S.K.D.A.V GOVERNMENT POLYTECHNIC ROURKELA

LECTURE NOTES

ON

MOBILE COMPUTING

DEPARTMENT OF INFORMATION TECHNOLOGY

5TH SEMESTER

PREPARED BY

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Th-5 MOBILE COMPUTING

(Common to CSE/IT)

Theory	**4 Periods per week**	**Internal Assessment**	**20 Marks**
Total Periods	**60**	**End Sem Exam**	**80 Marks**
Examination	**3hours**	**Total Marks**	**100Marks**

Topic wise distribution of periods

Sl. No.	Topics	Periods
1	Introduction to Wireless networks & Mobile Computing	06
2	Introduction to Mobile Development Framework	06
3	Wireless Transmission	06
4	Medium Access Control	06
5	Wireless LANs	06
6	Ubiquitous Wireless Communication	06
7	Mobile IP	06
8	Mobile Computing	06
9	Wireless Telecomm Networks	06
10	Messaging Services	06
	TOTAL	**60**

RATIONALE : Now a days the communication technology has become very fast in development of various application areas. This subject will expose the learner to have an idea how the wireless network works along with the architecture of Mobile computing.

OBJECTIVE: After completion of this course the student will be able to**:**

- To learn Mobile Computing Principles and Architecture
- To understand Mobility Management, GSM, and GPRS networks
- To know Short Message Service (SMS) technology, GPRS, WAP, CDMA, 3G
- Understand Wireless LAN, WiFi, and WLL (Wireless Local Loop) Architecture
- Understand the concept of Mobile IP.
- Learn Bluetooth, RFID, and Satellite Communications.
- To Know Next Generation Networks (NGN)

COURSE CONTENT

1. Introduction to Wireless networks & Mobile Computing

1.1 Networks
1.2 Wireless Networks
1.3 Mobile Computing
1.4 Mobile Computing Characteristics
1.5 Application of Mobile Computing

2. Introduction to Mobile Development Framework

2.1 C/S architecture
2.2 n-tier architecture
2.3 n-tier architecture and www
2.4 Peer-to Peer architecture
2.5 Mobile agent architecture

3. Wireless Transmission

3.1 Introduction
3.2 Signals
3.3 Period, Frequency and Bandwidth.
3.4 Antennas
3.5 Signal Propagation
3.6 Multiplexing
3.7 Modulation
3.8 Spread Spectrum
3.9 Cellular System

4. Medium Access Control

4.1 Introduction
4.2 Hidden/ Exposed Terminals
4.3 The basic Access Method
4.4 Near / Far Terminals
4.5 SDMA, FDMA,TDMA, CDMA

5. Wireless LANs

5.1 Wireless LAN and communication
5.2 Infrared
5.3 Radio Frequency
5.4 IR Advantages and Disadvantages
5.5 RF Advantages and Disadvantages
5.6 Wireless Network Architecture Logical
5.7 Types of WLAN
5.8 IEEE 802.11
5.9 MAC layer
5.10 Security
5.11 Synchronization
5.12 Power Management
5.13 Roaming
5.14 Bluetooth Overview

6. Ubiquitous Wireless Communication

6.1 Introduction
6.2 Scenario of Mobile Communication
6.3 Mobile Communication Generations 1G to 3G
6.4 3rd Generation Mobile Communication Network
6.5 Universal Mobile telecommunication System (UMTS)

7. Mobile IP

7.1 Overview
7.2 Working with mobile IP
7.3 Mobile IP Entities
7.4 Mobility Agents
7.5 Components of Mobile IP
7.6 Mobile IPv6 Features
7.7 Mobile IPv6 Address Types
7.8 Mobile IPv6 Address Scope

7.9 Mobile IP Operation

8. Mobile Computing

8.1 WWW architecture for Mobile computing
8.2 Need of WAP
8.3 Benefits of WAP
8.4 Examples of WAP
8.5 WAP- Architecture

8.6 WAP protocols
8.7 WML
8.8 WAP Push architecture
8.9 Push-Pull based data acquisition
8.10 I-mode
8.11 WAP 2.x

9. Wireless Telecomm Networks

9.1 GSM
9.2 GPRS
9.3 IS-95
9.4 CDMA-2000
9.5 W-CDMA
9.6 Wireless Sensor Networks

10. Messaging Services

10.1 Short Message Services (SMS)
10.2 Multimedia Message Services (MMS)
10.3 Multimedia transmission over wireless

Reference Books

Sl.No	Name of Authors	Title of the Book	Name of the publisher
01	Dr. N.NJani, Kamaljit I. Lakhtaria, Dr. Ashish N. Jani & Nita Kanabar	Mobile Computing	S.Chand & Company Ltd

UNIT-1
INTRODUCTION TO WIRELESS NETWORKS & MOBILE COMPUTING

1.1 Networks

- A **network** is a collection of computers, servers, networking devices, peripherals, or other devices connected and allow to share data, information, application s/w, audio or video,equipment/devices etc
- An example of a network is the Internet, which connects millions of people all over the world.
- Networks are used to share information through some communication media i.e. wired or wireless media.
- Wired media/medium-coaxial cable, twisted pair cable, fibre optics cable
- Wireless media/medium-infrared, radio waves, satellite communication, Bluetooth signal etc.
- The communication can be possible using networking devices such as:

  Bridges

  Repeaters

  Network Interface cards

  Switches

  Hubs

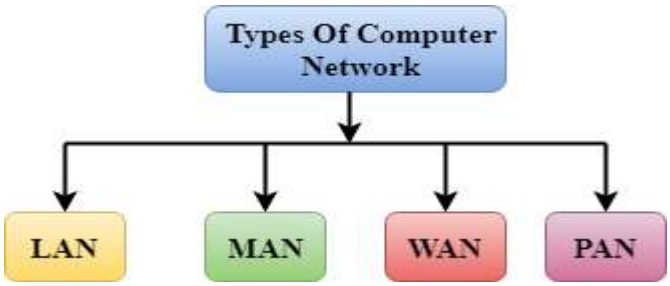
  Modems

  Routers

Computer Network Types

A computer network is a group of computers linked to each other that enables the computer to communicate with another computer and share their resources, data, and applications.

A computer network can be categorized by their size. A **computer network** is mainly of **four types**:



- LAN(Local Area Network)
- PAN(Personal Area Network)
- MAN(Metropolitan Area Network)
- WAN(Wide Area Network)

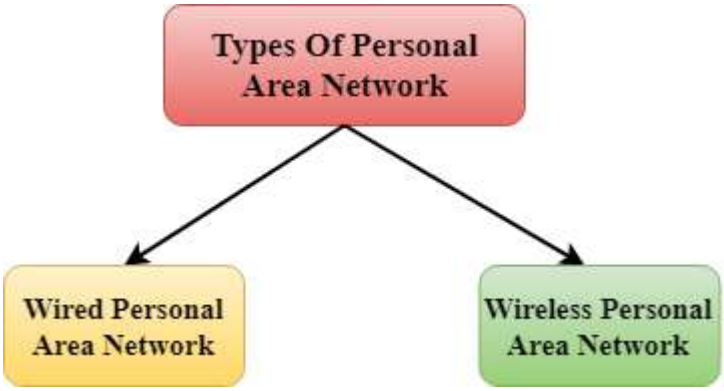
LAN(Local Area Network)

- Local Area Network is a group of computers connected to each other in a small area such as building, office.
- LAN is used for connecting two or more personal computers through a communication medium such as twisted pair, coaxial cable, etc.
- It is less costly as it is built with inexpensive hardware such as hubs, network adapters, and ethernet cables.
- The data is transferred at an extremely faster rate in Local Area Network.
- Local Area Network provides higher security.

PAN(Personal Area Network)

- Personal Area Network is a network arranged within an individual person, typically within a range of 10 meters.
- Personal Area Network is used for connecting the computer devices of personal use is known as Personal Area Network.
- **Thomas Zimmerman** was the first research scientist to bring the idea of the Personal Area Network.
- Personal Area Network covers an area of **30 feet**.
- Personal computer devices that are used to develop the personal area network are the laptop, mobile phones, media player and play stations.

There are two types of Personal Area Network:



- Wired Personal Area Network
- Wireless Personal Area Network

Wireless Personal Area Network: Wireless Personal Area Network is developed by simply using wireless technologies such as WiFi, Bluetooth. It is a low range network.

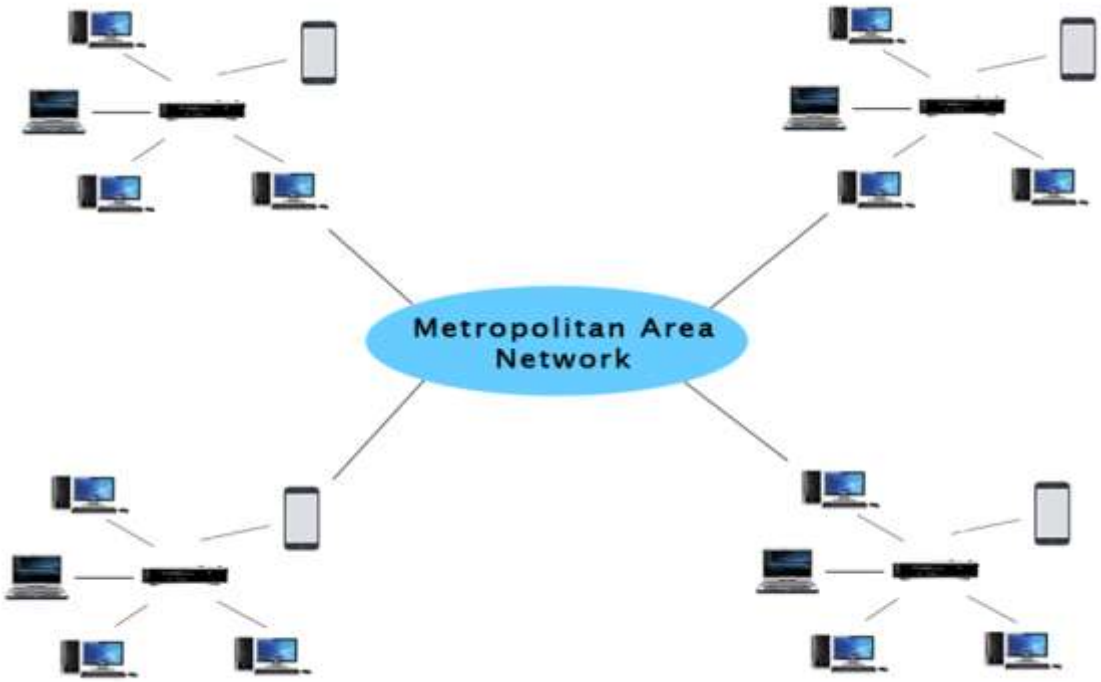
Wired Personal Area Network: Wired Personal Area Network is created by using the USB.

Examples Of Personal Area Network:

- **Body Area Network:** Body Area Network is a network that moves with a person. **For example**, a mobile network moves with a person. Suppose a person establishes a network connection and then creates a connection with another device to share the information.
- **Offline Network:** An offline network can be created inside the home, so it is also known as a **home network**. A home network is designed to integrate the devices such as printers, computer, television but they are not connected to the internet.
- **Small Home Office:** It is used to connect a variety of devices to the internet and to a corporate network using a VPN

MAN(Metropolitan Area Network)

- A metropolitan area network is a network that covers a larger geographic area by interconnecting a different LAN to form a larger network.
- Government agencies use MAN to connect to the citizens and private industries.
- In MAN, various LANs are connected to each other through a telephone exchange line.
- The most widely used protocols in MAN are RS-232, Frame Relay, ATM, ISDN, OC-3, ADSL, etc.
- It has a higher range than Local Area Network(LAN).

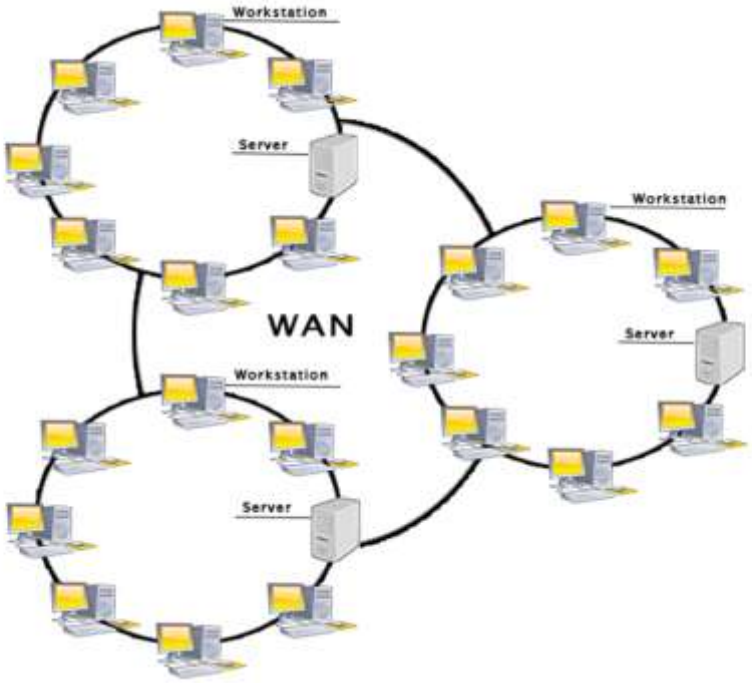


Uses Of Metropolitan Area Network:

- MAN is used in communication between the banks in a city.
- It can be used in an Airline Reservation.
- It can be used in a college within a city.
- It can also be used for communication in the military.

WAN(Wide Area Network)

- A Wide Area Network is a network that extends over a large geographical area such as states or countries.
- A Wide Area Network is quite bigger network than the LAN.
- A Wide Area Network is not limited to a single location, but it spans over a large geographical area through a telephone line, fibre optic cable or satellite links.
- The internet is one of the biggest WAN in the world.
- A Wide Area Network is widely used in the field of Business, government, and education.



Examples Of Wide Area Network:

- **Mobile Broadband:** A 4G network is widely used across a region or country.
- **Last mile:** A telecom company is used to provide the internet services to the customers in hundreds of cities by connecting their home with fiber.
- **Private network:** A bank provides a private network that connects the 44 offices. This network is made by using the telephone leased line provided by the telecom company.

Advantages Of Wide Area Network:

Following are the advantages of the Wide Area Network:

- **Geographical area:** A Wide Area Network provides a large geographical area. Suppose if the branch of our office is in a different city then we can connect with them through WAN. The internet provides a leased line through which we can connect with another branch.
- **Centralized data:** In case of WAN network, data is centralized. Therefore, we do not need to buy the emails, files or back up servers.
- **Get updated files:** Software companies work on the live server. Therefore, the programmers get the updated files within seconds.
- **Exchange messages:** In a WAN network, messages are transmitted fast. The web application like Facebook, Whatsapp, Skype allows you to communicate with friends.
- **Sharing of software and resources:** In WAN network, we can share the software and other resources like a hard drive, RAM.
- **Global business:** We can do the business over the internet globally.
- **High bandwidth:** If we use the leased lines for our company then this gives the high bandwidth. The high bandwidth increases the data transfer rate which in turn increases the productivity of our company.

Disadvantages of Wide Area Network:

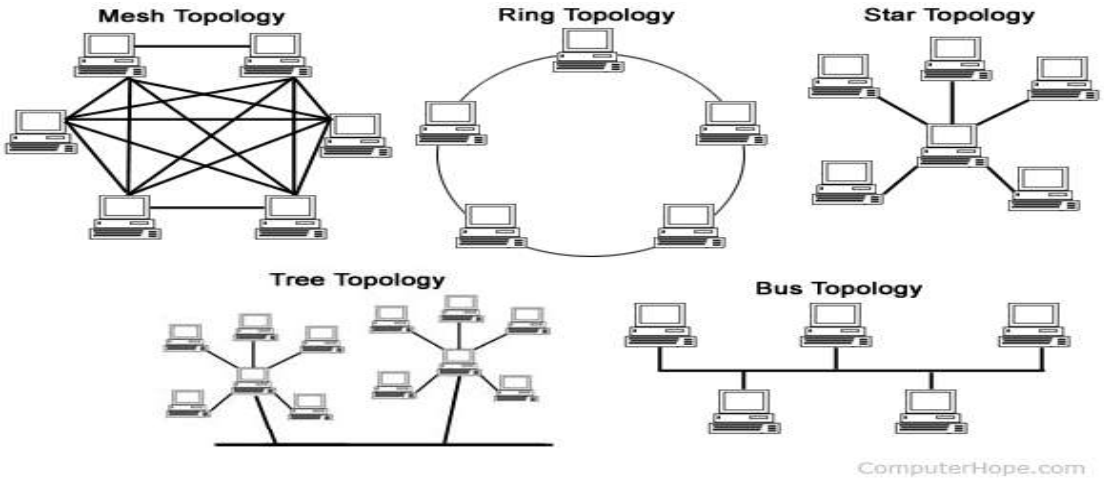
The following are the disadvantages of the Wide Area Network:

- **Security issue:** A WAN network has more security issues as compared to LAN and MAN network as all the technologies are combined together that creates the security problem.
- **Needs Firewall & antivirus software:** The data is transferred on the internet which can be changed or hacked by the hackers, so the firewall needs to be used. Some people can inject the virus in our system so antivirus is needed to protect from such a virus.
- **High Setup cost:** An installation cost of the WAN network is high as it involves the purchasing of routers, switches.
- **Troubleshooting problems:** It covers a large area so fixing the problem is difficult.

Network topologies

The term network topology describes the relationship of connected devices in terms of a geometric graph. Devices are represented as vertices, and their connections are represented as edges on the graph. It describes how many connections each device has, in what order, and what sort of hierarchy.

Typical network configurations include bus topology, mesh topology, ring topology, star topology, tree topology, and hybrid topology.



Most home networks are configured in a tree topology that connects to the Internet. Corporate networks often use tree topologies, but they also often incorporate star topologies and an Intranet.

WIRELESS NETWORK

Wireless Networks begins with an introduction to the different types of wireless networks, including Wi-Fi, ZigBee, cellular mobile, ad hoc, cognitive radio, wireless mesh, and wireless sensor. Subsequent chapters address more advanced topics such as:

- Mobility, bandwidth, and node location management issues in mobile networks
- Message communication techniques and protocols in ad hoc networks
- Recent research and future direction of wireless local area networks (WLANs)
- Deployment of sensor nodes in wireless sensor networks (WSNs)
- Energy-efficient communication in wireless networks
- Security aspects of wireless communication

Introduction to Mobile Computing

The rapidly expanding technology of cellular communication, wireless LANs, and satellite services will make information accessible anywhere and at any time. Regardless of size, most mobile computers will be equipped with a wireless connection to the fixed part of the network, and, perhaps, to other mobile computers. The resulting computing environment, which is often referred to as mobile or nomadic computing, no longer requires users to maintain a fixed and universally known position in the network and enables almost unrestricted mobility. Mobility and portability will create an entire new class of applications and, possibly, new massive markets combining personal computing and consumer electronics.

Mobile Computing is an umbrella term used to describe technologies that enable people to access network services anyplace, anytime, and anywhere.

Mobile computing systems are computing systems that may be easily moved physically and whose computing capabilities may be used while they are being moved. Examples are laptops, personal digital assistants (PDAs), and mobile phones. By distinguishing mobile computing systems from other computing systems we can identify the distinctions in the tasks that they are designed to perform, the way that they are designed, and the way in which they are operated. There are many things that a mobile computing system can do that a stationary computing system cannot do; these added functionalities are the reason for separately characterizing mobile computing systems.

It is very necessary that the reader understands these dimensions of mobile computing and keeps them in mind throughout the process of design and implementation of the mobile application.

The dimensions of mobility are as follows :

(a) Location Awareness : The definition of the mobile says the first dimension of mobile computing is the location. As the mobile devices do not work in a particular location the location of the mobile devices may changes in every moment of time so the primary design issue is the location management in the development of mobile devices.

(b) Network Connectivity Quality of Service (QOS) : The company focuses that our device is easily compatible for any type of network(wired or wireless). Mobility means loss of network connectivity. The QOS is defined as "The collective effort of service performances, which determine the degree of satisfaction of a user of this service". The services can have qualitative and quantitative.

(c) Limited Device Capabilities (Particularly Storage and CPU): The important issue is the storage related issues. The company's concern should be regarding the storage capacity of our device to improve the storage capacity of a mobile. Now a day’s mechanics are imposing more processing power and storage capacity into smaller chip.

(d) Limited Power Supply: The mobile devices are totally based on battery power which provides less power supply.

(e) Platform Proliferation: We need to design such type of device which would support any platform and any network.

CHARACTERISTICS OF MOBILE COMPUTING ENVIRONMENT

1. User mobility: user accesses the service while on move. – User should be able to move from one physical location on to another location and use the same service. – The service could be in the home network or a remote network. – Example: a user travels for business and uses corporate services and applications as if the user were in the office.

2. Network mobility :

- User moves from one network to another accessing the service seamlessly.
- Network itself is mobile as in MANET (Mobile AD-hoc Networks).

– User should be able to move from one network to another network and use the same service. – Example: a user travels from Hong Kong to New Delhi and uses the same GSM phone to access the corporate application through WAP (Wireless Application Protocol). In the home network, the user uses this service over GPRS (General Packet Radio Service), whereas in Delhi he accesses it over the GSM network.

3. Bearer Mobility: User uses the same service while switching the bearer.

– User should be able to move from one bearer to another and use the same service. – Example: a user was using a service through a WAP bearer in his home network in Bangalore. He travels to Coimbatore, where WAP is not supported, so he switches over to a voice or SMS (Short Message Service) bearer to access the same applica?on.

4. Device Mobility: User use the same service while switching from one device to other.

User should be able to move from one device to another and use the same service. – Example: sales representa?ves use soTware and services on their desktops in the office and con?nue to use these servers/SW seamlessly while on the road.

5. Session Mobility: User session should able to move from one user- agent environment to other.

– A user session should be able to move from one useragent environment to another. – Example: a user was using a service through a CDMA (Code Division Mul?ple Access) network. The user drives through a tunnel and gets disconnected from the network. The user then returns to the office and uses the desktop computer, con?nuing the unfinished session from where it was when the user got disconnected.

6. Service Mobility: – User should be able to move from one service to another. – Example: a user writes an Email and to complete the Email, the user needs to refer to some other informa?on. On a desktop PC, the user simply opens another service (e.g., browser) and moves between services using the task bar. The user should similarly be able to switch among services on resource-constrained wireless devices.

7. Host Mobility: User device can be server or host.

8. Agent Mobility : User –agent (browser, crawlers)or the application move from node to other.

A communication device can exhibit any one of the following characteristics: ¬

Fixed and wired: This configuration describes the typical desktop computer in an office. Neither weight nor power consumption of the devices allow for mobile usage. The devices use fixed networks for performance reasons.

Mobile and wired: mobile of today's laptops fall into this ĐategoɗLJ; useɖs carry the laptop from one hotel to the next , reconnecting to the ĐoŵpaŶĽJs network via the telephone network and a modem.

Fixed and wireless: This mode is used for installing networks, e.g., in historical buildings to avoid damage by installing wires, or at trade shows to ensure fast network setup.

Mobile and wireless: This is the most interesting case. No cable restricts the user, who can roam between different wireless networks.

APPLICATIONS OF MOBILE COMPUTING

In many fields of work, the ability to keep on the move is vital in order to utilise time efficiently. The importance of Mobile Computers has been highlighted in many fields of which a few are described below:

Vehicles: Music, news, road conditions, weather reports, and other broadcast information are received via digital audio broadcasting (DAB) with 1.5 Mbit/s. For personal communication, a universal mobile telecommunications system (UMTS) phone might be available offering voice and data connectivity with 384 kbit/s. The current position of the car is determined via the global positioning system (GPS). Cars driving in the same area 6 build a local ad-hoc network for the fast exchange of information in emergency situations or to help each other keep a safe distance. In case of an accident, not only will the airbag

be triggered, but the police and ambulance service will be informed via an emergency call to a service provider. Buses, trucks, and trains are already transmitting maintenance and logistic information to their home base, which helps to improve organization (fleet management), and saves time and money

Emergencies: An ambulance with a high-quality wireless connection to a hospital can carry vital information about injured persons to the hospital from the scene of the accident. All the necessary steps for this particular type of accident can be prepared and specialists can be consulted for an early diagnosis. Wireless networks are the only means of communication in the case of natural disasters such as hurricanes or earthquakes. In the worst cases, only decentralized, wireless ad-hoc networks survive.

Business: Managers can use mobile computers say, critical presentations to major customers. They can access the latest market share information. At a small recess, they can revise the presentation to take advantage of this information. They can communicate with the office about possible new offers and call meetings for discussing responds to the new proposals. Therefore, mobile computers can leverage competitive advantages. A travelling salesman today needs instant access to the company‘s database: to ensure that files on his or her laptop reflect the current situation, to enable the company to keep track of all activities of their travelling employees, to keep databases consistent etc. With wireless access, the laptop can be turned into a true mobile office, but efficient and powerful synchronization mechanisms are needed to ensure data consistency.

Credit Card Verification: At Point of Sale (POS) terminals in shops and supermarkets, when customers use credit cards for transactions, the intercommunication required between the bank central computer and the POS terminal, in order to effect verification of the card usage, can take place quickly and securely over cellular channels using a mobile computer unit. This can speed up the transaction process and relieve congestion at the POS terminals.

Replacement of Wired Networks: wireless networks can also be used to replace wired networks, e.g., remote sensors, for tradeshows, or in historic buildings. Due to economic reasons, it is often impossible to wire remote sensors for weather forecasts, earthquake detection, or to provide environmental information. Wireless connections, e.g., via satellite, can help in this situation. Other examples for wireless networks are computers, sensors, or information displays in historical buildings, where excess cabling may destroy valuable walls or floors.

Infotainment: wireless networks can provide up-to-date information at any appropriate location. The travel guide might tell you something about the history of a building (knowing via GPS, contact to a local base station, or triangulation where you are) downloading information about a concert in the building at the same evening via a local wireless network. Another growing field of wireless network applications lies in entertainment and games to enable, e.g., ad-hoc gaming networks as soon as people.

LIMITATIONS OF MOBILE COMPUTING 8. Resource constraints: Battery. 9. Interference: Radio transmission cannot be protected against interference using shielding and result in higher loss rates for transmitted data or higher bit error rates respectively. 10. Bandwidth: Although they are continuously increasing, transmission rates are still very low for wireless devices compared to desktop systems. Researchers look for more efficient communication protocols with low overhead. 11. Dynamic changes in communication environment: variations in signal power within a region, thus link delays and connection losses. 12. Network Issues: discovery of the connection-service to destination and connection stability. 13. Interoperability issues: the varying protocol standards. 14. Security constraints: Not only can portable devices be stolen more easily, but the radio interface is also prone to the dangers of eavesdropping. Wireless access must always include encryption, authentication, and other security mechanisms that must be efficient and simple to use.

UNIT-2.
INTRODUCTION TO MOBILE DEVELOPMENT FRAMEWORK

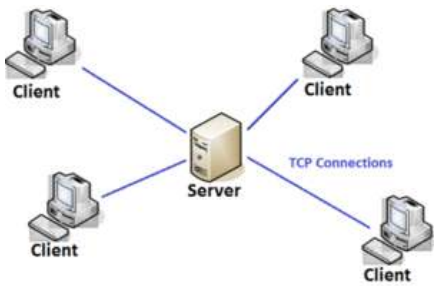
C/S ARCHITECTURE

- **Client** Server Architecture is a computing model in which the server hosts, delivers and manages most of the resources and services to be consumed by the client. This type of architecture has one or more client computers connected to a central server over a network or internet connection. This system shares computing resources. **Client/server architecture** is also known as a networking computing model or client/server network because all the requests and services are delivered over a network.
- The Client-server model is a distributed application structure that partitions task or workload between the providers of a resource or service, called servers, and service requesters called clients. In the client-server architecture, when the client computer sends a request for data to the server through the internet, the server accepts the requested process and delivers the data packets requested back to the client. Clients do not share any of their resources. Examples of Client-Server Model are Email, World Wide Web, etc.
- Client computers provide an interface to allow a computer user to request services of the server and to display the results the server returns. Servers wait for requests to arrive from clients and then respond to them.
- Ideally, a server provides a standardized transparent interface to clients so that clients need not be aware of the specifics of the system (i.e., the hardware and software) that is providing the service.
- Clients are often situated at workstations or on personal computers, while servers are located elsewhere on the network, usually on more powerful machines.
- This computing model is especially effective when clients and the server each have distinct tasks that they routinely perform.
- In hospital data processing, for example, a client computer can be running an application program for entering patient information while the server computer is running another program that manages the database in which the information is permanently stored.
- Many clients can access the server's information simultaneously, and, at the same time, a client computer can perform other tasks, such as sending e-mail. both client and server computers are considered intelligent devices.

HOW THE CLIENT-SERVER MODEL WORKS ?

- **Client:** When we talk the word **Client**, it mean to talk of a person or an organization using a particular service. Similarly in the digital world a **Client** is a computer (**Host**) i.e. capable of receiving information or using a particular service from the service providers (**Servers**).
- **Servers:** Similarly, when we talk the word **Servers**, It mean a person or medium that serves something. Similarly in this digital world a **Server** is a remote computer which provides information (data) or access to particular services.

So, its basically the **Client** requesting something and the **Server** serving it as long as its present in the database.



HOW THE BROWSER INTERACTS WITH THE SERVERS?
There are few steps to follow to interact with the servers a client.

- User enters the **URL**(Uniform Resource Locator) of the website or file. The Browser then requests the **DNS**(DOMAIN NAME SYSTEM) Server.
- **DNS Server** lookup for the address of the **WEB Server**.
- **DNS Server** responds with the **IP address** of the **WEB Server**.
- Browser sends over an **HTTP/HTTPS** request to **WEB Server's IP** (provided by **DNS server**).
- Server sends over the necessary files of the website.
- Browser then renders the files and the website is displayed. This rendering is done with the help of **DOM** (Document Object Model) interpreter, **CSS** interpreter and **JS Engine** collectively known as the **JIT** or (Just in Time) Compilers.

CHARACTERISTICS OF A CLIENT-SERVER ARCHITECTURE

- Client and server machines need different amount of hardware and software resources.
- Client and server machines may belong to different vendors.
- Horizontal scalability (increase of the client machines) and vertical scalability (migration to a more powerful server or to a multiserver solution)
- A client or server application interacts directly with a transport layer protocol to establish communication and to send or receive information.
- The transport protocol then uses lower layer protocols to send or receive individual messages. Thus, a computer needs a complete stack of protocols to run either a client or a server.
- A single server-class computer can offer multiple services at the same time; a separate server program is needed for each service.

Difference between Client Server Computing and Peer to Peer Computing

The major differences between client server computing and peer to peer computing are as follows:

- In client server computing, a server is a central node that services many client nodes. On the other hand, in a peer to peer system, the nodes collectively use their resources and communicate with each other.
- In client server computing the server is the one that communicates with the other nodes. In peer to peer to computing, all the nodes are equal and share data with each other directly.
- Client Server computing is believed to be a subcategory of the peer to peer computing.

Advantages of Client Server Computing

The different advantages of client server computing are −

- All the required data is concentrated in a single place i.e. the server. So it is easy to protect the data and provide authorisation and authentication.
- The server need not be located physically close to the clients. Yet the data can be accessed efficiently.
- It is easy to replace, upgrade or relocate the nodes in the client server model because all the nodes are independent and request data only from the server.
- All the nodes i.e. clients and server may not be build on similar platforms yet they can easily facilitate the transfer of data.

Disadvantages of Client Server Computing

The different disadvantages of client server computing are −

- If all the clients simultaneously request data from the server, it may get overloaded. This may lead to congestion in the network.

- If the server fails for any reason, then none of the requests of the clients can be fulfilled. This leads of failure of the client server network.
- The cost of setting and maintaining a client server model are quite high.

https://cio-wiki.org/wiki/Client_Server_Architecture

https://www.geeksforgeeks.org/client-server-model/

WHAT IS N-TIER?

An **N-Tier Application** program is one that is distributed among three or more separate computers in a distributed network.

N-tier architecture is also called multi-tier architecture because the software is engineered to have the processing, data management, and presentation functions physically and logically separated.

The most common form of n-tier is the 3-tier Application, and it is classified into three categories.

- User interface programming in the user's computer
- Business logic in a more centralized computer, and
- Required data in a computer that manages a database.

This architecture model provides Software Developers to create Reusable application/systems with maximum flexibility.

In **N-tier, "N"** refers to a number of tiers or layers are being used like – **2-tier, 3-tier or 4-tier, etc**. It is also called "**Multi-Tier Architecture"**.

The n-tier architecture is an industry-proven software architecture model. It is suitable to support enterprise level client-server applications by providing solutions to scalability, security, fault tolerance, reusability, and maintainability. It helps developers to create flexible and reusable applications.

What are the Benefits of N-Tier Architecture?

There are several benefits to using n-tier architecture for your software. These are scalability, ease of management, flexibility, and security.

- **Secure:** You can secure each of the three tiers separately using different methods.
- **Easy to manage:** You can manage each tier separately, adding or modifying each tier without affecting the other tiers.
- **Scalable:** If you need to add more resources, you can do it per tier, without affecting the other tiers.
- **Flexible:** Apart from isolated scalability, you can also expand each tier in any manner that your requirements dictate.

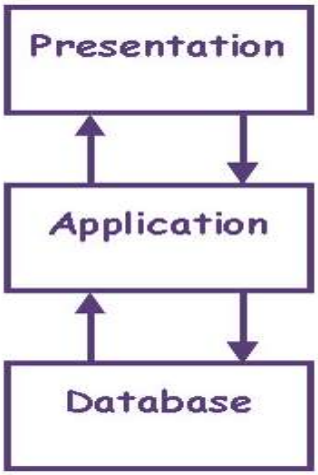
Other benefits include:

- **More efficient development.** N-tier architecture is very friendly for development, as different teams may work on each tier. This way, you can be sure the design and presentation professionals work on the presentation tier and the database experts work on the data tier.
- **Easy to add new features.** If you want to introduce a new feature, you can add it to the appropriate tier without affecting the other tiers.
- **Easy to reuse.** Because the application is divided into independent tiers, you can easily reuse each tier for other software projects. For instance, if you want to use the same program, but for a

different data set, you can just replicate the logic and presentation tiers and then create a new data tier.

N-Tier Architecture

A diagrammatic representation of an n-tier system depicts here – presentation, application, and database layers.



N Tier Architecture Diagram

These three layers can be further subdivided into different sub-layers depending on the requirements.

Some of the popular sites who have applied this architecture are

- MakeMyTrip.com
- Sales Force enterprise application
- Indian Railways – IRCTC
- Amazon.com, etc.

Some common terms to remember, so as to understand the concept more clearly:

- **Distributed Network:** It is a network architecture, where the components located at network computers coordinate and communicate their actions only by passing messages. It is a collection of multiple systems situated at different nodes but appears to the user as a single system.
- It provides a single data communication network which can be managed separately by different networks.
- An example of Distributed Network– where different clients are connected within LAN architecture on one side and on the other side they are connected to high-speed switches along with a rack of servers containing service nodes.
- **Client-Server Architecture:** It is an architecture model where the client (one program) requests a service from a server (another program) **i.e.** It is a request-response service provided over the internet or through an intranet.

  In this model, **Client** will serve as one set of program/code which executes a set of actions over the network. While **Server**, on the other hand, is a set of another program, which sends the result sets to the client system as requested.

- In this, client computer provides an interface to an end user to request a service or a resource from a server and on the other hand server then processes the request and displays the result to the end user.
- An example of Client-Server Model– an ATM machine. A bank is the server for processing the application within the large customer databases and ATM machine is the client having a user interface with some simple application processing.

- **Platform:** In computer science or software industry, a platform is a system on which applications program can run. It consists of a combination of hardware and software that have a built-in instruction for a processors/microprocessors to perform specific operations.
- In more simple words, the platform is a system or a base where any applications can run and execute to obtain a specific task.
- An example of Platform – A personal machine loaded with Windows 2000 or Mac OS X as examples of 2 different platforms.

- **Database:** It is a collection of information in an organized way so that it can be easily accessed, managed and updated.
- Examples of Database – MySQL, SQL Server, and Oracle Database are some common Db's.

Types of N-Tier Architectures

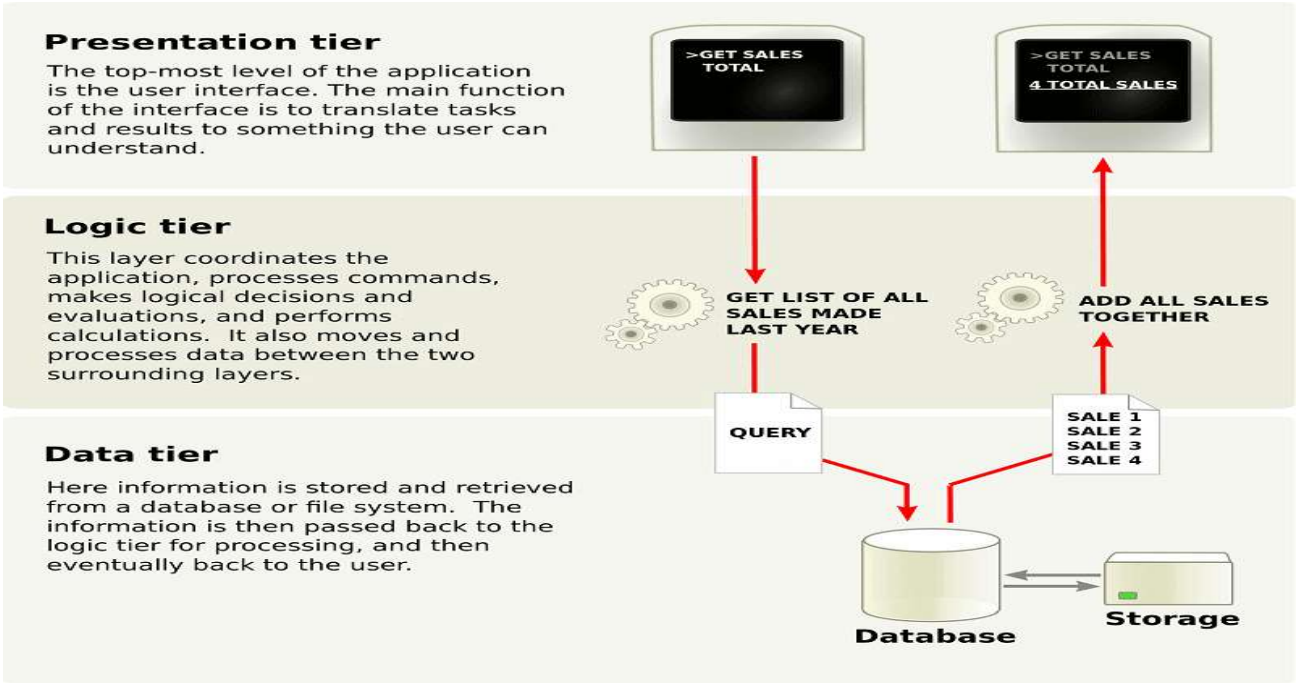
There are different types of N-Tier Architectures, like **3-tier Architecture, 2-Tier Architecture and 1- Tier Architecture.**

First, we will see 3-tier Architecture, which is very important.

3-Tier Architecture

By looking at the below diagram, you can easily identify that **3-tier architecture** has three different layers.

- Presentation layer
- Business Logic layer
- Database layer



3 Tier Architecture Diagram

Here we have taken a simple example of student form to understand all these three layers. It has information about a student like – Name, Address, Email, and Picture.

User Interface Layer or Presentation Layer

Business Access Layer –

This is the function of the business layer which accepts the data from the application layer and passes it to the data layer.

- Business logic acts as an interface between Client layer and Data Access Layer
- All business logic – like validation of data, calculations, data insertion/modification are written under business logic layer.
- It makes communication faster and easier between the client and data layer
- Defines a proper workflow activity that is necessary to complete a task.

Data Access Layer

This is the data layer function, which receives the data from the business layer and performs the necessary operation into the database.

2-Tier Architecture:

It is like Client-Server architecture, where communication takes place between client and server.

In this type of software architecture, the presentation layer or user interface layer runs on the client side while dataset layer gets executed and stored on server side.

There is no Business logic layer or immediate layer in between client and server.

Single Tier or 1-Tier Architecture:

It is the simplest one as it is equivalent to running the application on the personal computer. All of the required components for an application to run are on a single application or server.

Presentation layer, Business logic layer, and data layer are all located on a single machine.

Advantages and Disadvantages of Multi-Tier Architectures

Advantages of n-tier architecture include:

- Scalable – Scale separate tiers without touching other tiers
- Individual management – Prevents cascade effects; isolates maintenance
- Flexible – Expands in any way according to requirements
- Secure – Each tier can be secured separately and in different ways

Advantages	Disadvantages
• Scalability	• Increase in Effort
• Data Integrity	• Increase in Complexity
• Reusability	
• Reduced Distribution	
• Improved Security	
• Improved Availability	

Hence, it is a part of a program which encrypts real-world business problems and determines how data can be updated, created, stored, or changed to get the complete task done.

https://www.guru99.com/n-tier-architecture-system-concepts-tips.html

How It Works and Examples of N-Tier Architecture

When it comes to n-tier architecture, a three-tier architecture is fairly common. In this setup, you have the presentation or GUI tier, the data layer, and the application logic tier.

The application logic tier. The application logic tier is where all the "thinking" happens, and it knows what is allowed by your application and what is possible, and it makes other decisions. This logic tier is also the one that writes and reads data into the data tier.

The data tier. The data tier is where all the data used in your application are stored. You can securely store data on this tier, do transaction, and even search through volumes and volumes of data in a matter of seconds.

The presentation tier. The presentation tier is the user interface. This is what the software user sees and interacts with. This is where they enter the needed information. This tier also acts as a go-between for the data tier and the user, passing on the user's different actions to the logic tier.

Just imagine surfing on your favorite website. The presentation tier is the Web application that you see. It is shown on a Web browser you access from your computer, and it has the CSS, JavaScript, and HTML codes that allow you to make sense of the Web application. If you need to log in, the presentation tier will show you boxes for username, password, and the submit button. After filling out and then submitting the form, all that will be passed on to the logic tier. The logic tier will have the JSP, Java Servlets, Ruby, PHP and other programs. The logic tier would be run on a Web server. And in this example, the data tier would be some sort of database, such as a MySQL, NoSQL, or PostgreSQL database. All of these are run on a separate database server. Rich Internet applications and mobile apps also follow the same three-tier architecture.

And there are n-tier architecture models that have more than three tiers. Examples are applications that have these tiers:

- **Services** – such as print, directory, or database services
- **Business domain** – the tier that would host Java, DCOM, CORBA, and other application server object.
- **Presentation tier**

- **Client tier** – or the thin clients

One good instance is when you have an enterprise service-oriented architecture. The enterprise service bus or ESB would be there as a separate tier to facilitate the communication of the basic service tier and the business domain tier.

Considerations for Using N-Tier Architecture for Your Applications

Because you are going to work with several tiers, you need to make sure that network bandwidth and hardware are fast. If not, the application's performance might be slow. Also, this would mean that you would have to pay more for the network, the hardware, and the maintenance needed to ensure that you have better network bandwidth.

PEER-TO-PEER

Introduction

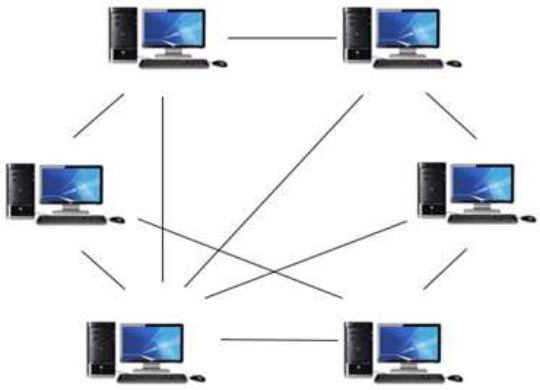
In Computer Networking, P2P is a file-sharing technology, allowing the users to access mainly the multimedia files like videos, music, e-books, games, etc. The individual users in this network are referred to as **peers**. The peers request files from other peers by establishing TCP or UDP connections.

Often referred to simply as peer-to-peer, or abbreviated P2P, a type of network in which each workstation has equivalent capabilities and responsibilities. This differs from client/server architectures, in which some computers are dedicated to serving the other machines in the system. Peer-to-peer networks are generally simpler, but they usually do not offer the same performance under heavy loads.

Multiple clients will interact with a central server in a typical client-server design. However, a P2P comprises a decentralized network of client and server peer-to-peer nodes that contribute, and consume network resources and share workloads. The need for a centralized server is therefore eliminated.

Peer-To-Peer network

- Peer-To-Peer network is a network in which all the computers are linked together with equal privilege and responsibilities for processing the data.
- Peer-To-Peer network is useful for small environments, usually up to 10 computers.
- Peer-To-Peer network has no dedicated server.
- Special permissions are assigned to each computer for sharing the resources, but this can lead to a problem if the computer with the resource is down.



TYPES OF P2P NETWORKS

- Pure P2P network: Also known as a fully peer-to-peer network. Here, there is no centralized dedicated server. All peers, therefore, perform the same function.
- Unstructured P2P network: This kind of network makes it simpler to connect a network's many devices. However, because of the absence of structure, users may experience difficulties finding uncommon material, even if the churning rate (the number of people entering and leaving the network) is high.
- Structured P2P network: This network provides an excellent platform for searching for uncommon material. However, setting up this kind of network is not simple.
- Hybrid P2P network: These networks are usually P2P; however, network communication is approached like the client-server type with a centralized, powerful device.

HOW DO P2P NETWORKS WORK?

How P2P works(Overview)

A peer-to-peer network allows computer hardware and software to communicate without the need for a server. Unlike client-server architecture, there is no central server for processing requests in a P2P architecture. The peers directly interact with one another without the requirement of a central server.

A distributed network of users maintains a peer-to-peer system. Since each node maintains a copy of the files and acts as both a client and a server to other nodes, they require no central administrator or server. As a result, any node may download or upload files to other nodes.

P2P networks work by allowing linked devices to exchange data from their hard drives. Users may search for and download files from other devices on the network using software programs intended to facilitate data sharing. Once the file download is completed, a user may serve as a file source for other users.

BENEFITS OF P2P NETWORKS

P2P networks offer many benefits compared to the client-server paradigm.

- **Cost efficiency:** There is no central server or network operating system (NOS) to maintain and pay for, making P2P economical.
- **Low failure rate:** There is no single point of failure unless the network is very tiny.
- **Robust and agile:** P2P networks are highly resistant to changes. If one peer quits, the entire network suffers little. When many peers join the network simultaneously, the network can easily manage the additional demand. Additionally, the absence of a centralized server means that P2P networks may withstand attacks quite effectively due to their decentralized structure.
- **Enhanced accessibility**: Because the file library is readily accessible, clients may access any file at any moment.
- **Efficient and straightforward retrieval:** In P2P networking, the retrieval procedure is uncomplicated. For example, when a system is abruptly short down or connection is lost during downloads, the network resumes the download from the point where it was interrupted once the connection is re-established.

EXAMPLES OF PEER-TO-PEER NETWORKS

P2P is adopted in many websites or platforms because of its efficiency, especially in file sharing. Some examples include:

- **BitTorren**t—a decentralized communication protocol that is used for file sharing and data dissemination on the internet.
- **Skype**—a VolP system created by Kazaa and used for phone calls and chat.
- **Bitcoin**— a cryptographic system that allows people to send money or receive money over the internet.
- **I2P overlay**—A network used for anonymous browsing of the internet.
- Other popular file-sharing platforms using P2P are Napster, Gnutella, Kazaa, Limeshare, and many others.

Advantages Of Peer-To-Peer Network:

- It is less costly as it does not contain any dedicated server.
- If one computer stops working but, other computers will not stop working.
- It is easy to set up and maintain as each computer manages itself.

Disadvantages Of Peer-To-Peer Network:

- In the case of Peer-To-Peer network, it does not contain the centralized system . Therefore, it cannot back up the data as the data is different in different locations.
- It has a security issue as the device is managed itself.

Mobile Agents in Mobile Computing

In Mobile Computing, Mobile Agents are the composition of computer software and data that can autonomously move from one computer to another computer and continue its execution on the destination computer.

In other words, you can say that An Mobile Agent is an autonomous program that is capable of moving from host to host in a network and interact with resources and other agents. In this process, the chance of data loss is scarce because the state of the running program is saved and then transported to the new host. It allows the program to continue execution from where it left off before migration. The most significant advantage of mobile agents is the possibility of moving complex processing functions to the location where you have enormous amounts of data and that have to be processed.

Mobile Agents are also called as transportable agents. They are classified into two types:

- **Mobile Agents with pre-defined path:** They have a static migration path.
- **Mobile Agents with undefined path i.e., Roamer:** They have dynamic migration paths. The mobile agents choose their path according to the present network condition.

Features of Mobile Agents

The mobile agents are autonomous with intelligence, social ability, learning, and the most important feature is their mobility. They are independent in nature, self-driven and do not require a

corresponding node for communication. They can work efficiently even after the user gets disconnected from the network.

Intelligence

Mobile Agents are capable of learning and searching for knowledge about their domain. That's why they are called intelligent agents because they possess a degree of domain knowledge. They can also transport their state from one environment to another without disturbing the previous holding data and be capable of performing appropriately in the new environment.

Autonomous

The Mobile Agents are Autonomous. It means the agents are not only motivated by the outside actions initiated by the users or system but also they have internal events that decided their performance and behavior. The mobile agents can also take an autonomous decision while selecting a node.

Mobility

Mobile Agents contain some degree of mobility. The agent is not limited to its home node only. They can migrate from one node to another and can carry out tasks along with them. This feature distributes the processing and balancing of the load. Another benefit of this capability is that when the user goes offline, the agents will still keep functioning.

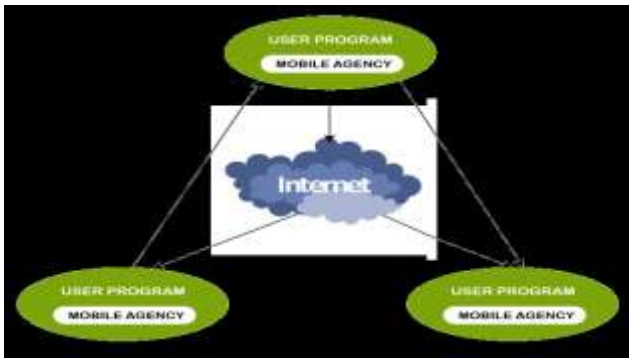
Communicative

Mobile Agents can communicate effectively with other agents, users and systems. The mobile agents use a communication language for inter-agent communication.

Life Cycle of Mobile Agents

The life cycle of mobile agents ensures the following conditions:

- They can adapt to the environment. For example, either home or foreign environment.
- They are capable of switching among the positions of one node to another.
- They are autonomous and focused on the final output.



Advantages of Mobile Agents

The following are some advantages of mobile agents over conventional agents:

- Mobile Agents are autonomous and self-driven in nature.
- They are maintenance-friendly or easily maintainable.

- They are Fault-tolerant. It means they are able to operate without an active connection between client and server.
- They reduce the compilation time.
- They provide less delay in the network.
- They provide fewer loads on the network.
- They facilitate parallel processing. It means they can be asynchronously executed on multiple heterogeneous network hosts.
- They provide dynamic adaptation in which their actions are dependent on the state of the host environment.

Disadvantages of Mobile Agents

The following are some disadvantages of mobile agents:

- The most significant disadvantage of mobile agents is their security. They are less secured

Applications of Mobile Agents

Mobile agents are used in the following applications:

- Mobile Agents are applied in a wide range of domains such as E-commerce, traffic control, network management, robotics, data-intensive applications etc.
- They are also used in grid computing, parallel computing, distributed computing and mobile computing etc.

UNIT-3
WIRELESS TRANSMISSION

Introduction

Wireless communications is the transmission of voice and data without cable or wires. In place of a physical connection, data travels through electromagnetic signals broadcast from sending facilities to intermediate and end-user devices.

The first wireless transmitters went on the air in the early 20th century using radiotelegraphy, which is radio communication using Morse code or other coded signals. Later, as modulation made it possible to transmit voice and music wirelessly, the medium became known as radio. Wireless transmitters use electromagnetic waves to carry voice, data, video or signals over a communication path.

Radio Transmission

Radio frequency is easier to generate and because of its large wavelength it can penetrate through walls and structures alike.Radio waves can have wavelength from 1 mm – 100,000 km and have frequency ranging from 3 Hz (Extremely Low Frequency) to 300 GHz (Extremely High Frequency). Radio frequencies are sub-divided into six bands.

Radio waves at lower frequencies can travel through walls whereas higher RF can travel in straight line and bounce back.The power of low frequency waves decreases sharply as they cover long distance. High frequency radio waves have more power.

Lower frequencies such as VLF, LF, MF bands can travel on the ground up to 1000 kilometers, over the earth's surface.

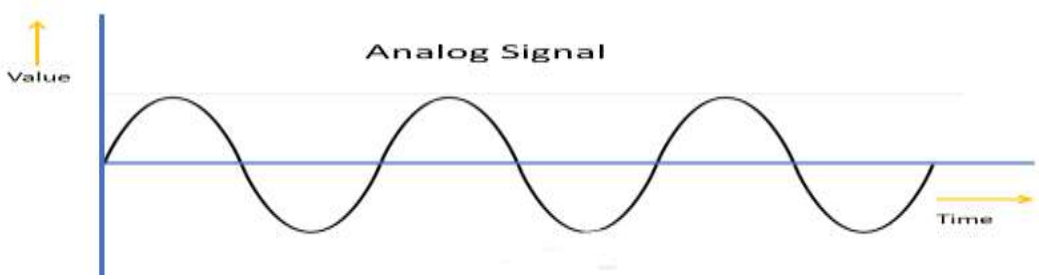
SIGNALS

A signal is an electrical or electromagnetic current that is used for carrying data from one device or network to another.

A signal is an electromagnetic or electrical current that is used for carrying data from one system or network to another. The signal is a function that conveys information about a phenomenon.

In electronics and telecommunications, it refers to any time-varying voltage that is an electromagnetic wave which carries information. A signal can also be defined as an observable change in quality such as quantity. There are two main types of signals: Analog signal and Digital signal.

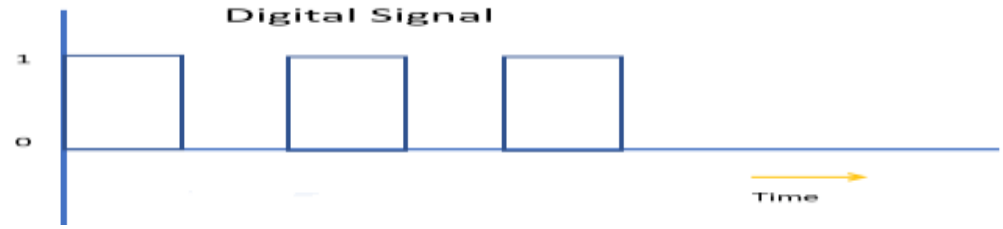
What is an Analog Signal?



Analog Signal

Analog signal is a continuous signal in which one time-varying quantity represents another time-based variable. These kind of signals works with physical values and natural phenomena such as earthquake, frequency, volcano, speed of wind, weight, lighting, etc.

What is a Digital Signal?



Digital Signal

A digital signal is a signal that is used to represent data as a sequence of separate values at any point in time. It can only take on one of a fixed number of values. This type of signal represents a real number within a constant range of values. Now, let's learn some key difference between Digital and Analog signals.

Difference between the Analog signals and Digital signals

Analog signals	**Digital signals**
Analog signals are difficult to get analysed at first.	Digital signals are easy to analyse.
Analog signals are more accurate than digital signals.	Digital signals are less accurate.
Analog signals take time to be stored. It has infinite memory.	Digital signals can be easily stored.
To record an analog signal, the technique used, preserves the original signals.	In recording digital signal, the sample signals are taken and preserved.
There is a continuous representation of signals in analog signals.	There is a discontinuous representation of signals in digital signals.
Analog signals produce too much noise.	Digital signals do not produce noise.
Examples of analog signals are Human voice, Thermometer, Analog phones etc.	Examples of digital signals are Computers, Digital Phones, Digital pens, etc.

PERIOD, FREQUENCY AND BANDWIDTH

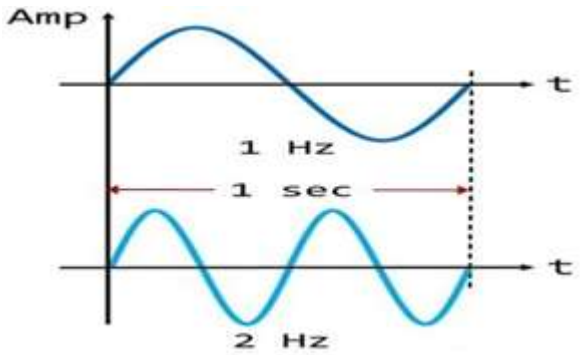
The period is the interval of time between events, so the period is the reciprocal of the frequency. For example, if a heart beats at a frequency of 120 times a minute (2 hertz), the period, T—the interval at which the beats repeat—is half a second (60 seconds divided by 120 beats).

Both frequency and bandwidth are the two major terms related to data transmission. The major difference between frequency and bandwidth is that frequency shows the number of complete cycles appearing in unit time. As against bandwidth is the overall amount of data transmitted in a unit time.

Both frequency and bandwidth have a similar measuring unit i.e., hertz**.** But the two have different meanings when studied in the context of networking. In this article, we will see how bandwidth is different from frequency.

Definition of Frequency

Frequency is defined as the total number of wave cycles present in each second of a waveform. It basically shows the occurrence of overall complete wave cycles in the unit time. The figure below represents two different waveforms:



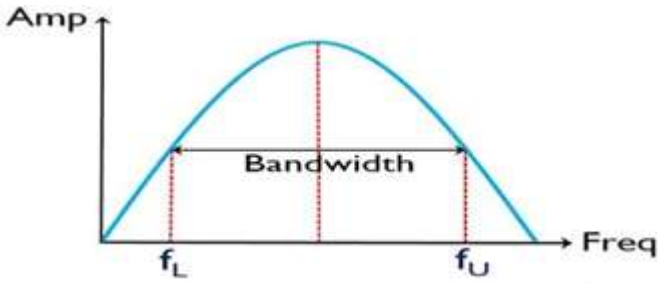
It is clear from the figure that the wavelength of the waveform is larger in the first case while it is quite smaller in the second case. This represents that the two signal waveforms have different frequencies.

As in the first case, the total complete cycle is only 1 per second. While in the second the overall complete cycle is 2 per second. Thus the frequency of the first signal is 1 Hz**.** whereas that of the second signal is 2Hz**.** Hence we can say that the frequency of a signal is dependent on the occurrence of the cycle in unit time.

Definition of Bandwidth

Bandwidth is completely related to frequency but definitely, bandwidth is not frequency. However, bandwidth is the range of frequencies. Bandwidth is defined as the difference in the upper and lower frequency components present in a signal. Thus, it specifies the amount of data being transmitted per second.

The figure below shows the bandwidth of a signal '**f**' with lower and upper frequencies as $\mathbf{f_l}$ and $\mathbf{f_u}$ respectively:



Basically, we know that a signal which is transmitted from an end to another consists of various frequency components. Then among the various frequencies how can we specify the range occupied by the complete signal?

As bandwidth provides an idea about the range of the transmitted signal. So, the range of the signal is determined by calculating the difference between the lowest and highest frequency component present in the signal.

Antennas

An antenna is an array of conductors (elements), electrically connected to the receiver or transmitter. It is a metallic structure that captures and/or transmits radio electromagnetic waves.

Types of antennas

Omnidirectional

Directional Antennas

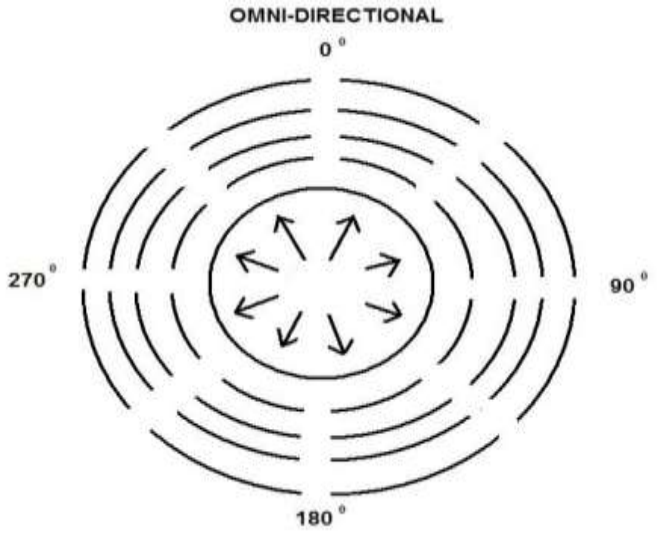
1. Omni-directional antenna

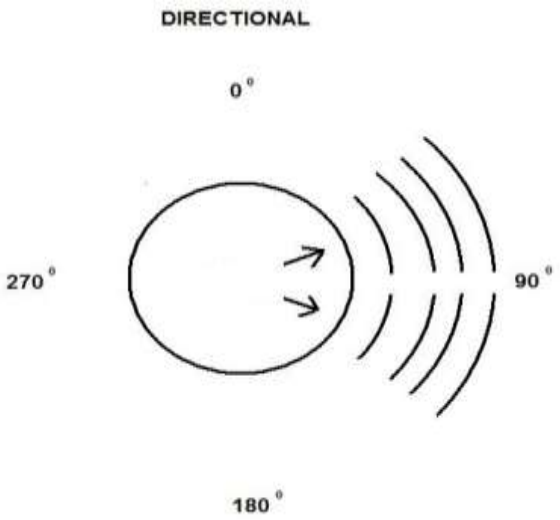
The Omni-directional antenna radiations radio power equally in all the directions. The power emitted is perpendicular to the axis. It further declines to zero towards the axis. It is commonly used in applications that require communication with multiple devices.

2. Directional antenna

The directional antenna radiations power in a specific direction. The power radiated thus has a strong beam. It prevents the radiations from any interference due to the radiations in a particular direction. It has a narrow beam and double gain as compared to the Omi-directional antenna.

The application of directional antenna includes GPS (Global Positioning system), cellular networks, etc.

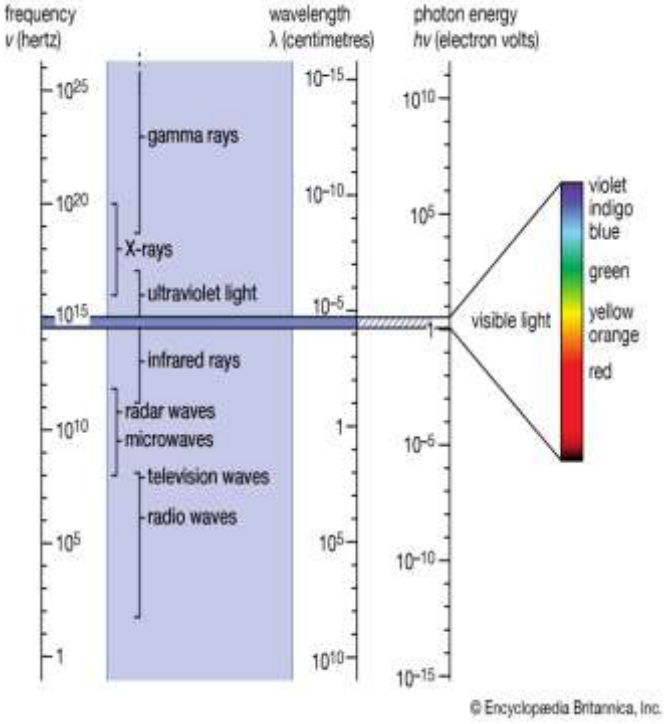




Signal Propagation

Electromagnetic spectrum, the entire distribution of electromagnetic radiation according to frequency or wavelength. Although all electromagnetic waves travel at the speed of light in a vacuum, they do so at a wide range of frequencies, wavelengths, and photon energies.

The entire electromagnetic spectrum, from the lowest to the highest frequency (longest to shortest wavelength), includes all radio waves (e.g., commercial radio and television, microwaves, radar), infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays. Nearly all frequencies and wavelengths of electromagnetic radiation can be used for spectroscopy.



Signal propagation is the movement of radio waves from a transmitter to a receiver. When the waves travel (propagate) from one point to another, they are, like light waves, affected by different phenomena such as light reflection, absorption, or scattering.

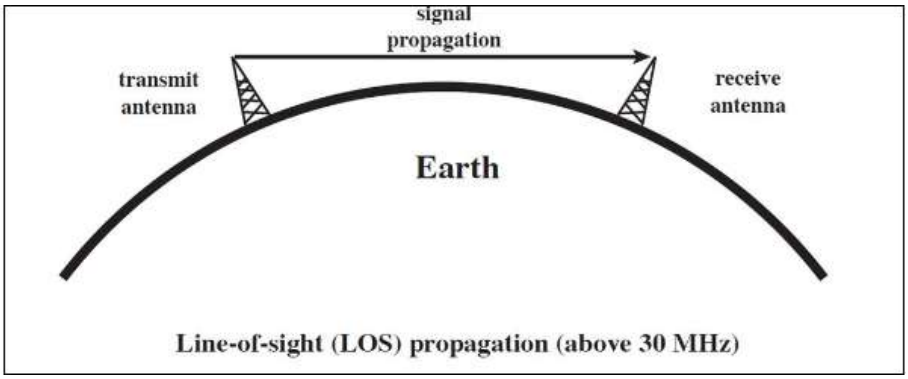
In Radio communication systems, we use wireless electromagnetic waves as the channel. The antennas of different specifications can be used for these purposes. The mode of propagation of electromagnetic waves in the atmosphere and in free space may be divided into the following three categories:

- The line of sight (LOS) propagation
- Ground wave propagation
- Skywave propagation

In ELF (Extremely low frequency) and VLF (Very low frequency) frequency bands, the Earth, and the ionosphere act as a wave-guide for electromagnetic wave propagation. In these frequency ranges, communication signals practically propagate around the world. The channel bandwidths are small. Therefore, the information is transmitted through these channels has slow speed and confined to digital transmission.

The line of Sight (LOS) Propagation

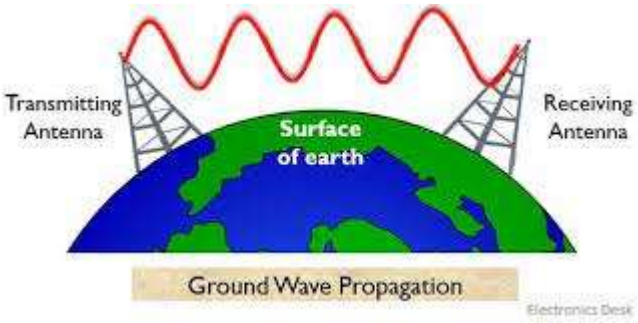
Among the modes of propagation, this line-of-sight propagation is the one, which we would have commonly noticed. In the line-of-sight communication, as the name implies, the wave travels a minimum distance of sight. Which means it travels to the distance up to which a naked eye can see. Then we need to employ an amplifier cum transmitter here to amplify the signal and transmit again.



The line-of-sight propagation will not be smooth if there occurs any obstacle in its transmission path. As the signal can travel only to lesser distances in this mode, this transmission is used for infrared or microwave transmissions.

Ground Wave Propagation

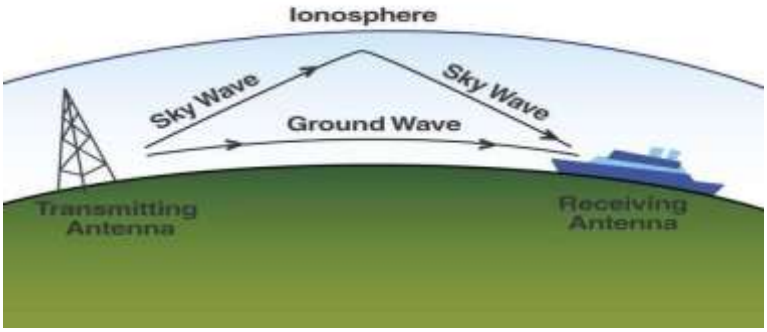
Ground wave propagation of the wave follows the contour of the earth. Such a wave is called a direct wave. The wave sometimes bends due to the Earth's magnetic field and gets reflected the receiver. Such a wave can be termed as a reflected wave. The following figure depicts ground wave propagation.



The wave then propagates through the Earth's atmosphere is known as a ground wave. The direct wave and reflected wave together contribute the signal at the receiver station. When the wave finally reaches the receiver, the lags are cancelled out. In addition, the signal is filtered to avoid distortion and amplified for clear output.

Sky Wave Propagation

Sky wave propagation is preferred when the wave has to travel a longer distance. Here the wave is projected onto the sky and it is again reflected back to the earth.



The sky wave propagation is well depicted in the above picture. Here the waves are shown to be transmitted from one place and where it is received by many receivers. Hence, it is an example of broadcasting.

The waves, which are transmitted from the transmitter antenna, are reflected from the ionosphere. It consists of several layers of charged particles ranging in altitude from 30-250 miles above the

surface of the earth. Such travel of the wave from the transmitter to the ionosphere and from there to the receiver on Earth is known as Sky Wave Propagation. The ionosphere is the ionized layer around the Earth's atmosphere, which is suitable for skywave propagation.

Multiplexing

Multiplexing is a technique used to combine and send the multiple data streams over a single medium. The process of combining the data streams is known as multiplexing and hardware used for multiplexing is known as a multiplexer.

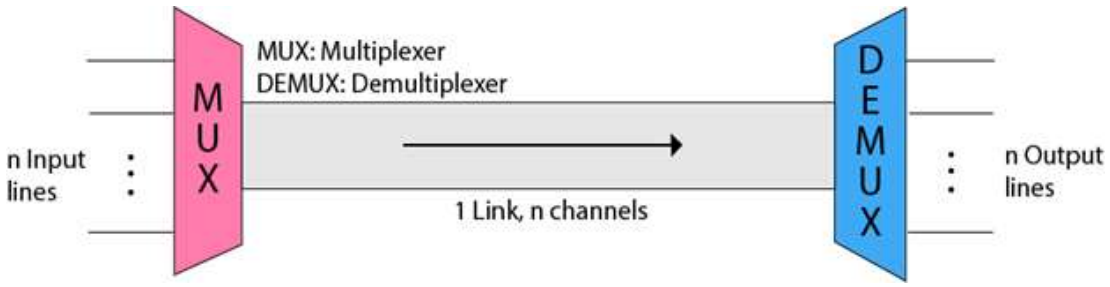
Multiplexing is achieved by using a device called Multiplexer (**MUX**) that combines n input lines to generate a single output line. Multiplexing follows many-to-one, i.e., n input lines and one output line.

Demultiplexing is achieved by using a device called Demultiplexer (**DEMUX**) available at the receiving end. DEMUX separates a signal into its component signals (one input and n outputs). Therefore, we can say that demultiplexing follows the one-to-many approach.

Why Multiplexing?

- The transmission medium is used to send the signal from sender to receiver. The medium can only have one signal at a time.
- If there are multiple signals to share one medium, then the medium must be divided in such a way that each signal is given some portion of the available bandwidth. For example: If there are 10 signals and bandwidth of medium is100 units, then the 10 unit is shared by each signal.
- When multiple signals share the common medium, there is a possibility of collision. Multiplexing concept is used to avoid such collision.
- Transmission services are very expensive.

Concept of Multiplexing



- The 'n' input lines are transmitted through a multiplexer and multiplexer combines the signals to form a composite signal.
- The composite signal is passed through a Demultiplexer and demultiplexer separates a signal to component signals and transfers them to their respective destinations.

Advantages of Multiplexing:

- More than one signal can be sent over a single medium.
- The bandwidth of a medium can be utilized effectively.

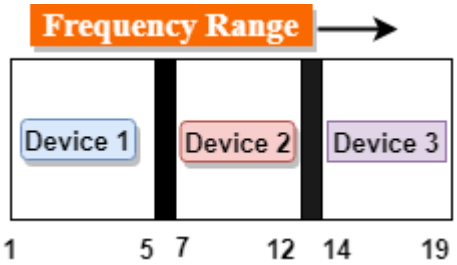
Multiplexing Techniques

Multiplexing techniques can be classified as:

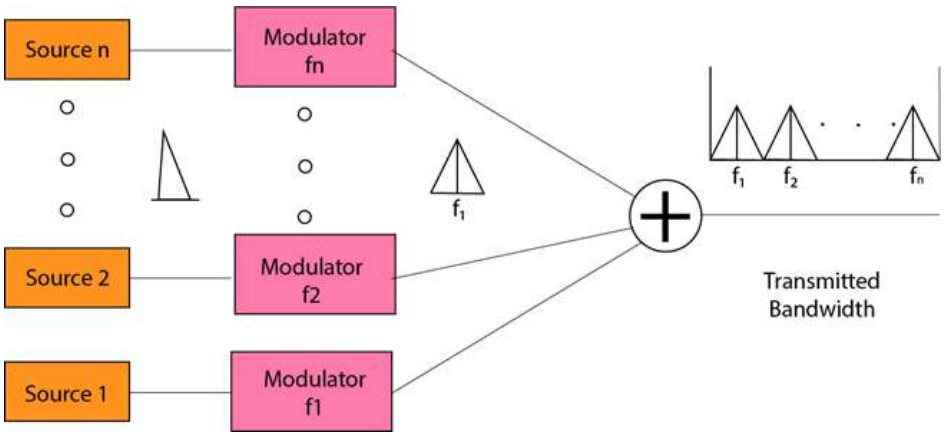
- Frequency-division multiplexing (FDM)
- Wavelength-division multiplexing (WDM)
- Time-division multiplexing (TDM)
- Code-division multiplexing (CDM)
- Space-division multiplexing (SDM)

Frequency-division Multiplexing (FDM)

- It is an analog technique.
- Frequency Division Multiplexing is a technique in which the available bandwidth of a single transmission medium is subdivided into several channels.



- In the above diagram, a single transmission medium is subdivided into several frequency channels, and each frequency channel is given to different devices. Device 1 has a frequency channel of range from 1 to 5.
- The input signals are translated into frequency bands by using modulation techniques, and they are combined by a multiplexer to form a composite signal.
- The main aim of the FDM is to subdivide the available bandwidth into different frequency channels and allocate them to different devices.
- Using the modulation technique, the input signals are transmitted into frequency bands and then combined to form a composite signal.
- The carriers which are used for modulating the signals are known as **sub-carriers**. They are represented as f1,f2..fn.
- **FDM** is mainly used in radio broadcasts and TV networks.



Advantages Of FDM:

- FDM is used for analog signals.
- FDM process is very simple and easy modulation.
- A Large number of signals can be sent through an FDM simultaneously.
- It does not require any synchronization between sender and receiver.

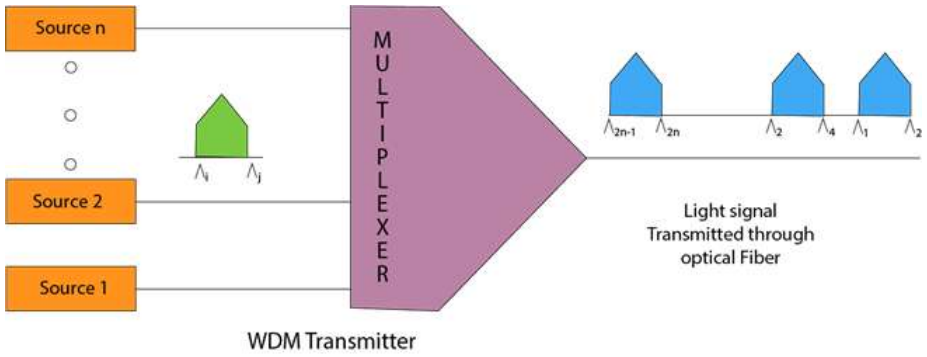
Disadvantages Of FDM:

- FDM technique is used only when low-speed channels are required.
- It suffers the problem of crosstalk.
- A Large number of modulators are required.
- It requires a high bandwidth channel.

Applications Of FDM:

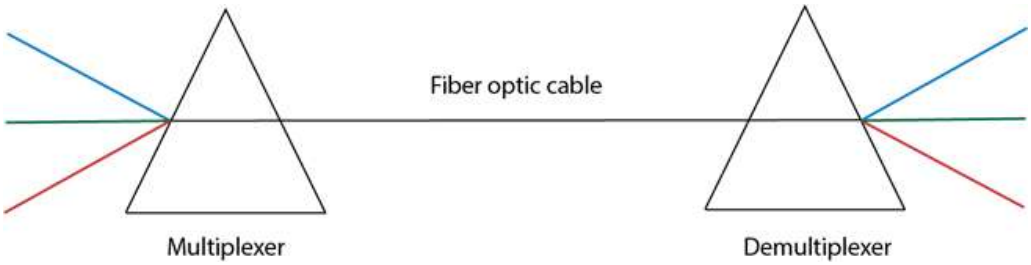
- FDM is commonly used in TV networks.
- It is used in FM and AM broadcasting. Each FM radio station has different frequencies, and they are multiplexed to form a composite signal. The multiplexed signal is transmitted in the air.

Wavelength Division Multiplexing (WDM)



- Wavelength Division Multiplexing is same as FDM except that the optical signals are transmitted through the fibre optic cable.
- WDM is used on fibre optics to increase the capacity of a single fibre.
- It is used to utilize the high data rate capability of fibre optic cable.
- It is an analog multiplexing technique.
- Optical signals from different source are combined to form a wider band of light with the help of multiplexer.
- At the receiving end, demultiplexer separates the signals to transmit them to their respective destinations.
- Multiplexing and Demultiplexing can be achieved by using a prism.
- Prism can perform a role of multiplexer by combining the various optical signals to form a composite signal, and the composite signal is transmitted through a fibre optical cable.

- Prism also performs a reverse operation, i.e., demultiplexing the signal.



Time Division Multiplexing

- It is a digital technique.
- In Frequency Division Multiplexing Technique, all signals operate at the same time with different frequency, but in case of Time Division Multiplexing technique, all signals operate at the same frequency with different time.
- In Time Division Multiplexing technique, the total time available in the channel is distributed among different users. Therefore, each user is allocated with different time interval known as a Time slot at which data is to be transmitted by the sender.
- A user takes control of the channel for a fixed amount of time.
- In Time Division Multiplexing technique, data is not transmitted simultaneously rather the data is transmitted one-by-one.
- In TDM, the signal is transmitted in the form of frames. Frames contain a cycle of time slots in which each frame contains one or more slots dedicated to each user.
- It can be used to multiplex both digital and analog signals but mainly used to multiplex digital signals.

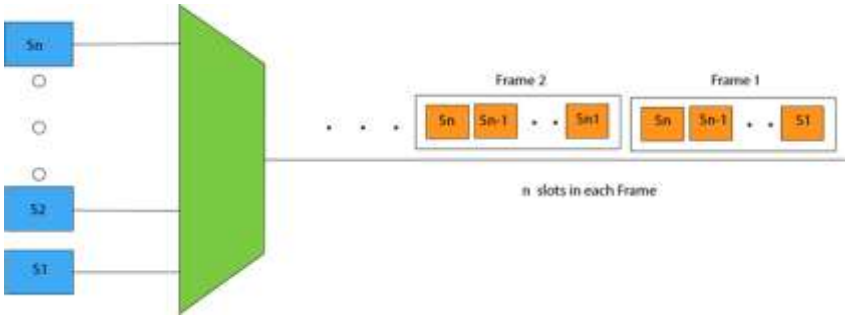
There are two types of TDM:

- Synchronous TDM
- Asynchronous TDM

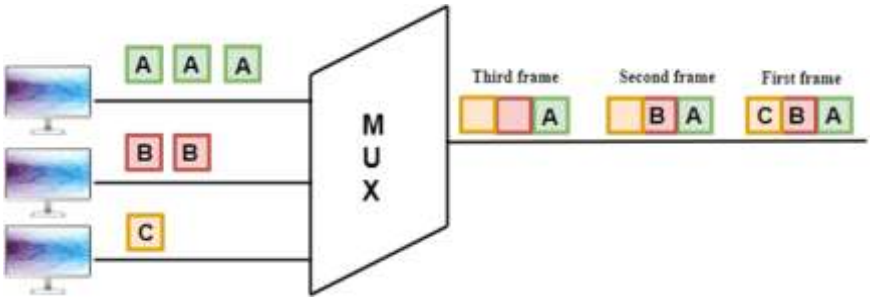
Synchronous TDM

- A Synchronous TDM is a technique in which time slot is preassigned to every device.
- In Synchronous TDM, each device is given some time slot irrespective of the fact that the device contains the data or not.
- If the device does not have any data, then the slot will remain empty.
- In Synchronous TDM, signals are sent in the form of frames. Time slots are organized in the form of frames. If a device does not have data for a particular time slot, then the empty slot will be transmitted.
- The most popular Synchronous TDM are T-1 multiplexing, ISDN multiplexing, and SONET multiplexing.

- If there are n devices, then there are n slots.



Concept Of Synchronous TDM



In the above figure, the Synchronous TDM technique is implemented. Each device is allocated with some time slot. The time slots are transmitted irrespective of whether the sender has data to send or not.

Disadvantages Of Synchronous TDM:

- The capacity of the channel is not fully utilized as the empty slots are also transmitted which is having no data. In the above figure, the first frame is completely filled, but in the last two frames, some slots are empty. Therefore, we can say that the capacity of the channel is not utilized efficiently.
- The speed of the transmission medium should be greater than the total speed of the input lines. An alternative approach to the Synchronous TDM is Asynchronous Time Division Multiplexing.

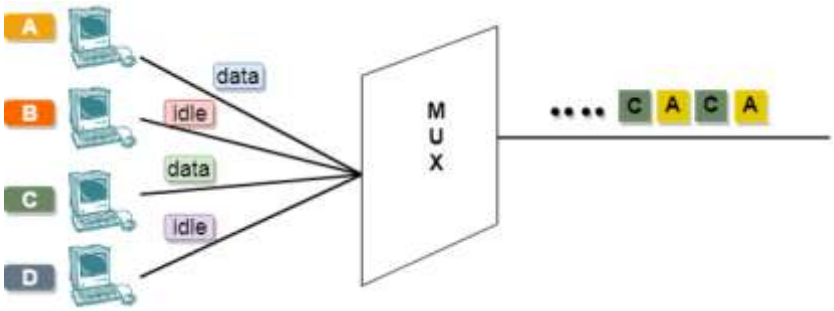
Asynchronous TDM

- An asynchronous TDM is also known as Statistical TDM.
- An asynchronous TDM is a technique in which time slots are not fixed as in the case of Synchronous TDM. Time slots are allocated to only those devices which have the data to send. Therefore, we can say that Asynchronous Time Division multiplexor transmits only the data from active workstations.
- An asynchronous TDM technique dynamically allocates the time slots to the devices.
- In Asynchronous TDM, total speed of the input lines can be greater than the capacity of the channel.
- Asynchronous Time Division multiplexor accepts the incoming data streams and creates a frame that contains only data with no empty slots.

- In Asynchronous TDM, each slot contains an address part that identifies the source of the data.

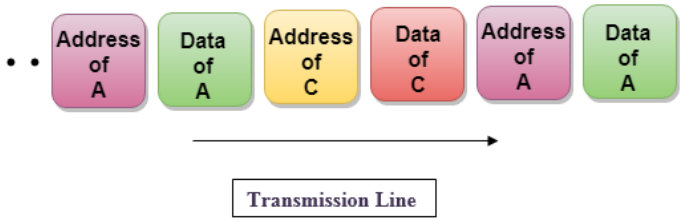
- The difference between Asynchronous TDM and Synchronous TDM is that many slots in Synchronous TDM are unutilized, but in Asynchronous TDM, slots are fully utilized. This leads to the smaller transmission time and efficient utilization of the capacity of the channel.
- In Synchronous TDM, if there are n sending devices, then there are n time slots. In Asynchronous TDM, if there are n sending devices, then there are m time slots where m is less than n (**m<n**).
- The number of slots in a frame depends on the statistical analysis of the number of input lines.

Concept Of Asynchronous TDM



In the above diagram, there are 4 devices, but only two devices are sending the data, i.e., A and C. Therefore, the data of A and C are only transmitted through the transmission line.

Frame of above diagram can be represented as:



The above figure shows that the data part contains the address to determine the source of the data.

Code Division Multiplexing

Code division multiplexing (CDM) is a networking technique in which multiple data signals are combined for simultaneous transmission over a common frequency band.

When CDM is used to allow multiple users to share a single communications channel, the technology is called code division multiple access (CDMA).

Multiplexing can be classified into the following four types:

- Frequency Division Multiplexing (FDM)
- Time Division Multiplexing (TDM)
- Code Division Multiplexing (CDM)

- Space Division Multiplexing (SDM)

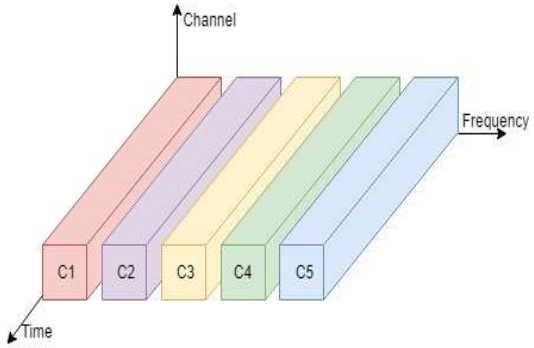
Frequency Division Multiplexing (FDM)

Frequency division multiplexing or FDM is inherently an analog technology. As the name specifies, in Frequency Division Multiplexing, the frequency dimension spectrum is split into smaller frequency bands. It combines several smaller distinct frequency ranges signals into one medium and sends them over a single medium. In FDM, the signals are electrical signals.

FDM's most common applications are a traditional radio or television broadcasting, mobile or satellite stations, or cable television.

For example: In cable TV, you can see that only one cable is reached to the customer's locality, but the service provider can send multiple television channels or signals simultaneously over that cable to all customers without any interference. The customers have to tune to the appropriate frequency (channel) to access the required signal.

In FDM, several frequency bands can work simultaneously without any time constraint.



Advantages of FDM

- The concept of frequency division multiplexing (FDM) applies to both analog signals and digital signals.
- It facilitates you to send multiple signals simultaneously within a single connection.

Disadvantages of FDM

- It is less flexible.
- In FDM, the bandwidth wastage may be high.

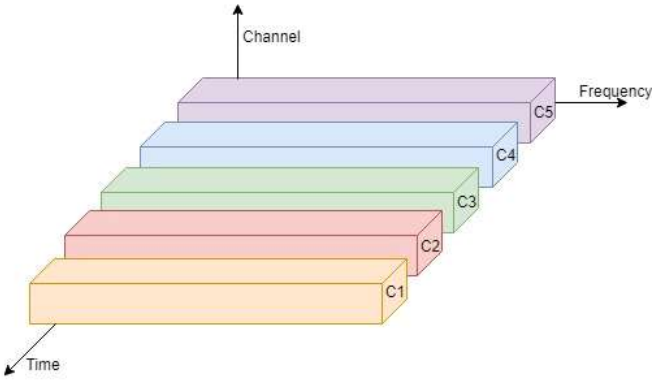
Usage

It is used in Radio and television broadcasting stations, Cable TV etc.

Time Division Multiplexing (TDM)

The Time Division Multiplexing or (TDM) is a digital or analog technology (in rare cases) that uses time, instead of space or frequency, to separate the different data streams. It is used for a specific amount of time in which the whole spectrum is used.

The Time frames of the same intervals are divided so that you can access the entire frequency spectrum at that time frame.



Advantages of TDM

- It facilitates a single user at a time.
- It is less complicated and has a more flexible architecture.

Disadvantages of TDM

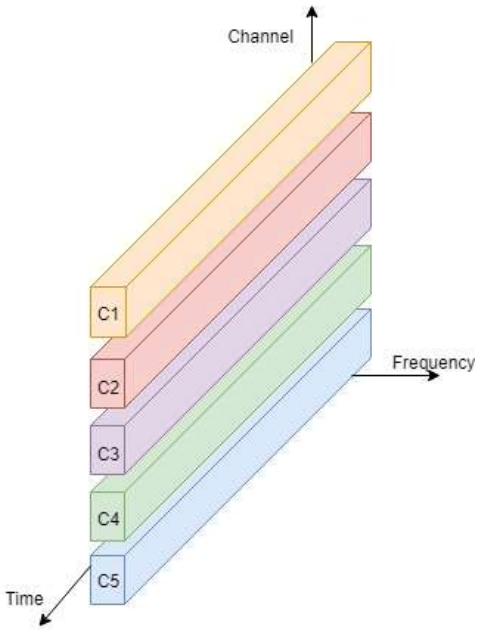
- It isn't easy to implement.

Usage

- It is mainly used in telephonic services.

Code Division Multiplexing (CDM)

The Code Division Multiplexing or (CDM) allots a unique code to every channel so that each of these channels can use the same spectrum simultaneously at the same time.



Advantages of CDM

- It is highly efficient.
- It faces fewer Inferences.

Disadvantages of CDM

- The data transmission rate is low.
- It is complex.

Usage

- It is mainly used in Cell Phone Spectrum Technology (2G, 3G etc.).

Space Division Multiplexing (SDM)

The Space Division Multiplexing or (SDM) is called a combination of Frequency Division Multiplexing (FDM) and Time Division Multiplexing (TDM).

It passes messages or data-parallel with the use of specific frequency at a specific. It means a particular channel will be used against a specific frequency band for some amount of time.

Advantages of SDM

- In SDM, the data transmission rate is high.
- It uses Time and Frequency bands at its maximum potential.

Disadvantages of SDM

- An inference may occur.
- It faces high inference losses.

Usage

- It is used in GSM (Global Service for Mobile) Technology.

Modulation

The process by which data/information is converted into electrical/digital signals for transferring that signal over a medium is called **modulation**. It increases strength for maximum reach of the signals. The process of extracting information/data from the transmitted signal is called **demodulation**. A Modem is a device that performs both modulation and demodulation processes. The various forms of modulation are designed to alter the characteristic of carrier waves. The most commonly altered characteristics of modulation include amplitude, frequency, and phase.

Carrier signal: The signals which contain no information but have a certain phase, frequency, and amplitude are called carrier signals.

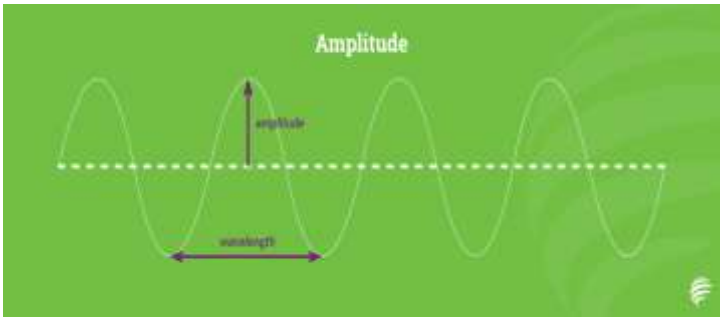
Modulated signals: The signals which are the combination of the carrier signals and modulation signals are modulated signals. The modulated signal is obtained after the modulation of the signals.

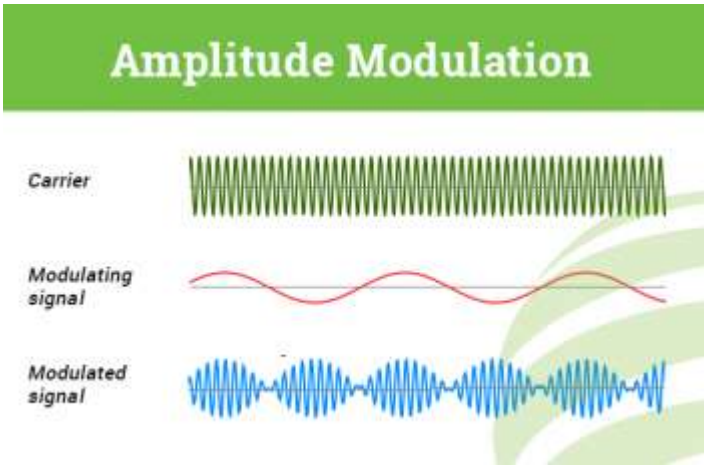
Modulation techniques are mainly divided into two types: Analog modulation, Digital modulation.

Analog modulation

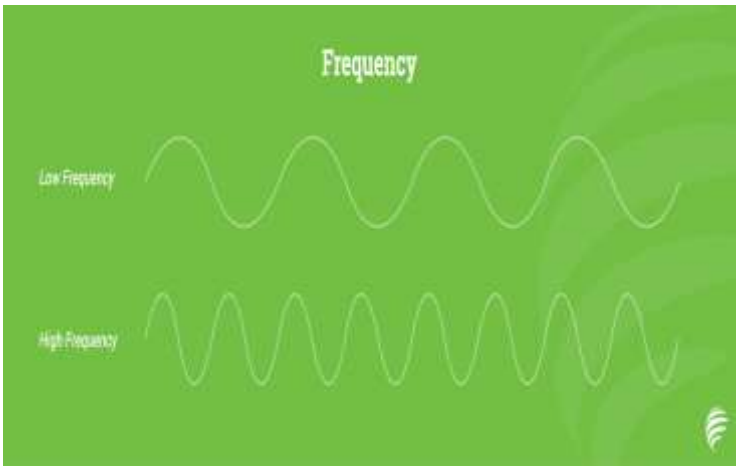
The following techniques—amplitude modulation, frequency modulation, and phase modulation—are analog modulation techniques. That is, they work by modulating a continuous carrier wave, rather than a signal encoded in binary digits as with digital techniques.

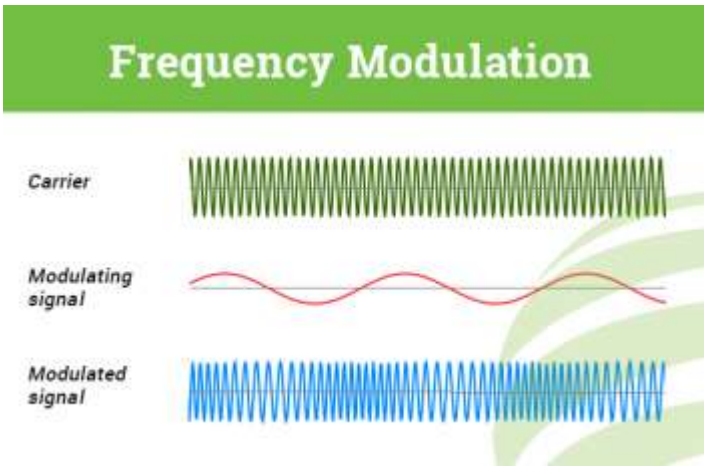
1. **Amplitude modulation:** It is a type of modulation in which only the amplitude of the carrier signal is varied to represent the data being added to the signals whereas the phase and the frequency of the signal are kept unchanged.



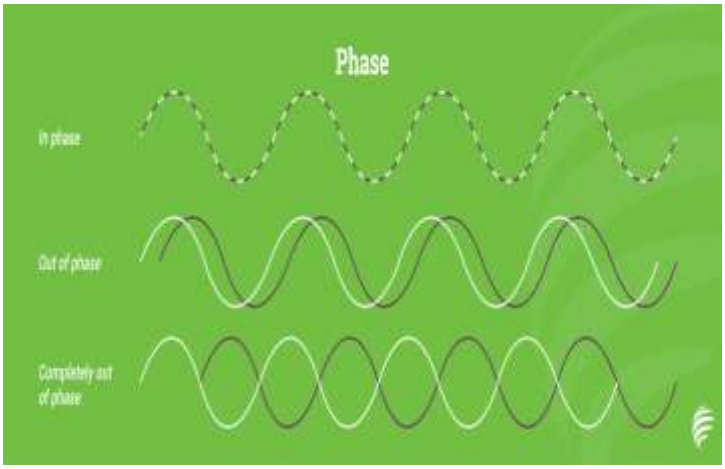


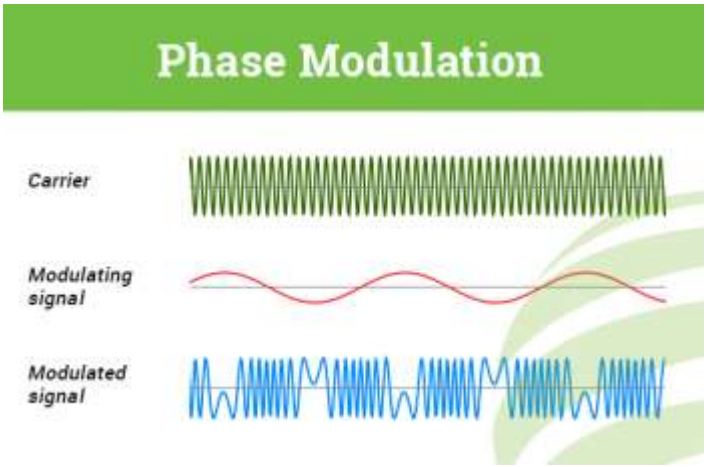
2. **Frequency modulation:** It is a type of modulation in which only the frequency of the carrier signal is varied to represent the frequency of the data whereas the phase and the amplitude of the signals are kept unchanged.





3. **Phase modulation:** It is a type of modulation in which the phase of the carrier signal is varied to represent the data being added to the signal. Different information values are represented by different phases. For example: '1' may be represented by 0° while '0' by 180°.





Digital modulation

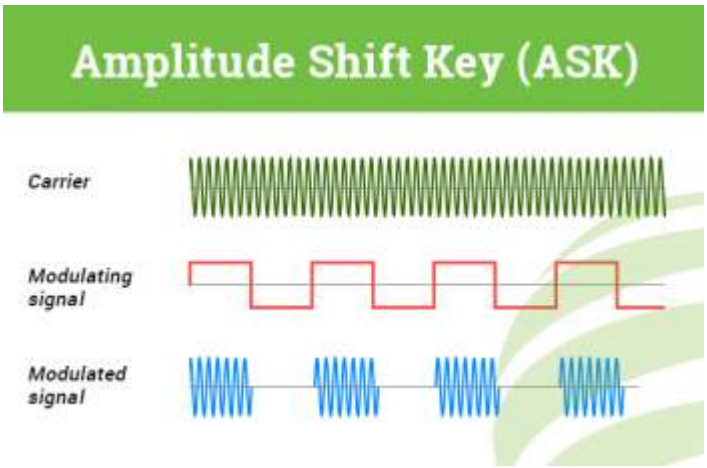
In order to transmit computer data and other digitized information over a communications channel, an analog carrier wave can be modulated to reflect the binary nature of the digital baseband signal. The parameters of the carrier that can be modified are the amplitude, the frequency, and the phase.

1. ASK or Amplitude Shift Key
2. FSK or Frequency Shift Key
3. PSK or Phase Shift Key

Amplitude-shift keying

This form of modulation is when the carrier amplitude is varied in proportion to message signal.

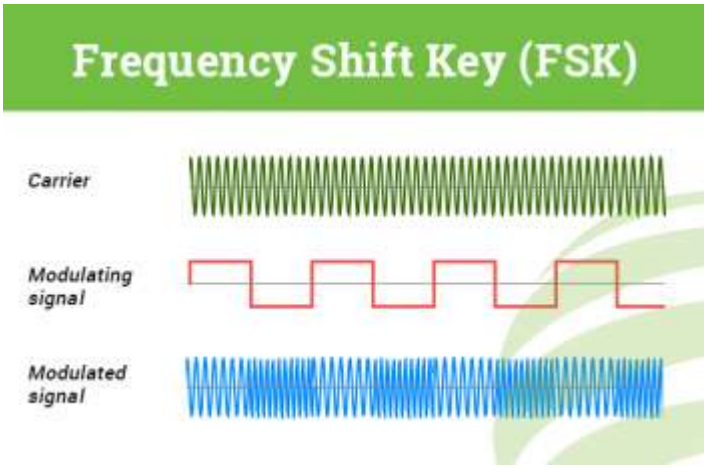
If amplitude is the only parameter of the carrier wave to be altered by the information signal, the modulating method is called amplitude-shift keying (ASK). ASK can be considered a digital version of analog amplitude modulation. In its simplest form, a burst of radio frequency is transmitted only when a binary 1 appears and is stopped when a 0 appears. In another variation, the 0 and 1 are represented in the modulated signal by a shift between two preselected amplitudes.



Frequency-shift keying

This type of modulation transmits data by varying the frequency of the carrier. In this modulation, the carrier has two predefined frequencies.

If frequency is the parameter chosen to be a function of the information signal, the modulation method is called frequency-shift keying (FSK). In the simplest form of FSK signaling, digital data is transmitted using one of two frequencies, whereby one frequency is used to transmit a 1 and the other frequency to transmit a 0.



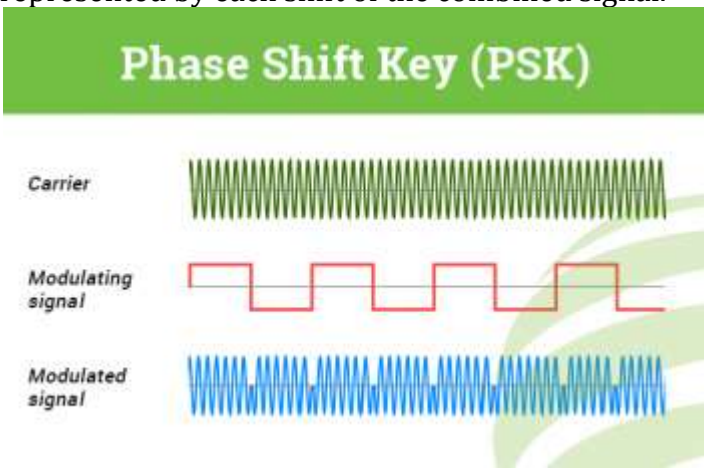
Phase-shift keying

With PSK, the phase of the carrier is shifted to transmit data.

When phase is the parameter altered by the information signal, the method is called phase-shift keying (PSK). In the simplest form of PSK, a single radio frequency carrier is sent with a fixed phase to represent a 0 and with a 180° phase shift—that is, with the opposite polarity—to represent a 1.

In addition to the elementary forms of digital modulation described above, there exist more-advanced methods that result from a superposition of multiple modulating signals. An example of the latter form of modulation is quadrature amplitude modulation (QAM). QAM signals actually transmit

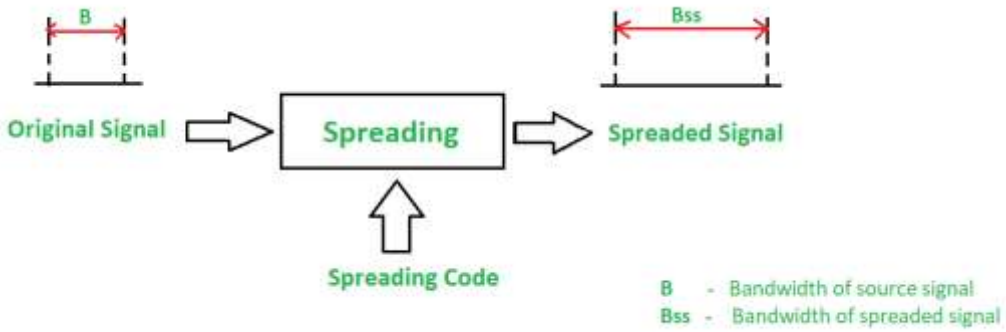
two amplitude-modulated signals in phase quadrature (i.e., 90° apart), so that four or more bits are represented by each shift of the combined signal.



Spread Spectrum

The increasing demand for wireless communications has problems due to limited spectrum efficiency and multipath propagation. The use of spread spectrum communication has simplified these problems. In the spread spectrum, signals from different sources are combined to fit into **larger bandwidth**.

Most stations use air as the medium for communication, stations must be able to share the medium without an interception and without being subject to jamming from a malicious intruder. To achieve this, spread-spectrum techniques add redundancy means it uses **extended bandwidth** to accommodate signals in a protective envelope so that more secure transmission is possible. The spread code is a series of numbers that looks random but are actually a pattern. The original bandwidth of the signal gets **enlarged** (spread) through the spread code as shown in the figure.



Spread Spectrum

Principles of Spread Spectrum process:

1. To allow redundancy, it is necessary that the bandwidth allocated to each station should be much larger than needed.
2. The spreading process occurs after the signal is created by the source.

Conditions of Spread Spectrum are:

1. The spread spectrum is a type of modulation where modulated signal BW is much larger than the baseband signal BW i.e. spread spectrum is a wide band scheme.
2. A special code (pseudo noise) is used for spectrum spreading and the same code is to be used to despread the signal at the receiver.

Characteristics of the Spread Spectrum are:

1. Higher channel capacity.
2. Ability to resist multipath propagation.
3. They cannot easily intercept any unauthorized person.
4. They are resistant to jamming.
5. The spread spectrum provides immunity to distortion due to multipath propagation.

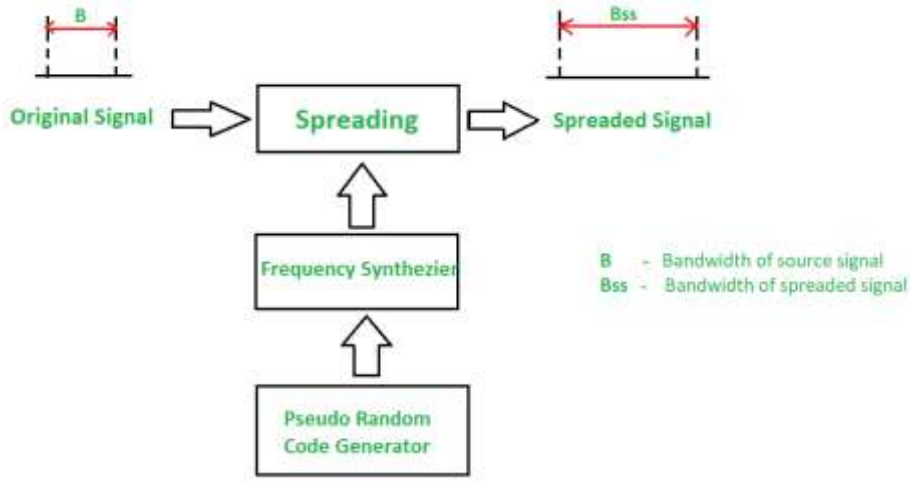
6. The spread spectrum offers multiple access capabilities.

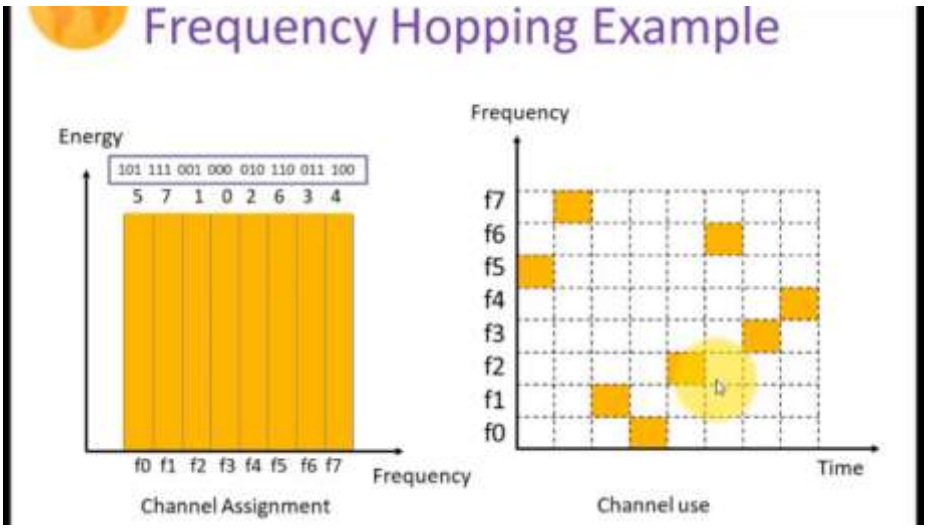
Two types of techniques for Spread Spectrum are:

1. Frequency Hopping Spread Spectrum (FHSS)
2. Direct Sequence Spread Spectrum (DSSS)

Frequency Hopping Spread Spectrum (FHSS):

In Frequency Hopping Spread Spectrum (FHSS), different carrier frequencies are modulated by the source signal i.e. M carrier frequencies are modulated by the signal. At one moment signal modulates one carrier frequency and at the subsequent moments, it modulates other carrier frequencies. The general block diagram of FHSS is shown in the below figure.





A pseudorandom code generator generates Pseudo-random Noise of some pattern for each hopping period $\mathbf{T_h}$. The frequency corresponding to the pattern is used for the hopping period and is passed to the frequency synthesizer. The synthesizer generates a carrier signal of that frequency. The figure above shows the spread signal via FHSS.

Advantages of FHSS:

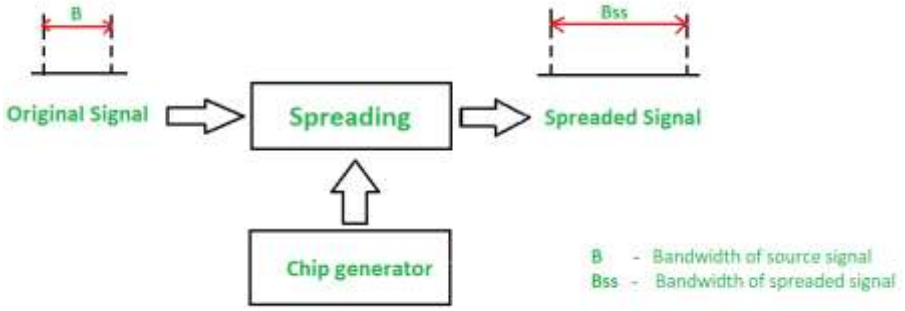
- Synchronization is not greatly dependent on distance.
- Processing Gain is higher than DSSS.

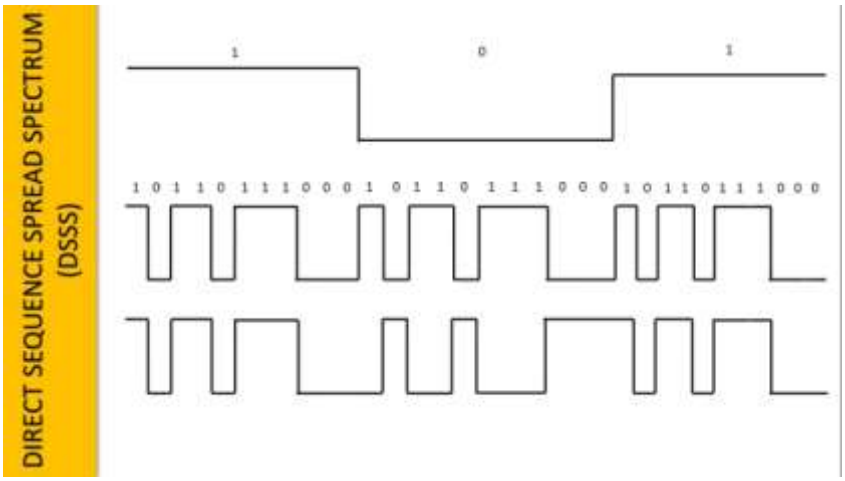
Disadvantages of FHSS:

- The bandwidth of the FHSS system is too large (in GHz).
- Complex and expensive Digital frequency synthesizers are required.

Direct Sequence Spread Spectrum (DSSS):

In DSSS, the bandwidth of the original signal is also expanded by a different technique. Here, each data bit is replaced with n bits using a spreading code called **chips,** and the bit rate of the chip is called as **chip-rate**. The chip rate is n times the bit rate of the original signal. The below Figure shows the DSSS block diagram.





Direct Sequence Spread Spectrum

In wireless LAN, the sequence with n = 11 is used. The original data is multiplied by **chips** (spreading code) to get the spread signal. The required bandwidth of the spread signal is 11 times larger than the bandwidth of the original signal.

Advantages of DSSS:

- The DSSS System combats the jamming most effectively.
- The performance of DSSS in presence of noise is superior to FHSS.
- Interference is minimized against the signals.

Disadvantages of DSSS:

- Processing Gain is lower than DSSS.
- Channel Bandwidth is less than FHSS.
- Synchronization is affected by the variable distance between the transmitter and receiver.

Cellular System

Early wireless systems had a high-power transmitter, covering the entire service area. This required a very huge amount of power and was not suitable for many practical reasons.

The cellular system replaced a large zone with a number of smaller hexagonal cells with a single BS (base station) covering a fraction of the area. Evolution of such a cellular system is shown in the given figures, with all wireless receivers located in a cell being served by a BS.

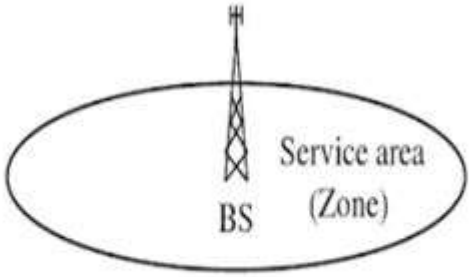


Fig: Early wireless system: large zone

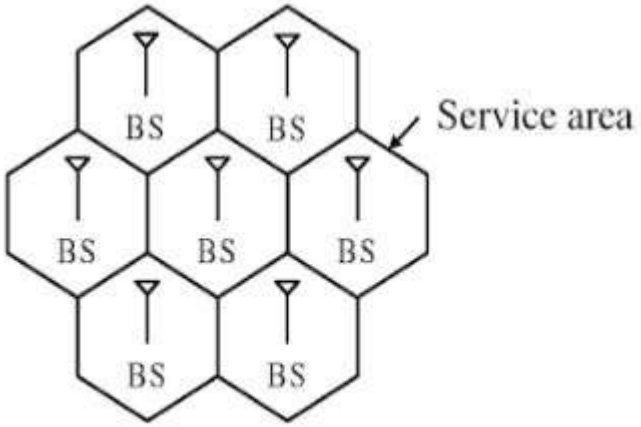


Fig: Cellular system: small zone

Wireless devices need to be supported for different types of services, the wireless device could be a wireless telephone laptop with wireless card, personal digital assistant (PDA), or web enabled phone. For simplicity, it could be called an MS.

In a cellular structure, a MS (mobile station) needs to communicate with the BS of the cell where the MS is currently located and the BS acts as a gateway to the rest of the world. Therefore, to provide a link, the MS needs to be in the area of one of the cells (and hence a BS) so that mobility of the MS can be supported. Several base stations are connected through hard-wires and are controlled by a BS controller (BSC), which in turn is connected to a mobile switching

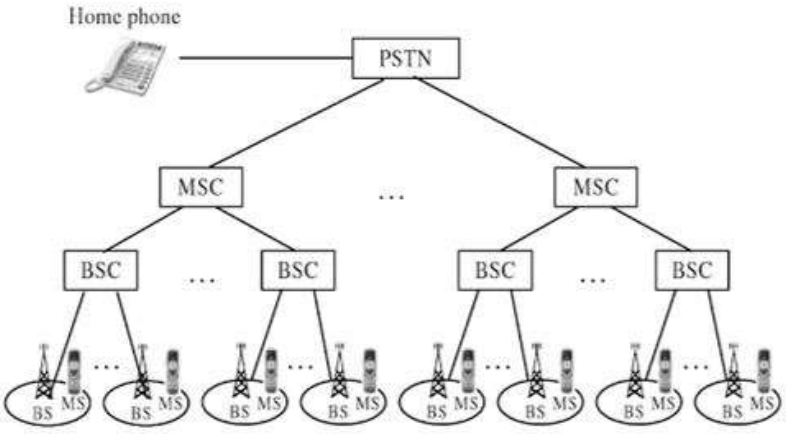
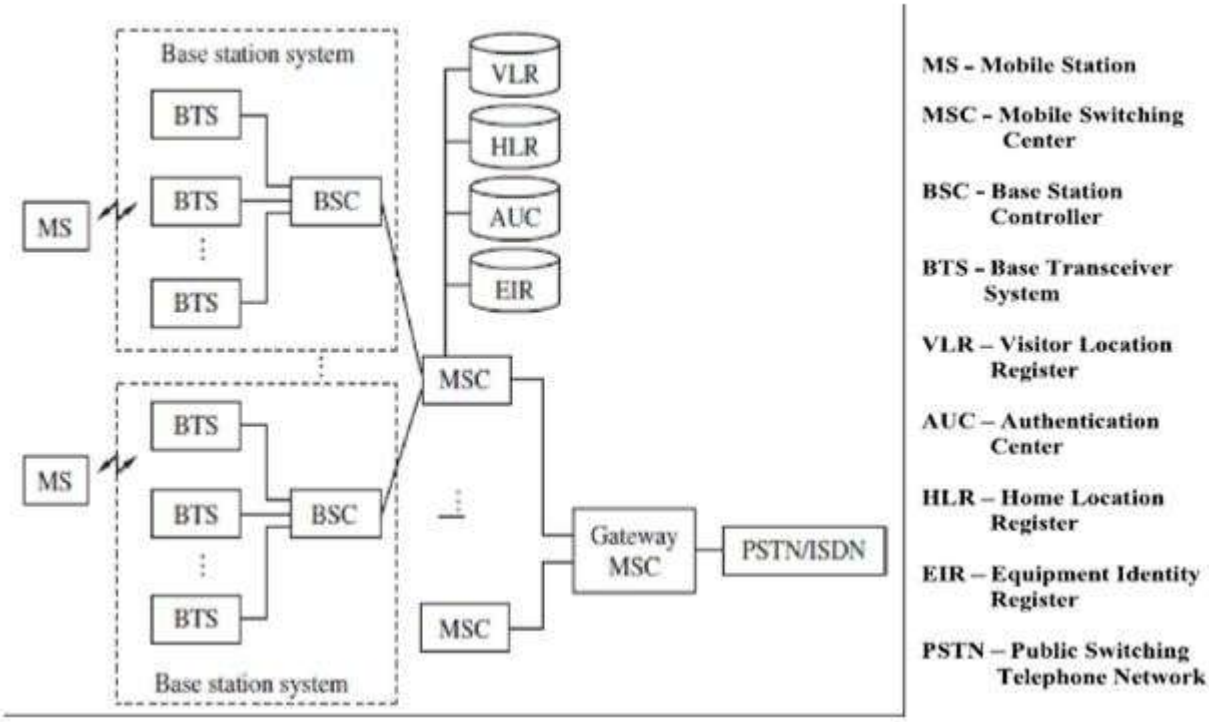


Fig: cellular system infrastructure

A cellular system requires a fairly complex infrastructure. A generic block diagram in shown in the figure:



A BS consists of a base transceiver system (BTS) and a BSC. Both tower and antenna are a part of the BTS, while all associated electronics are contained in the BSC.

The HLR (home location register) and VLR (visitor location register) are two sets of pointers that support mobility and enable the use of the same telephone numbers worldwide.

The AUC (authentication center) unit provides authentication and encryption parameters that verify the user's identity and ensure the confidentiality of each cell.

The EIR (equipment identity register) is a database that information about identity of mobile equipment. Both AUC and EIR can be implemented as individual stand-alone units or as a combined AUC/EIR unit.

The HLR is located at the MSC where MS is initially registered and is the initial home location for billing and access information.

In simple words, any incoming call, based on the calling number, is directed to the HLR of the home MS where the MS is registered. The HLR then points to the VLR of the MSC where the MS is currently located.

Bidirectional HLR-VLR pointers help in carrying out various functionalities, as illustrated in the figure:

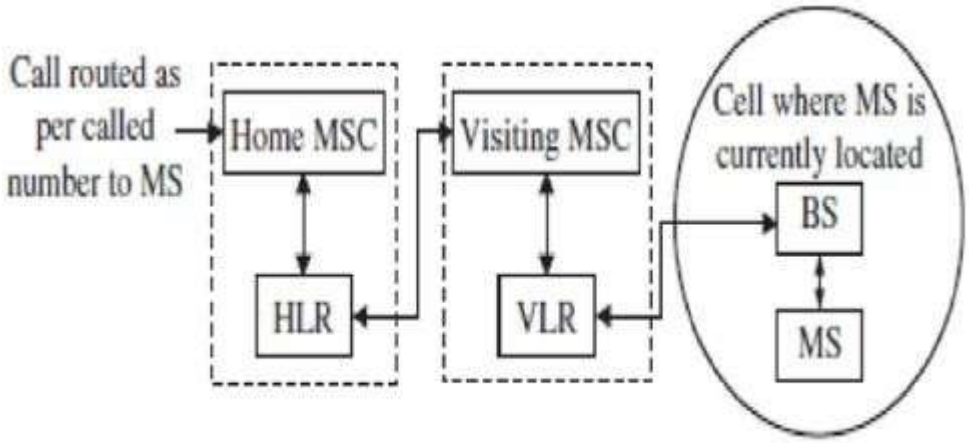


Fig: Redirection of a call to MS at a visiting location

The VLR contains information about all MS visiting that particular MSC and hence points to the HLR of the visiting MSs for exchanging related information about the MS.

Such a pointer allows calls to be routed or rerouted to the MS, wherever it is located. In cellular systems, a reverse direction pointer is needed that allows traversal of many control signals back and forth between the HLR and VLR such bidirectional HLR-VLR pointers help in carrying out various functionalities.

UNIT-4
MEDIUM ACCESS CONTROL

INTRODUCTION

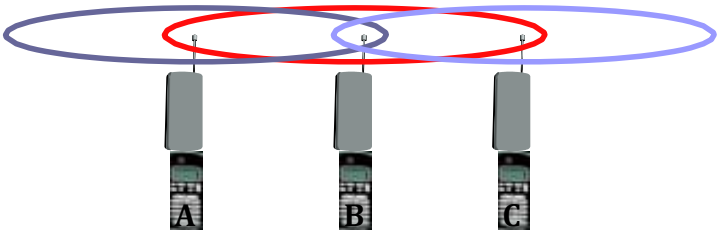
The medium access control (MAC) is a sub layer of the data link layer of the open system interconnections (OSI) reference model for data transmission. It is responsible for flow control and multiplexing for transmission medium. It controls the transmission of data packets via remotely shared channels. It sends data over the network interface card.

In wireless networks, multiple terminals need to communicate at the same time and a medium access control (MAC) protocol allows several terminals to transmit over the wireless channel and to share its capacity.MAC protocols multiplex several data streams of different terminals to share the same channel and deal with issues such as addressing, how a terminal obtains a channel when it needs one, and so forth.

HIDDEN AND EXPOSED TERMINALS

Hidden terminals: cause collisions

- A sends to B, C cannot receiveA
- C wants to send to B, C senses a "free" medium (CS fails)
- collision at B, A cannot receive the collision (CD fails)
- A is "hidden" for C: C is "hidden" for A

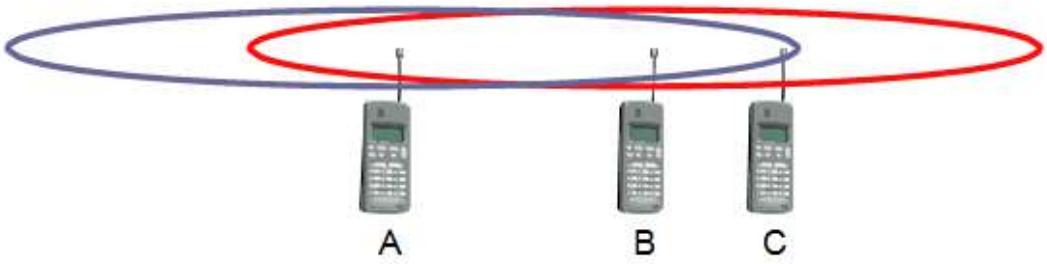


Exposed terminals: cause unnecessary delay

- B sends to A, C wants to send to another terminal (not A orB)
- C has to wait, CS signals a medium in use
- But A is outside the radio range of C, therefore waiting isnot necessary
  - A collision at B does not matter because the collision is too weak to propagate to A.
- C is "exposed" to B

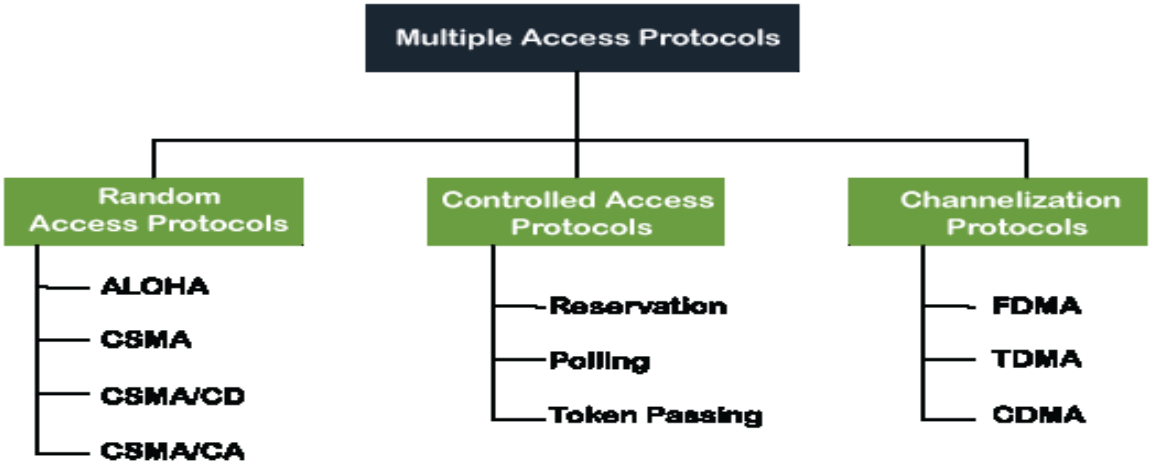
NEAR AND FAR TERMINALS

- Terminals A and B send, C receives
  - Signal strength decreases proportional to the square of thedistance
  - The signal of terminal B therefore drowns out A's signal
  - C cannot receive A



- If C for example was an arbiter (base station) for sending rights, terminal B would drown out terminal A already on the physical layer.

Following are the types of multiple access protocol that is subdivided into the different process as:



CSMA (Carrier Sense Multiple Access)

- The data link layer is used in a computer network to transmit the data between two devices or nodes.
- It divides the layer into parts such as **data link control** and the **multiple access resolution/protocol**.
- The upper layer has the responsibility to flow control and the error control in the data link layer, and hence it is termed as **logical of data link control**.
- Whereas the lower sub-layer is used to handle and reduce the collision or multiple access on a channel.
- Hence it is termed as media access control or the multiple access resolutions.
- When a sender and receiver have a dedicated link to transmit data packets, the data link control is enough to handle the channel.
- Suppose there is no dedicated path to communicate or transfer the data between two devices. In that case, multiple stations access the channel and simultaneously transmits the data over the channel.
- It may create collision and cross talk. Hence, the multiple access protocol is required to reduce the collision and avoid crosstalk between the channels.

- CSMA works on the principle that only one device can transmit signals on the network, otherwise a collision will occur resulting in the loss of data packets or frames.
- CSMA works when a device needs to initiate or transfer data over the network.
- Before transferring, each CSMA must check or listen to the network for any other transmissions that may be in progress.
- If it senses a transmission, the device will wait for it to end. Once the transmission is completed, the waiting device can transmit its data/signals.
- However, if multiple devices access it simultaneously and a collision occurs, they both have to wait for a specific time before reinitiating the transmission process.

SUMMARY:

- To minimize the chance of collision and therefore increase the performance the csma method was developed.
- Principle of CSMA: sense before transmit or listen before talk
- Two terms used here:
- carrier busy-transmission is taking place
- carrier idle-no transmission currently taking place
- It senses the traffic on a channel (idle or busy) before transmitting the data. It means that if the channel is idle, the station can send data to the channel. Otherwise, it must wait until the channel becomes idle. Hence, it reduces the chances of a collision on a transmission medium.
- The possibility of collision still exists because of propagation delay; a station may sense the medium and find it idle, only because the first bit sent by another station has not yet been received.

It has two flavors:

- CSMA/CD
- CSMA/CA

CSMA/CD-CARRIER SENSE MULTIPLE ACCESS WITH COLLISION DETECTION

- Carrier sense multiple access/collision detect (CSMA/CD) deals with transmissions after a collision has occurred.
- Half-duplex Ethernet networks have CSMA/CD built-in to deal with the challenges that come with wireless networks.
- Instead of trying to avoid collisions, CSMA/CD instructs network participants on how they should proceed when a collision does occur.
- The primary objective of CSMA/CD is to ensure that a collision does not happen on the next attempt.

SUMMARY: It is a **carrier sense multiple access/ collision detection** network protocol to transmit data frames. The CSMA/CD protocol works with a medium access control layer. Therefore, it first senses the shared channel before broadcasting the frames, and if the channel is idle, it transmits a frame to check whether the transmission was successful. If the frame is successfully received, the station sends another frame. If any collision is detected in the CSMA/CD, the station sends a jam/ stop signal to the shared channel to terminate data transmission. After that, it waits for a random time before sending a frame to a channel.

Problems in wireless networks

- Signal strength decreases proportional to the square of the distance

- The sender would apply CS and CD, but the collisions happen atthe receiver.
- It might be the case that a sender cannot "hear" the collision, i.e.,CD does not work
- Furthermore, CS might not work if, e.g., a terminal is"hidden"

CSMA/CA-CARRIER SENSE MULTIPLE ACCESS WITH COLLISION AVOIDANCE

- Carrier sense multiple access/collision avoidance (CSMA/CA) is a protocol for carrier transmission in 802.11 networks.
- It was developed to minimize the potential of a collision occurring when two or more stations send their signals over a data link layer.
- On a MAC layer protocol, CSMA/CA leverages a three-step carrier sense and transmission sequence. This approach helps to minimize the potential for collisions.
- **Carrier sense (CS).** Represents the idea that all participants may only send data over the network whenever the transmission medium is idle. CS detection will continue to check the channel, and the data will not be sent until the medium is available.
- **Multiple access (MA).** Because numerous stations share a transmission medium, it is vital that all of them adhere to a binding protocol to ensure communication.
- **Collision avoidance (CA).** A complex schedule that attempts to prevent potential collisions by ensuring that two or more participants do not initiate a transmission at the same time.
- Whenever overlapping does occur, it will be detected and the process will be repeated.

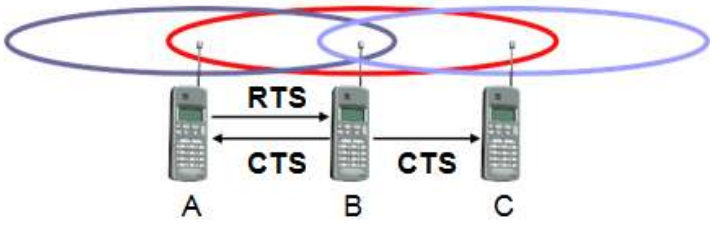
Multiple Access with Collision Avoidance-

- solves hidden terminal problem
- does not need a base station
- still random access but dynamic reservation

- **short signaling packets for collision avoidance**
  - RTS (request to send): a sender request the right to send from a receiver with a short RTS packet before it sends a data packet
  - CTS (clear to send): the receiver grants the right to send as soon as it is ready to receive
- **Signaling packets contain**
  - sender address
  - receiver address
  - packet size
- **Variants of this method can be found in IEEE802.11 as DFWMAC (Distributed Foundation Wireless MAC)**

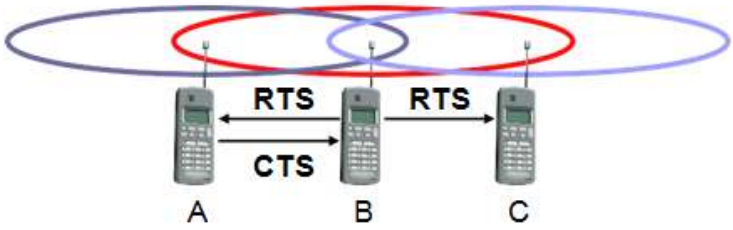
Multiple Access with Collision Avoidance avoids the problem of hidden terminals

- A and C want to send to B
- **A sends RTS first**
- C waits after receiving CTS from B



Multiple Access with Collision Avoidance avoids the problem of exposed terminals

- B wants to send to A, C to another terminal
- Now C does not have
- To wait for it cannot receive CTS from A



SUMMARY: It is a **carrier sense multiple access/collision avoidance** network protocol for carrier transmission of data frames. It is a protocol that works with a medium access control layer. When a data frame is sent to a channel, it receives an acknowledgment to check whether the channel is clear. If the station receives only a single (own) acknowledgments, that means the data frame has been successfully transmitted to the receiver. But if it gets two signals (its own and one more in which the collision of frames), a collision of the frame occurs in the shared channel. Detects the collision of the frame when a sender receives an acknowledgment signal.

Difference between CSMA/CA and CSMA/CD:-

S.NO	CSMA/CD	CSMA/CA
1.	CSMA / CD is effective after a collision.	Whereas CSMA / CA is effective before a collision.
2.	CSMA / CD is used in wired networks.	Whereas CSMA / CA is commonly used in wireless networks.
3.	It only reduces the recovery time.	Whereas CSMA/ CA minimizes the possibility of collision.
4.	CSMA / CD resends the data frame whenever a conflict occurs.	Whereas CSMA / CA will first transmit the intent to send for data transmission.
5.	CSMA / CD is used in 802.3 standard.	While CSMA / CA is used in 802.11 standard(Wi-fi)

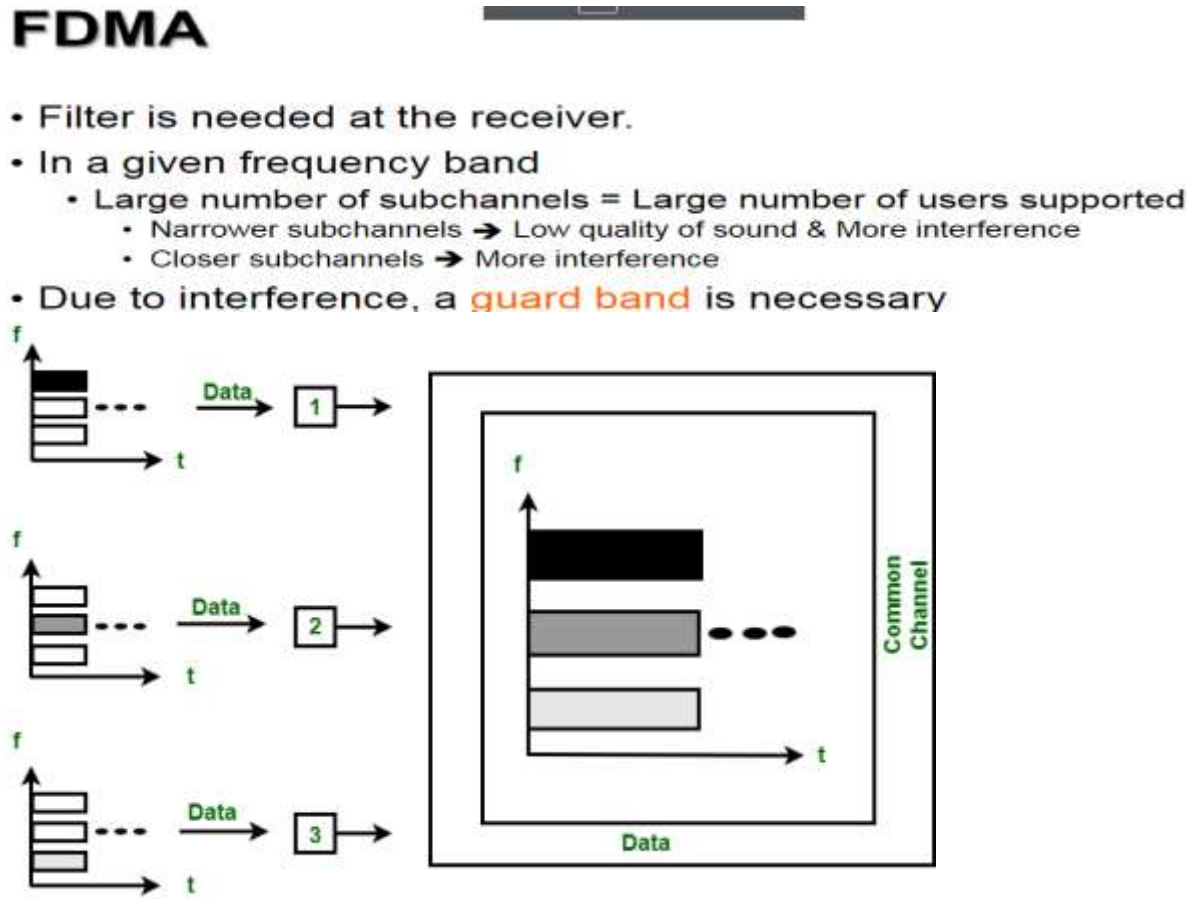
There are several different ways to allow access to the channel. These includes mainly the following –

- Frequency division multiple-access (FDMA)
- Time division multiple-access (TDMA)
- Code division multiple-access (CDMA)
- Space division multiple access (SDMA)

Frequency Division Multiple Access (FDMA)

FDMA is the basic technology for advanced mobile phone services. The features of FDMA are as follows.

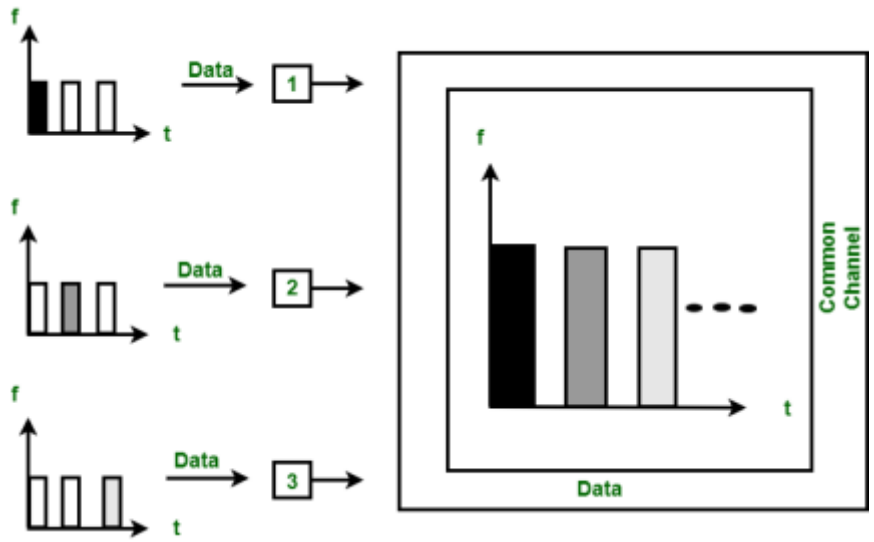
- FDMA allots a different sub-band of frequency to each different user to access the network.
- If FDMA is not in use, the channel is left idle instead of allotting to the other users.
- FDMA is implemented in Narrowband systems and it is less complex than TDMA.
- Tight filtering is done here to reduce adjacent channel interference.
- The base station BS and mobile station MS, transmit and receive simultaneously and continuously in FDMA.

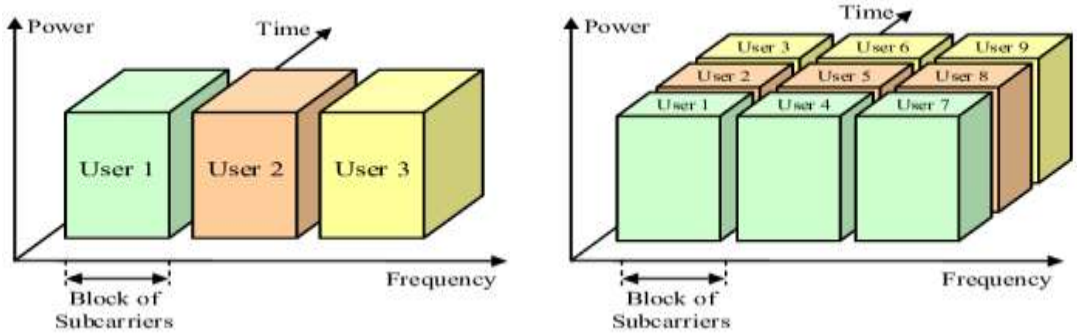


Time Division Multiple Access (TDMA)

In the cases where continuous transmission is not required, there TDMA is used instead of FDMA. The features of TDMA include the following.

- TDMA shares a single carrier frequency with several users where each users makes use of non-overlapping time slots.
- Data transmission in TDMA is not continuous, but occurs in bursts. Hence handsoff process is simpler.
- TDMA uses different time slots for transmission and reception thus duplexers are not required.
- TDMA has an advantage that is possible to allocate different numbers of time slots per frame to different users.
- Bandwidth can be supplied on demand to different users by concatenating or reassigning time slot based on priority.





FDMA (left) and FDMA with TDMA (right)

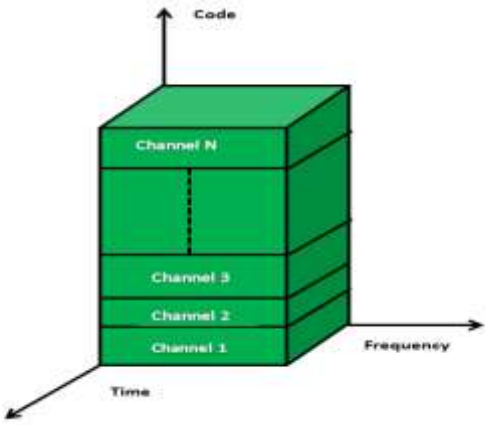
Code Division Multiple Access (CDMA)

Code division multiple access technique is an example of multiple access where several transmitters use a single channel to send information simultaneously. Its features are as follows.

- In CDMA every user uses the full available spectrum instead of getting allotted by separate frequency.
- CDMA is much recommended for voice and data communications.
- While multiple codes occupy the same channel in CDMA, the users having same code can communicate with each other.
- CDMA offers more air-space capacity than TDMA.
- The hands-off between base stations is very well handled by CDMA.

CDMA

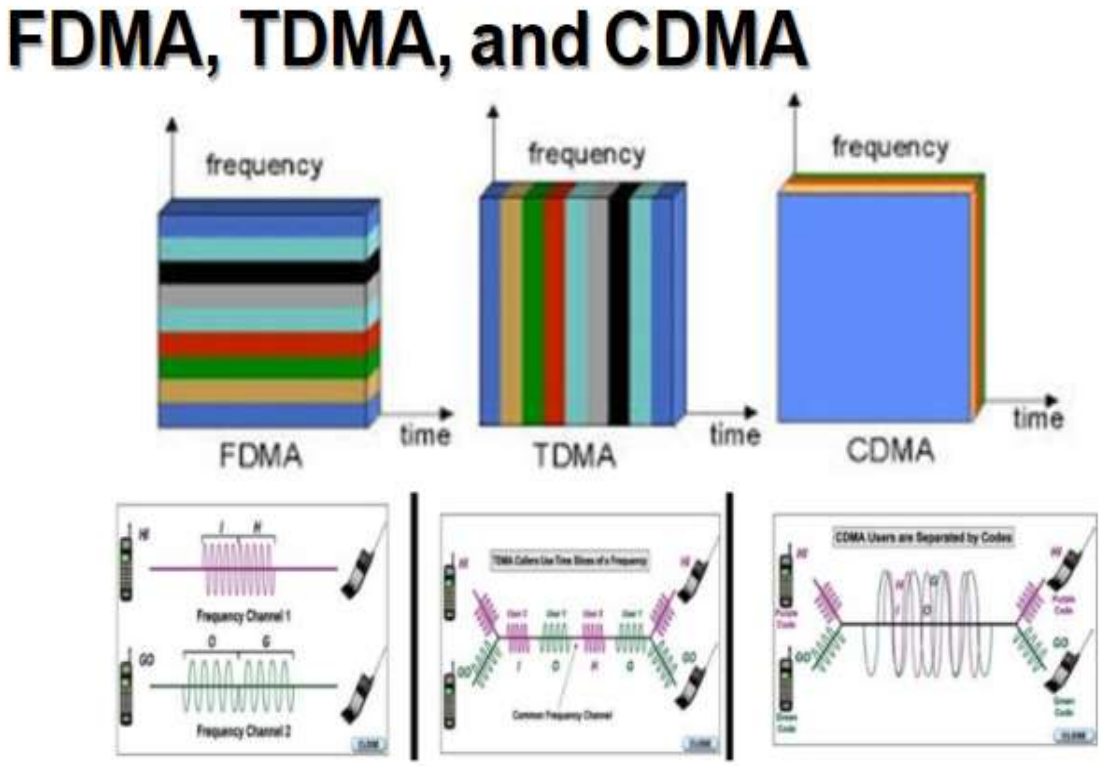
- Multiple signals in the same frequency band and in the same time slot.
- Each signal uses a different code (i.e., a spread spectrum code)
- Originally Spread Spectrum technology for a military use.
  - More secure against an eavesdropping
  - More resilient against a noise
- The receiver, must know:
  - Spread spectrum code
  - The time the code was generated ➔ Need to be synchronized
    - Currently use GPS (Global Positioning System)
-



Space Division Multiple Access (SDMA)

Space division multiple access or spatial division multiple access is a technique which is MIMO (multiple-input multiple-output) architecture and used mostly in wireless and satellite communication. It has the following features.

- All users can communicate at the same time using the same channel.
- SDMA is completely free from interference.
- A single satellite can communicate with more satellites receivers of the same frequency.
- The directional spot-beam antennas are used and hence the base station in SDMA, can track a moving user.
- Controls the radiated energy for each user in space.



Difference between FDMA, TDMA, and CDMA

Parameters	FDMA	TDMA	CDMA
Full Form	The term FDMA is an acronym for Frequency Division Multiple Access.	The term TDMA is an acronym for Time Division Multiple Access.	The term CDMA is an acronym for Code Division Multiple Access.
Mode of Operation	FDMA shares one single bandwidth among various stations by splitting it into sub-channels.	TDMA only shares the time of transmission via the satellite and not the channel.	The CDMA shares both- time and bandwidth among various stations by assigning a different code for every slot.
Idea of Transmission	It segments a single band of frequency into various disjoint sub-bands.	It segments the sending time of data into disjoint time slots- in a fixed or demand-driven pattern.	It spreads one spectrum into multiple slots by making use of orthogonal codes.
Codeword	The FDMA doesn't need a codeword.	The TDMA also needs no codeword.	The codeword is a prerequisite in the case of the CDMA.
Synchronization	FDMA does not require any synchronization.	TDMA requires synchronization.	CDMA also requires no synchronization.
Data Transmission Mode	Transmission occurs via a continuous signal in FDMA.	Transmission occurs via signals in bursts.	Transmission occurs via digital signals.
Rate of Data	FDMA supports a low rate of data.	TDMA supports a medium rate of data.	CDMA supports a high rate of data.
Flexibility	FDMA is a little flexible.	Flexibility is moderate in TDMA.	CDMA is highly flexible in nature.

Terminals	Every terminal possesses its own uninterrupted frequency.	Every terminal on the same frequency stays active for a very short time.	Every terminal can stay active during the same moment and the same place without any interruption.
Separation of Signals	It occurs by the process of filtration in the frequency domain.	It occurs by synchronizing the time domain.	It occurs via codes along with some special receivers.
Scheme of Transmission	It is continuous for FDMA.	It is discontinuous for TDMA.	It is continuous for CDMA.
Capacity of Cells	FDMA has a very limited cell capacity.	TDMA also has a very limited cell capacity.	CDMA does not possess any limit on a channel's capacity- but this system is interference-limited.
Advantages	FDMA is robust, established, and very simple.	TDMA is very flexible, fully digital, and established.	CDMA is flexible, requires lesser frequency planning, and has a softer handover of signals.
Disadvantages	FDMA is not very flexible, and the frequencies it possesses are a scarce resource.	TDMA needs guard space (for multipath propagation).	CDMA deals with very complex receivers. The senders/ transmitters require a more complicated form of power control.
Comment	FDMA typically combines with SDMA (Space Division Multiple Access) and TDMA.	TDMA holds the standards in a fixed network. Many mobile networks combine it by using it together with SDMA or FDMA.	CDMA still faces some major issues. It is highly complex and has lower expectations. It will probably integrate with FDMA and TDMA.

SUMMARY:

Access methods SDMA/FDMA/TDMA

SDMA (Space Division Multiple Access)

- allocating separate space to users in wireless networks.
- segment space into cells, or sectors with directed antennas
- SDMA is never used in isolation.
    - But always in combination with one or more other schemes (FDMA, TDMA, CDMA)

FDMA (Frequency Division Multiple Access)

- assign a certain frequency to a transmission channel between a sender and a receiver
- permanent (e.g., radio broadcast), slow hopping (e.g., GSM), fast hopping (FHSS, Frequency Hopping Spread Spectrum)
- Frequency Division Duplex (FDD)
    - used to divide up-link & down link channels.

TDMA (Time Division Multiple Access)

- assign the fixed sending frequency to a transmission channel between a sender and a receiver for a certain amount of time
- Fixed : (fixed TDM)
    - Allocating a certain time slot for a channel in a fixed pattern.
- Dynamic (Aloha)
    - MAC addresses are open used as identification.
    - It is flexible considering varying bandwidth requirements.

UNIT-5

WIRELESS LAN

Introduction

Wireless communication involves the transmission of information over a distance without the help of wires, cables or any other forms of electrical conductors.

Wireless communication is a broad term that incorporates all procedures and forms of connecting and communicating between two or more devices using a wireless signal through wireless communication technologies and devices.

Features of Wireless Communication

The evolution of wireless technology has brought many advancements with its effective features.

- The transmitted distance can be anywhere between a few meters (for example, a television's remote control) and thousands of kilometers (for example, radio communication).
- Wireless communication can be used for cellular telephony, wireless access to the internet, wireless home networking, and so on.
- Other examples of applications of radio wireless technology include GPS units, garage door openers, wireless computer mice, keyboards and headsets, headphones, radio receivers, satellite television, broadcast television and cordless telephones.

Wireless - Advantages

Wireless communication involves transfer of information without any physical connection between two or more points. Because of this absence of any 'physical infrastructure', wireless communication has certain advantages. This would often include collapsing distance or space.

Wireless communication has several advantages; the most important ones are discussed below −

Cost effectiveness

Wired communication entails the use of connection wires. In wireless networks, communication does not require elaborate physical infrastructure or maintenance practices. Hence the cost is reduced.

Example − Any company providing wireless communication services does not incur a lot of costs, and as a result, it is able to charge cheaply with regard to its customer fees.

Flexibility

Wireless communication enables people to communicate regardless of their location. It is not necessary to be in an office or some telephone booth in order to pass and receive messages.

Miners in the outback can rely on satellite phones to call their loved ones, and thus, help improve **their general welfare by keeping them in touch with the people who mean the most to them.**

Convenience

Wireless communication devices like mobile phones are quite simple and therefore allow anyone to use them, wherever they may be. There is no need to physically connect anything in order to receive or pass messages.

Example − Wireless communications services can also be seen in Internet technologies such as Wi-Fi. With no network cables hampering movement, we can now connect with almost anyone, anywhere, anytime.

Speed

Improvements can also be seen in speed. The network connectivity or the accessibility were much improved in accuracy and speed.

Example – A wireless remote can operate a system faster than a wired one. The wireless control of a machine can easily stop its working if something goes wrong, whereas direct operation can't act so fast.

Accessibility

The wireless technology helps easy accessibility as the remote areas where ground lines can't be properly laid, are being easily connected to the network.

Example – In rural regions, online education is now possible. Educators no longer need to travel to far-flung areas to teach their lessons. Thanks to live streaming of their educational modules.

Constant connectivity

Constant connectivity also ensures that people can respond to emergencies relatively quickly.

Example – A wireless mobile can ensure you a constant connectivity though you move from place to place or while you travel, whereas a wired land line can't.

UNIT-6

UBIQUITOUS WIRELESS COMMUNICATION

INTRODUCTION

With the developing of wireless technologies and networks, isolated network makes no sense without interconnection with each other in the future. The ubiquitous wireless mobile networks and systems aim to integrate various kinds of wireless heterogeneous networks so as to achieve intercommunication with anyone and/or anything at anytime from anywhere. In this article the primary concept and applications of the ubiquitous wireless mobile networks and systems are comprehensively reviewed. Key basic techniques for the ubiquitous mobile networks developing are discussed. In the end, some promising wireless heterogeneous networks integration in the nearly future are presented.

Ubiquitous computing (ubicomp) is a concept in software engineering and computer science where computing is made to appear everywhere and anywhere.

Mobile computing devices have changed the way we look at computing laptops and PDS have an changed us from our desktop computers a group of researchers at AT&T Laboratories Cambridge are preparing to put a new spin on mobile computing in addition to taking the hardware with you they are designing a ubiquitous networking system that allows your program applications to follow everywhere you whenever you go .

the idea of anywhere anytime by anything and anyone networking is at the core of a new emerging networking Technology referred to as a ubiquitous networking the the term ubiquitous is letting meaning being everywhere especially at the same time the concept of ubiquitous networking originated from the concept of ubiquitous computing which was aimed to make many computers available throughout the physical environment while making them effectively invisible to the users

Ubiquitous networking, also known as pervasive networking, is the distribution of communications infrastructure and wireless technologies throughout the environment to enable continuous connectivity. That capacity is an essential component of pervasive computing. (The terms are interchangeable, with slight variations, as either "ubiquitous" or "pervasive," which mean essentially the same thing.)

WHAT IS PERVASIVE COMPUTING? ∗ Pervasive computing is a term for the strongly emerging trend toward: ∗ Numerous, casually accessible, often invisible computing devices ∗ Frequently mobile or embedded in the environment ∗ Connected to an increasingly ubiquitous network structure.

Four main objectives of ubiquitous networking are as follows from networking constraints concerning capacity location and different link ups the constraints of terminal limitations from the constant of limited service and contains the constraint of network risk

Scenario of Mobile Communication

an industry has witnessed explosive growth in the number of subscribers particularly over the past few years however while usage measured in terms of the number of wireless minutes is increasing the price per minute for this services is falling average revenue per user is drinking profitable business with stagnant or even declining a rpu is one of the fundamental challenges mobile Carriers are facing today the industry is addressing this challenge in two ways new services for new user experiences mobile subscribers are willing to pay operation operating expenses of pets top of the is the violin infrastructure that mobile operators have to maintain regardless of whether they on on lease lines two primary ecosystems in the wireless industry term for mobile communications GSM code division multiple access CDMA

MOBILE COMMUNICATION GENERATIONP:1G to 3G

The cellular communications networks are known by their numeric generation: 1G, 2G, 3G, 4G and 5G. We are currently fully deployed in 4G with 5G gaining ground.

5G

The latest cellular generation began in 2018 and will take several years for nationwide adoption. 5G increases speed but at a cost of deploying many more cell towers when the high frequencies are used .

4G – LTE

Starting in the 2011 time frame, GSM and CDMA carriers embraced LTE, which offers higher speeds than 3G. 4G LTE integrates all communications (data, voice and video) using the IP protocol.]

4G – WiMAX

Sprint was the first carrier to offer a 4G network in the U.S using the WiMAX technology. It was rolled out to major cities in 2009 but was eventually dropped in favor of LTE.

4G - HSPA+

In late 2010, the ITU officially designated HSPA+ as a 4G technology, having previously defined it as

3G.

3G - WCDMA/HSDPA and CDMA2000

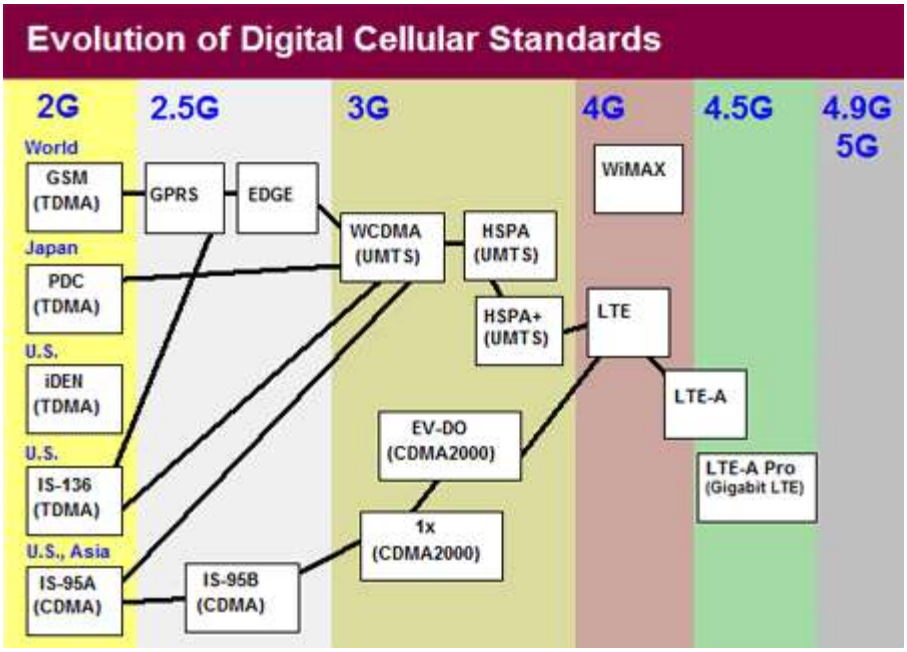
Launched after the turn of the century, the third generation features faster Internet access with downstream speeds up to 1 Mbps and more. The predominant 3G technologies on the GSM side are WCDMA and HSDPA with CDMA2000 on the CDMA side). 3G also embraces worldwide roaming for travellers.

2G/2.5G - GSM/CDMA, GPRS/EDGE/IS95-B

The second generation refers to the digital voice systems of the 1990s, replacing analog phones and based on the TDMA and CDMA air interfaces. First deployed in Europe, GSM became the predominant TDMA system worldwide. Data networks were added (GPRS, EDGE, IS-95B), and these so-called 2.5G technologies enabled Internet access and email with slow downstream speeds in the Kbps range.

1G - Analog Voice

Introduced in the late 1970s, the first cellular systems were analog voice. Years later, some 1G cellphones occasionally provided wireless data service to a laptop by connecting them to the laptop's dial-up modem, but hookups were precarious and the data transfer rate was minuscule.



While you connected to internet, the speed of your internet is depends upon the signal strength that has been shown in alphabets like 2G, 3G, 4G etc. right next to the signal bar on your home screen. Each Generation is defined as a set of telephone network standards , which detail the technological implementation of a particular mobile phone system. The speed increases and the technology used to achieve that speed also changes. For eg, 1G offers 2.4 kbps, 2G offers 64 Kbps and is based on GSM, 3G offers 144 kbps-2 mbps whereas 4G offers 100 Mbps - 1 Gbps and is based on LTE technology .

Features	1G	2G	3G	4G	5G
Start/Devlopment	1970/1984	1980/1999	1990/2002	2000/2010	2010/2015
Technology	AMPS, NMT, TACS	GSM	WCDMA	LTE, WiMax	MIMO, mm Waves
Frequency	30 KHz	1.8 Ghz	1.6 - 2 GHz	2 - 8 GHz	3 - 30 Ghz
Bandwidth	2 kbps	14.4 - 64 kbps	2 Mbps	2000 Mbps to 1 Gbps	1 Gbps and higher
AccessSystem	FDMA	TDMA/CDMA	CDMA	CDMA	OFDM/BDMA
Core Network	PSTN	PSTN	Packet Network	Internet	Internet

The aim of wireless communication is to provide high quality, reliable communication just like wired communication(optical fibre) and each new generation of services represents a big step(a leap rather) in that direction. This evolution journey was started in 1979 from 1G and it is still continuing to 5G. Each of the Generations has standards that must be met to officially use the G terminology. There are institutions in charge of standardizing each generation of mobile technology. Each generation has requirements that specify things like throughput, delay, etc. that need to be met to be

considered part of that generation. Each generation built upon the research and development which happened since the last generation. 1G was not used to identify wireless technology until 2G, or the second generation, was released. That was a major jump in the technology when the wireless networks went from analog to digital .

1G - First Generation

This was the first generation of cell phone technology . The very first generation of commercial cellular network was introduced in the late 70's with fully implemented standards being established throughout the 80's. It was introduced in 1987 by Telecom (known today as Telstra), Australia received its first cellular mobile phone network utilising a 1G analog system. 1G is an analog technology and the phones generally had poor battery life and voice quality was large without much security, and would sometimes experience dropped calls . These are the analog telecommunications standards that were introduced in the 1980s and continued until being replaced by 2G digital telecommunications. The maximum speed of 1G is 2.4 Kbps .

2G - Second Generation

Cell phones received their first major upgrade when they went from 1G to 2G. The main difference between the two mobile telephone systems (1G and 2G), is that the radio signals used by 1G network are analog, while 2G networks are digital . Main motive of this generation was to provide secure and reliable communication channel. It implemented the concept of CDMA and GSM . Provided small data service like sms and mms. Second generation 2G cellular telecom networks were commercially launched on the GSM standard in Finland by Radiolinja (now part of Elisa Oyj) in 1991. 2G capabilities are achieved by allowing multiple users on a single channel via multiplexing. During 2G Cellular phones are used for data also along with voice. The advance in technology from 1G to 2G introduced many of the fundamental services that we still use today, such as SMS, internal roaming , conference calls, call hold and billing based on services e.g. charges based on long distance calls and real time billing. The max speed of 2G with General Packet Radio Service (GPRS) is 50 Kbps or 1 Mbps with Enhanced Data Rates for GSM Evolution (EDGE). Before making the major leap from 2G to 3G wireless networks, the lesser-known 2.5G and 2.75G was an interim standard that bridged the gap.

3G - Third Generation

This generation set the standards for most of the wireless technology we have come to know and love. Web browsing, email, video downloading, picture sharing and other Smartphone

technology were introduced in the third generation. Introduced commercially in 2001, the goals set out for third generation mobile communication were to facilitate greater voice and data capacity, support a wider range of applications, and increase data transmission at a lower cost .

The 3G standard utilises a new technology called UMTS as its core network architecture - Universal Mobile Telecommunications System. This network combines aspects of the 2G network with some new technology and protocols to deliver a significantly faster data rate. Based on a set of standards used for mobile devices and mobile telecommunications use services and networks that comply with the International Mobile Telecommunications-2000 (IMT-2000) specifications by the International Telecommunication Union. One of requirements set by IMT-2000 was that speed should be at least 200Kbps to call it as 3G service.

3G has Multimedia services support along with streaming are more popular. In 3G, Universal access and portability across different device types are made possible (Telephones, PDA's, etc.). 3G increased the efficiency of frequency spectrum by improving how audio is compressed during a call, so more simultaneous calls can happen in the same frequency range. The UN's International Telecommunications Union IMT-2000 standard requires stationary speeds of 2Mbps and mobile speeds of 384kbps for a "true" 3G. The theoretical max speed for HSPA+ is 21.6 Mbps.

Like 2G, 3G evolved into 3.5G and 3.75G as more features were introduced in order to bring about 4G. A 3G phone cannot communicate through a 4G network , but newer generations of phones are practically always designed to be backward compatible, so a 4G phone can communicate through a 3G or even 2G network .

4G - Fourth Generation

4G is a very different technology as compared to 3G and was made possible practically only because of the advancements in the technology in the last 10 years. Its purpose is to provide high speed , high quality and high capacity to users while improving security and lower the cost of voice and data services, multimedia and internet over IP. Potential and current applications include amended mobile web access, IP telephony , gaming services, high-definition mobile TV, video conferencing, 3D television, and cloud computing.

The key technologies that have made this possible are MIMO (Multiple Input Multiple Output) and OFDM (Orthogonal Frequency Division Multiplexing). The two important 4G standards are WiMAX (has now fizzled out) and LTE (has seen widespread deployment). LTE (Long Term Evolution) is a series of upgrades to existing UMTS technology and will be rolled out on Telstra's existing 1800MHz frequency band. The max speed of a 4G network when the device is moving is 100 Mbps or 1 Gbps for low mobility communication like when stationary or walking, latency reduced from around 300ms to less than 100ms, and significantly lower congestion. When 4G first became available, it was simply a little faster than 3G. 4G is not the same as 4G LTE which is very close to meeting the criteria of the standards. To download a new game or stream a TV show in HD, you can do it without buffering .

Newer generations of phones are usually designed to be backward-compatible , so a 4G phone can communicate through a 3G or even 2G network. All carriers seem to agree that OFDM is one of the chief indicators that a service can be legitimately marketed as being 4G. OFDM is a type of digital modulation in which a signal is split into several narrowband channels at different frequencies. There are a significant amount of infrastructure changes needed to be implemented by service providers in order to supply because voice calls in GSM , UMTS and CDMA2000 are circuit switched, so with the adoption of LTE, carriers will have to re-engineer their voice call network. And again, we have the fractional parts: 4.5G and 4.9G marking the transition of LTE (in the stage called LTE-Advanced Pro) getting us more MIMO, more D2D on the way to IMT-2020 and the requirements of 5G .

5G - Fifth Generation

5G is a generation currently under development , that's intended to improve on 4G. 5G promises significantly faster data rates, higher connection density, much lower latency, among other improvements. Some of the plans for 5G include device-to-device communication, better battery consumption, and improved overall wireless coverage. The max speed of 5G is aimed at being as fast as 35.46 Gbps , which is over 35 times faster than 4G.

Key technologies to look out for: Massive MIMO , Millimeter Wave Mobile Communications etc. Massive MIMO, milimetre wave, small cells, Li-Fi all the new technologies from the previous decade could be used to give 10Gb/s to a user, with an unseen low latency, and allow connections for at least 100 billion devices . Different estimations have been made for the date of commercial introduction of 5G networks. Next Generation Mobile Networks Alliance feel that 5G should be rolled out by 2020 to meet business and consumer demands.

Generations of wireless communication

- Last Updated : 12 Oct, 2020

We have made very huge improvements in wireless communication and have expanded the capabilities of our wireless communication system. We all have seen various generations in our life. Let's discuss them one by one.

1G (1st Generation) :

- First time calling was introduced in mobile systems.
- It used analog signals.
- It used FDD scheme and typically allocated bandwidth of 25 Mhz.
- Coverage area was small.
- No roaming support between various operators.
- Low sound quality.
- Speed :- 24 kbps.

2G (2nd Generation) :

- Shifted from analog to digital.
- It supported voice and SMS both.
- Supported all 4 sectors of wireless industry namely Digital cellular, Mobile Data, PCS, WLAN,
- Moderate mobile data service.
- 2G WLAN provided high data rate & large area coverage.
- Speed :- 64 kbps.

2.5G came after 2G which used the concept of GPRS. Streaming was also introduced and mail services too.

Then came 2.75G or EDGE which was faster in providing services then 2.5G. It gave faster internet speed upto 128kbps and also used edge connection.

3G (3rd Generation) :

- Internet system was improved.
- Better system and capacity.
- Offers high speed wireless internet.
- Connection used was UMTS and WCMA.
- Speed :- 2mbps.

4G (4th Generation) :

- IP based protocols.
- LTE (Long term evaluation) was mainly for internet.
- Vo-LTE (Voice over LTE) is for both voice and internet.
- Freedom and flexibility to select any desired service with reasonable QOS.
- High usability.
- Supports multimedia service at low transmission cost.
- HD quality Streaming.

- Speed :-100mbps.

5G (5th Generation) :

It is yet to come in many countries but here are some notable points about 5G .

- Higher data rates rates.
- Connectivity will be more fast and secure,
- Data Latency will be reduced to a great level.
- Massive network capacity.
- It is 30 times faster than 4G.
- There would be more flexibility in the network.

UNIVERSAL MOBILE TELECOMMUNICATION SYSTEM

UMTS (Universal Mobile Telecommunications Service) is a third-generation (3G) broadband, packet-based transmission of text, digitized voice, video, and multimedia at data rates up to 2 megabits per second (Mbps).

UMTS offers a consistent set of services to mobile computer and phone users, no matter where they are located in the world.

UMTS is based on the **Global System for Mobile (**GSM**)** communication standard. It is also endorsed by major standards bodies and manufacturers as the planned standard for mobile users around the world.

Once UMTS is fully available, computer and phone users can be constantly attached to the Internet wherever they travel and, as they roam, will have the same set of capabilities.

Users will have access through a combination of terrestrial wireless and satellite transmissions.

Until UMTS is fully implemented, users can use multi-mode devices that switch to the currently available technology (such as GSM 900 and 1800) where UMTS is not yet available.

Previous cellular telephone systems were mainly circuit-switched, meaning connections were always dependent on circuit availability.

A packet-switched connection uses the Internet Protocol (IP), meaning that a virtual connection is always available to any other end point in the network.

UMTS also makes it possible to provide new services like alternative billing methods or calling plans.

For instance, users can choose to pay-per-bit, pay-per-session, flat rate, or asymmetric bandwidth options. The higher bandwidth of UMTS also enables other new services like video conferencing or IPTV.

UMTS may allow the Virtual Home Environment (VHE) to fully develop, where a roaming user can have the same services to either at home, in the office or in the field through a combination of transparent terrestrial and satellite connections.

The electromagnetic radiation spectrum for UMTS has been identified as frequency bands 1885-2025 MHz for future IMT-2000 systems, and 1980-2010 MHz and 2170-2200 MHz for the satellite portion of UMTS systems.

OBJECTIVES

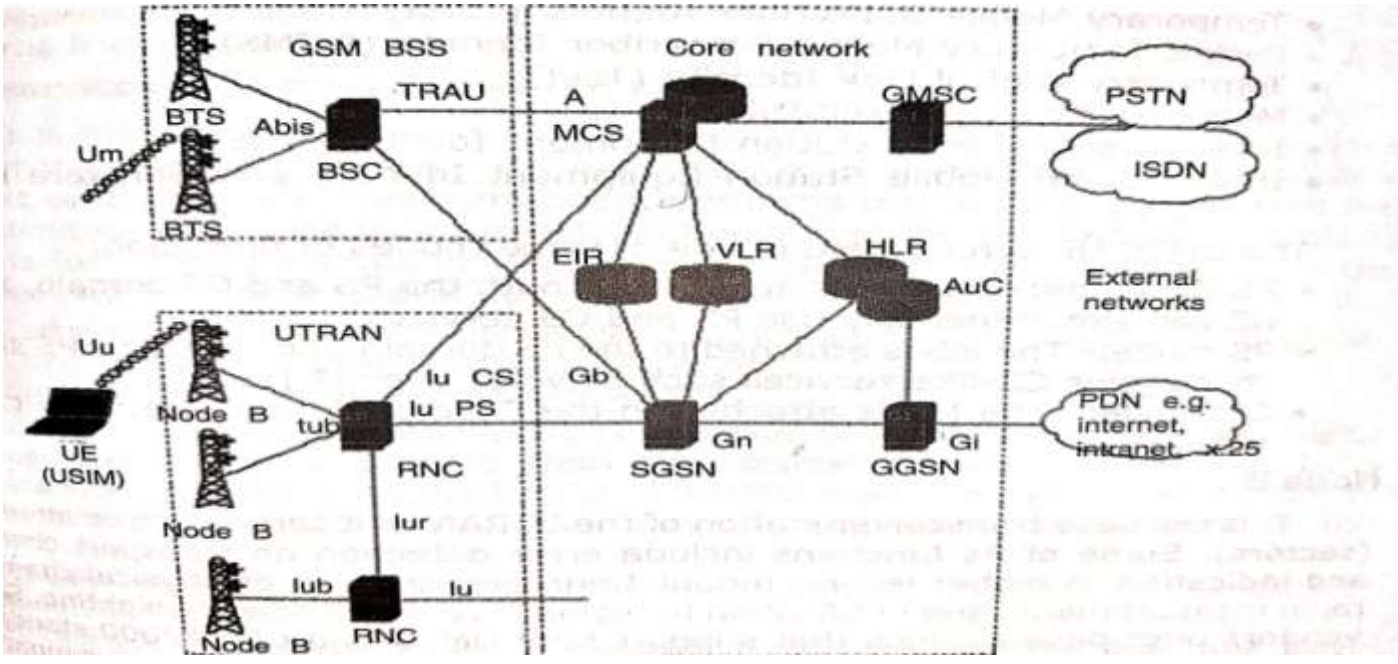
UMTS delivers the 3G services based on global standard IMT 2000. The main objectives of UMTS are as follows,

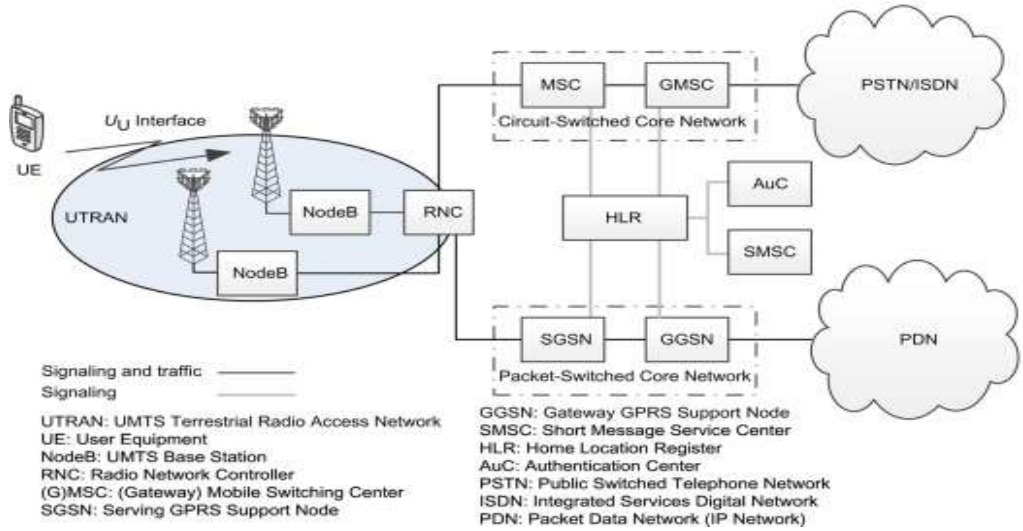
- Use of frequency bands of 1885 MHz - 2025 MHz and 2110 MHz - 2200 MHz as defined in IMT 2000 standard
- High frequency spectrum efficiency
- Integration of multiple networks such as terrestrial, satellite and indoor networks in a single system and one user equipment with low cost

- Seamless and global radio coverage
- Quality of service (QoS) comparable to current fixed networks
- No compromise in security on mobile use
- Service capability from text and voice up to multimedia for the whole population using satellite networks at low cost
- Numbering system independent of network and service provider
- Separation of service provision and network operation
- Flexibility for the introduction of new services and technical capabilities.

UMTS SERVICES

The UMTS network architecture





The UMTS network architecture can be divided into three main elements

1**. UE** or the mobile terminal.

2. **UMTS Terrestrial Radio Access Network (UTRAN):** UTRAN provides and manages the air interface for the overall UMTS network which consists of two main components:

a.

Radio Network Controller (RNC): This element of the radio network subsystem controls the NodeBs that are connected to it. The RNC undertakes the radio resource management and some of the mobility management functions. It is also the point at which the data encryption/decryption is performed to protect the user data privacy.

b.

NodeB: NodeB is the term used in UMTS to denote the base station transceiver. It contains the transmitter and receiver to communicate with the UEs within the cell. In order to facilitate effective HO between NodeBs under the control of different RNCs, the RNC communicates not only with the CN but also with neighboring RNCs.

3. **Core network:** The CN provides central processing and management for the system as well as interface to external networks, including [circuit-switched] public phone network and other cellular networks. The UMTS CN may be divided into two different areas:

a.

Circuit-switched elements: These elements are primarily based on the GSM network entities and carry data in a circuit-switched manner; that is, a dedicated channel for the duration of the call.

b.

Packet-switched elements: These network entities are designed to carry packet data. This enables much higher network usage as the capacity can be shared and data is carried as packets which are routed according to their destination.

The UMTS network architecture was required to provide a greater level of performance relative to GSM network. However, as many networks had migrated through the use of GPRS and EDGE, they already had the ability to carry data. Accordingly, many of the elements required for the UMTS network architecture were seen as a migration. This considerably reduced the cost of implementing the UMTS network as many elements were in place or needed simple upgrades.

Some network elements in UMTS CN, particularly those that are associated with registration, are shared by both circuit-switched and packet-switched domains and operate in the same way as they did with GSM. Fig. 15.17 shows the UMTS CN architecture. The circuit-switched elements of the UMTS CN architecture include the following network entities:

• MSC: This entity is essentially the same as that in the GSM network and manages the circuit-switched call flows.

• Gateway MSC (GMSC): This is the interface to the external networks.

The packet-switched elements of the UMTS CN architecture include the following network entities:

• Serving GPRS Support Node (SGSN): This entity was first developed when GPRS was introduced, and its use has been carried over to the UMTS network architecture. The SGSN provides a number of functions within the UMTS network architecture including the following:

- Mobility management: when a UE attaches to the packet-switched domain of the UMTS CN, SGSN generates mobility management information based on the mobile's current location.
- Session management: SGSN manages the data sessions providing the required QoS and also managing what are referred to as the Packet Data Protocol (PDP) contexts; that is, data bearers.
- Interaction with other network elements: SGSN is able to manage its elements within the network only by communicating with other areas of the network; for example, MSC and other circuit-switched areas.
- Billing: SGSN is also responsible billing. It achieves this by monitoring the flow of user data across the GPRS network. Call detail records are generated by SGSN before being transferred to the charging entities.

- Gateway GPRS Support Node (GGSN): This entity was also first introduced in the GPRS network. GGSN is the central element within the UMTS packet-switched network. It handles interworking between the UMTS packet-switched network and external packet-switched networks and can be considered as a sophisticated router. In terms of operation, when GGSN receives data addressed to a specific user, it checks if the user is active and then forwards the data to the SGSN serving that particular UE.

i. A UMTS system can be divided into a set of domains and the reference points that interconnect them.

ii. The UMTS network architecture is partly based on existing 2G network components and some new 3G network components. It inherits the basic functional elements from the GSM architecture on the core network (CN) side.

iii. The MS of GSM is referred as user equipment (UE) in UMTS. The MSC has quite similar functions both in GSM and UMTS. Instead of circuit-switched services for packet data, a new packet node SGSN is introduced. This SGSN is capable of supporting data rates of up to 2 Mbps.

iv. The core-network elements are connected to the radio network via the Iu interface, which is very similar to the A-interface used in GSM.

v. The major changes in the UMTS architecture are in the Radio Access Network (RAN), which is also called UMTS terrestrial RAN (UTRAN). There is a totally new interface called Iur,which connects two neighbouring Radio Network Controllers (RNCs).BSs are connected to the RNC via the Iub interface.

UMTS terrestrial RAN (UTRAN)

i. UTRAN consist of Radio Network Subsystems (RNSs). The RNS has two main elements: Node B and a Radio Network Controllers (RNC). ii. Radio network controller (RNC):

- The RNC is responsible for control of the radio resources in its area. One RNC controls multiple nodes B.
- The RNC in UMTS provides functions equivalent to the Base Station Controller (BSC) functions in GSM/GPRS networks.
- The major difference is that RNCs have more intelligence built-in than their GSM/GPRS counterparts. For example, RNCs can autonomously manage handovers without involving MSCs and SGSNs.

iii. Node B:

- The Node B is responsible for air-interface processing and some radio-resource management functions.
- The Node B in UMTS networks provides functions equivalent to the base transceiver station (BTS) in GSM/GPRS networks. UMTS operates at higher frequencies than GSM/GPRS and therefore the signal coverage range is less.

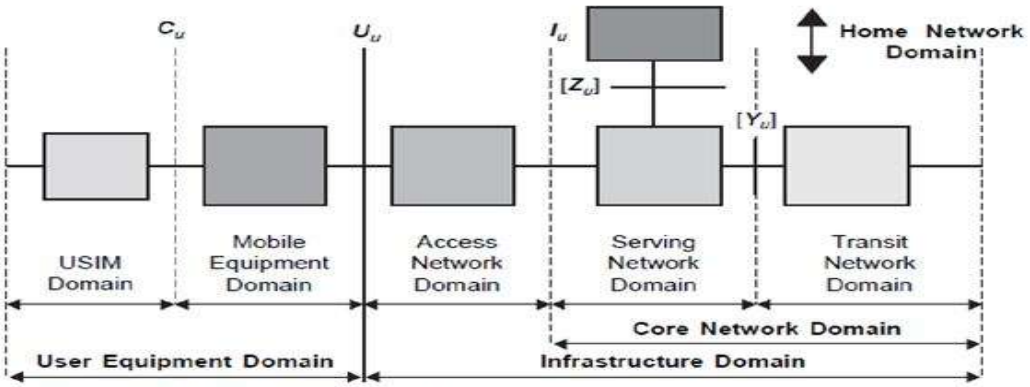
Features of UMTS interfaces:

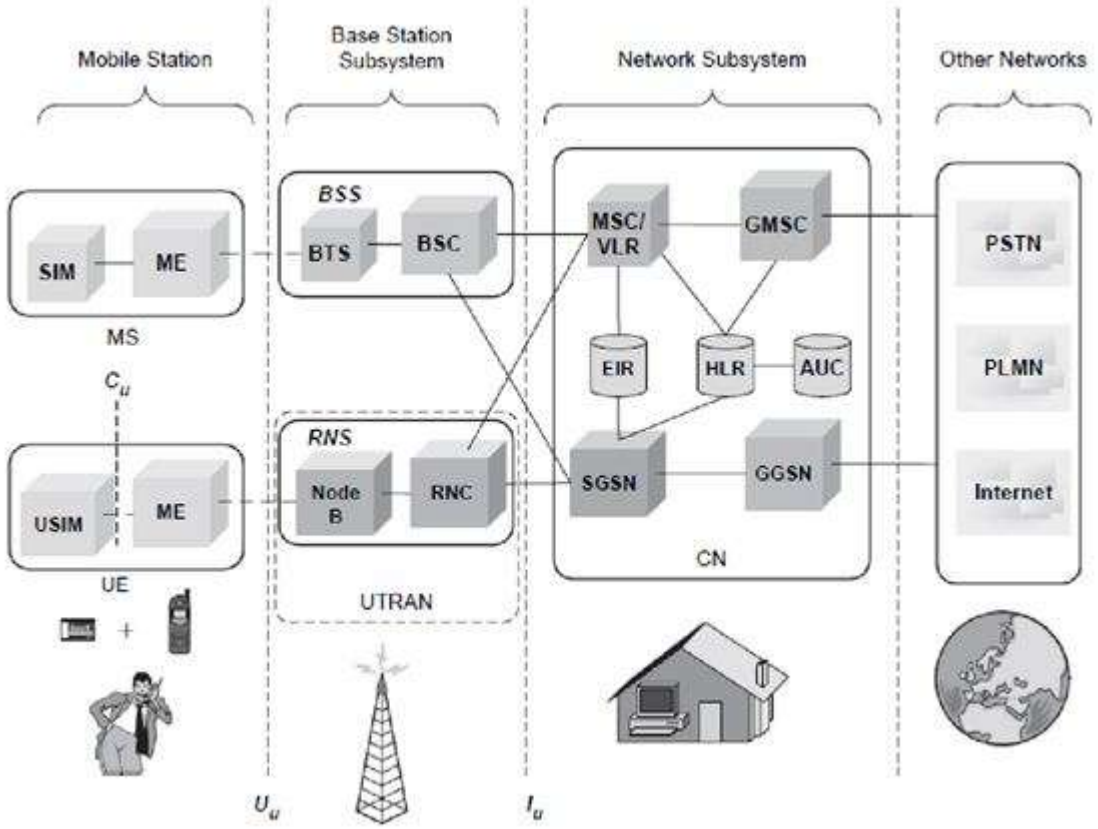
i. The UMTS interfaces can be categorized as follows:

a. Uu :

- This is the interface between the user equipment and the network. That is, it is the UMTS air interface.
- The equivalent interface in GSM/GPRS networks is the um interface.

b. The Iuis split functionally into two logical interfaces, Iupsconnecting the packet switched domain to the access network and the Iucsconnecting the circuit switched domain to the access network. The standards do not dictate that these are physically separate, but the user plane for each is different and the control plane may be different.





c. Iu –CS :

- This is the circuit-switched connection for carrying (typically) voice traffic and signaling between the UTRAN and the core voice network.
- The main signaling protocol used is Radio Access Network Application Part (RANAP).
- The equivalent interface in GSM/GPRS networks is the A-interface.

d. Iub :

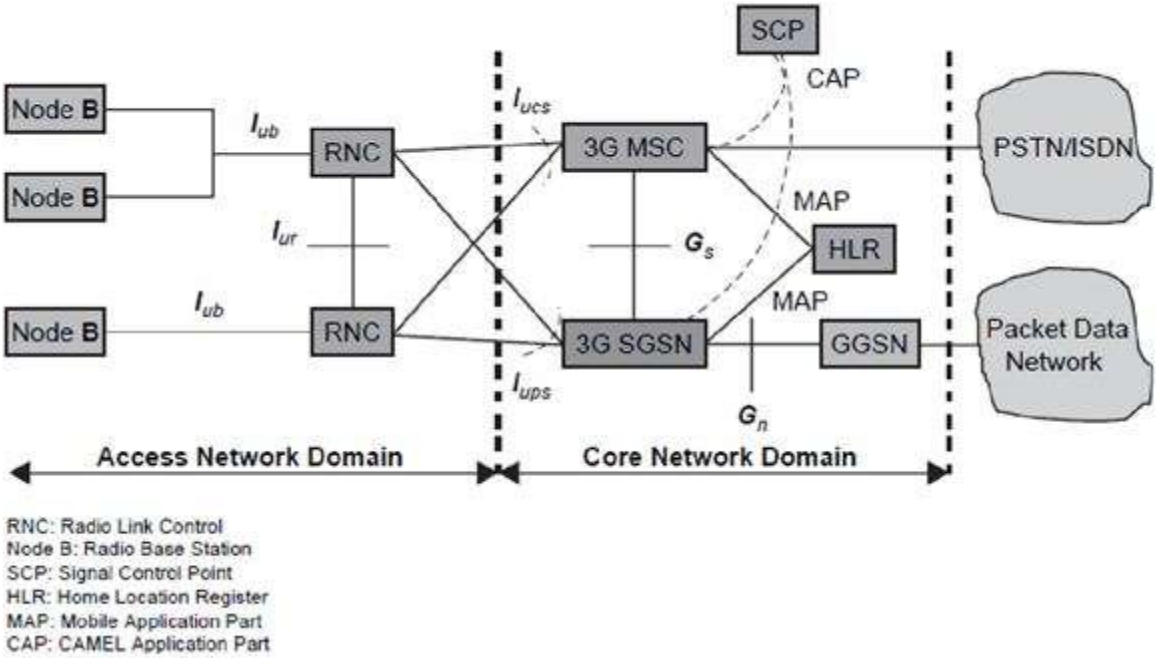
- This is the interface used by an RNC to control multiple Node Bs.
- The main signaling protocol used is Node B Application Part (NBAP).
- The equivalent interface in GSM/GPRS networks is the A-bis interface.
- The Iubinterface is the main standardized and open, unlike the A-bis interface.

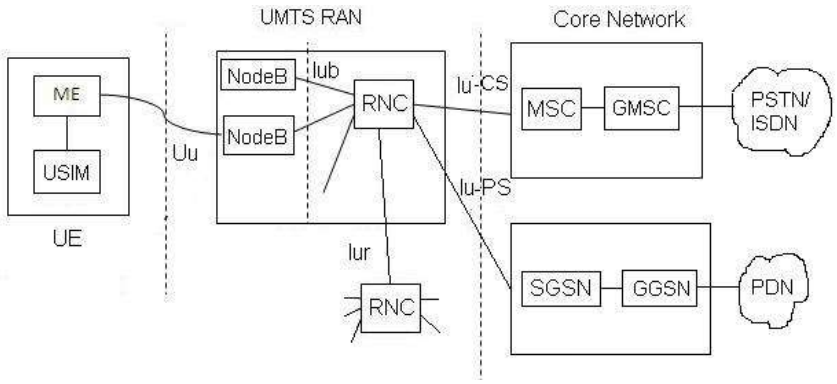
e. Iu –PS :

- This is the packet-switched connection for carrying (typically) data traffic and signaling between the UTRAN and the core data GPRS network.
- The main signaling protocol used is RANAP.
- The equivalent interface in GSM/GPRS networks is the Gb-interface.

f. Iur :

- The primary purpose of the Iur interface is to support inter-MSC mobility. When a mobile subscriber moves between areas served by different RNCs, the mobile subscriber's data is now transferred to the new RNC via Iur.
- The original RNC is known as the serving RNC and the new RNC is known as the drift RNC.
- The main signaling protocol used is Radio Network Subsystem Application Part (RNSAP).
- There is no equivalent interface in GSM/GPRS networks.





There are three main components in **UMTS network architecture**, User Equipments is composed of Mobile Equipment (ME) and USIM. Radio Access Network is composed of NodeB and RNC. Core Network is composed of circuit switched and packet switched functional modules. For Circuit switched (CS) operations MSC and GMSC along with database modules such as VLR, HLR will be available. For packet switched (PS) operations SGSN and GGSN will serve the purpose. GMSC will be connected with PSTN/ISDN in CS case. GGSN is connected with Packet data Network (PDN) for PS case. Interfaces between these entities are summarized below.

Uu interface between UE and NodeB
Iub interface between NodeB and RNC
Iur interface between RNC and RNC
Iu-CS interface between RNC and MSC
Iu-PS interface between RNC and SGSN

With the change from 2G to 3G, the emphasis for the systems changed from a focus on mobile voice communications to mobile data and general connectivity.

The foundations for the UMTS network had been set in place when GSM was launched. This provided the basic access elements as well as circuit switched voice. The additional of packet data with GPRS required additional network entities to be added. It was the combination of these two network elements that provided the basis for the 3G UMTS network architecture.

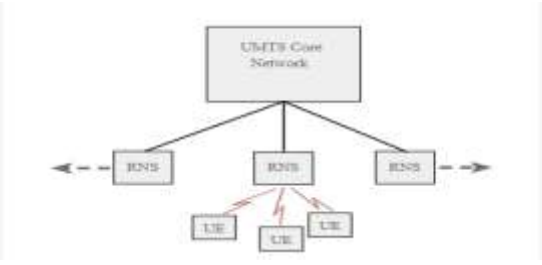
The radio access network changed considerably as a completely new radio interface was used based around the use of CDMA. Also the handset name was changed to user equipment indicating a change in its use from just a voice phone to a data set which could have been a phone, PDA or laptop, with many laptops requiring a 3G dongle to plug into a USB port.

3G UMTS network constituents

The UMTS network architecture can be divided into three main elements:

- **User Equipment (UE):** The User Equipment or UE is the name given to what was previous termed the mobile, or cellphone. The new name was chosen because the considerably greater functionality that the UE could have. It could also be anything between a mobile phone used for talking to a data terminal attached to a computer with no voice capability.
- **Radio Network Subsystem (RNS):** The RNS also known as the UMTS Radio Access Network, UTRAN, is the equivalent of the previous Base Station Subsystem or BSS in GSM. It provides and manages the air interface fort he overall network.
- **Core Network:** The core network provides all the central processing and management for the system. It is the equivalent of the GSM Network Switching Subsystem or NSS.

The core network is then the overall entity that interfaces to external networks including the public phone network and other cellular telecommunications networks.



The main UMTS network blocks

User Equipment, UE

The USER Equipment or UE is a major element of the overall 3G UMTS network architecture. It forms the final interface with the user. In view of the far greater number of applications and facilities that it can perform, the decision was made to call it a user equipment rather than a mobile. However it is essentially the handset (in the broadest terminology), although having access to much higher speed data communications, it can be much more versatile, containing many more applications. It consists of a variety of different elements including RF circuitry, processing, antenna, battery, etc.

There are a number of elements within the UE that can be described separately:

- **UE RF circuitry:** The RF areas handle all elements of the signal, both for the receiver and for the transmitter. One of the major challenges for the RF power amplifier was to reduce the power consumption. The form of modulation used for W-CDMA requires the use of a linear amplifier. These inherently take more current than non linear amplifiers which can be used for the form of modulation used on GSM. Accordingly to maintain battery life, measures were introduced into many of the designs to ensure the optimum efficiency.
- **Baseband processing:** The base-band signal processing consists mainly of digital circuitry. This is considerably more complicated than that used in phones for previous generations. Again this has been optimised to reduce the current consumption as far as possible.
- **Battery:** While current consumption has been minimised as far as possible within the circuitry of the phone, there has been an increase in current drain on the battery. With users expecting the same lifetime between charging batteries as experienced on the previous generation phones, this has necessitated the use of new and improved battery technology. Now Lithium Ion (Li-ion) batteries are used. These phones to remain small and relatively light while still retaining or even improving the overall life between charges.
- **Universal Subscriber Identity Module, USIM:** The UE also contains a SIM card, although in the case of UMTS it is termed a USIM (Universal Subscriber Identity Module). This is a more advanced version of the SIM card used in GSM and other systems, but embodies the same types of information. It contains the International Mobile Subscriber Identity number (IMSI) as well as the Mobile Station International ISDN Number (MSISDN). Other information that the USIM holds includes the preferred language to enable the correct language information to be displayed, especially when roaming, and a list of preferred and prohibited Public Land Mobile Networks (PLMN).

  The USIM also contains a short message storage area that allows messages to stay with the user even when the phone is changed. Similarly "phone book" numbers and call information of the numbers of incoming and outgoing calls are stored.

The UE can take a variety of forms, although the most common format is still a version of a "mobile phone" although having many data capabilities. Other broadband dongles are also being widely used.

3G UMTS Radio Network Subsystem

This is the section of the 3G UMTS / WCDMA network that interfaces to both the UE and the core network. The overall radio access network, i.e. collectively all the Radio Network Subsystem is known as the UTRAN UMTS Radio Access Network.

The radio network subsystem is also known as the UMTS Radio Access Network or UTRAN.

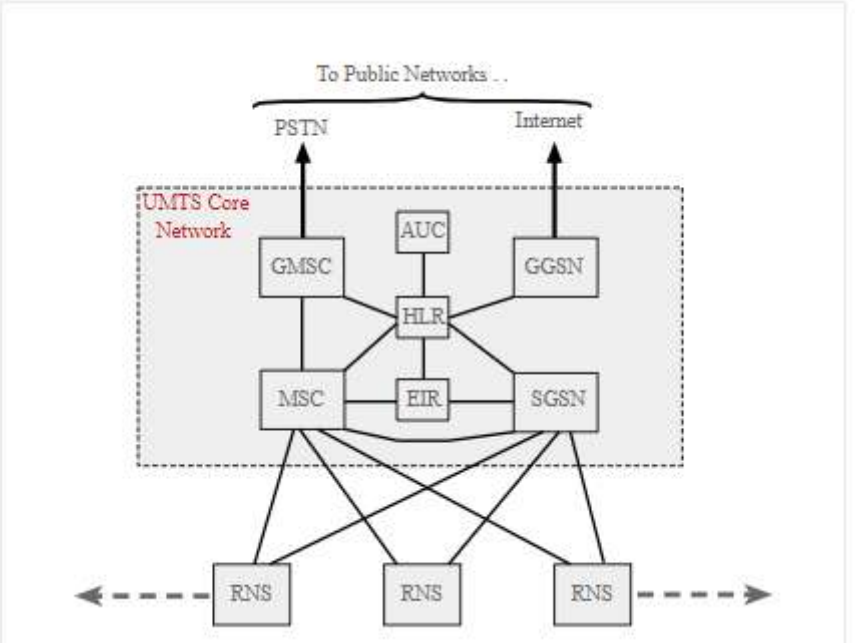
3G UMTS Core Network

The 3G UMTS core network architecture is a migration of that used for GSM with further elements overlaid to enable the additional functionality demanded by UMTS.

In view of the different ways in which data may be carried, the UMTS core network may be split into two different areas:

- **Circuit switched elements:** These elements are primarily based on the GSM network entities and carry data in a circuit switched manner, i.e. a permanent channel for the duration of the call.
- **Packet switched elements:** These network entities are designed to carry packet data. This enables much higher network usage as the capacity can be shared and data is carried as packets which are routed according to their destination.

Some network elements, particularly those that are associated with registration are shared by both domains and operate in the same way that they did with GSM.



UMTS Network Architecture Overview

Circuit switched elements

The circuit switched elements of the UMTS core network architecture include the following network entities:

- **Mobile switching centre (MSC):** This is essentially the same as that within GSM, and it manages the circuit switched calls under way.
- **Gateway MSC (GMSC):** This is effectively the interface to the external networks.

Packet switched elements

The packet switched elements of the 3G UMTS core network architecture include the following network entities:

- **Serving GPRS Support Node (SGSN):** As the name implies, this entity was first developed when GPRS was introduced, and its use has been carried over into the UMTS network architecture. The SGSN provides a number of functions within the UMTS network architecture.
    - Mobility management When a UE attaches to the Packet Switched domain of the UMTS Core Network, the SGSN generates MM information based on the mobile's current location.
    - Session management: The SGSN manages the data sessions providing the required quality of service and also managing what are termed the PDP (Packet data Protocol) contexts, i.e. the pipes over which the data is sent.
    - Interaction with other areas of the network: The SGSN is able to manage its elements within the network only by communicating with other areas of the network, e.g. MSC and other circuit switched areas.
    - Billing: The SGSN is also responsible billing. It achieves this by monitoring the flow of user data across the GPRS network. CDRs (Call Detail Records) are generated by the SGSN before being transferred to the charging entities (Charging Gateway Function, CGF).

Gateway GPRS Support Node (GGSN): Like the SGSN, this entity was also first introduced into the GPRS network. The Gateway GPRS Support Node (GGSN) is the central element within the

UMTS packet switched network. It handles inter-working between the UMTS packet switched network and external packet switched networks, and can be considered as a very sophisticated router. In operation, when the GGSN receives data addressed to a specific user, it checks if the user is active and then forwards the data to the SGSN serving the particular UE.

Shared elements

The shared elements of the 3G UMTS core network architecture include the following network entities:

- **Home location register (HLR):** This database contains all the administrative information about each subscriber along with their last known location. In this way, the UMTS network is able to route calls to the relevant RNC / Node B. When a user switches on their UE, it registers with the network and from this it is possible to determine which Node B it communicates with so that incoming calls can be routed appropriately. Even when the UE is not active (but switched on) it re-registers periodically to ensure that the network (HLR) is aware of its latest position with their current or last known location on the network.
- **Equipment identity register (EIR):** The EIR is the entity that decides whether a given UE equipment may be allowed onto the network. Each UE equipment has a number known as the International Mobile Equipment Identity. This number, as mentioned above, is installed in the equipment and is checked by the network during registration.
- **Authentication centre (AuC) :** The AuC is a protected database that contains the secret key also contained in the user's USIM card.

UMTS CHANNEL

3G UMTS includes:

What is UMTS Network architecture Radio access Radio interface Frequency bands UMTS CDMA Modulation Data channels UMTS TDD TD-SDCDMA Handover

Like any form of wireless data link, the data needs to be managed to enable the system to handle it efficiently and effectively.

3G UMTS transmissions are organised into frames slots and channels with the payload using physical, logical and transport data channels to carry the required data.

By doing this, the payload data as well as the control and status data can be carried in an efficient manner.

3G UMTS channel structures

3G UMTS uses CDMA techniques (as WCDMA) as its multiple access technology, but it additionally uses time division techniques with a slot and frame structure to provide the full channel structure.

A channel is divided into 10 ms frames, each of which has fifteen time slots each of 666 microseconds length. On the downlink the time is further subdivided so that the time slots contain fields that contain either user data or control messages.

On the uplink dual channel modulation is used so that both data and control are transmitted simultaneously. Here the control elements contain a pilot signal, Transport Format Combination Identifier (TFCI), FeedBack Information (FBI) and Transmission Power Control (TPC).

The channels carried are categorised into three:

- **Logical Channels:** The logical channels define the way in which the data will be transferred

- **Physical channels:** The physical channels carry the payload data and govern the physical characteristics of the signal.
- **Transport Channels:** The 3G transport channels along with the logical channel again defines the way in which the data is transferred

The channels are organised such that the logical channels are related to what is transported, whereas the physical layer transport channels deal with how, and with what characteristics. The MAC layer provides data transfer services on logical channels. A set of logical channel types is defined for different kinds of data transfer services.

3G UMTS Logical Channels:

- **Broadcast Control Channel (BCCH)** (downlink). This channel broadcasts information to UEs relevant to the cell, such as radio channels of neighbouring cells, etc.
- **Paging Control Channel (PCCH)** (downlink). This channel is associated with the PICH and is used for paging messages and notification information.
- **Dedicated Control Channel (DCCH)** (up and downlinks) This channel is used to carry dedicated control information in both directions.
- **Common Control Channel (CCCH)** (up and downlinks). This bi-directional channel is used to transfer control information.
- **Shared Channel Control Channel (SHCCH)** (bi-directional). This channel is bi-directional and only found in the TDD form of WCDMA / UMTS, where it is used to transport shared channel control information.
- **Dedicated Traffic Channel (DTCH)** (up and downlinks). This is a bidirectional channel used to carry user data or traffic.
-
- **Common Traffic Channel (CTCH)** (downlink) A unidirectional channel used to transfer dedicated user information to a group of UEs.

3G UMTS Physical Channels:

- **Primary Common Control Physical Channel (PCCPCH)** (downlink). This channel continuously broadcasts system identification and access control information.
- **Secondary Common Control Physical Channel (SCCPCH)** (downlink) This channel carries the Forward Access Channel (FACH) providing control information, and the Paging Channel (PACH) with messages for UEs that are registered on the network.
- **Physical Random Access Channel (PRACH)** (uplink). This channel enables the UE to transmit random access bursts in an attempt to access a network.
- **Dedicated Physical Data Channel (DPDCH)** (up and downlink). This channel is used to transfer user data.
- **Dedicated Physical Control Channel (DPCCH)** (up and downlink). This channel carries control information to and from the UE. In both directions the channel carries pilot bits and the Transport Format Combination Identifier (TFCI). The downlink channel also includes the Transmit Power Control and FeedBack Information (FBI) bits.
- **Physical Downlink Shared Channel (PDSCH)** (downlink). This channel shares control information to UEs within the coverage area of the node B.
- **Physical Common Packet Channel (PCPCH)** This channel is specifically intended to carry packet data. In operation the UE monitors the system to check if it is busy, and if not it then transmits a brief access burst. This is retransmitted if no acknowledgement is gained with a slight increase in power each time. Once the node B acknowledges the request, the data is transmitted on the channel.
- **Synchronisation Channel (SCH)** The synchronisation channel is used in allowing UEs to synchronise with the network.

- **Common Pilot Channel (CPICH)** This channel is transmitted by every node B so that the UEs are able estimate the timing for signal demodulation. Additionally they can be used as a beacon for the UE to determine the best cell with which to communicate.
- **Acquisition Indicator Channel (AICH)** The AICH is used to inform a UE about the Data Channel (DCH) it can use to communicate with the node B. This channel assignment occurs as a result of a successful random access service request from the UE.
- **Paging Indication Channel (PICH)** This channel provides the information to the UE to be able to operate its sleep mode to conserve its battery when listening on the Paging Channel (PCH). As the UE needs to know when to monitor the PCH, data is provided on the PICH to assign a UE a paging repetition ratio to enable it to determine how often it needs to 'wake up' and listen to the PCH.
- **CPCH Status Indication Channel (CSICH)** This channel, which only appears in the downlink carries the status of the CPCH and may also be used to carry some intermittent, or "bursty" data. It works in a similar fashion to PICH.
- **Collision Detection/Channel Assignment Indication Channel (CD/CA-ICH)** This channel, present in the downlink is used to indicate whether the channel assignment is active or inactive to the UE.

3G UMTS Transport Channels:

- **Dedicated Transport Channel (DCH)** (up and downlink). This is used to transfer data to a particular UE. Each UE has its own DCH in each direction.
- **Broadcast Channel (BCH)** (downlink). This channel broadcasts information to the UEs in the cell to enable them to identify the network and the cell.
- **Forward Access Channel (FACH)** (down link). This is channel carries data or information to the UEs that are registered on the system. There may be more than one FACH per cell as they may carry packet data.
- **Paging Channel (PCH)** (downlink). This channel carries messages that alert the UE to incoming calls, SMS messages, data sessions or required maintenance such as re-registration.
- **Random Access Channel (RACH)** (uplink). This channel carries requests for service from UEs trying to access the system
- **Uplink Common Packet Channel (CPCH)** (uplink). This channel provides additional capability beyond that of the RACH and for fast power control.
- **Downlink Shared Channel (DSCH)** (downlink).This channel can be shared by several users and is used for data that is "bursty" in nature such as that obtained from web browsing etc.

UMTS DATA, CODING AND HANDOVER

UMTS varies on three elements of the system, namely the way packet data is carried , the way speech coding is accomplished and handover , including hard , soft and softer handover

Packet Data

Packet data is an increasingly important element within mobile phone applications.WCDMA is able to carry data in this format in two ways : the first is for short data packets to be appended directly to a Random Access burst. This method is called common channel packet transmission and it is used for short infrequent packets. It is preferable to transmit short packet in this manner because the link maintenance needed for a dedicated channel would lead to an unacceptable overhead .Additionally the delay in setting up a packet data channel and transferring the operational mode to this former is avoided.

A multi pocket scheme the dedicated channel is maintained by transmitting power control and synchronisation information between subsequent packets.

Speech Coding

Speech coding in UMTS uses a variety of source rates.As a result variety of vocoder orders are employed including the gsm-r vocoder whenever it of rates are available in system known as adaptive multirate AMR may be employed by rate is to Sun according to the system capacity and the requirement is the same as that used on CSM the actual vocoder that is chosen is governed by the system

UMTS handover types

Within UMTS it is possible to define a number of different types of UMTS handover or handoff. With the advent of generic CDMA technology, new possibilities for effecting more reliable forms of handover became possible, and as a result one of a variety of different forms of handover are available depending upon the different circumstances.

For purely inter W-CDMA technology, there are three basic types of handover:

- **Hard handover:** This form of handover is essentially the same as that used for 2G networks where one link is broken and another established.
- **Soft handover:** This form of handover is a more gradual and the UE communicates simultaneously with more than one Node B or base station during the handover process.
- **Softer handover:** Not a full form of UMTS handover, but the UE communicates with more than one sector managed by the same NodeB.
- **UMTS inter RAT handover:** This form of handover occurs when mobiles have to change between Radio Access Technologies, e.g. UMTS to / from GSM or UMTS to / from 4G LTE, etc.

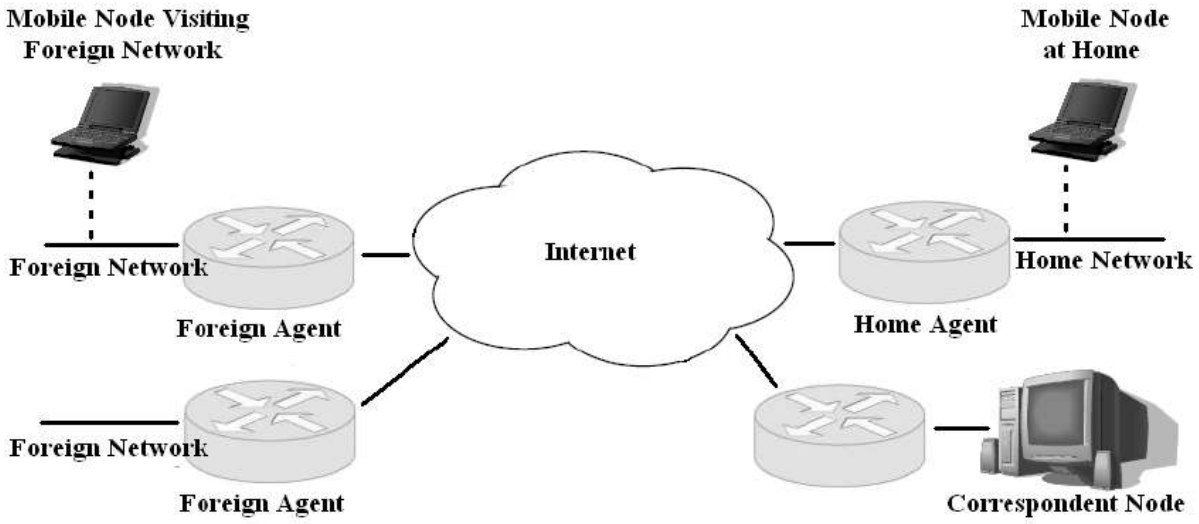
UNIT-7

Mobile IP

Mobile IP is a communication protocol (created by extending Internet Protocol, IP) that allows the users to move from one network to another with the same IP address. It ensures that the communication will continue without user's sessions or connections being dropped.

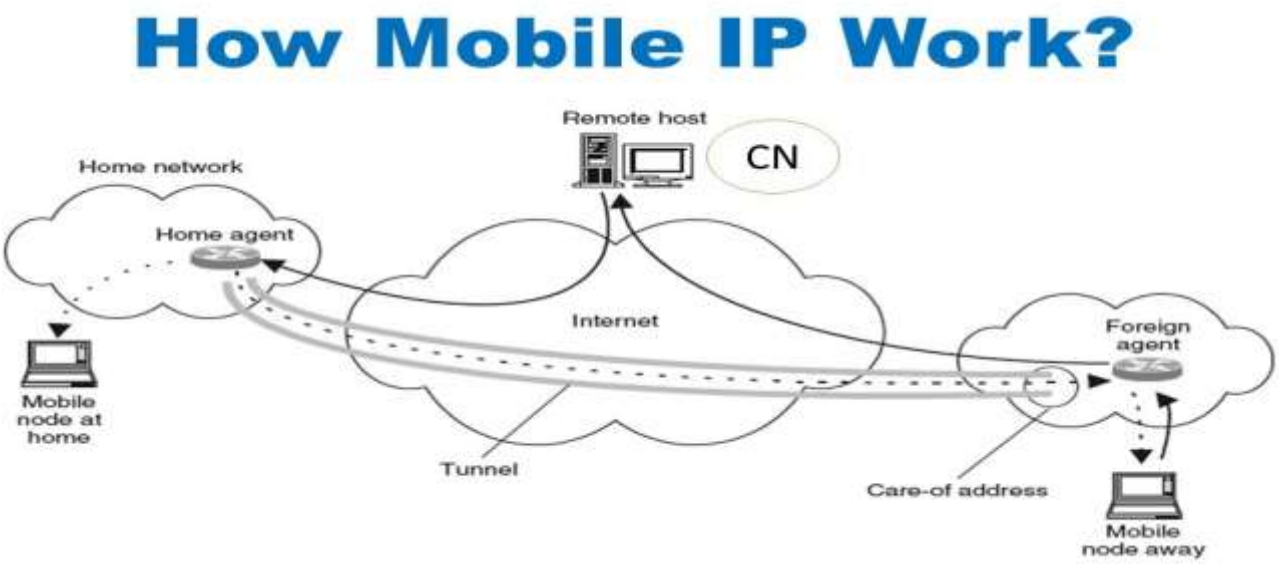
Terminologies/Mobile IP entities :

- **Mobile Node (MN):**
  It is the hand-held communication device that the user caries e.g. Cell phone.
- **Home Network:**
  It is a network to which the mobile node originally belongs to as per its assigned IP address (home address).
- **Home Agent (HA):**
  It is a router in home network to which the mobile node was originally connected
- **Home Address:**
  It is the permanent IP address assigned to the mobile node (within its home network).
- **Foreign Network:**
  It is the current network to which the mobile node is visiting (away from its home network).
- **Foreign Agent (FA):**
  It is a router in foreign network to which mobile node is currently connected. The packets from the home agent are sent to the foreign agent which delivers it to the mobile node.
- **Correspondent Node (CN):**
  It is a device on the internet communicating to the mobile node.
- **Care of Address (COA):**
  It is the temporary address used by a mobile node while it is moving away from its home network.



Working:
Correspondent node sends the data to the mobile node. Data packets contain correspondent node's address (Source) and home address (Destination). Packets reach to the home agent. But now mobile node is not in the home network, it has moved into the foreign network. Foreign agent sends the care-of-address to the home agent to which all the packets should be sent. Now, a tunnel will be established between the home agent and the foreign agent by the process of tunneling.

Tunneling establishes a virtual pipe for the packets available between a tunnel entry and an endpoint. It is the process of sending a packet via a tunnel and it is achieved by a mechanism called encapsulation.
Now, home agent encapsulates the data packets into new packets in which the source address is the home address and destination is the care-of-address and sends it through the tunnel to the foreign agent. Foreign agent, on other side of the tunnel receives the data packets, decapsulates them and sends them to the mobile node. Mobile node in response to the data packets received sends a reply in response to foreign agent. Foreign agent directly sends the reply to the correspondent node.



Key Mechanisms in Mobile IP:

1. **Agent Discovery/Discovering the care-of address:**

   Agents advertise their presence by periodically broadcasting their agent advertisement messages. The mobile node receiving the agent advertisement messages observes whether the message is from its own home agent and determines whether it is in the home network or foreign network.
2. **Agent Registration/Registering the care-of address:**

   Mobile node after discovering the foreign agent, sends registration request (RREQ) to the foreign agent. Foreign agent in turn, sends the registration request to the home agent with the care-of-address. Home agent sends registration reply (RREP) to the foreign agent. Then it forwards the registration reply to the mobile node and completes the process of registration.
3. **Tunneling the care-of address:**

   It establishes a virtual pipe for the packets available between a tunnel entry and an endpoint. It is the process of sending a packet via a tunnel and it is achieved by a mechanism called encapsulation. It takes place to forward an IP datagram from the home agent to the care-of-address. Whenever home agent receives a packet from correspondent node, it encapsulates the packet with source address as home address and destination as care-of-address.

Route Optimization in Mobile IP:

The route optimization adds a conceptual data structure, the binding cache, to the correspondent node. The binding cache contains bindings for mobile node's home address and its current care-of-address. Every time the home agent receives a IP datagram that is destined to a mobile node currently away from the home network, it sends a binding update to the correspondent node to update the information in the correspondent node's binding cache. After this the correspondent node can directly tunnel packets to the mobile node.

UNIT-8
MOBILE COMPUTING

WWW architecture for Mobile computing

WWW stands for **World Wide Web.** A technical definition of the World Wide Web is : all the resources and users on the Internet that are using the Hypertext Transfer Protocol (HTTP).

A broader definition comes from the organization that Web inventor **Tim Berners-Lee** helped found, the **World Wide Web Consortium (W3C).**

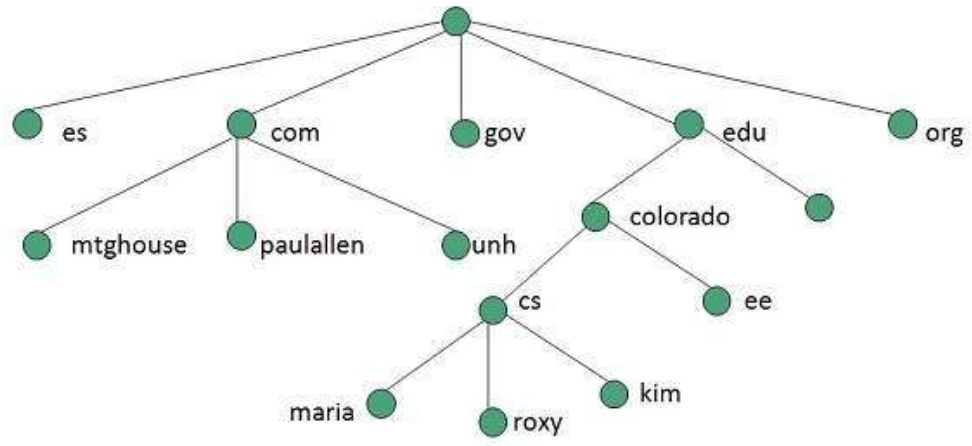
Components of Web:
There are 3 components of web:

1. **Uniform Resource Locator (URL):** serves as system for resources on web.
2. **HyperText Transfer Protocol (HTTP):** specifies communication of browser and server.
3. **Hyper Text Markup Language (HTML):** defines structure, organisation and content of webpage.

The World Wide Web is the universe of network-accessible information, an embodiment of human knowledge.

In simple terms, The World Wide Web is a way of exchanging information between computers on the Internet, tying them together into a vast collection of interactive multimedia resources.

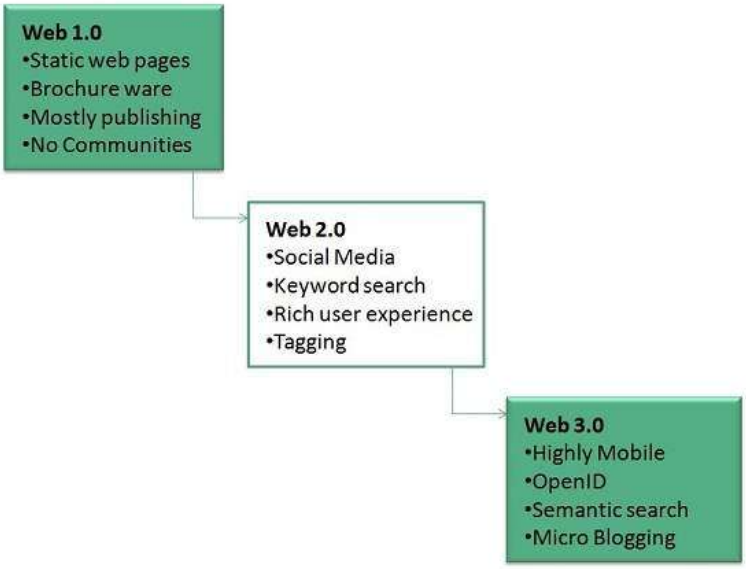
Internet and **Web** is not the same thing: Web uses internet to pass over the information.



EVOLUTION

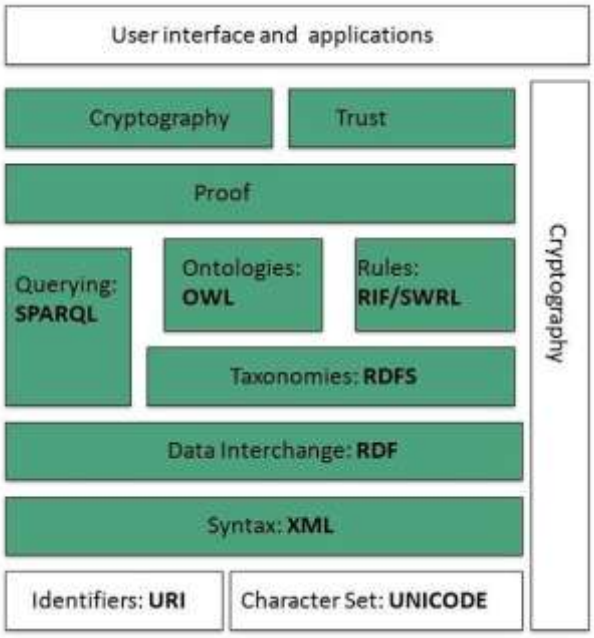
World Wide Web was created by **Timothy Berners Lee** in 1989 at **CERN** in **Geneva.** World Wide Web came into existence as a proposal by him, to allow researchers to work together effectively and efficiently at **CERN.** Eventually it became **World Wide Web.**

The following diagram briefly defines evolution of World Wide Web:



WWW ARCHITECTURE

WWW architecture is divided into several layers as shown in the following diagram:



Identifiers and Character Set

Uniform Resource Identifier (URI) is used to uniquely identify resources on the web and **UNICODE** makes it possible to built web pages that can be read and write in human languages.

Syntax

XML (Extensible Markup Language) helps to define common syntax in semantic web.

Data Interchange

Resource Description Framework (RDF) framework helps in defining core representation of data for web. RDF represents data about resource in graph form.

Taxonomies

RDF Schema (RDFS) allows more standardized description of **taxonomies** and other **ontological** constructs.

Ontologies

Web Ontology Language (OWL) offers more constructs over RDFS. It comes in following three versions:

- OWL Lite for taxonomies and simple constraints.
- OWL DL for full description logic support.
- OWL for more syntactic freedom of RDF

Rules

RIF and **SWRL** offers rules beyond the constructs that are available from **RDFs** and **OWL.** Simple Protocol and **RDF Query Language (SPARQL)** is SQL like language used for querying RDF data and OWL Ontologies.

Proof

All semantic and rules that are executed at layers below Proof and their result will be used to prove deductions.

Cryptography

Cryptography means such as digital signature for verification of the origin of sources is used.

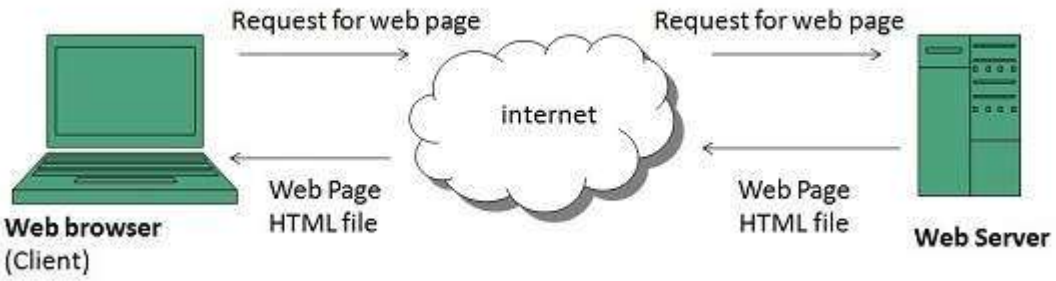
User Interface and Applications

On the top of layer **User interface and Applications** layer is built for user interaction.

WWW OPERATION

WWW works on client- server approach. Following steps explains how the web works:

1. User enters the URL (say, **http://www.abc.com**) of the web page in the address bar of web browser.
2. Then browser requests the Domain Name Server for the IP address corresponding to www.tutorialspoint.com.
3. After receiving IP address, browser sends the request for web page to the web server using HTTP protocol which specifies the way the browser and web server communicates.
4. Then web server receives request using HTTP protocol and checks its search for the requested web page. If found it returns it back to the web browser and close the HTTP connection.
5. Now the web browser receives the web page, It interprets it and display the contents of web page in web browser's window.



WIRELESS APPLICATION PROTOCOL (WAP)

WAP stands for **Wireless Application Protocol**. It is a protocol designed for micro-browsers and it enables the access of internet in the mobile devices. It uses the mark-up language WML (Wireless Mark-up Language and not HTML), WML is defined as XML 1.0 application.

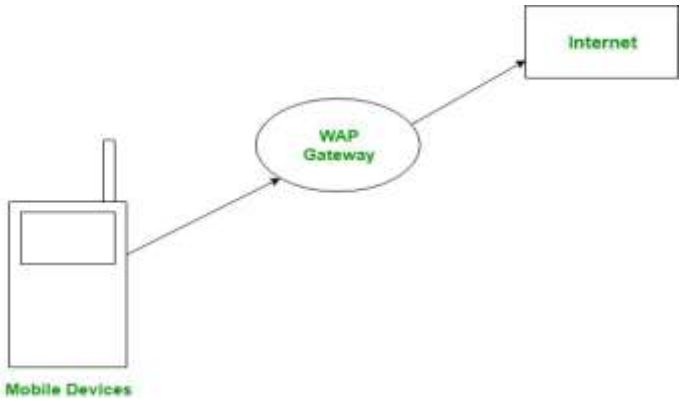
WAP is a De-Facto (something exists even though it may not be legally accepted as existing)standard or a protocol designed for micro-browsers, and it enables the mobile devices to interact, exchange and transmit information over the Internet.

Need of WAP

Having the performance and data transfer capacity of the common desktop computers in mind, the web designers constructed the internet technology for devices as powerful as those computers. Hand-held wireless devices have less powerful CPU's or low battery life, less memory, restricted power consumption smaller displays and different input devices. Similarly, wireless data networks have less bandwidth, more latency, less connection stability and less predictable availability than conventional wired networks.

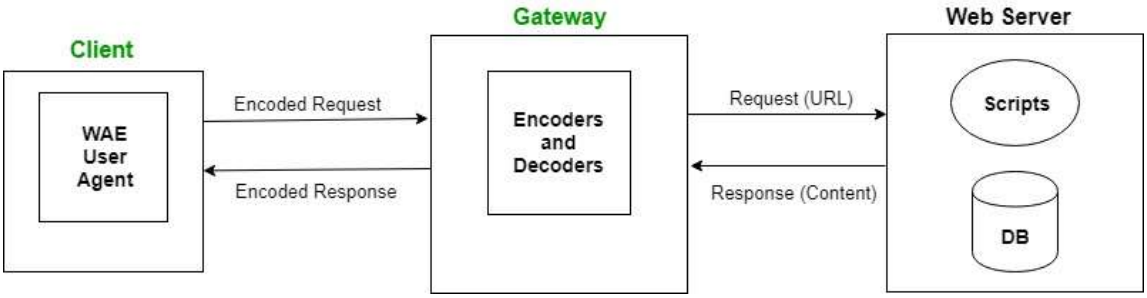
Benefits of WAP:

- It is device independent.
- It is network independent.
- WAP utilizes standard Internet markup language technology, XML.
- Optimizing the content and air link protocols.
- The Wireless Markup Language (WML) User Interface (UI) components map well onto existing mobile phone user interface.



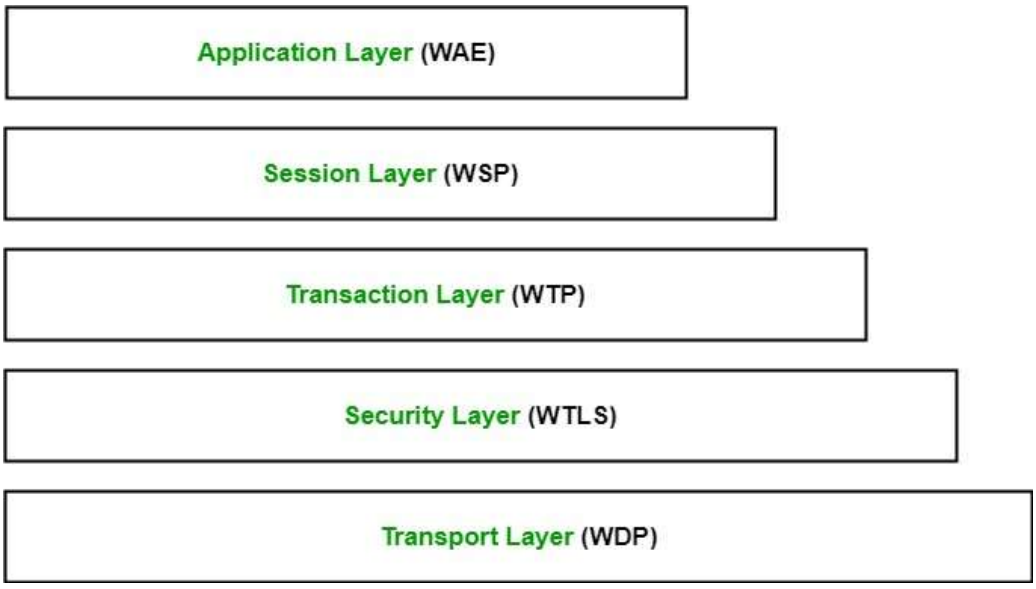
WAP is the set of rules governing the transmission and reception of data by computer applications

WAP Model:
The user opens the mini-browser in a mobile device. He selects a website that he wants to view. The mobile device sends the URL encoded request via network to a WAP gateway using WAP protocol.



The WAP gateway translates this WAP request into a conventional HTTP URL request and sends it over the internet. The request reaches to a specified Web server and it processes the request just as it would have processed any other request and sends the response back to the mobile device through WAP gateway in WML file which can be seen in the micro-browser.

WAP Protocol stack:



It specifies the different communications and data transmission layers used in the WAP model:

Application Layer: This layer consists of the Wireless Application Environment (WAE), mobile device specifications, and content development programming languages, i.e., WMLOOPs Concepts in Java

Session Layer: The session layer consists of the Wireless Session Protocol (WSP). It is responsible for fast connection suspension and reconnection.

Transaction Layer: The transaction layer consists of Wireless Transaction Protocol (WTP) and runs on top of UDP (User Datagram Protocol). This layer is a part of TCP/IP and offers transaction support.

Security Layer: It contains Wireless Transaction Layer Security (WTLS) and responsible for data integrity, privacy and authentication during data transmission.

Transport Layer: This layer consists of Wireless Datagram Protocol (WDP). It provides a consistent data format to higher layers of the WAP protocol stack.

Advantages of Wireless Application Protocol (WAP)

Following is a list of some advantages of Wireless Application Protocol or WAP:

- WAP is a very fast-paced technology.
- It is an open-source technology and completely free of cost.
- It can be implemented on multiple platforms.
- It is independent of network standards.
- It provides higher controlling options.
- It is implemented near to Internet model.
- By using WAP, you can send/receive real-time data.
- Nowadays, most modern mobile phones and devices support WAP.

Disadvantages of Wireless Application Protocol (WAP)

Following is a list of some disadvantages of Wireless Application Protocol or WAP:

- The connection speed in WAP is slow, and there is limited availability also.
- In some areas, the ability to connect to the Internet is very sparse, and in some other areas, Internet access is entirely unavailable.
- It is less secured.
- WAP provides a small User interface (UI).

Applications of Wireless Application Protocol (WAP)

The following are some most used applications of Wireless Application Protocol or WAP:

- WAP facilitates you to access the Internet from your mobile devices.
- You can play games on mobile devices over wireless devices.
- It facilitates you to access E-mails over the mobile Internet.
- Mobile hand-sets can be used to access timesheets and fill expenses claims.
- Online mobile banking is very popular nowadays.

- It can also be used in multiple Internet-based services such as geographical location, Weather forecasting, Flight information, Movie & cinema information, Traffic updates etc. All are possible due to WAP technology.

UNIT-9

WIRELESS TELECOMM NETWORK

GSM

GSM stands for **Global System for Mobile Communication.** GSM is an open and digital cellular technology used for mobile communication. It uses 4 different frequency bands of 850 MHz, 900 MHz, 1800 MHz and 1900 MHz . It uses the combination of FDMA and TDMA.
GSM is a globally accepted standard for digital cellular communication .GSM is the name of a standardization group established in 1982 to create a common European mobile cellular radio system operating at 900MHz.

GSM is having 4 different sizes of cells are used in GSM :

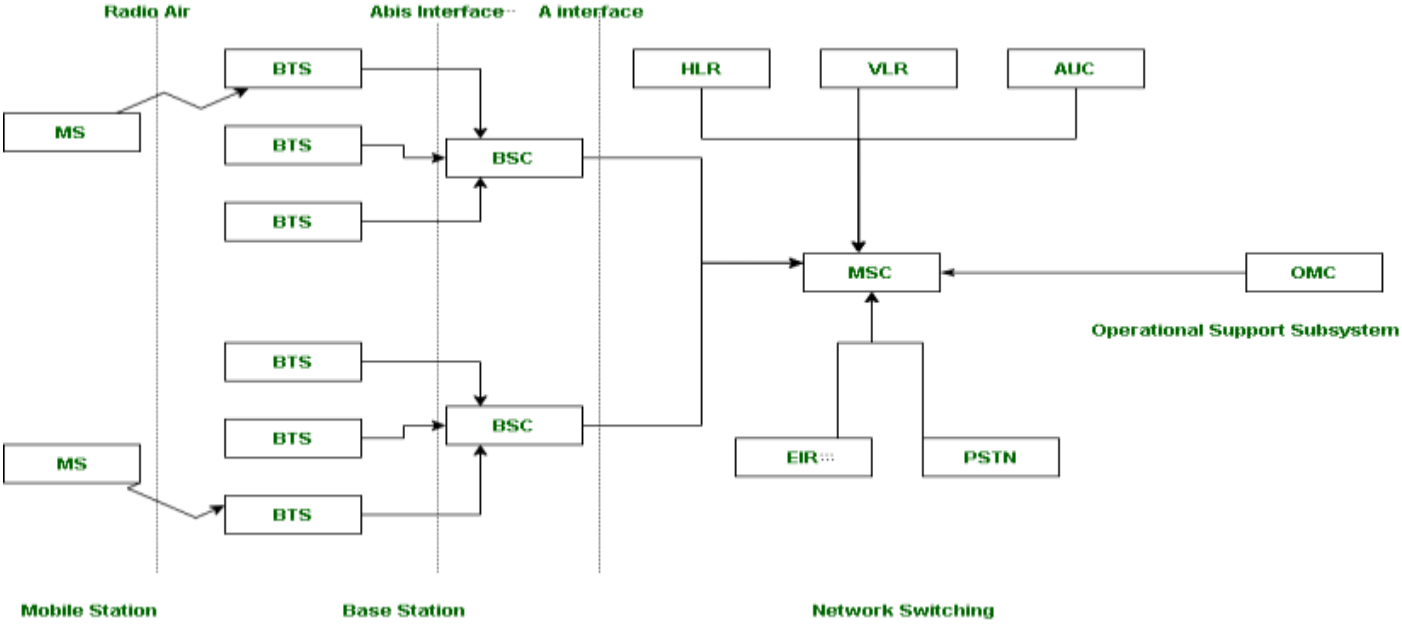
1. Macro : In this size of cell, Base Station antenna is installed.
2. Micro : In this size of cell, antenna height is less than the average roof level.
3. Pico : Small cells' diameter of few meters.
4. Umbrella : It covers the shadowed (Fill the gaps between cells) regions.

Features of GSM are :

1. Supports international roaming
2. Clear voice clarity
3. Ability to support multiple handheld devices.
4. Spectral / frequency efficiency
5. Low powered handheld devices.
6. Case of accessing network
7. International ISDN compatibility.

GSM is nothing but a larger system which is divided into further 3 subsystems.

1. **BSS :** BSS stands for Base Station Subsystem. BSS handles traffic and signaling between a mobile phone and the network switching subsystem. BSS having two components **BTS** and **BSC.**
2. **NSS :** NSS stands for Network and Switching Subsystem. NSS is to core network of GSM. That carried out call and mobility management functions for mobile phone present in network. NSS have different components like **VLR, HLR** and **EIR.**
3. **OSS :** OSS stands for Operating Subsystem. OSS is a functional entity which the network operator monitor and control the system. **OMC** is the part of OSS.



Functionality of different components-

1. MS : MS stands for Mobile System. MS comprises user equipment and software needed for communication with a mobile network. Mobile Station (MS) = Mobile Equipment(ME) + Subscriber Identity Module (SIM). Now, these mobile stations are connected to tower and that tower connected with BTS through TRX. TRX is a transceiver which comprises transmitter and receiver. Transceiver has two performance of sending and receiving.
2. BTS : BTS stands for Base Transceiver Station which facilitates wireless communication between user equipment and a network. Every tower has BTS.
3. BSC : BSC stands for Base Station Controller. BSC has multiple BTS. You can consider the BSC as a local exchange of your area which has multiple towers and multiple towers have BTS.
4. MSC : MSC stands for Mobile Switching Center. MSC is associated with communication switching functions such as call setup, call release and routing. Call tracing, call forwarding all functions are performed at the MSC level. MSC is having further components like VLR, HLR, AUC, EIR and PSTN.

- **VLR :** VLR stands for Visitor Location Register. VLR is a database which contains the exact location of all mobile subscribers currently present in the service area of MSC. If you are going from one state to another state then your entry is marked into the database of VLR.
- **HLR :** HLR stands for Home Location Register. HLR is a database containing pertinent data regarding subscribers authorized to use a GSM network.. If you purchase SIM card from in the HLR. HLR is like a home which contains all data like your ID proof, which plan you are taking, which caller tune you are using etc.
- **OMC :** OMC stands for Operation Maintenance Center. OMC monitor and maintain the performance of each MS, BSC and MSC within a GSM system.
- **AUC :** AUC stands for Authentication Center. AUC authenticates the mobile subscriber that wants to connect in the network.
- **EIR :** EIR stands for Equipment Identity Register. EIR is a database that keeps the record of all allowed or banned in the network. If you are banned in the network them you can't enter the network, and you can't make the calls.
- **PSTN :** PSTN stands for Public Switched Telephone Network. PSTN connects with MSC. PSTN originally a network of fixed line analog telephone systems. Now almost entirely digital in its core network and includes mobile and other networks as well as fixed telephones. The earlier landline phones which places at our home is nothing but PSTN.

Three subsystem BSS, NSS and OSS are connected with each other via some interfaces. Total three interfaces are there:

1. **Air Interface :** Air interface is also known as UM interface. Interface between MS and BTS is called as UM interface because it is mobile analog to the U interface of ISDN.
2. **Abis Interface :** It is a BSS internal interface linking with BTS and BSC.
3. **A interface :** It provides communication between BSS and MSC.

Hence, this is the complete architecture and functionalities of GSM components.

GPRS

General Packet Radio Service (GPRS) is a packet-based/ packet-oriented mobile data service on the global system for mobile communications (GSM) of 3G and 2G cellular communication systems. These packets can be straightforwardly directed to the packet changed systems from the GPRS portable stations.

It is a non-voice, high-speed and useful packet-switching technology intended for GSM networks. GPRS was built up by European Telecommunications Standards Institute (ETSI) because of the prior CDPD, and I-mode packet switched cell advances.

GPRS can be used to enable connections depending on Internet protocols that support a wide variety of enterprises, as well as commercial applications. It enables the sending and receiving of compact data bursts and large data volumes across mobile phone networks. Prior to sending the data, it is

broken into individual packets and shifted through the core network and radio. The data is then reassembled at the recipient's end.

Goals Of GPRS:

1. Consistent IP services
2. Leverage industry investment in IP
3. Open Architecture
4. Service innovation independent of infrastructure

Services Offered:

1. SMS messaging and broadcasting
2. Push-to-talk over cellular
3. Instant messaging and presence
4. Multimedia messaging service
5. Point-to-Point and Point-to-Multipoint services

Protocols supported:

1. Internet Protocol (IP)
2. Point-To-Point Protocol (PPP)

Benefits Of GPRS:

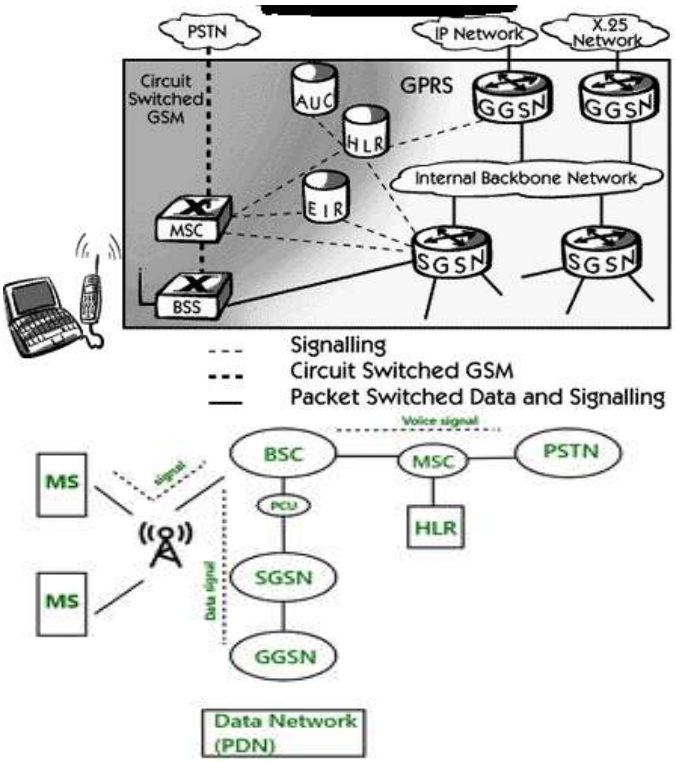
- **Mobility:**
  The capacity to keep up consistent voice and information interchanges while moving.
- **Cost Efficient:**
  Communication via GPRS is cheaper than through the regular GSM network.
- **Immediacy:**
  Allows customers to obtain connectivity when needed, regardless of location and without a lengthy login session.
- **Localization:**
  Enables customers to acquire data applicable to their present area.
- **Easy Billing:**
  GPRS packet transmission offers an easier to use billing than that offered by circuit switched administrations.

GPRS Network Architecture:

GPRS is usually attempts to reuse the existing GSM network elements as much as possible. There are new entities called GPRS that supports nodes (GSN) which are responsible for delivery and routing of data packets between mobile stations and external packets networks. There are two types of GSNs,

- Serving GPRS Support Node (SGNS)
- Gateway GPRS Support Node (GGNS)

These two modesare comparable to MD-IS in CPDP. There is also a new database called GPRS register which is located with HLR. It stores routing informations and maps the IMSI to a PDN address. Thus, GPRS Reference Architecture is shown as-



GPRS Network Architecture

Subsystems of GPRS Architecture

Mobile Station:

GPRS Services required New Mobile Station as the existing GSM phones are not capable of handling the enhanced air interface or the packet data. A wide variety of Mobile stations exist which includes a high-speed version of current phones to support high-speed data access like PC cards for laptop computers. These mobile stations are in backward compatibility mode in order to make voice calls which are used GSM.

Base Station Subsystem:

Each BSC requires the installation of Packet Control Units in addition to software upgrade. They provide physical and logical data interface to BSS to estimate packet data traffic. BTS too require a software upgrade but typically does not involve hardware enhancements.

When the traffic is originated at the subscriber mobile then it is transported over the air interface to BTS and then from BTS to BSC, the same way in standard GSM call. But at output of BSC the traffic is separated, the voice is sent to the mobile switching centre per standard GSM and the data is sent to the new device called the SGSN via the PCU.

GRPS Support Nodes:

- **SSGN:** The Serving GPRS Support Node is responsible for authentication of GPRS mobiles, registration of mobiles in the network, mobility management, and collecting information for charging for the use of the air interface.

- **GGSN:** The Gateway GPRS Support Node acts as an interface and a router to external networks. The GGSN contains routing information for GPRS mobiles, which is used to tunnel packets through the IP based internal backbone to the correct Serving GPRS Support Node.

Internal Back Network:

The internal backbone is an IP based network which is used to carry the new packets between different GSN. The process of Tunneling is used in-between SGSNs and GGSNs, this is done to safe exchange of domain informations outside the GPRS Network without informing internal backbone.

Mobility Support:

In a manner similar to GSM and CDPD, there are mechanism in GPRS to support mobility. There are two types of Mobility Support in GPRS Network-

- Attachment Procedure
- Location and Handoff Management

Short Messaging Services in GSM:

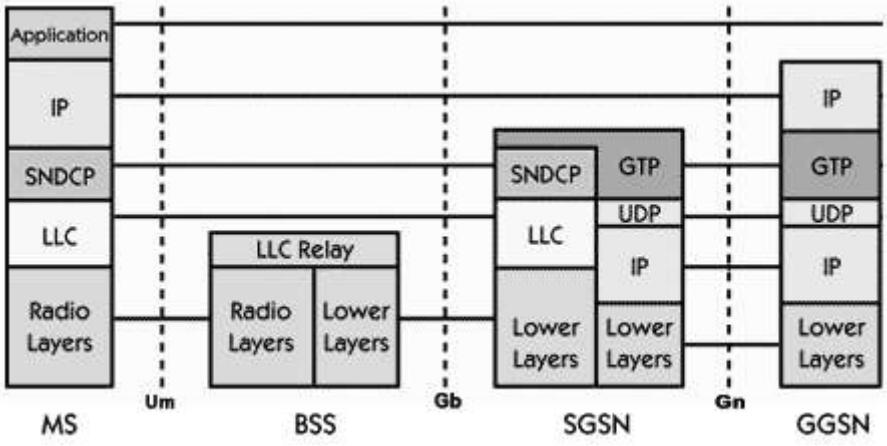
For the proliferation of GSM enable the introduction of SMS, which is similar to peer-to-peer instant messaging on the Internet. Users of SMS can exchange alphanumeric message of up to 160 char. within seconds of submission of the message.

Therefore, GPRS requires modifications to numerous GSM network elements as summarized below:

GSM Network Element	**Modification or Upgrade Required for GPRS.**
Mobile Station (MS)	New Mobile Station is required to access GPRS services. These new terminals will be backward compatible with GSM for voice calls.
BTS	A software upgrade is required in the existing Base Transceiver Station(BTS).
BSC	The Base Station Controller (BSC) requires a software upgrade and the installation of new hardware called the packet control unit (PCU). The PCU directs the data traffic to the GPRS network and can be a separate hardware element associated with the BSC.
GPRS Support Nodes (GSNs)	The deployment of GPRS requires the installation of new core network elements called the serving GPRS support node (SGSN) and gateway GPRS support node (GGSN).
Databases (HLR, VLR, etc.)	All the databases involved in the network will require software upgrades to handle the new call models and functions introduced by GPRS.

GPRS PROTOCOL SUITE

The flow of GPRS protocol stack and end-to-end message from MS to the GGSN is displayed in the below diagram. GTP is the protocol used between the SGSN and GGSN using the Gn interface. This is a Layer 3 tunneling protocol.



The process that takes place in the application looks like a normal IP sub-network for the users both inside and outside the network. The vital thing that needs attention is, the application communicates via standard IP, that is carried through the GPRS network and out through the gateway GPRS. The packets that are mobile between the GGSN and the SGSN use the GPRS tunneling protocol, this way the IP addresses located on the external side of the GPRS network do not have deal with the internal backbone. UDP and IP are run by GTP.

Sub-Network Dependent Convergence Protocol (SNDCP) and Logical Link Control (LLC) combination used in between the SGSN and the MS. The SNDCP flattens data to reduce the load on the radio channel. A safe logical link by encrypting packets is provided by LLC and the same LLC link is used as long as a mobile is under a single SGSN.

In case, the mobile moves to a new routing area that lies under a different SGSN; then, the old LLC link is removed and a new link is established with the new Serving GSN X.25. Services are provided by running X.25 on top of TCP/IP in the internal backbone.

IS-95

IS-95 stands for **Interim Standard 95** and is also known as **CDMAOne**. It was the first ever CDMA-based digital cellular technology and was developed by Qualcomm. It is an 2G cellular system based on DS-CDMA.

DSSS is Direct Sequence Spread Spectrum Technique which is a spread spectrum technique in which the data to be transmitted is encoded using spreading code and received and then decoded using the same code. It is used to avoid interference, spying and jamming. The spreading code used is known to transmitter and receiver only.
CDMA stands for Code Division Multiple Access. It uses the same bandwidth for all the users. However, each user is assigned a separate code which differentiates the from each other.

- **Features of IS-95 are:**
    - Efficient power control scheme.
    - Soft Handoffs.
    - Improved speech quality and reduced interference by having different multiple levels of diversity like: Frequency diversity, Spatial diversity, path diversity and time diversity.
    - Variable rate vocoder.

- Bandwidth recycling.
- Uses modulation as Quadrature Phase Shift keying.
- Channel/Chip rate is 1.2288 Mcps and Data rate of 9.6 kbps.

- **Services:**
  - Convolution Encoder.
  - Repetition Circuit.
  - Data Scrambling.
  - Quadrature Spreading and Modulation.
  - RF modulation.
  - Burst Randomizing.
  - Direct Sequence Spreading.

IS-95 is the first Qualcomm standard under CDMA digital cellular technology, but the term generally applies to a protocol revision (P_REV=1) that was developed by the Telecommunications Industry Association (TIA).

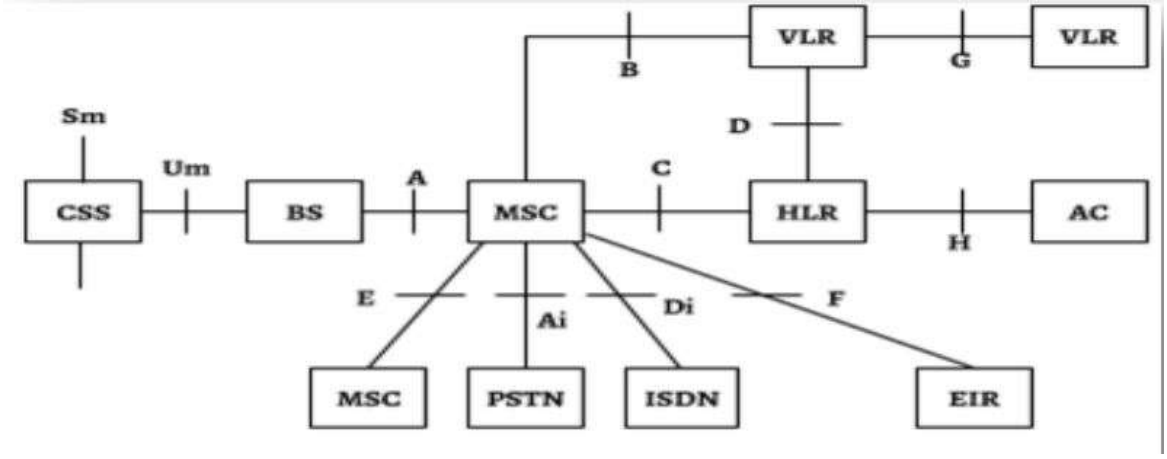
IS-95 was launched with the interoperability advantage of 1G (first-generation analog cellular network), which was IS-95's predecessor. If an interoperation option between IS-95 and an analog network exist, the latter standard's robust network infrastructure has an edge - even against its counterpart, Global System for Mobile Communications (GSM).

IS-95 base stations and handsets are data packet capable, and the IS-95 network uses IP based equipment. This infrastructure provides a high degree of compatibility for network operators implementing high-speed data services and allows network operators to evolve to third-generation (3G), which is an established IP-based standard.

Another advantage of an IS-95 network is IP gateway incorporation, or Interworking Function (IWF), which receives data from mobile phones in Point-to-Point Protocol (PPP) format. However, the IWF assigns a temporary IP address for that session, which provides flexibility to the IS-95 network infrastructure because it can incorporate any manufacturer's standard router into the IWF.

IS-95 ARCHITECTURE

Diagram:



CSS- Cellular Subscriber Station

BS-Base station

MSC- Mobile switching center

HLR-Home location registers

EIR-Equipment identity register

VLR- Visiting location registers

AC- Authentication center

Explanation :

Cellular Subscriber station:It is defined as a station in cellular radio service which is used when in motion at an unspecified location.

Home Location Register: Permanent database about mobile subscribers in a large service area.Database contains subscriber & location information. Database contains prepaid/postpaid, roaming restrictions, supplementary services.

Authentication Center: A unit called the AC provides authentication and encryption parameters that verify the user's identity and ensure the confidentiality of each call. The AC protects network operators from different types of fraud found in today's cellular world

Visitor Location Register: Temporary database which stores customer information for each roaming subscriber visiting the coverage area of particular MSC. It updates whenever new MS enters its area, by HLR database. It controls the mobiles roaming in its area.

Base station: A fixed station in a mobile radio system used for radio communication with mobile stations. Stations are located at the center or on the edge of a coverage region and consists of radio and transmitter and receiver antennas mounted on a tower

Mobile Switching Center: It co-ordinates the activities of all the base stations and connects the entire cellular system to the PSTN. A typical MSC handles 100,000 cellular subscribers and 5,000 simultaneous conversations at a time, and accommodates all billing and system maintenance functions as well.

EIR : The Equipment Identity Register (EIR) is a database that contains a record of the all theCellular Subscriber stationthat are allowed in a network as well as a database of all equipment that is banned, e.g. because it is lost or stolen.

CDMA-2000

CDMA2000 is a code division multiple access (CDMA) version of IMT-2000 specifications developed by International Telecommunication Union (ITU).

It includes a group of standards for voice and data services –

- **Voice –** CDMA2000 1xRTT, 1X Advanced
- **Data –** CDMA2000 1xEV-DO (Evolution-Data Optimized)

CDMA2000 is the solution of 3rd Generation based on Is-95. The interface of network defined for cdma2000 supports the network of second generation of all the present operators, independently of the technology (cdmaOne, Is-136 TDMA or GSM). TIA presented this norm to UIT like a part of the Imt- 2000 process. Cdma 2000 operate in TDD way and/or FDD way, cdma2000 offers speeds from 1.2 kbit/s to 2 Mbit/s. Cdma2000 in addition adds an interference guard band of 640 kHz by side for protection against interference in adjacent channels (interference co channel). Cdma2000 operates with synchronism between the mobile and the base station. 19 3G Systems: WCDMA(UMTS)&Cdma20000 CDMA2000 is a solution for operators of new radio networks that wish to take advantage from the dynamic ones of the market created by mobility and the Internet. CDMA2000 is as much an air interface as a solution of network to provide the services that the clients demand today. The objective of this the harmonization group is to provide a global roaming between the different modalities: CDMA 3G, CDMA2000 and WCDMA.

Features

- CDMA2000 is a family of technology for 3G mobile cellular communications for transmission of voice, data and signals.
- It supports mobile communications at speeds between 144Kbps and 2Mbps.
- It has packet core network (PCN) for high speed secured delivery of data packets.
- It applies multicarrier modulation techniques to 3G networks. This gives higher data rate, greater bandwidth and better voice quality. It is also backward compatible with older CDMA versions.
- It has multi-mode, multi-band roaming features.

CDMA2000 Packet Data Architecture

The architecture of CDMA2000 data system is based on the following components (as shown in Figure 4.3):

- A mobile station in a form of a handset, PDA, or PCMCIA card in handheld/portable computer supporting Simple IP or Mobile IP client or both
- CDMA2000-1x Radio Access Network (RAN)
- Packet Control Function (PCF)
- Packet Data Serving Node (PDSN) supporting FA functionality in case of Mobile IP
- Home and foreign AAA servers
- Home Agent (for the Mobile IP access method)

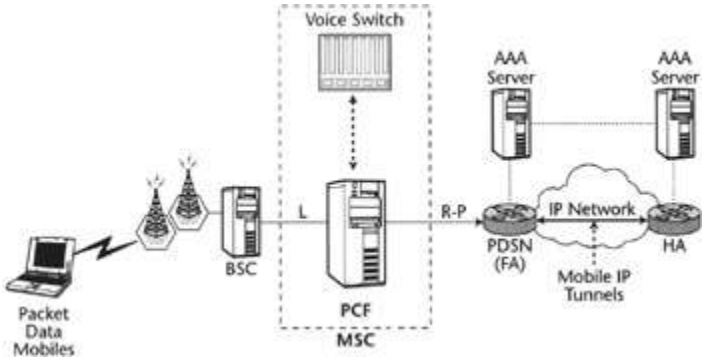


Fig. Example of CDMA2000 packet data architecture.

WCDMA

Wideband Code Division Multiple Access (WCDMA) is a third-generation (3G) standard that employs the direct-sequence code division multiple access (DS-CDMA) channel access method and the frequency-division duplexing (FDD) method to provide high-speed and high-capacity service. WCDMA is the most commonly used variant of the Universal Mobile Telecommunications System (UMTS). It was developed by Japan's NTT DoCoMo and formed the basis of its Freedom of Multimedia Access (FOMA) 3G Network.

Wideband CDMA is a third-generation (3G) wireless standard which allows use of both voice and data and offers data speeds of up to 384 Kbps.

The frequency bands for WCDMA are as follows: Europe and Asia - 2100MHz, North America - 1900MHz and 850MHz.

Some parts of the WCDMA are based on GSM technology and the networks are designed to integrate the GSM networks at some levels.

Difference between WCDMA and GSM :

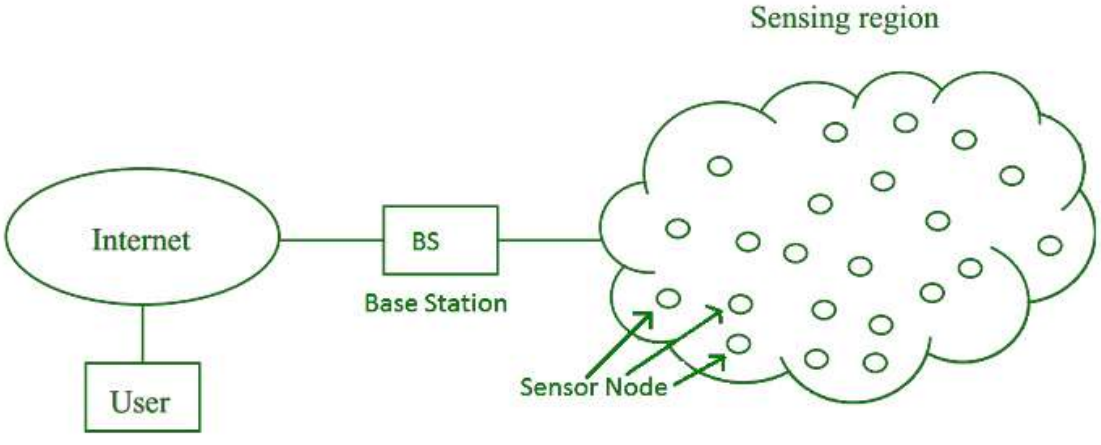
SL. No.	WCDMA	GSM
1.	It is a third-generation (3G)standard for cellular networks.	It is a second-generation (2G)standard for cellular networks.
2.	Nowadays, it is commonly used in all kinds of mobile phones.	At present, this technology is no longer used a lot in mobile as it is an older technology.
3.	It offers a wide area as compared to GSM.	It offers less area as compared to GSM.
4.	It is having better efficiency than GSM.	It is having poor efficiency as compared to WCDMA.
5.	It can be work any area throughout the world.	It can be work in European countries only.
6.	It is having a fast speed in communication over the network as compared to GSM.	It is having a slow speed in communication over the network as compared to WCDMA.
7.	It can support GSM technology as well.	It does not support WCDMA.
8.	In this, the signal can be treated effortlessly.	In this, the signal can't be treated effortlessly.

WIRELESS SENSOR NETWORKS

Wireless Sensor Network (WSN) is an infrastructure-less wireless network that is deployed in a large number of wireless sensors in an ad-hoc manner that is used to monitor the system, physical or environmental conditions.

Sensor nodes are used in WSN with the onboard processor that manages and monitors the environment in a particular area. They are connected to the Base Station which acts as a processing unit in the WSN System.

Base Station in a WSN System is connected through the Internet to share data.



WSN can be used for processing, analysis, storage, and mining of the data.

Applications of WSN:

1. Internet of Things (IOT)
2. Surveillance and Monitoring for security, threat detection
3. Environmental temperature, humidity, and air pressure
4. Noise Level of the surrounding
5. Medical applications like patient monitoring
6. Agriculture
7. Landslide Detection

Challenges of WSN:

1. Quality of Service
2. Security Issue
3. Energy Efficiency
4. Network Throughput
5. Performance
6. Ability to cope with node failure
7. Cross layer optimisation
8. Scalability to large scale of deployment

Components of WSN:

1. **Sensors:**

   Sensors in WSN are used to capture the environmental variables and which is used for data acquisition. Sensor signals are converted into electrical signals.
2. **Radio Nodes:**

   It is used to receive the data produced by the Sensors and sends it to the WLAN access point. It consists of a microcontroller, transceiver, external memory, and power source.
3. **WLAN Access Point:**

   It receives the data which is sent by the Radio nodes wirelessly, generally through the internet.
4. **Evaluation Software:**

   The data received by the WLAN Access Point is processed by a software called as Evaluation Software for presenting the report to the users for further processing of the data which can be used for processing, analysis, storage, and mining of the data

Types of Wireless Sensor Networks

Depending on the environment, the types of networks are decided so that those can be deployed underwater, underground, on land, and so on. Different types of WSNs include:

1. Terrestrial WSNs
2. Underground WSNs
3. Underwater WSNs
4. Multimedia WSNs
5. Mobile WSNs

UNIT-10
MESSAGING SERVICES

SHORT MESSAGE SERVICES (SMS)

SMS stands for Short Message Service.It is a technology that enables the sending and receiving of messages between mobile phones. SMS first appeared in Europe in 1992. It was included in the GSM (Global System for Mobile Communications) standards right at the beginning. Later it was ported to wireless technologies like CDMA and TDMA. The GSM and SMS standards were originally developed

by ETSI . ETSI is the abbreviation for European Telecommunications Standards Institute. Now

the 3GPP (Third Generation Partnership Project) is responsible for the development and maintenance of the GSM and SMS standards.

As suggested by the name "Short Message Service", the data that can be held by an SMS message is very limited. One SMS message can contain at most 140 bytes (1120 bits) of data, so one SMS message can contain up to:

- 160 characters if 7-bit character encoding is used. (7-bit character encoding is suitable for encoding Latin characters like English alphabets.)
- 70 characters if 16-bit Unicode UCS2 character encoding is used. (SMS text messages containing non-Latin characters like Chinese characters should use 16-bit character encoding.)

SMS text messaging supports languages internationally. It works fine with all languages supported by Unicode, including Arabic, Chinese, Japanese and Korean.

Besides text, SMS messages can also carry binary data. It is possible to send ringtones, pictures, operator logos, wallpapers, animations, business cards (e.g. VCards) and WAP configurations to a mobile phone with SMS messages.

One major advantage of SMS is that it is supported by 100% GSM mobile phones. Almost all subscription plans provided by wireless carriers include inexpensive SMS messaging service. Unlike SMS, mobile technologies such as WAP and mobile Java are not supported on many old mobile phone models.

History

The text message facility was first added to the mobile devices in the early 1980s. The action plan GSM for providing the services available to public data networks also to the mobile systems was approved in December 1982. According to this plan, the exchange of text messages was allowed either via mobile stations or via handling stations. Finally, the concept of SMS was thus developed in Franco-German cooperation by Friedhelm Hillebrand and Bernard Ghillebaert in 1984. The main idea behind the SMS concept was to use telephone optimized systems and to thus transport messages by making the use of signaling paths. The maximum length of text messages to be of 160 alpha-numeric characters was decided by Friedhelm Hillebrand.

In the current scenario, the SMS facility is supported by GSM, CDMA, and TDMA mobile networks. The facility of SMS is provided by all the telecommunication companies like Vodafone, airtel, idea, etc.

SMS is similar to paging. However, SMS messages do not require the mobile phone to be active and within range and will be held for a number of days until the phone is active and within range. SMS messages are transmitted within the same cell or to anyone with roaming service capability. They can also be sent to digital phones in a number of other ways, including:

- From one digital phone to another
- From Web-based applications within a Web browser
- From instant messaging clients like ICQ
- From VoIP applications like Skype
- From some unified communications applications.

Typical uses of SMS include:

- Notifying a mobile phone owner of a voicemail message
- Notifying a salesperson of an inquiry and contact to call
- Notifying a doctor of a patient with an emergency problem
- Notifying a service person of the time and place of their next call
- Notifying a driver of the address of the next pickup
- Enhanced messaging service (EMS), an adaptation of SMS that allows users to send and receive ringtones and operator logos, as well as combinations of simple media to and from EMS-compliant handsets.

SMS gateway is a website that lets you enter an SMS message to someone within the cell served by the gateway or that acts an international gateway for users with roaming capability.

Two types of GSM SMS have been defined. They are

1. **CELL BROADCAST**: it is a service which delivers short messages to all users in a given area at regular interval.
2. **POINT TO POINT SERVICE**: it is a service which sends short messages to a particular user.

Advantages

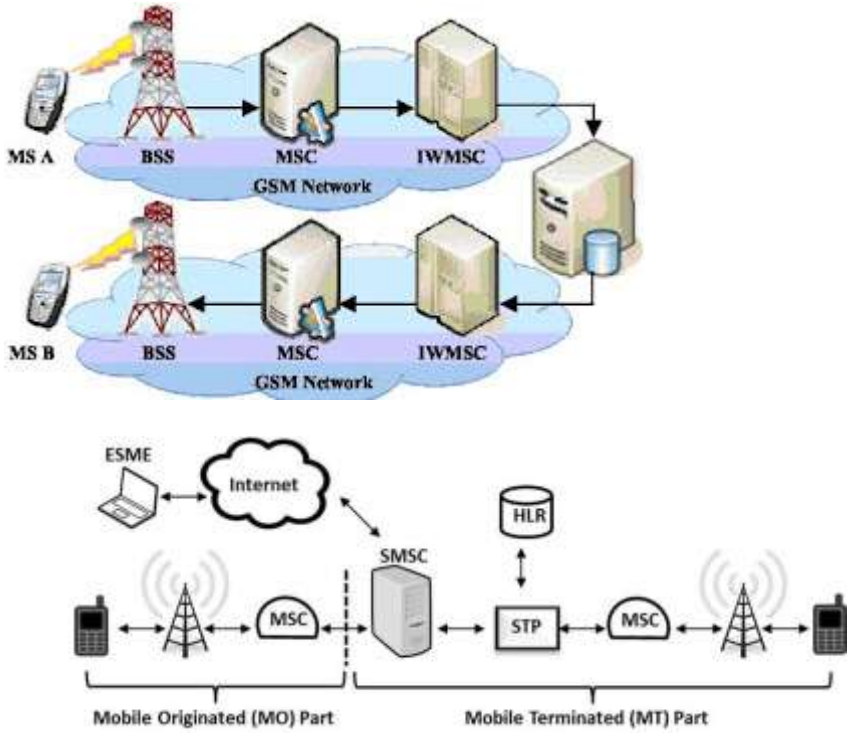
- It is a very reliable and attested platform for sending important information which ensures a guaranteed delivery of the information.
- It is a more discrete form of sending information in comparison to a phone call.
- It is provided automatically to all mobile devices and there is no requirement for an internet connection.
- The conversations among people are automatically stored until deleted by the people themselves.
- It does not require any app to be downloaded as it is already provided in all the mobile devices.

Disadvantages

- It has a limited length as it provides only 160 characters per text message.
- In order to send a text message one has to pay the cost for sending it as SMS facility is not free of cost.
- There is no possibility to unsend a message once sent.

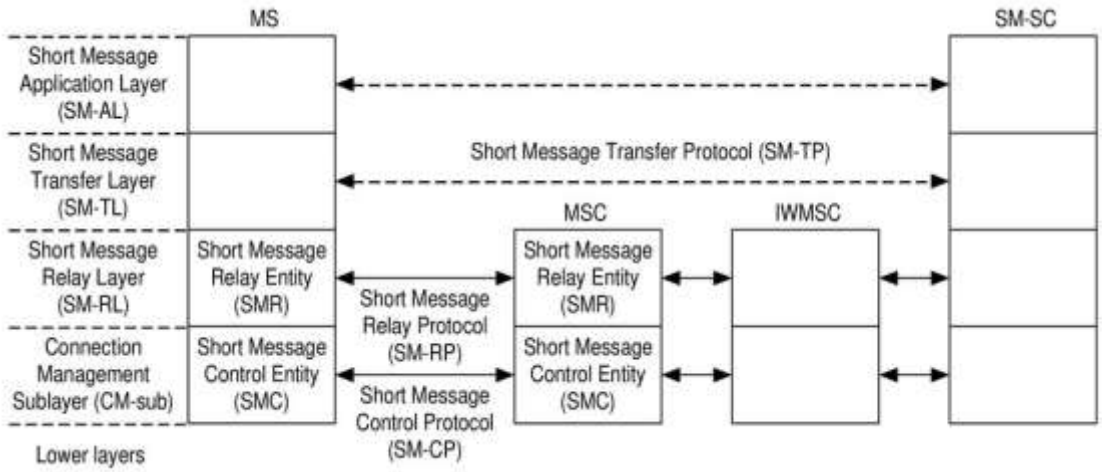
SMS Architecture

If any mobile user looking for the way how a SMS takes a rout to reach one user's mobile to another associate mobile user, So user should must aware about SMS architecture which plays a very important role. Anyone can easily find out the way by takes a look to understand GSM, illustrated figure below.



At the beginning, if a user sends a SMS to his buddy,the SMS first deliver from the MS which is know as Mobile Station A to SM-SC(Short Message Service Center) Via the Base Station System (BSS), and then it catch up to the Mobile Station center(MSC) and finally combine with InterworkingMSC(IW-MSC). The use of Short Message Service Center (SM-SC) to carry ahead the SMS message to the GSM network through a definite GSM-MSC called the Short Message Service gateway MSC (SMS-GMSC). The SM-SC is allowed to link with several GSM networks and to several SM-GMSCs in a GSM network. The SMS-GMSC come across the contemporary MSC of the message acceptor and then step ahead the SMS message to that Mobile Station center, pursue the Global System for Mobile Communication (GSM) roaming protocol.The MSC then Publish the SMS through the Base Station System (BSS) to the destination MSB.

SMS PROTOCOL HIERARCHY:



The purpose of the Short Message Service is to provide the means to transfer messages between a GSM PLMN Mobile Station (MS) and a Short Message Entity via a Service Centre, as described in GSM 03.40. The terms "MO" - Mobile Originating - and "MT" - Mobile Terminating - are used to indicate the direction in which the short message is sent.

This ETS describes the procedures necessary to support the Short Message Service between the MS and the MSC and vice versa, as described in GSM 03.40.

The procedures are based on services provided by the Mobility Management sublayer as described in GSM 04.07/04.08.

The CM-sublayer, in terms of the Short Message Service Support, provides services to the Short Message Relay Layer.

On the MS-side the Short Message Relay Layer provides services to the Short Message Transfer Layer. The Short Message Relay Layer is the upper layer on the network side (MSC), and the SM-user information elements are mapped to TCAP/MAP.

The peer protocol between two SMC entities is denoted SM-CP, and between two SMR entities, SM-RP.

Abbreviations:

SM-AL Short Message Application Layer

SM-TL Short Message Transfer Layer

SM-RL Short Message Relay Layer

SM-RP Short Message Relay Protocol

SMR Short Message Relay (entity)

CM-sub Connection Management sublayer

SM-CP Short Message Control Protocol

SMC Short Message Control (entity)

MM-sub Mobility Management sublayer

RR-sub Radio Resource Management sublayer

The architecture for mobile-originated messaging and mobileterminated messaging are similar, with the exception that the IWMSC is replaced by the GMSC. a The SMS protocol hierarchy consists of 4 layers: SM-AL, SM-TL, SM-RL, CM-sub. a In this hierarchy, the protocol between the IWMSC and the SM-SC below the transfer layer is not specified in GSM. a The protocol between the MSC and IWMSC is GSM MAP, utilizing SS7 TCAP. a The layers below the CM-sublayer are the mobility management mobility management (MM) and radio resource (RR) management radio resource (RR) management sublayer. a At the RR management layer the short message service is supported by control channels (e.g., SDCCH or SACCH).

SHORT MESSAGE TRANSFER LAYER These SM-TL-supported service primitives generate a reference number called Short Message Identifier (SMI) Message Identifier (SMI) for every short

message associated with the primitives. This SMI at the MS is not carried between the peer entity at the SM-SC (i.e., a short message may have different SMIs at the MS and the SMSC sides).

Four Types of Transfer Protocol Data Units (TPDUs)

- **SMS-SUBMIT (MS SUBMIT (MS -> SM-SC).** ‰ Conveys a short message (referred to as transfer protocol user short message (referred to as transfer protocol user data or TP-UD) from MS to the SM-SC. ‰ TP-UD optionally specifies the validity period that the short message can be buffered in the SM-SC if it cannot be delivered to the recipient immediately.
- **SMS-DELIVER (SM-SC -> MS).** ‰ Conveys a short message from the SM-SC to the MS. ‰ This TPDU includes a service center timestamp. The SM-SC uses this timestamp to inform the recipient MS about the arrival time of the short message at the SM-TL of the SM-SC. ‰ A boolean parameter, More-To-Send, is used to indicate if one or more messages are waiting in the SM-SC for delivery to the recipient MS.
- **SMS-STATUS-REPORT (SM-SC -> MS**). ‰ This report describes the status of the previously sent mobileoriginated short message. ‰ If the previous short message is not delivered successfully, this TPDU may report permanent errors, e.g.,

• Validity Period Expiration

• Incompatible Destination

• Temporary Errors, e.g., Congestion ‰

This TPDU is optionally initiated by SMS-SUBMIT.

- **SMS-Command (**MS Command (MS -> SM-SC). ‰ Can be a Query about the previous submitted short message ‰ Cancellation of the status report ‰ Deletion of the submitted message

SHORT MESSAGE RELAY LAYER The short message relay layer (SM-RL) provides services to transfer TPDUs and the corresponding delivery reports for SM-TL. aThese SM-RL-supported service primitives generate SM-RL SMI for the messages to be delivered. aFor a message, the SM-RL SMI at mobile side and SM-RL SMI at the SM-SC are the same.

The SMR entity at the MS communicates with the peer SMR at MSC by using the Short Message Relay Protocol (SM-RP). aSM-RP provides the networking functions between MS and SM-SC, which interworks with TCAP/MAP in the MSC.

Four Types of Relay Protocol Data Units (RPDUs) A RP-DATA (MS <-> SM-SC). ‰ Invoked by the SM-RL-DATA service primitives. ‰ RP-DATA contains the originating address, the terminating address, and the user data containing TPDU. ‰ A mobile-terminated RP-DATA may indicate if more waiting message in SM-SC. a RP-SM-MEMORY-AVAILABLE (MS AVAILABLE (MS -> Network). > Network). ‰ Invoked by the SM-RL-MEMORY-AVAILABLE primitive. ‰ SM-RL-MEMORY-AVAILABLE passes the necessary control information to indicate that the MS has memory available to receive one or more messages).

RP-ACK. ‰ Invoked by the SM-RL-REPORT primitives to acknowledge the corresponding RP-DATA or RP-SM-MEMORY-AVAILABLE data units. a RP-ERROR. ‰ Invoked by the SM-RL-REPORT primitive to report any error of a corresponding RP-DATA. ‰ An error may occur if ‰ (1) the message is too short to contain the complete message type, ‰ (2) the message reference is known, ‰ (3) the message type is unknown, or ‰ (4) the message content is semantically incorrect.

CONNECTION MANAGEMENT SUBLAYER (CM-SUB) The CM-Sub for SMS provides services to support the SM-RL. a In this layer, the Short Message Control (SMC) Short Message Control (SMC) entity at the MS communicates with the peer SMC at the MSC by using the Short-Message-Control Control-Protocol (SMCP). a The MS has two SMC entities. ‰ One handles the MS-Originated (MO) short message and ‰ The other handles the MS-Terminated (MT) short message service. Note that the SMC entities cannot simultaneously perform messaging in both directions.

The Protocol Elements for SMCP

CP-DATA- ‰ Invoked by the SM-CP service primitives MNSMS-DATA or MNSMS-ESTablish. ‰ These two primitives deliver RP-DU between the MS and the MSC.

CP-ACK- Acknowledges the corresponding CP-DATA. CP-ACK does not contain any specific information elements.

CP-ERROR- ‰ Invoked by the SM-CP service primitives MNSMS-ABORT or MNSMS-ERROR, which provide the cause of the messaging procedure error.

Multimedia Message Services (MMS)

MMS stands for **Multimedia Messaging Service**. It is the standard way to send messages from one device to another through a network.
As the name Multimedia, we can suggest from here that it is not only for sending text messages, we can also send multimedia like images, audio clips and video clips, and many more things.
It is the extension used for **SMS**(Short Message Service) where we send and receive text messages only with the limitation of only 160 characters in one SMS.
Most of the smartphones support MMS messaging nowadays. Basically it is the advanced version of the text messaging with the additional feature of multimedia.

Modes of sending MMS
There are basically six modes which are as follows:

- Sending messages to an MMS mobile phone via an MMS mobile phone.
  It can be sent in the same way as we send SMS messages, except that MMS messages include multimedia contents.
- Sending messages to a non-MMS mobile phone via an MMS mobile phone.
  Since the non-MMS mobile phones can't receive a multimedia message, the MMS system automatically forwards the messages to the receiver's corresponding email box and then sends a notification to his mobile phone.
- Sending messages to email boxes via an MMS mobile phone Multimedia messages can be sent via an MMS mobile phone to an email box, and the receiver logs on the email box to read the messages. However, most email boxes don't support multimedia messages yet.
- Sending messages to an MMS mobile phone via an email box.
  A user logs on to his email box, selects multimedia messages to sent, inputs a receiver's MMS mobile phone number, and send the messages as an attachment.
- Downloading multimedia messages from the internet to an MMS mobile phone.
  A user can customize and order multimedia messages on websites that provide MMSs and then send MMS to an MMS mobile phone.
- Sending messages from an MMS mobile phone to personal e-albums.
  A user can send MMS messages to his personal e-album via an MMS mobile phone. User writes MMS messages in mobile phones, inputs the album website number, and then sends the messages.

Advantages

- We can easily send and deliver MMS messages.

- The MMS messages which we received, we can store them (save them) and also we can forward messages.
- Users are using these services as they are user-friendly.
- These services are interactive.
- Image, video, and other media-rich content allows for better branding.

Disadvantages

- MMS service is not available on all mobile phones. So, we cannot use this service in all the phones.
- Some multimedia content has some resolution issues due to the varied display sizes of different phones.
- As it a service provided to us but there are also extra charges associated with it. If we have to use this service we have to pay extra charges for this service.
- Users who have opted in to an MMS database don't necessarily have an MMS enabled phone. Sending bulk MMS messages is often only available through a dedicated messaging platform rather than a network.

MMS messages are delivered using a combination of SMS and WAP technologies.

When a mobile phone receives an MMS message, what it is actually receiving is an MMS notification message which it receives over SMS (WAP Push). This MMS notification message contains header information about the MMS message, and a URL pointer that the recipient must fetch in order to retrieve the content of the MMS message.

This URL pointer is a dynamically generated URL for the MMS message content which is stored on the MMSC. In a typical phone-to-phone MMS transaction, the process of sending and receiving the MMS message works like this:

- The sending phone initiates a data connection that provides TCP/IP network connectivity, usually over GPRS.
- The sending phone performs an HTTP POST to an MMSC of the MMS message encoding in the MMS Encapsulation Format, as defined by the Open Mobile Alliance. The encoded MMS message includes all of the content of the MMS message, as well as header information, including a list of intended recipients for the message. (Note: In most environments, the HTTP POST will be routed through a proxy server. Some devices will use wireless profiled HTTP and TCP through a WAP 2.0 proxy server, while other devices will use the Wireless Session Protocol, WSP, through a conventional WAP proxy server/gateway.)
- The MMSC receives the MMS message submission and validates the message sender.
- The MMSC stores the content of the MMS message and makes it available as a dynamically generated URL link.
- The MMSC generates an MMS notification message, which is sent via WAP Push over SMS to the message recipient(s). This MMS notification message contains a URL pointer to the dynamically generated MMS content.
- The recipient receives the MMS notification message. It then initiates a data connection that provides TCP/IP network connectivity (usually over GPRS).
- The recipient phone performs an HTTP (or WSP) get to retrieve the MMS message content URL from the MMSC.

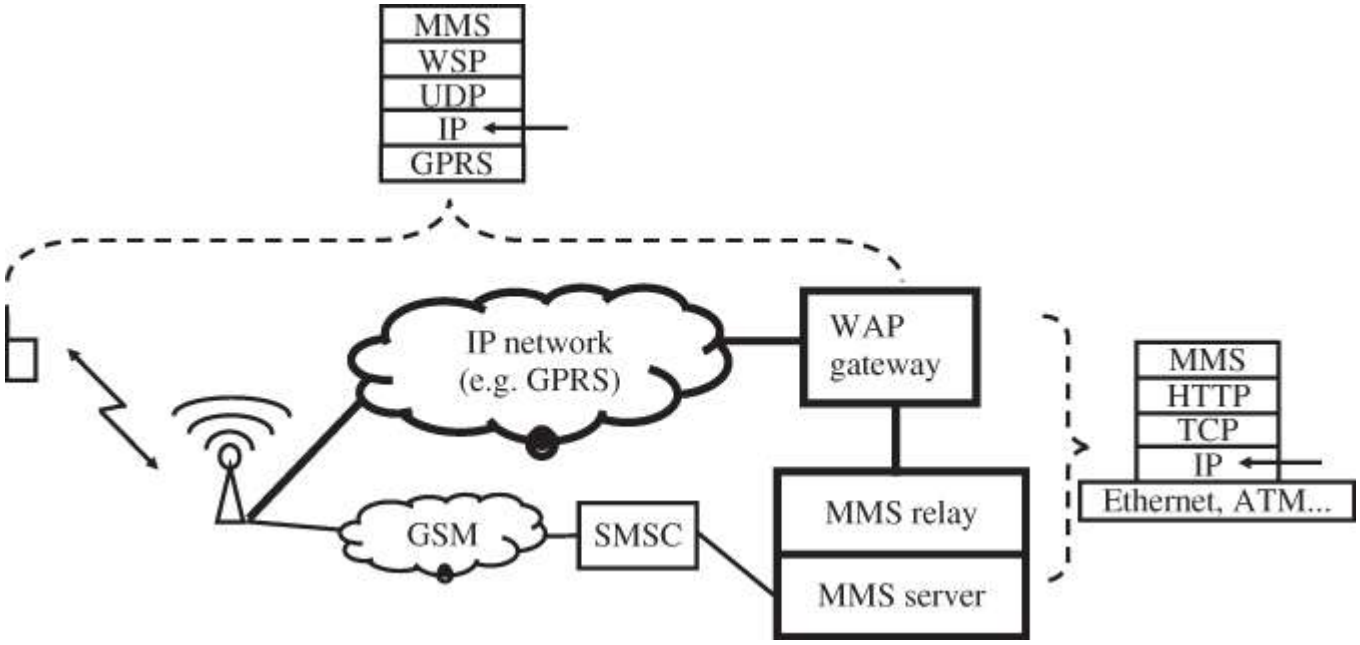
Explore these two types of configurations:

- 1.) Direct MMS delivery – In this configuration, NowSMS is an MMSC. Users and/or applications submit MMS messages to the NowSMS MMSC. The MMS message content is stored on the Now SMS & MMS Gateway, and the NowSMS MMSC publishes a dynamic URL for access to the MMS message content. NowSMS generates an MMS notification message to the recipient device which is sent over SMS, and this notification includes a URL pointer back to the MMS message content on the NowSMS server.
- 2.) MMS Gateway routing messages via an operator MMSC – NowSMS supports all of the major MMS related protocols, including MM7, MM4, MM1 and EAIF for this purpose. NowSMS also supports vendor specific proprietary versions of MM7, including the non-standard variations from Ericsson, LogicaCMG, and Materna AnnyWay. NowSMS also supports a

generic SMTP interface which can be used as an MM3 implementation. Any of these protocols can be used for connecting to an operator MMSC. Most frequently, at least as a starting point, what we see is the use of MM1 where NowSMS makes a GPRS connection over a GSM/GPRS modem, connects to the operator WAP gateway that is designated for MMS usage by the operator, and submits the message to the operator MMSC via the WAP gateway over the GPRS connection. (The operator MMS gateway then generates the dynamic URL and MMS notification message that is ultimately received by the recipient device.)

The problem with the Direct MMS Delivery approach is that the MMS client on every mobile phone is pre-configured with settings for how the phone sends and receives MMS messages. To send or receive an MMS message, the phone makes a GPRS connection (to a GPRS APN). It then usually connects to the MMSC for sending/receiving messages through a WAP proxy/gateway. The pre-configured MMS settings on many mobile operator networks are setup to connect to a special MMS-only GPRS APN which connects to an MMS-only WAP gateway … and this GPRS APN/WAP gateway is configured only to allow connections to the operator MMSC. If the recipient mobile phone is subscribed to an operator that has this type of setup, and you attempt direct MMS delivery, you can send the MMS notification to the phone over SMS, but the phone cannot retrieve the MMS message from your MMSC server because the GPRS APN/WAP Gateway does not allow it.

MMS architecture overview as defined in 3GPP TS 23.140 [8].



If a mobile device wants to send an MMS message, it establishes an IP connection to the MMS server via the GPRS network. The PDP context activation procedure that is required to get an IP address in the first place has already been described before. Instead of using the same APN as for a transparent connection to the Internet, the MMS service usually requires its own APN. This enables the operator to charge separately for the MMS traffic.

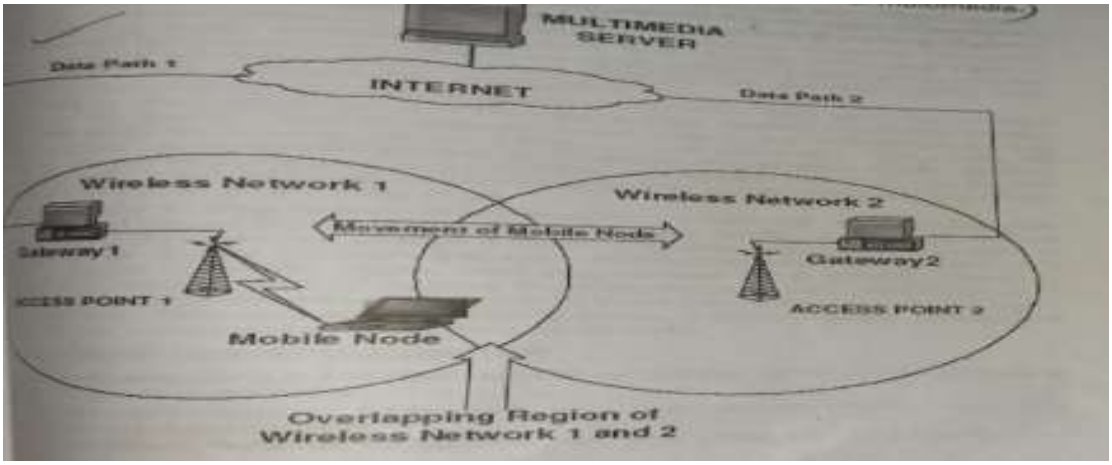
Multimedia transmission over wireless

Multimedia transmission over wireless networks highlighting general challenges driving the research on wireless technologies and networking techniques for mobile multimedia support.

Mobile computers, such as PDAs and laptop computers with multiple network interfaces are becoming very common. Many of the applications that run on a mobile computer involve multimedia,

such as video conferencing, audio conferencing, watching live movies, sports, etc. This chapter deals with multimedia communication in mobile wireless devices, and in particular, concentrates on the effect of mobility on streaming multimedia in wireless networks.

Streaming multimedia over wireless networks is a challenging task. Extensive research has been carried out to ensure a smooth and uninterrupted multimedia transmission to a Mobile Host (MH) over wireless media. The current research thrust is to ensure an uninterrupted multimedia transmission when the MH moves between networks or subnets. Ensuring uninterrupted multimedia transmission during handoff is challenging, because the MH is already receiving multimedia from the network to which it is connected; when it moves into another network, it needs to break the connection with the old network and establish a connection with the new network. Fig. 1 shows an MH connected to Wireless Network 1; when it moves it has to make a connection with the new network, say Wireless Network 2. The reestablishment of a new connection takes a considerable amount of time, resulting in the possibility of interruption and resulting loss of multimedia.



The current TCP/IP network infrastructure was not designed for mobility. It does not support handoff between IP networks. For example, a device running a realtime application, such as video conference, can not play smoothly when the user hands off from one wireless IP network to another, resulting in unsatisfactory performance to the user. Mobile IP (MIP) , from IETF, addresses the mobility problem. MIP extends the existing IP protocol to support host mobility, including handoff, by introducing two network entities: Home Agent (HA) and Foreign Agent (FA). The HA and FA work together to achieve host mobility. The correspondent node (CN) always communicates with the Mobile Node (MN) via its home network address, even though MH may not dwell in the home network. For CN to have seamless access to MN, the MH has to be able to handoff in a timely manner between networks.

Handoff latency is one of the most important indicators of handoff performance. Large handoff latency degrades performance of realtime applications. For example, a large handoff latency will introduce interruption in a video conference due to breaks in both audio and video data transmission. In addition to high handoff latency, MIP suffers from a number of other problems including Triangle Routing, high signalling traffic with the HA, etc.