UNIT V

5 Ubiquitous Clouds and the Internet of Things

Syllabus

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

Contents

5.1 Cloud Trends in Supporting Ubiquitous Computing

SPPU : May-19, Dec.-19

- Cloud computing provides the next generation of internet based, highly scalable distributed computing systems in which computational resources are offered as a service. It is a new computational model that enables convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction.
- However, ubiquitous computing refers to a scenario in which computing is omnipresent, and particularly in which devices that do not look like computers are endowed with computing capabilities. Ubiquitous cloud computing refers to the use of Internet resources at any place and any time for any objectives.

5.1.1 Ubiquitous Computing

- Ubiquitous computing is the method of enhancing computer use by making many computers available throughout the physical environment, but making them effectively invisible to the user. It is also known as pervasive computing.
- Ubiquitous Computing is a term associated with the Internet of Things (IoT) and refers to the potential for connected devices and their benefits to become commonplace.
- The word "ubiquitous" can be defined as "existing or being everywhere at the same time," "constantly encountered," and "widespread." When applying this concept to technology, the term ubiquitous implies that technology is everywhere and we use it all the time.
- Ubiquitous computing (ubicomp) is a post-desktop model of human-computer interaction in which information processing has been thoroughly integrated into everyday objects and activities.
- Fig. 5.1.1 shows the Ubiquitous system.
- Ubiquitous technology is often wireless, mobile, and networked, making its users more connected to the world around them and the people in it. Ubiquitous computing is changing our daily activities in a variety of ways.
- IBM cloud platforms are mostly built with IBM server clusters supported by IBM WebSphere. IBM Ensembles offer a virtualized cloud system for IaaS services. This system can put together a large resource pool to simplify management complexity.
- The purpose is to offer application flexibility and efficient resource deployment through dynamic server, storage and network ensembles.

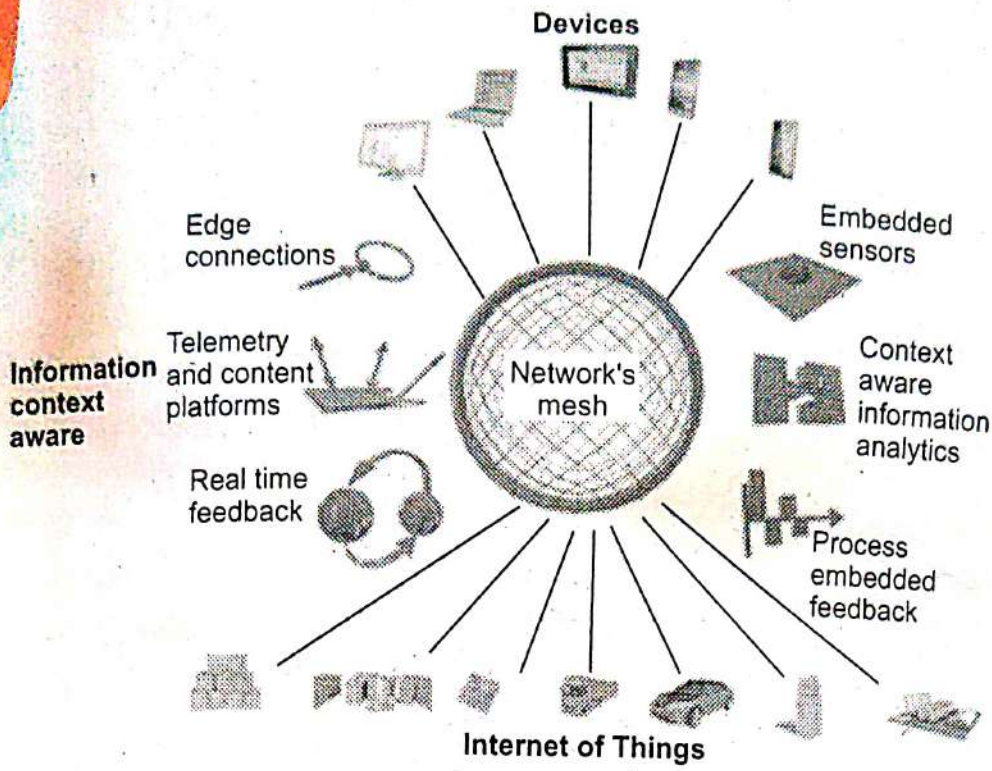


Fig. 5.1.1 Ubiquitous system

- IBM also developed the Tivoli Service Automation Manager (TSAM) for rapid design, deployment and management of service processes.
- WebSphere CloudBurst (WCA) is another platform for managing private clouds. IBM LotusLive offers an SaaS cloud for application service development. The services include an online conference service, coordinated office management and e-mail services.

5.1.2 Use of Clouds for HPC/HTC and Ubiquitous Computing

- Supercomputer sites and large data centers must provide high-performance computing services to huge numbers of Internet users concurrently. Because of this high demand, the Linpack Benchmark for High Performance Computing (HPC) applications is no longer optimal for measuring system performance.
- The emergence of computing clouds instead demands High-Throughput Computing (HTC) systems built with parallel and distributed computing technologies. We have to upgrade data centers using fast servers, storage systems, and high-bandwidth networks. The purpose is to advance network-based computing and web services with the emerging new technologies.
- HPC clouds are viewed as having the following properties :
  1. **Web Service-Based** : All resources from data storage to cluster job management are done via self-describing Web services.

2. **Virtualization** : For flexibility, cloud computing will require the use of virtualization.
3. **Clusters Are Provided On-Demand** : Clients should be able to specify requirements and then discover an existing cluster for immediate use.
4. **Guaranteed Performance** : Typically, if cluster nodes are allocated to clients, all nodes are expected to be within close proximity to each other.
5. **Use the Pay as You Go Model** : All HPC clients are billed for the resources they use and amounts thereof.

5.1.2.1 IBM Cloud Projects

- In November 2007, IBM announced the Blue Cloud Project based on open standards and open source software. The project is supported by more than 200 IBM web-scale researchers worldwide.
- Blue Cloud combines several existing software and virtualization packages on a specifically designed IBM hardware server platform.
- Open source and private software is combined to form the cloud computing environment. The Blue Cloud is built with x-servers, that are very similar to x86 processors.
- Linux runs on these servers supported by XEB-based virtualization software.
- IBM offers five different cloud provision models :
  1. Private cloud, owned and operated by the customer.
  2. Private cloud, owned by the customer but operated by IBM (or another provider).
  3. Private cloud, owned and operated by IBM (or another provider).
  4. Virtual private cloud services, based on multi tenant support for individual enterprises.
  5. Public cloud services, based on the provision of functions to individuals.
- IBM SmartCloud is a line of enterprise - class cloud computing technologies and services for building and using private, public and hybrid clouds. SmartCloud offerings can be purchased as self-service or managed services.
- IBM LotusLive offers a SaaS cloud for application service development. The services include an online conference service, coordinated office management, and e-mail services

IBM RC2 Cloud :

- The computer and IT infrastructures of eight IBM Research Centers are now strongly connected to form a private cloud, called the Research Compute Cloud (RC2).

- RC2 is web-based and provides solutions to establish an autonomous computing environment on user demand.
- RC2 cloud serves more than 3,000 IBM researchers and developers worldwide as a large testbed for private cloud services.

5.1.2.2 Cloud System from SGI

- SGI is a global leader in large-scale clustered computing, high performance storage, HPC and data center enablement and services.
- SGI has developed a cluster named Cyclone based on their specific super computer technology. This system is based on a specific shared memory model, which enables to reach a large amount of shared resources.
- This IT system offer a direct access to the hardware with dedicated improvement provided by SGI compute nodes.
- SGI has launched Cyclone, a large-scale, on-demand cloud computing service dedicated to technical applications. The Cyclone initially supports application partners and five technical domains, including computational fluid dynamics, finite element analysis, computational chemistry and materials, computational biology and ontologies.
- Cyclone is an on-demand cloud computing service specifically dedicated to technical applications. It supports a number of leading application partners and five technical domains, including computational fluid dynamics, finite element analysis, computational chemistry and materials, computational biology and ontology.
- Cyclone is available in two service models : SaaS and IaaS.
- With the SaaS model, Cyclone customers can significantly reduce time to results by accessing leading-edge open source applications and best-of-breed commercial software platforms from top independent software vendors. The IaaS model enables customers to install and run their own applications.
- With Cyclone's SaaS model, the company delivers access to open source applications and commercial software platforms from top independent software vendors.
- Fig. 5.1.2 shows SGI Cyclone HPC cloud for enabling SaaS and IaaS applications.
- SGI's cloud computing service is called Cyclone and is specifically dedicated for technical applications. Through Cyclone, SGI offers both a software stack and HPC hardware in a non-virtualized environment together with HPC applications.

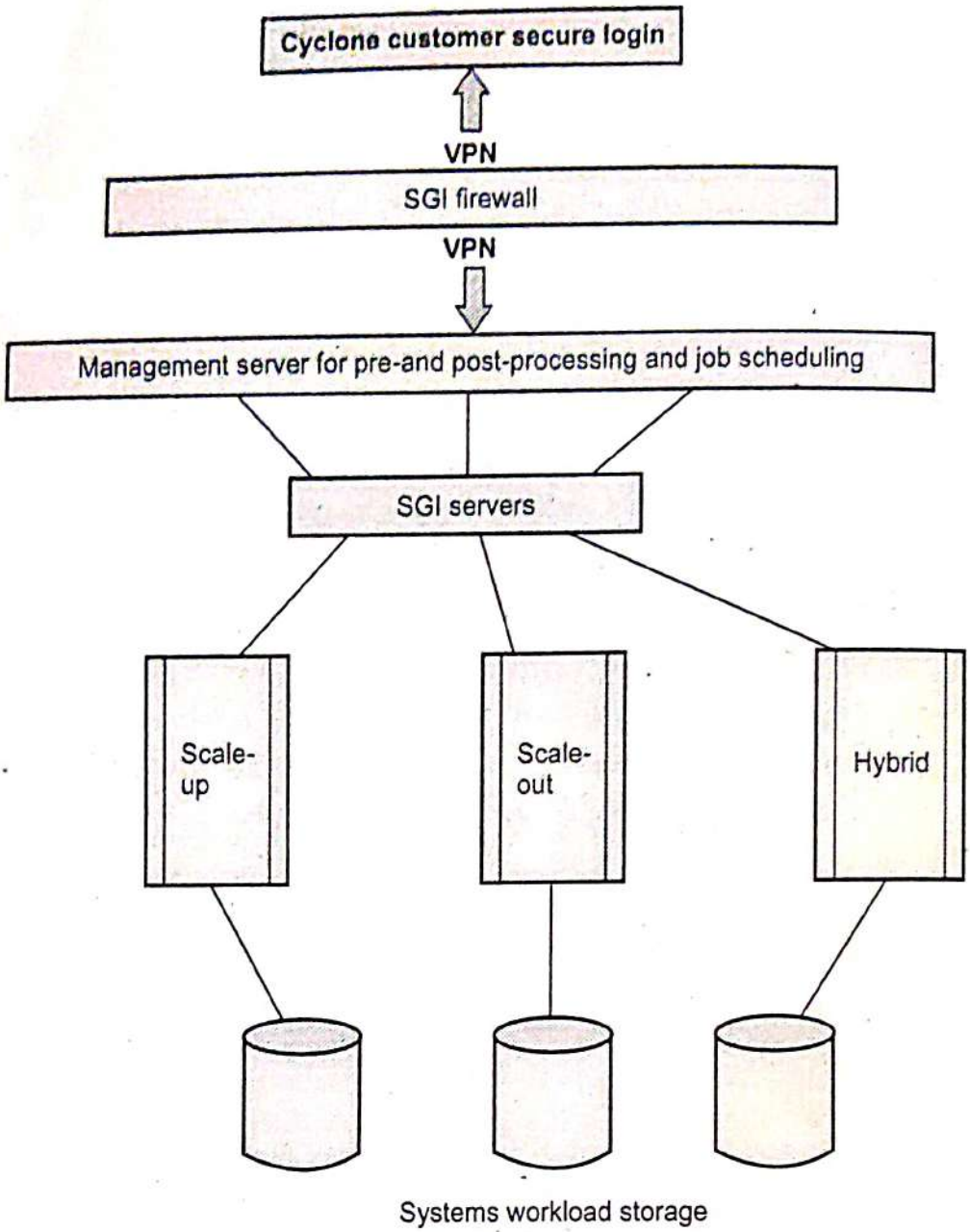


Fig. 5.1.2 SGI cyclone HPC cloud for enabling SaaS and IaaS applications

- Pulling from both open source and commercial vendors, they have applications in Computational biology, computational chemistry and materials, computational fluid dynamics, finite element analysis, and computational electromagnetics.

5.1.2.3 Salesforce

- Salesforce Sales Cloud is a Customer Relationship Management (CRM) platform designed to support sales, marketing and customer support in both Business-to-Business (B2B) and Business-to-Customer (B2C) contexts.
- Customer Relationship Management (CRM) is a strategy for managing all company's relationships and interactions with customers and potential customers. It helps to improve profitability.

- Sales Cloud is a fully customizable product that brings all the customer information together in an integrated platform that incorporates marketing, lead generation, sales, customer service and business analytics and provides access to thousands of applications through the AppExchange.
- The Sales Cloud gives a platform to connect with customers from complete, up-to-date account information to social insights, all in one place and available anytime, anywhere.
- The platform is provided as Software as a Service (SaaS) for browser-based access; a mobile app is also available. A real - time social feed for collaboration allows users to share information or ask questions of the user community.
- Salesforce.com offers five versions of Sales Cloud on a per-user, per month basis, from lowest to highest : Group, Professional, Enterprise, Unlimited and Performance.
- The company offers three levels of support contracts : Standard Success Plan, Premier Success Plan and Premier + Success Plan.
- Force.com platform also provides SOAP web service APIs. Mobile support is provided for subscribers with BlackBerry, iPhone and Windows mobile devices. The Salesforce.com SaaS and PaaS services can work in more than a dozen international languages.

5.1.3 Large - Scale Private Clouds at NASA and CERN

- The U.S. cloud, called Nebula, is developed by NASA and is designed for NASA scientists to run climate models on remote systems provided by NASA.
- The EU cloud is built by CERN in Geneva. This is a large private cloud for distributing data, applications and computing resources to thousands of scientists around the world.

5.1.3.1 NASA's Nebula Cloud

- Nebula is an open-source cloud computing platform that was developed to provide an improved alternative to building additional expensive data centers and to provide an easier way for NASA scientists and researchers to share large, complex data sets with external partners and the public.
- It enables NASA to build the complex weather models around its data centers, which is more cost-effective.
- Nebula is currently being used for education and public outreach, for collaboration and public input and for mission support.

- Nebula can serve SaaS, PaaS and IaaS needs across the agency. NASA uses Nebula for mission support, education and public outreach and to encourage collaboration and public input.
- Nebula is an excellent example of how NASA is championing ongoing partnerships with private industry and academia. Each component of the Nebula platform will be available individually, serving SaaS, PaaS, and IaaS needs across the agency.
- Fig. 5.1.3 shows the OpenNebula architecture.

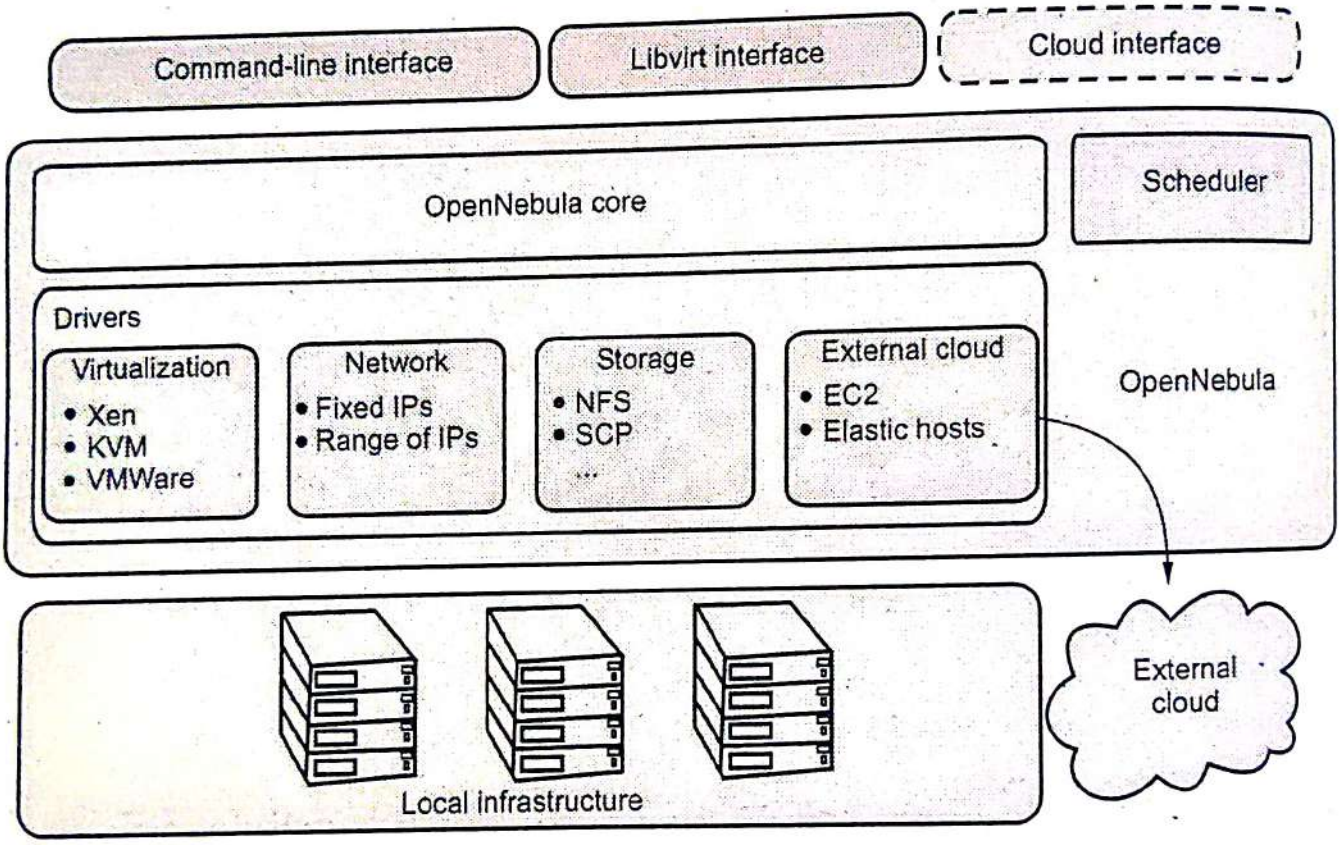


Fig. 5.1.3 OpenNebula architecture

- The core is a centralized component that manages the VM full life cycle, including setting up networks dynamically for groups of VMs and managing their storage requirements, such as VM disk image deployment or on-the-fly software environment creation.
- Capacity manager or scheduler : It governs the functionality provided by the core. The default capacity scheduler is a requirement/rank matchmaker.
- Access drivers : Access drivers provide an abstraction of the underlying infrastructure to expose the basic functionality of the monitoring, storage, and virtualization services available in the cluster.

- OpenNebula offers management interfaces to integrate the core's functionality within other data-center management tools, such as accounting or monitoring frameworks.
- NASA will use Nebula for mission support, education, and public outreach and to encourage collaboration and public input. Nebula will provide NASA with an easy, efficient, and secure way to interact and share data with the public.
- Nebula is available to NASA's internal project groups and its research and academic partners. It is not available for use by private industry or the general public.
- Nebula's architecture is designed from the ground up for interoperability with commercial Cloud service providers such as Amazon Web Services, offering NASA researchers the ability to easily port data sets and code to run on commercial Clouds.

5.1.4 Cloud Mashups for Agility and Scalability

- Mashup is a Web page or application that uses and combines data, presentation or functionality from two or more sources to create new services.
- The term implies easy, fast integration, frequently using open APIs and data sources to produce enriched results that were not necessarily the original reason for producing the raw source data.
- The main characteristics of the mashup are combination, visualization and aggregation. It is important to make existing data more useful, moreover for personal and professional use.
- Mashup composition tools are usually simple enough to be used by end-users. They generally do not require programming skills are rather support visual wiring of GUI widgets, services and components together.
- Mashup Architecture is 3-tier architecture.
- Presentation : Mashups are almost always presented visually, in portals or portal-like applications.
- Mashup Infrastructure : Technology for accessing, assembling and processing mashups, as well as ultimately serving them to applications.
- Information Sources : Virtually anything that is a 'service' can be an information source for a mashup. This includes internal databases, flat files, Java objects, Web Services and REST and external RSS feeds.
- Mashups all share three salient characteristics :
  1. They draw on sources of data directly on the web.

2. They transform, combine and re-transform this data to create innovative new outputs. Maps and timeline displays are typical mashup output formats.
3. They can usually be done in a few hours. The means that the transformations are created rapidly in a high-productivity environment.

- A mashup is an application that can display a Web page that shows data and supports features from two or more sources. Annotating a map such as Google maps is an example of a mashup. Mashups are considered one of the premier examples of Web 2.0, and that is technology's ability to support social network systems.
- A mashup requires three separate components :
  a) An interactive user interface, which is usually created with HTML/XHTML, Ajax, JavaScript, or CSS.
  b) Web services that can be accessed using an API, and whose data can be bound and transported by Web service protocols such as SOAP, REST, XML/HTTP, XML/RPC, and JSON/RPC.
  c) Data transfer in the form of XML, JSON (JavaScript Object Notation).

Types of Mashup :

- **Consumer mashup** is an application that combines data from multiple public sources within a browser and organizes it through a simple browser user interface.
- An **enterprise mashup,** also often called a business mashup, is an application that combines data from multiple internal and public sources and publishes the results to enterprise portals, application development tools or as a service in a service-oriented architecture.
- A **data mashup,** opposite to the consumer mashups, combine similar types of media and information from multiple sources into a single representation. The combination of all these resources create a new and distinct Web service that was not originally provided by either source.

Advantages of Mashup :

a) Mashups enable rapid application assembly and prototyping.
b) Time saving and rapid development.
c) It provides stability on EC2 virtual clusters.
d) Development of a mashup does not necessarily involve extensive IT skills.
e) The associated cost of application development is greatly reduced.

Disadvantages :

a) Most data sources are not made as a service.

b) Service reliability and QoS : The user is dependent on the other developers.

c) The integrity of the content can not be guaranteed either.

d) Security of these contents is another issue, especially for enterprises with very sensitive data.

5.1.5 Cloudlets for Mobile Cloud Computing

- The popularity of mobile applications on smartphones requires mobile devices to perform high-performing processing tasks. The computational resources of these devices are limited due to memory, battery life, heat, and weight dissipation.
- To overcome the limitations of mobile devices, cloud computing is considered the best solution. The major issues faced by cloud computing are expensive roaming charges and growing demand for radio access.
- A cloudlet (also called micro data center) is a new architectural element that arises from the convergence of mobile computing and cloud computing. It represents the middle tier of a 3-tier hierarchy : mobile device - cloudlet - cloud.
- A cloudlet is a mobility-enhanced small-scale cloud data center. The main purpose of the cloudlet is supporting resource-intensive and interactive mobile applications by providing powerful computing resources to mobile devices with lower latency.
- It builds on standard cloud technology. Cloudlets operate with LAN latency and bandwidth with only a few users at a time.
- Cloudlet makes it possible for mobile devices to access the Internet cloud easily in cost-effective mobile computing services.
- The idea is to use the cloudlet as a flexible gateway or portal to access the distant cloud. The cloudlet can be implemented on PCs, workstations or low-cost servers.

5.1.5.1 Difference between Cloud and Cloudlet

Particulars	Cloud	Cloudlet
State	Hard and Soft State	Soft State
Management	Professionally administered, 24 × 7 operator	Self-managed; little to no professional attention
Environment	Machine room with power conditioning and cooling	"Data center in a box" at business premises
Ownership	Centralized ownership	Decentralized ownership
Network Latency	Internet bandwidth	LAN bandwidth
Sharing	More users at a time	Few users at a time

Review Questions

1. *Explain the concept of cloudlet. Differentiate between cloud and cloudlet.*

   SPPU : May-19 End Sem, Marks 8

2. *Explain the concept of cloud mashup. Draw and explain architecture of IoT.*

   SPPU : May-19 End Sem, Marks 8

3. *Explain cloudlet. Differentiate between cloud and cloudlet.*

   SPPU : Dec.-19 End Sem, Marks 8

4. *Elaborate the idea of cloud mashups and explain its advantages.*

   SPPU: Dec.-19 End Sem, Marks 8

5.2 Performance of Distributed Systems and the Cloud

5.2.1 Performance Metrics for HPC/HTC Systems

- Performance metrics are throughput, multitasking scalability, availability measure, data security, and cost-effectiveness.
  1. System throughput measures the number of jobs that can be done per unit of time. The throughput measure is attributed to several key factors that affect the total execution time of all jobs processed in a given time window.
  2. Multitasking Scalability : Multitasking implies the use of a system to handle many jobs simultaneously or concurrently. System services should be able to scale both horizontally across the machine or cluster size and vertically from applications to middleware, runtime and OS support and hardware.
  3. System Availability : System availability refers to the percentage of time the system is up and running normally. This percentage reflects the effects of downtime after unexpected failures and scheduled maintenance for software upgrades.
  4. Cloud security is attributed to user confidentiality, data integrity, access control, firewalls, IDSes, defence capability.
  5. Cost Effectiveness : This refers to the estimate of an effective scale of economy achievable by a given system.

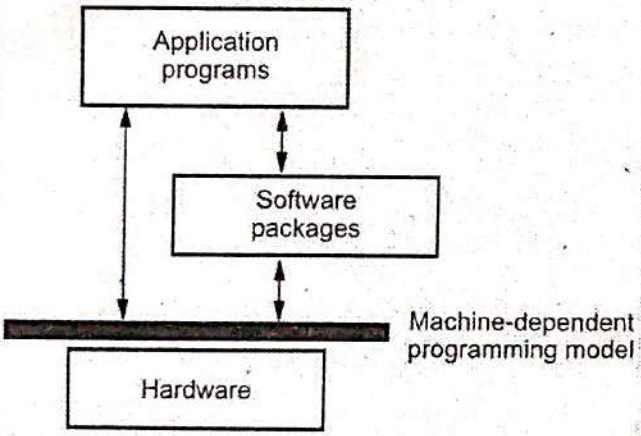
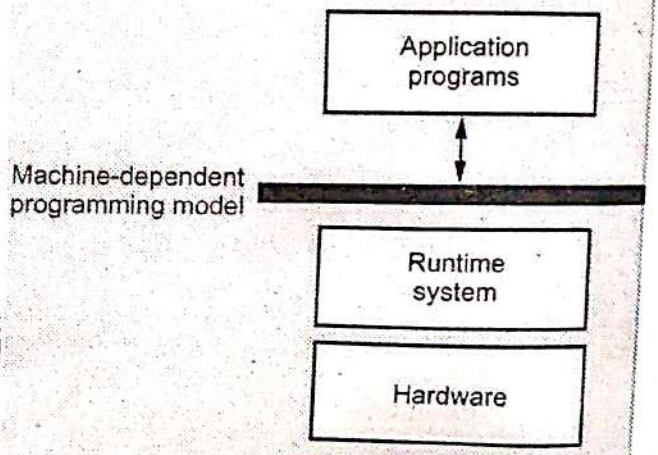
5.2.2 FutureGrid

- FutureGrid is not a production system, but rather an environment supporting a flexible development and testing platform for middleware and application users looking at interoperability, functionality, and performance issues.

- FutureGrid will make it possible for researchers to conduct experiments by submitting an experiment plan that is then executed via a sophisticated workflow engine, preserving the provenance and state information necessary to allow reproducibility.
- Rather than loading images onto VM's, FutureGrid supports Cloud, Grid and Parallel computing environments by provisioning software as needed onto "bare-metal" or VM's/Hypervisors using open source tools.
- Essential and Different features of FutureGrid :
  1. Unlike many clouds such as Amazon and Azure, FutureGrid allows robust reproducibility.
  2. FutureGrid is more than a Cloud; it is a general distributed Sandbox; a cloud grid HPC testbed.
  3. Supports 3 different IaaS environments (Nimbus, Eucalyptus, OpenStack).
  4. Supports research on cloud tools, cloud middleware and cloud-based systems as well as use of clouds in applications.
  5. FutureGrid has developed middleware and interface for **Computing TestbedaaS** e.g. Phantom (cloud user interface) Vine (virtual network) RAIN (deploy systems) and security/metric integration.
  6. FutureGrid has experience in **running cloud systems.**
- The FutureGrid Project makes it possible for researchers to tackle complex research challenges in computer science related to the use and security of grids and clouds
- The Grid'5000 distributed system links nine sites in France.

5.2.3 Data - Intensive Scalable Computing

- Data-intensive computing is a class of parallel computing applications which use a data parallel approach to process large volumes of data typically tearbytes or petabytes in size and typically referred to as big data.
- Data-intensive computing platforms typically use a parallel computing approach combining multiple processors and disks in large commodity computing clusters connected using high-speed communications switches and networks which allows the data to be partitioned among the available computing resources and processed independently to achieve performance and scalability based on the amount of data.
- Difference between conventional supercomputer and data intensive scalable computing :

Sr. No.	Conventional Supercomputers	Data-Intensive Scalable Computing
1.	An HPC system by which data is retrieved from remote sites and brought into the system for execution. Heavy data movement overhead.	An HTC data-center cluster which collects and maintains data. Computation collacated with storage for faster access.
2.	Heavy data movement overhead.	No data movement overhead.
3.	Machine-dependent programs written at a very low level. Use fewer software tools; need specialists to optimize.	Machine-independent application programs on data. Use runtime system controls to optimize execution through load balancing, etc.
4.	Main machine for batch processing when resources are ready. Uses offline visualization at remote site.	Interactive access with priority control and user intervention over large number of users simultaneously.
5.	Brittle systems with which to recover from most recent checkpoint.	Flexible error detection and recovery.
6.	Must bring down system for maintenance.	Use redundancy techniques to enter graceful degraded operations in case of failure.
7.		

5.3 Enabling Technologies for the Internet of Things

5.3.1 Internet of Things for Ubiquitous Computing

- Internet of Things (IoT) is a new paradigm that includes a network of smart objects, which are embedded sensors, communicating using the Internet. One of the areas that are leading up to IoT is Ubiquitous Computing (UbiComp). There are thus solutions such as frameworks, middlewares, and other development artifacts that come from the UbiComp community and can be used for IoT applications.

- Some aspects of ubiquitous computing have been realized through advancements in mobile technologies such as wearable devices and Radio-Frequency Identification (RFID) tags. The use of sensors and other tools in the IoT, however, has made technology truly pervasive in almost every imaginable location. The foundation of the IoT is Radio-Frequency Identification (RFID).
- Ubiquitous computing and the IoT have also benefited from the increasing data rates of high-speed networks and the use of edge computing to provide nearby processing and storage.
- Ubiquitous computing is a post-desktop model of human-computer interaction in which information processing is integrated into everyday objects and activities

5.3.2 Development of the Internet of Things

- The Internet of Things (IoT) 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 smartphones that interact with other smartphones, 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.
- Things are objects of the physical world (physical things) or of the information world (virtual world) which are capable of being identified and integrated into communication networks. Things have associated information, which can be static and dynamic.
- Physical things exist in the physical world and are capable of being sensed, actuated and connected. Examples of physical things include the surrounding environment, industrial robots, goods and electrical equipment.
- Virtual things exist in the information world and are capable of being stored, processed and accessed. Examples of virtual things include multimedia content and application software.
- A device is a piece of equipment with the mandatory capabilities of communication and optional capabilities of sensing, actuation, data capture, data storage and data processing.
- The devices collect various kinds of information and provide it to the information and communication networks for further processing. Some devices also execute operations based on information received from the information and communication networks.
- Fig. 5.3.1 shows roadmap of IoT development.

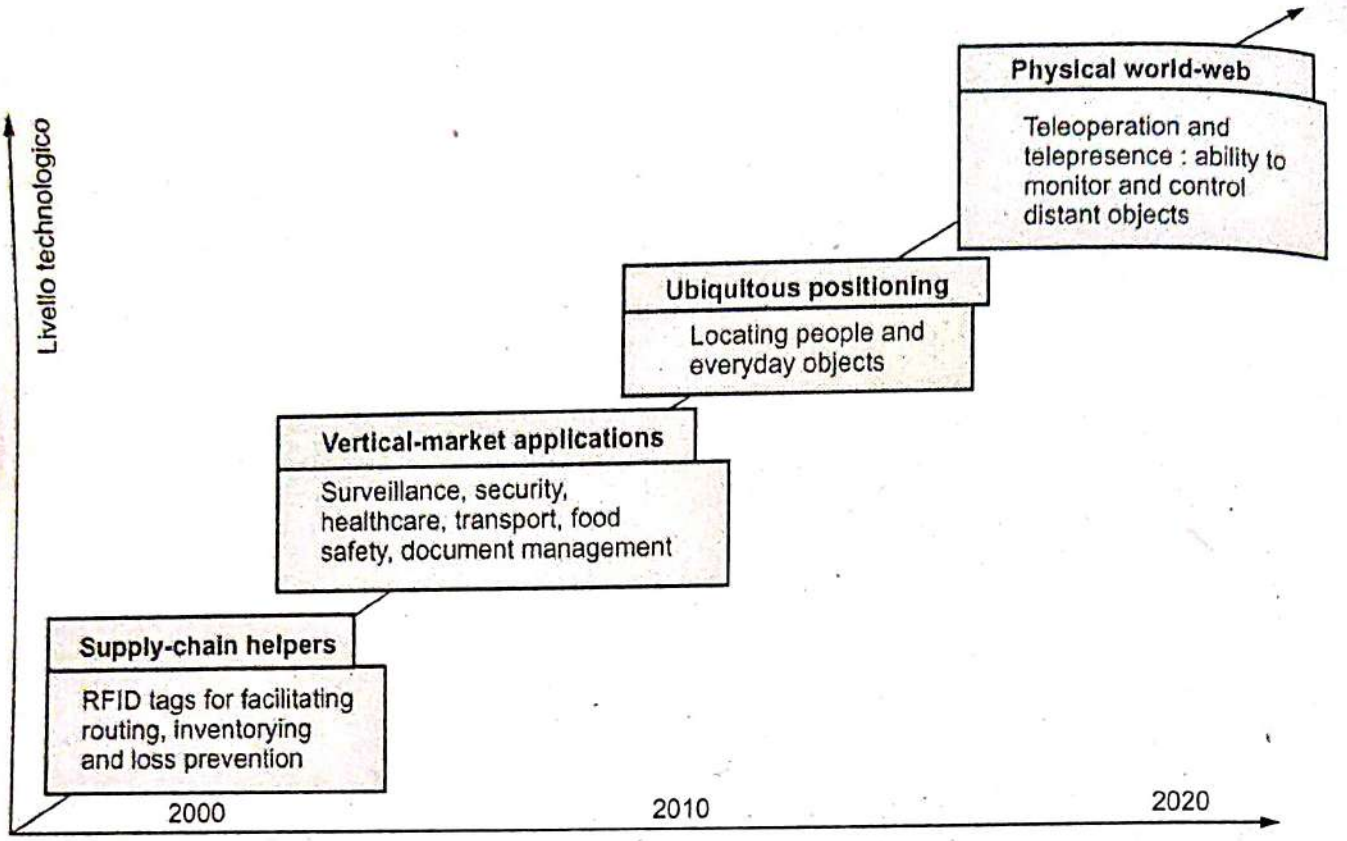


Fig. 5.3.1 Roadmap of IoT development

- 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.
- Wikipedia definition : The Internet of Things, also called The Internet of Objects, refers to a wireless network between objects, usually the network will be wireless and self-configuring, such as household appliances.
- WSIS 2005 Definition : By embedding short-range mobile transceivers into a wide array of additional gadgets and everyday items, enabling new forms of communication between people and things and between things.
- The Internet of Things refers to the capability of everyday devices to connect to other devices and people through the existing Internet infrastructure.
- Ubiquitous computing, pervasive computing, Internet protocol, sensing technologies, communication technologies and embedded devices are merged together in order to form a system where the real and digital worlds meet and are continuously in symbiotic interaction.
- The smart object is the building block of the IoT vision. By putting intelligence into everyday objects, they are turned into smart objects able not only to collect information from the environment and interact/control the physical world, but also to be interconnected, to each other, through Internet to exchange data and information.

5.3.3 Characteristics of the Internet of Things

1. Interconnectivity : Everything can be connected to the global information and communication infrastructure.
2. Heterogeneity : Devices within IoT have different hardware and use different networks but they can still interact with other devices through different networks.
3. Things-related services : Provides things-related services within the constraints of things, such as privacy and semantic consistency between physical and virtual thing.
4. Dynamic changes : The state of a device can change dynamically, thus the number of devices can vary.
5. Integrated into information network : IoT devices are integrated with information network for communication purpose. It will exchange data with other devices.
6. Self-adapting : Self-Adaptive is a system that can automatically modify itself in the face of a changing context, to best answer a set of requirements.
7. Self-configuration primarily consists of the actions of neighbour and service discovery, network organization and resource provisioning.

5.3.4 Enabling and Synergistic Technologies

- The technology to build IOT infrastructure is divided into two categories as shown in Fig. 5.3.2.
- Enabling technologies build up the foundations of the IoT. Among the enabling technologies, tracking (RFID), sensor networks, and GPS are critical

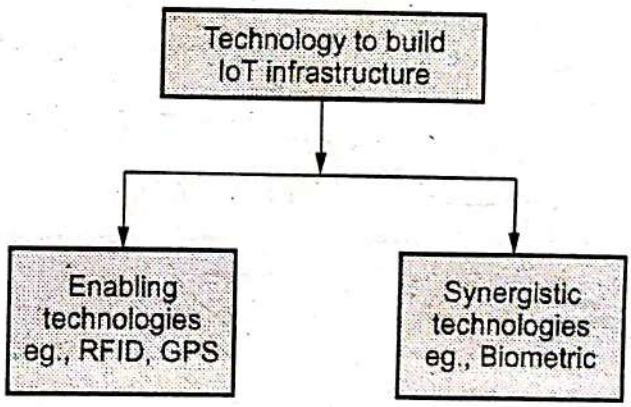


Fig. 5.3.2 Technologies to build IOT infrastructure

- Synergistic technologies play supporting roles. For example, biometrics could be widely applied to personalize the interactions among humans, machines, and objects. Artificial intelligence, computer vision, robotics, and telepresence can make our lives more automated in the future.
- Fig. 5.3.3 shows various enabling and synergistic technologies to build IOT infrastructure

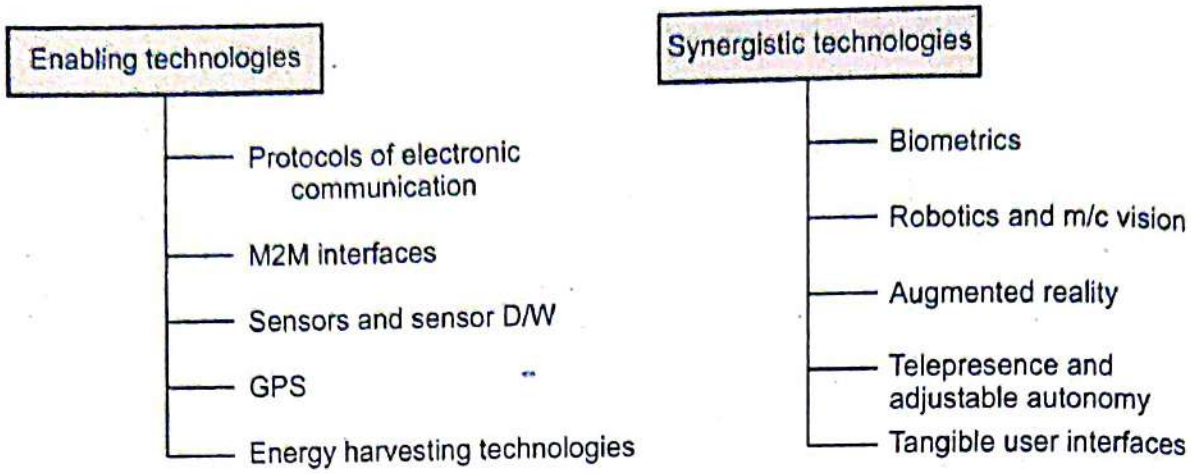


Fig. 5.3.3 Enabling and synergistic technologies

5.3.5 Architecture of the Internet of Things

- The IoT system is an event-driven architecture. Fig. 5.3.4 shows the architecture of IoT.

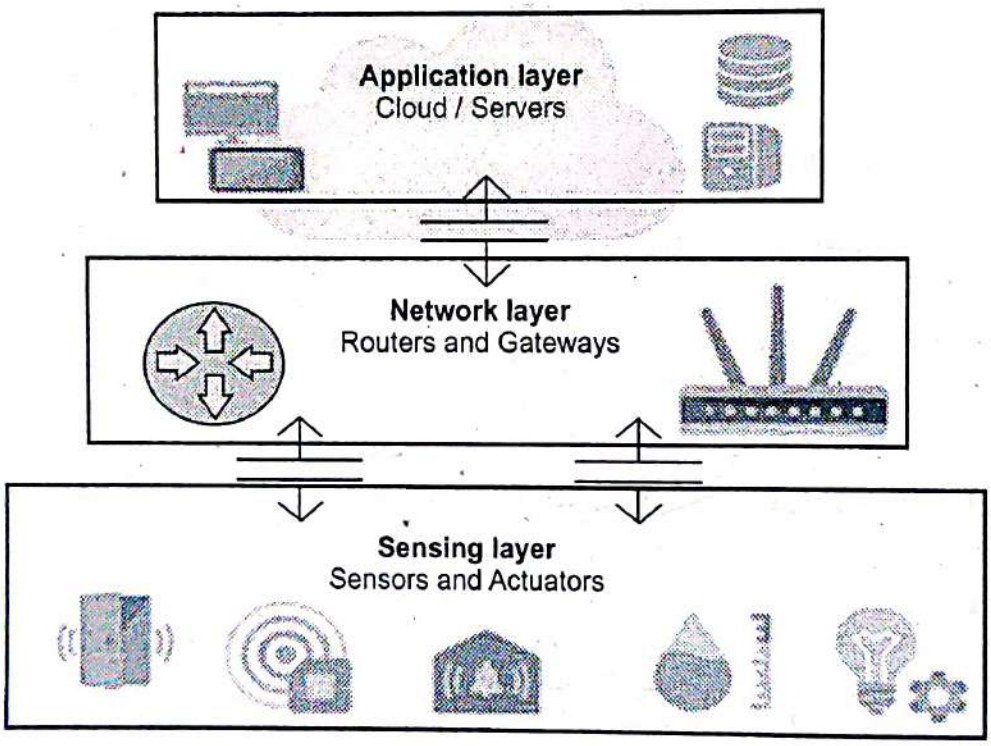


Fig. 5.3.4 Architecture of IoT

- The top layer is the IOT application layer which contains the application user interface. Application layer is at the top of the architecture and is responsible for delivery of various applications to different users in IoT.
- The applications can be from different industry segments such as : Manufacturing, logistics, retail, environment, public safety, healthcare, food and drug etc.

- With the increasing maturity of RFID technology, numerous applications are evolving which will be under the umbrella of IoT.
- The bottom layers represent various types of sensing devices : Namely RFID tags, ZigBee or other types of sensors, and road-mapping GPS navigators.
- The sensing devices are locally or wide-area-connected in the form of RFID networks, sensor networks, and GPS. Signals or information collected at these sensing devices are linked to the applications through the cloud computing platforms at the middle layer.
- The signal processing clouds are built over the mobile networks, the Internet backbone, and various information networks at the middle layer.
- The sensors enable the interconnection of the physical and digital worlds allowing real-time information to be collected and processed. The sensors have the capacity to take measurements such as temperature, air quality, movement and electricity.
- Sensors are grouped according to their unique purpose such as environmental sensors, body sensors, home appliance sensors and vehicle telemetric sensors, etc.
- Many of these hardware elements provide identification and information storage (e.g. RFID tags), information collection (e.g. sensors), and information processing (e.g. embedded edge processors).
- Sensing layer - Sensors, actuators and edge devices that interact with the environment
- Network Layer - Discovers, connects and translates devices over a network and in coordination with the application layer
- Application Layer - Data processing and storage with specialized services and functionality for users

5.3.6 RFID

- Radio-Frequency Identification (RFID) is an Automatic Data Capture technology that uses radio-frequency waves to read a movable item to identify, categorize and track.
- It is fast and does not require physical sight or contact between reader/scanner and the tagged item.
- It performs the operation using low cost components. It attempts to provide unique identification and backend integration that allows for wide range of applications.
- RFID tags contain at least two major parts. One is an integrated circuit for storing and processing information, modulating and demodulating a Radio-Frequency (RF)

signal, and other special functions. The other part is an antenna for receiving and transmitting the radio signals.

- Tags can be read-only or read-write. Tag memory can be factory or field programmed and optionally permanently locked (security). Data written to the tag left unlocked, can be modified over more than 100,000 times, allowing the the tag to be reused or updated
- Major components of RFID hardware :
  1. **RFID tag :** A tiny silicon chip attached to a small antenna.
  2. **Reader antenna :** It used to radiate the energy and then capture the return signal sent back from the tag.
  3. **Reader :** The device station that talks with the tags. A reader may support one or more antennae.
- Fig. 5.3.5 shows working of RFID.

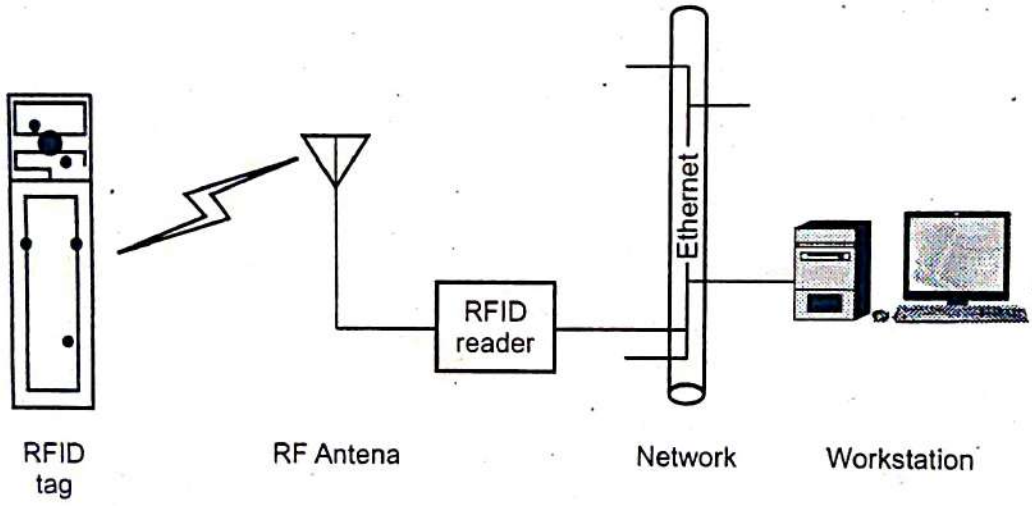


Fig. 5.3.5 RFID working

- In the active RFID system, the reader sends signal to the tag using an antenna. The tag receives this information and resends this information along with the information in its memory.
- The reader receives this signal and transmits to the processor for further processing.
- Processor or a Controller : It can be a host computer with a Microprocessor or a microcontroller which receives the reader input and process the data.
- Active and semi-passive RFID tags use internal batteries to power their circuits. An active tag can also use its own battery to broadcast radio waves to a reader, whereas a semi-passive tag relies on the reader to supply its power for broadcasting.

- Active and semi-passive tags are reserved for reading over 30 to 100 meters, if repeater batteries are used to boost a tag's range.
- **Types of RFID Systems :**
  1. **Active RFID system :** These are systems where the tag has its own power source like any external power supply unit or a battery. The only constraint being the life time of the power devices. These systems can be used for larger distances and to track high value goods like vehicles.
  2. **Passive RFID system :** These are systems where the tag gets power through the transfer of power from a reader antenna to the tag antenna. They are used for short range transmission.

Advantages of RFID

a) RFID technology automates data collection and vastly reduces human effort and error

b) RFID supports tag reading with no line-of-sight or item-by-item scans required

c) RFID readers can read multiple RFID tags simultaneously, offering increases in efficiency

d) All RFID tags within range can be detected instantly and matched with information in database

e) Assets can be cross-referenced against assigned locations and recorded as present, missing, or relocated

f) RFID can be integrated with active scanning and fixed readers for a totally automated tracking solution.

5.3.7 Wireless Sensor Networks

- A Wireless Sensor Network (WSN) is a network formed by a large number of sensor nodes where each node is equipped with a sensor to detect physical phenomena such as light, heat, pressure, etc.
- WSNs nowadays usually include sensor nodes, actuator nodes, gateways and clients. A large number of sensor nodes deployed randomly inside of or near the monitoring area. Form networks through self-organization.
- Sensor nodes monitor the collected data to transmit along to other sensor nodes by hopping. During the process of transmission, monitored data may be handled by multiple nodes to get to gateway node after multi-hop routing and finally reach the management node through the Internet or satellite.
- A sensor network consists of multiple detection stations called sensor nodes, each of which is small, lightweight and portable.

- Every sensor node is equipped with a transducer, microcomputer, transceiver and power source. The transducer generates electrical signals based on sensed data.
- The microcomputer processes and stores the sensor output. The transceiver, which can be hard-wired or wireless, receives commands from a central computer and transmits data to that computer.
- The power for each sensor node is derived from the electric utility or from a battery.
- Standards for WSN technology have been well developed, such as Zigbee (IEEE 802.15.4). The IEEE 802.15.4 is simple packet data protocol for lightweight wireless networks.
- It works well for long battery life, selectable latency for controllers, sensors, remote monitoring and portable electronics.

Generation of wireless sensor network :

Parameters	First Generation	Second Generation	Third Generation
Node Architecture	Separate sensing, processing and communication	Integrated sensing, processing and communication	Full integrated sensing, processing and communication
Protocol	Proprietary	Proprietary	Standard (Wi-Fi, WiMax)
Topology	Point to point, Star and Multi-hop	Client-server and peer to peer	Fully peer to peer
Power Supply	Large batteries	AA batteries	Solar
Life span	Hours, days and longer	Days to weeks	Months to years
Deployment mode	Physically installed	Hand placed	Embedded or nanotechnology based
Manufacturers	Custom constructors	Crossbow Technology, Inc., Sensoria Corp., Ember Corp.	Dust, Inc. and others

5.3.8 ZigBee Technology

- The IEEE 802.15.4 standard does not standardize the higher communication protocol layers, including the network and application layers. To assure interoperability between devices operating the IEEE 802.15.4 standard, the behaviour of these layers must be specified. The creation of such a specification has been taken by Zigbee Alliance.

General characteristics :

1. Data rates of 250 kbps, 20 kbps and 40 kbps.
2. Star or peer-to-peer operation.
3. Support for low latency devices.
4. CSMA-CA channel access.
5. Dynamic device addressing.
6. Fully handshaked protocol for transfer reliability.
7. Low power consumption.

- ZigBee communications can reach up to 500 m, with a data rate of up to 250 kbs, for a typical power consumption of 125 to 400 μW.
- As ZigBee is based on IEEE 802.15.4, there is no wake-up signal, but slots for sleep or activity or in asynchronous mode, devices sleeping anytime they have nothing to say, with an ever-vigilant coordinator.
- To use a ZigBee module with a microcontroller, you need to connect it to a UART. There are other, optional pins to use, including a number of analog inputs/digital IOs and a PWM output indicating the strength of the signal which you can directly connect to a LED pin for observation purposes.
- There are two modes of data transfer namely Beacon mode and Non Beacon mode.
- In Beacon mode, when the devices are not sending the data they may enter a low power state and reduces the power consumption.
- In Non-beacon mode, the end devices need to be wake up only while sending the data while the routers and coordinators need to be active most of the time.
- The ZigBee stack architecture is based on three major components; ZigBee Physical data/link level, ZigBee network layers and ZigBee Application support layer.
  Fig. 5.3.6 shows ZigBee architecture.

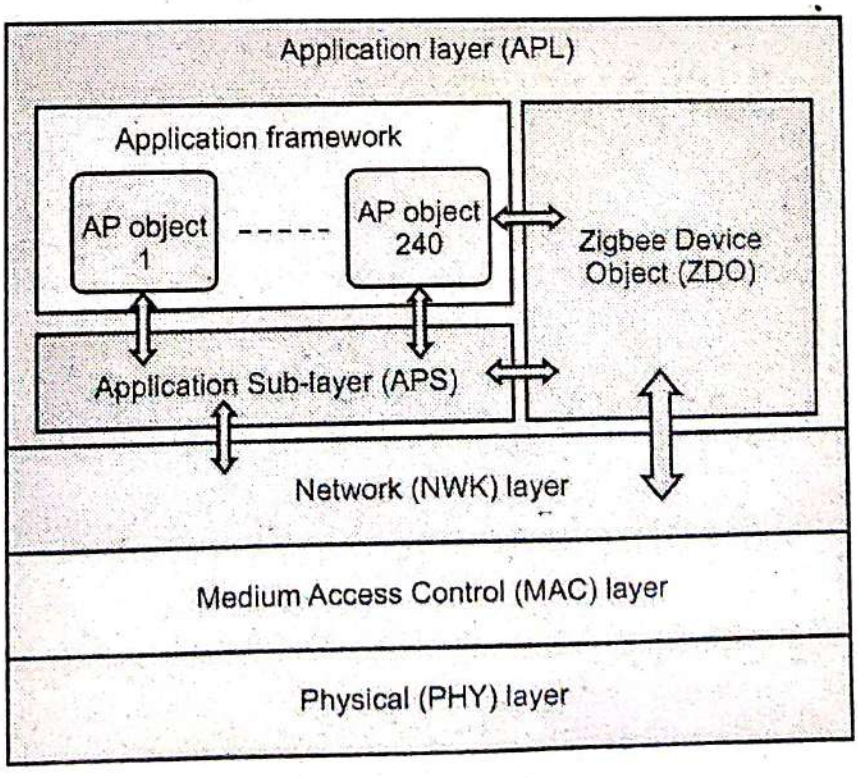
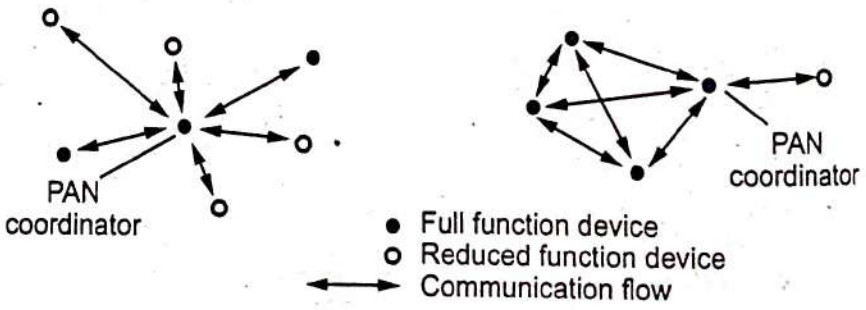


Fig. 5.3.6 ZigBee architecture

- Physical Layer : This layer does modulation and demodulation operations upon transmitting and receiving signals respectively.
- MAC Layer : This layer is responsible for reliable transmission of data by accessing different networks with the carrier sense multiple access collision avoidances. This also transmits the beacon frames for synchronizing communication.
- Network Layer : This layer takes care of all network-related operations such as network setup, end device connection, and disconnection to network, routing, device configurations, etc.
- Application Support Sub-Layer : This layer enables the services necessary for Zigbee device objects and application objects to interface with the network layers for data managing services. This layer is responsible for matching two devices according to their services and needs.
- Application Framework : It provides two types of data services as key-value pair and generic message services. The generic message is a developer-defined structure, whereas the key-value pair is used for getting attributes within the application objects.
- Fig. 5.3.7 shows star topology and peer-to-peer topology.
- There are three different types of ZigBee devices :



(a) Stratopology (b) Peer to peer technology

Fig. 5.3.7

- ZigBee coordinator (ZC) : This is the most capable ZigBee device serving as the coordinator or the root of a ZigBee network. There is exactly one coordinator in each network since it is the device that started the network. It is able to store information about the network, including acting as the trust center and repository of security keys.
- ZigBee Router (ZR) : This can as an intermediate router, passing on data from end device to end device.
- ZigBee End Device (ZED) : This contains just enough functionality to talk to the parent node. The end device cannot relay data from other devices. This relationship allows the node to be asleep a significant amount of the time, thereby ensuring a long battery life. A ZED requires the least amount of memory and therefore can be less expensive to manufacture than a ZR or ZC.

Advantages :

1. Zigbee technology has a flexible structure.
2. Zigbee technology is easy to control and monitor with the help of a remote
3. Zigbee technology is suitable for devices with low power.

5.3.9 GPS

- Global Positioning System is a satellite navigation system that furnishes location and time information to the user.
- Fixed or orbiting satellite transmitters broadcast timing signals and receiving device response signals to locate the position of moving objects. GPS is used for navigation in planes, ships, cars and trucks also.
- The system gives critical abilities to military and civilian users around the globe. GPS provides continuous real time, 3-dimensional positioning, navigation and timing worldwide.
- The GPS system consists of three segments :
  1) The space segment : the GPS satellites.
  2) The control system, operated by the U.S. military.
  3) The user segment, which includes both military and civilian users and their GPS equipment.
- Fig. 5.3.8 shows GPS technology.

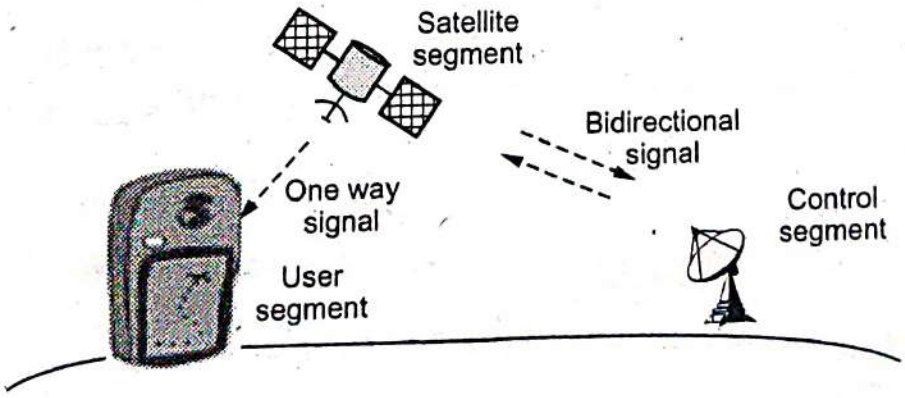


Fig. 5.3.8 GPS technology

- The space segment is the number of satellites in the constellation. It comprises of 29 satellites circling the earth.
- The control segment comprises of a master control station and five monitor stations outfitted with automic clocks that are spread around the globe.

- The user segment comprises of the GPS receiver, which receives the signals from the GPS satellites and determine how far away it is from each satellite.
- The GPS operation uses data from satellites to calculate the location, Usually it requires data from at least three satellites to triangulate the position.
- There is a concept known as Time To Fix First (TTFF). TTFF is the time lapse required to download the data before the commencement of calculations.
- TTFF depends on the frequent use of the device. If the chip is not used frequently, then TTFF will be high. Usually, the transmission rate of data from satellite is around 6 bytes per second.
- It takes for a GPS receiver about 65 to 85 millisecond to receive a radio signal from GPS satellite. If the device is used frequently, then the TTFF will be small as the data have already been downloaded.
- GPS devices or trackers which are available in the market can broadly be divided into two types those are active GPS devices and passive GPS devices.
- Types of GPS : Active GPS and Passive GPS.

Active GPS :

- Active GPS trackers monitor movement in real-time. In active GPS devices, the user can view the speed, location and other tracking details soon after the implementation of the device from any place.
- In active GPS trackers, GPRS module is in-built, which allows the device to transmit the data to the saver.
- If one has a web based tracking interface and source and map sources then the user will be able to track from anywhere; provided Internet connection is available.

Passive GPS :

- Passive GPS devices do not allow the user to view tracking information in real time. The information in the device can only be viewed after that information is downloaded to a computer.
- Tracking details normally include the data of the information, time of the information, direction traveled and stops made.

Working of GPS :

- GPS consists of three segments : the space segment, control segment, and user segment. Fig. 5.3.9 shows GPS working.

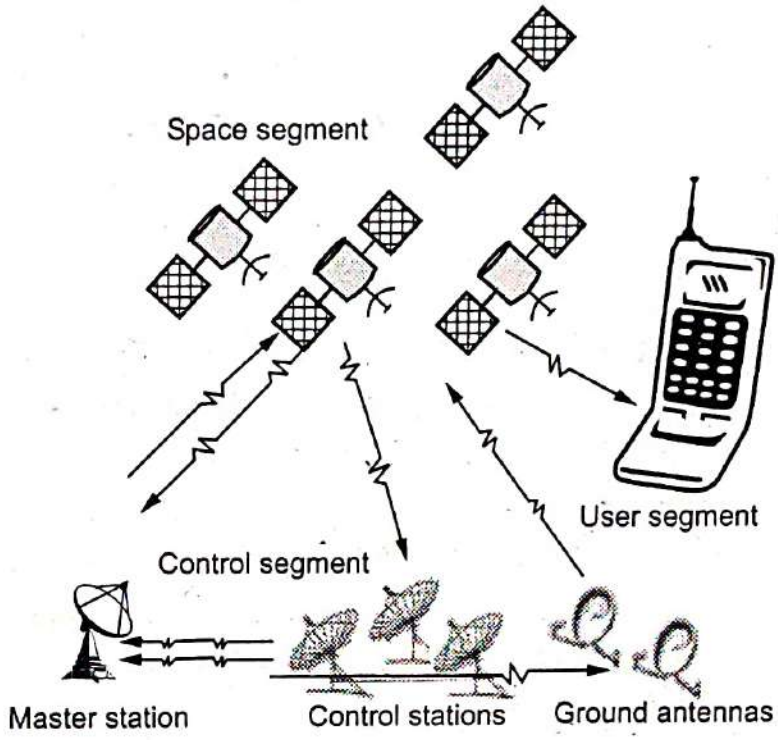


Fig. 5.3.9 GPS working

a) The space segment consists of 29 satellites, each in its own orbit 20,200 km above the Earth. The function of the space segment is utilized to route/navigation signals and to store and retransmit the route/navigation message sent by the control segment. These transmissions are controlled by highly stable atomic clocks on the satellites

b) The Control Segment consists of a system of tracking stations located around the world. The control segment comprises a master control station and five monitor stations outfitted with atomic clocks that are spread around the globe. The five monitor stations monitor the GPS satellite signals and then send that qualified information to the master control station.

c) The user segment consists of GPS-receivers, located in cars, planes or even in GPS collars for wildlife. They can be as small as a mobile phone.

- When a GPS receiver is first turned on, it downloads orbit information from all the satellites called an almanac. This process, the first time, can take as long as 12 minutes; but once this information is downloaded, it is stored in the receiver's memory for future use.
- The GPS receiver calculates the distance from each satellite to the receiver by using the distance formula : Distance = Velocity × Time.
- The receiver determines position by using triangulation. When it receives signals from at least three satellites the receiver should be able to calculate its approximate position. The receiver needs at least four or more satellites to

calculate a more accurate 3D position. The position can be reported in latitude/longitude, or other coordinate systems.

5.4 Innovative Applications of the Internet of Things

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

5.4.1 Applications of the Internet of Things

1. **Home :** Buildings where people live. It controls home and security systems.
2. **Offices :** Energy management and security in office buildings; improved productivity, including for mobile employees.
3. **Factories :** Places with repetitive work routines, including hospitals and farms; operating efficiencies, optimizing equipment use and inventory.
4. **Vehicles :** Vehicles including cars, trucks, ships, aircraft, and trains; condition-based maintenance, usage-based design, pre-sales analytics
5. **Cities :** Public spaces and infrastructure in urban settings; adaptive traffic control, smart meters, environmental monitoring, resource management.
6. **Worksites :** It is custom production environments like mining, oil and gas, construction; operating efficiencies, predictive maintenance, health and safety.

- Information interoperability covers technologies and processes for making in-formation available without a need to know interfacing methods of the entity creating or consuming the information.
- A smart space is a semantic information-centric extension of the IoT-aware connection of physical and virtual objects.

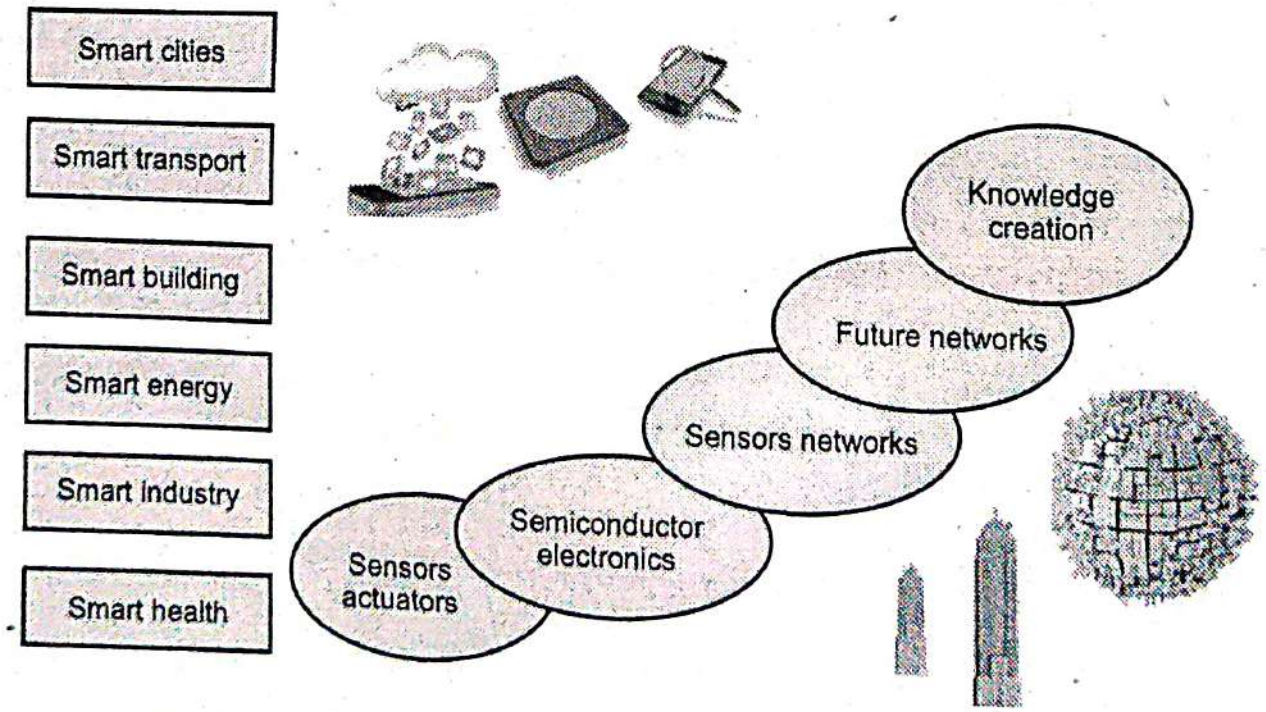


Fig. 5.4.1 IoT - Smart environment and smart spaces creation

- Smart environments are places where different kinds of embedded devices are interconnected in order to provide their occupants with intelligent services improving their comfort and convenience. These smart environments are seen to be important for the future urban ecosystems in terms of user friendliness, quality of life, energy efficiency and sustainability
- The security challenge includes traditional issues of open distributed systems, such as key exchange and resource restrictions, and specific problems caused by the dynamicity and heterogeneity of smart spaces.
- IoT applications need context-dependent and fine-grained access control. Smart space access control policies define which Knowledge Processors (KPs) are allowed to access which objects.

5.4.2 Specific Wireless Sensor Applications

- Following are the various applications of sensor networks :
- Military sensor networks to detect and gain as much information as possible about enemy movements, explosions and other phenomena of interest
- Sensor networks to detect and characterize chemical, biological, radiological, nuclear and explosive attacks and materials
- Sensor networks to detect and monitor environmental changes in plains, forests, oceans, and so on
- Wireless traffic sensor networks to monitor vehicle traffic on highways or in congested parts of a city
- Wireless surveillance sensor networks for providing security in shopping malls, parking garages, and other facilities
- Wireless parking lot sensor networks to determine whether the lot is occupied or available.

5.4.3 Retailing

1. Inventory Management :

- Retail involves the sale of goods from a single point (malls, markets, department stores etc) directly to the consumer in small quantities for his end use.
- Retail is a challenging business but the pressures of today's economic conditions are resulting in even more selective consumer shopping and spending.
- The effect of the internet of things on inventory management is the next huge thing in progress when it comes to Business Process Management (BPM).

- In any typical business, the process of ordering, storing, tracking and managing goods is a day to day requirement. As with all high investment top-tier businesses, this process becomes more complex with increasing amounts of supply and demand.
- This process involves huge transaction of monetary resources and hence it is impervious that a high preference is given to this in a BPM. Inventories that are mismanaged can create significant financial problems for a business, leading to a inventory shortage.
- Existing technologies such as bar coding and Radio-Frequency Identification (RFID) already let retailers monitor their inventories.
- IoT will enable this to be taken to the next level with significantly more data coming in the monitoring systems and products moving through the supply chain.
- This can considerably improve supply chain efficiencies and enable leaner inventories. Large retailers such as **Walmart** are already using IoT for supply chain and inventory management.
- Tracking is done using RFID readers attached to the retail store shelves.

2. Logistics : Route Generation and Scheduling

- Modern transportation system collects data from various places and multiple sources. Collected data is processed and decision is taken according to this. This information is also provided to stakeholders.
- Data driven transportation system is provided by using this data.
- Route generation and scheduling system can generate end to end routes using combination of route patterns and transportation modes.
- Cities around the world face common transport challenges - from increasing congestion, safety concerns and aging infrastructure to a lack of funding and increasing environmental impacts. Like their colleagues in city administration and government, transport officials are starting to implement "smart solutions" to address these challenges and provide improved mobility in their cities, better services for citizens and a more cost-effective transport network.
- Vehicle networking : Utilizing the new technologies, such as wireless communication, positioning and navigation, context awareness, to implement the connections between vehicle to vehicle, vehicle to man, vehicle to infrastructure, so that the integrated service can be provided.
- The Internet of Vehicles (IoV) is an integration of three networks : an inter-vehicle network, an intra-vehicle network, and vehicular mobile Internet.
- The application of IoT technology in providing information services, improving traffic efficiency, enhancing traffic safety, implementing supervision and control

and other aspects will make millions of people enjoy more comfortable, convenient and safe traffic service.

5.4.4 Supply Chain Management

- Supply line combines the processes, methodologies, tools, and delivery options to guide collaborative partners to work in a sequence to conduct business with high efficiency and delivery speed.
- A supply chain is an efficient network of facilities that procures materials, transforms these materials to finished products, and finally distributes the finished products to customers.
- Fig. 5.4.2 supply chain management.

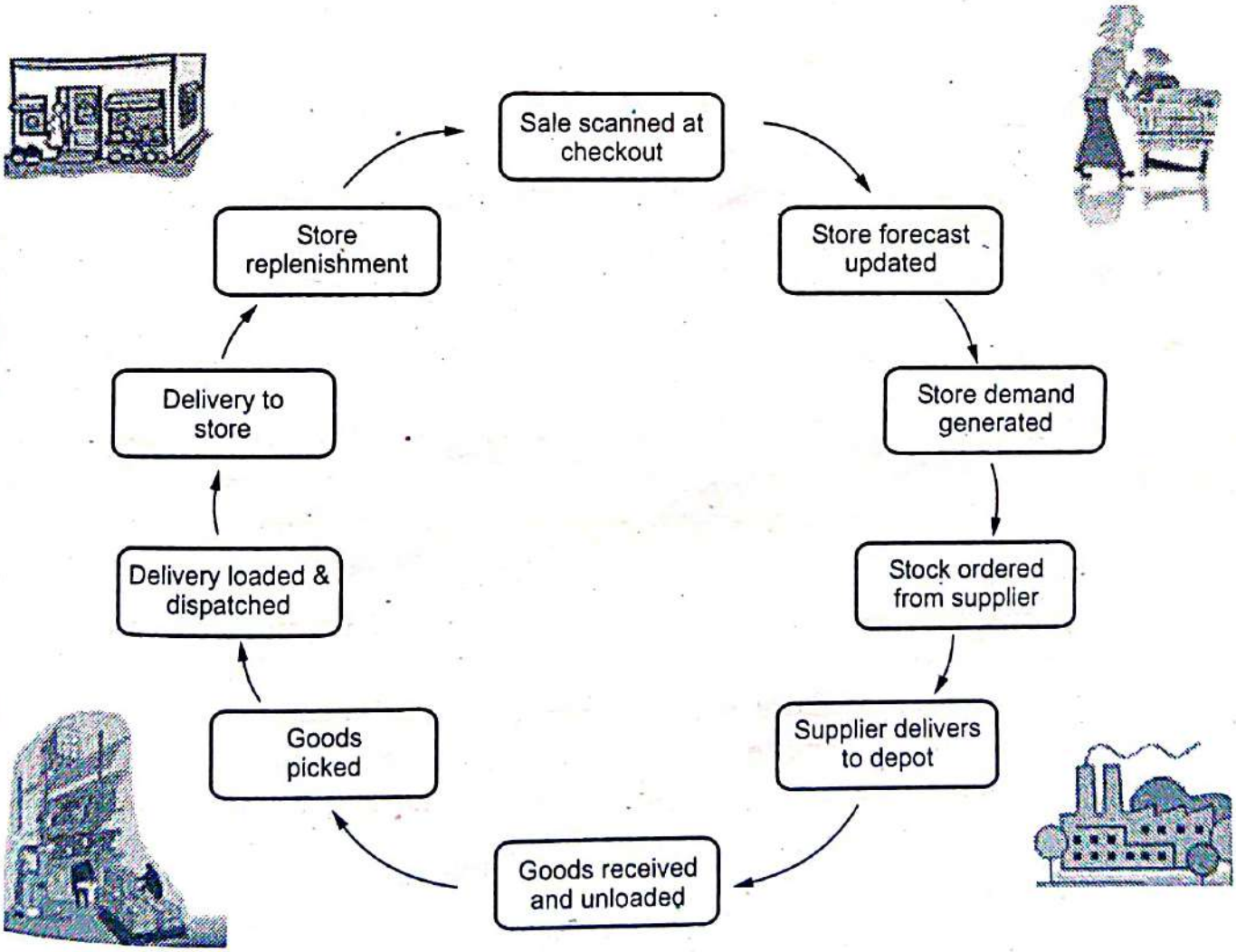


Fig. 5.4.2 Supply chain management

- Supply chain involves material suppliers, distribution centers, communication links, cloud data centers, a large number of retail stores, corporate headquarters and bank payments.

- These business partners are linked by satellite, Internet, wired and wireless networks, truck, train, or shipping companies, and electronic banking, cloud providers.
- Sensors, RFID tags, and GPS devices could be placed everywhere along the supply chain. The idea is to promote online business, e-commerce, or mobile transactions.
- Supply **chain management consists of five major stages :**
  1. **Planning and Coordination :** A plan or strategy must be developed to address how a good or service can satisfy the needs of customers.
  2. **Material and Equipment Supplies :** This phase involves building a strong relationship with the raw material suppliers and planning methods for shipping, delivery, and payment.
  3. **Manufacturing and Testing :** The product is tested, manufactured, and scheduled for delivery.
  4. **Product Delivery :** Customer orders are taken and delivery of goods is planned.
  5. **After-Sale Service and Returns :** Customers may return defective products and the company addresses customers' demands. Supply chain software is used by many companies for efficient supply chain management.

5.4.5 Smart Power Grid

- Smart grids are an advancement of the electricity grids that are being used currently. A smart grid is an electrical grid that uses modern technology (digital or analog) to collect and communicate electricity related information of both the suppliers and consumers.
- It not only enhances efficiency and reliability, but also improves the production and distribution of electricity to the consumers. The process of installing a smart grid necessarily means technical re-designing of the infrastructure at different levels. One such measure means replacing the existing electronic meters (or electromechanical meters) with smart meters, to enhance the sustainability and efficiency of the entire electrical system.
- Fig. 5.4.3 shows smart grid.
- It uses information technologies to improve how electricity travels from power plants to consumers and allows consumers to interact with the grid. It integrates new and improved technologies into the operation of the grid.
- The smart grid will require wide, seamless, often real-time use of applications and tools that enable grid operators and managers to make decisions quickly.

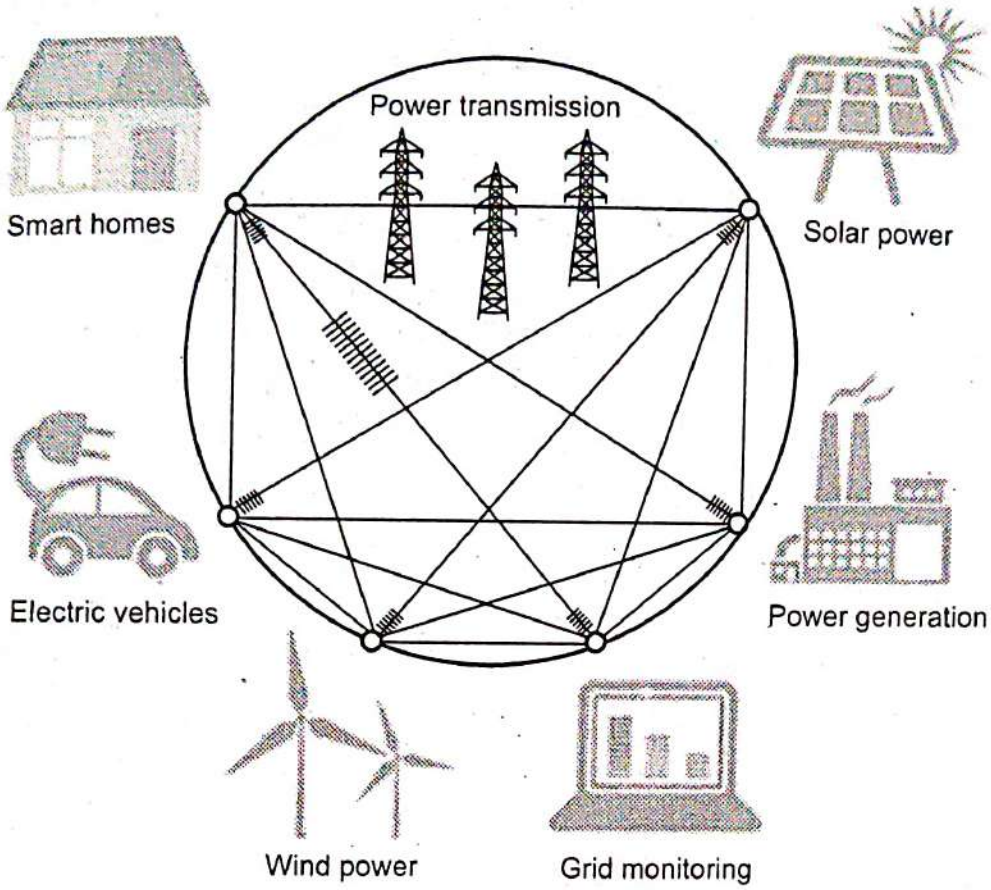


Fig. 5.4.3 Smart grid

- Decision support and improved interfaces will enable more accurate and timely human decision making at all levels of the grid, including the consumer level, while also enabling more advanced operator training.
- Energy storage systems are highly versatile and this is a technology that can meet the needs of various users and be utilized in diverse fields. These include power generators that use renewable energy, grid equipment like energy transmission and distribution equipment, as well as commercial facilities, factories and homes

5.4.6 Smart Buildings

- A smart building can be a shopping mall or a home, a hospital or a high-rise office tower. Smart buildings need monitoring and regulation of heating, air conditioning, lighting, and environmental changes.
- 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.

- 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.
- In automatic light control system, Light Dependent Resistor (LDR) sensor is used to detect bright/medium/dim/dark conditions. Smart-Lighting systems utilize motion and light sensors for performing the control algorithms.
- Smoke or gas detector sensor which detects the smoke and turns on the buzzer alarm and all these are update on the web page.
- MQ2 is a semiconductor type sensor, which can appropriately sense the presence of smoke, LPG, methane, butane, propane and other hydrocarbon.
- To detect any form of intrusion in restricted areas and report it immediately, following concept is used.
  1. A PIR sensor is required to detect the presence of any human being in the room.
  2. An RFID is required to validate the presence of the person in the room by tallying his identity with those in the database.
  3. A camera is required to click the picture of the room and send it via email as an alarm.
  4. An internet connection is required to register all these movements on a website so that it can be accessed from any place and any device.
- The different Input / Output devices are controlled using TCP/IP over the IEEE 802.11 standard protocol. Data being gathered from sensors, such as PIR sensors, temperature sensors, IR transmitter and receiver is being processed on micro - controller as a server.

5.4.7 Cyber - Physical System

- Cyber-Physical Systems (CPS) Definition : "A system comprising a set of interacting physical and digital components, which may be centralised or distributed, that provides a combination of sensing, control, computation and networking functions, to influence outcomes in the real world through physical processes".
- The main drivers for the development and evolution of Cyber Physical Systems (CPS) are the reduction of development costs and time along with the enhancement of the designed products.
- The CPS can interact with the real-world systems by means of Computation, Communication and controls. The interaction of computational and physical units leads to advanced implementations of Internet of Things (IoT). IoT and CPS are

designed to support real time applications which can manage many environmental datasets. In other words, CPS is a combination of digital controls and the physical environment.

- CPS is based on an information processing computer system, which is embedded into a product, like a car, plane or other device. These computer systems are used to perform specific tasks.
- For Example, in a car an embedded system would be the ABS (Anti-lock / Anti-Skid Braking System) to control brake force. This computer system interacts with the physical environment by means of sensors and actuators.
- These embedded systems are no longer standalone, they share their data via communication networks such as the internet with cloud computing where data from many embedded systems can be collected and processed. Thereby creating a system of systems.
- Connected embedded systems can be controlled and decentralized by a computational unit. The collected data can be processed automatically or by Human Machine Interface (HMI).

Relation between IoT and Cyber-Physical Systems :

- Cyber-physical systems integrate sensing, computation, control and networking into physical objects and infrastructure, connecting them to the Internet and to each other.
- Cyber-Physical Systems (CPS) are smart systems that include engineered interacting networks of physical and computational components.
- IoT refers to any systems of interconnected people, physical objects, and IT platforms, as well as any technology to better build, operate, and manage the physical world via pervasive data collection, smart networking, predictive analytics, and deep optimization.
- CPS includes software, hardware, sensors, actuators, and embedded systems, and is connected to human-machine interfaces and multiple systems.
- A number of sensors, actuators, and control devices are connected by a network to form a complex system for acquiring, processing, calculating, and analysing physical environment information and applying the results to the physical environment.
- The CPS is a technology closely related to the IoT, and a next-generation network-based distributed control system that combines a physical system with sensors and actuators and a computing element that controls it.
- The CPS is divided into three layers : The perceptual layer, the data transmission layer, and the application layer.

- The first layer or perception layer, includes the recognition and the sensor, and consists of the Global Positioning System (GPS), RFID, sensor, actuator, camera, and IoT.
- The collected data can be composed of sound, light, mechanical, chemical, thermal, electrical, biology and location data, and the sensor can generate real-time data through node collaboration in wide-area and local network domains.
- Thus, the perception layer recognizes and collects data, sends it to the communication layer, and collaborates between the IoT nodes in the network.
- The communication layer is responsible for exchanging and processing data between the sensor and the application in communication. This layer communicates using various technologies such as wire network devices and wireless. This is one of the key elements of the CPS, which typically has a wide range from local to global.
- The communication layer is also responsible for reliability and supports real-time transmission.
- The application layer can be applied and interacted with various fields, and is sometimes referred to by a different name depending on the application one is using.
- For example, a typical CPS is the Supervisory Control and Data Acquisition (SCADA) system used in critical infrastructures such as the Smart Grid and the Industrial Control System (ICS).
- This layer processes the information received from the data transport layer and includes the commands to be executed by the physical sensors and actuators, and it controls the commands to be used in each field.
- In addition, data aggregation of different resources, intelligent processing of large amounts of data, object control and management are performed.

Review Questions

1. *Draw and explain the architecture of the internet of things.* **SPPU : May-18 End Sem, Marks 8**
2. *What is RFID ? How does RFID work ?* **SPPU : May-18 End Sem, Marks 8**
3. *Availability is one of the most important security measure in IoT and cloud computing. Explain in detail.* **SPPU : Dec.-18 End Sem, Marks 8**
4. *Smart buildings is one of the major application of IoT and cloud computing. Elaborate with suitable diagram and examples.* **SPPU : Dec.-18 End Sem, Marks 8**

5. *Explain significance of RFID in IoT with suitable system architecture features and advantages in detail.* **SPPU : Dec.-18 End Sem, Marks 8**
6. *ZigBEE Technology is one of the enabling technologies for IoT. Explain in detail with suitable diagram.* **SPPU : Dec.-18 End Sem, Marks 6**
7. *Write short notes on :*
   i) WSN : A driving force of IoT and cloud computing
   ii) Significance of GPS in IoT. **SPPU : Dec.-18 End Sem, Marks 8**
8. *Draw and explain architecture of IoT.* **SPPU : Dec.-19 End Sem, Marks 8**
9. *Draw and explain working of GPS.* **SPPU : Dec.-19 End Sem, Marks 8**

5.5 Online Social and Professional Networking

SPPU : May-18, 19

- A social network is a group of collaborating, and/or competing individuals or entities that are related to each other. It may be presented as a graph, or a multi-graph; each participant in the collaboration or competition is called an actor and depicted as a node in the graph theory.
- Valued relations between actors are depicted as links, or ties, either directed or undirected, between the corresponding nodes.
- Actors can be persons, organizations, or groups - any set of related entities. As such, SNA may be used on different levels, ranging from individuals, web pages, families, small groups, to large organizations, parties, and even to nations.
- In general, a social network consists of actors (e.g., persons, organizations) and some form of relation among them. The network structure is usually modeled as a graph, in which vertices represent actors, and edges represent ties, i.e., the existence of a relation between two actors.
- The vocabulary, models and methods of network analysis also expand continuously through applications that require to handle ever more complex data sets.
- An example of this process are the advances in dealing with longitudinal data. New probabilistic models are capable of modelling the evolution of social networks and answering questions regarding the dynamics of communities. Formalizing an increasing set of concepts in terms of networks also contributes to both developing and testing theories in more theoretical branches of sociology.
- The purpose of social network analysis is to identify important actors, crucial links, roles, dense groups, and so on, in order to answer substantive questions about structure .

- Analysis methods available in visone are divided into four main categories according to the level or subject of interest : Vertex, dyad, group and network level
- Available analysis methods include actor-level centrality indices, e.g. closeness, betweenness, and pagerank, cohesive subgroups like cliques, k-cliques, and k-clans, centrality and connectedness
- These levels break further down into measures of the same objective, e.g., connectedness or cohesiveness. Analysis methods are accessible using the analysis tab in the control area.

5.5.1 Benefits of Social Network

1. High return visit rate : Users return to the social network community frequently. This opens up the opportunity for great page impressions and a huge advertising inventory.
2. User loyalty : Users connect to their friends and will not abandon them easily.
3. Virtual growth : Members invite their friends to the social network community. This is effective marketing at a low cost, and the OSN grows by itself.
4. Business model : With a social network community you can earn revenues through subscriptions to premium content in addition to advertising revenues.

5.5.2 Social Network Graph Properties

- Social network can be represented as a graph G = (V, E)

where V = The finite set of vertices

E = Finite set of edges such

- The most network analysis methods work on an abstract, graph based representation of real world networks. It is shown in Fig. 5.5.1.

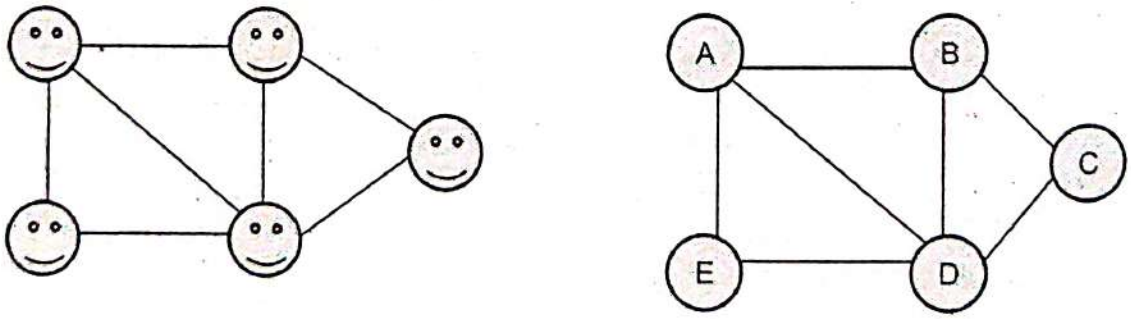


Fig. 5.5.1

	A	B	C	D	E
A	0	1	0	1	1
B	1	0	1	1	0
C	0	1	0	1	0
D	1	1	1	0	1
E	1	0	0	1	0

Fig. 5.5.2 Graph based representation of real world networks

- When representing a network as a graph, all of the connections are pair wise and hence represented by ties known as edges.
- Networks can be described using a mixture of local, global, and intermediate-scale perspectives. Accordingly, one of the key uses of network theory is the identification of summary statistics for large networks in order to develop a framework for analyzing and comparing complex structures
- SNA can produce maps like the one featured below, and provide statistical measures of relationships between actors. In SNA maps, the nodes represent the different actors in the network, and the lines represent the relationships between the various actors.
- The size of the node often represents the relative importance of that actor in the network, and the thickness of the connecting line denotes the strength of the relationship.
- Clustering for a single vertex can be measured by the actual number of the edges between the neighbors of a vertex divided by the possible number of edges between the neighbors.
- When taking the average over all vertices, we get to the measure known as clustering coefficient. The clustering coefficient of a tree is zero, which is easy to see if we consider that there are no triangles of edges (triads) in the graph. In a tree, it would never be the case that our friends are friends with each other.
- The coordination degree measures the ability of the vertices in a graph to interchange information. There are several ways in which we can model this magnitude. One of the easiest is to consider the coordination degree to be exponentially related with the distance between the vertices.
- To define the total co-ordination degree of a vertex "i" in a graph as the sum of all the coordination degrees between that particular vertex and the rest :

$$\Gamma_i = \sum_{j=1}^{N} \gamma_{ij}$$

Where N is the order of the graph.

- Graph density (D) is defined as the total number of observed lines in a graph divided by the total number of possible lines in the same graph. Density ranges from 0 to 1.

$$\text{Density (D)} = \frac{\text{Number of lines (L)}}{(\text{Number of points } (\text{Number of points} - 1))/2}$$

$$= \frac{2L}{g(g-1)}$$

5.5.3 Communities and Applications of Social Networks

- Industry communities : Special industrial workers or professionals are often connected with one another. They share knowledge and work experience.
- Artist communities : These network communities are specifically composed to enable arists, musicians or celebrities to personalize and intensify their contact with their existing fans as well as enabling contact among community members.
- Sport communities : These are network communities for special interests and activities of athletes and sport fans. People can find friends, celebrate their passion and exchange ideas.
- Health communities : These are dedicated to the needs of actors concerned about health issues.
- Congress and event communities : These are customized to support all preparations necessary for congress and events as well as all processes thereafter.
- Alumni communities : After completing their studies, alumni can find fellow students, stay in touch and foster friendships.

5.5.4 Twitter

- Twitter is known as a micro-blogging site. Twitter is a social networking site that relies on micro-blogging for communication.
- Twitter was created by Jack Dorsey who wanted to build a service that would help people be aware of what their friends were up to; a type of user status service.
- Usually blogging consists of people setting up basic websites where they write whatever they want, whether it be politics, sport, cooking, fashion etc.
- Posting a message is known as a tweet. People make connections by following other people's twitter feeds.

- Once you click follow, anything that person or organization says will appear on your timeline. You can tweet a person by putting the @ symbol before their username.
- By typing short, 140 character message users can communicate with their followers and get information spread around.
- The twitter web interface utilizes the Ruby on Rails framework. Twitter message handling is done by software written in the programming language Scala.
- The framework allows for additional web services and applications to interact and combine with Twitter. The search functionality on Twitter makes use of hashtags to search for specific messages.
- A hashtag is basically the # symbol followed by the search term. Users correspond with each other bia SMS, by means of five gateway numbers.
- Some of the Twitter based services and applications are :
  1. TwitME : Twitter client for Palm OS
  2. UberTwitter : Application used to post twitter updates on Blackberry phones and also to find other Uber Twitter users.
  3. Autopilot Tweet : Desktop application for Twitter automation
  4. Auto Tweeter : Desktop application that can be used to send automatic tweets from a user's computer at scheduled intervals.
  5. Blip. FM : Music sharing web site that can be integrated with Twitter accounts.
  6. aMAP.to : Web site service that allows users to create short URL map links for Twitter, email and other posts.

  a) **@name tag :** The first is the @name tag. If you want to address a tweet to someone specific on Twitter, you type @ and then their username. When you hit enter, it will pop up in their feed regardless if they follow you or not.

  b) **RT tag :** This is a retweet. If you see something that you love, you can hit the retweet button, which would insert the "RT" tag and the name of the Twitter user you are retweeting. You can also enter this information manually as well, even though using the retweet button is easier and quicker. You would type "RT @name : whatever the message was".

  c) **Hash tags :** Twitter also supports the use of # hash tags to specify the subject of a tweet. For example, if your tweet relates to an iphone you could use the # iphone has tag. This aids Twitter's search service in finding tweets about a specific subject and also allows users to track all new tweets on a given subject in real time.

d) **Lists :** A list is the same as an account and people can choose to follow the list and the list can follow people. Therefore, if someone wanted to create a conservative political list, they might follow the big conservative names. People who are interested in that line of politics would then follow the list and get updates whenever they post. It condenses the tweets to the list so your feed doesn't become a mess.

- Twitter timelines are a list of tweets or messages displayed in the order in which were sent, with the most recent on top.
- There are different types of twitter timelines. Home timelines are what every Twitter users sees on their home page by default, a list or stream of tweets from all the people they follow, which gets updated in real time.
- Timelines are collections of tweets with relatively low velocity ; streams are samples of public tweets flowing through Twitter in real time.
- Twitter's API provides everything from simple features such as the tweet button which can be placed on any website to the full suite of searches, follow/unfollow and timeline functionality that Twitter client's like Hootsuite and TweetDeck use to access your Twitter account.

Architecture

- Twitter system consists of three components : crawler, indexer, and searcher.
- Each component differs in the functions it performs. They are used together through balanced co-ordination to form a complete system.
- Fig. 5.5.3 shows the Twitter access architecture.

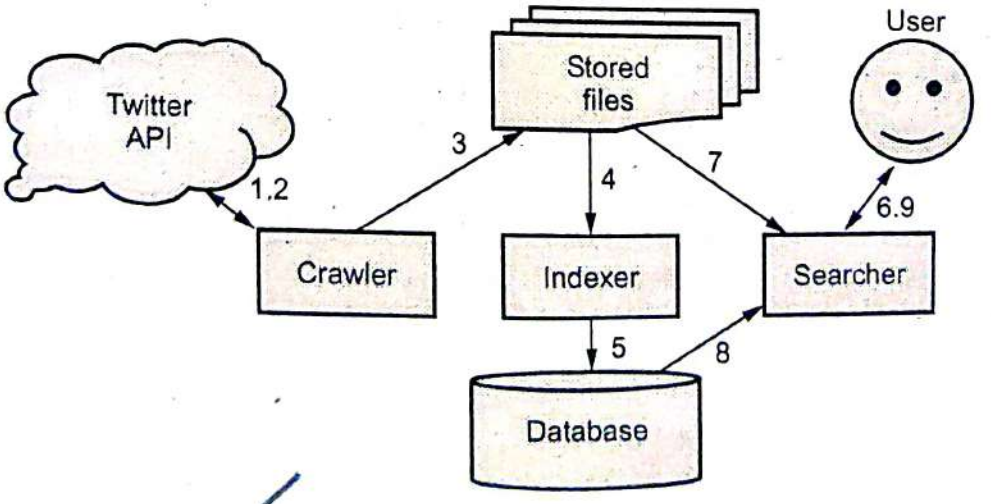


Fig. 5.5.3 Twitter access architecture

1. The crawler sends a request to the Twitter API.
2. The Twitter API responds with the Twitter data.
3. The crawler stores the data into files.

4. The indexer reads the stored files as input.
5. The indexer stores the data in a database as output.
6. Users send a search query to the searcher.
7. The searcher reads the data from the database and calculates a rank.
8. The searcher reads associated raw tweets.

- Twitter calls microblog posts from users tweets. Each tweet has a 140-character limit which is inherited from text messaging.
- Simplicity is provided with an HTTP-based open source API and sharing posts with third-party applications. Twitter's API consists of two different parts : A Search API and a REST API.
- The REST API enables Twitter developers to access core Twitter data. This data includes tweets, timelines and user data. The search API enables developers to query the tweets. It also provides information about trending topics. The usage of both APIs is subject to rate limiting.

5.5.5 Facebook

- Focuses on building and relating social relations among people who share common interests, activities and experiences.
- It allows continuous contact to and from anyone in the world with an Internet connection.
- Users have a "profile" with a picture* and other personal details as they wish, including "limited profile".
- Facebook gives users opportunity to control their own searchability and visibility.
- Privacy Features are provided by many social networks, especially with Facebook, but users rarely use these features.
- Facebook's friendship model is symmetric and requires a mutual agreement between users to gain visibility into one another's interactions and activities.
- Facebook is self-proclaimed as a social graph, it's been steadily transforming into a valuable interest graph as well, because it maintains relationships between people and the things that they're interested in through its Facebook pages and "Likes" feature.
- Facebook's friendship model is symmetric and requires a mutual agreement between users to gain visibility into one another's interactions and activities.
- Facebook's social graph is a massive graph data structure representing social interactions and consisting of nodes and connections between the nodes.

- The Graph API provides the primary means of interacting with the Social Graph, and the best way to get acquainted with the Graph API is to spend a few minutes tinkering around with the Graph API Explorer.
- The Facebook platform is the set of services, tools and products provided by the social networking service Facebook for third-party developers to create their own applications and services that access data in Facebook.
- Facebook is imply a proxy, reading the browser requests, passing them onto your servers, reading your servers' responses and then parsing that information back to the user in HTML format.
- Fig. 5.5.4 shows Facebook architecture.

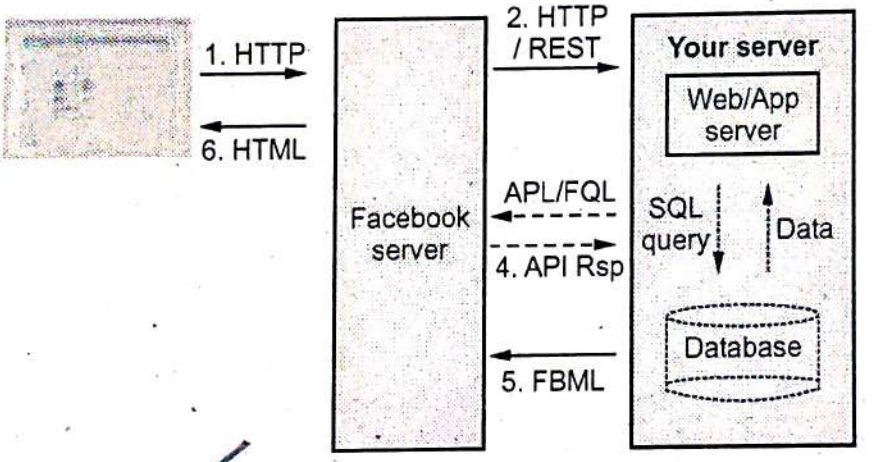


Fig. 5.5.4 Facebook architecture

- Fig. 5.5.5 shows working.

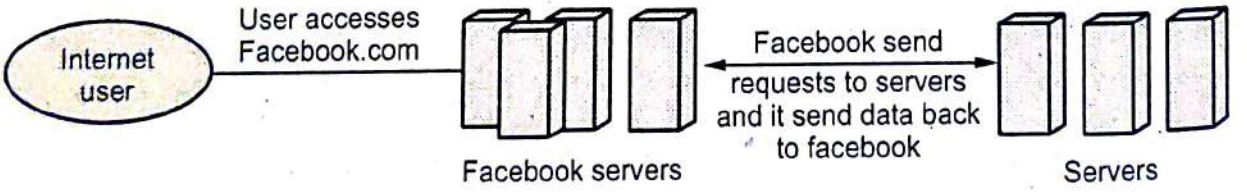


Fig. 5.5.5

- The platform offers a set of programming interfaces and tools which enable developers to integrate with the open "social graph" of personal relations and other things like songs, places and Facebook pages.
- Applications on Facebook.com, external websites and devices are all allowed to access the graph. Platform components are as follows :
  1. **Graph API :** It is the core of Facebook platform, enabling developers to read from and write data into Facebook. The Graph API presents a simple, consistent view of the Facebook social graph, uniformly representing objects in the graph and the connections between them.

2. **Authentication :** Facebook authentication enables developer's applications to interact with the Graph API on behalf of Facebook users and it provides a single-sign on mechanism across web, mobile and desktop apps.
3. **Social pugins :** It include button, recommendations and activity feed-enable developers to provide social experiences to their users with just a few lines of HTML.
4. **Open graph protocol :** The open graph protocol enables developers to integrate their pages into Facebook's global mapping/tracking tool social graph. These pages gain the functionality of other graph objects including profile links and stream updates for connected users.

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Review Questions

1. *Draw and explain architecture of Facebook platform.*

SPPU : May-18, 19 End Sem, Marks 8

2. *Draw and explain Twitter architecture and access protocol sequence.*

SPPU : May-18 End Sem, Marks 8