Unit - VI

6 Advanced Techniques in Cloud Computing

Syllabus

Future Trends in cloud Computing, Mobile Cloud, ***Automatic Cloud Computing :*** *Comet Cloud.* ***Multimedia Cloud :*** *IPTV, Energy Aware Cloud Computing, Jungle Computing, Distributed Cloud Computing Vs Edge Computing, Containers, Docker, and Kubernetes, Introduction to DevOps.* ***IOT and Cloud Convergence :*** *The Cloud and IoT in your Home, The IOT and cloud in your Automobile, PERSONAL : IoT in Healthcare.*

Contents

6.1 Future Trends in Cloud Computing

- The future of Cloud computing as a combination of cloud-based software products and on-premises compute which will help to create hybrid IT solutions.
- Multi-cloud refers to the presence of more than one cloud service (public or private). The service is sourced from different cloud vendors.
- Multi-cloud distributes workloads across multiple cloud environments. You can use a private cloud for storing sensitive data. At the same time, host less sensitive workloads on the public cloud.
- When a combination of private as well as a third-party public cloud service is used, this is known as Hybrid cloud computing. The primary use of this type of cloud computing is to allow you to shift your workload between the private and public clouds, thus, allowing you to have more flexibility. This is one example of how a hybrid/multi-cloud solution can be used to reduce a users workload.
- With the help of the Internet of Things, the quality of the internet can be increased. With the help of the IoT and Cloud Computing, we can store data in the cloud, for further analyze and provide enhanced performance.

6.1.1 Just Enough Operating System

- 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 Mobile Cloud

- 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. 6.2.1 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.

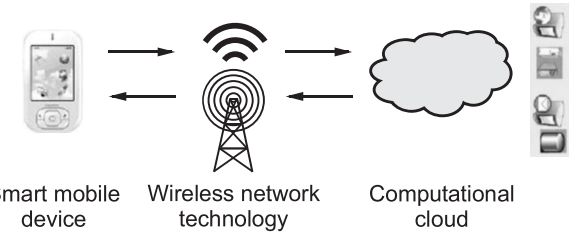

Fig. 6.2.1 Block diagram of mobile cloud

- 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. 6.2.2 shows mobile cloud computing architecture.

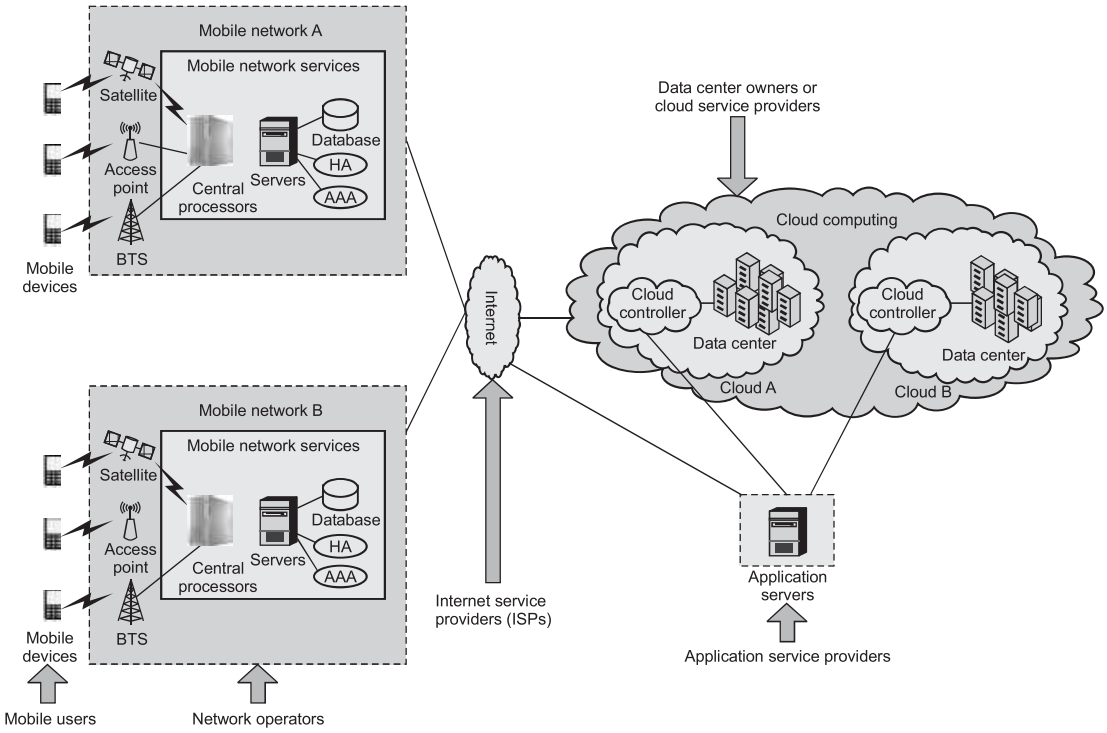

Fig. 6.2.2 Mobile cloud computing architecture

- 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 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.

6.2.1 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.

6.2.2 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.

6.3 Automatic Cloud Computing

SPPU : June-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. 6.3.1 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.
- 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.

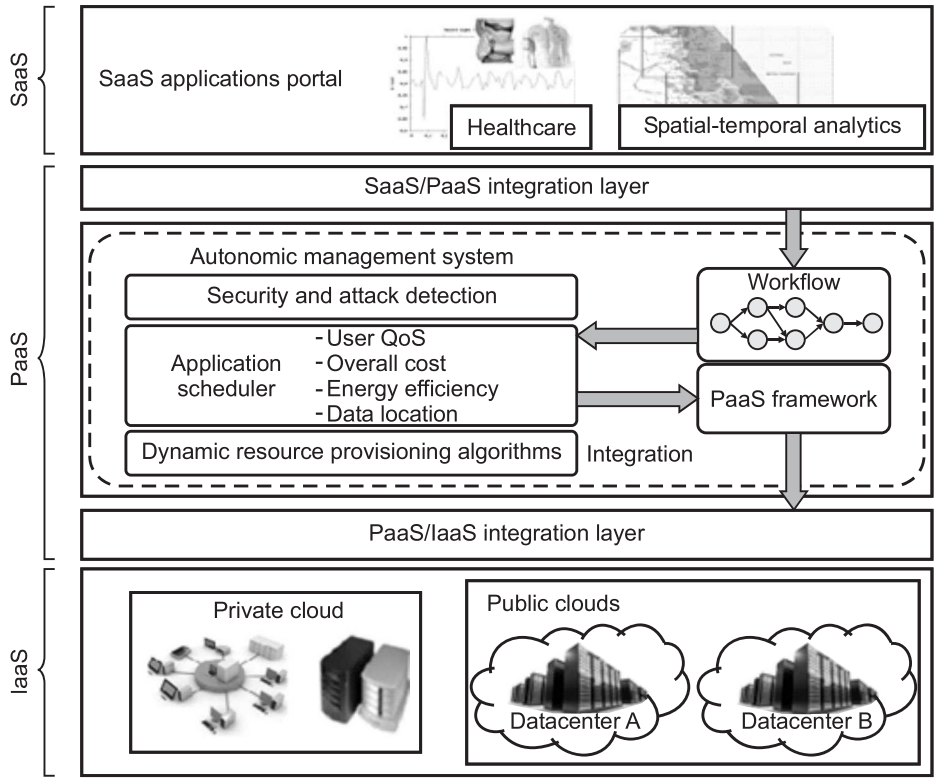

Fig. 6.3.1 System architecture for autonomic cloud management

- 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.

6.3.1 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. 6.3.2 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.
- 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.

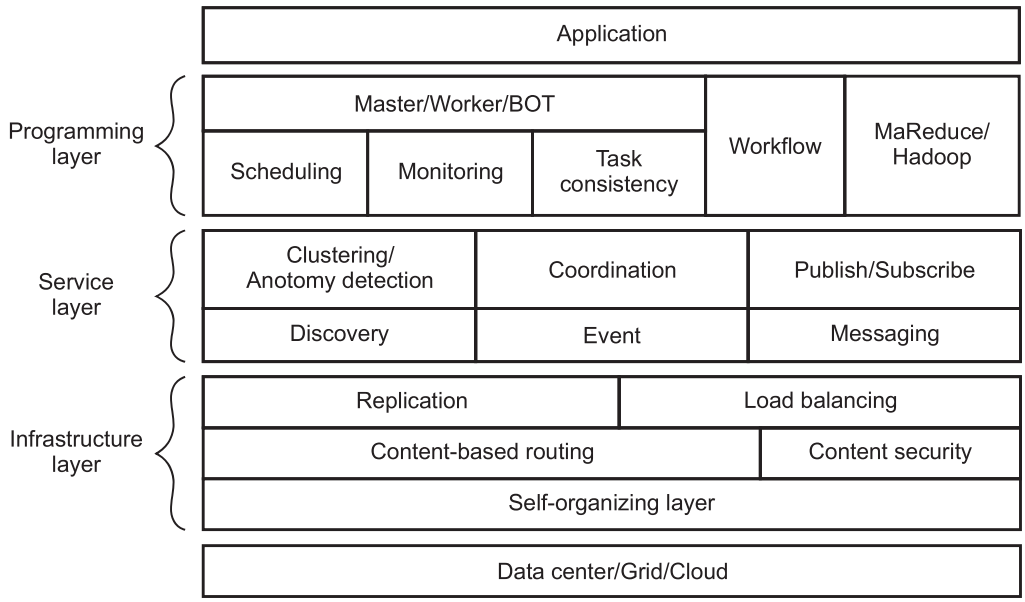

Fig. 6.3.2 CometCloud architecture for autonomic cloudbursts

- 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. *Describe cloudlets for mobile cloud computing with neat diagram and differentiate between cloudlets and clouds.* **SPPU : June-19, End Sem, Marks 8**

6.4 Multimedia Cloud

- 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. 6.4.1 shows fundamental concept of multimedia cloud.

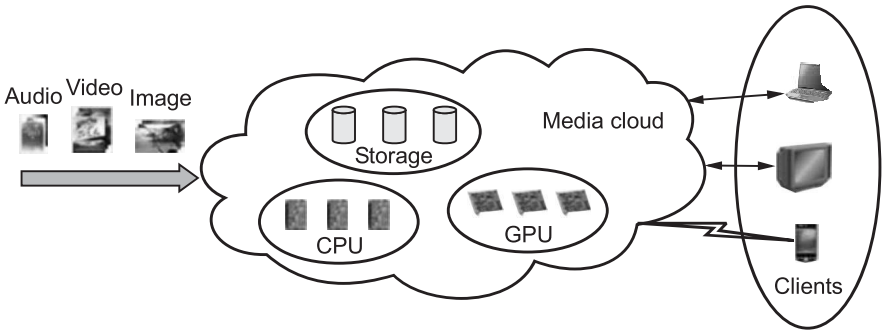

Fig. 6.4.1 Fundamental concept of multimedia cloud

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

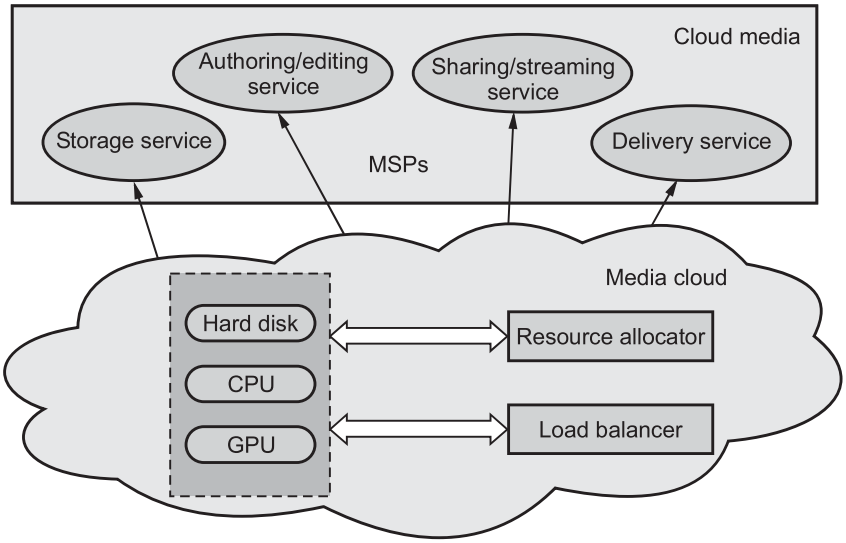

Fig. 6.4.2 Relation between cloud media and media cloud

- 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.

6.4.1 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.

6.5 Energy Aware Cloud Computing

SPPU : June-19

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

6.5.1 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.

6.5.2 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.

6.5.3 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

6.5.4 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.

Review Question

1. *What is energy aware cloud computing ? Explain in detail.*

SPPU : June-19, End Sem, Marks 8

6.6 Jungle Computing

- 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.

6.7 Docker

SPPU : June-19, Dec.-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

6.7.1 Process Simplification

- Docker can simplify both workflows and communication, and that usually starts with the deployment story.
- Fig. 6.7.1 shows workflow with and without docker.

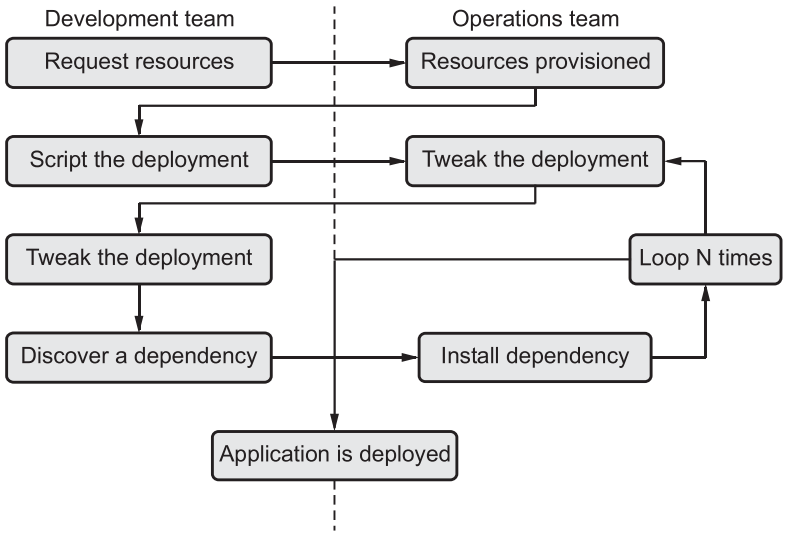

Fig. 6.7.1 Traditional deployment workflow (without Docker)

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. Go to step 5 and 6
8. The application is deployed.

- Fig. 6.7.2 shows Docker deployment workflow.

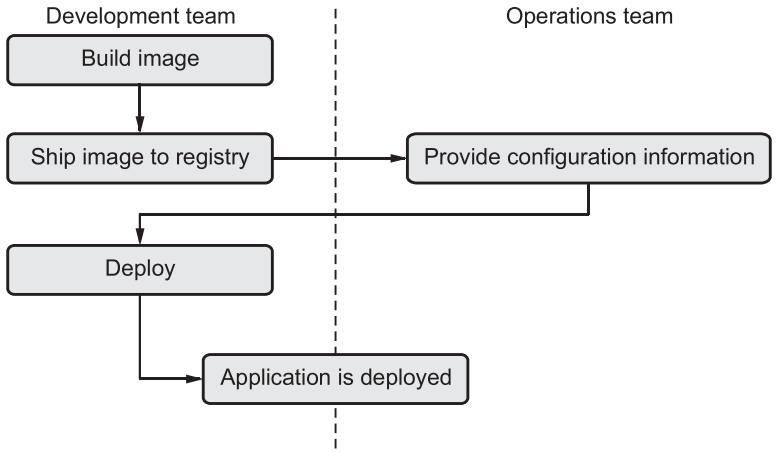

Fig. 6.7.2 Docker deployment workflow

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.

6.7.2 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.

6.7.3 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. 6.7.3 shows docker architecture.

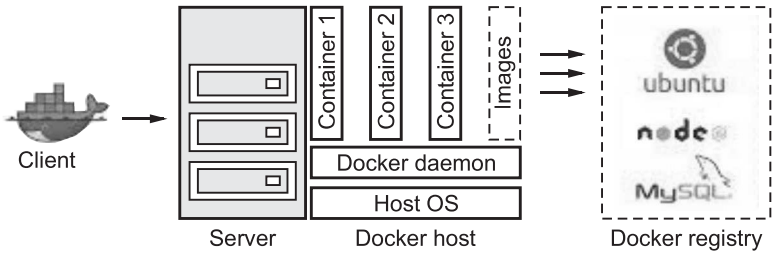

Fig. 6.7.3 Docker architecture

- 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.

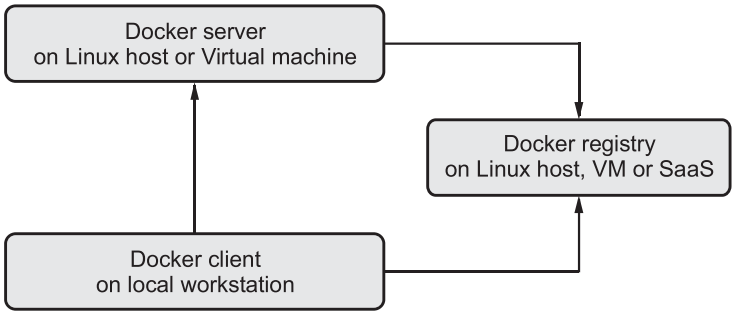

Fig. 6.7.4 Data flow

- 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.

6.7.4 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. 6.7.5 shows 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.

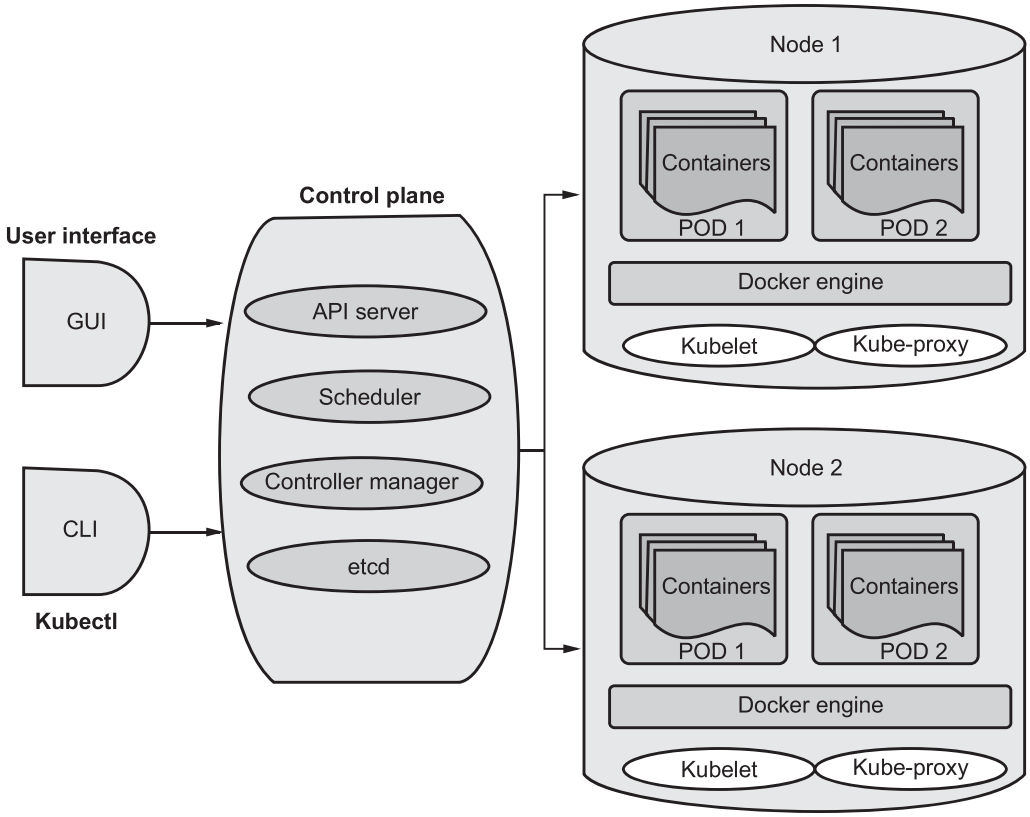

Fig. 6.7.5 Kubernetes architecture

- **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. *Explain the client server architecture of docker ? What are network ports and unix sockets ?* **SPPU : June-19, End Sem, Marks 8**
2. *Explain docker with respect to process simplification. Broad support and Adoption, architecture.* **SPPU : June-19, End Sem, Marks 8**
3. *Explain traditional as well as docker deployment workflow, Client server architecture of docker ?* **SPPU : Dec.-19, End Sem, Marks 8**

6.8 Introduction to DevOps

- DevOps is a collaboration between Development and IT Operations to make software production and deployment in an automated and repeatable way. DevOps helps to increase the organization's speed to deliver software applications and services. The word 'DevOps' is a combination of two words, 'Development' and 'Operations.'
- Developers are willing to push out software faster and faster. Operations, on the other hand, knows that rapid-fire changes without proper safeguards could destabilize the system, which goes directly against their charter.
- DevOps should be used for large distributed applications such as eCommerce sites or applications hosted on a cloud platform.
- DevOps bridges the gap between development and operations, creating significant efficiencies across the development and deployment of software. DevOps includes a strong emphasis on automation, helping reduce the overall number of errors.

6.9 IOT and Cloud Convergence

- Cloud computing in IoT works as part of a collaboration and is used to store IoT data. The cloud is a centralised server containing computer resources that can be accessed whenever required. Cloud computing is an easy travel method for the large data packages generated by the IoT through the Internet.
- 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.
- 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

6.9.1 The Cloud and IoT in your Home

- Home automation is the automatic control of electronic devices in your home. These devices are connected to the Internet, which allows them to be controlled remotely.

- Interconnected devices enable to intelligently monitor and control smart homes in a future Internet of Things.
- Energy saving applications, for example, control indoor climate and electricity usage by employing context information to switch off appliances (e.g., lights, computers), reduce room temperature, close windows, or stop warm water circulation.
- Home automation works on three levels :
  1. **Monitoring :** Monitoring means that users can check in on their devices remotely through an app. For example, someone could view their live feed from a smart security camera.
  2. **Control :** Control means that the user can control these devices remotely, like planning a security camera to see more of a living space.
  3. **Automation :** Finally, automation means setting up devices to trigger one another, like having a smart siren go off whenever an armed security camera detects motion.
- Example : Smart Lighting

6.9.1.1 Smart Lighting

- Smart control the lights with automation signal system to save energy. Smart, connected lighting is the next - generation energy - efficient LED products with additional sensors to sense things such as occupancy and temperature.

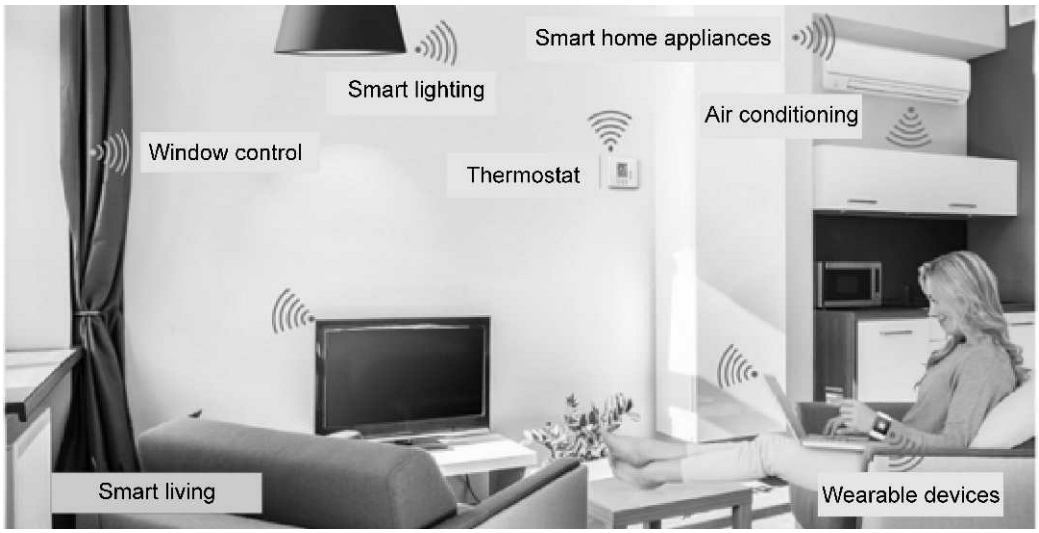

Fig. 6.9.1 Smart home

- In automatic light control system, Light Dependent Resistor (LDR) sensor is used to detect bright /medium /dim /dark conditions.

- It is simple enough to envision the addition of sensors and communications to create that initial concept of smarter, more adaptive lighting. If people are present, turn the lights on; if not, turn them off. Or use your smart phone to connect to the lighting system and tune it to the desired brightness level or to a particular color.
- Smart lighting is considered the one of the main solutions for energy reduction by means of controlling lighting level according to desired need with minimum energy consumption.
- Smart - lighting systems utilize motion and light sensors for performing the control algorithms.
- The system uses motion and light sensors for detecting the surrounding environment. There are lamps controlled with the specific lighting level in order to supply the adequate amount of lighting required without affecting the user visibility.
- Certainly the required lighting level is strongly dependent on the weather conditions. In clear weather at night might require more luminance than cloudy one, due to the reflection from the clouds.
- While during mist and foggy weathers require the highest possible lighting level, as the visibility reaches its lowest. On snowy weather it might require an intermediate level between clear and foggy.
- During night it requires high lighting levels, while at day it needs just fade level to provide guidance or turn off if the weather is clear. The lighting concentration in the yard is affected by the above conditions.

6.9.2 The IOT and Cloud in your Automobile

- Today, users of IoT devices can evaluate engine performance, control air temperature, and measure physical health indicators with only a few clicks.
- Conventional perceptions of the automotive industry are radically changing with IoT development. Predictive maintenance, Wi-Fi capabilities powered by 3G/4G/5G functionality, Car2Car connectivity, and advanced fleet management are only a few examples of how IoT-based solutions are shaping the new automotive age.
- The automobile industry is one of the fastest-growing markets for IoT-based solutions. The number of installed connectivity units in vehicles is likely to increase by 67 % between 2018 and 2020.
- Predictive maintenance technology is based on the use of IoT connectivity tools that collect data on the performance of different parts, transfer that data to the cloud in real time, and evaluate the risks of potential malfunction of a car's

hardware or software. After information is processed, a driver is notified and advised of any necessary service or repair to avoid potential incidents.

- Fig. 6.9.2 shows battery working.

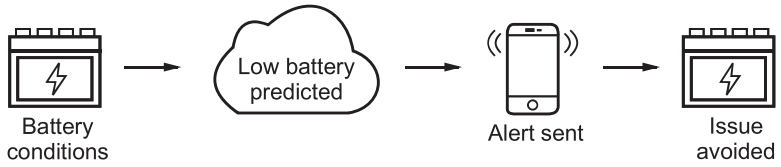

Fig. 6.9.2 Battery working

- Predictive maintenance can facilitate vehicle use by both private owners and dealerships with large fleets of vehicles. It enables end-users to get the right information in advance. With IoT connectivity tools, you can forget about unplanned stops or breakdowns during the ride.

6.9.2.1 Remote Vehicle Diagnostics

- Remote Vehicle Diagnostics Solution monitors the health of the vehicle, determines the root cause of the problem / failure and provides real time information of vehicle parameters to assess its performance against benchmarks.
- The solution monitors the health of the electric vehicle, commercial vehicle, utility vehicle and provides insight to field support staff to determine the root cause of the problem. It also enables the customers to access information about the vehicle. Commercial / Utility vehicles being driven across the country extensively over time for various purposes are in need of a diagnostic check which is automated through the offering.
- By monitoring all the aspects of the car is easier to detect any problem in advance by sending all sensor readings to a certified center where technicians and engineers will apply their expertise to find and predict imminent failures of key systems integrated in the vehicle.
- Modern commercial vehicles support on board diagnostic standard. Next generation vehicles will have sophisticated on-board connectivity equipment, providing wireless network access to the vehicle for infotainment and other telematics services. Fig. 6.9.3 shows remote vehicle diagnostics.
- In vehicle, sensors connect to the vehicle terminal which is responsible for collecting, storing, processing and reporting information and responding to commands from supervision platforms.
- The vehicle terminal consists of the microprocessor, data storage, GPS module, wireless communication transmission module, real time clock and data communication interface.

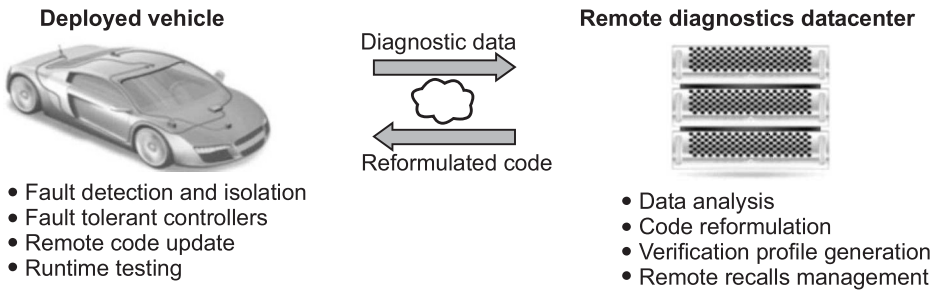

Fig. 6.9.3 Remote vehicle diagnostics solution

6.9.3 PERSONAL : IoT in Healthcare

- 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.
- 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.
- Smart healthcare is an important research area for Internet of Things, which employs sensors and other information identifying technologies, wireless and wired networks to realize large-scale, multi-layer interaction between patients and medical equipments, medical staff and healthcare institutions.
- Some challenges in the healthcare system are as follows :
  1. **Smarter hospital :** Smarter hospital is an important improvement of smart healthcare system. 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. It is also important for smart healthcare to ensure the data realtimeness.

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.

6.10 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				

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Notes

Solved Model Question Paper (In Sem)

Cloud Computing

Time : 1 Hour] **[Maximum Marks : 30**

N.B : ***i) Attempt Q.1 or Q.2, Q.3 or Q.4.***

ii) Neat diagrams must be drawn wherever necessary.

iii) Figures to the right side indicate full marks.

iv) Assume suitable data, if necessary.

Q.1 a) *What is cloud computing ? Explain it.* **[Refer section 1.1]** **(3)**

b) *Explain characteristics of cloud computing.* **[Refer section 1.2.1]** **(4)**

c) *Explain various cloud service models.* **[Refer section 1.6]** **(8)**

OR

Q.2 a) *Explain difference between public and private cloud.* **[Refer section 1.10.1]** **(3)**

b) *What is Infrastructure as a Service (IaaS) ? List merits and demerits.* **[Refer section 1.6.3]** **(5)**

c) *Discuss briefly cloud computing reference model.* **[Refer section 1.8.2]** **(7)**

Q.3 a) *What is NAS ? Compare NAS and SAN.* **[Refer section 2.1]** **(4)**

b) *Explain data intensive technologies for cloud computing.* **[Refer section 2.6.5]** **(4)**

c) *Explain cloud data stores. Disucss data store types.* **[Refer section 2.4]** **(7)**

OR

Q.4 a) *What is cloud data management interface ?* **[Refer section 2.6.2]** **(3)**

b) *What is cloud file system ?* **[Refer section 2.3.3]** **(5)**

c) *What is cloud provisioning ? Explain its benefits and characteristics. Also explain its types.* **[Refer section 2.2.3]** **(7)**

Solved Model Question Paper (End Sem)

Cloud Computing

Time : $2\frac{1}{2}$ Hours] **[Maximum Marks : 70**

N.B : i) Attempt Q.1 or Q.2, Q.3 or Q.4, Q.5 or Q.6, Q.7 or Q.8.

ii) Neat diagrams must be drawn wherever necessary.

iii) Figures to the right side indicate full marks.

iv) Assume suitable data, if necessary.

Q.1 a) *What is server virtualization ? Explain requirement of server virtualization. List advantages and disadvantages of server virtualization.* **[Refer section 3.3.2]** **(8)**

b) *Explain full and para virtualization with examples.* **[Refer sections 3.3.4 and 3.4]** **(10)**

OR

Q.2 a) *Explain in brief virtual clusters and resource management.* **[Refer section 3.6]** **(5)**

b) *Explain different levels of virtualization implementation with neat diagram. Also give example of each.* **[Refer section 3.3]** **(5)**

c) *Explain anatomy of cloud infrastructure.* **[Refer section 3.10.1]** **(8)**

Q.3 a) *Write a note on services offered by Amazon ?* **[Refer section 4.1]** **(8)**

b) *Explain steps to configure server for EC2 ?* **[Refer section 4.2]** **(9)**

OR

Q.4 a) *Explain the steps to create an Amazon S3 bucket and managing associated objects ?* **[Refer section 4.2.2]** **(8)**

b) *Discuss Google App engine. [*Refer section 4.7] **(9)**

Q.5 a) *What is risk management ? Explain risk in cloud computing.* **[Refer section 5.1]** **(6)**

b) *Explain cloud security services.* **[Refer section 5.6]** **(6)**

c) *Discuss secure cloud software requirements.* **[Refer section 5.8]** **(6)**

OR

Q.6 a) *Briefly explain cloud security issues and challenges.* **[Refer section 5.4]** **(6)**

b) *Discuss enterprise-wide risk management in cloud.* **[Refer section 5.2]** **(6)**

c) *How secure cloud software testing is performed? Discuss types of cloud testing.* **[Refer section 5.9]** **(6)**

Q.7 a) *Explain traditional as well as docker deployment workflow, Client server architecture of Docker ?* **[Refer section 6.7]** **(9)**

b) *Describe cloudlets for mobile cloud computing with neat diagram and differentiate between cloudlets and clouds.* **[Refer section 6.2]** **(8)**

OR

Q.8 a) *What is energy aware cloud computing ? Explain in detail.* **[Refer section 6.5]** **(8)**

b) *What is automatic cloud computing ? Discuss briefly CometCloud.* **[Refer section 6.3]** **(9)**

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TEXT BOOKS FOR T.E. (COMP) SEM VI

Compulsory Subjects

1. Web Technology *(A. A. Puntambekar)*
2. Data Science and Big Data Analytics *(I. A. Dhotre, Dr. Kalpana V. Metre)*
3. Artificial Intelligence *(Anamitra Deshmukh-Nimbalkar, Dr. Vaishali P. Vikhe)*

Elective Subjects

4. Information Security *(I. A. Dhotre, Dr. Swati Nikam)*
5. Augmented and Virtual Reality *(Dr. Ninad More, Sunita Patil)*
6. Cloud Computing *(I. A. Dhotre)*
7. Software Modeling and Architecture *(A. A. Puntambekar)*