Unit VI

6 Future of Cloud Computing

Syllabus

***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.*

Contents

6.1 How the Cloud will Change Operating Systems

- 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 customer's 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.

- Key components of OS are as follows :
  1. **Kernel :** It manages memory, processes, etc.
  2. **Device drivers :** It drive different hardware from different vendors.
  3. **User interfaces :** It includes command line shell and Window system.
  4. **File system :** It provides a hierarchical way to persist data.
  5. **Security :** It authenticates users and protects information.

Squeezed Sandwich

- With virtualization, operating systems moved up in the software stack. The role of managing and abstracting hardware is relinquished to hypervisors underneath the virtual machines. So the OS is squeezed by virtualization from the bottom.
- Long before virtualization, there have been concepts of software middleware including database, messaging, etc.
- These provide a higher level platform for applications, and result in a higher quality of products and higher developer productivity.
- Also, the rise of software virtual machines like JVM and .Net, have abstracted the OS services to a higher level of programming APIs. So the OS is less important from the application development point of view. It has been squeezed from the top as well.

6.1.1 Just enough Operating System (JeOS)

- Just Enough Operating System (JeOS) is a tech design concept in which a leaner version of an OS replaces the full version to run on a specific device or hardware setup.
- Users of cloud based software access applications via a browser. They thus do not need an OS to do more than run the browser.
- Cloud systems share memory, disk space, peripherals and other resources among multiple applications and users by providing each with isolated access to the network, storage, and server virtualization layers.
- The systems use a hypervisor to isolate allocated hardware resources to run workloads.
- In contrast to the traditional operating system, a JeOS offers only the components necessary to make an application run, without unnecessary interfaces, functions, libraries, and services.
- It is packaged with the software to form a prebuilt, preconfigured, ready to-run application appliance within a virtual machine.

- The JeOS is a lightweight, low memory-footprint, easy-to-install system including only the code necessary to boot and support a file system, storage devices, and networking.
- Ubuntu Linux-based OS, which has a JeOS version. Other JeOS platforms include Novell's SUSE Linux Enterprise JeOS, Oracle's Enterprise Linux JeOS, and Sun's OpenSolaris JeOS.

6.2 Location - aware Applications

SPPU : Dec.-19

- 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 are 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
- Location-aware applications use the geographical position of a mobile worker or an asset to execute a task.
- Position is detected mainly through satellite technologies, such as a GPS, or through mobile location technologies in cellular networks and mobile devices.
- Examples include fleet management applications with mapping, navigation and routing functionalities, government inspections and integration with geographic information system applications.
- Advantages of location-aware application :
  1. Presents an affordable implementation without using extra hardware.
  2. It offers location awareness within building or area where GPS cannot be used.
  3. It helps in building customized map.

Review Question

1. *Write short note on : Location aware applications* **SPPU : Dec.-19, End sem, Marks 6**

6.3 Intelligent Fabrics, Paints and More

SPPU : Dec.-19

- 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
- Smart fabric could be used to create clothes or other textiles with dynamically changing colors or patterns. Possibilities include :
  1. A shirt linked to your Tinder profile, that subtly changes color when you are near someone you have "swiped right" on.
  2. A striped scarf that offers real-time bus information; the stripes fade one by one, indicating the number of minutes before the bus arrives.
  3. A shirt with a slogan that updates automatically to match your Facebook status.
  4. A single garment that lets the wearer customize its color or pattern for the day.
  5. A watch woven directly into the cuff of the garment.
- Smart materials are the materials, which can sense and react to environmental conditions. According to the manner of reaction, they can be divided into three categories.
  1. **Passive smart** : Sense environmental conditions. Ex : Temperature measurement.
  2. **Active smart** : Sense and react to the environmental conditions. Ex : Wearable electronics.
  3. **Very smart** : Sense, react and adapt to the environment conditions. Ex : Color changing materials.
- Smart fabrics and cloud analytics improve the future of health care.

- The Intelligent Fabric technology simplifies the process of designing a network by eliminating the need to set many details.
- A simple input based on the locations of network equipment, the number and type of access ports as well as interconnection distance and bandwidth enables the designer to choose the appropriate Alcatel-Lucent Enterprise equipment for the design.
- The Intelligent Fabric technology by default includes self-configuration of the network equipment through Auto-Fabric eliminating many manual tasks during the deployment process.
- The fabric is autonomously created just by unpacking, mounting, connecting and powering up the systems.
- Elimination of the manual setup processes shortens the time-to-production of the infrastructure and reduces the chances of errors in the deployment process.
- The Intelligent Fabric technology makes the network components aware of their physical and logical topologies through self-attachment.
- The fabric can attach itself to the existing adjacent systems including infrastructure, Wi-Fi or LAN, servers, and the user's devices, and to automatically configure the appropriate connectivity settings.
- The iFab technology provides network profiles to authenticate, recognize and classify those devices automatically regardless of location.
- The Intelligent Fabric technology enables seamless operation due to the intrinsic self-healing capabilities. Self-healing enables continued operation for critical enterprise networks even in the case of failure.
- Any component failure, link or node, is detected in real time with automated re-routing of the traffic. The network can be upgraded while in service, significantly reducing or eliminating the need for disruptive maintenance windows.
- Visibility, monitoring and reporting are the key ingredients for company infrastructure management.
- The Intelligent Fabric technology both automates the workflows across the infrastructure, and ensures that all the aspects are visible to the IT organization through a single pane of glass.
- The Intelligent Fabric technology enables complete visibility of the infrastructure.
- Together with logical and physical topologies, any component of the fabric, applications and the workflows can be examined both in general and in detail.

6.3.1 Application

- The Smart fabrics also famous as electronic textiles and smart textiles are digital enhanced fabrics that uses technology of light and battery to operate.
- These fabrics have technology to sense the environmental condition. The smart fabrics work through the signals that are received from the central control unit.
- The electrical processor embedded in the fabric analysis and evaluates the signals. The entire functioning of the smart fabrics work with the help of nanotechnology.
- Some of the generic applications of smart textiles are healthcare (telemedicine and use of biomedical clothing), Life belt (transabdominal wearable device), Life Jacket (constantly monitors and read the heart rate measurements and blood pressure), Military defence (monitoring toxic gases and prevents injuries), sportswear (monitoring athlete performance) , fashion and entertainment (club wear garments that reacts to light and environment), and the smart bra (measures hear rates through sensors).

1. Health care
   - The development of wearable monitoring systems is already having an effect on healthcare in the form of "Telemedicine".
   - Wireless-enabled garment with embedded textile sensors for simultaneous acquisition and continuous Monitoring of ECG, respiration, EMG, and physical activity.
   - The "smart cloth" embeds a strain fabric sensor based on piezo resistive yarns and fabric electrodes realized with metal based yarns.
2. Life belt is a trans-abdominal wearable device for long-term health monitoring that facilitates the parental monitoring procedures for both the mother and the fetus. Hospitals and obstetric clinics, on the other hand, might avoid the frequent visit of additional patients, so the remote health monitoring provided by this. "Life belt" will contribute to a significant reduction of the hospital's load.
3. Life jacket is a medical device worn by the patient that consequently reads their blood pressure or monitors the heart rate; the information is transferred to a computer and read by medical staff. A specialized camera in the form of headwear has been developed to be worn by paramedics. Visual information captured by the camera can be transferred directly to medical staff at the hospital enabling them to advise instantly on appropriate treatment.
4. Military/Defense : In extreme environmental conditions and hazardous situations there is a need for real time information technology to increase the protection and survivability of the people working in those conditions. Improvements in performance and additional capabilities would be of immense assistance within professions such as the defense forces and emergency response services.

5. Sportswear : Sports enthusiasts are able to benefit from integrated fabric sensors and display panels. They monitor heart rate and blood pressure during a gym workout or morning run and are able to analyse the information giving feedback on performance along with playing mood/ performance enhancing music.

Review Question

1. *Write short note on : Intelligent fabric and paints* **SPPU : Dec.-19, End sem, Marks 6**

6.4 The Future of Cloud TV

- 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.
- There are several advantages of cloud-based services-the key benefits are that the service is software-based, so one doesn't need a physical location to run the operations. As a result, real estate, infrastructure and manpower cost reduce dramatically.

- For instance, if a Bollywood film channel wants to check if it has a market in the US, it can use the cloud-based technology to launch without adding to its cost by leasing a satellite for a minimum of three to five years.
- A product of ActiveVideo, a Silicon Valley software company, CloudTV is available on more than 15 million devices.

6.5 Future of Cloud - based Smart Devices

- First there was computer, then came smart phone and now there are many devices that people use as computing platforms.
- Tablets, TVs, eBook readers are things of the past.
- Now there are Google Glass, Samsung Watch, Smart TV and many more. The list of devices with processor for computations that can be connected to Internet are increasing every day.
- Following are a couple of interesting uses of Google Glass :
  1. **Fast training for employees :** It takes a lot of training to operate a laser cutter. This can be taught more efficiently by overlaying visual aids onto the machine, enabling employees to learn how to use the equipment faster than conventional tutorials.
  2. **Museum Tours :** Audio recordings used currently will be enhanced with visual components. It'd be great to look at any painting hanging at the Met, have a software to recognize it and retrieve additional information on demand by a simple gesture.
- Fig. 6.5.1 shows smart device.
- Cloud computing has become a great enabler of cross platform applications, i.e. applications that can run on multiple platforms.

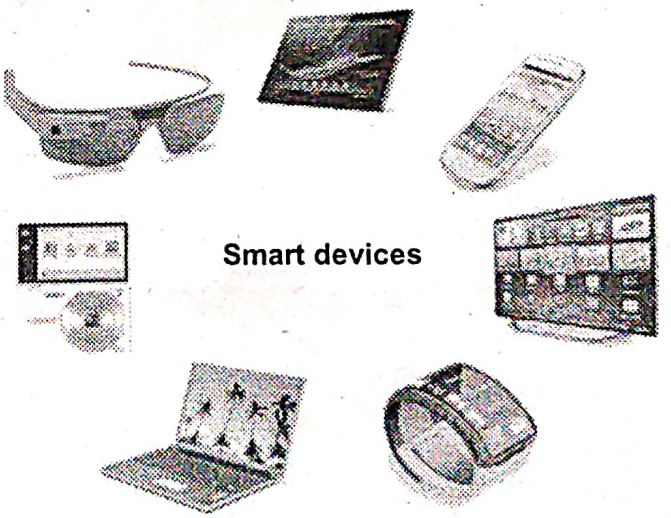

Fig. 6.5.1 Smart device

Technologies behind cross platform cloud applications :

- **Cross platform :** This is a common framework that enables the same programming code to get executed on different platforms
- **Cloud applications :** In cloud application, most or all the data is stored on remote servers and delivered over a network

- **Software :** The common framework is hosted within the cloud itself with minimal software as required by the user's device. In most cases, the interface is web-based, with only basic Internet connectivity being the client's requirement. Thus a cross platform cloud application is always portable. If one server shuts down, the service continues without getting noticed by end users. If the equipment changes, the new one is included to the collective pool of resources so that the software can adapt to interface with the new equipment.
- Hardware technology and IT industry are undergoing major modifications. Especially the ones related to network connectivity are gaining new norms.

6.6 Faster Time to Market for Software Applications

- Time to market is a term for the period of time between the first ideas around a product and its eventual availability on consumer markets.
- Companies use the time-to-market metric to evaluate how products are developed and how a specific project handles external competition.
- 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.

6.7 Home - based Cloud Computing

- 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. 6.7.1 shows home based cloud computing.
- 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.

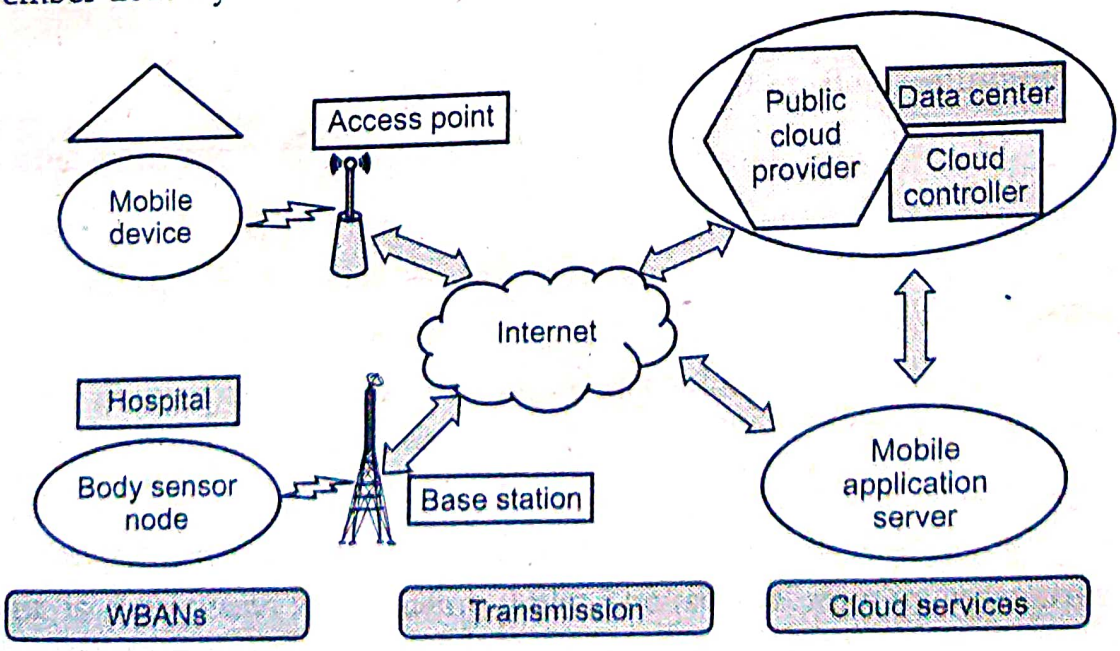

Fig. 6.7.1 Home based cloud computing

- 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 patient's 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.

6.8 Mobile Cloud

SPPU : May-18, Dec.-19

- 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.
- Fig. 6.8.1 shows 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.

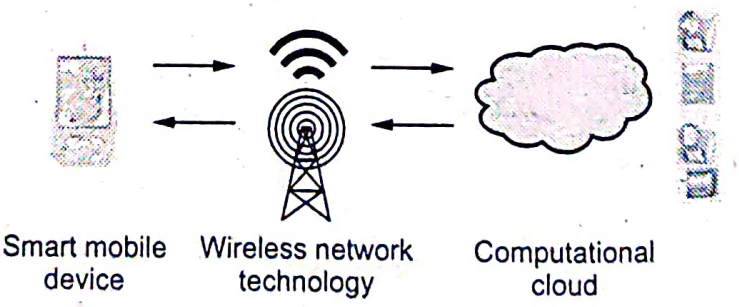

Fig. 6.8.1 Block diagram of mobile cloud

- 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. 6.8.2 shows mobile cloud computing architecture.

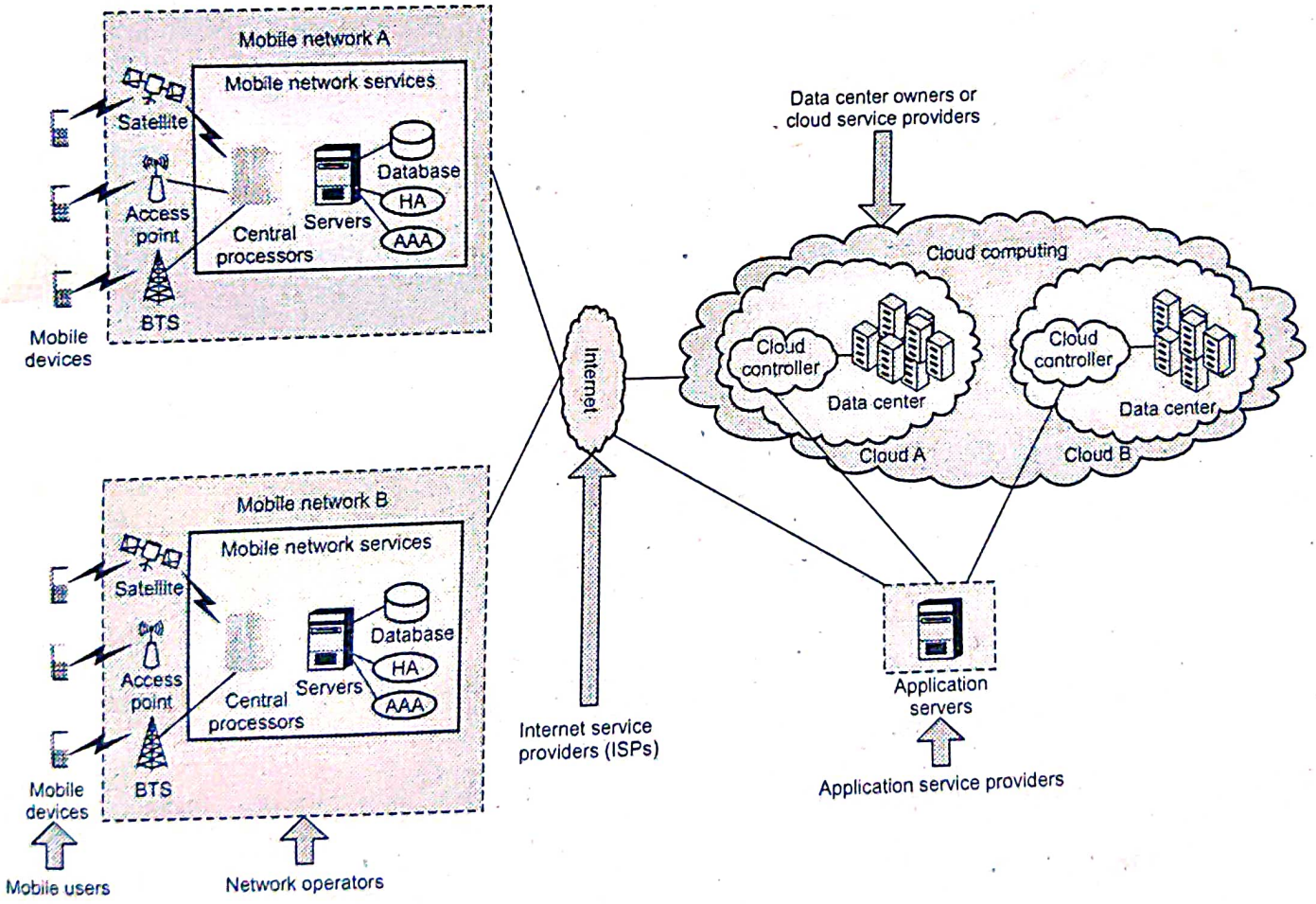

Fig. 6.8.2 Mobile cloud computing architecture

- 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 informations 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 user's 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.

6.8.1 Advantages and Disadvantages

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.

6.8.2 Mobile Cloud Application

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.

Review Questions

1. *Explain architecture of mobile cloud computing with diagram.* **SPPU : May-18, End sem, Marks 10**
2. *Write short note on : Mobile cloud computing.* **SPPU : Dec-19, End sem, Marks 5**

6.9 Automatic Cloud Engine

SPPU : May-19

- 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.
- Autonomic monitoring are mostly implemented on specific layers of the cloud computing architecture.
- Fig. 6.9.1 shows the high-level architecture enabling autonomic management of SaaS applications on Clouds.

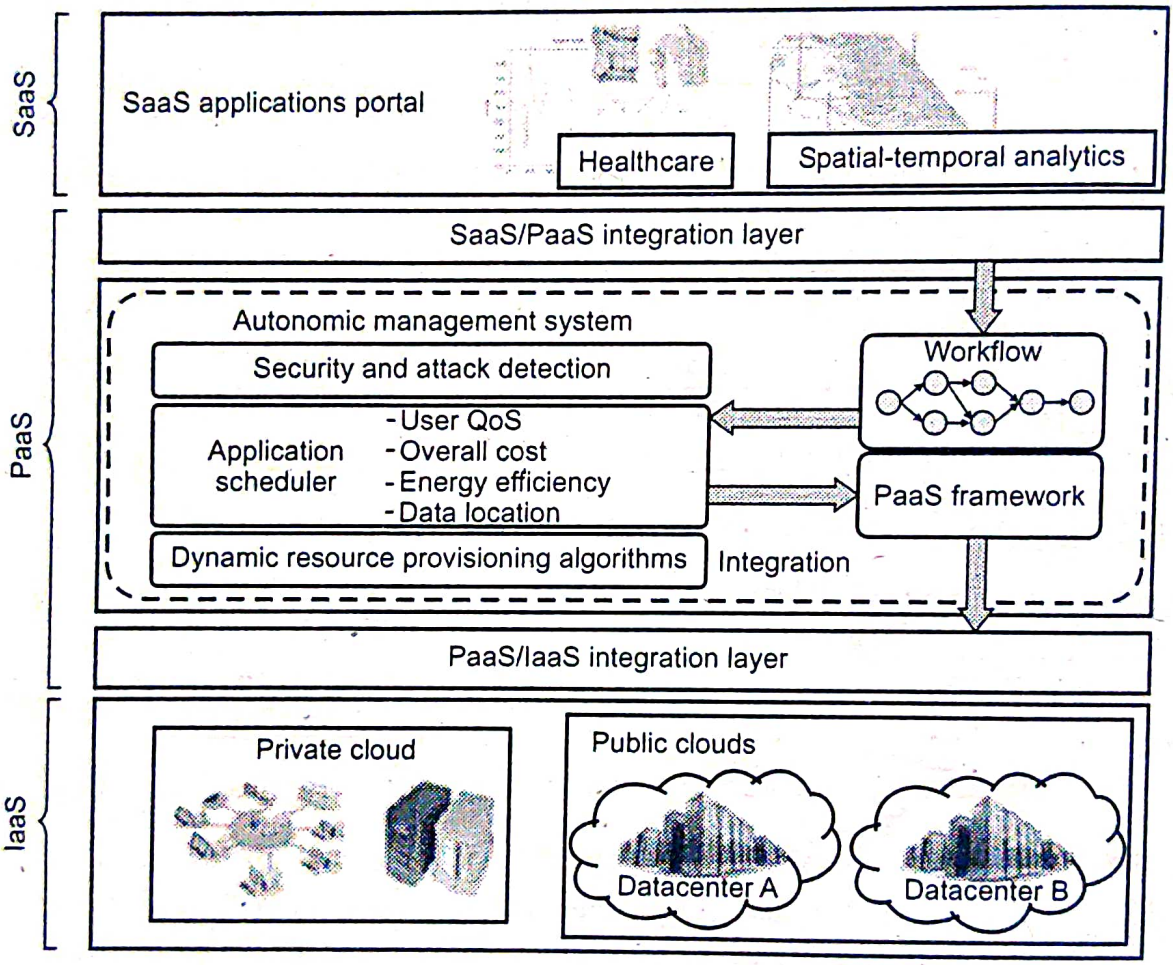

Fig. 6.9.1 System architecture for autonomic cloud management

- SaaS application portal : This component hosts the SaaS application using a Web Service-enabled portal system.
- Users or brokers acting on their behalf submit service requests from anywhere in the world to these SaaS applications.
- 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.

- User QoS-based application scheduler and dynamic resource provisioning algorithms are added as plug-ins.
- Infrastructure as a service : This layer comprises distributed resources provided by private 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.
- The autonomic management system incorporates the following services in the PaaS layer : Security and attack detection, application scheduling and dynamic provisioning.
- The autonomic manager is composed by the following components, with specific roles :
- **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.
- **Energy-efficient scheduler :** One of the main objectives to be optimized during the application scheduling process is energy utilization. Applications need to be scheduled in resources in such a way that their total energy consumption is minimized. However, the algorithm has to achieve this goal without compromising SLAs and cost.
- **Dynamic resource provisioning algorithms :** This component implements the logic for provisioning and managing virtualized resources in private and public Cloud environments based on the resource requirements as directed by the application scheduler.
- **Security and attack detection :** This component implements all the checks to be performed when requests are received in order to evaluate their legitimacy. This prevents the scaling-up of resources to respond to requests created with the intention of causing a Denial of Service or other forms of cyber-attacks.
- The module must be able to distinguish between authorized access and attacks, and in case of suspicion of attack, it can either decide to drop the request or avoid excessive provision of resources to it.

6.9.1 CometCloud

- 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. 6.9.2 shows CometCloud architecture for autonomic cloudbursts.

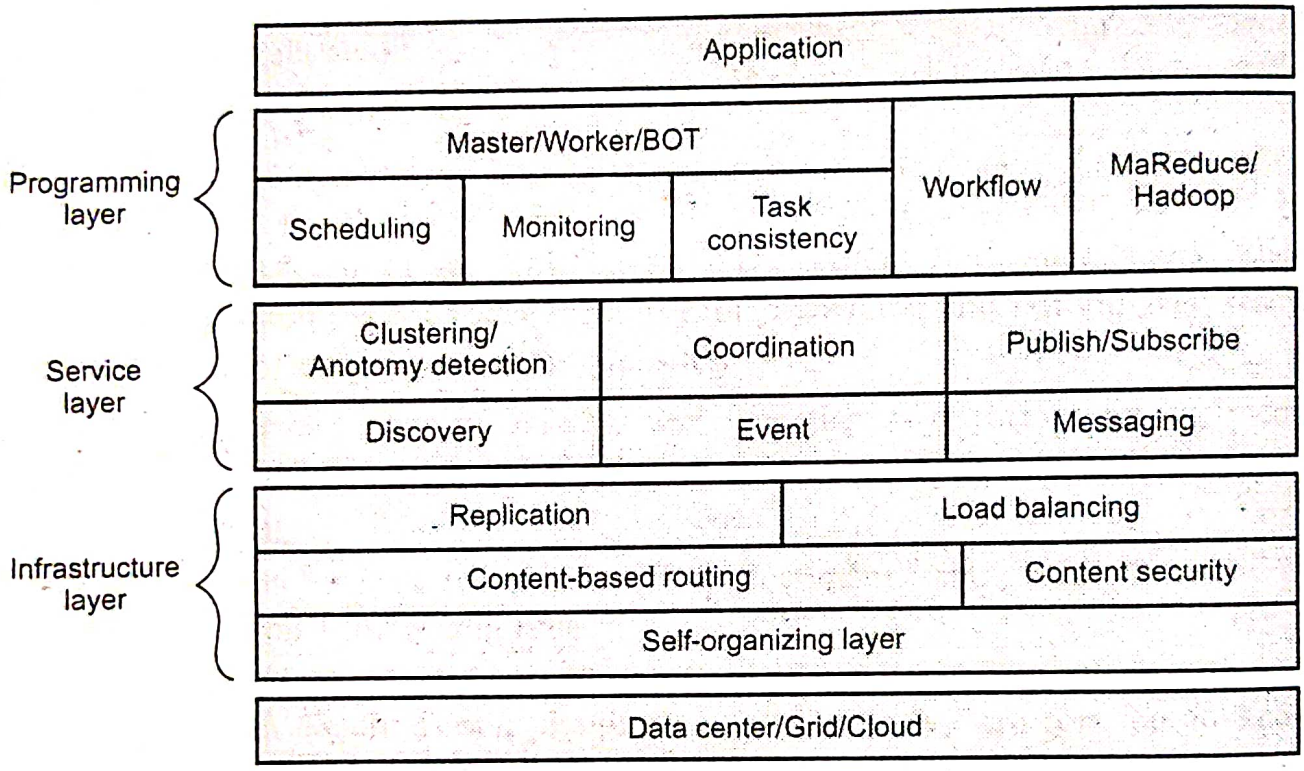

Fig. 6.9.2 CometCloud architecture for autonomic cloudbursts

- 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.
- 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.

Review Question

1. *Explain following concepts with diagrams : automatic cloud engine*

SPPU : May-19, End sem, Marks 6

6.10 Multimedia Cloud

SPPU : May-19

- 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. 6.10.1 shows fundamental concept of multimedia cloud.

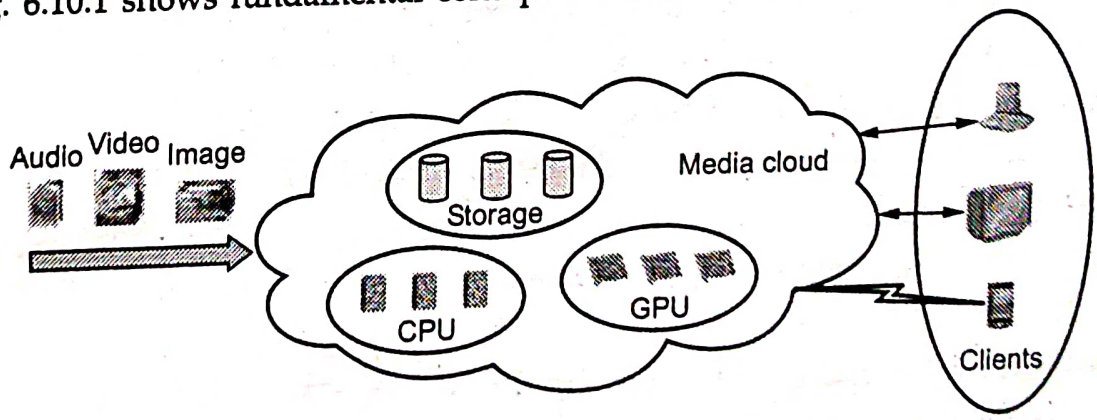

Fig. 6.10.1 Fundamental concept of multimedia cloud

- 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. 6.10.2 shows relation between cloud media and media cloud.

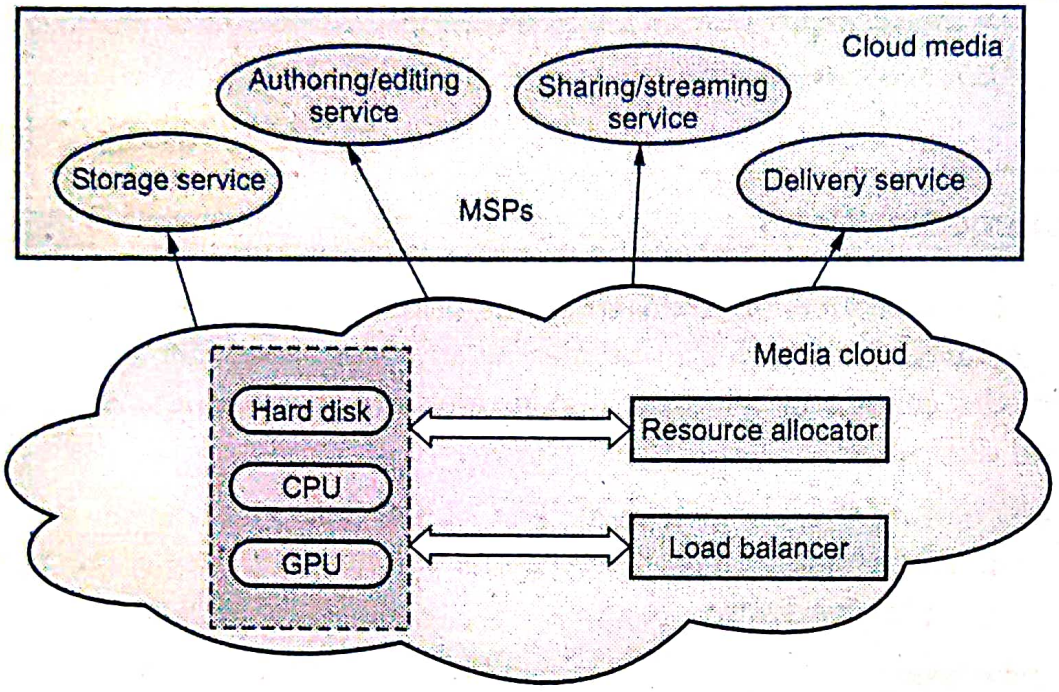

Fig. 6.10.2 Relation between cloud media and media cloud

- 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.

6.10.1 IPTV

- 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.
- There are several advantages of cloud-based services-the key benefits are that the service is software-based, so one doesn't need a physical location to run the operations. As a result, real estate, infrastructure and manpower cost reduce dramatically.
- For instance, if a Bollywood film channel wants to check if it has a market in the US, it can use the cloud-based technology to launch without adding to its cost by leasing a satellite for a minimum of three to five years.
- A product of ActiveVideo, a Silicon Valley software company, CloudTV is available on more than 15 million devices.

Review Question

1. *Explain following concepts with diagrams : Multimedia cloud.*

SPPU : May-19, End sem, Marks 6

6.11 Energy Aware Cloud Computing

SPPU : May-19, Dec.-19

- The energy consumption of cloud computing continues to be an area of significant concern as data center growth continues to increase.

6.11.1 Green Cloud

- 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.

6.11.2 Green Computing

- 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.

6.11.3 Energy - Saving Software Techniques

- 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

.11.4 Key Issue Related to Cloud Computing Energy Efficiency

- Objective of computing by business providers for cloud.
- Cost-wise advantage of public cloud computing provides over traditional data centers.
- Improvement of sustainability while shifting to the cloud.
- Impact of using cloud computing on carbon emission from the data center operations.
- By migrating to the cloud, industries can achieve significant energy saving and reduced pollution.
- The reduction in energy consumption was larger and not by a reduced number of servers.

eview Questions

1. *Explain key issues related to energy efficiency in cloud computing.* **SPPU : May-19, End sem, Marks 8**
2. *Write short note on : Energy aware cloud computing.* **SPPU : Dec.-19, End sem, Marks 6**

6.12 Jungle Computing

SPPU : May-19, Dec.-18,19

- 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.
- 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.

Review Questions

1. *Explain following concepts with diagrams : Jungle computing.*
   SPPU : May-19, End sem, Marks 6
2. *What is jungle computing ? Explain why there is need of jungle computing ?*
   SPPU : Dec.-18, End sem, Marks 8
3. *Write short note on : Jungle computing.* **SPPU : Dec.-19, End sem, Marks 5**

6.13 Docker at a Glance

SPPU : May-18, 19, Dec.-18, 19

- 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.

6.13.1 Process Simplification

- Docker can simplify both workflows and communication, and that usually starts with the deployment story.
- Fig. 6.13.1 shows workflow with and without docker.
  [Refer Fig. 6.13.1 on next page]
  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.

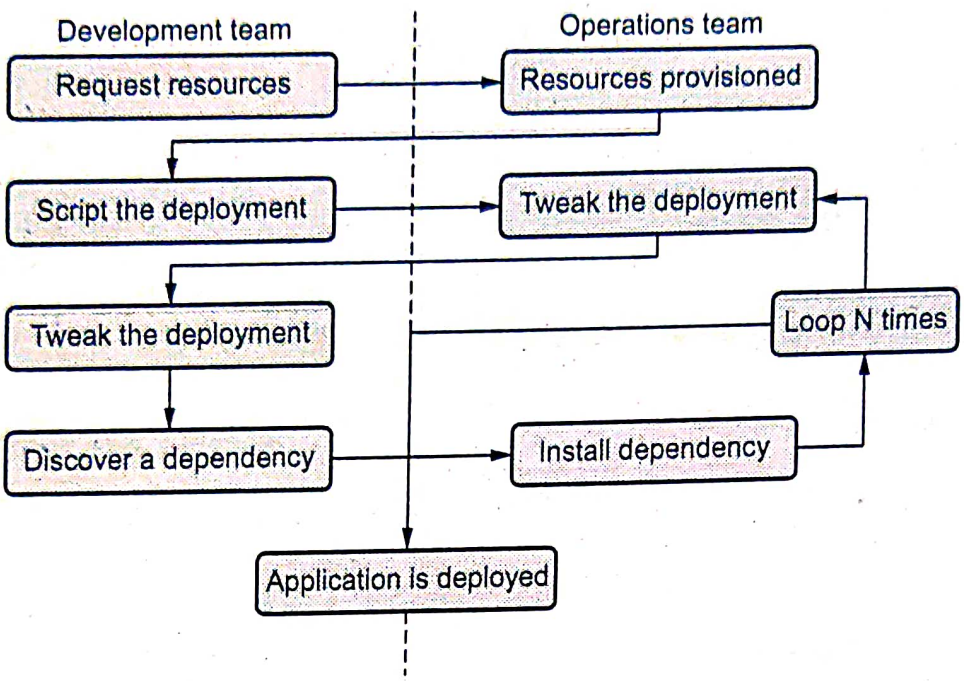

Fig. 6.13.1 Traditional deployment workflow (without Docker)

- Fig. 6.13.2 shows Docker deployment workflow.

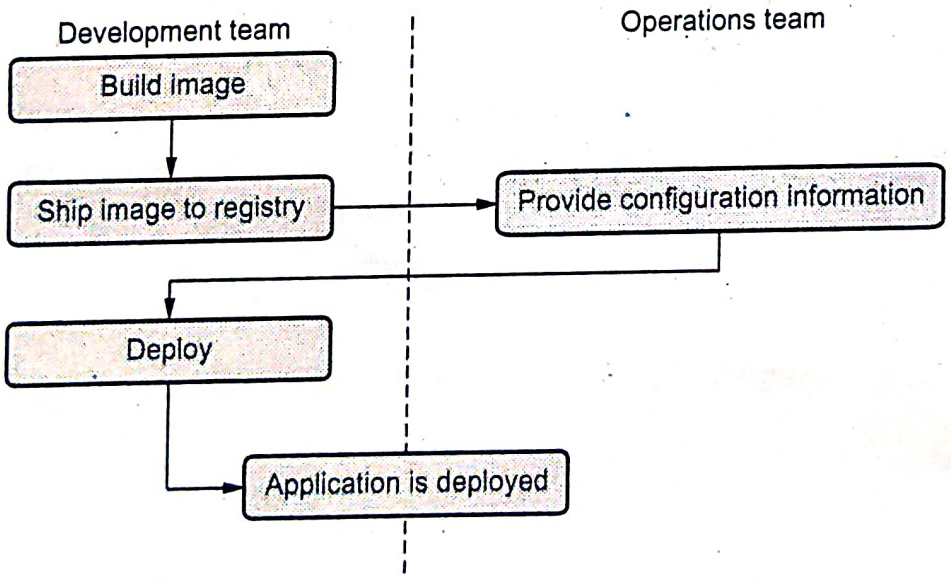

Fig. 6.13.2 Docker deployment workflow

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.

6.13.2 Broad Support and Adoption

- Docker is increasingly well supported, with the majority of the large public clouds. For example, Docker runs on AWS Elastic Beanstalk, Google AppEngine, IBM Cloud, Microsoft Azure, etc.
- Google's Eric Brewer announced that Google would be supporting Docker as its primary internal container format. Rather than just being good PR for these companies, what this means for the Docker community is that there is starting to be a lot of money backing the stability and success of the Docker platform.
- When docker released their libswarm development library at docker-Con 2014, an engineer from Orchard demonstrated deploying a docker container to a heterogeneous mix of cloud providers at the same time.
- The Docker-client runs directly on most major operating systems, but because the Docker server uses Linux containers, it does not run on non-Linux systems.
- Docker has traditionally been developed on the Ubuntu Linux distribution, but today most Linux distributions and other major operating systems are now supported where possible.

6.13.3 Architecture

- The fundamental architecture of Docker is a simple client - server model, with only one executable that acts as both components, depending on how you invoke the docker command.
- Underneath those simple exteriors, Docker heavily leverages kernel mechanisms such as IPTABLES, virtual bridging, cgroups, namespaces, and various filesystem drivers.
- Fig. 6.13.3 shows docker architecture.

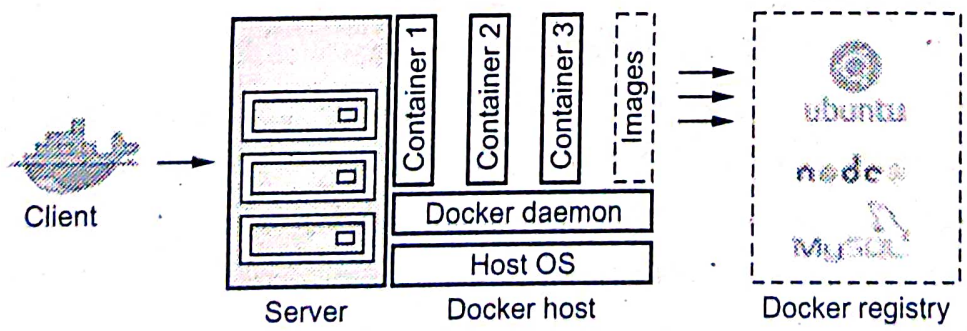

Fig. 6.13.3 Docker architecture

- It consists of two parts : The client and the server. Registry is one more components which stores docker images and metadata about those images.

- 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.

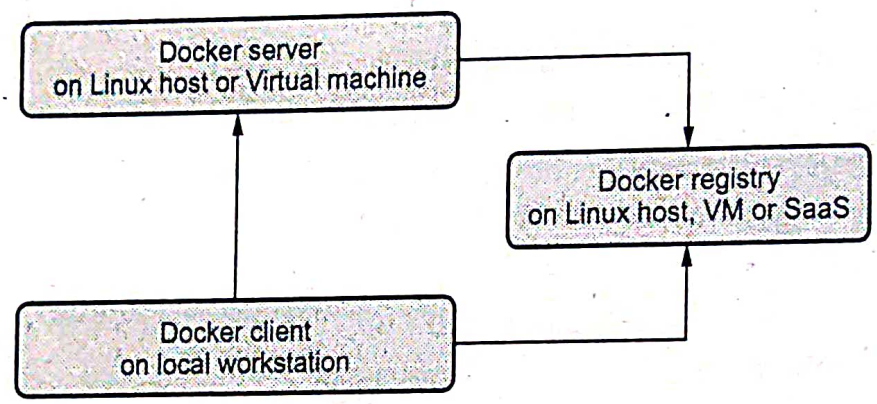

Fig. 6.13.4 Data flow

- The command used by docker depend on docker AP. 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.

6.13.4 Container and Kubernetes

- A container image is a ready-to-run software package that includes everything a program needs to execute, including the code and any run-times it needs, application and system libraries, and default values for any important settings.
- Container orchestration is concerned with the management of container lifecycles, particularly in large, dynamic environments. Container orchestration is used by software teams to control and automate a variety of tasks on container management.
- Container orchestration works in any context where containers are employed. It can assist you in deploying the same program across several environments without having to rewrite it.
- Kubernetes is an open-source container management platform that unifies a cluster of machines into a single pool of compute resources. With kubernetes, you organize your applications in groups of containers, which it runs using the Docker engine, taking care of keeping your application running as you request.
- Kubernetes is an open source container orchestration platform that automates many of the manual processes involved in deploying, managing, and scaling containerized applications.
- Kubernetes was originally developed and designed by engineers at Google.
- The primary responsibility of kubernetes is container orchestration. That means making sure that all the containers that execute various workloads are scheduled to run physical or virtual machines.
- The containers must be packed efficiently following the constraints of the deployment environment and the cluster configuration. In addition, kubernetes must keep an eye on all running containers and replace dead, unresponsive, or otherwise unhealthy containers.
- Kubernetes uses docker to run images and manage containers.
- Kubernetes allows several containers to work in harmony, reducing operational burden. Interestingly, this includes docker containers. Kubernetes can be integrated with the docker engine, and uses "Kubelets" to coordinate the scheduling of docker containers.
- The docker engine runs the container image, which is created by running docker build. The higher-level concepts (load balancing, service discovery, and network policies) are controlled by kubernetes. When combined, both docker and kubernetes can develop a modern cloud architecture. However, it should be remembered the two systems, at their core, are fundamentally different.
- Fig. 6.13.5 shows kubernetes architecture.

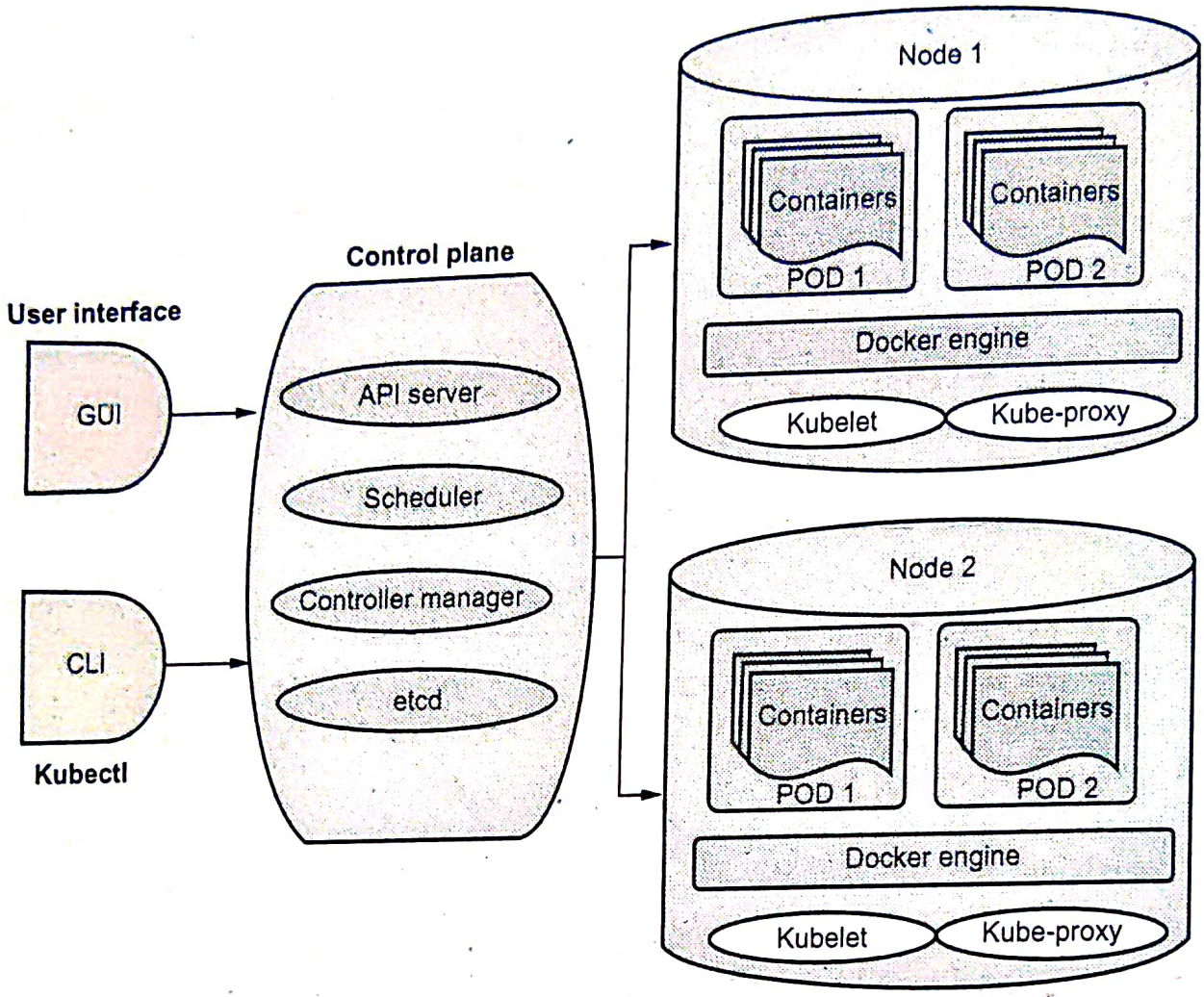

Fig. 6.13.5 Kubernetes architecture

- **Kubelet :** This function runs on nodes, reads container manifests, and assures defined containers have started and are running.
- **Node :** These perform the assigned tasks, with the kubernetes master controlling them.
- **Master :** This controls the kubernetes nodes and is the source of all task assignments.
- **Pod :** When one or more containers are deployed to one node. Containers in a pod will share a host name, an IP address, IPC, and other resources.
- **Replication controller :** Controls the number of "identical" copies in a pod that should be running in different locations on the cluster.
- **Service :** This will decouple the work definitions from the pods. Service requests are automatically sent to the right pod, regardless of location.
- **Kubectl :** The primary configuration tool for kubernetes.
- **Kubernetes objects :** These are persistent entities within the Kubernetes system. They are used to represent the state of the cluster

Review Questions

1. *What is docker ? Draw and explain docker deployment workflow.*
   SPPU : May-18, End sem, Marks 8, May-19, End sem, Marks 10
2. *What is docker ? Explain its workflow in details.* **SPPU : Dec.-18, End sem, Marks 8**
3. *Draw architecture for docker and explain its components.*
   SPPU : Dec.-18, End sem, Marks 8
4. *What is docker ? Explain docker workflow with diagram.*
   SPPU : Dec.-19, End sem, Marks 8

6.14 Multiple Choice Questions

Q.1 Which of the following is NOT cloud application features ?

[a] Multitenancy [b] Elasticity
[c] Homogeneous cloud platform [d] On-demand service

Q.2 _____ are a set of agreements that are signed between the user and service providers.

[a] Service level agreement [b] Service oriented architecture
[c] Service layer agreement [d] Software level agreement

Q.3 Which of the following is associated with considerable vendor lock-in ?

[a] PaaS [b] IaaS
[c] CaaS [d] SaaS

Q.4 Kubernetes uses _____ to run images and manage containers.

[a] Jungle [b] Docker
[c] AWS [d] None

Q.5 Jungle computing is _____ computing system.

[a] parallel [b] cluster
[c] grid [d] distributed

Q.6 Docker engine is a _____ based application.

[a] client [b] server
[c] client-server [d] all of these

Answer Keys for Multiple Choice Questions :

Q.1	c	Q.2	a	Q.3	a	Q.4	b	Q.5	d	Q.6	c