **[SPPU : May - 16, End Sem, Marks 6]**

Ans. : i) OS level virtualization : • Operating-system-level virtualization is a server-virtualization method where the kernel of an operating system allows for multiple isolated user-space instances, instead of just one. Such instances, which are sometimes called containers and software containers.

- This refers to an abstraction layer between traditional OS and user applications.

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

- Containers behave like real servers. With containers you can create a portable, consistent operating environment for development, testing, and deployment.

- This virtualization creates virtual hosting environments to allocates hardware resources among a large number of mutually distrusting users.

- Operating-system-level virtualization usually imposes little to no overhead, because programs in virtual partitions use the operating system's normal system call interface and do not need to be subjected to emulation or be run in an intermediate virtual machine.

- Operating system-level virtualization is not as flexible as other virtualization approaches since it cannot host a guest operating system different from the host one, or a different guest kernel.

- Instead of trying to run an entire guest OS, container virtualization isolates the guests, but doesn't try to virtualize the hardware. Instead, you have containers for each virtual environment.

- With container-based technologies, you'll need a patched kernel and user tools to run the virtual environments. The kernel provides process isolation and performs resource management.

- **Advantages of OS virtualization :**

1. OS virtualization provide least overhead among all types of virtualization solution.

2. They offer highest performance and highest density of virtual environment.

3. Low resource requirements.

4. High scalability.

Disadvantage of OS virtualization

- They support only one operating system as base and guest OS in a single server.

- Library support level virtualization :

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

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

- Another example is the vCUDA which allows applications executing within VMs to leverage GPU hardware acceleration.

ii) Application level virtualization : Virtualization at the application level virtualizes an application as a VM. On a traditional OS, an application often runs as a process. Therefore, application-level virtualization is also known as process-level virtualization.

- A fully virtualized application is not installed in the traditional sense, although it is still executed as if it were. The application behaves at runtime like it is directly interfacing with the original operating system and all the resources managed by it, but can be isolated to varying degrees.

- Full application virtualization requires a virtualization layer. Application virtualization layers replace part of the runtime environment normally provided by the operating system.

- The layer intercepts all disk operations of virtualized applications and transparently redirects them to a virtualized location, often a single file.

- The application remains unaware that it accesses a virtual resource instead of a physical one. Since the application is now working with one file instead of many files spread throughout the system, it becomes easy to run the application on a different

computer and previously incompatible applications can be run side-by-side.

• The most popular approach is to deploy high level language (HLL) VMs. Here the virtualization layer sits as an application program on top of the operating system, and the layer exports an abstraction of a VM that can run programs written and compiled to a particular abstract machine definition. Any program written in the HLL and compiled for this VM will be able to run on it.

• **Benefits :**

1. Application virtualization uses fewer resources than a separate virtual machine.

2. Application virtualization also enables simplified operating system migrations.

3. Applications can be transferred to removable media or between computers without the need of installing them, becoming portable software.

• **Limitations :**

1. Not all computer programs can be virtualized

2. Lower performance.

Q.6 Write short note on VMware architecture.

☞ **[SPPU : May-16, End Sem, Marks 4]**

Ans. : • VMware's technology is based on full virtualization concept.

• VMware implements full virtualization either in the desktop environment (Type II hypervisors) or the server environment (Type I hypervisors).

• Fig. Q.6.1 shows full virtualization reference model.

• In both the cases, full virtualization is possible through the direct execution for non-sensitive instructions and binary translation for sensitive instructions or hardware traps, thus enabling the virtualization of architecture like x86.
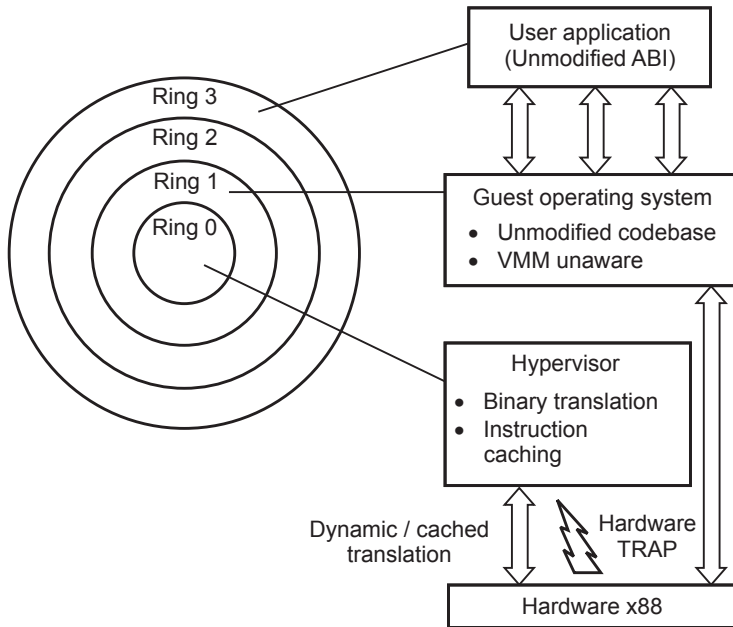
Fig. Q.6.1 Full virtualization reference model

- VMware is widely used as it tends to virtualize x86 architectures, which executes unmodified on-top of their hypervisors. With the introduction of hardware-assisted virtualization, full virtualization is possible to achieve by support of hardware.

- But earlier, x86 guest operating systems unmodified in a virtualized environment could be executed only with the use of dynamic binary translation.

- VMware achieves full virtualization by providing virtual representation of memory and I/O devices. Memory virtualization constitutes another challenge of virtualized environments and can deeply impact per - formance without the appropriate hardware support.

Q.7 Explain the following :
i) Network virtualization ii) Desktop virtualization

☞ **[SPPU : April-17, In Sem, Marks 5]**

Ans. : i) Network virtualization : Network virtualization refers to the technology that enables partitioning or aggregating a collection of network resources and presenting them to various users in a way that each user experiences an isolated and unique view of the physical network.

- Network virtualization creates virtual networks whereby each application sees its own logical network independent of the physical network.

- A virtual LAN (VLAN) is an example of network virtualization that provides an easy, flexible, and less expensive way to manage networks.

- VLANs make large networks more manageable by enabling a centralized configuration of devices located in physically diverse locations.

- Fig. Q.7.1 shows network virtualization.
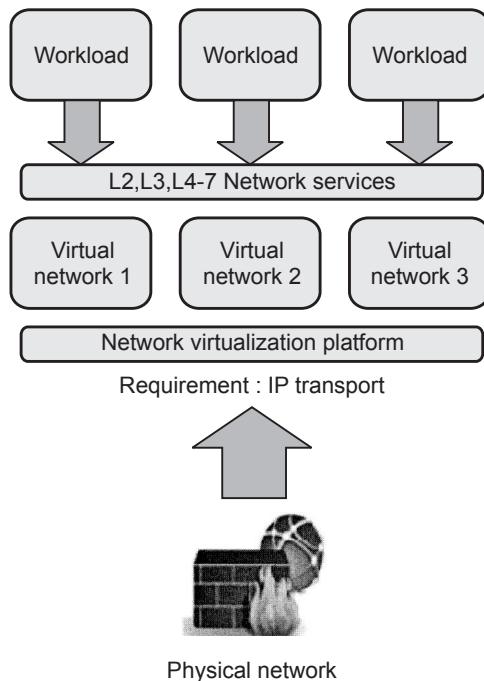
Fig. Q.7.1 Network virtualization

- Consider a company in which the users of a department are separated over a metropolitan area with their resources centrally located at one office.

- In a typical network, each location has its own network connected to the others through routers. When network packets cross routers, latency influences network performance.

- With VLANs, users with similar access requirements can be grouped together into the same virtual network. This setup eliminates the need for network routing.

- As a result, although users are physically located at disparate locations, they appear to be at the same location accessing resources locally.

- In addition to improving network performance, VLANs also provide enhanced security by isolating sensitive data from the other networks and by restricting access to the resources located within the networks.

- Network virtualization decouples the roles of the traditional Internet service providers (ISPs) into infrastructure providers (InPs) and service providers (SPs)

- Benefits :

1. Reduces the number of physical devices needed.
2. Easily segment networks.
3. Permits rapid change / scalability and agile deployment.
4. Security from destruction of physical devices.

ii) Desktop virtualization : • Desktop virtualization is software technology that separates the desktop environment and associated application software from the physical client device that is used to access it.

- Virtual Desktop Infrastructure is a computing model that enables desktop virtualization and contains all hardware and software elements required to support the virtualized environment

- Virtual Desktop Infrastructure is a term that refers to using a virtualized desktop that is hosted on a Virtual machine that lives on a server.

- Virtual Desktop Infrastructure is built on VMware virtual infrastructure hardware. Desktop virtual machines are hosted on server hardware running VMware Virtual Infrastructure software. These desktop environments are then accessed remotely from a thick or thin client via a remote desktop protocol such as RDP

- In other words, there is no physical desktop computer in front of you, but rather a terminal or remote desktop connection to a virtual machine that is hosted, secured and fully customizable per user basis.

- VDI allows businesses and IT departments to streamline the cost of equipment by utilizing a single server to host multiple desktops for end-users while delivering a secure platform that is accessible to users from virtually anywhere they are.

- Many firms use this Virtual Desktop Infrastructure for applications and business functions that additionally cut the cost of ownership and use down tremendously.

- Advantages include :

  1. Simpler provisioning of new desktops.

  2. Reduced downtime in the event of server or client hardware-failures.

  3. Lower cost of deploying new applications.

  4. Desktop image-management capabilities.

  5. Longer refresh cycle for client desktop infrastructure because you do not need a hardware upgrade for every client when a new OS or application requires it.

  6. Secure remote access to an enterprise desktop environment.

3.2 : Virtualization Structures/Tools and Mechanisms

Q.8 What is Virtual Machine Manager (VMM)? Explain major types of VMM. ☞ [SPPU : April-17, In Sem, Marks 5]

Ans. : • Hypervisor or virtual machine monitor is computer software, firmware or hardware that creates and runs virtual machines.

• A computer on which a hypervisor runs one or more virtual machines is called a host machine, and each virtual machine is called a guest machine.

• The Virtualization layer is the middleware between the underlying hardware and virtual machine represented in the system, also known as Virtual Machine Monitor (VMM).

• In computing, a hypervisor is a virtualization platform that allows multiple operating systems to run on a host computer at the same time. The term usually refers to an implementation using full virtualization.

• Hypervisors are currently classified in two types :

1. **Type 1 hypervisor** is software that runs directly on a given hardware platform . A "guest" operating system thus runs at the second level above the hardware.

2. **Type 2 hypervisor** is software that runs within an operating system environment. A "guest" operating system thus runs at the third level above the hardware.

• Type 1 hypervisors are commonly considered bare metal hypervisors, in that the hypervisor code itself runs directly on top of your hardware.

• Type 1 hypervisors tend to enjoy much better performance than type 2 hypervisors, due in part to their direct positioning on top of hardware.

• Unlike type 1 hypervisors, a type 2 hypervisor must be installed on top of an existing OS. These hypervisors tend to have better hardware compatibility because they use software-based virtualization.

- For example, you can install a type 2 hypervisor on your laptop much more easily than you could install a type 1 hypervisor. Its drivers are Windows' drivers (or Linux's drivers), which are much greater in number than ESX's, for example.

- Performance is the downside with a type 2 hypervisor. Because those hypervisors need to work within the confines of an existing OS, their virtualization performance is limited by the OS's extra software layer.

Q.9 Write short note on : Xen   ☞ **[SPPU : Oct-17, End Sem, Marks 5]**

Ans. : • Xen is a type 1 hypervisor that creates logical pools of system resources so that many virtual machines can share the same physical resources.

- Xen is a hypervisor that runs directly on the system hardware. It inserts a virtualization layer between the system hardware and the virtual machines, turning the system hardware into a pool of logical computing resources that Xen can dynamically allocate to any guest operating system.

- Fig. Q.9.1 shows Xen architecture.
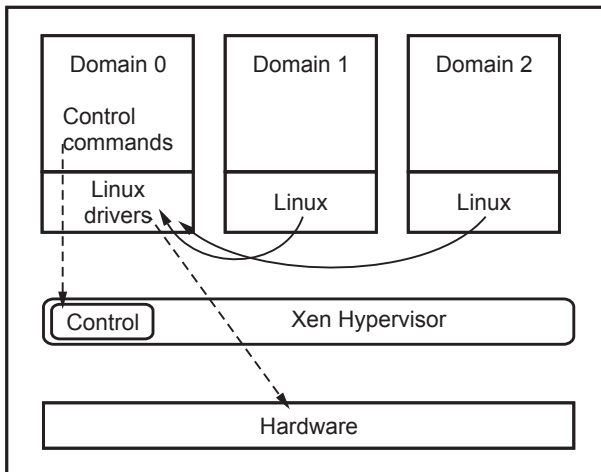
Fig. Q.9.1 : Xen architecture

- The operating systems running in virtual machines interact with the virtual resources as if they were physical resources. Xen provides a virtual environment located between the hardware and the OS.

- Xen doesn't include any device drivers; it provides a mechanism by which a guest-OS can have direct access to the physical devices.

- The core components of Xen are the hypervisor, kernel and applications. Many guest operating systems can run on the top of the hypervisor; but it should be noted that one of these guest OS controls the others.

- This guest OS with the control ability is called Domain 0 , the others are called Domain U. Domain 0 is first loaded when the system boots and can access the hardware directly and manage devices by allocating the hardware resources for the guest domains (Domain U).

- The Control Domain (or Domain 0) is a specialized Virtual Machine that has special privileges like the capability to access the hardware directly, handles all access to the system's I/O functions and interacts with the other Virtual Machines.

- It also exposes a control interface to the outside world, through which the system is controlled. The Xen Project hypervisor is not usable without Domain 0, which is the first VM started by the system.

Q.10 What do you mean by virtualization ? Differentiate between Full virtualization and Para virtualization.

☞ **[SPPU : May-17, End Sem, Marks 5]**

Ans. :

Full virtualization	Para virtualization
Full Virtualization relies upon binary translation to trap and to virtualize certain sensitive instructions.	Para-virtualization refers to communication between the guest OS and the hypervisor to improve performance and efficiency
Example : VMware	Example : Xen architecture

Full Virtualization doesn't need to modify the host OS	Para-virtualization involves modification of OS kernel.
Normal instructions can run directly on the host OS.	Para-virtualized systems won't run on native hardware.
Full virtualization uses binary translation and direct execution	Para virtualization uses hyper-calls.
Performance is good.	Performance is better in certain cases.
Guest software does not require any modifications since the underlying hardware is fully simulated.	Hardware is not simulated and the guest software run their own isolated domains.

Also refer Q.1.

Q.11 Write short note on :
i) Full virtualization   ii) Para virtualization

☞ **[SPPU : Dec-18, End Sem, Marks 4]**

Ans. : i) Full virtualization : Full Virtualization doesn't need to modify the host OS; it relies upon binary translation to trap and to virtualize certain sensitive instructions.

• Fig. Q.11.1 shows full virtualization.
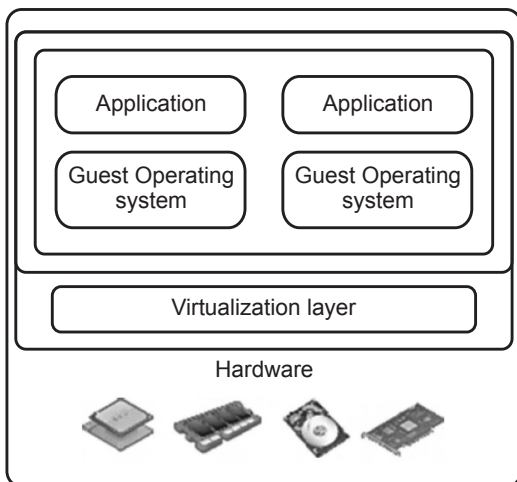
Fig. Q.11.1 : Full virtualization

- VMware Workstation applies full virtualization, which uses binary translation to automatically modify x86 software on-the-fly to replace critical instructions.

- Normal instructions can run directly on the host OS. This is done to increase the performance overhead - normal instructions are carried out in the normal manner, but the difficult and precise executions are first discovered using a trap and executed in a virtual manner.

- This is done to improve the security of the system and also to increase the performance.

Host based virtualization :

- Virtualization implemented in a host computer rather than in a storage subsystem or storage appliance.

- Virtualization can be implemented either in host computers, in storage subsystems or storage appliances, or in specific virtualization appliances in the storage interconnect fabric.

- The guest OS are installed and run on top of the virtualization layer. Dedicated applications may run on the VMs. Certainly, some other applications can also run with the host OS directly.

- **Advantages of host-based architecture :**

1. The user can install this VM architecture without modifying the host OS.

2. The host-based approach appeals to many host machine configurations.

ii) Para virtualization : • Para-virtualization refers to communication between the guest OS and the hypervisor to improve performance and efficiency.

- Para-virtualization involves modifying the OS kernel to replace non-virtualizable instructions with hyper-calls that communicate directly with the virtualization layer hypervisor.

- The hypervisor also provides hyper-call interfaces for other critical kernel operations such as memory management, interrupt handling and time keeping.

- Xen is an open source para-virtualization solution that requires modifications to the guest operating systems but achieves near native performance by collaborating with the hypervisor.

- Fig. Q.11.2 shows para-virtualization architecture.

- In Para-virtualization, the virtual machine does not necessarily simulate hardware, but instead offers a special API that can only be used by modifying the "guest" OS. This system call to the hypervisor is called a "hypercall" in Xen.

Private server	Private server	.....	Private server
Operating system			
Hardware			
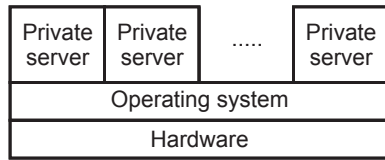
Fig. Q.11.2

- Para-virtualization shares the process with the guest operating system.

Problems with para-virtualization

1. Para-virtualized systems won't run on native hardware

2. There are many different para-virtualization systems that use different commands, etc.

Q.12 What is Virtual Machine Monitor ? Explain three requirements for a VMM.

Ans. : • Hardware level virtualization inserts a layer between real hardware and traditional OS. This layer is commonly called the Virtual Machine Monitor (VMM) and it manages the hardware resources of a computing system.

- Three requirements for a VMM.

  1. VMM should provide an environment for programs which is essentially identical to the original machine.

  2. The programs run in this environment should show, at worst, only minor decreases in speed.

3. VMM should be in complete control of the system resources. Any program run under a VMM should exhibit a function identical to that which it runs on the original machine directly.

Q.13 What are the challenges to cloud computing in OS level virtualization ?

- Cloud computing is transforming the computing landscape by shifting the hardware and staffing costs of managing a computational center to third parties.

- Cloud computing has at least **two challenges :**

1. The ability to use a variable number of physical machines and virtual machine 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.

2. It is related to slow operation of instantiating new virtual machine. Currently, new virtual machines originate either as fresh boots or as replicates of a template VM, unaware of the current application state. Therefore, to better support cloud computing, a large amount of research and development should be done

Q.14 Why operating system level virtualization is required ?

Ans. : • Operating system level virtualization provides feasible solution for hardware level virtualization issue. It inserts a virtualization layer inside an operating system to partition a machine's physical resources.

- It enables multiple isolated VMs within a single operating system kernel. This kind of VM is often called a virtual execution environment (VE), Virtual Private System (VPS), or simply container .

- From the user's point of view, virtual execution environment look like real servers.

- This means a virtual execution environment has its own set of processes, file system, user accounts, network interfaces with IP addresses, routing tables, firewall rules etc.

• Although VEs can be customized for different people, they share the same operating system kernel. Therefore, OS-level virtualization is also called single-OS image virtualization.

Q.15 Discuss the significance of Hypervisor in cloud ? Define server virtualization and application virtualization.

☞ **[SPPU : May-17, End Sem, Marks 5]**

Ans. : • A hypervisor is a hardware virtualization technique that allows multiple guest operating systems (OS) to run on a single host system at the same time.

• Application virtualization is the separation of an installation of an application from the client computer accessing it.

• With application virtualization, each application brings down its own set of configurations on-demand, and executes in a way so that it sees only its own settings. This leaves the host operating system and existing settings unaltered.

• Application virtualization can be an effective way for organizations to implement and maintain their desktop applications.

• One of the benefits of application virtualization is that administrators only need to install an application once to a centralized server rather than to multiple desktops. This also makes it simpler to update applications and roll out patches.

Also refer Q.8.

Q.16 Compare KVM, Xen and VMware workstation.

Ans. : Comparison between KVM, Xen and Vmware :

KVM	Xen	VMware
Kernel-based Virtual Machine (KVM) is an open source virtualization technology built into Linux.	Xen is the open source hypervisor included in the Linux kernel and, as such, it is available in all Linux distributions.	VMware virtualizes computing, from the data center to the cloud to mobile devices, to help our customers be more agile, responsive, and profitable.

Developed by Red Hat	Developed by Xensource	Developed by VMware
It runs on arbitrary OS	Not runs on arbitrary OS	It runs on arbitrary OS
License available under GPL version 2	License available under GNU GPL v2+	Proprietary
Host OS : Linux, FreeBSD	Host OS : GNU/Linux	Host OS : Linux, windows
Used by full, para virtualization and hardware assisted virtualization	Used by para virtualization and hardware assisted virtualization	Used by full - virtualization
Used in virtualized server isolation, software development and cloud computing	Used in virtualized server isolation, software development and cloud computing	Used by technical professional, trainer

3.3 : Virtualization of CPU, Memory, and I/O Devices

Q.17 Explain hardware support for Virtualization.

Ans. : • Modern operating systems and processors allow multiple processes to run simultaneously.

• A protection mechanism should exist in the processor so that all instructions from different processes will not access the hardware directly, this will lead to a system crash.

• All processors should have at least two modes: user mode and supervisor mode.

• Modes are used to control the access to the hardware directly. Instructions running in the supervisor mode are called privileged instructions and the others are unprivileged.

• Ex: VMware Workstation

• In a virtualized environment, it is more difficult to make OSes and applications run correctly because there are more layers in the machine stack.

Q.18 Explain hardware-assisted CPU Virtualization.

Ans. :

- Certain processors such as Intel VT provide hardware assistance for CPU virtualization.

- When using this assistance, the guest can use a separate mode of execution called guest mode. The guest code, whether application code or privileged code, runs in the guest mode.

- On certain events, the processor exits out of guest mode and enters root mode. The hypervisor executes in the root mode, determines the reason for the exit, takes any required actions, and restarts the guest in guest mode.

- Fig. Q.18.1 shows Intel hardware-assisted CPU virtualization
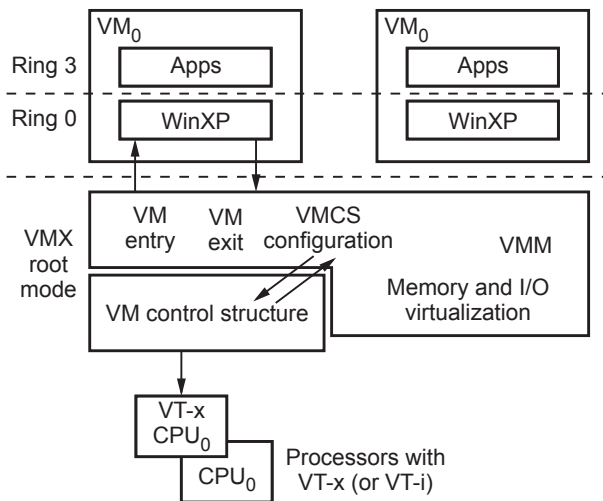
Fig. Q.18.1 Intel hardware-assisted CPU virtualization

- When you use hardware assistance for virtualization, there is no need to translate the code. As a result, system calls or trap-intensive workloads run very close to native speed.

- Some workloads, such as those involving updates to page tables, lead to a large number of exits from guest mode to root mode.

Depending on the number of such exits and total time spent in exits, this can slow down execution significantly.

- CPU virtualization features enable faithful abstraction of the full prowess of Intel CPU to a virtual machine.

- All software in the VM can run without any performance, as if it was running natively on a dedicated CPU. Live migration from one Intel CPU generation to another, as well as nested virtualization, is possible.

Q.19 Explain memory virtualization.

Ans. : • Memory virtualization features allow abstraction isolation and monitoring of memory on a per virtual machine (VM) basis. These features may also make live migration of VMs possible, add to fault tolerance, and enhance security.

- Example features include direct memory access (DMA) remapping and extended page tables (EPT), including their extensions: accessed and dirty bits, and fast switching of EPT contexts.

- The VMkernel manages all machine memory. The VMkernel dedicates part of this managed machine memory for its own use. The rest is available for use by virtual machines.

- Virtual machines use machine memory for two purposes: each virtual machine requires its own memory and the VMM requires some memory and a dynamic overhead memory for its code and data.

- The virtual memory space is divided into blocks, typically 4KB, called pages. The physical memory is also divided into blocks, also typically 4 KB.

- When physical memory is full, the data for virtual pages that are not present in physical memory are stored on disk. ESX/ESXi also provides support for large pages.

- The VMM is responsible for mapping the guest physical memory to the actual machine memory.

- Each page table of a guest OS has a page table allocated for it in the VMM. The page table in the VMM which handles all these is called a shadow page table.

- As it can be seen all this process is nested and inter-connected at different levels through the concerned address. If any change occurs in the virtual memory page table or TLB, the shadow page table in the VMM is updated accordingly.
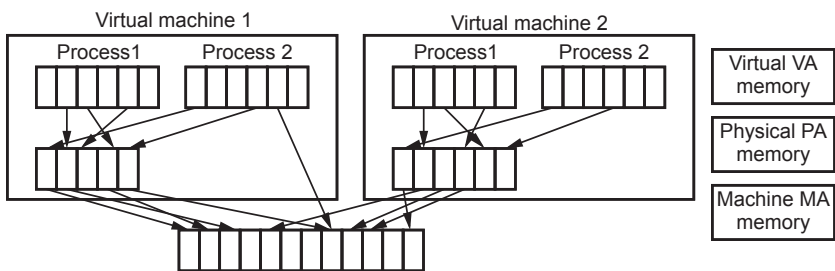
Fig. Q.19.1

Q.20 Write short note on I/O virtualization.

Ans. : • I/O Virtualization involves managing of the routing of I/O requests between virtual devices and shared physical hardware.

- The there are three ways to implement this. They are full device emulation, para-VZ and direct I/O.

1. **Full Device Emulation :** This process emulates well-known and real-world devices. All the functions of a device or bus infrastructure such as device enumeration, identification, interrupts etc. are replicated in the software, which itself is located in the VMM and acts as a virtual device. The I/O requests are trapped in the VMM accordingly.

2. **Para-virtualization :** This method of I/O VZ is taken up since software emulation runs slower than the hardware it emulates. In para-VZ, the frontend driver runs in Domain-U; it manages

the requests of the guest OS. The backend driver runs in Domain-0 and is responsible for managing the real I/O devices. This methodology (para) gives more performance but has a higher CPU overhead.

3. **Direct I/O virtualization :** This lets the VM access devices directly; achieves high performance with lower costs. Currently, it is used only for the mainframes.

• I/O virtualization features facilitate offloading of multi-core packet processing to network adapters as well as direct assignment of virtual machines to virtual functions, including disk I/O.

• Examples include Virtual Machine Device Queues (VMDQ), Single Root I/O Virtualization.
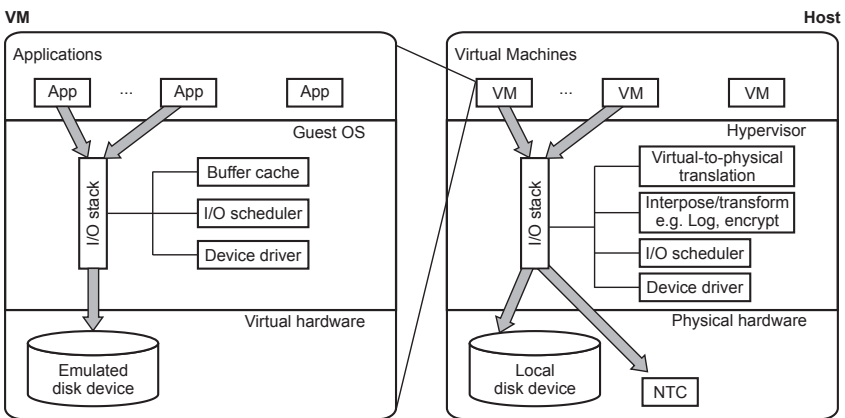
Fig. Q.20.1 : I/O virtualization

3.4 Virtual Clusters and Resource Management

Q.21 Explain characteristics of virtual cluster.

Ans. : Characteristics :

• The virtual cluster nodes can be either physical or virtual machines. Multiple VMs running with different OSs can be deployed on the same physical node.

- A VM runs with a guest OS, which is often different from the host OS, that manages the resources in the physical machine, where the VM is implemented.

- The purpose of using VMs is to consolidate multiple functionalities on the same server. This will greatly enhance the server utilization and application flexibility.

- VMs can be colonized (replicated) in multiple servers for the purpose of promoting distributed parallelism, fault tolerance, and disaster recovery.

- The size (number of nodes) of a virtual cluster can grow or shrink dynamically, similarly to the way an overlay network varies in size in a P2P network.

- The failure of any physical nodes may disable some VMs installed on the failing nodes. But the failure of VMs will not pull down the host system.

Q.22 How to managing a Virtual Cluster ?

Ans. : Virtual cluster is managed by four ways:

- We can use a guest-based manager, by which the cluster manager resides inside a guest OS. Ex: A Linux cluster can run different guest operating systems on top of the Xen hypervisor.

- We can bring out a host-based manager which itself is a cluster manager on the host systems. Ex : VMware HA (High Availability) system that can restart a guest system after failure.

- An independent cluster manager, which can be used on both the host and the guest - making the infrastructure complex.

- Finally, we might also use an integrated cluster (manager), on the guest and host operating systems; here the manager must clearly distinguish between physical and virtual resources.

Q.23 Explain virtual machine states.

Ans. : • **Inactive State :** This is defined by the VZ platform, under which the VM is not enabled.

- **Active State :** This refers to a VM that has been instantiated at the VZ platform to perform a task.

- **Paused State :** VM has been instantiated but disabled temporarily to process a task or is in a waiting state itself.

- **Suspended State :** A VM enters this state if its machine file and virtual resources are stored back to the disk.

Q.24 What are the live migration steps ? Explain.

Ans. : • **Steps 0 and 1 :** Start migration automatically and checkout load balances and server consolidation.

- **Step 2 :** Transfer memory (transfer the memory data + recopy any data that is changed during the process). This goes on iteratively till changed memory is small enough to be handled directly.

- **Step 3 :** Suspend the VM and copy the last portion of the data.

- **Steps 4 and 5 :** Commit and activate the new host. Here, all the data is recovered, and the VM is started from exactly the place where it was suspended, but on the new host

Q.25 Write short note on File System Migration.

Ans. : • To support VM migration from one cluster to another, a consistent and location-dependent view of the file system is available on all hosts.

- Each VM is provided with its own virtual disk to which the file system is mapped to. The contents of the VM can be transmitted across the cluster by inter-connections (mapping) between the hosts.

- But migration of an entire host is not advisable due to cost and security problems. We can also provide a global file system across all host machines where a VM can be located.

- This methodology removes the need of copying files from one machine to another, all files on all machines can be accessed through network.

- It should be noted here that the actual files are not mapped or copied. The VMM accesses only the local file system of a machine and the original/modified files are stored at their respective systems only.

- This decoupling improves security and performance but increases the overhead of the VMM - every file has to be stored in virtual disks in its local files.

3.5 : Virtualization for Data-Center Automation

Q.26 What is pre copy and post copy of live migration ?

Ans. : • In pre copy, which is manly used in live migration, all memory pages are first transferred; it then copies the modified pages in the last round iteratively. Here, performance 'degradation' will occur because migration will be encountering dirty pages all around in the network before getting to the right destination. The iterations could also increase, causing another problem. To encounter these problems, check-pointing/recovery process is used at different positions to take care of the above problems and increase the performance.

- In post-copy, all memory pages are transferred only once during the migration process. The threshold time allocated for migration is reduced. But the downtime is higher than that in pre-copy.

Q.27 Describe server consolidation in data centers.

Ans. : • The heterogeneous workloads in the data center can be roughly divided into two categories : chatty workloads and noninteractive workloads.

- Chatty workloads may burst at some point and return to a silent state at some other point. For example, video services can be used by a lot of people at night and few people use it during the day.

- Noninteractive workloads do not require people's efforts to make progress after they are submitted. Server consolidation is an

approach to improve the low utility ratio of hardware resources by reducing the number of physical servers.

• The use of VMs increases resource management complexity.

• It enhances hardware utilization. Many underutilized servers are consolidated into fewer servers to enhance resource utilization. Consolidation also facilitates backup services and disaster recovery.

• In a virtual environment, the images of the guest OSes and their applications are readily cloned and reused.

• Total cost of ownership is reduced.

• Improves availability and business continuity.

• Automation of data-center operations includes resource scheduling, architectural support, power management, automatic or autonomic resource management, performance of analytical models, and so on.

• In virtualized data centers, an efficient, on-demand, fine-grained scheduler is one of the key factors to improve resource utilization.

• Dynamic CPU allocation is based on VM utilization and application-level QoS metrics.

• One method considers both CPU and memory flowing as well as automatically adjusting resource overhead based on varying workloads in hosted services.

• Another scheme uses a two-level resource management system to handle the complexity involved. A local controller at the VM level and a global controller at the server level are designed.

Q.28 Define Instance manager, Group manager, cloud manager.

Ans. : • Instance Manager controls the execution, inspection, and termination of VM instances on the host where it runs.

- Group Manager gathers information about and schedules VM execution on specific instance managers, as well as manages virtual instance network.

- Cloud Manager is the entry-point into the cloud for users and administrators. It queries node managers for information about resources, makes scheduling decisions, and implements them by making requests to group managers.

Q.29 Explain concept of trust management in virtualized data centers.

Ans. : • Virtual machine in the host machine entirely encapsulates the state of the guest operating system running inside it.

- Encapsulated machine state can be copied and shared over the network and removed like a normal file, which proposes a challenge to VM security.

- In general, a VMM can provide secure isolation and a VM accesses hardware resources through the control of the VMM, so the VMM is the base of the security of a virtual system.

- Normally, one VM is taken as a management VM to have some privileges such as creating, suspending, resuming, or deleting a VM.

Q.30 What is intrusion detection system? Explain function of IDS. Also explain benefit and limitations of IDS.

Ans. : • Intrusion detection is a set of techniques and methods that are used to detect suspicious activity both at the network and host level. Intrusion Detection System is software, hardware or combination of both used to detect intruder activity.

- Fig. Q.30.1 shows IDS. (See Fig. Q.30.1 on next page)

- A lightweight intrusion detection system can easily be deployed on any node of a network, with minimal disruption to operations. Snort is a libpcap based packet sniffer and logger that can be used as a lightweight network intrusion detection system.
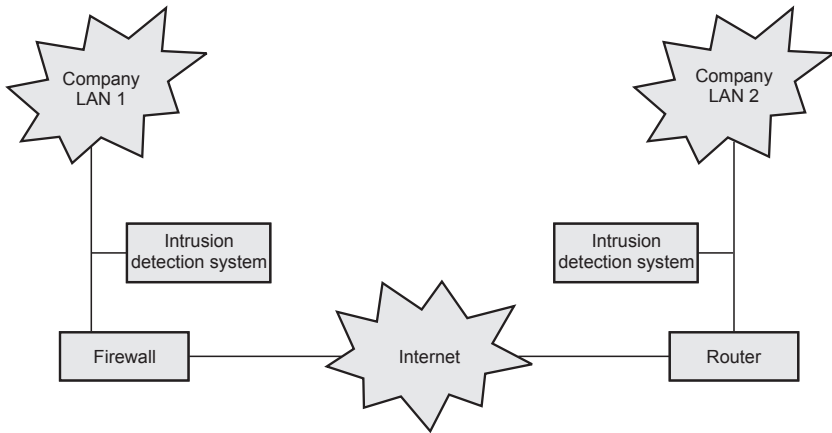
Fig. Q.30.1 IDS

- IDSs serve three essential security functions; monitor, detect and respond to unauthorized activity

- **Functions of intrusion detection systems**

1. IDS monitor and do analysis of user and system activity.

2. Auditing of system configurations and vulnerabilities.

3. Assessing the integrity of critical system and data files.

4. Recognition of activity patterns reflecting known attacks.

5. Statistical analysis for abnormal activity patterns.

- **Benefits of intrusion detection**

1. Improving integrity of other parts of the information security infrastructure.

2. Improved system monitoring.

3. Tracing user activity from the point of entry to point of exit or impact.

4. Recognizing and reporting alterations to data files.

5. Spotting errors of system configuration and sometimes correcting them.

6. Recognizing specific types of attack and alerting appropriate staff for defensive responses.

7. Keeping system management personnel up to date on recent corrections to programs.

8. Allowing non-expert staff to contribute to system security.

9. Providing guidelines in establishing information security policies.

Limitations of IDS

1. Detect attack only after they have entered the network.

2. Cannot expect to detect all malicious activity at all-time handling alert to trigger false positive or false negative alarm.

3. Cannot be integrated with filtering rules security to stop traffic from attacking.

3.6 : Common Standards : The Open Cloud Consortium

Q.31 What is Open Cloud Consortium (OCC) ?

Ans. : • The Open cloud Consortium is a 501(c)(3) non-profit venture which provides cloud computing and data commons resources to support "scientific, environmental, medical and health care research."

• The Open Cloud Consortium has four working groups, one of which is the Open Science Data Cloud (OSDC).

• The infrastructure of the OSDC has been designed to address the challenges inherent in transporting large datasets, to balance the needs of data management and data analysis, and to archive data.

• The OSDC is based on a shared community infrastructure where hardware and software are shared among researchers and projects at the scale where it is most efficient to centrally locate and process data.

- It supports the development of standards for cloud computing and frameworks for interoperating between clouds; develops benchmarks for cloud computing; and supports reference implementations for cloud computing, preferably open source reference implementations.

- The OCC has a particular focus in large data clouds. It has developed the "MalStone Benchmark" for large data clouds and is working on a reference model for large data clouds.

Q.32 Write short note on Open Virtualization format (OVF).

Ans. : • OVF is an open standard, specified by the Distributed Management Task Force (DMTF), for packaging and distributing a virtual appliance consisting of one or more virtual machines (VMs).

- An OVF Package is composed of metadata and file elements that describe virtual machines, plus additional information that is important to the deployment and operation of the applications in the OVF package. Its file extension is .ovf.

- An OVF Package always includes a descriptor file (*.ovf) and may also include a number of other files.

File type	Description
Descriptor	The descriptor specifies the virtual hardware requirements of the service and can also include other information such as descriptions of virtual disks, the service itself, and guest operating systems, a license agreement (EULA), instructions to start and stop VMs in the appliance, and instructions to install the service. The descriptor file extension is .ovf.
Manifest	The manifest is an SHA-1 digest of every file in the package, allowing the package contents to be verified by detecting any corruption. The manifest file extension is .mf.

Signature	The signature is the digest of the manifest signed with the public key from the X.509 certificate included in the package, and allows the package author to be verified. The signature file extension is .cert.
Virtual disks	OVF does not specify a disk image format. An OVF package includes files comprising virtual disks in the format defined by the virtualization product that exported the virtual disks. XenServer produces OVF packages with disk images in Dynamic VHD format; VMware products and Virtual Box produce OVF packages with virtual disks in Stream-Optimized VMDK format.

3.7 : Standards for Application Developers

Q.33 Write short note on AJAX.

Ans. : • AJAX is an acronym for Asynchronous JavaScript And XML. It is not a programming language but simply a development technique for creating interactive web applications.

• The technology uses JavaScript to send and receive data between a web browser and a web server.

• The AJAX technique makes web pages more responsive by exchanging data with a server behind the scenes, instead of reloading an entire web page each time a user makes a change.

• With AJAX, web applications can be faster, more interactive, and more user friendly.

• AJAX uses an XMLHTTPRequest object to send data to a web server, and XML is commonly used as the format for receiving server data, although any format including and plain text can be used.

• AJAX is based on Open Standards.

• Ajax is a group of interrelated web development methods used on the client-side to create interactive web applications. The name implies that XML is used.

- However, many prefer to use URL-encoded data when sending data from the client to the server and JSON as the response.

- URL-encoded data sent by JavaScript code matches HTML form data sent by a browser when a user clicks the submit button. Managing form data received from a client is very easy when using LSP. The server also includes functions that automatically create JSON from Lua tables.

- **Benefits of Ajax :**

1. **Callbacks :** Ajax is used to perform a callback, making a quick round trip to and from the server to retrieve and/or save data without posting the entire page back to the server.

2. **Making Asynchronous Calls :** Ajax allows you to make asynchronous calls to a web server.

3. **Increased Speed :** The main purpose of Ajax is to improve the speed, performance and usability of a web application.

4. **User-Friendly :** Because a page postback is being eliminated, Ajax enabled applications will always be more responsive, faster and more user-friendly.

Q.34 What is used of JSON? Explain in detail.

Ans. : • JavaScript Object Notation (JSON) is used to format data. It is commonly used in Web as a vehicle to describe data being sent between systems.

- JSON is much easier to use with JavaScript than XML. When it comes to Ajax and JavaScript, JSON Web Services are replacing XML Web Services.

- The JSON format is often used for serializing and transmitting structured data over a network connection. It is often used to transmit data between a server and web application, serving as an alternative to XML.

- JSON is based on a subset of Javascript, containing object and array. Objects contain pairs of property and value. Arrays contain values. A value could be a string, number, object array, true, false or null.

- On average, JSON requires less characters, and so less bytes, than the same data in XML. Because it uses JavaScript syntax, it requires less parsing than XML when used in Ajax Applications

Q.35 What is XML? Explain logical and physical structure.

Ans. : • XML stands for eXtensible Markup Language. It is emerging as a standard for exchanging data on the Web. It enables separation of content (XML) and presentation (XSL).

- The XML standard was created by W3C to provide an easy to use and standardized way to store self describing data.

- XML is a markup language in a standard plain text format. It contains structured or semi-structured data in verbose user-defined tags presented in a hierarchical way (tree-like structure)

- XML is not a replacement for HTM and traditional databases. XML documents are used either as a container to store semi-structured data or a media to exchange data between heterogeneous application.

- XML can be used to provide more information about the structure and meaning of the data in the Web pages rather than just specifying how the Web pages are formatted for display on the screen.

- XML provides the ability to structure, optionally validate, and transform data, allowing it to be used across various applications in a platform independent manner.

- The term "Extensible" refers to the capability of being extended while the phase "Markup Language" refers to the set of conventions used for encoding textual information.

- XML documents have both logical and physical structure. A document is built up from storage units called entities. They can contain parsed or unparsed data.

- Parsed entities contain characters that formed either character data or markups. Markups are used to encode the logical and physical structure of the document. Both structures are subject of limitations.

Logical Structure :

The document logical structure consists of declarations, elements, comments, processing instructions and character references.

• Every well-formed document contains one or more elements that form a tree hierarchy. Consequently, there is exactly one element at the highest level of the hierarchy that serves as a root for the tree. Every element has content and zero or more attributes.

Physical Structure

• Every XML document is composed of storage units called entities. An entity has a name and content. The name is used to form a reference to the entity. There are two exceptions of entities without names - the document entity and the part of the DTD that is not contained in the document.

• An entity can contain references to other entities. There is a special entity called document entity or root that serves as a main storage unit. XML processors always start document processing from that unit, which can contain the whole document.

Q.36 Explain similarities and comparison of JSON and XML

Ans. : Similarities :

• Both are human readable

• Both have very simple syntax

• Both are hierarchical

• Both are language independent

• Both can be used by Ajax

• Both supported in APIs of many programming languages

Differences :

• Syntax is different

• JSON is less verbose.

• JSON can be parsed by JavaScript's eval method.

• JSON includes arrays.

- Names in JSON must not be JavaScript reserved words.

- XML can be validated.

Q.37 What is Atom and RSS ? Where both are used ?

Ans. : Atom : • Atom is the name of an XML-based Web content and metadata syndication format, and an application-level protocol for publishing and editing Web resources belonging to periodically updated websites.

- Before the development of ATOM, RSS was the used format for web content syndication. People using RSS 2.0 felt there were considerable deficiencies in the format. RSS 2.0 was frozen and not changed.

- All Atom feeds must be well-formed XML documents, and are identified with the application/atom+xml media type.

RSS :

- RSS stands for Really Simple Syndication. It's an easy way for you to keep up with news and information that's important to you, and helps you avoid the conventional methods of browsing or searching for information on websites.

- Now the content you want can be delivered directly to you without cluttering your inbox with e-mail messages. This content is called a "feed."

- RSS is written in the Internet coding language known as XML (eXtensible Markup Language).

- RSS is a format based on XML and is used for rapid distribution of various facilities.

- RSS content can be monitored using an RSS browser or aggregator. RSS aggregator comes in the form of client application. Application can be run on personal computer or as web application accessed via web browser.

- RSS has become the standard technology for automatically publishing information to large audiences.

Q.38 How RSS readers works ?

Ans. : • Websites summarize content in an RSS feed (XML document). Visitors download an RSS reader.

• There are generally two different types of RSS readers. The first kind of feed reader is a self contained program and the second kind of feed reader uses a web browser.

• Many of the programs are free, but generally those that have a small fee are more robust. Visitors select the content and summariezes what they wish to view in a news aggregator or RSS reader.

• Content is added to the news reader by entering the URL or web address of the XML file. Clicking on the RSS link will provide the URL of the feed.

• Some RSS readers will auto-detect an XML file on a site indicating that a feed is available. Each time the feed is updated the content being viewed in the RSS reader indicates that there is new content.

• This insures that the customer has current information related to the topics they choose. Professionals estimate that RSS will soon rival e-mail's popularity as a content delivery method.

Q.39 Explain difference between RSS and Atom.

Ans. :

RSS	Atom
Real Simple Syndication (RSS) is a family of web feeds formats that are used to publish frequently updated works.	Atom refers to a pair of standards for web feeds.
RSS shows the date timestamps of data when the feed was created and last updated.	Atom shows the date timestamp when the website was last updated.
RSS has a more complicated aggregating and extracting process.	Atom has an easier aggregating and extracting process.

RSS does not distinguish a partial from an excerpt.	Atom distinguishes a partial from an excerpt.
RSS has two main publishing protocols; Blogger protocol and MetaWeblog.	Atom has one standardized protocol.

3.8 : Standards for Security in Cloud Computing

Q.40 What is OAuth ? Explain its working.

Ans. : OAuth : The latest iteration of OAuth, formalized in 2012, is the version 2.0. OAuth provides authorization to APIs

- As one can imagine, it is much more accommodating to current trends and needs in the industry.

- OAuth includes the notion of Access Token as the mechanism of choice for allowing access to restricted resources. In other words, an Access Token is the authorization issued to a client.

- OAuth has following roles:

  1. A resource server called as OAuth Provider –the entity which is hosting the resource.
  2. End User that owns the resource that is being requested.
  3. Client -OAuth Consumer-the entity requesting for resource.

- Fig. Q.40.1 shows working of OAuth.

  1. User is logged into a social network platform like Facebook (OAuth Consumer in this case) and wants to import contacts from email provider such as Gmail (OAuth Provider in this case).
  2. OAuth Consumer redirects the request to OAuth Provider to generate a request token and secret key.
  3. OAuth Provider generates request token and secret key and sends it to OAuth Consumer.
  4. OAuth Consumer asks the user to authorize and sends the user the request token received from OAuth Provider.
  5. On clicking the link, secret key is passed over to OAuth Provider using API.
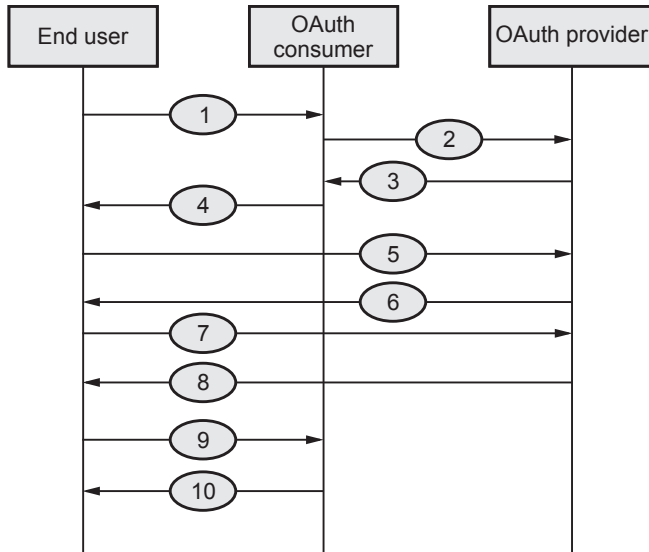
Fig. Q.40.1 OAuth working

6. OAuth Provider asks the user to authorize the OAuth Consumer to consume its data.

7. User confirms the OAuth Consumer to consume its data.

8. OAuth Provider sends user a "request token" and a "request token secret" and redirects the user to OAuth Consumer.

9. User gets redirected to OAuth Consumer with a "request token" and a "request token secret".

10. OAuth Consumer presents the "request token" and the "request token secret" and asks for user contacts.

Limitations :

1. OAuth 1.0 was vulnerable to session fixation attack.

2. OAuth 2.0 does not have native encryption capabilities.

END...✍

4 Amazon Web Services

<div style="border:1px solid black">

Important Points to Remember

- Amazon Web Services (AWS) is a cloud computing platform from Amazon that provides customers with a wide array of cloud services.

- Amazon Elastic File System provides a simple, scalable, elastic file system for Linux-based workloads for use with AWS Cloud services and on-premises resources

- Dark Web is referred to the data which are not indexed by any standard search engine such as Google or Yahoo.

- The AWS Global Infrastructure consists of multiple geographical locations which are called Regions

- The Amazon Elastic Block Store (EBS) allows AWS users to provide EC2 instances with persistent storage in the form of volumes that can be mounted at instance startup

- Amazon S3 defines a bucket name as a series of one or more labels, separated by periods.

- AWS Storage Gateway is a hybrid storage service that enables your on-premises applications to seamlessly use AWS cloud storage

- Elastic Load Balancing automatically distributes incoming application traffic across multiple Amazon EC2 instances

- VPC is the logical division of a service provider's public cloud multi-tenant architecture to support private cloud computing

</div>

4.1 Services Offered by Amazon

Q.1 What is Amazon Web Services ? List its advantages and disadvantages.

Ans. : • Amazon Web Services (AWS) is a collection of remote computing services (web services) that together make up a cloud computing platform, offered over the Internet by Amazon.com.

• AWS is a cloud computing platform from Amazon that provides customers with a wide array of cloud services.

• The AWS Cloud infrastructure is built around Regions and Availability Zones (AZs). A Region is a physical location in the world where we have multiple AZs. AZs consist of one or more discrete data centers, each with redundant power, networking, and connectivity, housed in separate facilities.

• These AZs offer you the ability to operate production applications and databases that are more highly available, fault tolerant, and scalable than would be possible from a single data center.

AWS Services

• AWS consists of many cloud services that you can use in combinations tailored to your business or organizational needs.

• With Amazon Web Services you will find a complete cloud platform ready to use for virtually any workload.

• The user requests to the server by the method such as E-mail either to register or to transfer the domain.

• Your request which includes all information will be sent to Amazon API Gateway restful service.

• API Gateway will transfer the collected user information to an AWS lambda function.

• AWS Lambda function will generate an e-mail and forward it to the 3rd party mail server using Amazon SES.

• Components of Amazon Web Service Architecture are Amazon API Gateway, AWS Lambda, Amazon Simple Email Service.

• API Gateway is a front-door to access data, business logic and functionality. API Gateway will provide a restful API endpoint for our AWS Lambda function.
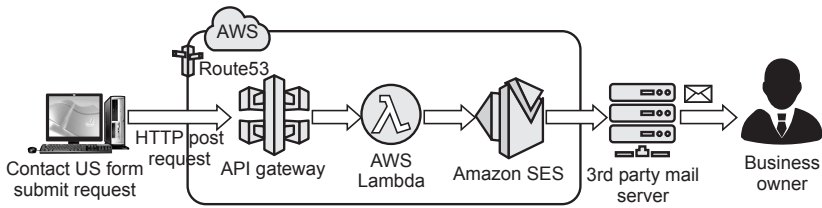
Fig. Q.1.1 AWS

- API works at small as well as large-scale and helps developers to manage, spectator, create and provide security to the API's.

- AWS Lambda is a compute service that runs your back-end code and responds to events such as object uploads to Amazon S3 bucket, Dynamo DB or in-app activity. The Lambda function will get all the information from a user through API Gateway.

- Amazon Simple Email Service helps us to send E-mail with minimal setup and maximum deliverability. It is integrated with AWS management console so that you can monitor your sending activity. Amazon Simple Email Service helps us by monitoring insecurity.

Advantages and Disadvantages of AWS

Advantages :

1. Easy to Use.

2. No Capacity Limits : Organizations launch different projects and the guess what capacity they will need.

3. Provides Speed and Agility.

4. Secure and reliable : AWS provides security and also helps to protect the privacy as it is stored in AWS data centers.

Disadvantages :

1. Limitations OF Amazon EC2 : AWS sets default limits on resources which vary from region to region. These resources consist of images, volumes, and snapshots.

2. Technical Support Fee : AWS charges you for immediate support.

3. Security Limitations.

Q.2 Explain AWE infrastructure and AWS Global infrastructure.

Ans. : AWS Infrastructure

- AWS is a secure cloud services platform, offering compute power, database storage, content delivery and other functionality to help businesses scale and grow.

- Amazon specializes in a low-margin approach to business, and it carries that perspective into AWS.

- Unlike almost every other player in the cloud computing market, Amazon has focused on creating a low-margin, highly efficient offering, and that offering starts with the way Amazon has built out its infrastructure.

- Amazon builds its hardware infrastructure from commodity components. Commodity refers to using equipment from lesser-known manufacturers who charge less than their brand name competitors.

- Amazon has created a unique, highly specialized software environment in order to provide its cloud computing services.

- The software infrastructure is based on virtualization. AWS uses the open source Xen Hypervisor as its software foundation.

- Amazon had to create a tremendous software infrastructure in order to be able to offer its computing capability as a service.

- Amazon had to provide a set of interfaces (API), to allow users to manage every aspect of AWS.

- Designed for flexibility : Amazon designed AWS to address users like itself, users that need rich computing services available at a moment's notice to support their application needs and constantly changing business conditions.

- Amazon has implemented a rich software infrastructure to allow users access to large quantities of computing resources.

AWS Global Infrastructure

- The AWS Global Infrastructure consists of multiple geographical locations which are called Regions. AWS Regions are divided up in Availability Zones which consist of one or more psychically separated data centers.

- These Regions and Availability Zones provide a way to build highly available, fault tolerant, and scalable infrastructures.

- All Availability Zones (AZs) are connected through low latency, high throughput, and highly redundant networking.

- An AWS Region is a geographic location in the world, from where Amazon operates its Cloud services, for example, the US West region, Singapore region, and EU region.

- The AWS Cloud has 18 geographic Regions and 1 Local Region, which are grouped into larger geographical areas for easy management.

- Points of Presence : Another part of the AWS Global Infrastructure are Points of Presence (POP). The POPs are used for both AWS CloudFront to deliver content to end users at high speeds. As of April 2018, there are 114 Points of Presence in 56 cities across 24 countries.

- **Availability zone** is merely a data center or a collection of data centers. Each Availability zone in a Region has separate power, networking and connectivity to reduce the chances of two zones failing simultaneously.

- No two Availability zones share a data center; however, the data centers within a particular Availability zone are connected to each other over redundant low-latency private network links.

Q.3 What is dark web ? Explain in brief.

Ans. : • The Dark Web may be used for legitimate purposes as well as to conceal criminal or otherwise malicious activities.

- Individuals can access the Dark Web by using special software such as Tor (The Onion Router).

- Tor is relies upon a network of volunteer computers to route users' web traffic through a series of other users' computers such that the traffic cannot be traced to the original user. Some developers have created tools, such as Tor2web that may allow individuals access to Tor-hosted content without downloading and installing the Tor software, though accessing the Dark Web through these means does not anonymize activity.

- While on the Dark Web, individuals may communicate through means such as secure email, web chats, or personal messaging hosted on Tor.

- The furthest corners of the Deep Web, known as the Dark Web, contain content that has been intentionally concealed. The Dark Web may be accessed both for legitimate purposes and to conceal criminal or otherwise malicious activities.

- Online content that isn't indexed by search engines belongs to what has come to be called the "Deep Web", that is, content on the World Wide Web that is hidden. Any site that suppresses Web crawlers from indexing it is part of the Deep Web.

- The Deep Web is also known as hidden Web, Undernet, Deepnet or Invisible Web.

- Fig. Q.3.1 shows layers of Internet.

- The Deep Web includes :

1. Database generated Web pages or dynamic content

2. Pages without links

3. Private or limited access Web pages and sites
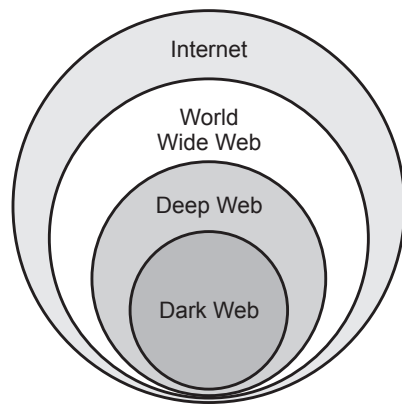
Fig. Q.3.1 Layer of Internet

4. Information contained in sources available through executable code such as JavaScript.

5. Documents and files that aren't in a form that can be searched, which includes not only media files, but information in non-standard file formats

- Content on the Deep (and Dark) Web, however, may not be caught by web crawlers for a number of reasons, including that it may be unstructured, unlinked, or temporary content. As such, there are different mechanisms for navigating the Deep Web than there are for the Surface Web.

Q.4 Write short note on AWS Ecosystem.

Ans. : • AWS ecosystem is made up of three subsystems :

1. AWS computing services provided by Amazon.

2. Computing services provided by third parties that operate on AWS.

3. Complete applications offered by third parties that run on AWS.

- **AWS computing services provided by Amazon :** Amazon provided more than 25 services and launching more all the time. AWS also provides large range of cloud computing services.

- **Computing services provided by third parties that operate on AWS :** For building applications, these services are used. For example, AWS offers some billing capability to enable users to build applications and charge people to use them, but the AWS service doesn't support many billing use cases, user-specific discounts based on the size of the company.

- **Complete applications offered by third parties that run on AWS :** User can use software as a service without installing software on his machine.

4.2 EC2 - Configuring a Server

Q.5 What is Amazon EC2? How it provides programming environment? Explain EC2 function and advantages.

Ans. : • Amazon Elastic Compute Cloud (Amazon EC2) is a web service that provides resizable compute capacity in the cloud. It is designed to make web-scale computing easier for developers and system administrators.

• The Amazon EC2 simple web service interface allows you to obtain and configure capacity with minimal friction. It provides you with complete control of your computing resources and lets you run on Amazon's proven computing environment.

• Amazon EC2 reduces the time required to obtain and boot new server instances (called Amazon EC2 instances) to minutes, allowing you to quickly scale capacity, both up and down, as your computing requirements change.

• Amazon EC2 changes the economics of computing by allowing you to pay only for capacity that you actually use. Amazon EC2 provides developers and system administrators the tools to build failure resilient applications and isolate themselves from common failure scenarios.

• EC2 allows creating Virtual Machines (VM) on-demand. Pre-configured template Amazon Machine Image (AMI) can be used get running immediately. Creating and sharing your own AMI is also possible via the AWS Marketplace.

• Amazon Machine Image (AMI) is a template for software configuration (Operating System, Application Server, and Applications). Fig. Q.5.1 shows AMI and instance.

• Instance is a AMI running on virtual servers in the cloud. Each instance type offers different compute and memory facilities. Create an Amazon Machine Image (AMI) containing your applications, libraries, data and associated configuration settings. Or use pre-configured, templated images to get up and running immediately.
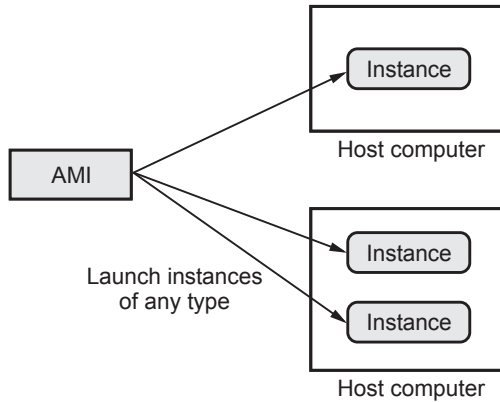
Fig. Q.5.1 AMI and instance

- Auto scaling allows automatically scale of the capacity up seamlessly during demand spikes to maintain performance and scales down during demand lulls to minimize costs.

- Elastic load balancing automatically distributes incoming application traffic across multiple Amazon EC2 instances. It provide tools to build failure resilient applications by launching application instances in separate availability zones.

- Pay only for resources actually consume, instance-hours. VM Import/Export enables you to easily import virtual machine images from your existing environment to Amazon EC2 instances and export them back at any time.

- Boto is a Python package that provides programmatic connectivity to Amazon Web Services.

launching an EC2 instance :

```
#/usr/bin/python
 import boto.ec2
conn = boto.ec2.connect_to_region("us-west-2")
conn.run_instances(
   'ami-6ac2a85a',
   key_name='nitheesh_oregon',
   instance_type='t1.micro',
```

   security_groups=['nitheesh_oregon']
)

Stop instances :

```
#/usr/bin/python
import boto.ec2
conn = boto.ec2.connect_to_region("us-west-2")
conn.stop_instances(instance_ids=['instance-id-1',
'instance-id-2'])
```

- Boto supports more than fifty Amazon services, running the whole range from compute, database, application and payments and billing.

- EC2 functions :

  1. Load variety of operating system.

  2. Install custom applications.

  3. Manage network access permission.

  4. Run image using as many/few systems as you desire.

- EC2 advantages :

  1. Amazon EC2 enables you to increase or decrease capacity within minutes.

  2. User have complete control of your Amazon EC2 instances.

  3. Support flexible cloud hosting services

  4. Secure : Amazon EC2 works in conjunction with Amazon VPC to provide security and robust networking functionality.

  5. Reliable : Amazon EC2 offers a highly reliable environment where replacement instances can be rapidly and predictably commissioned.

Q.6 Explain concept of Amazon Auto scaling.

Ans. : • Auto scaling is a service offered by Amazon Web Services that helps customers automatically adjust their Amazon EC2 capacity according to the current load. A typical use case consists of a web application served by multiple web servers that are deployed across multiple availability zones. An Elastic Load

Balancer (ELB) would distribute network traffic across this group of web servers.

- AutoScaling can be used for auto scaling IoT applications and IoT platforms deployed on Amazon EC2. Auto scaling allows user to specify a server group, called an Auto Scaling Group (ASG), in which you define :

  1. A minimum number of servers to run.

  2. A maximum number of servers to run.

  3. Optionally, an initial number of servers to run.

  4. The AZs in which you want the servers to run.
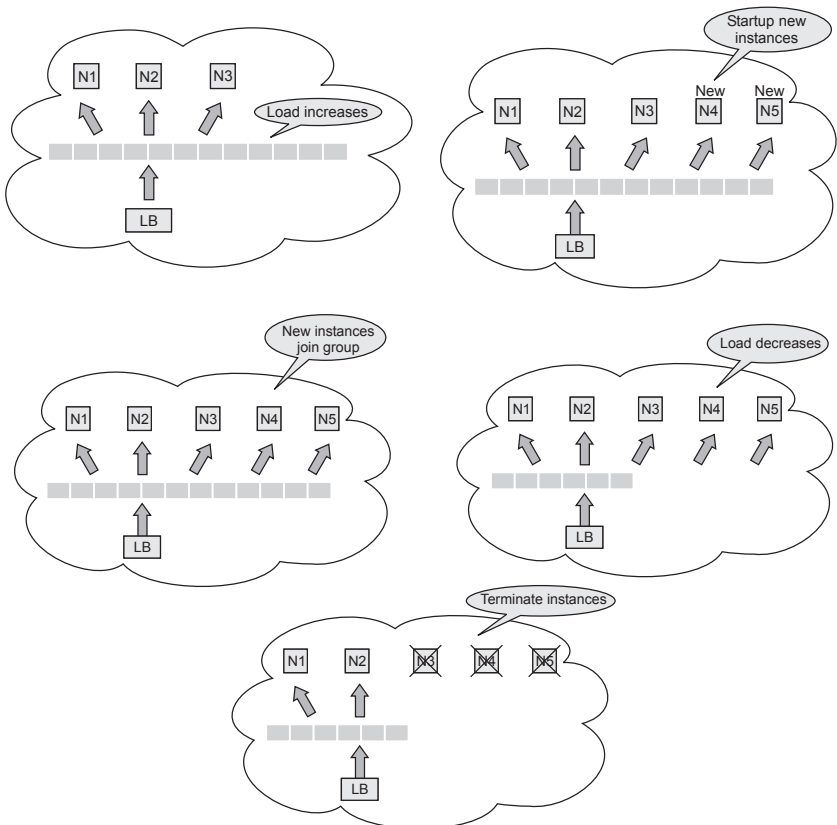
Fig. Q.6.1 Auto scaling

- Fig Q.6.1 shows concept of AutoScaling.

- Auto scaling consists of the following four components :

    1. Launch Configuration (LC) : LC tells auto scaling how to configure the EC2 instances it launches.

    2. Auto Scaling Group (ASG) : It defines where the EC2 instances described in a LC will run, what the minimum number of instances must be and what the maximum number of instances must be.

    3. Auto Scaling Policy (ASP) : Defines how an ASG should be changed, which includes whether to increase or decrease the number of EC2 instances by a certain percentage or by an exact number or to change to an exact number of EC2 instances.

    4. Scheduled Action (SA) : It is an action that is triggered at a specific time to decrease or increase the number of EC2 instances running in an ASG.

Q.7 Write short note on EUCALYPTUS.

☞ **[SPPU : Dec.-18, End Sem, Marks 6]**

Ans. : • Eucalyptus stands for Elastic Utility Computing Architecture for Linking Your Programs to Useful Systems.

- It is an open-source software framework that provides the platform for private cloud computing implementation on computer clusters.

- Eucalyptus implements infrastructure as a service (IaaS) methodology for solutions in private and hybrid clouds.

- Eucalyptus provides a platform for a single interface so that users can calculate the resources available in private clouds and the resources available externally in public cloud services.

- It is designed with extensible and modular architecture for Web services. It also implements the industry standard Amazon Web Services (AWS) API. This helps it to export a large number of APIs for users via different tools.

- The goal of Eucalyptus is to allow sites with existing clusters and server infrastructure to host a cloud that is interface-compatible with Amazon's AWS and the Sun Cloud open API.

- Eucalyptus cloud computing architecture is highly scalable because of its distributed nature. The Cloud level of the computing architecture is comprised of only two components and while used by many users, the transactions at each component are typically small.

- The Node level may have many components, but each component only supports a few users, even though the transactions are larger. This distributed cloud architecture is flexible enough to support businesses of any size.

- The Eucalyptus cloud platform pools together existing virtualized infrastructure to create cloud resources for infrastructure as a service, network as a service and storage as a service.

- Eucalyptus features include :

  1. Supports both Linux and Windows virtual machines (VMs).
  2. Application program interface- (API) compatible with Amazon EC2.
  3. Compatible with Amazon Web Services (AWS) and Simple Storage Service (S3).
  4. Works with multiple hypervisors including VMware, Xen and KVM.
  5. Can be installed and deployed from source code or DEB and RPM.
  6. Internal processes communications are secured through SOAP and WS-Security.
  7. Multiple clusters can be virtualized as a single cloud.
  8. Administrative features such as user and group management and reports.

- Fig. Q.7.1 shows Eucalyptus software architecture.

Fig. Q.7.1 Eucalptus software architecture

- The following terminology is used by Eucalyptus.

  1. Images : Any software module, configuration, application software or system software bundled and deployed in the Eucalyptus cloud is called a Eucalyptus machine image (EMI).

  2. Instances : When we run the image and use it, it becomes an instance. The controller will decide how much memory to allocate and provide all other resources.

  3. Networking : The Eucalyptus network is divided into three modes :

 a) Managed mode : In this mode, it just manages a local network of instances, which includes security groups and IP addresses.

 b) System mode : In this mode, it assigns a MAC address and attaches the instance's network interface to the physical network through the NC's bridge.

 c) Static mode : In this mode, it assigns IP addresses to instances.

  4. Access control is used to provide restriction to users. Each user will get a unique identity. All identities can be grouped and managed by access control.

5. Eucalyptus elastic block storage (EBS) provides block-level storage volumes, which we can attach to an instance.

6. Auto scaling and load balancing is used to automatically create or destroy instances or services based on requirements. CloudWatch provides different metrics for measurement.

- Cloud controller : Cloud controller (CLC) is the main controller, which manages the entire cloud platform. It provides a Web and EC2 compatible interface. All the incoming requests come through the Cloud controller.

- Walrus : This is similar to AWS S3. It provides persistent storage to all the instances. It can contain any kind of data like application data, volume or image snapshots.

- Cluster controller : This is the heart of the cluster within a Eucalyptus cloud. It manages VM (instance) execution and service level agreements. It communicates with the storage and network controller.

- Storage controller : Storage controller (SC) is similar to AWS EBS. It provides block level storage to instances and snapshots within a cluster. If an instance wants persistent storage outside of storage, then it must pass through Walrus. The storage controller doesn't handle this kind of request.

- Node controller : NC (node controller) hosts all the instances and manages their end points. There is no limit to the number of NCs in the Eucalyptus cloud. It takes images and also caches from Walrus and creates instances. One should manage the number of NCs used as it affects the performance.

4.3 Virtual Amazon Cloud & Amazon EBS

Q.8 What is a Virtual private cloud ? List its features and benefits.

Ans. : Virtual Private Clouds

- Virtual Private Cloud (VPC) is an on-demand configurable pool of shared computing resources allocated within a public cloud

environment, providing a certain level of isolation between the different organizations using the resources.

- VPC is the logical division of a service provider's public cloud multi-tenant architecture to support private cloud computing.

- This model enables an enterprise to achieve the benefits of private cloud, such as more granular control over virtual networks and an isolated environment for sensitive workloads, while still taking advantage of public cloud resources.

- Amazon Virtual Private Cloud provides a bridge between a company's existing network and the AWS cloud.

- VPC connects your network resources to a set of AWS systems over a Virtual Private Network (VPN) connection and extends security systems, firewalls, and management systems to include their provisioned AWS servers.

- Amazon VPC is integrated with Amazon EC2, but Amazon plans to extend the capabilities of VPC to integrate with other systems in the Amazon cloud computing portfolio.

- In a virtual private cloud model, the public infrastructure-as-a-service provider is responsible for ensuring that each private cloud customer's data remains isolated from every other customer's data both in transit and inside the cloud provider's network.

- This can be accomplished through the use of security policies requiring some or all of the following elements: encryption, tunneling, private IP addressing or allocating a unique Virtual Local Area Network (VLAN) to each customer.

- A virtual private cloud user can define and directly manage network components, including IP addresses, subnets, network gateways and access control policies.

AWS VPC Features

1. AWS VPC is flexible to connectivity as it can get connected to the Internet, data center based on AWS resources that one can expose publically and those which one has to keep private.

2. It privately connects to the Software as service solutions which Is supported by AWS Private link.

3. Ability to privately connect the VPCs within your own organizations and internal services across different accounts.

4. Privately connect to Virtual Private Network without using an Internet gateway.

5. Peer VPCs together to share resources across multiple virtual networks owned by the owner or other AWS accounts.

6. Using network access control list inbound and outbound access to and from individual subnets is controlled.

7. It provides a feature of security such that the data stored in Amazon S3 can only be accessed from within your Amazon VPC.

8. Using VPC peering you can connect your AWS VPC with other VPCs and access resources in the other VPCs.

Benefits of Amazon Virtual Private Cloud

1. **Secure :** It provides advanced security features, such as security groups and network access control lists, to enable inbound and outbound filtering at the instance level and subnet level.

2. **Simple :** You can create a VPC quickly and easily using the AWS Management Console.

3. **All the scalability and reliability of AWS :** Amazon VPC provides all of the same benefits as the rest of the AWS platform.

Q.9 Describe Elastic block store ? What is use of snapshots in EBS ?

Ans. : • Amazon Elastic Block Store (Amazon EBS) provides persistent block storage volumes for use with Amazon EC2 instances in the AWS Cloud.

- Each Amazon EBS volume is automatically replicated within its Availability Zone to protect you from component failure, offering high availability and durability.

- EBS volumes are highly available and reliable storage volumes that can be attached to any running instance that is in the same Availability Zone.

- EBS volumes are particularly well-suited for use as the primary storage for file systems, databases, or for any applications that require fine granular updates and access to raw, unformatted, block-level storage.

- The size of an EBS volume can be configured by the user and can range from 1 GB to 1 TB.

- The network-based EBS storage service is delivered in volumes, which can be attached to an EC2 instance and used just like a disk drive. Because a volume can become unformatted, it must have a file system installed (formatted) on it before it can be used.

- Amazon EBS is well suited to both database-style applications that rely on random reads and writes, and to throughput-intensive applications that perform long, continuous reads and writes.

- Amazon EBS encryption offers you a simple encryption solution for your EBS volumes without the need for you to build, manage, and secure your own key management infrastructure.

- When you create an encrypted EBS volume and attach it to a supported instance type, data stored at rest on the volume, disk I/O, and snapshots created from the volume are all encrypted.

- Amazon EBS encryption uses AWS Key Management Service (AWS KMS) master keys when creating encrypted volumes and any snapshots created from your encrypted volumes.

- EBS can make your applications more reliable, because the storage is separate from any specific instance.

- A large repository of public data set snapshots can be restored to EBS volumes and seamlessly integrated into AWS cloud-based applications.

- Performance metrics, such as bandwidth, throughput, latency, and average queue length, are available through the AWS Management Console.

- These metrics, provided by Amazon CloudWatch, allow you to monitor the performance of your volumes to make sure that you are providing enough performance for your applications without paying for resources you don't need.

- Amazon EBS storage costs depend on how much EBS storage, in terms of gigabyte-per-month, is provisioned in a particular account.

- While EC2 instances only accrue charges while they're running, the EBS volumes attached to instances continue to retain information and hence accrue charges, even when the instance is stopped.

- An EBS snapshot is a point-in-time backup of an EBS volume. It is a "copy" of the data on in EBS volume. EBS snapshots are billed at a lower rate than active EBS volumes.

- If an EBS block has low access volume, the active volume of this EBS block can be deleted after the information stored in EBS is copied to an EBS Snapshot.

EBS Snapshots

- Amazon EBS provides the ability to create snapshots (backups) of any EBS volume and write a copy of the data in the volume to Amazon S3, where it is stored redundantly in multiple Availability Zones.

- The volume does not need to be attached to a running instance in order to take a snapshot.

- As you continue to write data to a volume, you can periodically create a snapshot of the volume to use as a baseline for new volumes.

- These snapshots can be used to create multiple new EBS volumes or move volumes across Availability Zones. Snapshots of encrypted EBS volumes are automatically encrypted.

- When you create a new volume from a snapshot, it's an exact copy of the original volume at the time the snapshot was taken.

- EBS volumes that are restored from encrypted snapshots are automatically encrypted. The snapshots can be shared with specific AWS accounts or made public.

- When you create snapshots, you incur charges in Amazon S3 based on the volume's total size. For a successive snapshot of the volume, you are only charged for any additional data beyond the volume's original size.

- Snapshots are incremental backups, meaning that only the blocks on the volume that have changed after your most recent snapshot are saved.

Q.10 What is S3 URL ? Write S3 URL naming conventions ? Explain S3 bucket limitation.

Ans. : •The S3 protocol is used in a URL that specifies the location of an Amazon S3 bucket and a prefix to use for reading or writing files in the bucket.

S3 URL naming conventions :

- Amazon S3 defines a bucket name as a series of one or more labels, separated by periods, that adhere to the following rules :

1. The bucket name can be between 3 and 63 characters long, and can contain only lower-case characters, numbers, periods, and dashes.

2. Each label in the bucket name must start with a lowercase letter or number.

3. The bucket name cannot contain underscores, end with a dash, have consecutive periods, or use dashes adjacent to periods.

4. The bucket name cannot be formatted as an IP address (198.51.100.24).

S3 bucket limitations are as follows :

1. By default, you can create up to 100 buckets in each of your AWS accounts; limit can be increased by submitting a request to AWS.

2. Bucket Ownership is not transferable.

3. There is no limit to the number of objects that can be stored in a bucket.

4. You cannot create a bucket within another bucket.

Q.11 What is Amazon S3 ? Explain working of S3 and also list its feature.

Ans. : • Amazon S3 has a simple web services interface that you can use to store and retrieve any amount of data, at any time, from anywhere on the web. S3 can serve as a raw data store for IoT systems for storing raw data, such as sensor data, log data, audio and video data.
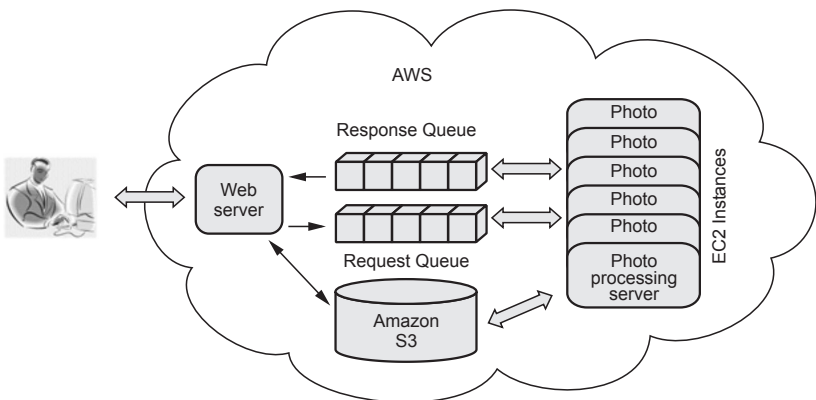
Fig. Q.11.1 Amazon S3 working

- Features :

   1. Unlimited storage.

   2. Highly scalable : In terms of storage, request rate and concurrent users.

   3. Reliable : Store redundant data in multiple facilities and on multiple devices.

   4. Secure : Flexibility to control who / how / when / where to access the data.

   5. Performance : Choose region to optimize for latency / minimize costs.

- Example : Online photo processing service.

Procedure :

1. Web server receive request.

2. Put request message in the queue.

3. Pictures stored in S3.

4. Multiple EC2 instances run photo processing.

5. Put back in the queue.

6. Return.

- Store data on Amazon's distributed system containing multiple servers within Amazon's data center locations. Amazon doesn't offer you a GUI based tool to access your data. You can use one of the several tools online or build one through APIs.

- Amazon EC2 provides three type of storage option : Amazon EBS, Amazon S3 and Instance Storage. Amazon EBS (Elastic Block Store) provides with persistent, block-level storage. Basically additional hard disk that you can attach to instance. It suitable for apps which require database, filesystem, block level storage.

- A **bucket** is a container for objects stored in Amazon S3. Every object is contained in a bucket. For example, if the object named "photos/puppy.jpg" is stored in the rakshita bucket, then it is
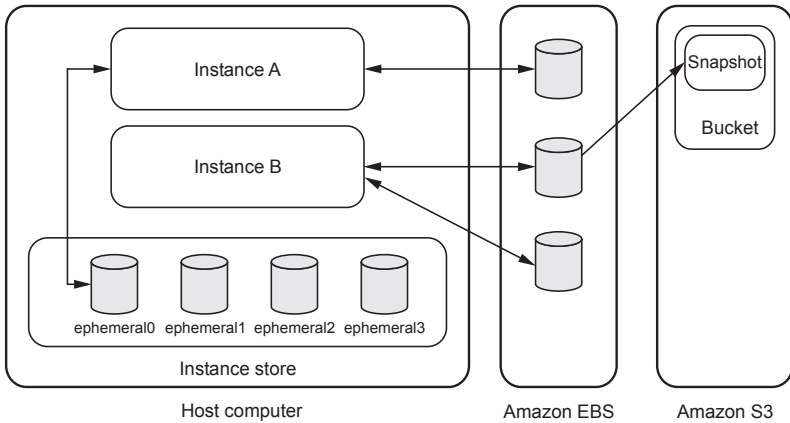
Fig. Q.11.2 Amazon EBS and S3

addressable using the URL

http://rakshita.s3.amazonaws.com/photos/puppy.jpg

- Buckets serve several purposes : They organize the Amazon S3 namespace at the highest level, they identify the account responsible for storage and data transfer charges, they play a role in access control and they serve as the unit of aggregation for usage reporting.

- **Objects** are the fundamental entities stored in Amazon S3. Objects consist of object data and metadata. The data portion is opaque to Amazon S3. The metadata is a set of name-value pairs that describe the object. These include some default metadata, such as the date last modified and standard HTTP metadata, such as content-type. You can also specify custom metadata at the time the object is stored.

- A **key** is the unique identifier for an object within a bucket. Every object in a bucket has exactly one key. Because the combination of a bucket, key and version ID uniquely identify each object, Amazon S3 can be thought of as a basic data map between "bucket + key + version" and the object itself. Every

object in Amazon S3 can be uniquely addressed through the combination of the web service endpoint, bucket name, key and optionally, a version.

- **Regions** :   You can choose the geographical region where Amazon S3 will store the buckets you create. Objects stored in a region never leave the region unless you explicitly transfer them to another region.

Q.12 Describe Amazon Elastic file system.

Ans. : • Amazon Elastic File System (Amazon EFS) provides a simple, scalable, elastic file system for Linux-based workloads for use with AWS Cloud services and on-premises resources.

- Amazon EFS is a fully managed service that requires no changes to your existing applications and tools, providing access through a standard file system interface for seamless integration.

- Amazon EFS provides file system access semantics, such as strong data consistency and file locking.

- Amazon EFS supports two forms of encryption for file systems, encryption in transit and encryption at rest.

- To access your Amazon EFS file system in a VPC, you create one or more mount targets in the VPC. A mount target provides an IP address for an NFSv4 endpoint at which you can mount an Amazon EFS file system.

- You mount your file system using its DNS name, which will resolve to the IP address of the EFS mount target in the same Availability Zone as your EC2 instance.

- You can create one mount target in each Availability Zone in a region. If there are multiple subnets in an Availability Zone in your VPC, you create a mount target in one of the subnets, and all EC2 instances in that Availability Zone share that mount target.

- After creating a file system, by default, only the root user (UID 0) has read-write-execute permissions. For other users to modify the file system, the root user must explicitly grant them access.

Benefits :

1. Dynamic Elasticity

2. Shared file storage

3. Scalable Performance

4. Cost-effective

Q.13 Explain steps to create an EBS volume using the console.

Ans. : Steps to create an EBS volume using the console

1. Open the Amazon EC2 console at https://console.aws.amazon.com/ec2/.

2. From the navigation bar, select the region in which you would like to create your volume. This choice is important because some Amazon EC2 resources can be shared between regions, while others cannot.

3. In the navigation pane, choose ELASTIC BLOCK STORE, Volumes.

4. Choose Create Volume.

5. For Volume Type, choose a volume type.

   Note : Some AWS accounts created before 2012 might have access to availability zones in us-west-1 or ap-northeast-1 that do not support Provisioned IOPS SSD (io1) volumes. If you are unable to create an io1 volume (or launch an instance with an io1 volume in its block device mapping) in one of these regions, try a different availability zone in the region. You can verify that an Availability Zone supports io1 volumes by creating a 4 GiB io1 volume in that zone.

6. For Size (GiB), type the size of the volume.

7. With a Provisioned IOPS SSD volume, for IOPS, type the maximum number of input/output operations per second (IOPS) that the volume should support.

8. For availability zone, choose the availability zone in which to create the volume. EBS volumes can only be attached to EC2 instances within the same availability zone.

9. To create an encrypted volume, select the encrypted box and choose the master key you want to use when encrypting the volume. You can choose the default master key for your account, or you can choose any customer master key (CMK) that you have previously created using the AWS Key Management Service. Available keys are visible in the Master Key menu, or you can paste the full ARN of any key that you have access to.

   Note : Encrypted volumes can only be attached to selected instance types.

10. (Optional) Choose Create additional tags to add tags to the volume. For each tag, provide a tag key and a tag value.

11. Choose Create Volume.

4.4 AWS Storage and Content Delivery Identify Key

Q.14 Describe Glacier storage service.

Ans. : • Amazon Glacier is a low-cost cloud storage service for data with longer retrieval times offered by Amazon Web Services.

• Amazon Glacier provides durable storage for any type of data format that will be accessed in three to five hours.

• Amazon Glacier stores data in archives and vaults. An archive is a block of data that may consist of a single file or aggregated data in the form of TAR or zip files.

• Glacier archives range in size from 1 byte to 40 terabytes (TB); there are no limits to how much data and how many archives an AWS user can store in Glacier.
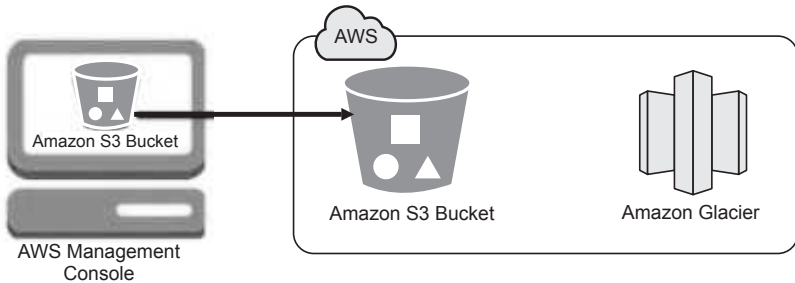
Fig. Q.14.1

- Amazon offers a multipart upload feature for higher throughput and reliability for archives over 100 MB.

- Pricing : Amazon charges per gigabyte (GB) of data stored per month on Glacier. While uploading data to Glacier is free, Amazon charges a fee for a retrieval request that's more than 5% of the customer's average monthly storage.

- **Vault** is a way to group archives together in Amazon S3 Glacier. You organize your data in Amazon S3 Glacier using vaults. Each archive is stored in a vault of your choice. You may control access to your data by setting vault-level access policies using the AWS Identity and Access Management (IAM) service

Amazon S3 Glacier :

- Amazon S3 Glacier is an extremely low-cost storage service that provides secure, durable, and flexible storage for data backup and archival.

- With Amazon S3 Glacier, customers can reliably store their data for as little as $0.004 per gigabyte per month.

- Amazon S3 Glacier enables customers to offload the administrative burdens of operating and scaling storage to AWS, so that they don't have to worry about capacity planning, hardware provisioning, data replication, hardware failure detection and repair, or time-consuming hardware migrations.

Q.15 What is AWS Storage Gateway ?

Ans. : • AWS Storage Gateway is a hybrid storage service that enables your on-premises applications to seamlessly use AWS cloud storage.

• User can use the service for backup and archiving, disaster recovery, cloud data processing, storage migration.

• The service helps to reduce and simplify datacenter and branch or remote office storage infrastructure. User applications connect to the service through a virtual machine or hardware gateway appliance using standard storage protocols, such as NFS, SMB and iSCSI.

• The gateway connects to AWS storage services, such as Amazon S3, Amazon Glacier, Amazon EBS, and AWS Backup, providing storage for files, volumes, snapshots, and virtual tapes in AWS.

• The service includes a highly-optimized data transfer mechanism, with bandwidth management, automated network resilience, and efficient data transfer, along with a local cache for low-latency on-premises access to your most active data.

4.5 AWS Load Balancing & Elastic Load Balancer

Q.16 Explain AWS Elastic load balancer with its types.

Ans. : • Elastic Load Balancing automatically distributes incoming application traffic across multiple Amazon EC2 instances. It enables you to achieve greater levels of fault tolerance in your applications, seamlessly providing the required amount of load balancing capacity needed to distribute application traffic.

• It can dynamically grow and shrink the load-balancing capacity to adjust to traffic demands and also support sticky sessions to address more advanced routing needs.

• ELB ensures that client requests are sent to the appropriate servers and avoiding any server hotspots.

- It supports load balancing of HTTP, HTTPS and TCP traffic to EC2 instances. It also detects and removes failing instances.

- Dynamically grows and shrinks based on traffic and integrates with Auto Scaling.

- Elastic Load Balancing supports three types of load balancers : Application Load Balancers, Network Load Balancers, and Classic Load Balancers.

1.Classic Load Balancers

- Classic Load Balancing, which analyzes basic network and application data and ensure fault tolerance if one of the EC2 instances running web application happens to fail.

- Classic Load Balancers distribute upcoming traffic to different EC2 instances in multiple Availability Zones. During this process, there is a chance of the fault tolerance of your application.

- These Load Balancers detect healthy and unhealthy instance and direct the traffic towards only healthy ones. It also helps in a way such that without disrupting the flow of requests to your application you can add or remove instances from your load balancers as your need changes.

- Your load balancer serves as a single point of contact for clients. This increases the availability of your application.

- You can add and remove instances from your load balancer as your needs change, without disrupting the overall flow of requests to your application

- Health checks can be monitored so that the load balancer only sends requests to the healthy instances.

2.Application Load Balancers

- Application Load Balancing, which looks at content request and routes traffic to the appropriate container or micro-service based on the Application content information.

- Application Load Balancer is best suited for load balancing of HTTP and HTTPS traffic and provides advanced request routing targeted at the delivery of modern application architectures, including micro-services and containers.

- Operating at the individual request level (Layer 7), Application Load Balancer routes traffic to targets within Amazon Virtual Private Cloud (Amazon VPC) based on the content of the request.

- The User can analyze the rules of the listener and can modify it by sending it to different target groups based on the content of the application traffic even when the target is associated with multiple target groups.

- Benefits of Application Load balancers :

  a) Load Balancer's performance improve in Application Load Balancer.

  b) Access logs containing information compress such that they may not require the additional space.

  c) Provides benefit for registering targets by IP address, including targets outside the VPC for the load balancer.

3. Network Load Balancer

- Network Load Balancer is best suited for load balancing of TCP traffic where extreme performance is required.

- Operating at the connection level (Layer 4), Network Load Balancer routes traffic to targets within Amazon Virtual Private Cloud (Amazon VPC) and is capable of handling millions of requests per second while maintaining ultra-low latencies.

- Network Load Balancer is also optimized to handle sudden and volatile traffic patterns.

- Benefits of Network Load Balancers -

  a) NLB Provides the Support for static IP addresses for the load balancer.

  b) Provides support for registering targets by IP address which includes target outside the VPC for the Load Balancer.

c) Provides support for monitoring the health of each service independently

Q.17 Explain benefits of Elastic load balancer.

Ans. :

1. **Highly available :** It automatically distributes incoming traffic across multiple targets - Amazon EC2 instances, containers, and IP addresses - in multiple Availability Zones and ensures only healthy targets receive traffic.

2. **Secure :** Elastic Load Balancing works with Amazon Virtual Private Cloud (VPC) to provide robust security features, including integrated certificate management, user-authentication, and SSL/TLS decryption.

3. **Elastic :** Elastic Load Balancing is capable of handling rapid changes in network traffic patterns.

4. **Flexible :** It allows you to use IP addresses to route requests to application targets. This offers you flexibility in how you virtualize your application targets, allowing you to host more applications on the same instance.

5. **Robust monitoring and auditing :** Elastic Load Balancing allows you to monitor your applications and their performance in real time with Amazon CloudWatch metrics, logging, and request tracing.

6. **Hybrid load balancing :** Elastic Load Balancing offers ability to load balance across AWS and on-premises resources using the same load balancer. This makes it easy for you to migrate, burst, or failover on-premises applications to the cloud.

Q.18 Describe Amazon RDS.

Ans. : • Amazon Relational Database Service (RDS) is a web service that makes it easy to set up, operate and scale a relational database in the cloud. RDS gives access to the capabilities of a familiar MySQL, Oracle or Microsoft SQL Server database engine. Code, applications and tools already used with existing databases can be used with RDS.

- Amazon RDS is just a replacement to running your own database server. With a simple sequence of commands at the console, you can choose from two commercial DBMS (Oracle or Microsoft SQL Server) or two open source DBMS (MySQL or PostgreSQL).

- Amazon RDS automatically patches the database software and backs up the database, storing the backups for a user-defined retention period and enabling point-in-time recovery.

- Amazon RDS provides scaling the compute resources or storage capacity associated with the Database Instance.Pay only for the resources actually consumed, based on the DB Instance hours consumed, database storage, backup storage and data transfer.

- On-Demand DB Instances let you pay for compute capacity by the hour with no long-term commitments. Reserved DB Instances give the option to make a low, one-time payment for each DB Instance and in turn receive a significant discount on the hourly usage charge for that DB Instance.

- Amazon RDS provides you six familiar database engines to choose from, including Amazon Aurora, PostgreSQL, MySQL, MariaDB, Oracle and Microsoft SQL Server.

- Create the actual RDS instance :

```
instance = conn.create_dbinstance ( id=identifier,
instance_class="db." + instance_class,
allocated_storage=allocated_storage,
    engine=engine,    db_name=db_name,
master_username=master_username,
master_password=master_password,
    db_subnet_group_name=identifier,
vpc_security_groups=security_groups, port=port)
```

Advantages :

1. Fast and easy to administer : Amazon RDS makes it easy to go from project conception to deployment.

2. Available and durable : Amazon RDS runs on the same highly reliable infrastructure used by other Amazon Web Services.

3. Highly scalable : You can scale your database's compute and storage resources.

4. Secure : Amazon RDS makes it easy to control network access to your database.

END...✍

5 Ubiquitous Clouds and the Internet of Things

Important Points to Remember

- Ubiquitous cloud computing refers to the use of Internet esources at any place and any time for any objectives.

- Nebula is an open-source cloud computing platform.

- SGI is a global leader in large-scale clustered computing, high performance storage, HPC and data center enablement and services.

- Mashup is a Web page or application that uses and combines data, presentation or functionality from two or more sources to create new services.

- A cloudlet is a mobility-enhanced small-scale cloud data center.

- FutureGrid is more than a Cloud; it is a general **distributed Sandbox**; a cloud grid HPC testbed.

- Every sensor node is equipped with a transducer, microcomputer, transceiver and power source.

- RFID is an Automatic Data Capture technology that uses radio-frequency waves to read a movable item to identify, categorize and track.

- Cyber-physical system(CPS) is an embedded system which integrates the computing process with the physical world as an interactive and intelligent system.

5.1 Cloud Trends in Supporting Ubiquitous Computing

Q.1 What is Ubiquitous computing ? Explain about IBM cloud project.

Ans. : • Ubiquitous computing is the method of enhancing computer use by making many computers available throughout the physical environment, but making them effectively invisible to the user.

- Ubiquitous cloud computing refers to the use of Internet resources at any place and any time for any objectives.

- IBM cloud platforms are mostly built with IBM server clusters supported by IBM WebSphere. IBM Ensembles offer a virtualized cloud system for IaaS services. This system can put together a large resource pool to simplify management complexity.

- The purpose is to offer application flexibility and efficient resource deployment through dynamic server, storage, and network ensembles.

- IBM also developed the Tivoli Service Automation Manager (TSAM) for rapid design, deployment, and man-agement of service processes.

- WebSphere CloudBurst (WCA) is another platform for managing private clouds. IBM LotusLive offers an SaaS cloud for application service development. The services include an online conference service, coordinated office management, and e-mail services.

IBM Blue Cloud System

- In November 2007, IBM announced the Blue Cloud Project based on open standards and open source software. The project is supported by more than 200 IBM web-scale researchers worldwide.

- Blue Cloud combines several existing software and virtualization packages on a specifically designed IBM hardware server platform.

- Open source and private software is combined to form the cloud computing environment. The Blue Cloud is built with x-servers, that are very similar to x86 processors.

- Linux runs on these servers supported by XEB-based virtualization software.

Q.2 Write short note on NASA's Nebula Cloud.

Ans. : • Nebula is an open-source cloud computing platform that was developed to provide an improved alternative to building additional expensive data centers and to provide an easier way for NASA scientists and researchers to share large, complex data sets with external partners and the public.

- Nebula is an excellent example of how NASA is championing ongoing partnerships with private industry and academia.

- Each component of the Nebula platform will be available individually, serving SaaS, PaaS, and IaaS needs across the agency.

- NASA will use Nebula for mission support, education, and public outreach and to encourage collaboration and public input.

- Nebula will provide NASA with an easy, efficient, and secure way to interact and share data with the public.

- Nebula is available to NASA's internal project groups and its research and academic partners. It is not available for use by private industry or the general public.

- Nebula's architecture is designed from the ground up for interoperability with commercial Cloud service providers such as Amazon Web Services, offering NASA researchers the ability to easily port data sets and code to run on commercial Clouds.

Q.3 Explain properties of High Performance Computing (HPC) cloud.

Ans. : • HPC clouds are viewed as having the following properties :

1. **Web Service-Based :** All resources from data storage to cluster job management are done via self-describing Web services.

2. **Virtualization :** For flexibility, cloud computing will require the use of virtualization.

3. **Clusters Are Provided On-Demand :** Clients should be able to specify requirements and then discover an existing cluster for immediate use

4. **Guaranteed Performance :** Typically, if cluster nodes are allocated to clients, all nodes are expected to be within close proximity to each other.

5. **Use the Pay as You Go Model :** All HPC clients are billed for the resources they use and amounts thereof.

Q.4 Explain challenges for HPC cloud.

Ans. : • Challenges are listed below :

1. **Interface Challenges :** Most cloud and cluster solutions offer command line interfaces but rarely (if at all) present graphical interfaces. Even when provided, graphical interfaces tend to act as command line wrappers.

2. **Performance Challenges :** At the very least, a cluster hosted in a cloud should run applications as fast than existing physical clusters. Currently, there is no mechanism in place to evaluate performance factors such as current CPU utilization and network IO.

3. **Communication Challenges :** A common issue with clouds is their network performance, e.g., EC2. Network performance cannot be solved by using an Infiniband network alone. There is still the issue of network topologies within clouds. Even if a cloud is hosted within a single location, the virtualized nature of clouds may cause a single cluster to be hosted across multiple systems.

4. **Intelligence Challenges :** While cloud computing offers resources as a utility, they are not always intelligent when allocating resources to clients.

5. **Configuration Challenges :** As well as providing clusters in clouds, it has to be possible to reconfigure the specifications of existing clusters for different types of cluster applications.

6. **SLA Challenges :** One of the most difficult challenges is forming and maintaining agreements between clients and services.

7. **Workflow :** The final challenge when creating HPC clouds is supporting client workflows. Not all HPC problems are processed using a single application; some problems require a chain of multiple different applications.

Q.5 Write short note on SGI Cyclone Cloud for High-Performance Computing.

Ans. : • SGI is a global leader in large-scale clustered computing, high performance storage, HPC and data center enablement and services.

• SGI has developed a cluster named Cyclone based on their specific super computer technology. This system is based on a specific shared memory model, which enables to reach a large amount of shared resources.

• This IT system offer a direct access to the hardware with dedicated improvement provided by SGI compute nodes.

• Cyclone is an on-demand cloud computing service specifically dedicated to technical applications. It supports a number of leading application partners and five technical domains, including computational fluid dynamics, finite element analysis, computational chemistry and materials, computational biology, and ontology.

• Cyclone is available in two service models: SaaS and IaaS.

• With the SaaS model, Cyclone customers can significantly reduce time to results by accessing leading-edge open source applications and best-of-breed commercial software platforms from top independent software vendors.

• The IaaS model enables customers to install and run their own applications.

Q.6 Explain difference between HPC and Cloud.

Ans. :

HPC	Cloud
HPC size is small to medium.	Cloud size is small to large.
HPC uses homogeneous resources.	Cloud uses heterogeneous resources.
Initial capital investment cost is high.	Initial capital investment cost is low.
Network type is private .	Network type is public.
SLA requirement is very strict.	SLA requirement is low.

Q.7 What is mashup ? Explain different types of mashup.

Ans. : • Mashup is a Web page or application that uses and combines data, presentation or functionality from two or more sources to create new services.

• The term implies easy, fast integration, frequently using open APIs and data sources to produce enriched results that were not necessarily the original reason for producing the raw source data.

• The main characteristics of the mashup are combination, visualization, and aggregation. It is important to make existing data more useful, moreover for personal and professional use.

• Mashup composition tools are usually simple enough to be used by end-users. They generally do not require programming skills and rather support visual wiring of GUI widgets, services and components together.

• Mashup Architecture is 3-tier architecture.

• Presentation : Mashups are almost always presented visually, in portals or portal-like applications.

• Mashup Infrastructure : Technology for accessing, assembling, and processing mashups, as well as ultimately serving them to applications.

• Information Sources : Virtually anything that is a 'service' can be an information source for a mashup. This includes internal

databases, flat files, Java objects, Web Services and REST and external RSS feeds.

- Mashups all share three salient characteristics :

1. They draw on sources of data directly on the web.

2. They transform, combine, and re-transform this data to create innovative new outputs. Maps and timeline displays are typical mashup output formats.

3. They can usually be done in a few hours. That means that the transformations are created rapidly in a high-productivity environment.

Types of Mashup :

- **Consumer mashup** is an application that combines data from multiple public sources within a browser and organizes it through a simple browser user interface.

- An **enterprise mashup**, also often called a business mashup, is an application that combines data from multiple internal and public sources, and publishes the results to enterprise portals, application development tools, or as a service in a service-oriented architecture.

- A **data mashup**, opposite to the consumer mashups, combine similar types of media and information from multiple sources into a single representation. The combination of all these resources create a new and distinct Web service that was not originally provided by either source.

Q.8 What is cloudlet ?

Ans. : • A cloudlet (also called micro data center) is a new architectural element that arises from the convergence of mobile computing and cloud computing. It represents the middle tier of a 3-tier hierarchy: mobile device - cloudlet - cloud.

- A cloudlet is a mobility-enhanced small-scale cloud datacenter. The main purpose of the cloudlet is supporting resource-intensive

and interactive mobile applications by providing powerful computing resources to mobile devices with lower latency.

• It builds on standard cloud technology.

Q.9 Explain Pros and Cons of the Mashup.

Ans. : Pros :

1. Mashups allow for the reuse of existing applications.

2. They also allow for rapid application development.

3. Development of a mashup does not necessarily involve extensive IT skills.

4. The associated cost of application development is greatly reduced.

5. Applications are better tailored to users' needs.

Cons :

1. A user might have no control over the quality and features of the content.

2. Even if reliability of the content source is established, a potential problem is scalability.

3. The integrity of the content can not be guaranteed either.

4. Most data sources are not yet built on a service-oriented architecture (SOA).

5. Only software that can be accessed with a web browser can be included in a mashup.

Q.10 What are the differences between local cloudlets and distant clouds ?

Ans. :

Local cloudlets	Distant clouds
It support only soft state.	It support soft state and hard state.
Decentralized ownership by local business	Centralized ownership by Amazon, Yahoo etc.

Bandwidth/network sharing is in between few number of users.	Internet bandwidth sharing in between 100 to 1000 uses at a time.
Self management	Professional administration is required.
Data center in a box at business premises as an environment	Machine room with power condition and cooling

Q.11 Explain in brief mobile cloud computing with architecture. Also given example, advantages and disadvantages.

Ans. : • One of the main benefits of cloud computing is reducing downtime and wasted expenditure for servers and other computer equipment. A given company is required to purchase the minimum amount of hardware necessary to handle the maximum points of stress on their system.

• Given situations where the strain and traffic are highly variable this leads to wasted money. For example, Amazon.com, a pioneer in cloud computing, at times used as little as 10% of their capacity so that they would have enough capacity to deal with those rarer high strain times.

• *Mobile Cloud Computing (MCC)* at its simplest, refers to an infrastructure where both the data storage and data processing happen outside of the mobile device.

Smart mobile device   Wireless network technology   Computational cloud
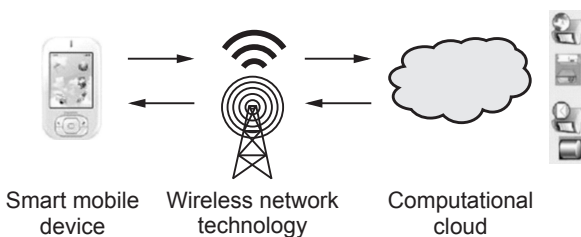
Fig. Q.11.1 Block diagram of mobile cloud

• Mobile cloud applications move the computing power and data storage away from mobile phones and into the cloud, bringing applications and mobile computing to not just smart phone users but a much broader range of mobile subscribers".

- Mobile cloud applications move the computing power and data storage away from the mobile devices and into powerful and centralized computing platforms located in clouds, which are then accessed over the wireless connection based on a thin native client.

- Mobile devices face many resource challenges (battery life, storage, bandwidth etc.). Cloud computing offers advantages to users by allowing them to use infrastructure, platforms and software by cloud providers at low cost and elastically in an on-demand fashion.

- Mobile cloud computing provides mobile users with data storage and processing services in clouds, obviating the need to have a powerful device configuration (e.g. CPU speed, memory capacity), as all resource-intensive computing can be performed in the cloud.

- Fig. Q.11.2 shows mobile cloud computing architecture.
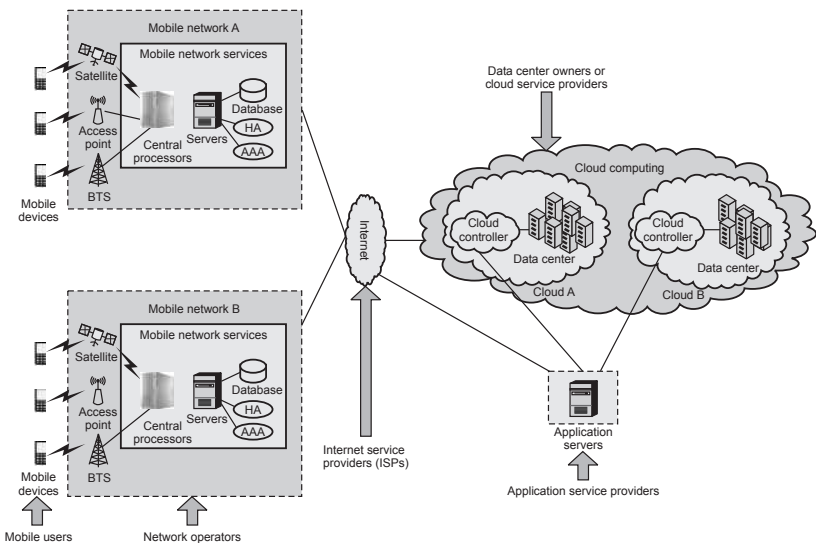
Fig. Q.11.2 Mobile cloud computing architecture

- In mobile cloud computing mobile network and cloud computing are combined, thereby providing an optimal services for mobile clients. Cloud computing exists when tasks and data are kept on individual devices. Applications run on a remote server and then sent to the client.

- Here the mobile devices are connected to the mobile networks through the base stations; they will establish and control the connections (air interface) and functional interfaces between the mobile networks and mobile devices.

- Mobile users send service requests to the cloud through a web browser or desktop application. The information's are transmitted to the central processors that are connected to the servers providing mobile network services. Here, services like AAA (Authentication, Authorization and Accounting) can be provided to the users based on Home Agent (HA) and subscriber's data stored in databases.

- Mobile devices are connected to the mobile networks via base stations that establish and control the connections and functional interfaces between the networks and mobile devices.

- Mobile users' requests and information are transmitted to the central processors that are connected to servers providing mobile network services.

- The subscribers' requests are delivered to a cloud through the Internet.

- In the cloud, cloud controllers process the requests to provide mobile users with the corresponding cloud services.

Advantages :

1. Saves battery power

2. Makes execution faster

3. Improves data storage capacity and processing power

4. Improves reliability and availability:Keeping data and application in the clouds reduces the chance of lost on the mobile devices.

5. Dynamic provisioning: Dynamic on-demand provisioning of resources on a fine-grained, self-service basis

Disadvantages :

1. Must send the program states (data) to the cloud server.

2. Network latency can lead to execution delay.

5.2 Performance of Distributed Systems and the Cloud

Q.12 What is FutureGrid ? List goals of FutureGrid. Explain essential and different features of FutureGrid.

Ans. : • FutureGrid is not a production system, but rather an environment supporting a flexible development and testing platform for middleware and application users looking at interoperability, functionality, and performance issues.

• FutureGrid will make it possible for researchers to conduct experiments by submitting an experiment plan that is then executed via a sophisticated workflow engine, preserving the provenance and state information necessary to allow reproducibility.

• Rather than loading images onto VM's, FutureGrid supports Cloud, Grid and Parallel computing environments by provisioning software as needed onto "bare-metal" or VM's/Hypervisors using (changing) open source tools.

• Essential and Different features of FutureGrid :

1. Unlike many clouds such as Amazon and Azure, FutureGrid allows **robust reproducible** .

2. FutureGrid is more than a Cloud; it is a general **distributed Sandbox;** a cloud grid HPC testbed.

3. Supports 3 different **IaaS environments** (Nimbus, Eucalyptus, OpenStack)

4. Supports **research on cloud tools,** cloud middleware and cloud-based systems as well as **use of clouds** in applications

5. FutureGrid has developed middleware and interfaces for **Computing TestbedaaS** e.g. Phantom (cloud user interface) Vine (virtual network) RAIN (deploy systems) and security/metric integration.

6. FutureGrid has experience in **running cloud systems.**

Q.13 What lessons learnt from FutureGrid ?

Ans. : • Unexpected major use from Computer Science and Middleware
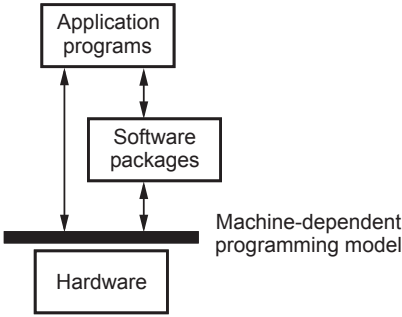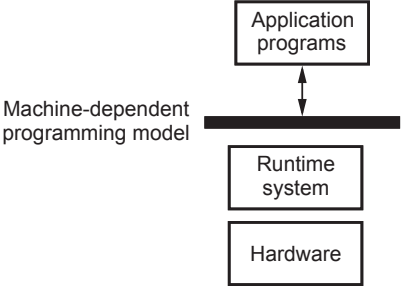
• Rapid evolution of Technology like   Eucalyptus, Nimbus, OpenStack

• Open source IaaS maturing as in "Paypal To Drop VMware From 80,000 Servers and Replace It With OpenStack" (Forbes) eBay to switch broadly?

• Need interactive not batch use; nearly all jobs short

• Substantial "TestbedaaS" technology needed and FutureGrid developed

• Lessons more positive than DoE Magellan report   but goals different

• Still serious performance problems in clouds for networking and device (GPU) linkage; many activities outside FG addressing

• One can get good Infiniband performance (MPI) on a peculiar OS + Mellanox drivers but not general yet

• We identified characteristics of "optimal hardware"

• Run system with integrated software (computer science) and systems administration team

• Build Computer Testbed as a Service Community

Q.14 What is data-intensive scalable computing ? How it is different from conventional supercomputer ?

Ans. : • Data-intensive computing is a class of parallel computing applications which use a data parallel approach to process large volumes of data typically terabytes or petabytes in size and typically referred to as big data.

• Data-intensive computing platforms typically use a parallel computing approach combining multiple processors and disks in large commodity computing clusters connected using high-speed communications switches and networks which allows the data to be partitioned among the available computing resources and processed independently to achieve performance and scalability based on the amount of data.

• Difference between conventional supercomputer and data intensive scalable computing:

Conventional Supercomputers	Data-Intensive Scalable Computing
An HPC system by which data is retrieved from remote sites and brought into the system for execution. Heavy data movement overhead	An HTC data-center cluster which collects and maintains data. Computation collocated with storage for faster access.
Heavy data movement overhead.	No data movement overhead
Machine-dependent programs written at a very low level. Use fewer software tools; need specialists to optimize	Machine-independent application programs on data. Use runtime system controls to optimize execution through load balancing, etc
Main machine for batch processing when resources are ready. Uses offline visualization at remote site	Interactive access with priority control and user intervention over large number of users simultaneously
Brittle systems with which to recover from most recent checkpoint.	Flexible error detection and recovery

Must bring down system for maintenance	Use redundancy techniques to enter graceful degraded operations in case of failure
Application programs → Software packages → Hardware (Machine-dependent programming model)	Application programs → (Machine-dependent programming model) Runtime system Hardware

Q.15 Explain performance metrics for HPC/HTC systems.

Ans. : • Performance metrics are throughput, multitasking scalability, availability measure, data security, and cost-effectiveness.

1. System throughput measures the number of jobs that can be done per unit of time. The throughput measure is attributed to several key factors that affect the total execution time of all jobs processed in a given time window.

2. Multitasking Scalability : Multitasking implies the use of a system to handle many jobs simultaneously or concurrently. System services should be able to scale both horizontally across the machine or cluster size and vertically from applications to middleware, runtime and OS support, and hardware.

3. System Availability : System availability (λ) refers to the percentage of time the system is up and running normally. This percentage reflects the effects of downtime after unexpected failures and scheduled maintenance for software upgrades.

4. Cloud security is attributed to user confidentiality, data integrity, access control, firewalls, IDSes, defense capability.

5. Cost Effectiveness : This refers to the estimate of an effective scale of economy achievable by a given system.

5.3 Enabling Technologies for the Internet of Things (RFID, Sensor Networks and ZigBee Technology, GPS)

Q.16 What is Internet of Things? Explain characteristics of IoT.

Ans. : • The Internet of Things (IoT) is the network of physical objects i.e. devices, vehicles, buildings and other items embedded with electronics, software, sensors, and network connectivity that enables these objects to collect and exchange data.

• **WSIS 2005 Definition :** By embedding short-range mobile transceivers into a wide array of additional gadgets and everyday items, enabling new forms of communication between people and things, and between things.

• A phenomenon which connects a variety of things. Everything that has the ability to communicate.

• The Internet of Things is the intelligent connectivity of physical devices driving massive gains in efficiency, business growth, and quality of life.

• The Internet of Things refers to the capability of everyday devices to connect to other devices and people through the existing Internet infrastructure. Devices connect and communicate in many ways. Examples of this are smart phones that interact with other smart phones, vehicle-to-vehicle communication, connected video cameras, and connected medical devices. They are able to communicate with consumers, collect and transmit data to companies, and compile large amounts of data for third parties.

• IoT data differs from traditional computing. The data can be small in size and frequent in transmission. The number of devices, or nodes, that are connecting to the network are also greater in IoT than in traditional PC computing.

• Machine-to-Machine communications and intelligence drawn from the devices and the network will allow businesses to automate certain basic tasks without depending on central or cloud based applications and services.

• The smart object is the building block of the IoT vision. By putting intelligence into everyday objects, they are turned into

smart objects able not only to collect information from the environment and interact /control the physical world, but also to be interconnected, to each other, through Internet to exchange data and information.

Characteristics of the Internet of Things

1. **Interconnectivity :** Everything can be connected to the global information and communication infrastructure.

2. **Heterogeneity :** Devices within IoT have different hardware and use different networks but they can still interact with other devices through different networks.

3. **Things-related services :** Provides things-related services within the constraints of things, such as privacy and semantic consistency between physical and virtual thing.

4. **Dynamic changes :** The state of a device can change dynamically.

Q.17 Explain architecture of the Internet of Things.

Ans. : • The IoT system is an event-driven architecture. Fig. Q.17.1 shows architecture of IoT.
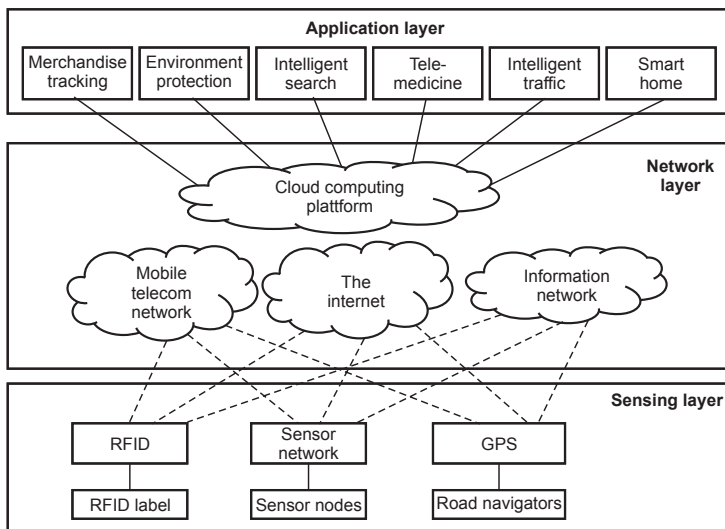
Fig. Q.17.1 IoT architecture

- The top or first layer is the IOT application layer which contains the application user interface.

- Application layer is at the top of the architecture and is responsible for delivery of various applications to different users in IoT.

- The applications can be from different industry segments such as: manufacturing, logistics, retail, environment, public safety, healthcare, food and drug etc.

- With the increasing maturity of RFID technology, numerous applications are evolving which will be under the umbrella of IoT.

- The bottom layers represent various types of sensing devices: namely RFID tags, ZigBee or other types of sensors, and road-mapping GPS navigators.

- The sensing devices are locally or wide-area-connected in the form of RFID networks, sensor networks, and GPSes. Signals or information collected at these sensing devices are linked to the applications through the cloud computing platforms at the middle layer.

- The signal processing clouds are built over the mobile networks, the Internet backbone, and various information networks at the middle layer.

- The sensors enable the interconnection of the physical and digital worlds allowing real-time information to be collected and processed. The sensors have the capacity to take measurements such as temperature, air quality, movement and electricity.

- Sensors are grouped according to their unique purpose such as environmental sensors, body sensors, home appliance sensors and vehicle telemetric sensors, etc.

- Many of these hardware elements provide identification and information storage (e.g. RFID tags), information collection (e.g.

sensors), and information processing (e.g. embedded edge processors).

Q.18 What is RFID and RFID tag ? Explain working of RFID.

Ans. : • Radio-Frequency Identification (RFID) is an Automatic Data Capture technology that uses radio-frequency waves to read a movable item to identify, categorize and track.

• It is fast and does not require physical sight or contact between reader/scanner and the tagged item.

• It performs the operation using low cost components. It attempts to provide unique identification and backend integration that allows for wide range of applications.

• RFID tags contain at least two major parts. One is an integrated circuit for storing and processing information, modulating and demodulating a radio-frequency (RF) signal, and other special functions. The other part is an antenna for receiving and transmitting the radio signals.

• Tags can be read-only or read-write. Tag memory can be factory or field programmed and optionally permanently locked (security). Data written to the tag left unlocked, can be modified over more than 100,000 times, allowing the the tag to be reused or updated.

• Major components of RFID hardware :

1. **RFID tag :** A tiny silicon chip attached to a small antenna.

2. **Reader antenna :** It used to radiate the energy and then capture the return signal sent back from the tag.

3. **Reader :** The device station that talks with the tags. A reader may support one or more antennae.

• Fig. Q.18.1 shows working of RFID.

• In the active RFID system, the reader sends signal to the tag using an antenna. The tag receives this information and resends this information along with the information in its memory.
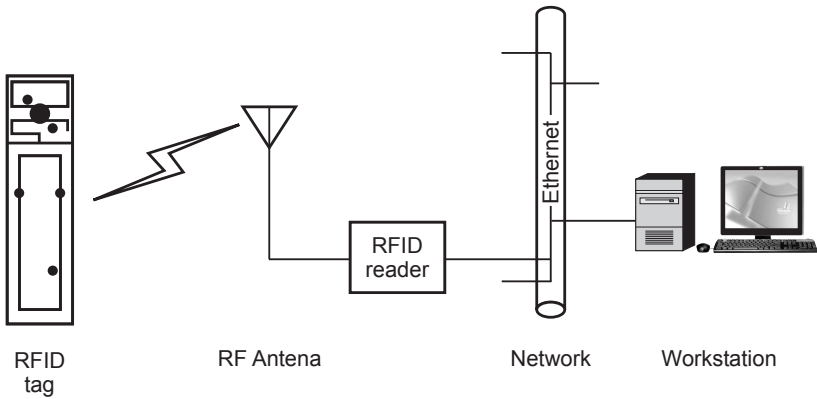
Fig. Q.18.1 RFID working

- The reader receives this signal and transmits to the processor for further processing.

- Processor or a Controller: It can be a host computer with a Microprocessor or a microcontroller which receives the reader input and process the data.

- Active and semi-passive RFID tags use internal batteries to power their circuits. An active tag can also use its own battery to broadcast radio waves to a reader, whereas a semi-passive tag relies on the reader to supply its power for broadcasting.

- Active and semi-passive tags are reserved for reading over 30 to 100 meters, if repeater batteries are used to boost a tag's range.

- **Types of RFID Systems :**

1. **Active RFID system :** These are systems where the tag has its own power source like any external power supply unit or a battery. The only constraint being the life time of the power devices. These systems can be used for larger distances and to track high value goods like vehicles.

2. **Passive RFID system :** These are systems where the tag gets power through the transfer of power from a reader antenna to the tag antenna. They are used for short range transmission.

Q.19 Write short note on wireless sensor network.

Ans. : Wireless Sensor Networks

- A wireless sensor network (WSN) is a network formed by a large number of sensor nodes where each node is equipped with a sensor to detect physical phenomena such as light, heat, pressure, etc.

- WSNs nowadays usually include sensor nodes, actuator nodes, gateways and clients. A large number of sensor nodes deployed randomly inside of or near the monitoring area, form networks through self-organization.

- Sensor nodes monitor the collected data to transmit along to other sensor nodes by hopping. During the process of transmission, monitored data may be handled by multiple nodes to get to gateway node after multi- hop routing, and finally reach the management node through the internet or satellite.

- A sensor network consists of multiple detection stations called sensor nodes, each of which is small, lightweight, and portable.

- Every sensor node is equipped with a transducer, microcomputer, transceiver, and power source. The transducer generates electrical signals based on sensed data.

- The microcomputer processes and stores the sensor output. The transceiver, which can be hard-wired or wireless, receives commands from a central computer and transmits data to that computer.

- The power for each sensor node is derived from the electric utility or from a battery.

- Standards for WSN technology have been well developed, such as Zigbee (IEEE802.15.4). The IEEE 802.15.4 is simple packet data protocol for lightweight wireless networks.

- It works well for long battery life, selectable latency for controllers, sensors, remote monitoring and portable electronics.

Q.20 Explain generation of wireless sensor network.

Ans. :

Parameters	First Generation	Second Generation	Third Generation
Node Architecture	Separate sensing, processing and communication	Integrated sensing, processing and communication	Full integrated sensing, processing and communication
Protocol	Proprietory	Proprietory	Standard (Wi-Fi, WiMax)
Topology	Point to point, Star and multi-hop	Client-server and peer to peer	Fully peer to peer
Power Supply	Large batteries	AA batteries	Solar
Life span	Hours, days and longer	Days to weeks	Months to years
Deployment mode	Physically installed	Hand placed	Embedded or nanotechnology based
Manufacturers	Custom constructors	Crossbow Technology, Inc., Sensoria Corp., Ember Corp	Dust, Inc., and others

Q.21 Write short note on ZigBee Network

Ans. : • In 2002, seeing that neither Wi-Fi nor Bluetooth could not fit some of their needs for embedded systems, a number of industrial companies formed the consortium called ZigBee Alliance, aimed at providing standards for low cost / low consumption wireless communications. Then, with the birth of IEEE 802.15.4 group.

• ZigBee communications can reach up to 500m, with a data rate of up to 250kbs, for a typical power consumption of 125 to 400 μW.

- As ZigBee is based on IEEE 802.15.4, there is no wake-up signal, but slots for sleep or activity, or in asynchronous mode, devices sleeping anytime they have nothing to say, with an ever-vigilant coordinator.

- To use a ZigBee module with a microcontroller, you need to connect it to a UART. There are other, optional pins to use, including a number of analog inputs / digital IOs and a PWM output indicating the strength of the signal which you can directly connect to a LED pin for observation purposes.

- There are two modes of data transfer namely Beacon mode and Non Beacon mode.

- In Beacon mode, when the devices are not sending the data they may enter a low power state and reduces the power consumption.

- In Non-beacon mode, the end devices need to be wake up only while sending the data while the routers and coordinators need to be active most of the time.

- Fig. Q.21.1 shows star topology and peer-to-peer topology.

● Full function device
○ Reduced function device
◄—► Communication flow

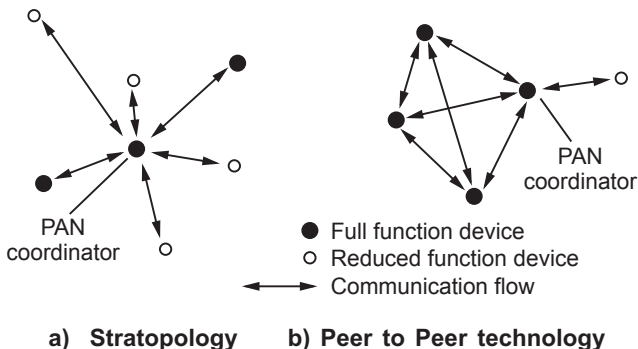**a) Stratopology   b) Peer to Peer technology**

Fig. Q.21.1

- There are three **different types of ZigBee devices :**

- **ZigBee coordinator (ZC) :** This is the most capable ZigBee device serving as the coordinator or the root of a ZigBee network. There

is exactly one coordinator in each network since it is the device that started the network. It is able to store information about the network, including acting as the trust center and repository of security keys.

- **ZigBee Router (ZR) :** This can act as an intermediate router, passing on data from end device to end device.

- **ZigBee End Device (ZED) :** This contains just enough functionality to talk to the parent node. The end device cannot relay data from other devices. This relationship allows the node to be asleep a significant amount of the time, thereby ensuring a long battery life. A ZED requires the least amount of memory, and therefore can be less expensive to manufacture than a ZR or ZC.

Q.22 How wireless sensor network help health monitoring system ?

Ans. : • Wireless sensors support offer many possibilities for measuring different parameters of the human body and most of them are imperceptible and comfortable to use.

- IoT devices can be used to enable remote health monitoring and emergency notification systems. These health monitoring devices can range from blood pressure and heart rate monitors to advanced devices capable of monitoring specialized implants.

- Smart health systems provide health related services using a network, some kind of connection between intelligent agents. These intelligent agents could be computing devices, mobile phones, sensors, Fitbit smart bands, surgical devices, devices that measure your blood chemistry, or devices that measure your brainwaves. Any of these things could be intelligent agents.

- Fig. Q.22.1 shows smart health monitoring system using wireless sensor.

- The human actors, patients or healthcare providers for example could be intelligent agents in this system. The sensors, devices, computers, applications, and human actors are all intelligent agents that might be connected in the smart health system.
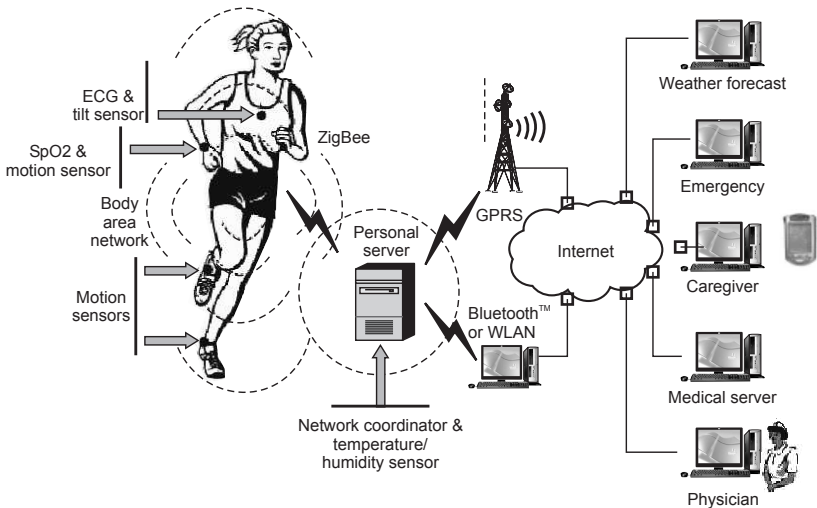
Fig. Q.22.1 Smart health monitoring system using wireless sensor

• Some **challenges in the healthcare system** are as follows :

1. **Smarter hospital :** A natural problem is how to build a smarter hospital for greatly improving medical services and patient experience.

2. **Data integration/realtimeness :** How to combine heterogeneous health data sources in a unified and meaningful way enables the discovery and monitoring of health data from different sources.

3. **Medical resource shortness :** There are not enough medical resources for the population. For example, there are fewer doctors and high-level healthcare institutions but more patients.

4. **"Low" usage of community health service centers**. In contrast with community health service centers, people prefer the high-level healthcare institutions. This results in the low usage of community service centers.

5. **Bad health habits.** The citizens have some bad health habits that contribute to poor health, for instance, smoking and no sport.

6. **Lack of information sharing**. Hospitals are not sharing enough information. This leads to the following two problems at least. First, the health information records of patients cannot be queried. Second, there is lack of medical cooperation between hospitals.

• The links between the many applications in health monitoring are :

1. Applications require the gathering of data from sensors.

2. Applications must support user interfaces and displays.

3. Applications require network connectivity for access to infrastructural services.

4. Applications have in-use requirements such as low power, robustness, durability, accuracy and reliability.

• Connected medical devices and associated IoT technologies will primarily be used to achieve the following capabilities :

1. Access real time visibility of the patient's condition, his/her activities, context and physiological parameters.

2. Monitor compliance to prescribed treatment, diet and exercise regimes.

3. Provide feedback and cues to patients, family members, doctors and caregivers in order to implement corrective action.

4. Leverage high performance computing for real time feedback and use evidence-based medicine for better patient outcome.

Q.23 What is Global Positioning System (GPS)? Explain working of GPS.

Ans. : • Global Positioning System is a satellite navigation system that furnishes location and time information to the user.

- Fixed or orbiting satellite transmitters broadcast timing signals and receiving device response signals to locate the position of moving objects. GPS is used for navigation in planes, ships, cars and trucks also.

- The system gives critical abilities to military and civilian users around the globe. GPS provides continuous real time, 3-dimensional positioning, navigation and timing worldwide.

- The GPS system consists of three segments :

1) The space segment: the GPS satellites

2) The control system, operated by the U.S. military,

3) The user segment, which includes both military and civilian users and their GPS equipment.
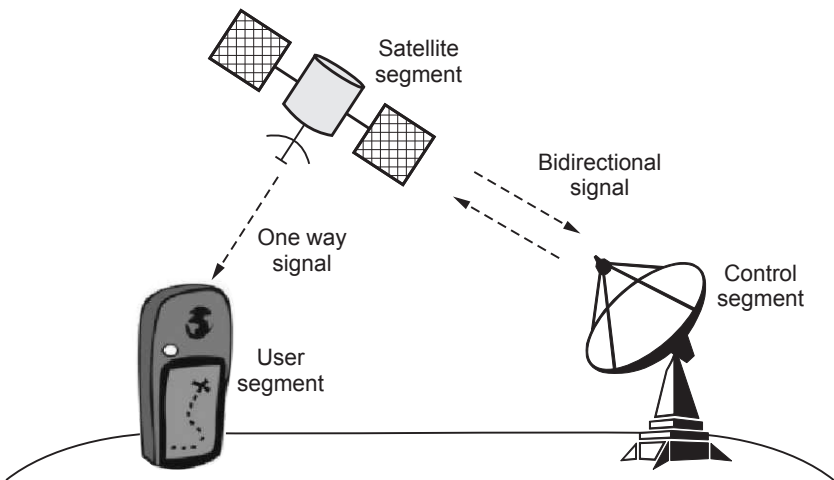
Fig. Q.23.1

- The space segment is the number of satellites in the constellation. It comprises of 29 satellites circling the earth.

- The control segment comprises of a master control station and five monitor stations outfitted with atomic clocks that are spread around the globe.

- The user segment comprises of the GPS receiver, which receives the signals from the GPS satellites and determine how far away it is from each satellite.

- The GPS operation uses data from satellites to calculate the location, Usually it requires data from at least three satellites to triangulate the position.

- There is a concept known as Time To Fix First (TTFF). TTFF is the time lapse required to download the data before the commencement of calculations.

- TTFF depends on the frequent use of the device. If the chip is not used frequently, then TTFF will be high. Usually, the transmission rate of data from satellite is around 6 bytes per second.

- It takes for a GPS receiver about 65 to 85 millisecond to receive a radio signal from GPS satellite. If the device is used frequently, then the TTFF will be small as the data have already been downloaded.

- GPS devices or trackers which are available in the market can broadly be divided into two types those are active GPS devices and passive GPS devices.

Q.24 What is difference between active and passive GPS?

Ans. : Active GPS :

- Active GPS trackers monitor movement in real-time. In active GPS devices, the user can view the speed, location, and other tracking details soon after the implementation of the device from any place.

- In active GPS trackers, GPRS module is in-built, which allows the device to transmit the data to the saver.

- If one has a web based tracking interface and source and map sources then the user will be able to track from anywhere; provided internet connection is available.

Passive GPS :

- Passive GPS devices do not allow the user to view tracking information in real time. The information in the device can only be viewed after that information is downloaded to a computer.

- Tracking details normally include the date of the information, time of the information, direction traveled and stops made.

5.4 Innovative Applications of the Internet of Things

Q.25 List the specific wireless sensor applications.

Ans. : Applications of sensor networks :

- **Military sensor networks :** used to detect and gain an information as possible about enemy movements, explosions, and other phenomena of interest.

- **Sensor networks :** Used to detect and characterize chemical, biological, radiological, nuclear, and explosive attacks and materials.

- Sensor networks also used **to detect and monitor environmental changes** in plains, forests, oceans.

- Wireless traffic sensor networks to **monitor vehicle traffic on highways** or in congested parts of a city.

- Wireless surveillance sensor networks for **providing security** in shopping malls, parking garages.

- Wireless parking lot sensor networks to determine whether the lot is occupied or available area.

Q.26 How IoT helps to organization in supply chain management ?

Ans. : • Supply line combines the processes, methodologies, tools, and delivery options to guide collaborative partners to work in a sequence to conduct business with high efficiency and delivery speed.

- A supply chain is an efficient network of facilities that procures materials, transforms these materials to finished products, and finally distributes the finished products to customers.

- Fig. Q.26.1 supply chain management.
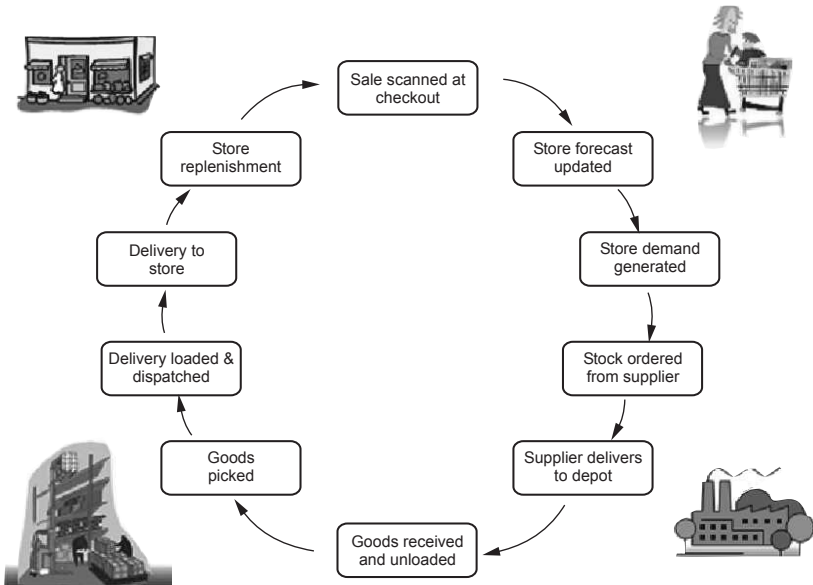
Fig. Q.26.1

- Supply chain involves material suppliers, distribution centers, communication links, cloud data centers, a large number of retail stores, corporate headquarters and bank payments.

- These business partners are linked by satellite, Internet, wired and wireless networks, truck, train, or shipping companies, and electronic banking, cloud providers.

- Sensors, RFID tags, and GPS devices could be placed everywhere along the supply chain. The idea is to promote online business, e-commerce, or mobile transactions.

- Supply **chain management consists of five major stages :**

1 : Planning and Coordination : A plan or strategy must be developed to address how a good or service can satisfy the needs of customers.

2 : Material and Equipment Supplies : This phase involves building a strong relationship with the raw material suppliers and planning methods for shipping, delivery, and payment.

3 : Manufacturing and Testing : The product is tested, manufactured, and scheduled for delivery.

4 : Product Delivery : Customer orders are taken and delivery of goods is planned.

5 : After-Sale Service and Returns : Customers may return defective products and the company addresses customers' demands. Supply chain software is used by many companies for efficient supply chain management.

Q.27 Write short note on Smart Power Grid.

Ans. : • Smart grids are an advancement of the electricity grids that are being used currently. A smart grid is an electrical grid that uses modern technology (digital or analog) to collect and communicate electricity related information of both the suppliers and consumers.

• It not only enhances efficiency and reliability, but also improves the production and distribution of electricity to the consumers. The process of installing a smart grid necessarily means technical re-designing of the infrastructure at different levels. One such measure means replacing the existing electronic meters (or electromechanical meters) with smart meters, to enhance the sustainability and efficiency of the entire electrical system.

• Fig. Q.27.1 shows smart grid.

• It uses information technologies to improve how electricity travels from power plants to consumers and allows consumers to interact with the grid. It integrates new and improved technologies into the operation of the grid.

• The smart grid will require wide, seamless, often real-time use of applications and tools that enable grid operators and managers to make decisions quickly.
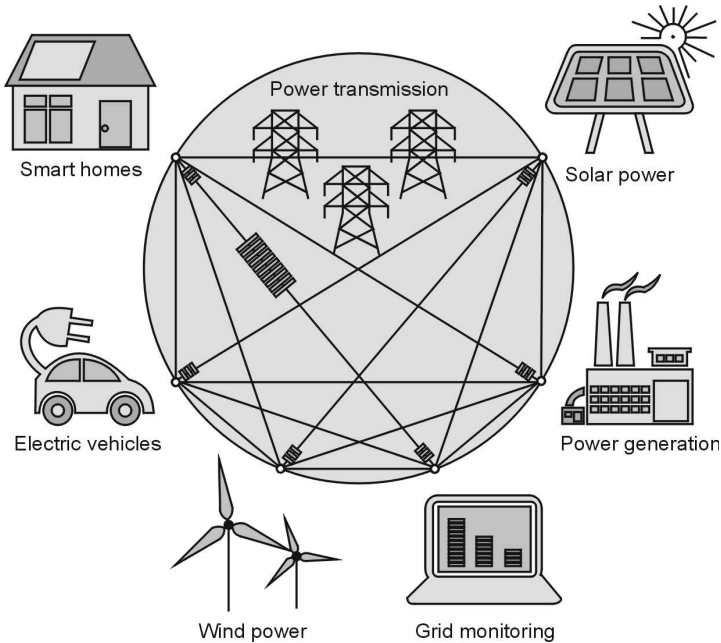
Fig. Q.27.1 Smart grid

• Decision support and improved interfaces will enable more accurate and timely human decision making at all levels of the grid, including the consumer level, while also enabling more advanced operator training.

• Energy storage systems are highly versatile and this is a technology that can meet the needs of various users and be utilized in diverse fields. These include power generators that use renewable energy, grid equipment like energy transmission and distribution equipment, as well as commercial facilities, factories and homes.

Q.28 Write short note on Smart Cities.

Ans. : • The number of urban residents is growing by nearly 60 million every year. In addition, more than 60 percent of the world's population will be living in cities by 2050. As a result, people occupying just 2 percent of the world's land will consume about

three-quarters of its resources. Moreover, more than 100 cities of 1 million people will be built in the next 10 years.

• Over the past decade, the city of Amsterdam, the Netherlands, has developed a vision for collaborating, envisioning, developing, and testing numerous connected solutions that could pave the way to a smarter, greener urban environment.

• Fig. Q.28.1 shows concept of smart city.

Fig. Q.28.1 Smart city

• Innovations will aim to improve the quality of life in cities, encompassing security issues and energy resourcefulness. Smart city includes :

1. Smarter management of city infrastructure using Big Data analytics.

2. Collaboration across multiple and disparate agencies using cloud technologies.

3. Real-time data collection, enabling quick response using mobile technologies.

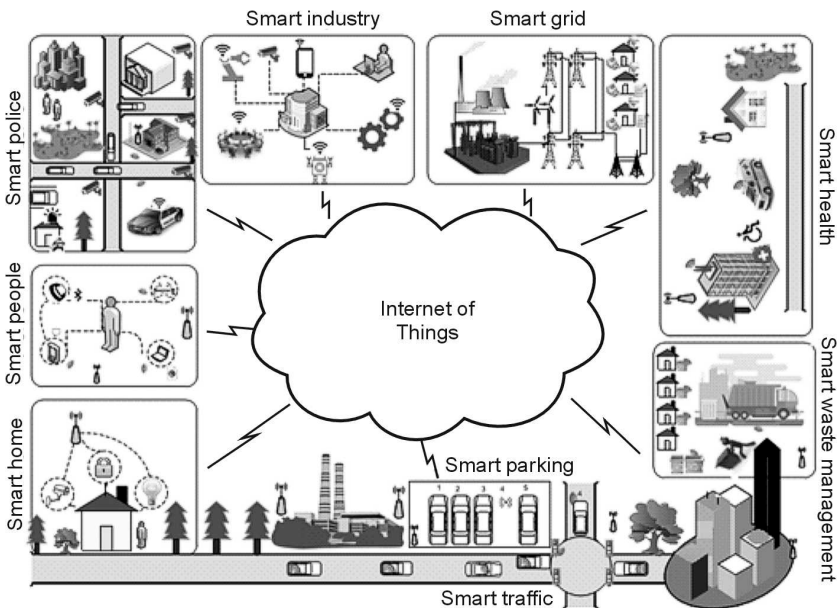4. Enhanced security : improved public safety and law enforcement, and more efficient emergency response.

5. Better city planning improved schematics, project management and delivery.

6. Networked utilities smart metering and grid management.

7. Building developments more automation, and better management and security.

• With smart city applications producing continuous large data from heterogeneous sources, existing relational database technologies are inadequate to handle such huge amounts of data given the limited processing speed and the significant storage expansion cost.

• To address this problem, big data processing technologies, which are based on distributed data management and parallel processing, have provided enabling platforms for data repositories, distributed processing, and interactive data visualization.

Q.29 What is Cyber-Physical System ? Explain in brief.

Ans. : • Cyber-physical system (CPS) is a mechanism that is controlled or monitored by computer-based algorithms, tightly integrated with the Internet and its users.

• In cyber-physical systems, physical and software components are deeply intertwined, each operating on different spatial and temporal scales, exhibiting multiple and distinct behavioral modalities, and interacting with each other in a myriad of ways that change with context.

• Examples of CPS include smart grid, autonomous automobile systems, medical monitoring, process control systems, robotics systems, and automatic pilot avionics.

- Cyber-physical system(CPS) is an embedded system which integrates the computing process with the physical world as an interactive and intelligent system. CPSes appear in many computer and TV game systems.

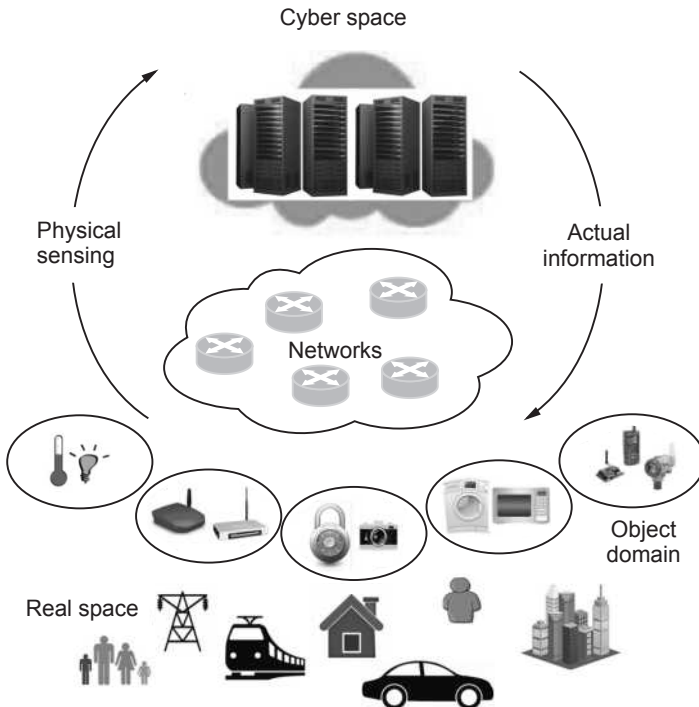- Fig. Q.29.1 shows cyber physical space.

Cyber space

Fig. Q.29.1 Cyber physical space

- CPS features tight coordination between the system's computational and physical elements.

In CPS, computing elements coordinate and communicate with sensors, which monitor cyber and physical indicators, and actuators, which modify the cyber and physical environment where they are run.

- CPSs often seek to control the environment in some way. CPSs use sensors to connect all distributed intelligence in the environment to gain a deeper knowledge of the environment, which enables a more accurate actuation.

- In the manufacturing environment, CPSs can improve processes by sharing real-time information among the industrial machines, manufacturing supply chain, suppliers, business systems, and customers.

- In smart building environments, smart devices and CPSs interact to reduce energy consumption, to increase safety and security, and to improve inhabitants' comfort.

- In the transportation environment, individual vehicles and the infrastructure can communicate with each other, sharing real-time information about traffic, location, or issues, in order to prevent accidents or congestion, improve safety, and ultimately save money and time.

5.5 Online Social and Professional Networking

Q.30 What is social network ? Explain development of Social Network Analysis.

Ans. : • A social network is a group of collaborating, and/or competing individuals or entities that are related to each other. It may be presented as a graph, or a multi-graph; each participant in the collaboration or competition is called an actor and depicted as a node in the graph theory.

- Valued relations between actors are depicted as links, or ties, either directed or undirected, between the corresponding nodes.

- Actors can be persons, organizations, or groups - any set of related entities. As such, SNA may be used on different levels, ranging from individuals, web pages, families, small groups, to large organizations, parties, and even to nations.

- In general, a social network consists of actors (e.g., persons, organizations) and some form of relation among them. The

network structure is usually modeled as a graph, in which vertices represent actors, and edges represent ties, i.e., the existence of a relation between two actors.

- The vocabulary, models and methods of network analysis also expand continuously through applications that require to handle ever more complex data sets.

- An example of this process are the advances in dealing with longitudinal data. New probabilistic models are capable of modelling the evolution of social networks and answering questions regarding the dynamics of communities. Formalizing an increasing set of concepts in terms of networks also contributes to both developing and testing theories in more theoretical branches of sociology.

- The purpose of social network analysis is to identify important actors, crucial links, roles, dense groups, and so on, in order to answer substantive questions about structure .

- Analysis methods available in visone are divided into four main categories according to the level or subject of interest: vertex, dyad, group, and network level.

- Available analysis methods include actor-level centrality indices, e.g. closeness, betweenness, and page rank, cohesive subgroups like cliques, k-cliques, and k-clans, centrality and connectedness.

- These levels break further down into measures of the same objective, e.g., connectedness or cohesiveness. Analysis methods are accessible using the analysis tab in the control area.

Q.31 List and explain ideas for providing of online social network services.

Ans. : • Personal page or profiles for each user linked by social connections

- Social graph traversal along specific social links or networks

- Communication tools among participants or registered users

- Ability to share music, photos, and videos with friends or professional groups

- Operation of a community in special niche areas like health care, sports, and hobbies

- Customized software tools or databases are used in OSN services

- Strong customer loyalty and fast membership growth are seen

- Provider revenue from embedded advertisement and access to premium content

Q.32 Explain Representative /application Online Social Networks.

Ans. : • Social network analysis (SNA) is an important and valuable tool for knowledge extraction from massive and un-structured data. Social network provides a powerful abstraction of the structure and dynamics of diverse kinds of inter-personal connection and interaction.

- Facebook is a social networking service and website that connects people with other people, and share data between people. A user can create a personal profile, add other users as friends, exchange data, create and join common interest communities.

- Twitter is a social net-working and microblogging service. The users of Twitter can exchange text-based posts called tweets. A tweet is a maximum 140 characters long but can be augmented by pictures or audio recording. The main concept of Twitter was to build a social network formed by friends and fol-lowers. Friends are people who you follow, followers are those who follow you.

- The role of social networks in labor markets deserves attention for at least two reasons: first, because of the central role networks play in disseminating information about job openings they place a critical role in determining whether labor markets function efficiently; and second, because network structure ends up having implications for things like human capital investment as well as inequality.

- Social network analysis (SNA) primarily focuses on applying analytic techniques to the relationships between individuals and groups, and investigating how those relationships can be used to infer additional information about the individuals and groups.

- SNA is used in a variety of domains. For example, business consultants use SNA to identify the effective relationships between workers that enable work to get done; these relationships often differ from connections seen in an organizational chart.

- Law enforcement personnel have used social networks to analyze terrorist networks and criminal networks. The capture of Saddam Hussein was facilitated by social network analysis : military officials constructed a network containing Hussein's tribal and family links, allowing them to focus on individuals who had close ties to Hussein.

Q.33 List the benefits of Social Network.

Ans. : Benefits :

1. High return visit rate : Users return to the social network community frequently. This opens up the opportunity for great page impressions and a huge advertising inventory.

2. User loyalty : Users connect to their friends and will not abandon them easily.

3. Virtual growth : Members invite their friends to the social network community. This is effective marketing at a low cost, and the OSN grows by itself.

4. Business model : With a social network community you can earn revenues through subscriptions to premium content in addition to advertising revenues.

Q.34 Write short note on : Graph-Theoretic Analysis of Social Networks.

Ans. : • Social network can be represented as a graph G = (V, E)

where   V = the finite set of vertices

        E = finite set of edges such

- The most network analysis methods work on an abstract, graph based representation of real world networks. It is shown in Fig. Q.34.1.

	A	B	C	D	E
A	0	1	0	1	1
B	1	0	1	1	0
C	0	1	0	1	0
D	1	1	1	0	1
E	1	0	0	1	0
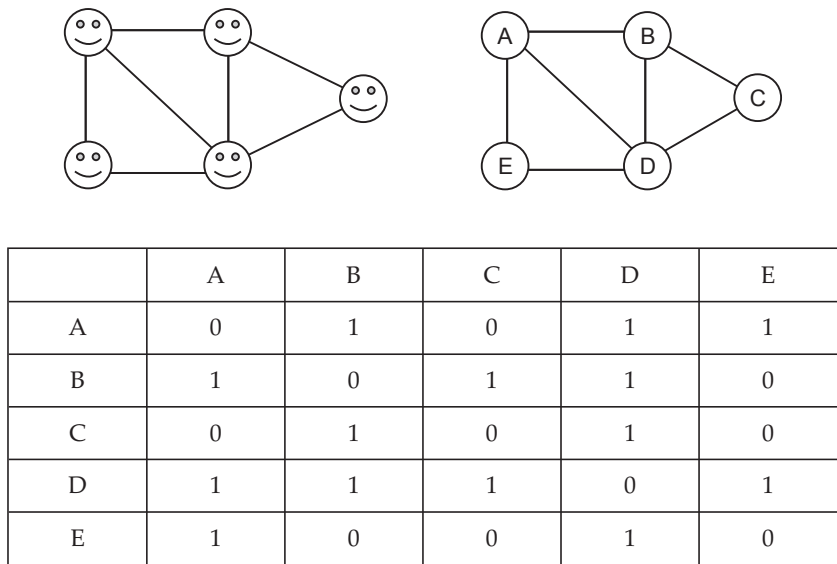
Fig. Q.34.1 Graph based representation of real world networks

- When representing a network as a graph, all of the connections are pair-wise and hence represented by ties known as edges.

- Networks can be described using a mixture of local, global, and intermediate-scale perspectives. Accordingly, one of the key uses of network theory is the identification of summary statistics for large networks in order to develop a framework for analyzing and comparing complex structures

- SNA can produce maps like the one featured below, and provide statistical measures of relationships between actors. In SNA maps, the nodes represent the different actors in the network, and the lines represent the relationships between the various actors.

- The size of the node often represents the relative importance of that actor in the network, and the thickness of the connecting line denotes the strength of the relationship.

- Clustering for a single vertex can be measured by the actual number of the edges between the neighbors of a vertex divided by the possible number of edges between the neighbors.

- When taken the average over all vertices, we get to the measure known as clustering coefficient. The clustering coefficient of a tree is zero, which is easy to see if we consider that there are no triangles of edges (triads) in the graph. In a tree, it would never be the case that our friends are friends with each other.

- The coordination degree measures the ability of the vertices in a graph to interchange information. There are several ways in which we can model this magnitude. One of the easiest is to consider the coordination degree to be exponentially related with the distance between the vertices.

- To define the total co-ordination degree of a vertex "i" in a graph as the sum of all the coordination degrees between that particular vertex and the rest :

$$\Gamma_i \ = \ \sum_{j\,=\,1}^{N} Y_{ij}$$

where N is the order of the graph.

- Graph density (D) is defined as the total number of observed lines in a graph divided by the total number of possible lines in the same graph. Density ranges from 0 to 1.

$$\text{Density (D)} = \frac{\text{Number of lines (L)}}{(\text{Number of points (Number of points} - 1))/\,2} = \frac{2L}{g\,(g-1)}$$

Q.35 List and explain Social Networking communities.

Ans. : Social networking communities are as follows :

- **Industry communities :** Special industrial workers or professionals are often connected with one another. They share knowledge and work experience.

- **Artist communities :** These network communities are specifically composed to enable artists, musicians, or celebrities to personalize and intensify their contact with their existing fans as well as enabling contact among community members.

- **Sport communities :** These are network communities for special interests and activities of athletes and sport fans. People can find friends, celebrate their passion, and exchange ideas.

- **Health communities :** These are dedicated to the needs of actors concerned about health issues.

- **Congresses and event communities :** These are customized to support all preparations necessary for congresses and events, as well as all processes thereafter.

- **Alumni communities :** After completing their studies, alumni can find fellow students, stay in touch, and foster friendships.

Q.36 Draw and explain Twitter architecture and access protocol sequence.

Ans. : • Twitter is known as a micro-blogging site. Twitter is a social networking site that relies on micro-blogging for communication.

- Twitter system consists of three components : crawler, indexer, and searcher.

- Each component differs in the functions it performs. They are used together through balanced coordination to form a complete system.

- Fig. Q.36.1 shows the Twitter access architecture. (See Fig. Q.36.1 on next page)

1. The crawler sends a request to the Twitter API.

2. The Twitter API responds with the Twitter data.

3. The crawler stores the data into files.

4. The indexer reads the stored files as input.

5. The indexer stores the data in a database as output.
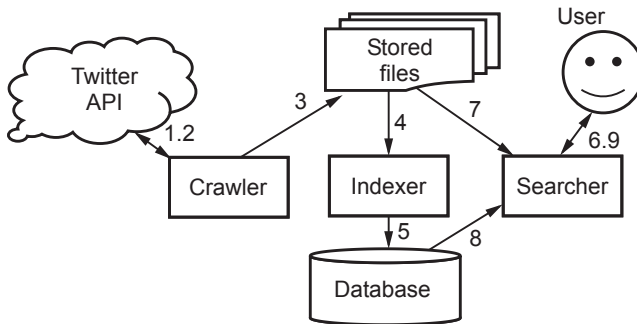
Fig. Q.36.1 : Twitter access architecture

6. Users send a search query to the searcher.

7. The searcher reads the data from the database and calculates a rank.

8. The searcher reads associated raw tweets.

• Twitter calls microblog posts from users tweets. Each tweet has a 140-character limit which is inherited from text messaging.

• Simplicity is provided with an HTTP-based open source API and sharing posts with third-party applications. Twitter's API consists of two different parts : a Search API and a REST API.

The REST API enables Twitter developers to access core Twitter data. This data includes tweets, timelines, and user data. The Search API enables developers to query the tweets. It also provides information about trending topics. The usage of both APIs is subject to rate limiting.

Q.37 Draw and explain architecture of Facebook platform.

Ans. : • The Facebook platform is the set of services, tools, and products provided by the social networking service Facebook for third-party developers to create their own applications and services that access data in Facebook.

• Facebook is simply a proxy, reading the browser requests, passing them onto your servers, reading your servers' responses, and then parsing that information back to the user in HTML format.

• Fig. Q.37.1 shows Facebook architecture.
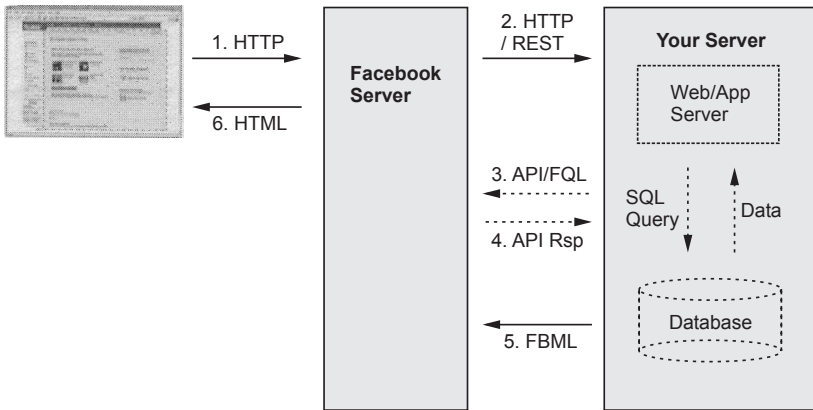
Fig. Q.37.1 Facebook architecture

• The platform offers a set of programming interfaces and tools which enable developers to integrate with the open "social graph" of personal relations and other things like songs, places, and Facebook pages.

• Applications on facebook.com, external websites, and devices are all allowed to access the graph. Platform components are as follows :

1. **Graph API :** It is the core of Facebook platform, enabling developers to read from and write data into Facebook. The Graph API presents a simple, consistent view of the Facebook social graph, uniformly representing objects in the graph and the connections between them.

2. **Authentication :** Facebook authentication enables developers' applications to interact with the Graph API on behalf of Facebook users, and it provides a single-sign on mechanism across web, mobile, and desktop apps.

3. **Social plugins :** It includes button, recommendations, and activity Feed - enable developers to provide social experiences to their users with just a few lines of HTML.

4. **Open Graph protocol :** The Open Graph protocol enables developers to integrate their pages into Facebook's global mapping/tracking tool social graph. These pages gain the functionality of other graph objects including profile links and stream updates for connected users.

• Fig. Q.37.2 shows working.
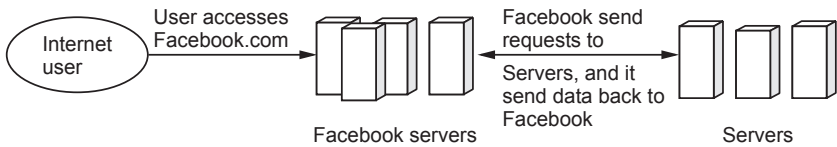
Fig. Q.37.2

Q.38 Write short note on ubiquitous system challenges and outlook.

Ans. : • Four scenarios illustrate a range of benefits and challenges of ubiquitous computing :

1. Personal memories

2. 21st Century scheduled transport service

3. Foodstuff management

4. Utility regulation

Personal memories :

• A digital camera automatically captures a visual of part of the physical world scene on an inbuilt display. The use of digital cameras enables photography to be far less intrusive for the subject than using film cameras.

• Fig. Q.38.1 shows example of a ubiquitous computing application.

• The camera can autofocus and auto-expose recorded images and video so that recordings are automatically in focus and selected parts of the scene are lit to the optimum degree.
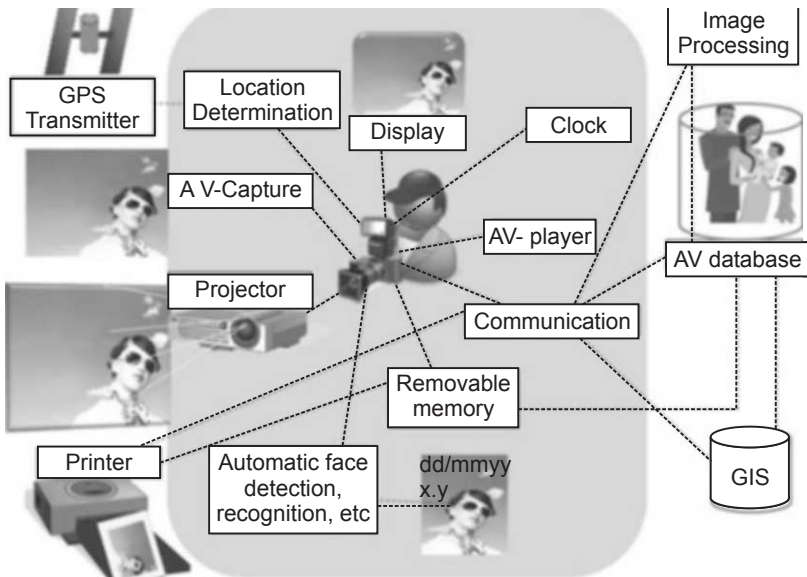
Fig. Q.38.1 Example of a ubiquitous computing application

- The context of the recording such as the location and date/time is also automatically captured using inbuilt location and clock systems.

- Ubiquitous computing (UbiCom) encompasses a wide spectrum of computers, not just devices that are general purpose computers, multi-function ICT devices such as phones, cameras and games consoles, ATMs, vehicle control systems, mobile phones, electronic calculators, household appliances, and computer peripherals such as routers and printers.

21st Century scheduled transport service :

- In a twentieth-century scheduled transport service, timetables for a scheduled transport service, e.g., taxi, bus, train, plane, etc. to pick up passengers or goods at fixed or scheduled point are only accessible at special terminals and locations.

- Passengers and controllers have a limited view of the actual time when vehicles arrive at designated way-points on the route. Passengers or goods can arrive and wait long times at designated pick-up points.

- The transport system may need to deal with conflicting goals such as picking up more passengers and goods to generate more revenue for services rendered versus minimizing how late the vehicle arrives at pre-set points along its route.

Foodstuff management :

- A ubiquitous home environment is designed to support healthy eating and weight regulation for food consumers. A conventional system performs this manually.

- A next generation system (semi-)automates this task using networked physical devices such as fridges and other storage areas for food and drink items which can monitor the food in and out.

- Sensors are integrated in the system, e.g., to determine the weight of food and of humans.

- Scanners can be used to scan the packaging of food and drink items for barcodes, text tables, expiry dates and food ingredients and percentages by weight.

Utility regulation :

- A ubiquitous home environment is designed to regulate the consumption of a utility (such as water, energy or heating) and to improve usage efficiency.

- For example, currently utility management, e.g., energy management, products are manually configurable by human users, utilize stand-alone devices and are designed to detect local user context changes.

- User context-aware energy devices can be designed to switch themselves on in a particular way, e.g., a light switches on, heating switches on when it detects the presence of a user otherwise it switches off.

END...✍

6 | Future of Cloud Computing

Important Points to Remember

- Location is a fundamental aspect of the new, exciting world of mobile web-enabled services.

- A set of compute, storage, memory and I/O components joined through a fabric interconnect and the software to configure and manage them

- HTML5 apps offer write once, run anywhere mobile app development

- Time to market (TTM) is the length of time it takes from a product being conceived until its being available for sale.

- Autonomic Computing is the ability of distributed system to manage its resources with little or no human intervention

- CometCloud is an autonomic computing engine for cloud and grid environments.

- CometCloud is composed of a programming layer, a service layer, and an infrastructure layer

- Multimedia cloud computing is the processing, accessing and storing of multimedia contents like audio, video and image using the services and applications available in the cloud without physically acquiring them

- Green computing is the environmentally responsible and eco-friendly use of computers and their resources.

- Jungle Computing System consists of all compute resources available to end-users, which includes clusters, clouds, grids, desktop grids, supercomputers, as well as stand-alone machines and even mobile devices.

- Docker is a tool that promises to easily encapsulate the process of creating a distributable artifact for any application, deploying it at scale into any environment, and streamlining the workflow and responsiveness of agile software organizations.

6.1 How the Cloud Will Change Operating Systems, Location-Aware Applications

Q.1 How cloud will impact future operating system ?

Ans. : • Cloud computing is a technology deployment approach that has the potential to help organizations better use IT resources to increase flexibility and performance.

- One of the most important ways to support the underlying complexity of well-managed cloud computing resources is through the operating system.

- An operating system such as Linux supports important standards that enhance portability and interoperability across cloud environments.

- Operating system platforms are designed to hide much of the complexity required to support applications running in complex and federated environments. Much of the functionality required for the efficient operation of many applications is built in to the operating system.

- The operating system implements the level of security and quality of service to ensure that applications are able to access the resources needed to deliver an acceptable level of performance.

- Operating system exists to allow users to run programs and store and retrieve data from one user session to the next.

- One of the most significant requirements for companies adopting cloud computing is the need to adopt a hybrid approach to computing. To do so, most organizations will continue to

maintain their traditional data center to support complex mixed workloads.

- For example, an organization may choose a public cloud environment for development and test workloads, a private cloud for customer-facing web environments that deal with personal information, and a traditional data center for legacy billing and financial workloads.

- Virtualization requires some level of workload isolation since virtualized applications are stored on the same physical server. However, cloud computing adds the concept of multi-tenancy.

- Multi-tenancy is the sharing of resources by multiple organizations, which requires that each customer's data and applications be stored and managed separately from other customers' data and applications.

- Both virtualization and multi-tenancy support have to be implemented in a secure manner. As virtualization and multi-tenancy become the norm in cloud environments, it is critical that security be built in at the core.

- When servers are virtualized it makes it very easy for a new image to be created with little effort.

Q.2 What is Locations-Aware Applications ?

Ans. : • Location is a fundamental aspect of the new, exciting world of mobile web-enabled services.

- The usefulness of many of today's most popular mobile applications and services is determined by onekey factor : where you are at the exact moment when you're using the service.

- Location based service is a service where

  1. The user is able to determine their location.

  2. The information provided is spatially related to the user's location.

  3. The user is offered dynamic or two-way interaction with the location information or content.

- Components of location based services are as follows :
  1. Mobile device   2. Content provider
  3. Communication network   4. Positioning component

Q.3 What Is Fabric-Based Infrastructure ? Which are the services provided by Intelligent Fabrics.

Ans. : • The term"fabric" is used by different vendors, analysts, and IT groups to describe different things.

- A set of compute, storage, memory and I/O components joined through a fabric interconnect and the software to configure and manage them.

- A fabric thus provides the capability to reconfigure all system components - server, network, storage, and specialty engines - at the same time, the flexibility to provide resources within the fabric to workloads as needed, and the capability to manage systems holistically.

- Services provided by Intelligent Fabrics are as follows :
  1. It automatically adjust the room temperature when body temperature change.
  2. It monitors the body functions such as blood presser, sugar level etc

> **6.2 The Future of Cloud TV, Future of Cloud-Based Smart Devices**

Q.4 Write short note on Future of Cloud TV.

Ans. : • Today, consumers watch video on a variety of connected devices. New Over-The-Top (OTT) providers such as Netflix are offering direct-to-consumer services with low prices, advanced user interfaces and easy access to multi-screen video.

- Changing usage patterns brought on by subscriber desire to watch content at the time, location and on the device of their choosing are increasing content distribution costs.

- Pay TV providers are particularly susceptible to these trends and need to adapt their traditional TV delivery architectures to offer innovative services that attract and retain customers.

- The traditional Set-Top Box (STB) will disappear. The functions of today's STB hardware will be carried out in the network and by the connected device itself, eliminating the cost and complexity of managing home-based STBs.

- Traffic will be all unicast. Over time, device format fragmentation, time-shifting viewing habits and service personalization will erode broadcast and multicast efficiencies.

- Ultimately, every end user will be served with a unique stream. Services will be deployed in the cloud.

- Dedicated video platforms will migrate to cloud-based services, reducing costs and accelerating time to market.

- Operators will move from vertically integrated middleware stacks to more open architectures with best-of-breed components.

- Cloud DVR technology makes all TV content available on demand, on any device and in any location

6.3 Cloud and Mobile

Q.5 List and explain mobile cloud application.

Ans. :

Mobile Gaming	• M-game is a high potential market generating revenues for service providers.
	• Can completely offload game engine requiring large computing resource (e.g., graphic rendering) to the server in the cloud.
	• Offloading can also save energy and increase game playing time (eg. MAUI allows fine-grained energy-aware offloading of mobile codes to a cloud)
	• Rendering adaptation technique can dynamically adjust the game rendering parameters based on communication constraints and gamers' demands

Mobile Healthcare	• M-healthcare is to minimize the limitations of traditional medical treatment (eg. Small storage, security/privacy, medical errors, …)
	• M-healthcare provides mobile users with convenient access to resources (eg. medical records)
	• M-healthcare offers hospitals and healthcare organizations a variety of on-demand services on clouds
Mobile Learning	• M-learning combines e-learning and mobility
	• Traditional m-learning has limitations on high cost of devices/network, low transmission rate, limited educational resources
	• Cloud-based m-learning can solve these limitations
	• Enhanced communication quality between students and teachers
	• Help learners access remote learning resources
Mobile Commerce	• M-commerce allows business models for commerce using mobile devices.
	• Examples : Mobile financial, mobile advertising, mobile shopping.
	• M-commerce applications face various challenges
	• Integrated with cloud can help address these issues
	• Example : Combining 3G and cloud to increase data processing speed and security level.

Q.6 How HTML5 will drive mobile applications ?

Ans. : • HTML5 apps offer write once, run anywhere mobile app development. They are a collection of web pages optimized for mobile devices that bring advanced capabilities for streaming video and audio data, handling graphics and animation and providing offline support.

• They also add semantic elements, form controls and multimedia components, as well as a number of new APIs that support geolocation services, drag-and-drop operations, local application caching and more.

- HTML5 seldom works alone. Most HTML5 apps integrate Cascading Style Sheets (CSS), which define how the HTML components render within a browser, and JavaScript, which includes the APIs for working with text, objects and arrays.

- All major browsers support these technologies, making it possible to implement Web-based apps across a wide range of devices.

- HTML5 mobile application development framework toolkits contain libraries of CSS and JavaScript files that developers can include in the HTML.

- Frameworks handle many of the issues that arise with building HTML5 apps. Memory and performance limitations are key considerations for HTML5 mobile application development

6.4 Faster Time to Market for Software Applications

Q.7 Define time to market ? What do you mean faster time to market for software application ?

Ans. : • Time To Market (TTM) is the length of time it takes from a product being conceived until its being available for sale.

- TTM is important in industries where products are outmoded quickly. A common assumption is that TTM matters most for first-of-a-kind products, but actually the leader often has the luxury of time, while the clock is clearly running for the followers.

- Nowadays software companies clearly understand that time costs money and that they need all possible tools to get their products to market as fast as possible with no compromise to quality.

- So they expect a wider range of features, a variety of services, scalability, high performance and flexible pricing out-of-the-box from their cloud providers.

- This motivates hosting vendors to expand their offerings with PaaS and CaaS solutions, and migrate their current users from commodity VPS to the advanced platforms.

- The bottom line is that success in the mobile market can be driven as much by who is there first as much as it may be driven by the quality of the applications being delivered; as such, minimizing the time to market is paramount.

- With so many cloud-based offerings available that can help speed up everything from development to deployment to runtime operations, it's no wonder that those who are serious about mobile development are leaning hard on the various PaaS, SaaS and IaaS offerings available on the market today.

6.5 Home-Based Cloud Computing

Q.8 How cloud computing is used in home application ?

Ans. : • Cloud computing has been evolved as a key computing platform for sharing resources and services. People should have a relatively convenient environment for handling Home-appliances.

- Existing Home-Appliance control systems are not providing complete control over Home-Appliances and also difficult to control from distant places.

- Framework is composed of mobile users, Home-appliances and the cloud environment. Mobile that the user is going to use should contain Internet facility.

- A mobile user can use a smart phone with internet connection to control and handle Home-appliances through Web2.0 Blog-based interfaces in Web2.0 Platform.

- Mobile User can control the Home-appliances, using the Device Profile of Web Services in the cloud environment and can control completely by not only switching on and off but also can change settings of the devices and also from any far places.

- Home-based healthcare could enable the care recipients to live independently at home. Healthcare providers could monitor the patients based on their shared daily health data, and provide some clinical suggestions, as well as giving feedback through

reports of medical examinations that the patients have undergone.

• Cloud computing services can support almost any type of medical software applications for healthcare organizations.
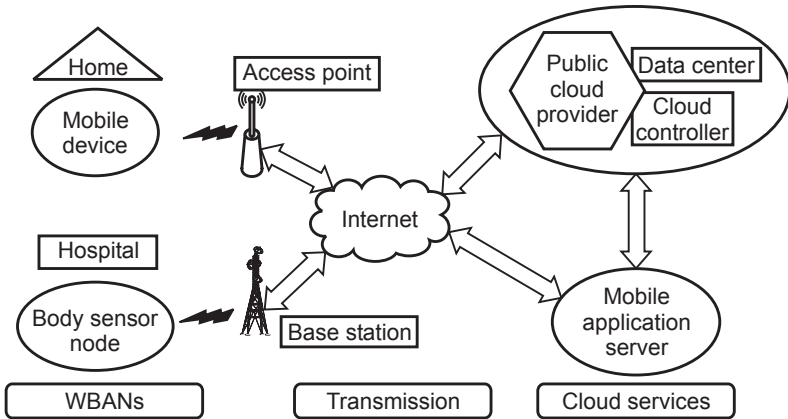
Fig. Q.8.1

• Cloud computing can offer practical solutions as in the new clinical information management system called "Collaborative Care Solution" that was developed in November 2010 by IBM and Active Health Management.

• It was beneficial for patients who were suffering from chronic conditions to connect with their physicians and follow up their prescribed medications.

• Management of data was more efficient in regards to the growing numbers of patients' data and information through electronic and personal health records.

• This could be viewed from the perspective of data storage and the number of servers needed to cope up with theses enormous amounts of data.

• What facilitates the function of cloud computing is the usage of smart phones and tablets that support medical staff and patients to access healthcare services.

- Data storage services can help to build a healthcare information integration platform to integrate different healthcare providers. Thus, necessary medical information resources will be shared between healthcare providers and recipients

6.6 Autonomic Cloud Engine

Q.9 What do you mean autonomic cloud computing ? Explain system architecture for autonomic Cloud management.

Ans. : • Autonomic Computing is the ability of distributed system to manage its resources with little or no human intervention. It involves intelligently adapting to environment and requests by users in such a way the user does not even know.

Fig. Q.9.1 : System architecture for autonomic Cloud management

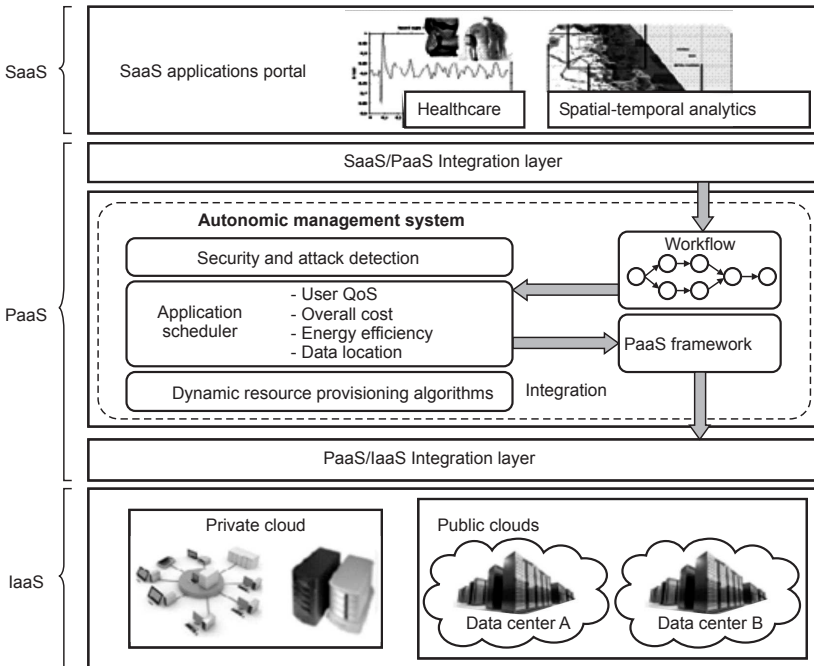- Autonomic monitoring are mostly implemented on specific layers of the cloud computing architecture. (See Fig. on next page)

- Fig. Q.9.1 shows the high-level architecture enabling autonomic management of SaaS applications on Clouds.

- SaaS Application Portal : This component hosts the SaaS application using a Web Service-enabled portal system.

- Autonomic Management System and PaaS Framework : This layer serves as a Platform as a Service. Its architecture comprises of autonomic management components to be integrated in the PaaS level, along with modules enforcing security and energy efficiency.

- Infrastructure as a Service : This layer comprises distributed resources provided by private (enterprise networks) and public Clouds.

- SaaS is described as a software application deployed as a hosted service and accessed over the Internet.

- In order to manage the SaaS applications in large scale, the PaaS layer has to coordinate the Cloud resources according to the SaaS requirements, which is ultimately the user QoS.

- Application Scheduler : The scheduler is responsible for assigning each task in an application to resources for execution based on user QoS parameters and the overall cost for the service provider.

Q.10 Write short note on CometCloud

Ans. : • CometCloud is based on a decentralized coordination substrate, and supports highly heterogeneous and dynamic cloud/Grid infrastructures, integration of public/private clouds and cloudbursts.

- CometCloud is an autonomic computing engine for cloud and grid environments.

- CometCloud is composed of a programming layer, a service layer, and an infrastructure layer. Fig. Q.10.1 shows CometCloud architecture for autonomic cloudbursts.

- The infrastructure layer uses the Chord self-organizing overlay, and the Squid information discovery and content-based routing substrate built on top of Chord.

- The routing engine supports flexible content-based routing and complex querying using partial keywords, wildcards, or ranges.
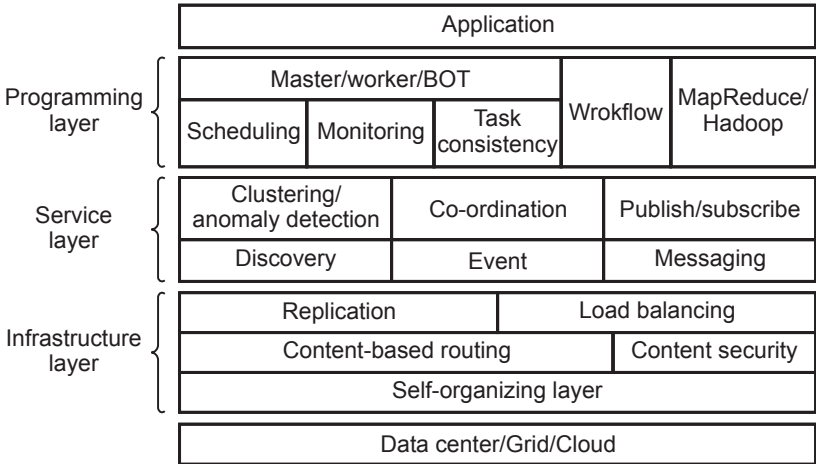
Fig. Q.10.1 : CometCloud architecture for autonomic cloudbursts

- This layer also provides replication and load balancing services, and it handles dynamic joins and leaves of nodes as well as node failures.

- The service layer provides a range of services to supports autonomics at the programming and application level. An application can switch between spaces at runtime and can simultaneously use multiple spaces.

- This layer also provides asynchronous (publish/subscribe) messaging and evening services.

- The programming layer provides the basic framework for application development and management. It supports a range of paradigms including the master/worker/BOT. Masters generate tasks and workers consume them.

6.7 Multimedia Cloud

Q.11 Write short note on Multimedia Cloud Computing.

Ans. : • Due to the invention of cloud computing, nowadays users can easily access the multimedia content over the internet at any time. User can efficiently store the multimedia content of any type and of any size in the cloud after subscribing it with no difficulties.

• Not only storing the media content like Audio, Video and Image, but can process them within the cloud since the computation time for processing media data is more in complex hardware.

• After processing the processed data can be easily received from the cloud through a client without any need of installing complex hardware.

• Fig. Q.11.1 shows fundamental concept of multimedia cloud.
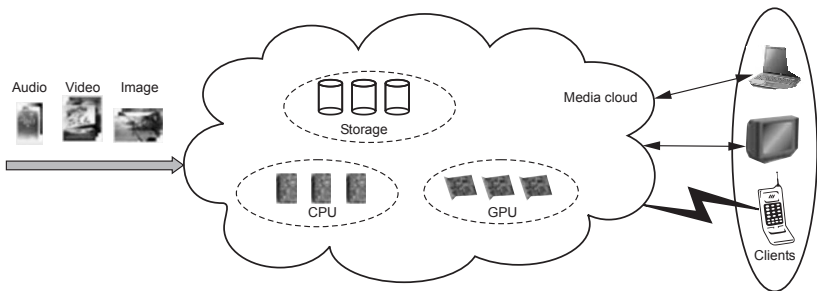
Fig. Q.11.1

• Thus Multimedia cloud computing is the processing, accessing and storing of multimedia contents like audio, video and image using the services and applications available in the cloud without physically acquiring them.

• Currently many company's clouds like AmazonEC2, Google Music, DropBox, SkyDrive provides content management system within the cloud network.

• The users of these clouds can access the multimedia content for example; the user can view a video anywhere in the world at anytime using their Computers, tablets or smart phones.

- Cloud media is, a cloud which has the multimedia content of the owner of that particular cloud. The media content can be accessed through the multimedia signaling protocols in the cloud and can be streamed to clients present in computers, tablets, cars and smart phones.

- Fig. Q.11.2 shows relation between cloud media and media cloud.
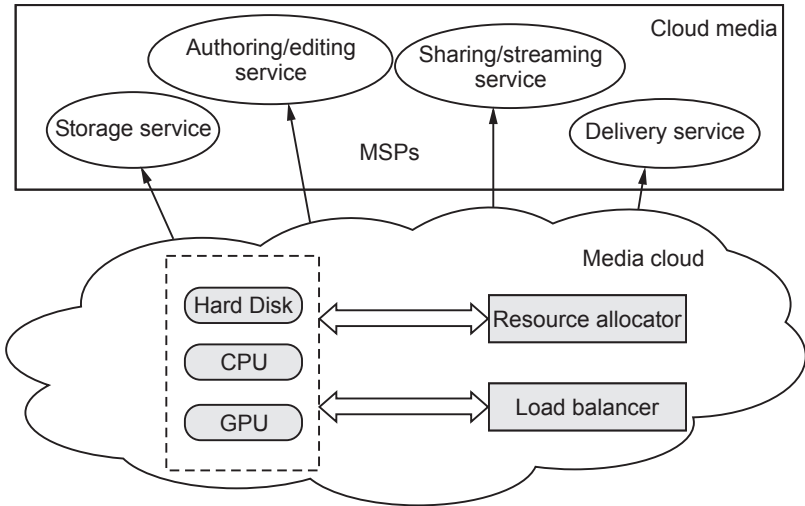
Fig. Q.11.2 : relation between cloud media and media cloud

- Not only processing, but the media content can be shared between clouds using the streaming protocols like TCP/IP, UDP, RTP, HTTP etc.

- Streaming of media content involves, loading or buffering media data, coding, mixing, rating and rendering over the service providers.

- Other profiling, packetizing, tokenizing of media contents will be done by the cloud based on the streaming protocols used and it will be streamed to the client system.

- Cloud media technology offers number of key benefits to its service providers as well as the users through increased

implementation time, efficient data storage capacity, less computation and cost.

- It created a striking impact in the multimedia content processing like editing, storing, encrypting and decrypting, gaming, streaming, compressing etc

6.8 Energy Aware Cloud Computing, Jungle Computing

Q.12 What is Green computing ? What are the benefits of Green computing ?

Ans. : • Computers today are an integral part of individuals' lives all around the world; but unfortunately these devices are toxic to the environment given the materials used, their limited battery life and technological obsolescence.

- Green IT refers to the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems such as monitors, printers, storage devices, and networking and communications systems efficiently and effectively with minimal or no impact on the environment.

- Green computing refers to the practice and procedures of using computing resources in an environment friendly way while maintaining overall computing performance.

- Green computing is the environmentally responsible and eco-friendly use of computers and their resources.

- Computers and other IT infrastructure consume significant amounts of electricity, which is increasing day by day, placing a heavy burden on our electric grids and contributing to greenhouse gas (GHG) emissions.

- Green IT, also known as green computing.

- To promote green computing concepts at all possible levels, the following four complementary approaches are employed :

  1 Green use : Minimizing the electricity consumption of computers and their peripheral devices and using them in an eco-friendly manner

2 Green disposal : Re-purposing an existing computer or appropriately disposing of, or recycling, unwanted electronic equipment

3 Green design : Designing energy-efficient computers, servers, printers, projectors and other digital devices

4 Green manufacturing : Minimizing waste during the manufacturing of computers and other subsystems to reduce the environmental impact of these activities.

- "Electronic waste" may be defined as discarded computers, office electronic equipment, entertainment device electronics, mobile phones, television sets, and refrigerators. This includes used electronics which are destined for reuse, resale, salvage, recycling, or disposal.

- Green computing represents a responsible way to address the issue of global warming. By adopting green computing practices, business leaders can contribute positively to environmental stewardship and protect the environment while also reducing energy and paper costs.

Benefit of Green IT

- Green IT benefits the environment by improving energy efficiency, lowering GHG emissions, using less harmful materials and encouraging reuse and recycling.

1. Reduced in power and resource consumption
2. Green technology helps manage and recycle waste material
3. Reduced environmental impact and carbon footprint.
4. Improved operational efficiency

Q.13 Write short note on Green Cloud.

Ans. : • Cloud computing is a highly scalable and cost-effective infrastructure for running HPC, enterprise and Web applications. However, the growing demand of Cloud infrastructure has drastically increased the energy consumption of data centers, which has become a critical issue. Energy-efficient solutions are required to minimize the impact of Cloud computing on the environment.

- Data centres are not only expensive to maintain, but also unfriendly to the environment.

- Cloud service providers need to adopt measures to ensure that their profit margin is not dramatically reduced due to high energy costs.

- Amazon.com's estimate the energy-related costs of its data centers amount to 42 % of the total budget that include both direct power consumption and the cooling infrastructure amortized over a 15-year period.

- Google, Microsoft, and Yahoo are building large data centers in barren desert land surrounding the Columbia River, USA to exploit cheap hydroelectric power.

- There is also increasing pressure from Governments worldwide to reduce carbon footprints, which have a significant impact on climate change.

- As **energy costs** are **increasing** while **availability dwindles,** there is a need to **shift focus** from optimising data centre resource management for pure **performance** alone to optimising for **energy efficiency** while maintaining high service level performance.

- **Green Cloud computing** model that achieves not only efficient processing and utilisation of computing infrastructure, but also minimise energy consumption.

- Exponential data growth leads to greater storage needs. The traditional approach of adding more disks and storage systems satisfies demand, but also increases power, cooling, and space requirements.

- Green storage is the practice of using a variety of "clean energy" storage methods and products to cut down on a data center's carbon footprint, as well as cost.

- There are a number of systems that can be used for green storage, and by analyzing your data center and specific needs, you can choose a combination of solutions that work for your environment :

  1. Tape is a popular method of green storage that is widely used. Tape has no moving parts that use up energy, is portable and has a longer shelf-life than other storage technology.

  2. Virtualized servers can host up to 20 virtualized servers on one physical server. This improves efficiency and cuts down on the need for expensive hardware.

  3. Not as widely used, but growing in popularity, are Solid-State Drives (SSDs), which are energy efficient and faster than mechanical hard disk drives. However, SSDs come at a higher cost than other methods.

  4. A massive array of idle disks (MAID) system only spins active drives, cutting down on energy use and prolonging shelf-life. This architecture has been around for a while but hasn't widely caught on largely

Q.14 Explain Energy-saving software techniques.

Ans. : • Reducing power consumption is a challenge to system designers. Portable systems, such as laptop computers and Personal Digital Assistants (PDAs) draw power from batteries; so reducing power consumption extends their operating times.

- For desktop computers or servers, high power consumption raises temperature and deteriorates performance and reliability. Power consumed by the CPU is significant.

- The total energy consumed by the system per cycle is the sum of energies consumed by the processor and L1 cache, interconnects and pins, memory, L2 cache, the DC-DC converter and the efficiency losses in the battery.

- Energy-saving software techniques are as follows :

Techniques	Sub-types
Computational Efficiency	1. Algorithm
	2. Multithreading
	3. uArch tuning
	4. vectorination
Data Efficiency	1. Caching
	2. Asynchronous I/O
Context Awareness	1. AC/DC
	2. Policy for power
	3. thresholds
Idle Efficiency	1. timer resolution
	2. background activity
	3. C-states

6.9 Jungle Computing

Q.15 What is Jungle Computing ? What are the reasons for using Jungle Computing ?

Ans. : • Jungle computing is distributed computing system.

• A Jungle Computing System consists of all compute resources available to end-users, which includes clusters, clouds, grids, desktop grids, supercomputers, as well as stand-alone machines and even mobile devices.

• Reasons for using Jungle Computing Systems :

1. An application may require more compute power than available in any one system a user has access to.

2. Different parts of an application may have different computational requirements, with no single system that meets all requirements.

- From a high-level view, all resources in a Jungle Computing System are in some way equal, all consisting of some amount of processing power, memory and possibly storage.

- End-users perceive these resources as just that : a compute resource to run their application on

Q.16 What are Jungle computing systems ?

Ans. : • When grid computing was introduced over a decade ago, its foremost visionary aim was to provide efficient and transparent socket computing over a distributed set of resources.

- Many other distributed computing paradigms have been introduced, including peer-to-peer computing, volunteer computing and more recently cloud computing.

- These paradigms all share many of the goals of grid computing, eventually aiming to provide end-users with access to distributed resources with as little effort as possible.

- These new distributed computing paradigms have led to a diverse collection of resources available to research scientists, which include stand-alone machines, cluster systems, grids, clouds, desktop grids, etc.

- With clusters, grids and clouds thus being equipped with multi-core processors and many-core 'add-ons', systems available to scientists are becoming increasingly hard to program and use.

- Despite the fact that the programming and efficient use of many-cores is known to be hard, this is not the only problem. With the increasing heterogeneity of the underlying hardware, the efficient mapping of computational problems onto the 'bare metal' has become vastly more complex. Now more than ever, programmers must be aware of the potential for parallelism at all levels of granularity.

6.10 Docker at a Glance

Q.17 What is Docker ? List the benefits of the Docker Workflow

Ans. : • Docker is quickly changing the way that organizations are deploying software at scale.

• Docker is a tool that promises to easily encapsulate the process of creating a distributable artifact for any application, deploying it at scale into any environment, and streamlining the workflow and responsiveness of agile software organizations.

• Benefits :

1. Packaging software in a way that leverages the skills developers already have.

2. Bundling application software and required OS file systems together in a single standardized image format

3. Abstracting software applications from the hardware without sacrificing resources

Q.18 What is Process Simplification? Explain workflow with and without docker.

Ans. : • Docker can simplify both workflows and communication, and that usually starts with the deployment story. Fig. Q.18.1 shows workflow with and without docker.

1. Application developers request resources from operations engineers.

2. Resources are provisioned and handed over to developers.

3. Developers script and tool their deployment.

4. Operations engineers and developers tweak the deployment repeatedly.

5. Additional application dependencies are discovered by developers.

6. Operations engineers work to install the additional requirements.

7. Go to step 5 and 6

8. The application is deployed.

Development team   **Operations team**
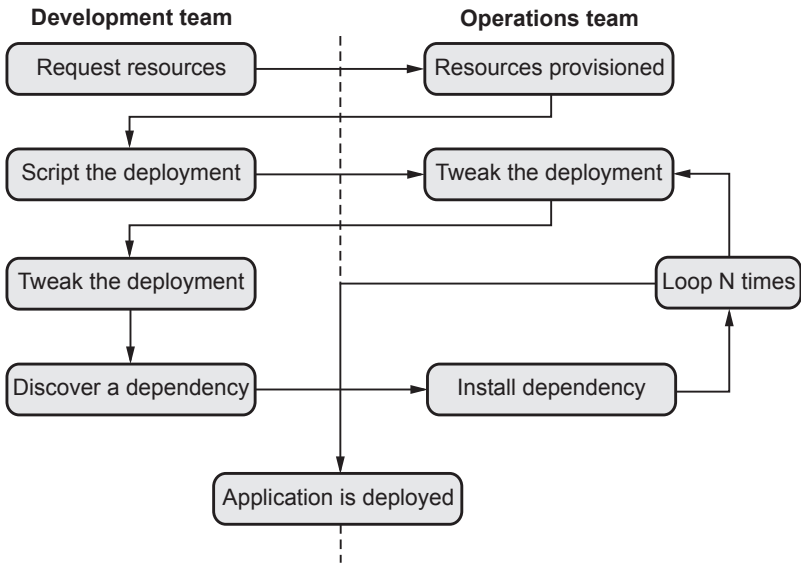
Fig. Q.18.1(a) : Traditional deployment workflow(without Docker)

1. Application developers request resources from operations engineers.

2. Resources are provisioned and handed over to developers.

3. Developers script and tool their deployment.

4. Operations engineers and developers tweak the deployment repeatedly.

5. Additional application dependencies are discovered by developers.

6. Operations engineers work to install the additional requirements.

7. Loop over steps 5 and 6 Nmore times.

8. The application is deployed.

• Fig. Q.18.1(b) shows Docker deployment workflow

Development team   **Operations team**
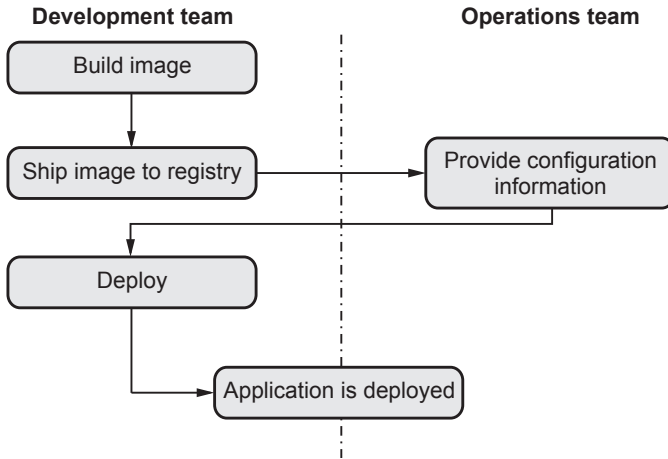
Fig. Q.18.1(b) : Docker deployment workflow

1. Developers build the Docker image and ship it to the registry.

2. Operations engineers provide configuration details to the container and provision resources.

3. Developers trigger deployment

Q.19 Explain briefly Docker client/server model.

Ans. : • Fig. Q.19.1 shows Docker client- server model. It consists of two parts : the client and the server. Registry is one more components which stores Docker images and metadata about those images.
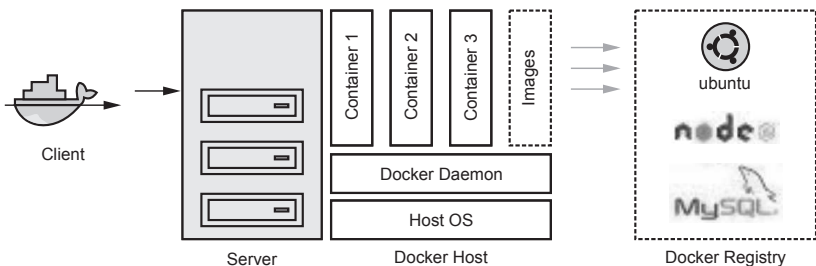
Fig. Q.19.1 : Client-server model
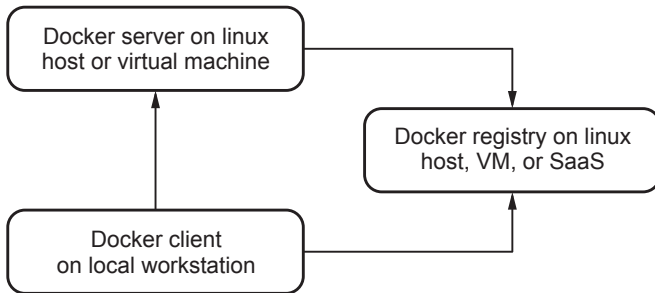
Fig. Q.19.2 : Data flow

- Docker Engine is a client-server based application with following components -

    1. A server which is a continuously running service called a daemon process.

    2. A REST API which interfaces the programs to use talk with the daemon and give instruct it what to do.

    3. A command line interface client.

- Docker client is the primary service using which Docker users communicate with the Docker. When we use commands "docker run" the client sends these commands to dockerd, which execute them out.

- The command used by docker depend on Docker API. In Docker client can interact more than one daemon process.

- The Docker images are building the block of docker or docker image is a read-only template with instructions to create a Docker container. Docker images are the most build part of docker life cycle

- The server does the ongoing work of running and managing your containers, and you use the client to tell the server what to do.

- The Docker daemon can run on any number of servers in the infrastructure, and a single client can address any number of servers.

- Clients drive all of the communication, but Docker servers can talk directly to image registries when told to do so by the client.

- Clients are responsible for directing servers what to do, and servers focus on hosting containerized applications.

- Docker registry keeps Docker images. We can run our private registry.

- When we run the docker pull and docker run commands, the required images are pulled from our configured registry directory.

- Using Docker push command, the image can be uploaded to our configured registry directory.

END... ✍

APRIL-2019 [IN SEM] - 253	Solved Paper

Course 2015

Time : 1 Hour]   **[Maximum Marks : 30**

Instructions to the candidates :

1) Solve Q.1 or Q.2, Q.3 or Q.4, Q.5 or Q.6.

2) Figures to the right indicate full marks.

3) Assume suitable data, whenever necessary.

Q.1 **a)** *What is cloud computing ? What are the components of cloud computing ? Explain with neat diagram.*
(Refer Q.4 and Q.5 of Chapter 1) [5]

       b) *What are the advantages and disadvantages of cloud computing ?* **(Refer Q.8 of Chapter 1)** [5]

<div align="center">OR</div>

Q.2 **a)** *Explain cloud deployment models as per the NIST guidelines.*
(Refer Q.19 of Chapter 2) [6]

       b) *Explain benefits of SaaS in detail.*
(Refer Q.12 of Chapter 1) [4]

Q.3 **a)** *Draw and explalin cloud file system GFS/HDFS.*
(Refer Q.4 of Chapter 2) [5]

       b) *Explain the working of Google Data Store.*
(Refer Q.18 (b) of Chapter 2) [5]

<div align="center">OR</div>

Q.4 **a)** *How do you Store Big Table tables on GFS/HDFS.*
(Refer Q.13 of Chapter 2) [5]

       b) *Draw and explain architecture of Amazon Dynamo.*
(Refer Q.17 of Chapter 2) [5]

Q.5 **a)** *Explain different levels of virtualization implementation with neat diagram Also give example of each.*
(Refer Q.2 and Q.5 of Chapter 3) [5]

    b) *Discuss the disadvantages of hardware level virtualization along with the solutions to overcome.*

(Refer Q.17 and Q.18 of Chapter 3)   **[5]**

<div align="center">**OR**</div>

Q.6   **a)**   *What is hypervisor ? Write a short note on Xen architecture.*

(Refer Q.9 of Chapter 3)   **[5]**

    b) *Explain full and para virtualization with examples.*

(Refer Q.11 of Chapter 3)   **[5]**

END... ✍

Course 2015

Time : 2 ½ Hours]   [Maximum Marks : 70

Instructions to the candidates :

1) Answer Q.1 or Q.2, Q.3 or Q.4, Q.5 or Q.6, Q.7 or Q.8, Q.9 or Q.10.

2) Draw neat diagram wherever necessary.

3) Assume suitable data, if necessary.

4) Figures to the right indicate full marks.

Q.1 a) *Explain in detail the benefits and limitations that are offered by the cloud to organizations when they hire cloud services. Also, explain about the security concerns for the organisations while using cloud services.* **[5]**

Ans. : Refer Q.8 of Chapter - 1

• Cloud computing is a basic technology for sharing of resources on the internet. Virtualization is a central innovation for empowering cloud resource sharing. Confidentiality of data storage is the essential alarm for assurance of data security so cloud computing does not provide robust data privacy.

• All details of data migration to cloud remain hidden from the customers. The problem in cloud computing environments are security of cloud computing.

• Cloud computing involves using internet hosting rather than local severs, to make data and services easily accessible across locations and devices. It is a system where most businesses and people work from more than one computing device.

• Cloud computing can refer to either the applications or services delivered through the internet as well as to the software and hardware that facilitate these services.

• Clouds typically have single security architecture but have many customers with different demands. Cloud security issues may

drive and define how we adopt and deploy cloud computing solutions.

- Highly sensitive data is likely to be on private clouds where organizations have complete control over their security model. Cloud computing is about gracefully losing control while maintaining accountability even if the operational responsibility falls upon one or more third parties.

- In cloud computing environments, it will be necessary to be able to prove the security state of a system, regardless of its location or proximity to other, potentially insecure virtual machines.

- Virtual machines are dynamic. They can quickly be reverted to previous instances, paused and restarted, relatively easily. They can also be readily cloned and seamlessly moved between physical servers.

- Cloud computing servers use the same operating systems, enterprise and web applications as localized virtual machines and physical servers. The ability for an attacker or malware to remotely exploit vulnerabilities in these systems and applications is a significant threat to virtualized cloud computing environments.

b) *Write a note on cloud file systems with architecture.*

(Refer Q.1 and Q.4 of Chapter - 2)   **[5]**

OR

Q.2 a) *Write a note on multitenant nature of Saas Solutions.*   **[5]**

Ans. : • In order to achieve cost efficiencies in delivering same applications to various sets of users it is a vital and obvious choice that an increasing number of applications are Multi-tenant instead of single tenant.

- Multi-tenant application should be able to satisfy the needs of multiple sub-organizations or sections within the organization (multiple tenants), using the single, shared stake of software and hardware.

- Fig. 1 shows multi-tenant organization.
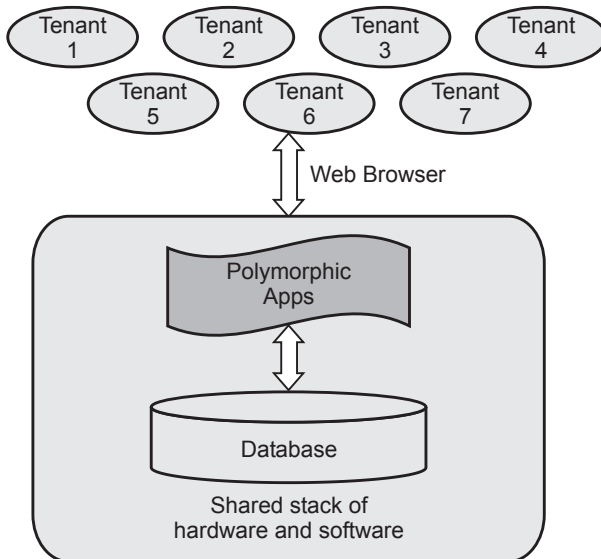
Fig. 1 Multi-tenant organization

- A traditional static application is not capable of addressing unique challenges of multi-tenancy.

- A Multi-tenant application should be dynamic in nature, or polymorphic, to fulfill the specific expectations of various tenants and their users.

- Application components need to be generated at runtime from meta-data-i.e. data about the application itself.

- When tenants create custom application entities (i.e., custom tables), programmatically need to track of Meta-data concerning the entities, their Attribute, relationships, and other entity definition characteristics.

- A few large database tables store the structured and unstructured data separately for all virtual tables, and a set of related, specialized pivot tables in order to maintain data that makes the combined data set fully functional.

- A multi-tenant cloud is a cloud computing architecture that allows customers to share computing resources in a public or

private cloud. Each tenant's data is isolated and remains invisible to other tenants.

Open shared application and one shared database

Fig. 2 Multi-tenant technology

• It allows multiple users to work in a software environment at the same time, each with their own separate user interface, resources and services.

• The multitenant application design was created to enable multiple users (tenants) to access the same application logic simultaneously.

• Tenants can individually customize features of the application, such as :

1. **User interface :** Tenants can define a specialized look for their application interface.

2. **Business process :** Tenants can customize the rules, logic, and workflows of the business processes that are implemented in the application.

3. **Data model :** Tenants can extend the data schema of the application to include, exclude, or rename fields in the application data structures.

4. **Access control :** Tenants can independently control the access rights for users and groups.

• Benefits of a Multitenancy technology :

1. **Costs savings :** It yields tremendous economy of scale for the provider so he can offer the service at a lower cost to customers.

2. **Improved quality, user satisfaction and customer retention :** A multitenant application is one large community hosted by the provider which can gather operational information from the collective user population and make frequent, incremental

improvements to the service that benefit the entire user community at once.

3. **Improved security :** most current enterprise security models are perimeter-based, making them vulnerable to inside attacks.

- Common characteristics of multitenant applications are as follows :

1. **Usage isolation -** The usage behavior of one tenant does not affect the application availability and performance of other tenants.2.

2. **Data security -** Tenants cannot access data that belongs to other tenants.

3. **Recovery -** Backup and restore procedures are separately executed for the data of each tenant.

4. **Application upgrade -** Tenants are not negatively affected by the synchronous upgrading of shared software artifacts.

5. **Scalability -** The application can scale to accommodate increases in usage by existing tenants and/or increases in the number of tenants.

6. **Metered usage -** Tenants are charged only for the application processing and features that are actually consumed.

7. **Data tier isolation -** Tenants can have individual databases, tables and schemas isolated from other tenants.

   b) *Explain open cloud consortium.*

(Refer Q.31 of Chapter - 3)   **[5]**

Q.3   a) *Explain the following threats related to cloud computing.*   **[5]**

   i) Disk failure   ii) Disgrunted employees   iii) Network failure.

Ans. : i) Disk failure : Disk derives are mechanical device and they will eventually wear out and fail. All mechanical device have an associated Mean Time Between Failure (MTBF) rating.

ii) Disgrunted employees : Disgrunted employees can harm a company by launching a computer virus, changing or deleting files or exposing system password. In some cases, they can cause

significant damage to the company's reputation or to its intellectual property.

iii) Network failure : For simple network, the network will remain down until the faulty device or cable is identified and replaced.

    b) *Explain the solution stack : LAMP. Also, explain how LAPP is considered as more powerful alternative to the more popular LAMP stack.*

[5]

Ans. : • Solution stack is a set of different programs or application software that are bundled together in order to produce a desired result or solution.

• This may refer to any collection of unrelated applications taken from various subcomponents working in sequence to present a reliable and fully functioning software solution. Many computer companies like Microsoft and Linux provide different solution stacks to clients.

a) LAMP

• LAMP is an archetypal model of web service stacks, named as an acronym of the names of its original four open-source components : The Linux operating system, the Apache HTTP Server, the MySQL relational database management system (RDBMS), and the PHP programming language.

• The common software components that make up a traditional LAMP stack are :

1. **Linux :** The operating system (OS) makes up our first layer. Linux sets the foundation for the stack model. All other layers run on top of this layer.

2. **Apache :** The second layer consists of web server software, typically Apache Web Server. This layer resides on top of the Linux layer. Web servers are responsible for translating from web browsers to their correct website.

3. **MySQL :** Our third layer is where databases live. MySQL stores details that can be queried by scripting to construct a website. MySQL usually sits on top of the Linux layer alongside Apache/layer 2. In high end configurations, MySQL can be off loaded to a separate host server.

4. **PHP :** Sitting on top of them all is our fourth and final layer. The scripting layer consists of PHP and/or other similar web programming languages. Websites and Web Applications run within this layer.

b) LAPP

• The LAPP stack is an open source web platform that can be used to run dynamic web sites and servers. It is considered by many to be a powerful alternative to the more popular LAMP stack and includes Linux, Apache, PostgreSQL (instead of MySQL) and PHP, Python and Perl.

• LAPP uses Linux as the operating system, Apache as the Web server, PostGreSQL as the RDBMS, and PHP as the object-oriented scripting language. Perl or Pythonmay be substituted for PHP.

OR

Q.4 **a)** *Explain the following* [5]

  i) CPU virtualization **(Refer Q.18 of Chapter - 3)**
  ii) Memory virtualization **(Refer Q.19 of Chapter - 3)**

  b) *How to improve performance through load balancing ? Explain how load balancing takes help of a server to route traffic to other servers which share the workload.* [5]

Ans. : • Across the web, site experience a wide range of network traffic requirements. For simple web page, client web browser request an HTML page and then related graphics, CSS from the web server.

• Fig. 3 shows load balancing uses a server to route the traffic to multiple server.

• Typically, a load balancer sits between the client and the server accepting incoming network and application traffic and distributing the traffic across multiple backend servers using various algorithms.

• By balancing application requests across multiple servers, a load balancer reduces individual server load and prevents any one

application server from becoming a single point of failure, thus improving overall application availability and responsiveness.
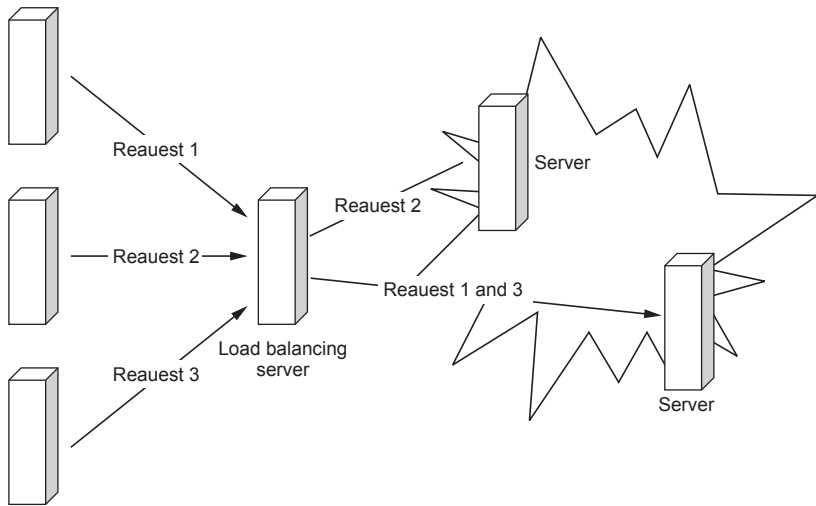
Fig. 3

- Load balancers consider two factors before forwarding a request to a backend server. They will first ensure that the server they choose is actually responding appropriately to requests and then use a pre-configured algorithm to select one from the set of healthy servers.

- Cloud load balancing is the process of distributing workloads and computing resources across one or more servers. This kind of distribution ensures maximum throughput in minimum response time.

- The workload is segregated among two or more servers, hard drives, network interfaces or other computing resources, enabling better resource utilization and system response time. Thus, for a high traffic website, effective use of cloud load balancing can ensure business continuity.

- There is a variety of load balancing methods, which use different algorithms for different needs.

1. Least Connection Method - This method directs traffic to the server with the fewest active connections. This approach is quite useful when there are a large number of persistent client connections which are unevenly distributed between the servers.

2. Least Response Time Method - This algorithm directs traffic to the server with the fewest active connections and the lowest average response time.

3. Least Bandwidth Method - This method selects the server that is currently serving the least amount of traffic measured in megabits per second (Mbps).

4. Round Robin Method - This method cycles through a list of servers and sends each new request to the next server. When it reaches the end of the list, it starts over at the beginning.

5. Weighted Round Robin Method - The weighted round-robin scheduling is designed to better handle servers with different processing capacities. Each server is assigned a weight. Servers with higher weights receive new connections before those with less weights and servers with higher weights get more connections than those with less weights.

Q.5   a) *Explain the steps for configuring a server for EC2.*   **[9]**

Ans. : • Let's get started with Amazon Elastic Compute Cloud (Amazon EC2) by launching, connecting to and using a Linux instance. An instance is a virtual server in the AWS cloud. With Amazon EC2, you can setup and configure the operating system and applications that run on your instance.

• When you sign up for AWS, you can get started with Amazon EC2 using the AWS Free Tier.

• The instance is an Amazon EBS-backed instance (meaning that the root volume is an EBS volume). You can either specify the availability zone in which your instance runs or let Amazon EC2 select an availability zone for you. When you launch your instance, you secure it by specifying a key pair and security group. When you connect to your instance, you must specify the private key of the key pair that you specified when launching your instance.

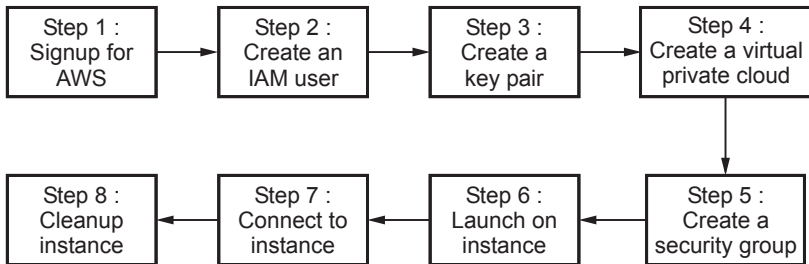- Various steps to configure Amazon EC2 Linux instance is shown in Fig. 4.

```
┌──────────┐   ┌──────────┐   ┌──────────┐   ┌──────────────┐
│ Step 1 : │   │ Step 2 : │   │ Step 3 : │   │  Step 4 :    │
│ Signup for│→ │ Create an│→ │ Create a │→ │ Create a virtual│
│   AWS    │   │ IAM user │   │ key pair │   │ private cloud │
└──────────┘   └──────────┘   └──────────┘   └──────────────┘
                                                     │
                                                     ↓
┌──────────┐   ┌──────────┐   ┌──────────┐   ┌──────────────┐
│ Step 8 : │   │ Step 7 : │   │ Step 6 : │   │  Step 5 :    │
│ Cleanup  │← │Connect to│← │Launch on │← │  Create a     │
│ instance │   │ instance │   │ instance │   │ security group│
└──────────┘   └──────────┘   └──────────┘   └──────────────┘
```

Fig. 4 Steps to signup for EC2

Step 1 : SignUp for AWS

- When you signup for Amazon Web Services (AWS), your AWS account is automatically signed up for all services in AWS, including Amazon EC2. You are charged only for the services that you use.

- With Amazon EC2, you pay only for what you use. If you are a new AWS customer, you can get started with Amazon EC2 for free.

Step 2 : Create an IAM user

- Services in AWS, such as Amazon EC2, require that you provide credentials when you access them, so that the service can determine whether you have permission to access its resources. The console requires your password.

- You can create access keys for your AWS account to access the command line interface or API. However, we don't recommend that you access AWS using the credentials for your AWS account; we recommend that you use AWS Identity and Access Management (IAM) instead.

- Create an IAM user and then add the user to an IAM group with administrative permissions or grant this user administrative permissions. You can then access AWS using a special URL and the credentials for the IAM user. If you signed up for AWS but

have not created an IAM user for yourself, you can create one using the IAM console.

Step 3 : Create a key pair

• AWS uses public-key cryptography to secure the login information for your instance. A Linux instance has no password; you use a key pair to log in to your instance securely. You specify the name of the key pair when you launch your instance, then provide the private key when you log in using SSH.

• If you haven't created a key pair already, you can create one using the Amazon EC2 console. Note that if you plan to launch instances in multiple regions, you'll need to create a key pair in each region.

Step 4 : Create a Virtual Private Cloud (VPC)

• Amazon VPC enables you to launch AWS resources into a virtual network that you've defined, known as a Virtual Private Cloud (VPC). The newer EC2 instance types require that you launch your instances in a VPC. If you have a default VPC, you can skip this section and move to the next task, create a security group. To determine whether you have a default VPC, open the Amazon EC2 console and look for default VPC under account attributes on the dashboard.

Step 5 : Create a security group

• Security groups act as a firewall for associated instances, controlling both inbound and outbound traffic at the instance level. You must add rules to a security group that enable you to connect to your instance from your IP address using SSH. You can also add rules that allow inbound and outbound HTTP and HTTPS access from anywhere. Note that if you plan to launch instances in multiple regions, you'll need to create a security group in each region.

Step 6 : Launch an instance

• You can launch a Linux instance using the AWS management console as described in the following procedure.

1. Open the Amazon EC2 console at
   https://console.aws.amazon.com/ec2/.

2. From the console dashboard, choose **Launch Instance.**

3. The **Choose an Amazon Machine Image (AMI)** page displays a list of basic configurations, called Amazon Machine Images (AMIs), that serve as templates for your instance. Select an HVM version of Amazon Linux 2. Notice that these AMIs are marked "Free tier eligible."

4. On the **Choose an Instance Type** page, you can select the hardware configuration of your instance. Select the t2.micro type, which is selected by default. Notice that this instance type is eligible for the free tier.

5. Choose **Review and Launch** to let the wizard complete the other configuration settings for you.

6. On the **Review Instance Launch** page, under security groups, you'll see that the wizard created and selected a security group for you. You can use this security group or alternatively you can select the security group that you created when getting setup using the following steps.

   a) Choose **Edit security groups.**

   b) On the **Configure Security Group** page, ensure that **Select an existing security** group is selected.

   c) Select your security group from the list of existing security groups and then choose **Review and Launch.**

7. On the **Review Instance Launch** page, choose **Launch.**

8. When prompted for a key pair, select **Choose an existing key pair,** then select the key pair that you created when getting setup. When you are ready, select the acknowledgement check box and then choose launch instances.

9. A confirmation page lets you know that your instance is launching. Choose **View Instances** to close the confirmation page and return to the console.

10. On the **Instances** screen, you can view the status of the launch. It takes a short time for an instance to launch. When you launch an instance, its initial state is pending. After the instance starts, its state changes to running and it receives a public DNS name.

11. It can take a few minutes for the instance to be ready so that you can connect to it. Check that your instance has passed its status checks; you can view this information in the status checks column.

Step 7 : Connect to your Instance

Several ways to connect to your Linux instance is shown in Table 1.

Your computer OS	Topic
Linux	Connecting to your Linux instance using SSH.
Windows	Connecting to your Linux instance from Windows using PuTTY.
	Connecting to your Linux instance from Windows using Windows Subsystem for Linux.
Other	Connecting to your Linux instance using MindTerm

Table 1 Ways to connect to Linux instance

Step 8 : Cleanup your instance

• After you've finished with the instance, you should cleanup by terminating the instance.

• Terminating an instance effectively deletes it; you can't reconnect to an instance after you've terminated it.

• If you launched an instance that is not within the AWS free tier, you'll stop incurring charges for that instance as soon as the instance status changes to shutting down or terminated. If you'd like to keep your instance for later, but not incur charges, you can stop the instance now and then start it again later.

• To terminate your instance following steps can be used :

1) In the navigation pane, choose instances. In the list of instances, select the instance.

2) Choose actions, instance state, terminate.

3) Choose yes, terminate when prompted for confirmation.

• Amazon EC2 shuts down and terminates your instance. After your instance is terminated, it remains visible on the console for a short while and then the entry is deleted.

b) *What are AWS load balancing services ? Explain the elastic load balancer and its types with its advantages.*

(Refer Q.16 and Q.17 of Chapter - 4)   **[8]**

OR

Q.6 a) *Explain the steps to create to amanzon S3 bucket and managing associated object.*   **[8]**

Ans. : • You can use Amazon S3 to store and retrieve any amount of data at any time, from anywhere on the web. By completing the steps in this quick start guide, you will successfully create a new S3 bucket, add a file to it, retrieve this file, and finally delete it, all within the AWS Free Tier.

• When you sign up for AWS, your AWS account is automatically signed up for all services in AWS, including Amazon S3. If you don't have an AWS account, use the following procedure to create one.

To sign up for AWS

1. Open https://aws.amazon.com/, and then choose Create an AWS Account.

   Note : If you previously signed in to the AWS Management Console using AWS account root user credentials, choose Sign in to a different account. If you previously signed in to the console using IAM credentials, choose Sign-in using root account credentials. Then choose Create a new AWS account.

2. Follow the online instructions. Part of the sign-up procedure involves receiving a phone call and entering a verification code using the phone keypad.

Step 1 : Create an Amazon S3 Bucket

• First, you need to create an Amazon S3 bucket where you will store your objects.

1. Sign in to the preview version of the AWS Management Console

2. Under Storage & Content Delivery, choose S3 to open the Amazon S3 console.

3. From the Amazon S3 console dashboard, choose Create Bucket.

4. In Create a Bucket, type a bucket name in Bucket Name. The bucket name you choose must be globally unique across all existing bucket names in Amazon S3 (that is, across all AWS customers).

5. In Region, choose Oregon.

6. Choose Create.

• When Amazon S3 successfully creates your bucket, the console displays your empty bucket in the Buckets pane.

Step 2 : Upload a File to Your Amazon S3 Bucket

• Now that you have created a bucket, you're ready to add an object to it. An object can be any kind of file, a document, a photo, a video, a music file, or other file type.

1. In the Amazon S3 console, choose the bucket where you want to upload an object, choose Upload, and then choose Add Files.

2. In the file selection dialog box, find the file that you want to upload, choose it, choose Open and then choose Start Upload.

• You can watch the progress of the upload in the Transfer pane.

Step 3 : Retrieve a File from Your Amazon S3 Bucket

• Now that you have added an object to a bucket, you can open and view it in a browser. You can also download the object to your local computer.

1. In the Amazon S3 console, choose your S3 bucket, choose the file that you want to open or download, choose Actions, and then choose Open or Download.

2. If you are downloading an object, specify where you want to save it.

• The procedure for saving the object depends on the browser and operating system that you are using.

Step 4 : Delete a File From Your Amazon S3 Bucket

- If you no longer need to store the file you've uploaded to your Amazon S3 bucket, you can delete it.

- Within your S3 bucket, select the file that you want to delete, choose Actions and then choose Delete.

- In the confirmation message, choose OK.

    b) *What is an amazon EBS snapshot ? Give steps to create EBS snapshot.* **(Refer Q.13 of Chapter - 4)** [9]

Q.7 **a)** *Describe cloudlets for mobile cloud computing with neat diagram and differentiate between cloudlets and clouds.*
(Refer Q.10 and Q.11 of Chapter - 5) [8]

    b) *Write a note on innovative application of IoT.*
(Refer Q.28 of Chapter - 5) [9]

OR

Q.8 **a)** *Explain performance metrics for HPC / HTC systems.*
(Refer Q.15 of Chapter - 5) [9]

    b) *Explain the Cyber Physical System (CPS). Explain CPS components.* **(Refer Q.29 of Chapter - 5)** [8]

Q.9 **a)** *Explain the client server architecture of docker ? What are network ports and unix sockets ?* **(Refer Q.19 of Chapter - 6)** [8]

    b) *What is energy aware cloud computing ? Explain in detail.*
(Refer Q.13 of Chapter - 6) [8]

OR

Q.10 a) *What is impact of cloud on operating systems in future ?*
(Refer Q.1 of Chapter - 6) [8]

    b) *Explain docker with respect to process simplification. Board support and adoption, architecture.* **(Refer Q.18 of Chapter - 6)** [8]

| DECEMBER-2019 [END SEM] [5670] - 717 | **Solved Paper** |

Course 2015

Time : 2 $\frac{1}{2}$ Hours]   **[Maximum Marks : 70**

Q.1 **a)** *Write note on identity management as a service (IDaas).*
(Refer Q.20 of Chapter - 1)   **[7]**

   b) *Write a note on different cloud storage providers.*
(Refer Q.18 of Chapter - 2)   **[7]**

   c) *Write a note on solution stacks : LAMP and LAPP.*
(Refer Q.3 (b) of May - 2019)   **[6]**

<div align="center">**OR**</div>

Q.2 **a)** *Explain the term "Limited Portability between Cloud Providers".*   **[7]**

Ans. : • Portability is a measure used to determine the impact of moving cloud consumer IT resources and data between clouds.

• Cloud portability is the ability to move applications and data from one cloud computing environment to another with minimal disruption.

• Cloud portability enables the migration of cloud services from one cloud provider to another or between a public cloud and a private cloud.

• A cloud consumer's application has a decreased level of portability when assessing a potential migration from cloud A to cloud B, because the cloud provider of cloud B does not support the same security technologies as cloud A.

• Cloud data portability is the ability to easily transfer data from one cloud service to another cloud service or between a cloud service customer's system and a cloud's service.

• It is achieved by the source service supplying the data in exactly the format that is accepted by the target service. But, even if the formats do not match, the transformation between them may be simple and straightforward to achieve with commonly available tools.

• Cloud application portability is the ability to easily transfer an application or application components from one cloud service to a
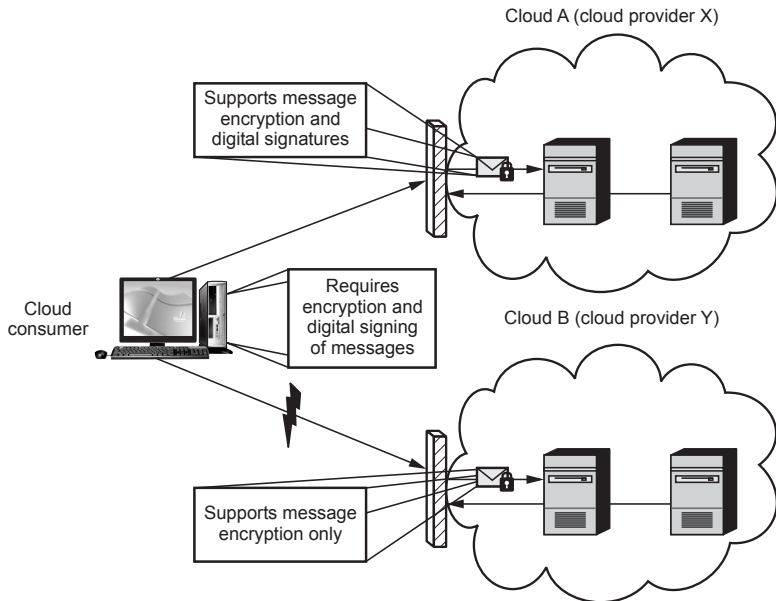
Fig. 1 Cloud portability

comparable cloud service or from a cloud service customer's system to a cloud service.

- The key is the ease of moving the application or application components. The application may require recompiling or relinking for the target cloud service, but it should not be necessary to make significant changes to the application code.

b) *Explain the storage model of bigtable.*
(Refer Q.11 of Chapter - 2) [7]

c) *Explain open virtualization format ?*
(Refer Q.32 of Chapter - 3) [6]

Q.3 a) *Explain "Snap Shotting an EBS Volume and Increasing Performance" ?* **(Refer Q.9 of Chapter - 4)** [9]

b) *Write a note on services offered by amazon ?*
(Refer Q.1 of Chapter - 4) [8]

OR

Q.4 a) *Explain the steps to create an amazon S3 bucket and managing associated objects ?* **(Refer Q.6 (a) of May-2019)** [9]

b) *Explain steps to configure server for EC2 ?*
(Refer Q.5 (a) of May-2019) [8]

Q.5 a) *Explain graph theoretic analysis of social network ?*
(Refer Q.34, Chapter - 5) [9]

b) *Write a note on supply chain management, retailing ?*
(Refer Q.26, Chapter - 5) [8]

OR

Q.6 a) *Explain RFID tags and device components ?*
(Refer Q.18 of Chapter - 5) [9]

b) *Write a note on performance metrics for HPC/HTC systems ?*
(Refer Q.15 of Chapter - 5) [8]

Q.7 a) *Explain immutable infrastructure, workflow, building application in docker ?* **(Refer Q.18 of Chapter - 6)** [8]

Ans. : • Immutable infrastructure is an approach to managing services and software deployments on IT resources wherein components are replaced rather than changed. An application or services is effectively redeployed each time any change occurs.

• Docker containers were designed to be immutable.

• Another benefit to using docker containers to implement your immutable infrastructure, is that it helps manage data persistence or stateful components, like an application's database. Stateful components cannot simply be destroyed and redeployed using a server image.

b) *Explain traditional as well as docker deployment workflow, client server architecture of docker ?*
(Refer Q.18 and Q.19 of Chapter - 6) [8]

OR

Q.8 a) *Write a notes on energy aware cloud computing, energy efficiency in cloud computing ?*
(Refer Q.13 and Q.14 of Chapter - 6) [8]

b) *Explain the comet cloud architecture with diagram.*
(Refer Q.10 of Chapter - 6) [8]

END...✍