MCA-104: Information Technology

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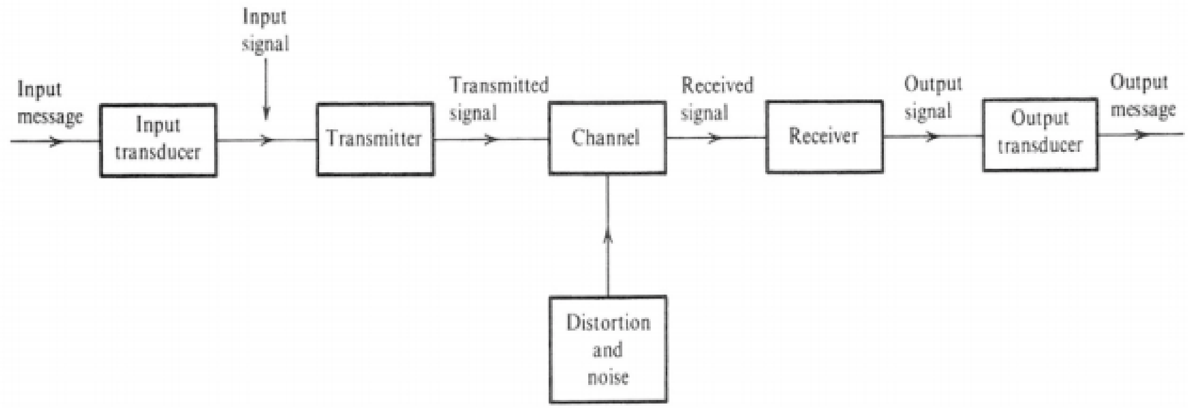
INTRODUCTION AND BASIC CONCEPT OF MODERN COMMUNICATION AND TECHNOLOGY: CDMA, WLL, GSM, VOIP, BLUETOOTH, WI-FI

BASIC COMMUNICATION SYSTEM

A basic communication system, irrespective of the fact that it is wired or wireless, can be represented by the following block diagram:



The basic components and terminologies, which will be followed throughout the course, are:

- **Transducers**: Transducers are devices that convert a physical quantity into electrical signals, or vice versa. Here, the input transducer converts the input message, which could be spoken as it is in the case of a cellular network system, and converts it into electrical impulses, which is then sent. The received electrical impulses are converted back into speech at the output transducer.

- **Transmitter:** Transmitters are devices that convert the electrical signal into a form, say radio waves that can be used to transmit the message signal.

- **Channel**: The channel is the medium through which the transmitted signal passes. It is here that it faces the danger of being attenuated or being exposed to external distortive signals called noise signals.

- **Receiver**: Receivers converts the transmitted signal back to electrical impulses, after receiving it. It is here that certain signal processing processes are done on the received signal to either eliminate or at least reduce the effects of noise on the transmitted signal.

WIRELESS COMMUNICATION?

- Wireless communication is the process of transmission of data from the sender to the receiver without the need for any sort of physical medium or connections, such as wires and cables, for propagation.
- The channel for communication is generally considered to be air and the means of propagation are radio waves.
- The frequency of the radio waves varies based on application, lower frequencies to transmit over longer distances (like Deep-Space Communication) and higher frequencies over shorter distances (like Bluetooth).
- Apart from the conventionally used radio waves, there are other methods to achieve wireless communication, which include the use of light, magnetic and electric fields or even sound, though they are quite uncommon.
- Some examples of wireless communication include cellular phones, GPS devices, TV/AC remotes, walkie-talkies, and car keys.

Advantages of Wireless Communication:

Wireless communication has revolutionized the way how people communicate since its inception in 1896 when Marconi had invented the Radio. The advantages that wireless communication provide its wired counterparts are as follows:

- **Flexibility and Modularity**

Wireless communication is said to be flexible and modular. This means that the addition of more and more users into the network is a seamless and effortless process that doesn't require any additional infrastructure to be set up (other than getting the user a unique identification entity, such as SIM cards in cellular networks), unlike wired communication systems.

- **Cost-effectiveness**

Adding to the previous factor of flexibility, the absence of the need for additional infrastructure for every new member of the network implies a lower installation cost per person. Maintenance costs are also quite low as a majority of the components of the wireless systems are not physical entities that could fall victim to wear and tear.

- **Convenience**

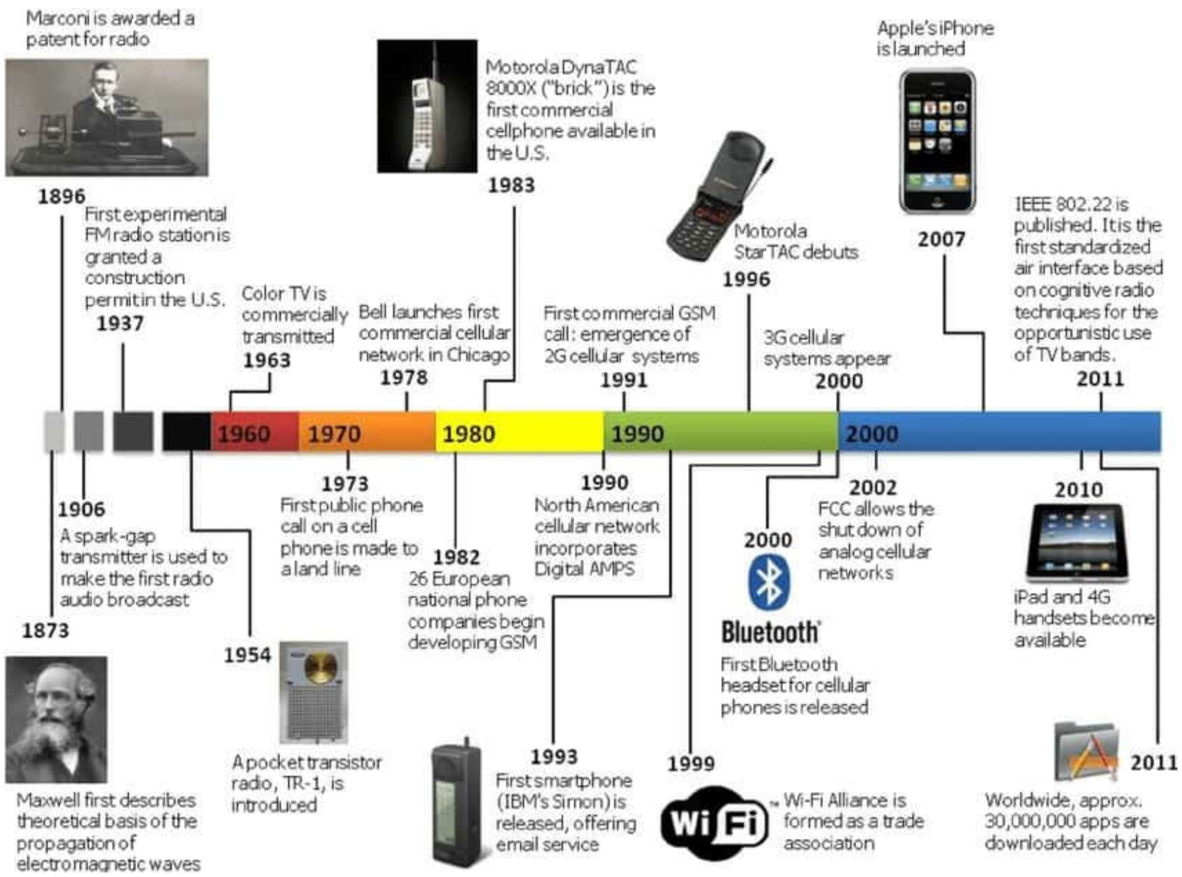
A major advantage of wireless communication is its ability to provide user mobility, meaning that unlike wired communication, the destination address doesn't mean a fixed destination location. This effectively boils down to the fact that the user can be anywhere across the world (obviously somewhere where he's able to wirelessly access the network), and he'd still be able to communicate.

- **Constant Accessibility**

The wireless networks are up most of the time and can be accessed by any authorized person, from any place of his/her choice. Wireless systems also ensure that people in areas where wired communication is not possible, such as rocky terrains where laying ground lines are tough, remain connected.

HISTORY OF WIRELESS COMMUNICATION

The following image gives a brief overview of the evolution of wireless communication through the years:



Some major inventions/discoveries in wireless communication are as follows:

- ➢ In 1873, Maxwell proposed the idea of using electromagnetic waves to propagate the transmission of message signals, which is the underlying concept behind wireless communication.

- Guglielmo Marconi invented the first wireless device, the wireless Telegraph, in 1896 and was awarded the patent for his radio the same year. The very next year, the first wireless message was sent, which read “Are you ready?”, across a distance of 6km.
- Soon, advancements in radio broadcasting took place and in 1933, the first FM radio station was built in the United States.
- In 1946, the first commercial telephone service was set up by AT&T and Southern Bell in Saint Louis, Missouri, USA, and the service was made available to private customers as well.
- In 1947, a tiny device that revolutionized the computing industry was invented. The transistor, which replaced the much bigger vacuum tubes, made possible the marriage of computers and communications and also brought compactness into the picture.
- In 1954, the first among a line of transistor radios were built, which could fit in one’s pocket comfortably.
- During the 1970s and 1980s, various companies such as Bell industries and Motorola came up with their idea of a commercial cellular phone for the masses, available for the public, which also initiated the first generation(1G) of mobile telephony.
- In the 1990s, GSM came into the picture, connecting many more people, and brought about the second generation of mobile telephony(2G).
- Wireless Fidelity(WiFi) came into existence in the late 1990s.
- Soon after, in the year 2000, Bluetooth was invented along with the release of the third-generation (3G) of mobile telephony. These two technologies revolutionized the way people shared messages, bringing more into the wireless world.
- In 2007, Apple released its first iPhone2 (the first “actual smartphone”), which lead to an exponential increase in the number of smartphones in the market.
- In 2010, the fourth generation(4G) of mobile telephony rolled out, which provide facilities such as Voice over LTE.

CODE DIVISION MULTIPLE ACCESS (CDMA)

CDMA stands for Code Division Multiple Access. It is one of the two second-generation systems for cellular phones available today. Even though the shift towards 5G cellular phone networks should, in theory, remove the split between the two types of networks, phones will still behave differently in areas where only 2G or3G networks are operating.

Code Division Multiple Access is a channel access method used by several radio communication *technologies*. It is a digital cellular technology and an example of multiple access. It is generally used for mobile communication.

Multiple accesses mean that several transmitters can send information simultaneously over a single communication channel. In this system, different CDMA codes are assigned to different users and the user can access the whole bandwidth for the entire duration. It optimizes the use of available bandwidth as it transmits over the entire frequency range and does not limit the user's frequency range.

Thus, CDMA allows several users to share a band of frequencies without undue interference between the users. It is used as a access method in many mobile phone standards.

CDMA technology was developed during World War II. It was developed by English allies to protect their wireless transmissions from jamming. When the war ended, Qualcomm patented this technology and made it commercially available. The first CDMA system was launched in September 1995 in Hong Kong by Hutchison Telephone Co.

❖ Usage

- It is used in the Global Positioning System (GPS).
- It is used by several mobile phone companies (e.g. Qualcomm standard IS-2000 also known as CDMA2000)
- W-CDMA is used in UTMS 3G mobile phone standard.
- CDMA has been used in OmniTRACS satellite system for transportation.

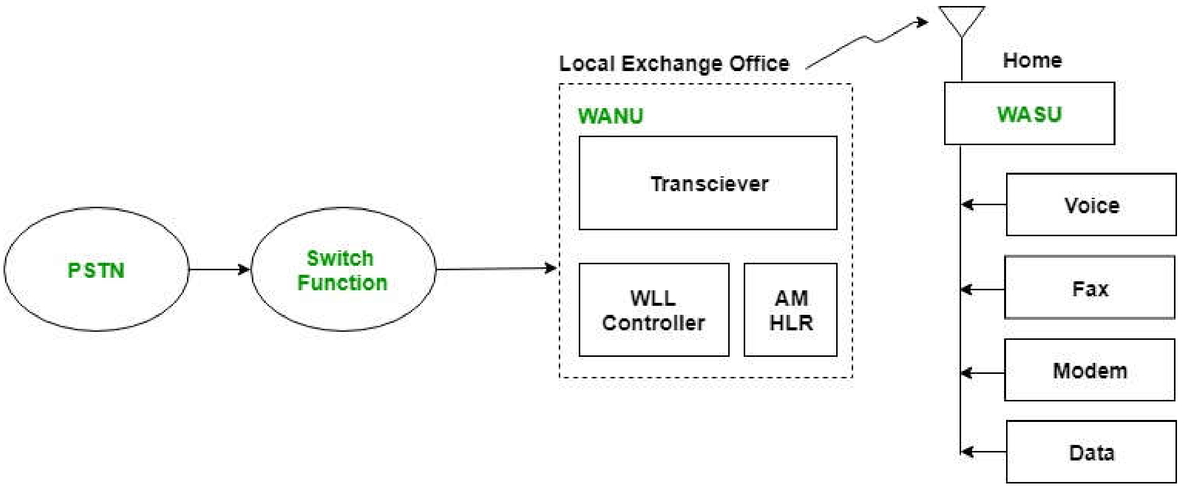
❖ **Categories of CDMA**

- Synchronous CDMA (orthogonal codes)
- Asynchronous CDMA (pseudorandom codes)

WIRELESS LOCAL LOOP (WLL)

Local loop is a circuit line from a subscriber's phone to the local central office (LCO). But the implementation of local loop of wires is risky for the operators, especially in rural and remote areas due to less number of users and increased cost of installation. Hence, the solution for it is the usage of wireless local loop (WLL) which uses wireless links rather than copper wires to connect subscribers to the local central office.

WLL Architecture:



WLL components:

1. **PSTN:** It is Public Switched Telephone Network which is a circuit switched network. It is a collection of world's interconnected circuit switched telephone networks.
2. **Switch Function:** Switch Function switches the PSTN among various WANUs.
3. **WANU:** It is short for Wireless Access Network Unit. It is present at the local exchange office. All local WASUs are connected to it. Its functions includes: Authentication, Operation & maintenance, Routing, Transceiving voice and data. It consists of following sub-components:
4. **Transceiver**: It transmits/receives data.
5. **WLL Controller:** It controls the wireless local loop component with WASU.
6. **AM:** It is short for Access Manager. It is responsible for authentication.
7. **HLR:** It is short for Home Location Register. It stores the details of all local WASUs.

WASU (Wireless Access Subscriber Units):
It is short for Wireless Access Subscriber Units. It is present at the house of the subscriber. It

connects the subscriber to WANU and the power supply for it is provided locally.

Advantages of WLL:

- It eliminates the first mile or last mile construction of the network connection.
- Low cost due to no use of conventional copper wires.
- Much more secure due to digital encryption techniques used in wireless communication.
- Highly scalable as it doesn't require the installation of more wires for scaling it.

Features of WLL:

- Internet connection via modem
- Data service
- Voice service
- Fax service

GSM (GLOBAL SYSTEM FOR MOBILE COMMUNICATION)?

GSM stands for **G**lobal **S**ystem for **M**obile Communication. It is a digital cellular technology used for transmitting mobile voice and data services. The concept of GSM emerged from a cell-based mobile radio system at Bell Laboratories in the early 1970s. GSM is the name of a standardization group established in 1982 to create a common European mobile telephone standard.

GSM is the most widely accepted standard in telecommunications and it is implemented globally.GSM is a circuit-switched system that divides each 200 kHz channel into eight 25 kHz time-slots. GSM operates on the mobile communication bands 900 MHz and 1800 MHz in most parts of the world. In the US, GSM operates in the bands 850 MHz and 1900 MHz.

GSM owns a market share of more than 70 percent of the world's digital cellular subscribers. GSM makes use of narrowband Time Division Multiple Access (TDMA) technique for transmitting signals. GSM was developed using digital technology. It has an ability to carry 64 kbps to 120 Mbps of data rates. Presently GSM supports more than one billion mobile subscribers in more than 210 countries throughout the world.

GSM provides basic to advanced voice and data services including roaming service. Roaming is the ability to use your GSM phone number in another GSM network.GSM digitizes and compresses data, then sends it down through a channel with two other streams of user data, each in its own timeslot.

Why GSM?

Listed below are the features of GSM that account for its popularity and wide acceptance.

- Improved spectrum efficiency
- International roaming
- Low-cost mobile sets and base stations (BSs)

- High-quality speech

- Compatibility with Integrated Services Digital Network (ISDN) and other telephone company services

- Support for new services

GSM History

The following table shows some of the important events in the rollout of the GSM system.

Years	Events
1982	Conference of European Posts and Telegraph (CEPT) establishes a GSM group to widen the standards for a pan-European cellular mobile system.
1985	A list of recommendations to be generated by the group is accepted.
1986	Executed field tests to check the different radio techniques recommended for the air interface.
1987	Time Division Multiple Access (TDMA) is chosen as the access method (with Frequency Division Multiple Access [FDMA]). The initial Memorandum of Understanding (MoU) is signed by telecommunication operators representing 12 countries.
1988	GSM system is validated.

1989	The European Telecommunications Standards Institute (ETSI) was given the responsibility of the GSM specifications.
1990	Phase 1 of the GSM specifications is delivered.
1991	Commercial launch of the GSM service occurs. The DCS1800 specifications are finalized.
1992	The addition of the countries that signed the GSM MoU takes place. Coverage spreads to larger cities and airports.
1993	Coverage of main roads GSM services starts outside Europe.
1994	Data transmission capabilities launched. The number of networks rises to 69 in 43 countries by the end of 1994.
1995	Phase 2 of the GSM specifications occurs. Coverage is extended to rural areas.
1996	June: 133 network in 81 countries operational.
1997	July: 200 network in 109 countries operational, around 44 million subscribers worldwide.
1999	Wireless Application Protocol (WAP) came into existence and became operational in 130 countries with 260 million subscribers.
2000	General Packet Radio Service(GPRS) came into existence.
2001	As of May 2001, over 550 million people were subscribers to mobile telecommunications.

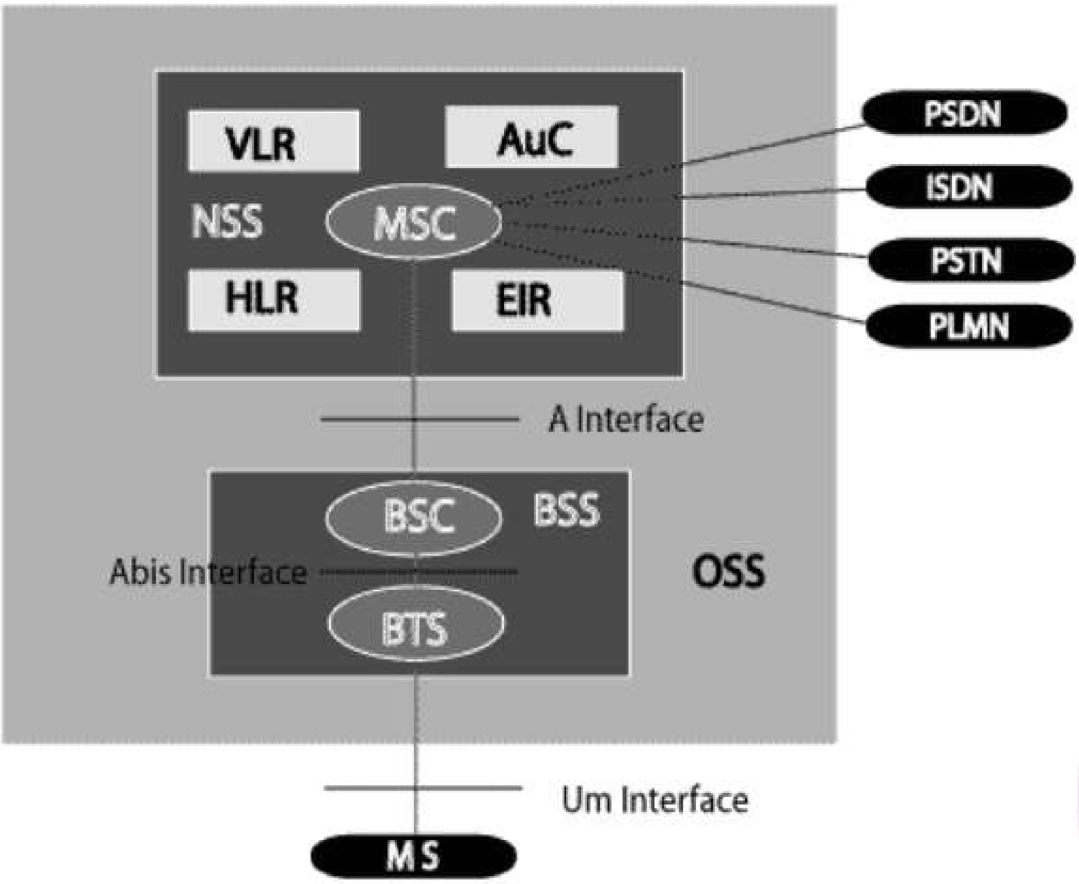
A GSM network comprises of many functional units. These functions and interfaces are explained in this chapter. The GSM network can be broadly divided into:

- The Mobile Station (MS)
- The Base Station Subsystem (BSS)

- The Network Switching Subsystem (NSS)

- The Operation Support Subsystem (OSS)

Given below is a simple pictorial view of the GSM architecture.



The additional components of the GSM architecture comprise of databases and messaging systems functions:

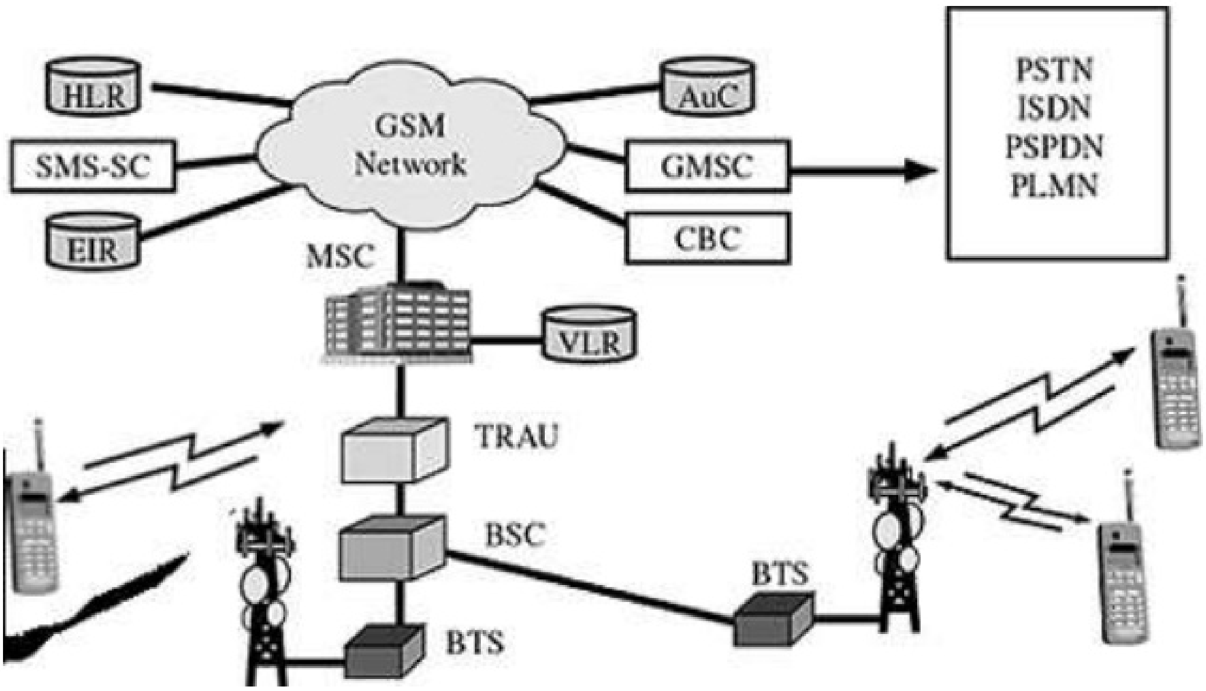
· Home Location Register (HLR)

· Visitor Location Register (VLR)

· Equipment Identity Register (EIR)

- Authentication Center (AuC)
- SMS Serving Center (SMS SC)
- Gateway MSC (GMSC)
- Chargeback Center (CBC)
- Transcoder and Adaptation Unit (TRAU)

The following diagram shows the GSM network along with the added elements:



The MS and the BSS communicate across the Um interface. It is also known as the air interface or the radio link. The BSS communicates with the Network Service Switching (NSS) center across the A interface.

GSM network areas

In a GSM network, the following areas are defined:

Cell : Cell is the basic service area; one BTS covers one cell. Each cell is given a Cell Global Identity (CGI), a number that uniquely identifies the cell.

Location Area : A group of cells form a Location Area (LA). This is the area that is paged when a subscriber gets an incoming call. Each LA is assigned a Location Area Identity (LAI). Each LA is served by one or more BSCs.

MSC/VLR Service Area : The area covered by one MSC is called the MSC/VLR service

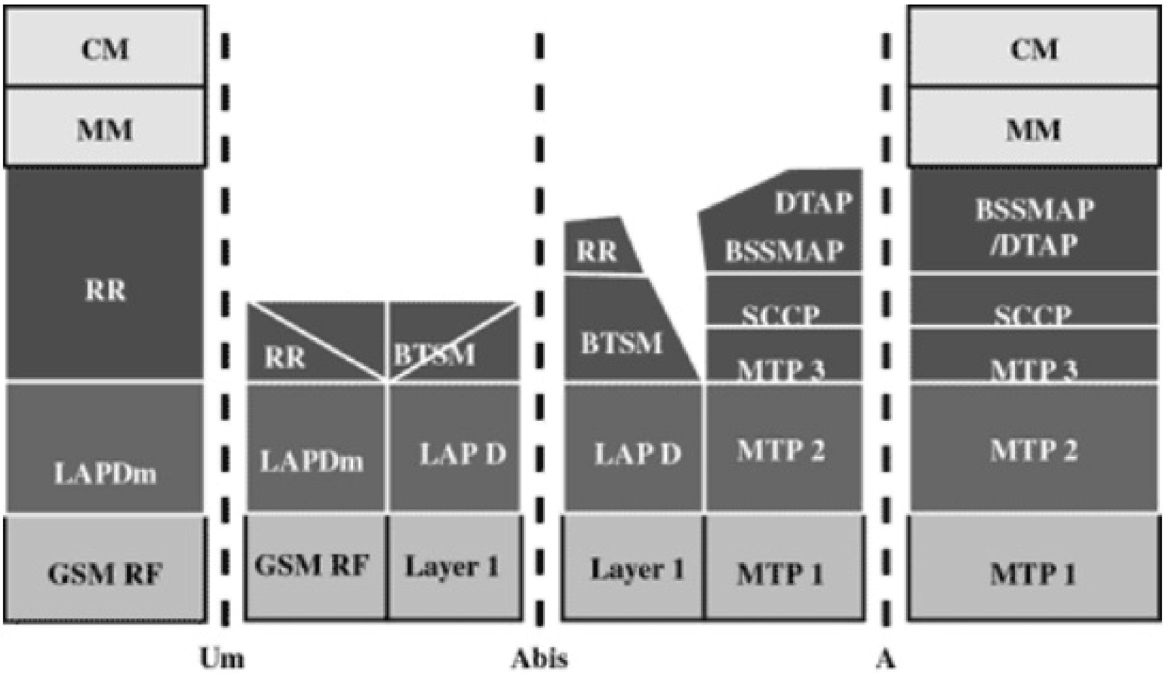
area.

PLMN : The area covered by one network operator is called the Public Land Mobile Network (PLMN). A PLMN can contain one or more MSCs.

GSM protocol stack

GSM architecture is a layered model that is designed to allow communications between two different systems. The lower layers assure the services of the upper-layer protocols. Each layer passes suitable notifications to ensure the transmitted data has been formatted, transmitted, and received accurately.

The GMS protocol stacks diagram is shown below:



MS Protocols

Based on the interface, the GSM signalling protocol is assembled into three general layers:

Layer 1 : The physical layer. It uses the channel structures over the air interface.

Layer 2 : The data-link layer. Across the Um interface, the data-link layer is a modified version of the Link access protocol for the D channel (LAP-D) protocol used in ISDN, called Link access protocol on the Dm channel (LAP-Dm). Across the A interface, the Message Transfer Part (MTP), Layer 2 of SS7 is used.

Layer 3 : GSM signalling protocol‘s third layer is divided into three sublayers: o Radio Resource Management (RR),

o Mobility Management (MM), and

o Connection Management (CM).

MS to BTS Protocols

The RR layer is the lower layer that manages a link, both radio and fixed, between the MS and the MSC. For this formation, the main components involved are the MS, BSS, and MSC. The responsibility of the RR layer is to manage the RR-session, the time when a mobile is in a dedicated mode, and the radio channels including the allocation of dedicated channels.

The MM layer is stacked above the RR layer. It handles the functions that arise from the mobility of the subscriber, as well as the authentication and security aspects. Location management is concerned with the procedures that enable the system to know the current location of a powered-on MS so that incoming call routing can be completed.

The CM layer is the topmost layer of the GSM protocol stack. This layer is responsible for Call Control, Supplementary Service Management, and Short Message Service Management. Each of these services are treated as individual layer within the CM layer. Other functions of the CC sub layer include call establishment, selection of the type of service (including alternating between services during a call), and call release.

BSC Protocols

The BSC uses a different set of protocols after receiving the data from the BTS. The Abis interface is used between the BTS and BSC. At this level, the radio resources at the lower portion of Layer 3 are changed from the RR to the Base Transceiver Station Management (BTSM). The BTS management layer is a relay function at the BTS to the BSC.

The RR protocols are responsible for the allocation and reallocation of traffic channels between the MS and the BTS. These services include controlling the initial access to the system, paging for MT calls, the handover of calls between cell sites, power control, and call termination. The BSC still has some radio resource management in place for the frequency coordination, frequency allocation, and the management of the overall network layer for the Layer 2 interfaces.

To transit from the BSC to the MSC, the BSS mobile application part or the direct application part is used, and SS7 protocols is applied by the relay, so that the MTP 1-3 can be used as the prime architecture.

MSC Protocols

At the MSC, starting from the BSC, the information is mapped across the A interface to the MTP Layers 1 through 3. Here, Base Station System Management Application Part (BSS MAP) is said to be the equivalent set of radio resources. The relay process is finished by the layers that are stacked on top of Layer 3 protocols, they are BSS MAP/DTAP, MM, and CM. This completes the relay process.

To find and connect to the users across the network, MSCs interact using the control-signalling network. Location registers are included in the MSC databases to assist in the role of determining how and whether connections are to be made to roaming users.Each GSM MS user is given a HLR that in turn comprises of the user‘s location and subscribed services.

VLR is a separate register that is used to track the location of a user.

When the users move out of the HLR covered area, the VLR is notified by the MS to find the location of the user. The VLR in turn, with the help of the control network, signals the HLR of the MS‘s new location. With the help of location information contained in the user‘s HLR, the MT calls can be routed to the user.

GSM addressing

GSM treats the users and the equipment in different ways. Phone numbers, subscribers, and equipment identifiers are some of the known ones. There are many other identifiers that have been well-defined, which are required for the subscriber‘s mobility management and for addressing the remaining network elements. Vital addresses and identifiers that are used in GSM are addressed below.

International Mobile Station Equipment Identity (IMEI)

The International Mobile Station Equipment Identity (IMEI) looks more like a serial number which distinctively identifies a mobile station internationally. This is allocated by the equipment manufacturer and registered by the network operator, who stores it in the Entrepreneurs-in-Residence (EIR). By means of IMEI, one recognizes obsolete, stolen, or non-functional equipment.

Following are the parts of IMEI:

- **Type Approval Code (TAC)** : 6 decimal places, centrally assigned.
- **Final Assembly Code (FAC)** : 6 decimal places, assigned by the manufacturer.
- **Serial Number (SNR)** : 6 decimal places, assigned by the manufacturer.
- **Spare (SP)** : 1 decimal place.

Thus, IMEI = TAC + FAC + SNR + SP. It uniquely characterizes a mobile station and gives clues about the manufacturer and the date of manufacturing.

International Mobile Subscriber Identity (IMSI)

Every registered user has an original International Mobile Subscriber Identity (IMSI) with a valid IMEI stored in their Subscriber Identity Module (SIM).

IMSI comprises of the following parts:

- **Mobile Country Code (MCC)** : 3 decimal places, internationally standardized.
- **Mobile Network Code (MNC)** : 2 decimal places, for unique identification of mobile network within the country.
- **Mobile Subscriber Identification Number (MSIN)** : Maximum 10 decimal places, identification number of the subscriber in the home mobile network.

Mobile Subscriber ISDN Number (MSISDN)

The authentic telephone number of a mobile station is the Mobile Subscriber ISDN Number

(MSISDN). Based on the SIM, a mobile station can have many MSISDNs, as each subscriber is assigned with a separate MSISDN to their SIM respectively.

Listed below is the structure followed by MSISDN categories, as they are defined based on international ISDN number plan:

Country Code (CC) : Up to 3 decimal places.

· **National Destination Code (NDC)** : Typically 2-3 decimal places.

· **Subscriber Number (SN)** : Maximum 10 decimal places.

Mobile Station Roaming Number (MSRN)

Mobile Station Roaming Number (MSRN) is an interim location dependent ISDN number, assigned to a mobile station by a regionally responsible Visitor Location Register (VLA). Using MSRN, the incoming calls are channelled to the MS.

The MSRN has the same structure as the MSISDN.

· **Country Code (CC)** : of the visited network.

· **National Destination Code (NDC)** : of the visited network.

· **Subscriber Number (SN)** : in the current mobile network.

Location Area Identity (LAI)

Within a PLMN, a Location Area identifies its own authentic Location Area Identity (LAI). The LAI hierarchy is based on international standard and structured in a unique format as mentioned below:

· **Country Code (CC)** : 3 decimal places.

· **Mobile Network Code (MNC)** : 2 decimal places.

· **Location Area Code (LAC)** : maximum 5 decimal places or maximum twice 8 bits coded in hexadecimal (LAC < FFFF).

Temporary Mobile Subscriber Identity (TMSI)

Temporary Mobile Subscriber Identity (TMSI) can be assigned by the VLR, which is responsible for the current location of a subscriber. The TMSI needs to have only local significance in the area handled by the VLR. This is stored on the network side only in the VLR and is not passed to the Home Location Register (HLR).

Together with the current location area, the TMSI identifies a subscriber uniquely. It can contain up to 4 × 8 bits.

Local Mobile Subscriber Identity (LMSI)

Each mobile station can be assigned with a Local Mobile Subscriber Identity (LMSI), which is an original key, by the VLR. This key can be used as the auxiliary searching key for each mobile station within its region. It can also help accelerate the database access. An LMSI is assigned if the mobile station is registered with the VLR and sent to the HLR. LMSI comprises of four octets (4x8 bits).

Cell Identifier (CI)

Using a Cell Identifier (CI) (maximum 2 × 8) bits, the individual cells that are within an LA can be recognized. When the Global Cell Identity (LAI + CI) calls are combined, then it is uniquely defined.

GSM security

GSM is the most secured cellular telecommunications system available today. GSM has its security methods standardized. GSM maintains end-to-end security by retaining the confidentiality of calls and anonymity of the GSM subscriber.

Temporary identification numbers are assigned to the subscriber‘s number to maintain the privacy of the user. The privacy of the communication is maintained by applying encryption algorithms and frequency hopping that can be enabled using digital systems and signalling.

Mobile Station Authentication

The GSM network authenticates the identity of the subscriber through the use of a challenge-response mechanism. A 128-bit Random Number (RAND) is sent to the MS. The MS computes the 32-bit Signed Response (SRES) based on the encryption of the RAND with the authentication algorithm (A3) using the individual subscriber authentication key (Ki). Upon receiving the SRES from the subscriber, the GSM network repeats the calculation to verify the identity of the subscriber.

The individual subscriber authentication key (Ki) is never transmitted over the radio channel, as it is present in the subscriber's SIM, as well as the AUC, HLR, and VLR databases. If the received SRES agrees with the calculated value, the MS has been successfully authenticated and may continue. If the values do not match, the connection is terminated and an authentication failure is indicated to the MS.

The calculation of the signed response is processed within the SIM. It provides enhanced security, as confidential subscriber information such as the IMSI or the individual subscriber authentication key (Ki) is never released from the SIM during the authentication process.

Signalling and Data Confidentiality

The SIM contains the ciphering key generating algorithm (A8) that is used to produce the 64-bit ciphering key (Kc). This key is computed by applying the same random number (RAND) used in the authentication process to ciphering key generating algorithm (A8) with the individual subscriber authentication key (Ki).

GSM provides an additional level of security by having a way to change the ciphering key, making the system more resistant to eavesdropping. The ciphering key may be changed at regular intervals as required. As in case of the authentication process, the computation of the ciphering key (Kc) takes place internally within the SIM. Therefore, sensitive information such as the individual subscriber authentication key (Ki) is never revealed by the SIM.

Encrypted voice and data communications between the MS and the network is accomplished by using the ciphering algorithm A5. Encrypted communication is initiated by a ciphering mode request command from the GSM network. Upon receipt of this command, the mobile station begins encryption and decryption of data using the ciphering algorithm (A5) and the ciphering key (Kc).

Subscriber Identity Confidentiality

To ensure subscriber identity confidentiality, the Temporary Mobile Subscriber Identity (TMSI) is used. Once the authentication and encryption procedures are done, the TMSI is sent to the mobile station. After the receipt, the mobile station responds. The TMSI is valid in the location area in which it was issued. For communications outside the location area, the Location Area Identification (LAI) is necessary in addition to the TMSI.

GSM Billing

GSM service providers are doing billing based on the services they are providing to their customers. All the parameters are simple enough to charge a customer for the provided services.

Telephony Service

These services can be charged on per call basis. The call initiator has to pay the charges, and the incoming calls are nowadays free. A customer can be charged based on different parameters such as:

- International call or long distance call.
- Local call.
- Call made during peak hours.
- Call made during night time.
- Discounted call during weekends.
- Call per minute or per second.
- Many more other criteria can be designed by a service provider to charge their customers.

SMS Service

Most of the service providers charge their customer's SMS services based on the number of text messages sent. There are other prime SMS services available where service providers charge more than normal SMS charge. These services are being availed in collaboration of Television Networks or Radio Networks to demand SMS from the audiences.

Most of the time, the charges are paid by the SMS sender but for some services like stocks and share prices, mobile banking facilities, and leisure booking services, etc. the recipient of the SMS has to pay for the service.

GPRS Services

Using GPRS service, you can browse, play games on the Internet, and download movies. So a service provider will charge you based on the data uploaded as well as data downloaded on your mobile phone. These charges will be based on per Kilo Byte data downloaded/uploaded.

Additional parameter could be a QoS provided to you. If you want to watch a movie, then a low QoS may work because some data loss may be acceptable, but if you are downloading a zip file, then a single byte loss will corrupt your complete downloaded file.Another parameter could be peak and off peak time to download a data file or to browse the Internet.

Supplementary Services

Most of the supplementary services are being provided based on monthly rental or absolutely free. For example, call waiting, call forwarding, calling number identification, and call on hold are available at zero cost.

Call barring is a service, which service providers use just to recover their dues, etc., otherwise this service is not being used by any subscriber. Call conferencing service is a form of simple telephone call where the customers are charged for multiple calls made at a time. No service provider charges extra charge for this service.

Closed User Group (CUG) is very popular and is mainly being used to give special discounts to the users if they are making calls to a particular defined group of subscribers. Advice of Charge (AoC) can be charged based on number of queries made by a subscriber.

Difference between CDMA and GSM

The major difference between CDMA and GSM are given below.

Criteria	CDMA	GSM
Technology	CDMA is based on spread-spectrum technology which makes the optimum use of available bandwidth.	GSM operates on the wedge spectrum. it uses both time division multiple access (TDMA) and frequency division multiple access (fdma). TDMA provide multi-user access by cutting up the channel into different time slice and fdma provides the multi-user access by separating the used frequency.
Security	CDMA is more secure than GSM.	GSM is less secure than CDMA.
Global reach	CDMA is used in usa and some part of canada and japan. CDMA is used only by 24% of the users worldwide.	GSM is used over 80% of the world network in over 210 countries. GSM is used 76% of the users worldwide.
Data Transfer Rate	CDMA has faster data transfer as compared to GSM.	GSM has slower data transfer as compared to CDMA.
Radiation exposure	CDMA phones emits less radiation than GSM phones.	GSM phones emits continuous wave pulses and emits almost 28 times more radiation than CDMA phones.

What are GSM vs. CDMA vs. LTE differences?

The big difference among GSM, CDMA and LTE (long-term evolution) cellular-wireless communications is the technology behind them and the business objectives each is designed to meet. GSM is the oldest of the three. Developed and adopted as a standard in Europe, GSM used the processor/chip technologies available at the time to encode and decode data.

For a time, mobile operators deployed 2G GSM across many countries worldwide except for the U.S. and several countries in South America. Incompatibility with existing analog AMPS systems largely drove these exceptions. To provide the necessary interim compatibility with GSM, they evaluated GSM's economies of scale for their networks. Carriers employed D-AMPS (Digital-Advanced Mobile Phone Service), a digital version of AMPS based on Interim Standard (IS)-136 for TDMA networking (itself an evolution of the original 2GL D-AMPS standard, IS-54) from the Electronics Industries Association/Telecommunication Industry Association. It eventually became clear that TDMA protocols weren't sufficiently spectrum efficient to support fast-growing cellular services, however. This led to the introduction of CDMA protocols.

ITU IS-95, also known as cdmaOne, became the CDMA digital cellular standard in 1993, gaining popularity in countries using older Analog AMPS systems. That said, IS-95 needed powerful processors because coding and decoding CDMA required significantly more compute power than decoding and coding TDMA. As a result, CDMA phones were more expensive than GSM models.

Cellular technology evolved from there. For data, GSM introduced GPRS, which led to EDGE, while cdma One led to ANSI-2000 1xRTT. That, in turn, led to EV-DO. Because of their superior efficiency, 3GPP adopted CDMA protocols under Wide-Band CDMA (W-CDMA) for implementation in 3G UMTS.

VOICE OVER INTERNET PROTOCOL (VOIP)

- **Voice over Internet Protocol (VoIP),** is a technology that allowing you to make voice calls over a broadband Internet connection instead of an analog (regular) phone line. Some VoIP services allow you to call people using the same service, but others may allow you to call anyone. They can have a telephone number – including local, long-distance, mobile, and international numbers or not. Some VoIP services only work over your computer or a special VoIP phone while other services allow you to use a traditional phone connected to a VoIP adapter.

- **How VoIP / Internet Voice Works –** Voice is converted into a digital signal by VoIP services that travel over the Internet. If the regular phone number is called, the signal is converted to a regular telephone signal i.e. an analog signal before it reaches the destination. VoIP can allow you to make a call directly from a computer having a special VoIP phone, or a traditional phone connected to a special adapter. Wireless hot spots in locations such as airports, hospitals, cafes, etc allow you to connect to the Internet and can enable you to use VoIP service wirelessly.

- **Equipments Required** – A high-speed Internet connection is required which can be through a cable modem or high-speed services such as a local area network. A computer, adaptor, or specialized phone is required. Some VoIP services only work over your computer or a special VoIP phone. Other services allow you to use a traditional phone connected to a VoIP adapter. If you use your computer some software and an inexpensive microphone are needed. VoIP phones plug directly into your broadband connection and operate largely like a traditional telephone. If you use a telephone with a VoIP adapter, you can dial just as you always have, and the service provider may also provide a dial tone.

Advantages of VoIP –

1. Some VoIP services offer features and services that are not available with a traditional phone, or are available but only for an additional fee.
2. Paying for both a broadband connection and a traditional telephone line can be avoided.
3. Smoother connection than an analog signal can be provided.

Disadvantages of VoIP –

1. Some VoIP services don't work during power outages and the service provider may not offer backup power.
2. Not all VoIP services connect directly to emergency services through emergency service numbers.
3. VoIP providers may or may not offer directory assistance.

BLUETOOTH

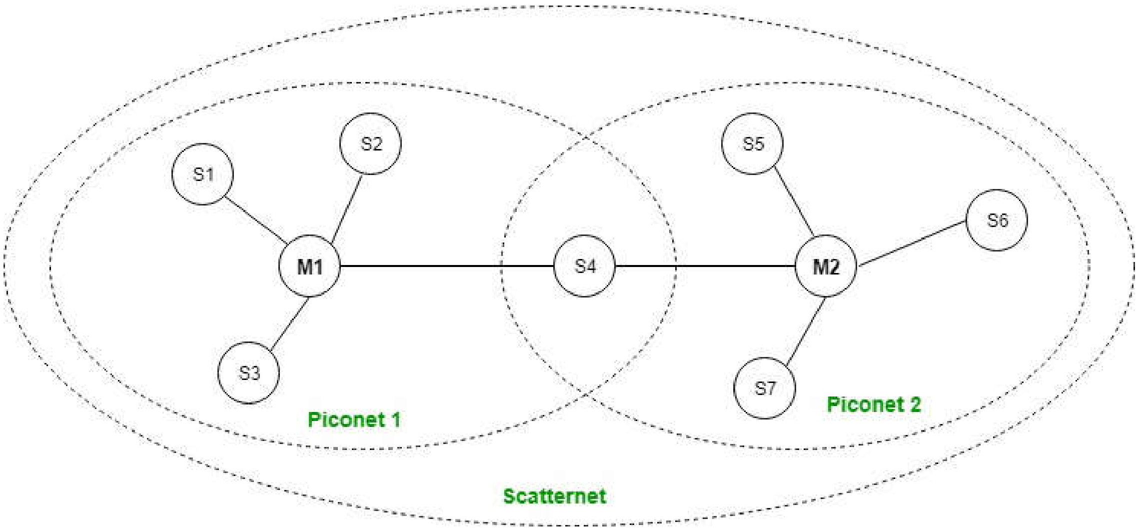
It is a Wireless Personal Area Network (WPAN) technology and is used for exchanging data over smaller distances. This technology was invented by Ericson in 1994. It operates in the unlicensed, industrial, scientific and medical (ISM) band at 2.4 GHz to 2.485 GHz. Maximum devices that can be connected at the same time are 7. Bluetooth ranges upto 10 meters. It provides data rates upto 1 Mbps or 3 Mbps depending upon the version. The spreading technique which it uses is FHSS (Frequency hopping spread spectrum). A Bluetooth network is called a **piconet** and a collection of interconnected piconets is called **scatternet**.

Bluetooth Architecture:

The architecture of Bluetooth defines two types of networks:

1. Piconet

2. Scatternet



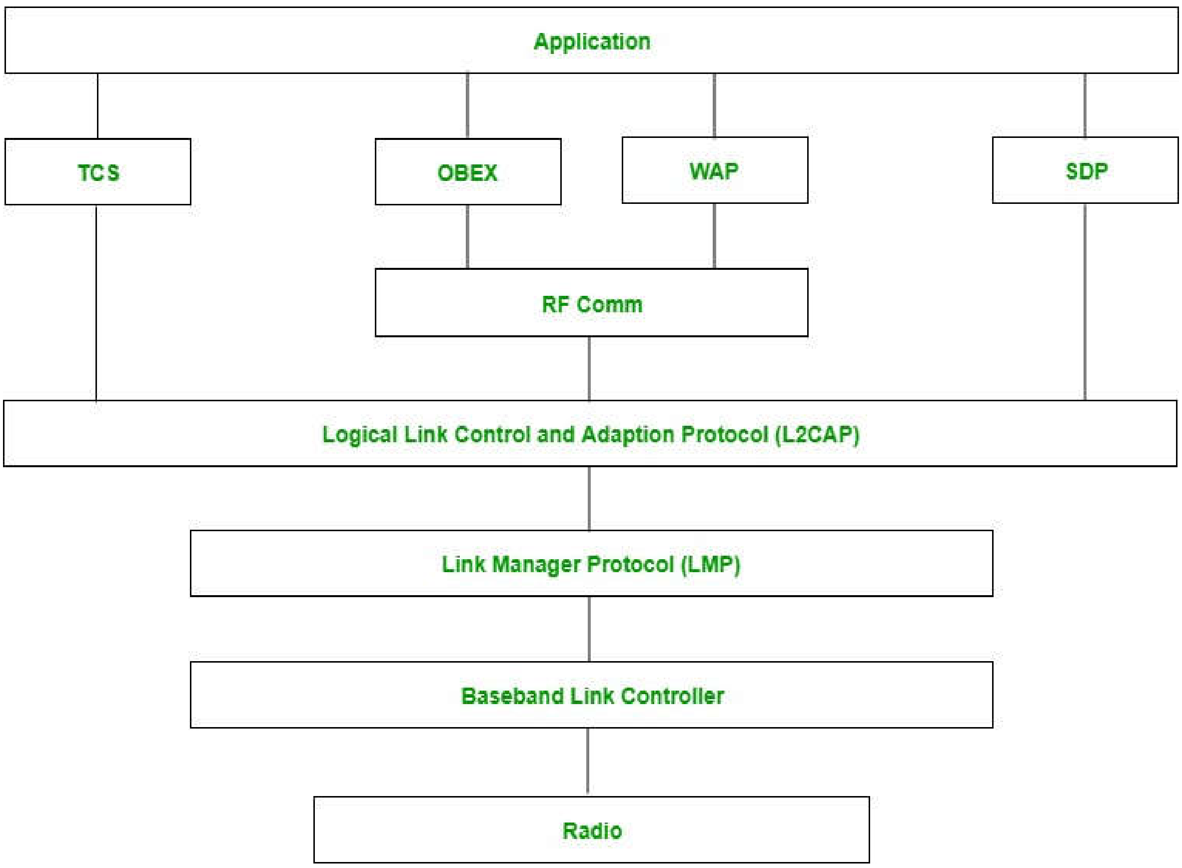
- **Piconet:**

Piconet is a type of Bluetooth network that contains one primary node called master node and seven active secondary nodes called slave nodes. Thus, we can say that there are total of 8 active nodes which are present at a distance of 10 meters. The communication between the primary and secondary node can be one-to-one or one-to-many. Possible communication is only between the master and slave; Slave-slave communication is not possible. It also have 255 parked nodes, these are secondary nodes and cannot take participation in communication unless it gets converted to the active state.

- **Scatternet:**

It is formed by using various piconets. A slave that is present in one piconet can act as master or we can say primary in another piconet. This kind of node can receive message from master in one piconet and deliver the message to its slave into the other piconet where it is acting as a slave. This type of node is refer as bridge node. A station cannot be master in two piconets.

Bluetooth protocol stack:



1. **Radio (RF) layer:**

   It performs modulation/demodulation of the data into RF signals. It defines the physical characteristics of bluetooth transceivers. It defines two types of physical link: connection-less and connection-oriented.

2. **Baseband Link layer:**
   It performs the connection establishment within a piconet.

3. **Link Manager protocol layer:**
   It performs the management of the already established links. It also includes authentication and encryption processes.

4. **Logical Link Control and Adaption protocol layer:**
   It is also known as the heart of the Bluetooth protocol stack. It allows the communication between upper and lower layers of the Bluetooth protocol stack. It packages the data packets received from upper layers into the form expected by lower layers. It also performs the segmentation and multiplexing.

5. **SDP layer:**
   It is short for Service Discovery Protocol. It allows to discover the services available on another Bluetooth enabled device.

6. **RF comm layer:**
   It is short for Radio Frontend Component. It provides serial interface with WAP and OBEX.

7. **OBEX:**
   It is short for Object Exchange. It is a communication protocol to exchange objects between 2 devices.

8. **WAP:**
   It is short for Wireless Access Protocol. It is used for internet access.

9. **TCS:**
   It is short for Telephony Control Protocol. It provides telephony service.

10. **Application layer:**
    It enables the user to interact with the application.

Advantages:

- Low cost.
- Easy to use.
- It can also penetrate through walls.
- It creates an adhoc connection immediately without any wires.
- It is used for voice and data transfer.

Disadvantages:

- It can be hacked and hence, less secure.
- It has slow data transfer rate: 3 Mbps.
- It has small range: 10 meters.

WIFI ("Wireless Fidelity")

Wi-Fi is a wireless networking technology that allows devices such as computers (laptops and desktops), mobile devices (smart phones and wearables), and other equipment (printers and video cameras) to interface with the Internet. It allows these devices--and many more--to exchange information with one another, creating a network.

Internet connectivity occurs through a wireless router. When you access Wi-Fi, you are connecting to a wireless router that allows your Wi-Fi-compatible devices to interface with the Internet.

Wi-Fi is a wireless networking technology that uses radio waves to provide wireless high-speed Internet access. A common misconception is that the term Wi-Fi is short for "wireless fidelity," however Wi-Fi is a trademarked phrase that refers to IEEE 802.11x standards.

Wi-Fi originated in Hawaii in 1971, where a wireless UHF packet network called ALOHAnet was used to connect the islands. Later protocols developed in 1991 by NCR and AT&T called Wave LAN became the precursor to the IEEE 802.11 standards.

The Wi-Fi Alliance was formed in 1999 and currently owns the Wi-Fi registered trademark. It specifically defines Wi-Fi as any "wireless local area network (WLAN) products that are based on the Institute of Electrical and Electronics Engineers' (IEEE) 802.11 standards."

Initially, Wi-Fi was used in place of only the 2.4GHz 802.11b standard, however the Wi-Fi Alliance has expanded the generic use of the Wi-Fi term to include any type of network or WLAN product based on any of the 802.11 standards, including 802.11b, 802.11a, etc. in an attempt to stop confusion about wireless LAN interoperability.

What does Wi-Fi mean?

Wi-Fi is not an acronym; it is a brand name created by a marketing firm that's meant to serve as an interoperability seal for marketing efforts.

How does Wi-Fi work?

On the technical side, the IEEE 802.11 standard defines the protocols that enable communications with current Wi-Fi-enabled wireless devices, including wireless routers and wireless access points. Wireless access points support different IEEE standards.

Each standard is an amendment that was ratified over time. The standards operate on varying frequencies, deliver different bandwidth, and support different numbers of channels.

What is a wireless access point?

A wireless access point (AP) allows wireless devices to connect to the wireless network. Having a Cisco wireless network makes it easy to bring new devices online and provides flexible support to mobile workers.

What a wireless access point does for your network is similar to what an amplifier does for your home stereo. An access point takes the bandwidth coming from a router and stretches it so that many devices can go on the network from farther distances away. But a wireless access point does more than simply extend Wi-Fi. It can also give useful data about the devices on the network, provide proactive security, and serve many other practical purposes.

What is a wireless router?

Wireless routers are commonly found in homes. They're the hardware devices that Internet service providers use to connect you to their cable or xDSL Internet network.

A wireless router is sometimes referred to as a wireless local area network (WLAN) device. A wireless network is also called a Wi-Fi network.

A wireless router combines the networking functions of a wireless access point and a router. Read more about wireless routers.

What is a desktop Wi-Fi router?

The most common way for users to connect to the Internet wirelessly is with a desktop wireless (Wi-Fi) router. These routers look like small boxes with multiple short antennas to help broadcast the signal throughout a home or workplace. The farther a user is from the base Wi-Fi router, the weaker the signal. So multiple wireless routers, called range extenders, usually are placed throughout the workspace. Wi-Fi range extenders, placed in an array, boost or extend Internet coverage.

What is a mobile hotspot?

A mobile hotspot is a common feature on smartphones with both tethered and untethered connections. When you turn on your phone's mobile hotspot, you share your wireless network connection with other devices that can then access the Internet.

What is portable Wi-Fi hotspot?

A portable Wi-Fi hotspot is a mobile hotspot obtained through a cell phone carrier. It's a small device that uses cellular towers that broadcast high-speed 3G or 4G broadband signals. Multiple devices, like iPads and laptops, can then connect wirelessly to the device, which in turn seamlessly connects to the Internet where ever you travel. Similar to a cell phone, the portable hotspot's monthly cost is based on the data usage plan you select. A portable Wi-Fi hotspot is a more reliable way to access the Internet than searching for static public Wi-Fi hotspots.

Difference between WiFi and WiMax:

WiFi	WiMax
Wifi is defined under IEEE 802.11x standards where x stands for various WiFi versions.	WiMax is defined under IEEE 802.16y standards where y stands for various WiMax versions.

WiFi	**WiMax**
WiFi is for LAN (Local Area Network) applications.	WiMax is for MAN (Metropolitan Area Network) applications.
WiFi does not guarantee any Quality of Service (Qos).	WiMax guarantee Quality of Service (Qos).
WiFi network range is around 100 meters.	WiMax network can reach about 50-90 km.
WiFi MAC layer uses CSMA/CA protocol which is not connection oriented.	WiMax is connection oriented in nature.
WiFi is short range technology.	WiMax is long range technology.
WiFi connection can transmit upto 54 mbps.	WiMax connection can transmit upto 70 mbps.

Communication Technology (Generation) 1G, 2G, 3G, 4G & 5G

1G V Simply, the **"G"** stands for **"GENERATION"** . 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.

- **6G - Sixth Generation**

6G is the sixth generation standard currently under development for wireless communications technologies supporting cellular data networks. It is the planned successor to 5G and will likely be significantly faster. Like its predecessors, 6G networks will probably be broadband cellular networks, in which the service area is divided into small geographical areas called cells, a 6G network works in combination of 4G and 5G networks. Several companies

(Nokia, Ericsson, Huawei, Samsung, LG, Apple, Xiaomi), as well as several countries (India, China, Japan and Singapore), have shown interest in 6G networks.

6G networks are expected to exhibit even more heterogeneity (be even more diverse) than their predecessors and are likely to support applications beyond current mobile use scenarios, such as virtual and augmented reality (VR/AR), ubiquitous instant communications, pervasive intelligence and the Internet of Things (IoT). It is expected that mobile network operators will adopt flexible decentralized business models for 6G, with local spectrum licensing, spectrum sharing, infrastructure sharing, and intelligent automated management underpinned by mobile edge computing, artificial intelligence, short-packet communication and blockchain technologies.

The evolution of 1G to 5G

TYPE	DEPLOYMENT	TECHNOLOGIES AND STANDARDS	FEATURES
1G	Analog telecommunication deployed in the 1980s	■ Advanced Mobile Phone Service (AMPS) ■ Nordic Mobile Telephone (NMT)	Voice calls, NMT for simple integrated data and messaging
2G	Digital cellular deployed in the 1990s	■ Code-division multiple access (CDMA) ■ Global System for Mobile Communications (GSM)/ Enhanced Data rates for GSM Evolution (EDGE) ■ Time-division multiple access (TDMA)	Voice, SMS text messages, low-rate data
3G	First broadband, deployed in 2000	■ CDMA2000 1X/Evolution-Data Optimized (EVDO) ■ Universal Mobile Telecommunications Service (UMTS)/high-speed packet access (HSPA) ■ Worldwide Interoperability for Microwave Access (WiMAX)	Offers speeds from 144 Kbps to 2 Mbps indoors, enabling rich content
4G	Deployed in 2010	■ LTE	100s of Mbps to 1 Gbps with video and streaming capabilities
5G	First deployed in 2018	■ International Telecommunication Union (ITU)/ International Mobile Communications (IMT)-2020 defined technical objectives ■ 3rd Generation Partnership Project (3GPP) is developing 5G specifications	3x higher spectral efficiency than 4G and peak downlink throughputs to peak 20 Gbps

4G LTE is a GSM technology and a major upgrade over 3G in terms of data transfer speeds. It offers no way of making phone calls in the traditional sense, however. To make regular phone calls, LTE uses specialized voice over Internet Protocol (VoIP) for what's referred to as VoLTE.

CDMA and GSM technologies eventually converged through Orthogonal Frequency Division Multiple Access (OFDMA), LTE's encoding protocol. OFDMA is also the encoding protocol used for WiMAX and Wi-Fi networks.

As 5G becomes more commonplace, there's an expectation that it will come with new encoding protocols. It's still too early to predict whether 5G will be a progressive evolution in telecommunications or mark a technological revolution in this market. Either way, most telecommunication industry watchers agree that its effects will be global in scale and dramatic.

Download speeds from GPRS to 5G compared

GENERATION NETWORK	TECHNOLOGY TYPE	TYPICAL DOWNLOAD SPEED (MEGABITS PER SECOND)	MAX DOWNLOAD SPEED (MBPS)
2G	GPRS	<0.1	0.1
	Edge	0.1	0.3
3G	3G (Basic)	0.1	0.3
	HSPA	1.5	7.2
	HSPA+	4	21
	DC-HSPA+	8	42
4G	LTE Category 4	15	150
4G+	LTE-Advanced Cat6	30	300
	LTE-Advanced Cat9	45	450
	LTE-Advanced Cat12	60	600
	LTE-Advanced Cat16	90	979
5G	5G	150-200	1,000-10,000 (1 to 10 gigabits per second)

COMMUNICATION OVER RADIO

Spectrum Radio Frequency Spectrum is a key distinguishing factor used to compare alternative mobile radio systems. Radio spectrum for communications ranges from approximately 30 Hz (termed Extremely Low Frequency [ELF]) to above 100 GHz (termed Extremely High Frequency [EHF]). Because of its capability to provide very wide area coverage and penetrate sea water, ELF has been used for global systems for providing low-rate submarine communications. EHF, on the other hand, can be used for Line-of-Sight (LoS) microwave communications. Table shows the complete range of radio frequency spectrum used in communication systems and provides some examples of spectrum use.

Table 1-1 *Radio Frequency Spectrum*

Band Name	Frequency Range	Example Communication Use
Extremely Low Frequency	3–30 Hz	Submarine communications
Super Low Frequency	30–300 Hz	Submarine communications
Ultra Low Frequency	300–3,000 Hz	Underground communications
Very Low Frequency	3–30 kHz	Navigation
Low Frequency	30–300 kHz	AM broadcasting
Medium Frequency	300–3,000 kHz	AM broadcasting
High Frequency	3–30 MHz	Shortwave broadcast; amateur radio
Very High Frequency	30–300 MHz	Private mobile radio; FM and television broadcasting
Ultra High Frequency	300–3,000 MHz	Television broadcasting, cellular radio, and wireless LANs
Super High Frequency	3–30 GHz	Wireless LANs; point-to-point and point-to-multipoint microwave
Extremely High Frequency	30–300 GHz	Point-to-point microwave

Table 1-1 highlights how the characteristics of the different bands of the radio spectrum vary. In general, the lower the frequency, the better the range (for example, in the extreme case, a single ELF transmitter is able to cover the entire planet), but the bandwidths available are limited (for example, the same ELF systems typically provided a global system with total system capacity below 50 bps). Conversely, EHF systems can provide incredible capacity, but they incur significant attenuation by atmospheric effects due, for example, to extreme humidity, rain, or molecular absorption, and thus are prone to significant losses in non-Line-of-Sight (LoS) deployments.

- **Propagation**

Because of its relative scarcity, mobile systems are required to re-use the allocated radio spectrum across a particular network of cell sites. Radio frequency signals need to propagate between the cell site antenna and the mobile wireless terminal. As the signals propagate, they exhibit a path loss as the emitted energy is dispersed over an increasing area. Estimating the path loss is critical in determining both the coverage provided by a single cell site and the bandwidth available to the IP services offered in that cell coverage area. The benchmark of propagation loss is that of free space—in other words, the loss in a region that is free from all objects that might absorb or reflect the radio energy. Because the emitted energy from an isotropic antenna is dispersed over the surface of a sphere (with the transmitting antenna at the center of the sphere), the received energy is inversely proportional to the surface area of the sphere (4 π r2, where r is the radius of the sphere), as illustrated in Figure. Using this approach, you can see that the free space path loss follows an inverse square law with changing distance from the antenna, r.

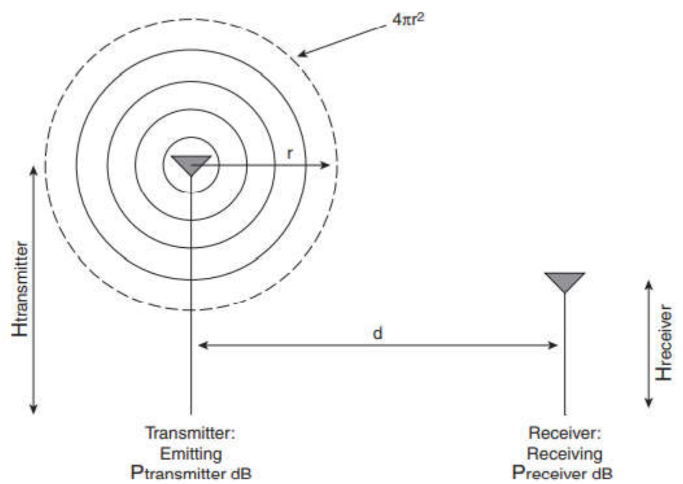


Figure 1-1 *Free Space Loss*

- **Fast Fading**

Whereas the previous analysis concentrated on propagation in ideal free space or with simple two-ray models, the reality is that mobile radio systems operate with a variety of obstacles and reflections both between and around the base station and mobile terminal, as shown in Figure 1-3. The combination of the disparate propagation paths is called multipath—where the transmitted signal arrives at the receiver from various directions over a multiplicity of paths, with each individual path having its own electrical path length and degree of attenuation.

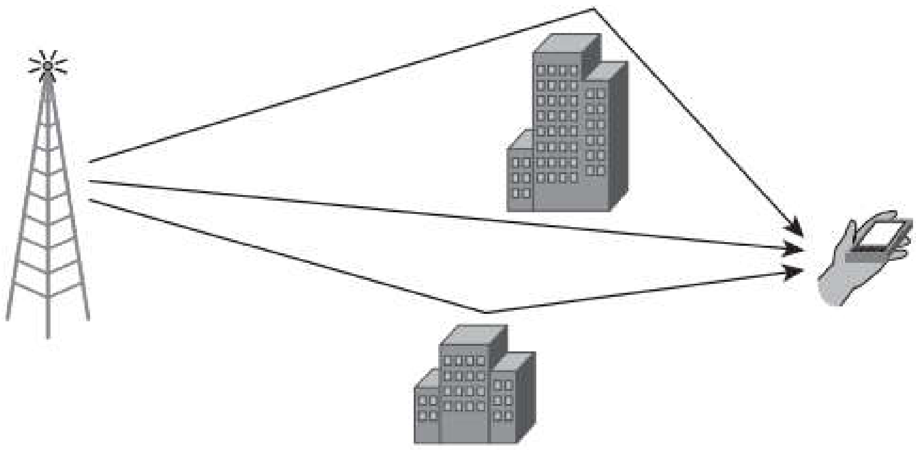


Figure 1-3 *Multipath Propagation*

MICROWAVE SYSTEMS

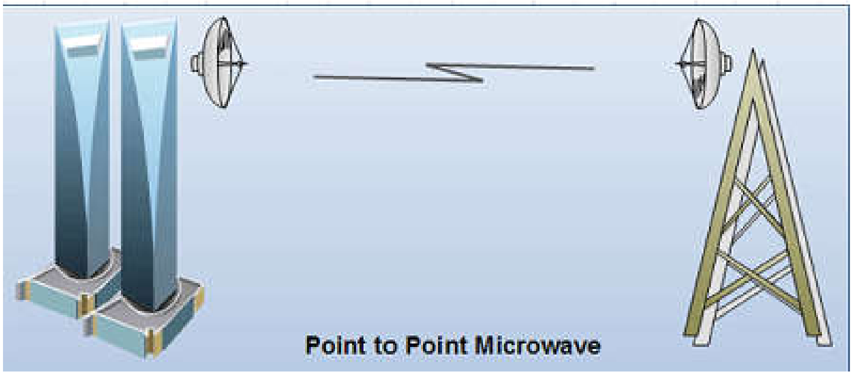
Microwave signals are used to transmit data without the use of cables. The microwave signals are similar to **radio and television signals**. Microwaves are used for **long-distance communication**. In **microwave communication** parabolic antennas are mounted on towers to send data to other antennas.

- ## Introduction to microwaves

Microwaves – As the name implies, are very short waves .In general RF extends from dc upto Infrared region and these are forms of electromagnetic energy. A glance look at the various frequency ranges makes it clear that UHF(Ultra high frequency) & SHF (super high frequencies) constitutes the Microwave frequency range with wave length (λ) extending from 1 to 100 cm The basic principle of low frequency radio waves and microwaves are the same .Here the phenomena are readily explained in terms of current flow in a closed electric circuit. At low frequencies , we talk in terms of lumped circuit elements such as C. L, R which can be easily identified and located in a circuit . On the other hand in Microwave circuitry , the inductance & capacitance are assumed to be distributed along a transmission line . Microwaves are electromagnetic waves whose frequencies range from 1 GHz to 1000 GHz (1 GHz =109). Microwaves so called since they are defined in terms of their wave length, micro in the sense tinny ness in wave length , period of cycle (CW wave) , λ is very short. Microwave is a signal that has a wave length of 1 foot or less $\lambda \leq 30.5$ cm .= 1 foot. F= 984MHz approximately 1 GHz

Microwave radio, a form of radio transmission that use. Ultra-high frequencies developed out of experiments with radar (radio detecting and ranging) during the period preceding World War II. There are several frequency ranges assigned to microwave systems, all of which are in the Giga Hertz (GHz) range and the wavelength in the millimeter range. This very short wavelength gives rise to the term microwave. Such high frequency signals are especially susceptible to attenuation and, therefore must be amplified or repeated after a particular distance.

In order to maximize the strength of such a high frequency signal and, therefore, to increase the distance of transmission at acceptable levels, the radio beams are highly focused. The transmit antenna is centered in a concave, reflective metal dish which serves to focus the radio beam with maximum effect on the receiving antenna, as illustrated in Figure. The receiving antenna, similarly, is centered in a .concave metal dish, which serves to collect the maximum amount of incoming signal.



It is a point-to-point, rather than a broadcast, transmission system. Additionally, each antenna must be within line of sight of the next antenna. Given the curvature of the earth, and the obvious problems of transmitting through it, microwave hops generally are limited to 50 miles (80 km). If the frequencies are higher within the microwave band given in Table 2.1, this impact is more than lower frequencies in the same band.

Frequency Bands Maximum Antenna Separation Analog/Digital 4-6 GHz 32-48 km Analog 10-12 GHz 16-24 km Digital 18-23 GHz 8-11 km Digital.

General Properties of Microwave Transmission:

Configuration Microwave radio consists of antennae centered within reflective dishes that are attached to structures such as towers or buildings. Cables connect the antennae to the actual transmit (receive) equipment.

Bandwidth Microwave offers substantial bandwidth, often in excess of 6 Gbps.

Error Performance Microwave, especially digital microwave, performs well in this regard, assuming proper design. However, such high frequency radio is particularly susceptible to environmental interference, e.g. precipitation, haze, smog, and smoke. Generally speaking, however, microwave performs well in this regard.

Distance Microwave clearly is distance limited, especially at the higher frequencies. This limitation can be mitigated through special and more complex arrays of antennae incorporating spatial diversity in order to collect more signals.

Security As is the case with all radio systems, microwave is inherently not secure. Security must be imposed through encryption (scrambling) of the signal.

Cost The acquisition, deployment and rearrangement cost of microwave can be high. However, it often compares very favorably with cabled systems, which require right-of-way, trenching, conduit, splicing, etc.

Applications Microwave originally was used for long haul voice and data communications. Competing long distance carriers, microwave was found the most attractive alternative to cabled systems, due to the speed and low cost qf deployment where feasible, however, fiber optic technology is currently used in this regard. Contemporary applications include private networks, interconnection of cellular radio switches, and as an alternative to cabled systems in consideration of difficult terrain.

Advantages of Microwave

1. It offers ease of communication over difficult terrain.
2. Microwaves have the ability to communicate over oceans.

Disadvantages of Microwave

1. It is an insecure communication.
2. Its propagation is susceptible to weather effects like rains, thunderstorms, etc.
3. Implementation and maintenance cost is high.
4. Bandwidth is limited.

APPLICATION AREAS OF MICROWAVES

- RADAR
- Surveillance (air traffic control)
- Navigation (direction finding)
- Meteorology 2-MEDICINE
- Treatment of Diseases
- Microwave Imaging 3-SURVEYING
- LAND HEATING INDUSTRIAL QUALITY CONTROL
- RADIO ASTRONOMY NAVIGATION VIA GLOBAL POSITIONING SYSTEMS
- REMOTE SENSING POWER TRANSMISSION•

COMMUNICATION SATELLITE

A satellite is an object that revolves around another object. For example, earth is a satellite of The Sun, and moon is a satellite of earth.

A **communication satellite** is a **microwave repeater station** in a space that is used for telecommunication, radio and television signals. A communication satellite processes the data coming from one earth station and it converts the data into another form and send it to the second earth station.

Communication satellites may be owned by government or private organizations. Presently, there are more than 2000 communication satellites in the sky. Some of its uses are −

- Internet
- Military operations
- Television
- Telephone
- Radio

Communication satellites are broadly categorized into three types depending upon the orbit in which they are placed.

- **Geostationary Satellite (GEO)** − They are at 36,000 km from the earth's surface. They have same orbital period as earth's rotation. So they appear to be still in the sky. At least 3 GEOs are needed for global coverage.
- **Medium Earth Orbit Satellite (MEO)** − They are placed between the two Van Allen belts, at a distance between 2,000 km to 36,000 km from the earth's surface. At least 10 MEOs are needed for global coverage.
- **Low Earth Orbit Satellite (LEO)** − They are situated below the Lower Van Allen belt. Their orbital altitude is 160 km to 2000 km. For global coverage, as high as 50 LEOs are required.

How a Satellite Works:

Two stations on earth want to communicate through radio broadcast but are too far away to use conventional means. The two stations can use a relay station for their communication. One earth station transmits the signal to the satellite.

Uplink frequency is the frequency at which ground station is communicating with satellite. The satellite transponder converts the signal and sends it down to the second earth station, and this is called **Downlink frequency**. The second earth station also communicates with the first one in the same way.

Advantages of Satellite

The advantages of Satellite Communications are as follows −

- The Coverage area is very high than that of terrestrial systems.

- The transmission cost is independent of the coverage area.
- Higher bandwidths are possible.

Disadvantages of Satellite

The disadvantages of Satellite Communications are as follows −

- Launching satellites into orbits is a costly process.
- The bandwidths are gradually used up.
- High propagation delay for satellite systems than the conventional terrestrial systems.

Satellite Communication Basics Details

The process of satellite communication begins at an **earth station**. Here an installation is designed to transmit and receive signals from a satellite in orbit around the earth. Earth stations send information to satellites in the form of high powered, high frequency (GHz range) signals.

The satellites **receive** and **retransmit** the signals back to earth where they are received by other earth stations in the coverage area of the satellite. **Satellite's footprint** is the area which receives a signal of useful strength from the satellite.

The transmission system from the earth station to the satellite through a channel is called the **uplink**. The system from the satellite to the earth station through the channel is called the **downlink**.

Satellite Frequency Bands:

The satellite frequency bands which are commonly used for communication are the **Cband, Ku-band,** and **Ka-band**. C-band and Ku-band are the commonly used frequency spectrums by today's satellites.

It is important to note that there is an inverse relationship between frequency and wavelength i.e. when frequency increases, wavelength decreases this helps to understand the relationship between **antenna diameter** and **transmission frequency**. Larger antennas (satellite dishes) are necessary to gather the signal with increasing wavelength.

Earth Orbits

A satellite when launched into space, needs to be placed in certain orbit to provide a particular way for its revolution, so as to maintain accessibility and serve its purpose whether scientific, military or commercial. Such orbits which are assigned to satellites, with respect to earth are called as **Earth Orbits**. The satellites in these orbits are Earth Orbit Satellites.

The important kinds of Earth Orbits are −

- Geo-synchronous Earth Orbit
- Geo-stationary Earth Orbit
- Medium Earth Orbit

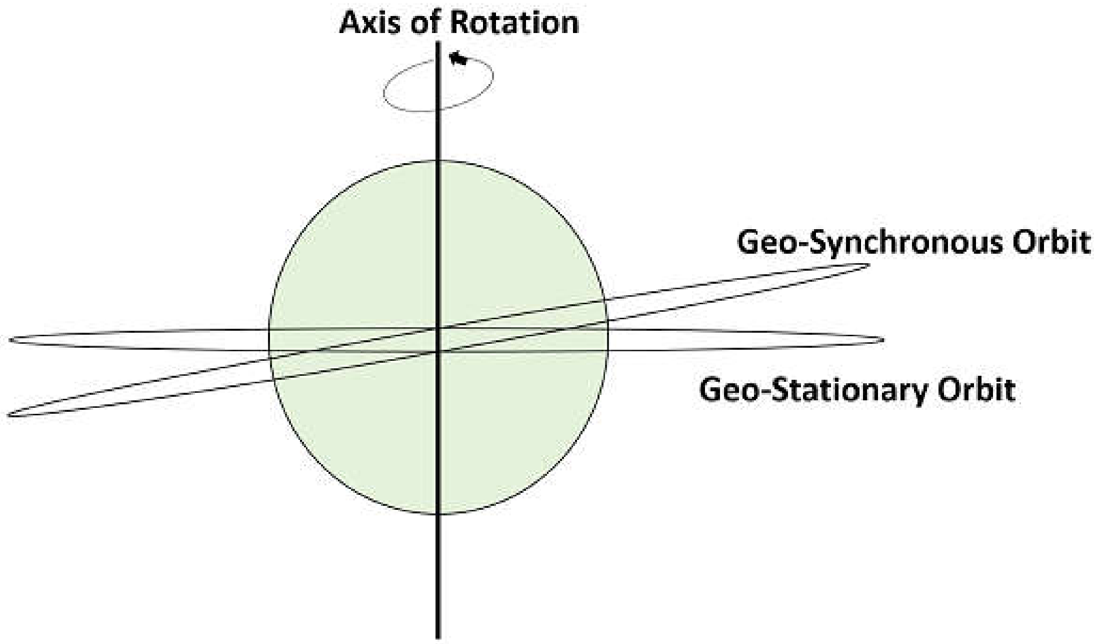
- Low Earth Orbit

Geo-synchronous Earth Orbit (GEO) Satellites

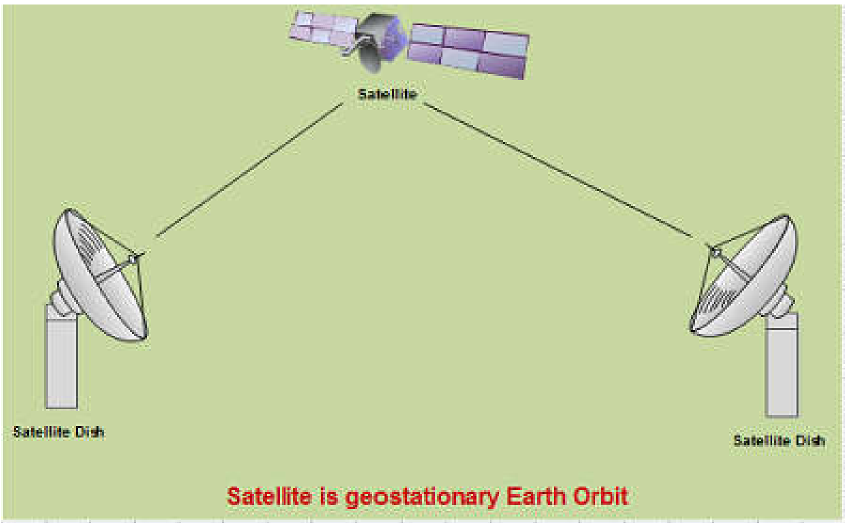
A Geo-synchronous Earth orbit Satellite is one which is placed at an altitude of 22,300 miles above the Earth. This orbit is synchronized with a **side real day** (i.e., 23hours 56minutes). This orbit can **have inclination and eccentricity**. It may not be circular. This orbit can be tilted at the poles of the earth. But it appears stationary when observed from the Earth.

The same geo-synchronous orbit, if it is **circular** and in the plane of equator, it is called as geo-stationary orbit. These Satellites are placed at 35,900kms (same as geosynchronous) above the Earth's Equator and they keep on rotating with respect to earth's direction (west to east). These satellites are considered **stationary** with respect to earth and hence the name implies.

Geo-Stationary Earth Orbit Satellites are used for weather forecasting, satellite TV, satellite radio and other types of global communications.



The above figure shows the difference between Geo-synchronous and Geo- Stationary orbits. The Axis of rotation indicates the movement of Earth.



The main point to note here is that every Geo-Stationary orbit is a Geo-Synchronous orbit. But every Geo-Synchronous orbit is NOT a Geo-stationary orbit.

Medium Earth Orbit (MEO) Satellites

Medium earth orbit (MEO) satellite networks will orbit at distances of about 8000 miles from earth's surface. Signals transmitted from a MEO satellite travel a shorter distance. This translates to improved signal strength at the receiving end. This shows that smaller, more lightweight receiving terminals can be used at the receiving end.

Since the signal is travelling a shorter distance to and from the satellite, there is less transmission delay. **Transmission delay** can be defined as the time it takes for a signal to travel up to a satellite and back down to a receiving station.

For real-time communications, the shorter the transmission delay, the better will be the communication system. As an example, if a GEO satellite requires 0.25 seconds for a round trip, then MEO satellite requires less than 0.1 seconds to complete the same trip. MEOs operates in the frequency range of 2 GHz and above.

Low Earth Orbit (LEO) Satellites

The LEO satellites are mainly classified into three categories namely, little LEOs, big LEOs, and Mega-LEOs. LEOs will orbit at a distance of 500 to 1000 miles above the earth's surface.

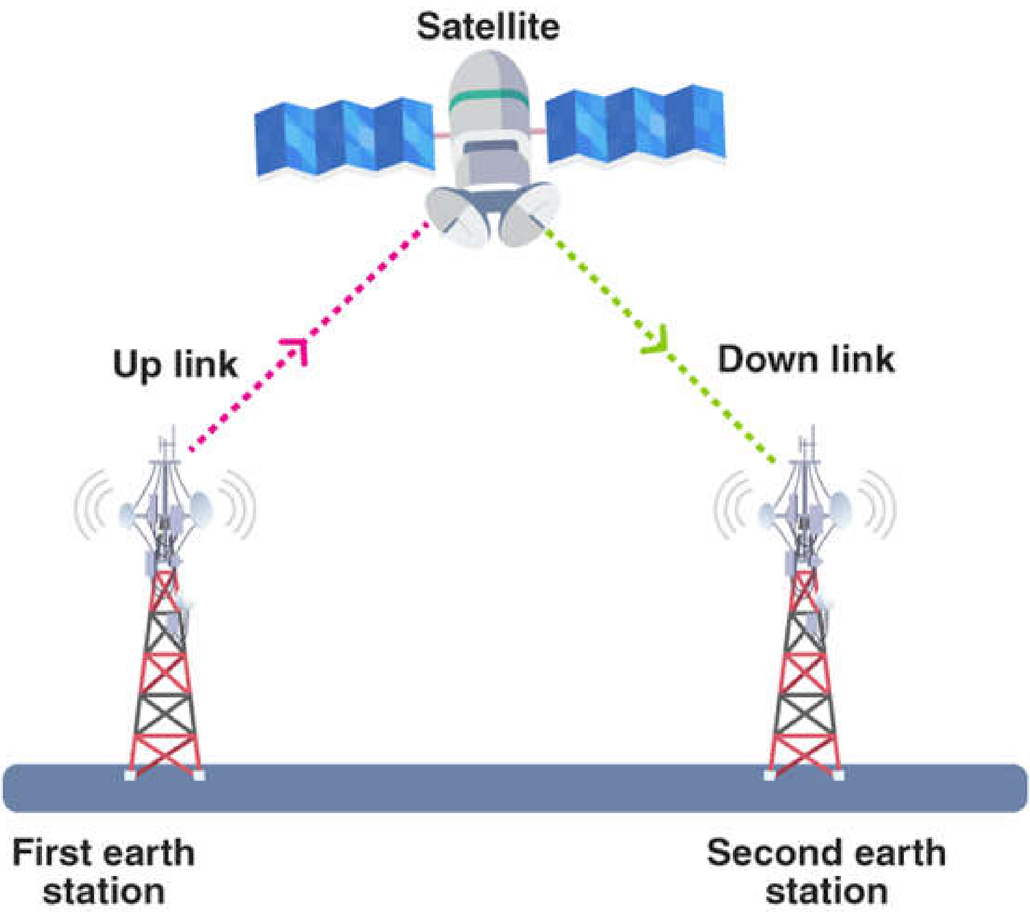
This relatively short distance reduces transmission delay to only 0.05 seconds. This further reduces the need for sensitive and bulky receiving equipment. Little LEOs will operate in the 800 MHz (0.8 GHz) range. Big LEOs will operate in the 2 GHz or above range, and Mega-LEOs operates in the 20-30 GHz range.

The higher frequencies associated with **Mega-LEOs** translates into more information carrying capacity and yields to the capability of real-time, low delay video transmission scheme.

High Altitude Long Endurance (HALE) Platforms

Experimental HALE platforms are basically highly efficient and lightweight airplanes carrying communications equipment. This will act as **very low earth orbit geosynchronous satellites**.

These crafts will be powered by a combination of battery and solar power or high efficiency turbine engines. HALE platforms will offer **transmission delays of less than 0.001 seconds** at an altitude of only 70,000 feet, and even **better signal strength** for very lightweight hand-held receiving devices.



Orbital Slots

Here there may arise a question that with more than **200 satellites** up there in geosynchronous orbit, how do we keep them from running into each other or from attempting to use the same location in space? To answer this problem, international regulatory bodies like the International Telecommunications Union (**ITU**) and national government organizations like the Federal Communications Commission (**FCC**) designate the locations on the geosynchronous orbit where the communications satellites can be located.

These locations are specified in degrees of longitude and are called as **orbital slots**. The FCC and ITU have progressively reduced the required spacing down to only 2 degrees for C-band and Ku-band satellites due to the huge demand for orbital slots.

Applications of Satellite Communication

- Telephone
- Television
- Digital cinema
- Radio broadcasting
- Amateur radio
- Internet access
- Military
- Disaster Management

Satellite communication has a number of advantages:

Advantages :

- Through satellite transmission, coverage over geographical area is quite large mainly for sparsely populated areas.
- High bandwidth.
- Wireless and mobile communication applications can be easily established by satellite communication independent of location.
- It is used in wide variety of applications such as global mobile communication, private business networks, Long distance telephone transmission, weather forecasting, radio/TV signal broadcasting, gathering intelligence in military, navigation of ships and air crafts, connecting remote areas, television distribution etc.
- Security in satellite transmission is usually provided by the coding and decoding equipment.
- Service from one single provider is easy to obtain and uniform service is available.
- Over long distances, it can be cheaper.
- The laying and maintenance is easy and cheap in satellite communication therefore it is best alterative.

- During critical condition, each Earth Station may be removed relatively quickly from a location and reinstalled somewhere else.
- Ground station sites are easy to install and maintain.

Disadvantages :

- Design, development, investment and insurance of satellite requires higher cost.
- To reach the satellite from Earth, time can vary between 270 milliseconds and return again to 320 milliseconds. This propagation delay can cause an echo over telephone connections
- Satellites are not easy to repair and maintain.
- Some circumstances like weather or sunspots affect the satellite's signal and can cause interference and make proper operation of the satellite very difficult.
- It requires to be monitored and controlled on regular periods so that it remains in the orbit, once it has been launched

Radar Communication:

We can observe different objects around the world. Similarly, radar-like radio detection and ranging is used to assist the pilots while flying through fog because the pilot cannot notice that where they are traveling. The radar used in the airplanes is similar to a torchlight that works with radio waves in place of light. The airplane transmits a blinking radar signal and listens out for any indications of that signal from nearby objects. Once the indications are noticed, then the airplane identifies something is near & it uses the time taken for the indications to reach for discovering how distant away it is. This article discusses an overview of Radar and its working.

Who Invented Radar?

Similar to several inventions, the radar system is not easy to give credit to an individual because it was the outcome of earlier work on the properties of electromagnetic radiation for the accessibility of numerous electronic devices. The question of main concern is more complicated by the hide of military privacy under which radio location techniques were examined in different countries in the early days of World War-II.

This review writer finally concluded that when radar system is a clear case of direct creation, Robert Watson-Watt's note on Aircraft's Detection & Location of by Radio Methods published immediately 50 years ago. So it was the most significant solitary publication in this field. British achievement in the fight of Britain allocated much to the expansion of a radar system that included technical growth with operational feasibility.

What is a Radar System?

RADAR stands for Radio Detection and Ranging System. It is basically an electromagnetic system used to detect the location and distance of an object from the point where the RADAR is placed. It works by radiating energy into space and monitoring the echo or reflected signal from the objects. It operates in the UHF and microwave range.

A radar is an electromagnetic sensor, used to notice, track, locate, and identify different objects which are at certain distances. The working of radar is, it transmits electromagnetic energy in the direction of targets to observe the echoes and returns from them. Here the targets are nothing but ships, aircraft, astronomical bodies, automotive vehicles, spacecraft, rain, birds, insects, etc. Instead of noticing the target's location and velocity, it also obtains their shape and size sometimes.

The main objective of radar as compared with infrared and optical sensing devices is to discover faraway targets under difficult climate conditions & determines their distance, range, through precision. Radar has its own transmitter which is known as a source of illumination for placing targets. Generally, it works in the microwave area of the electromagnetic spectrum that is calculated in hertz when frequencies extend from 400 MHz to 40 GHz. The essential components which are used in the radar

Radar undergoes quick development during the years 1930-the 40s to reach the requirements of the military. It is still broadly used through the armed forces, wherever several technological advances have created. Simultaneously, radar is also utilized in civilian applications particularly in controlling air traffic, observation of weather, navigation of ship, environment, sensing from remote areas, observation of planetary, measurement of speed in industrial applications, space surveillance, law enforcement, etc.

Working Principle

The **radar working principle** is very simple because it transmits electromagnetic power as well as examines the energy returned back to the target. If the returned signals are received again at the position of their source, then an obstacle is in the transmission way. This is the working principle of radar.

Fundamentals of Radar

The RADAR system generally consists of a transmitter that produces an electromagnetic signal which is radiated into space by an antenna. When this signal strikes an object, it gets reflected or reradiated in many directions. This reflected or echo signal is received by the radar antenna which delivers it to the receiver, where it is processed to determine the geographical statistics of the object.

The range is determined by calculating the time taken by the signal to travel from the RADAR to the target and back. The target's location is measured in angle, from the direction of the maximum amplitude echo signal, the antenna points to. To measure the range and location of moving objects, the Doppler Effect is used.

The essential parts of this system include the following.

- **A Transmitter:** It can be a power amplifier like a Klystron, Travelling Wave Tube, or a power Oscillator like a Magnetron. The signal is first generated using a waveform generator and then amplified in the power amplifier.
- **Waveguides:** The waveguides are transmission lines for transmission of the RADAR signals.
- **Antenna:** The antenna used can be a parabolic reflector, planar arrays, or electronically steered phased arrays.
- **Duplexer:** A duplexer allows the antenna to be used as a transmitter or a receiver. It can be a gaseous device that would produce a short circuit at the input to the receiver when the transmitter is working.
- **Receiver:** It can be a superheterodyne receiver or any other receiver which consists of a processor to process the signal and detect it.
- **Threshold Decision:** The output of the receiver is compared with a threshold to detect the presence of any object. If the output is below any threshold, the presence of noise is assumed.

How Does Radar use Radio?

Once the radar is placed on a ship or plane, then it requires a similar essential set of components to produce radio signals, transmit them into space and receive them by something, and finally display the information to understand it. A magnetron is one kind of device, used to generate radio signals which are used through radio. These signals are similar to light signals because they travel at the same speed but their signals are much longer with fewer frequencies.

The light signals wavelength is 500 nanometers, whereas the radio signals used by radar normally range from centimeters to meters. In an electromagnetic spectrum, both the signals like radio and light are made with variable designs of magnetic and electrical energy throughout the air. The magnetron in radar generates microwaves the same as a microwave oven. The main disparity is that the magnetron within radar has to transmit the signals several miles, rather than just small distances, so it is more powerful as well as much larger.

Whenever the radio signals have been transmitted, then an antenna functions as a transmitter to transmit them into the air. Generally, the antenna shape is bent so it mainly focuses the signals into an exact and narrow signal; however radar antennas also normally revolve so they can notice actions over a huge area.

The radio signals travel outside from the antenna with 300,000 km per second speed until they strike something and some of them return back to the antenna. In a radar system, there is an essential device namely a duplexer. This device is used to make the antenna change from side to side in between a transmitter & a receiver.

Types of Radar

There are different types of radars which include the following.

- **Bistatic Radar**

This type of radar system includes a Tx-transmitter & an Rx- receiver that is divided through a distance that is equivalent to the distance of the estimated object. The transmitter & the receiver are situated at a similar position is called a monastic radar whereas the very long-range surface to air & air to air military hardware uses the bistatic radar.

➢ Doppler Radar

It is a special type of radar that uses the Doppler Effect to generate data velocity regarding a target at a particular distance. This can be obtained by transmitting electromagnetic signals in the direction of an object so that it analyzes how the action of the object has affected the returned signal's frequency.

This change will give very precise measurements for the radial component of an object's velocity within relation toward the radar. The applications of these radars involve different industries like meteorology, aviation, healthcare, etc.

➢ Monopulse Radar

This kind of radar system compares the obtained signal using a particular radar pulse next to it by contrasting the signal as observed in numerous directions otherwise polarizations. The most frequent type of monopulse radar is the conical scanning radar. This kind of radar evaluates the return from two ways to measure the position of the object directly. It is significant to note that the radars which are developed in the year 1960 are monopulse radars.

➢ Passive Radar

This kind of radar is mainly designed to notice as well as follow the targets through processing indications from illumination within the surroundings. These sources comprise communication signals as well as commercial broadcasts. The categorization of this radar can be done in the same category of bistatic radar.

➢ Instrumentation Radar

These radars are designed for testing aircraft, missiles, rockets, etc. They give different information including space, position, and time both in the analysis of post-processing & real-time.

➢ Weather Radars

These are used to detect the direction and weather by using radio signals through circular or horizontal polarization. The frequency choice of weather radar mainly depends on a compromise of performance among attenuation as well as precipitation refection as an outcome of atmospheric water steam. Some types of radars are mainly designed to employ Doppler shifts to calculate the wind speed as well as dual-polarization to recognize the types of rainfall.

- **Mapping Radar**

These radars are mainly used to examine a large geographical area for the applications of remote sensing & geography. As a result of synthetic aperture radar, these are restricted to quite stationary targets. There are some particular radar systems used to detect humans after walls that are more different as compared with the ones found within construction materials.

- **Navigational Radars**

Generally, these are the same to search radars but, they available with small wavelengths that are capable of replicating from the ground & from stones. These are commonly used on commercial ships as well as long-distance airplanes. There are different navigational radars like marine radars which are placed commonly on ships to avoid a collision as well as navigational purposes.

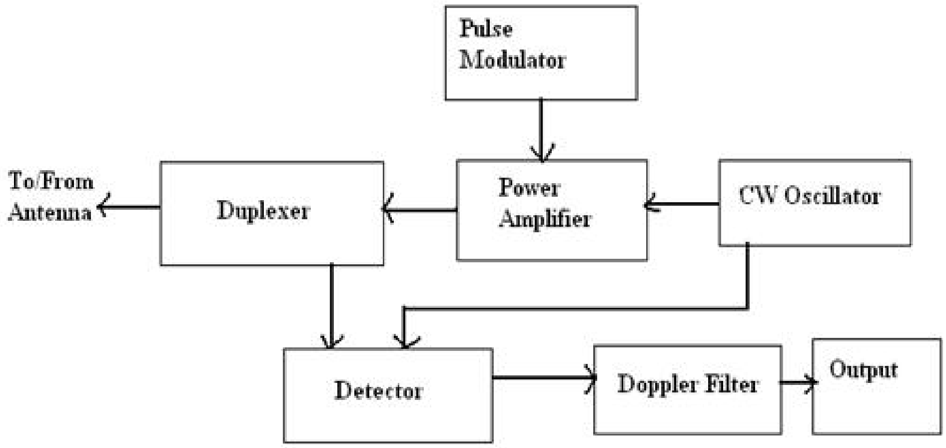
- **Pulsed RADAR**

Pulsed RADAR sends high power and high-frequency pulses towards the target object. It then waits for the echo signal from the object before another pulse is sent. The range and resolution of the RADAR depend on the pulse repetition frequency. It uses the Doppler shift method.

The principle of RADAR detecting moving objects using the Doppler shift works on the fact that echo signals from stationary objects are in the same phase and hence get canceled while echo signals from moving objects will have some changes in phase. These radars are classified into two types.

- **Pulse-Doppler**

It transmits high pulse repetition frequency to avoid Doppler ambiguities. The transmitted signal and the received echo signal are mixed in a detector to get the Doppler shift and the difference signal is filtered using a Doppler filter where the unwanted noise signals are rejected.

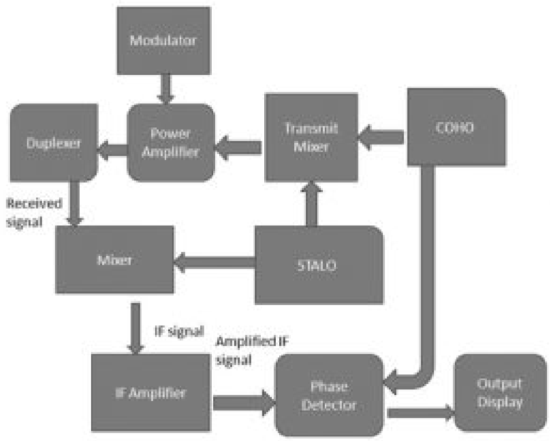


Block Diagram of Pulsed Doppler RADAR

Moving Target Indicator

It transmits low pulse repetition frequency to avoid range ambiguities. In an MTI RADAR system, the received echo signals from the object are directed towards the mixer, where they are mixed with the signal from a stable local oscillator (STALO) to produce the IF signal.

This IF signal is amplified and then given to the phase detector where its phase is compared with the phase of the signal from the Coherent Oscillator (COHO) and the difference signal is produced. The Coherent signal has the same phase as the transmitter signal. The coherent signal and the STALO signal are mixed and given to the power amplifier which is switched on and off using the pulse modulator.



MTI Radar

Continuous Wave

The continuous wave RADAR doesn't measure the range of the target but rather the rate of change of range by measuring the Doppler shift of the return signal. In a CW RADAR electromagnetic radiation is emitted instead of pulses. It is basically used for speed measurement.

The RF signal and the IF signal are mixed in the mixer stage to generate the local oscillator frequency. The RF signal is then transmitted signal and the received signal by the RADAR antenna consists of the RF frequency plus the Doppler shift frequency. The received signal is mixed with the local oscillator frequency in the second mixture stage to generate the IF frequency signal.

This signal is amplified and given to the third mixture stage where it is mixed with the IF signal to get the signal with Doppler frequency. This Doppler frequency or Doppler shift gives the rate of change of range of the target and thus the velocity of the target is measured.

Radar Range Equation

There are different kinds of versions available for the radar range equations. Here, the following equation is one of the fundamental types for an only antenna system.

Applications

The **applications of radar** include the following.

- ✓ **Military Applications**

It has 3 major applications in the Military:

- In air defense, it is used for target detection, target recognition, and weapon control (directing the weapon to the tracked targets).
- In a missile system to guide the weapon.
- Identifying enemy locations on the map.

- ✓ **Air Traffic Control**

It has 3 major applications in Air Traffic control:

- To control air traffic near airports. The Air Surveillance RADAR is used to detect and display the aircraft's position in the airport terminals.
- To guide the aircraft to land in bad weather using Precision Approach RADAR.
- To scan the airport surface for aircraft and ground vehicle positions

- ✓ **Remote Sensing**

It can be used for observing whether or observing planetary positions and monitoring sea ice to ensure a smooth route for ships.

- ✓ **Ground Traffic Control**

It can also be used by traffic police to determine the speed of the vehicle, controlling the movement of vehicles by giving warnings about the presence of other vehicles or any other obstacles behind them.

- ✓ **Space**

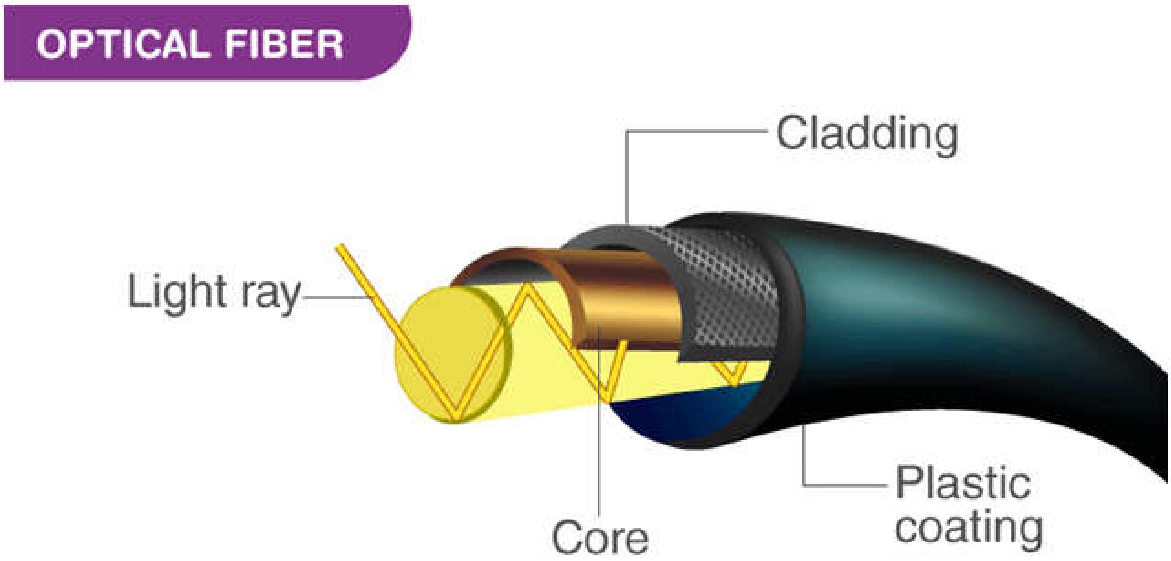
It has 3 major applications

- To guide the space vehicle for a safe landing on the moon
- To observe the planetary systems
- To detect and track satellites
- To monitor the meteors

FIBER OPTICS CABLE

What is an Optical Fiber?

Optical fiber is the technology associated with data transmission using light pulses travelling along with a long fiber which is usually made of plastic or glass. Metal wires are preferred for transmission in optical fiber communication as signals travel with fewer damages. Optical fibers are also unaffected by electromagnetic interference. The fiber optical cable uses the application of total internal reflection of light. The fibers are designed such that they facilitate the propagation of light along with the optical fiber depending on the requirement of power and distance of transmission. Single-mode fiber is used for long-distance transmission, while multimode fiber is used for shorter distances. The outer cladding of these fibers needs better protection than metal wires.



Types of Optical Fibers

The types of optical fibers depend on the refractive index, materials used, and mode of propagation of light.

The classification based on the refractive index is as follows:

- **Step Index Fibers:** It consists of a core surrounded by the cladding, which has a single uniform index of refraction.
- **Graded Index Fibers:** The refractive index of the optical fiber decreases as the radial distance from the fiber axis increases.

The classification based on the materials used is as follows:

- **Plastic Optical Fibers:** The poly methyl methacrylate is used as a core material for the transmission of the light.
- **Glass Fibers:** It consists of extremely fine glass fibers.

The classification based on the mode of propagation of light is as follows:

- **Single-Mode Fibers:** These fibers are used for long-distance transmission of signals.
- **Multimode Fibers:** These fibers are used for short-distance transmission of signals.

The mode of propagation and refractive index of the core is used to form four combination types of optic fibers as follows:

- Step index-single mode fibers
- Graded index-Single mode fibers
- Step index-Multimode fibers
- Graded index-Multimode fibers

How Does an Optical Fibre Work?

The optical fiber works on the principle of total internal reflection. Light rays can be used to transmit a huge amount of data, but there is a problem here – the light rays travel in straight lines. So unless we have a long straight wire without any bends at all, harnessing this advantage will be very tedious. Instead, the optical cables are designed such that they bend all the light rays' inwards (using TIR). Light rays travel continuously, bouncing off the optical fiber walls and transmitting end to end data. Although light signals do degrade over progressing distances, depending on the purity of the material used, the loss is much less compared to using metal cables. A Fibre Optic Relay System consists of the following components:

- The Transmitter – It produces the light signals and encodes them to fit to transmit.
- The Optical Fibre – The medium for transmitting the light pulse (signal).
- The Optical Receiver – It receives the transmitted light pulse (signal) and decodes them to be fit to use.
- The Optical Regenerator – Necessary for long-distance data transmission.

Advantages of Optical Fibre Communication

- Economical and cost-effective
- Thin and non-flammable
- Less power consumption
- Less signal degradation

- Flexible and lightweight

ISDN-their properties

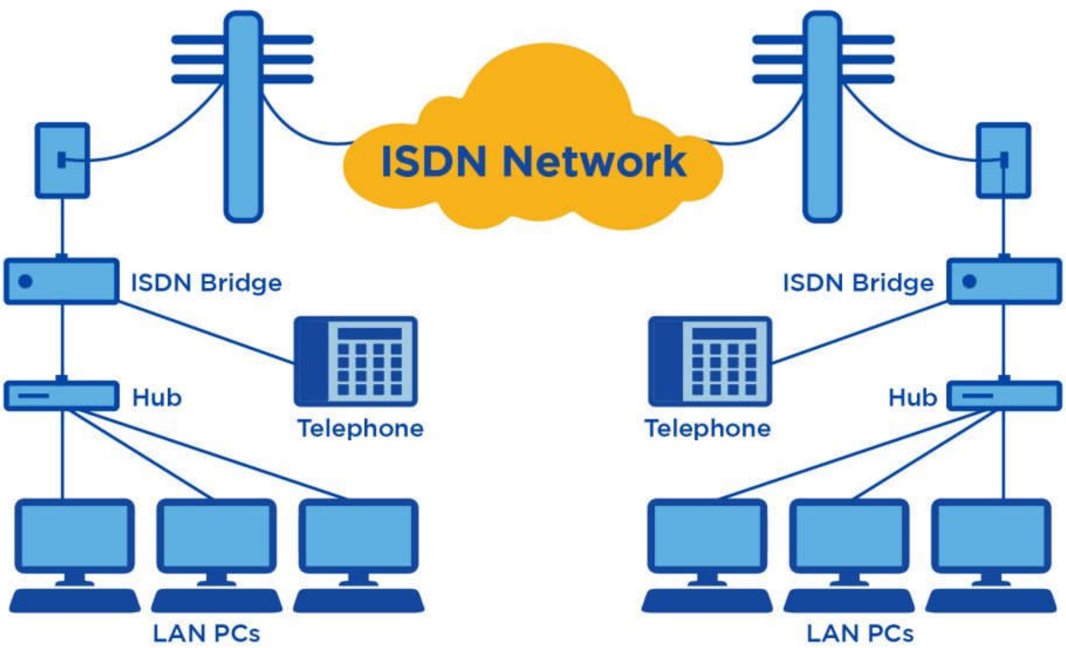
ISDN or Integrated Services Digital Network is a circuit-switched telephone network system that transmits both data and voice over a digital line. You can also think of it as a set of communication standards to transmit data, voice, and signaling.

These digital lines could be copper lines. It was designed to move outdated landline technology to digital.

ISDN connections have a reputation for providing better speeds and higher quality than traditional connections. Faster speeds and better connections allow data transmissions to travel more reliably.

The modern upgrade to an ISDN would be using a **SIP trunk provider** — they use the data for business phone service to a PBX.

How ISDN works



It's easy enough to define ISDN, but do you know how it works?

Most people use ISDN for high-speed internet when options like DSL or cable modem connections are not available.

Setting up ISDN is something you'll want to work on with your Internet Service Provider (ISP). A lot of the steps can easily be done from your home.

Your ISDN will be plugged in through a traditional **POTS (Plain Old Telephone Service**) line that can access both phone numbers at once.

You'll have to make sure you have a working POTS line and assigned phone numbers to begin.

After that, you can follow the steps below to get your voice and data communications up and running.

What are the advantages of ISDN?

- So why do people use ISDN?
- It first started as an alternative to your dial-up connection that provided higher internet speeds.
- To access the internet with ISDN, users had to connect through a digital modem.
- People still use ISDN for internet access in areas where broadband internet isn't an option. For the most part, ISDN for internet access is being phased out.
- There have been many attempts to improve the ISDN service.
- Broadband ISDN, also known as B-ISDN, transmitted data over fiber optic cable. Another attempt was ISDN BRI which attempted to improve voice services.

Some of the reasons people choose ISDN are:

- It offers multiple digital services that operate through the same copper wire
- Digital signals broadcast through telephone lines.
- ISDN provides a higher data transfer rate.
- Can connect devices and allow them to operate over a single line. This includes credit card readers, fax machines, and other manifold devices.
- It is up and running faster than other modems.

Geographic Information System (GIS)

Introduction

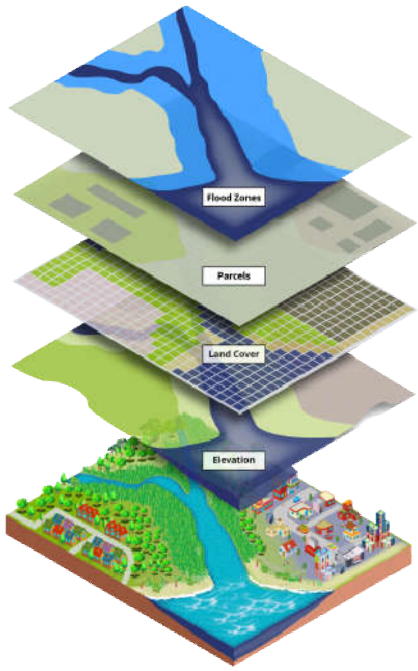
Geographical Information System (GIS) is a technology that provides the means to collect and use geographic data to assist in the development of Agriculture. A digital map is generally of much greater value than the same map printed on a paper as the digital version can be combined with other sources of data for analyzing information with a graphical presentation. The GIS software makes it possible to synthesize large amounts of different data, combining different layers of information to manage and retrieve the data in a more useful manner. GIS provides a powerful means for agricultural scientists to better service to the farmers and farming community in answering their query and helping in a better decision making to implement planning activities for the development of agriculture.

Overview of GIS

A Geographical Information System (GIS) is a system for capturing, storing, analyzing and managing data and associated attributes, which are spatially referenced to the Earth. The geographical information system is also called as a geographic information system or geospatial information system. It is an information system capable of integrating, storing, editing, analyzing, sharing, and displaying geographically referenced information. In a more generic sense, GIS is a software tool that allows users to create interactive queries, analyze the spatial information, edit data, maps, and present the results of all these operations. GIS technology is becoming essential tool to combine various maps and remote sensing information to generate various models, which are used in real time environment. Geographical information system is the science utilizing the geographic concepts, applications and systems.

Geographical Information System can be used for scientific investigations, resource management, asset management, environmental impact assessment, urban planning, cartography, criminology, history, sales, marketing, and logistics. For example, agricultural planners might use geographical data to decide on the best locations for a location specific crop planning, by combining data on soils, topography, and rainfall to determine the size and location of biologically suitable areas. The final output could include overlays with land ownership, transport, infrastructure, labour availability, and distance to market centers.

What is GIS mapping?



GIS mapping produces visualizations of geospatial information. The 4 main ideas of Geographic Information Systems (GIS) are:

- Create geographic data.
- Manage it in a database.
- Analyze and find patterns.
- Visualize it on a map.

Because viewing and analyzing data on maps impacts our understanding of data, we can make better decisions using GIS.

What are applications of GIS?

Every day, GIS powers millions of decisions around world such as these 1000 GIS applications. It makes a big impact in our life and you might not even realize. For example, we use GIS for:

- Pinpointing new store locations
- Reporting power outages
- Analyzing crime patterns
- Routing in car navigation
- Forecasting and predicting weather

Components of GIS

GIS enables the user to input, manage, manipulate, analyze, and display geographically referenced data using a computerized system. To perform various operations with GIS, the components of GIS such as software, hardware, data, people and methods are essential.

Software

GIS software provides the functions and tools needed to store, analyze, and display geographic information. Key software components are (a) a database management system (DBMS) (b) tools for the input and manipulation of geographic information (c) tools that support geographic query, analysis, and visualization (d) a graphical user interface (GUI) for easy access to tools. GIS software are either commercial software or software developed on Open Source domain, which are available for free. However, the commercial software is copyright protected, can be expensive and is available in terms number of licensees. Currently available commercial GIS software includes Arc/Info, Intergraph, MapInfo, Gram++ etc. Out of these Arc/Info is the most popular software package. And, the open source software are AMS/MARS etc.

Hardware

Hardware is the computer on which a GIS operates. Today, GIS runs on a wide range of hardware types, from centralized computer servers to desktop computers used in stand-alone or networked configurations.

Data

The most important component of a GIS is the data. Geographic data or Spatial data and related tabular data can be collected in-house or bought from a commercial data provider. Spatial data can be in the form of a map/remotely-sensed data such as satellite imagery and aerial photography. These data forms must be properly georeferenced (latitude/longitude). Tabular data can be in the form attribute data that is in some way related to spatial data. Most GIS software comes with inbuilt Database Management Systems (DBMS) to create and maintain a database to help organize and manage data.

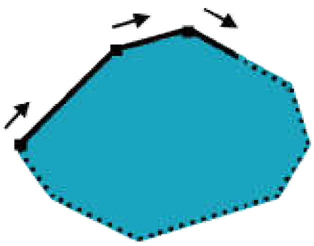
GIS stores location data as thematic layers. Each data set has an attribute table that stores information about the feature. The two main types of GIS data are raster and vector:

Raster

Raster look like grids because they store data in rows and columns. They can be discrete or continuous. For example, we often represent land cover, temperature data and imagery as raster data.

Vector

Vectors are points, lines and polygons with vertices. For example, fire hydrants, contours and administrative boundaries are often vectors.



Users

GIS technology is of limited value without the users who manage the system and to develop plans for applying it. GIS users range from technical specialists who design and maintain the system to those who use it to help them do their everyday work. 6 These users are largely interested in the results of the analyses and may have no interest or knowledge of the methods of analysis. The user-friendly interface of the GIS software allows the nontechnical users to have easy access to GIS analytical capabilities without needing to know detailed software commands. A simple User

Interface (UI) can consist of menus and pull-down graphic windows so that the user can perform required analysis with a few key presses without needing to learn specific commands in detail.

Functions of GIS

General-purpose GIS software performs six major tasks such as input, manipulation, management, query and analysis, Visualization.