Multiplexing

Many to one/One to many

Multiplexing

- Multiplexing is the sharing of a medium or bandwidth. It is the process in which multiple signals coming from multiple sources are combined and transmitted over a single communication/physical line

- The lines on the left direct their transmission streams to a multiplexer(MUX), which combines them into a single stream(many-to-one).
- At the receiving end, that stream is fed into a demultiplexer(DEMUX), which separates the stream back into its component transmissions(one-to-many) and directs them to their corresponding lines.
- Word link refers to the physical path.
- The word channel refers to the portion of a link that carries a transmission between a given pair of lines.

  One link can have many(n) channels.

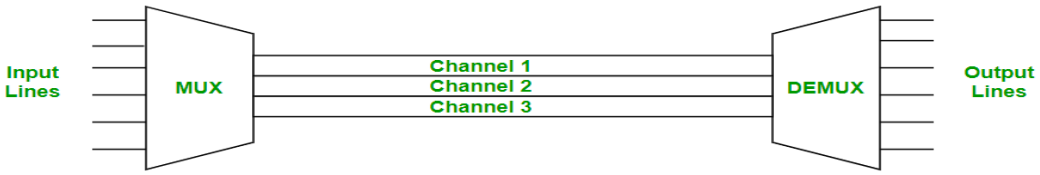
There are three basic multiplexing techniques:

- Frequency-division multiplexing
- Wavelength-division multiplexing
- Time-division multiplexing

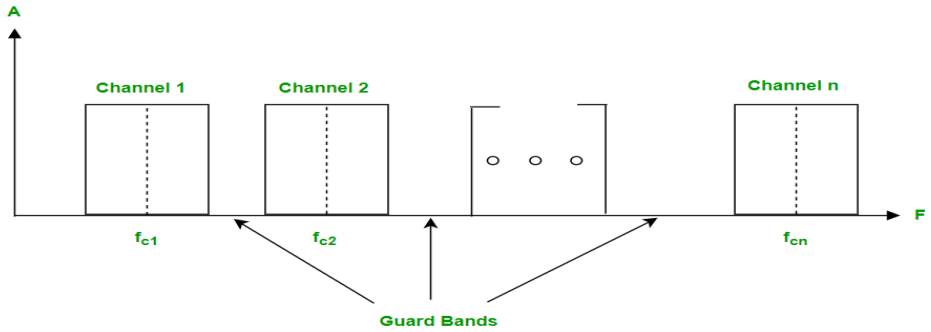
The first two techniques are designed for analog signals ,the third for digital signals

Frequency Division Multiplexing

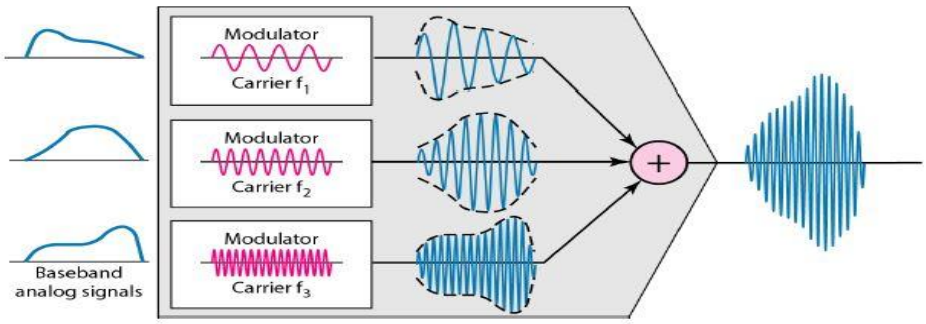
- Frequency division multiplexing is defined as a type of multiplexing where the bandwidth of a single physical medium is divided into a number of smaller, independent frequency channels.



- In the figure frequency dimension is subdivided into several non overlapping frequency bands
- There is always some unused frequency spaces between channels known as guard bands.
- Guard bands reduce effect of overlapping between adjacent channels

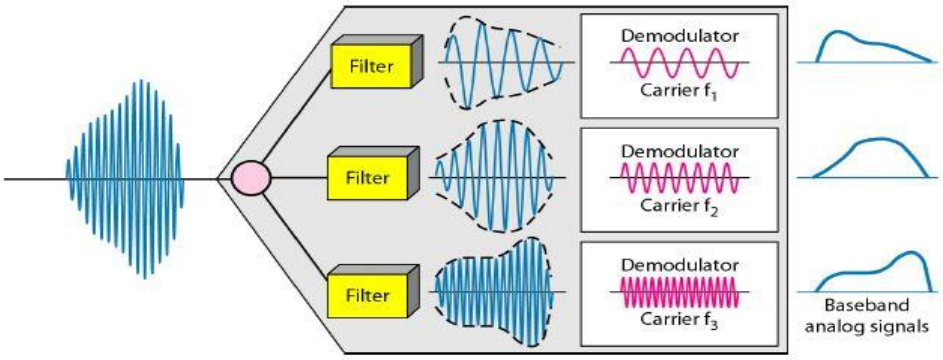


Multiplexing Process



- Each source generates a signal of a similar frequency range.
- Inside the multiplexer, these similar signals modulates different carrier frequencies(f1,f2 and f3).
- The resulting modulated signals are then combined into a single composite signal that is sent out over a media link that has enough bandwidth to accommodate it.

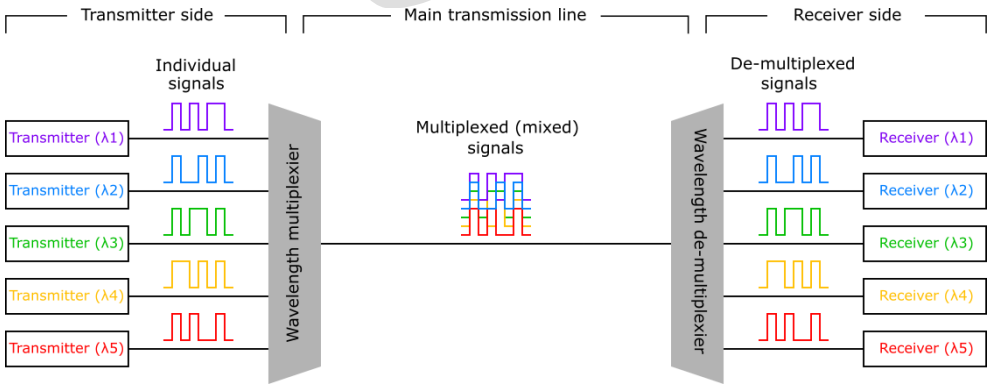
Demultiplexing Process



- The demultiplexer uses a series of filters to decompose the multiplexed signal into its constituent component signals.
- The individual signals are then passed to a demodulator that separates them from their carriers and passes them to the output lines.

Wavelength Division Multiplexing

- Wavelength Division Multiplexing is used on fiber optics to increase the capacity of a single fiber. It is an analog multiplexing technique. Optical signals from the different sources are combined to form a wider band of light with the help of multiplexers. At the receiving end, the demultiplexer separates the signals to transmit them to their respective destinations.
- WDM is conceptually the same as FDM, except that the multiplexing and demultiplexing involve optical signal transmitted through fiber-optic channels.
- The idea is the same: we are combining different signals of different frequencies.
- The difference is that the frequencies are very high.



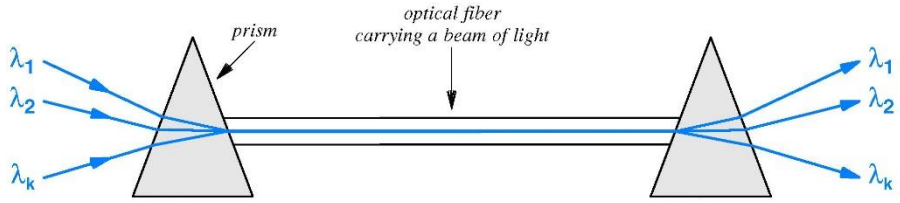
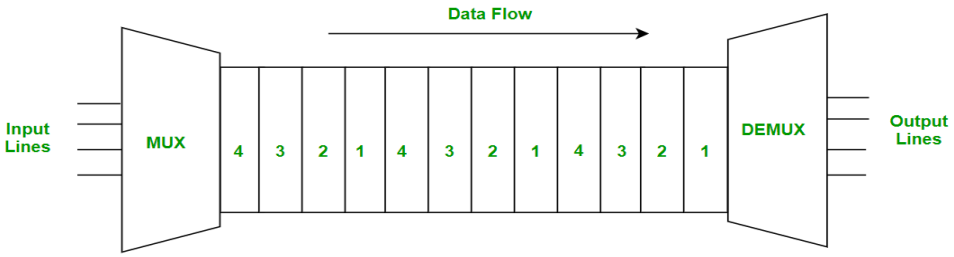


Figure 11.7 Illustration of prisms used to combine and separate wavelengths of light in wavelength division multiplexing technologies.

- We want to combine multiple light sources into one single light at the multiplexer and do the reverse at the demultiplexer.
- The combining and splitting of light sources are easily handled by a prism.
- Prism bends a beam of light based on the angle of incidence and the frequency
- Using this technique, a multiplexer can be made to combine several input beams of light, each containing a narrow band of frequencies, into one output beam of a wider band of frequencies.
- A demultiplexer can also be made to reverse the process.

Time Division Multiplexing

- Time-division multiplexing is defined as a type of multiplexing wherein FDM, instead of sharing a portion of the bandwidth in the form of channels, in TDM, time is shared. Each connection occupies a portion of time in the link.
- In Time Division Multiplexing, all signals operate with the same frequency (bandwidth) at different times.

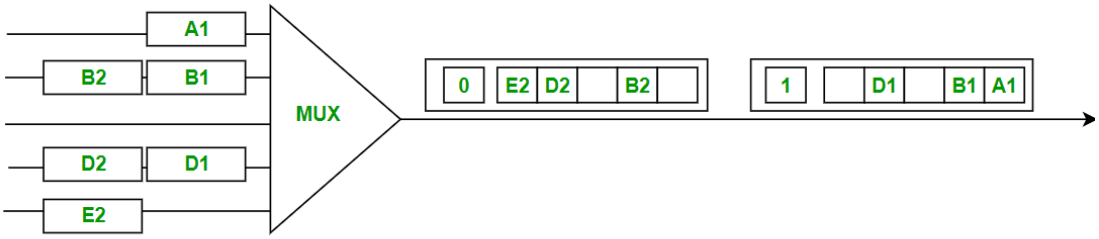


- Link is shown sectioned by time rather than by frequency.
- In the figure, portions of signals 1,2,3, and 4 occupy the link sequentially

There are two types of Time Division Multiplexing:

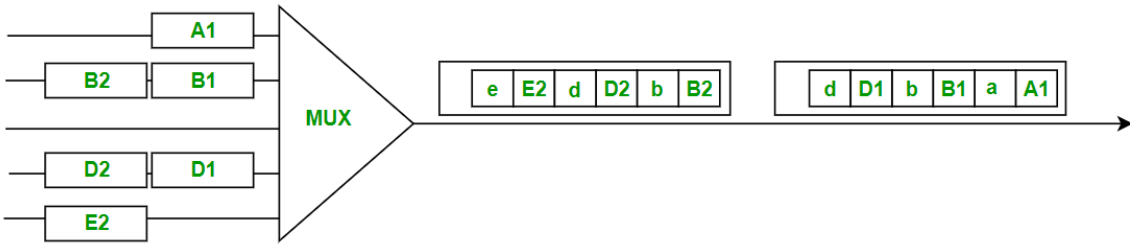
- **Synchronous Time Division Multiplexing**
- **Statistical (or Asynchronous) Time Division Multiplexing**

Synchronous TDM :



- Synchronous TDM is a type of Time Division Multiplexing where the input frame already has a slot in the output frame. Time slots are grouped into frames. One frame consists of one cycle of time slots.
- Synchronous TDM is not efficient because if the input frame has no data to send, a slot remains empty in the output frame.
- In synchronous TDM, we need to mention the synchronous bit at the beginning of each frame.

Statistical TDM(Asynchronous TDM) :



- Statistical TDM is a type of Time Division Multiplexing where the output frame collects data from the input frame till it is full, not leaving an empty slot like in Synchronous TDM.
- In statistical TDM, we need to include the address of each particular data in the slot that is being sent to the output frame.

Statistical TDM is a more efficient type of time-division multiplexing as the channel capacity is fully utilized and improves the bandwidth efficiency.

Application of Multiplexers

Multiplexers are used in various applications wherein multiple-data need to be transmitted by using a single line.

Communication System

A communication system has both a communication network and a transmission system. By using a multiplexer, the efficiency of the communication system can be increased by allowing the transmission of data, such as audio and video data from different channels through single lines or cables.

Computer Memory

Multiplexers are used in computer memory to maintain a huge amount of memory in the computers, and also reduce the number of copper lines required to connect the memory to the other parts of the computer.

Telephone Network

In telephone networks, multiple audio signals are integrated on a single line of transmission with the help of a multiplexer.

Transmission from the Computer System of a Satellite

The multiplexer is used to transmit the data signals from the computer system of a spacecraft or a satellite to the ground system by using a GSM satellite.

Mobile Communication: GSM and GSM system architecture

- Mobile Communication is the use of technology that allows us to communicate with others in different locations without the use of any physical connection(wires or cables).
- A mobile phone is an example of mobile communication (wireless communication).

Features of Mobile Communication

High capacity load balancing:

- Each wired or wireless infrastructure must incorporate high capacity load balancing.
- High capacity load balancing means, when one access point is overloaded, the system will actively shift users from one access point to another depending on the capacity which is available.

Network management system:

- Now a day, wireless networks are much more complex and may consist of hundreds or even thousands of access points.

- The wireless networks have a smarter way of managing the entire network from a centralized point.

Role based access control:

- Role based access control (RBAC) allows you to assign roles based on what, who, where and how a user or device is trying to access your network.

Flexibility:

- Wireless communication enables the people to communicate with each other regardless of location. There is no need to be in an office or some telephone booth in order to pass and receive messages.

Accessibility:

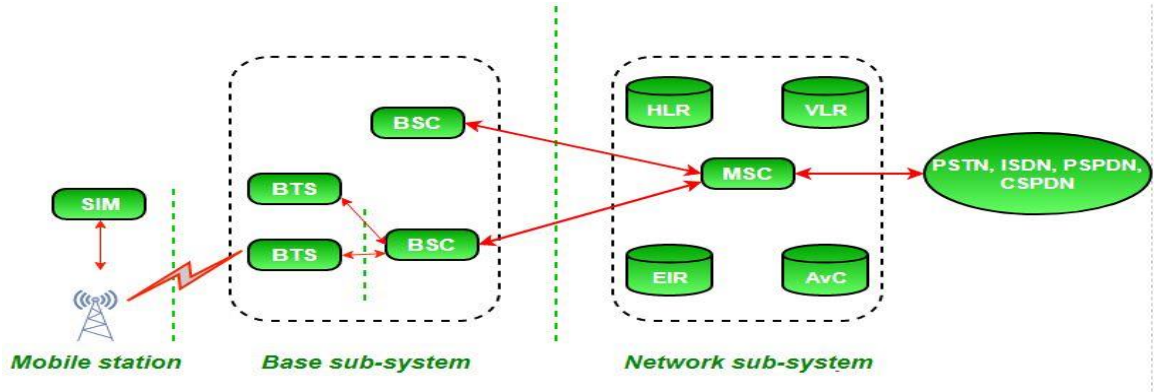
- With the help of wireless technology easy accessibility to the remote areas is possible.

Constant connectivity:

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

GSM

- GSM stands for Global System for Mobile Communication.
- It is 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 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 Kbps to 120 Mbps of data rates.
- **GSM SYSTEM ARCHITECTURE**



Mobile Station (MS):

- Simply , it means a mobile phone.
- Mobile Station is made up of two entities.

A. Mobile equipment(ME): It is a portable, vehicle mounted, hand held device.

- It is uniquely identified by an IMEI number(International mobile equipment identity).
- It is used for voice and data transmission.

B. Subscriber Identity module(SIM):

- It is a smart card that contains the International Mobile Subscriber Identity (IMSI) number.
- It allows users to send and receive calls and receive other subscriber services.
- It is protected by password or PIN.
- It contains encoded network identification details. It has key information to activate the phone.

Base Station Subsystem(BSS):

- It is also known as radio subsystem, provides and manages radio transmission paths between the mobile station and the Mobile Switching Center (MSC).
- BSS also manages interface between the mobile station and all other subsystems of GSM.
- It consists of two parts : Base Transceiver Station(BTS) and Base Station Controller(BSC).

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Base transceiver system(BTS): It maintains the radio component with MS.

- It encodes, encrypts, multiplexes, modulates and feeds the RF signal to the antenna.

Base station controller (BSC): Its function is to allocate necessary time slots between the BTS and MSC.

- It manages radio resources for BTS.

Network Switching Subsystem(NSS)

- It manages the switching functions of the system and allows MSCs to communicate with other networks such as PSTN and ISDN.
- It consist of

A. Mobile Switching Centre: It is a heart of the network. It manages communication between GSM and other networks.

- It manages call set up function, routing and basic switching.

B. Home location register(HLR): It is the reference database for subscriber parameter like subscriber's ID, location, authentication key etc.

C. Visitor location register(VLR): It contains copy of most of the data stored in HLR which is temporary and exist only until subscriber is active.

D. Equipment identity register (EIR): It is a database which contains a list of valid mobile equipment on the network.

E.Authentication center(AuC): It perform authentication of subscriber.

Public Switched Telephone Network(PSTN)

- **ISDN** or Integrated Services Digital Network
- **PSPDN-** Packet-Switched Public Data Network
- **CSPDN-** Circuit Switched Public Data Network

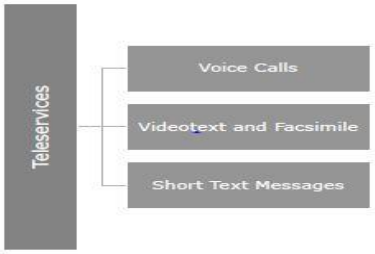
GSM : Mobile Services

GSM offers three basic types of services-

- **Telephony services or teleservices**
- **Data services or bearer services**
- **Supplementary services**

Teleservices

- The abilities of a Bearer Service are used by a Teleservice to transport data.
- These services are further transited in the following ways



Bearer Services

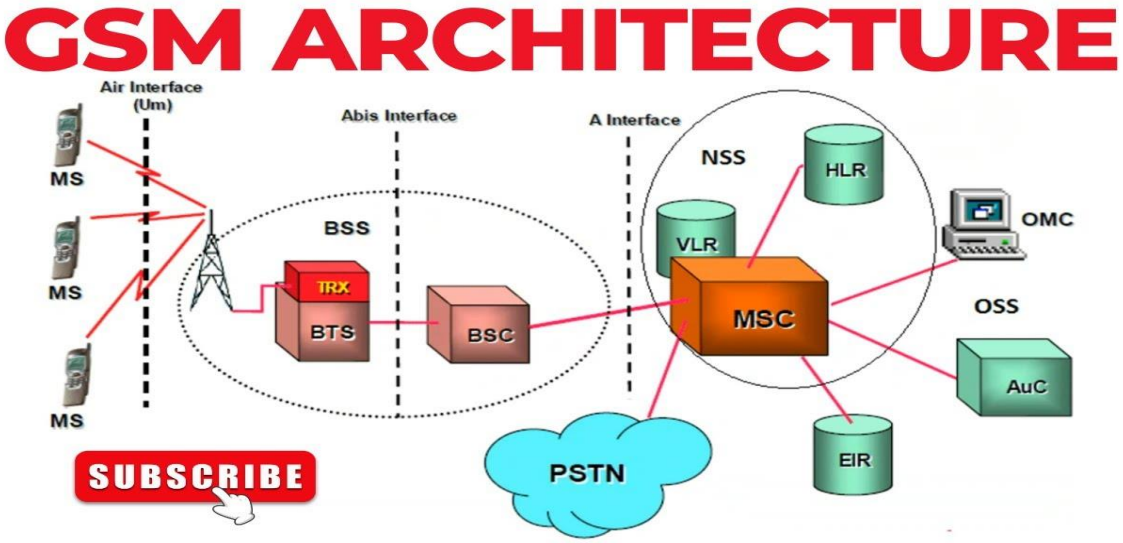
- Data services or Bearer Services are used through a GSM phone to receive and send data is the essential building block leading to widespread mobile Internet access and mobile data transfer.
- GSM currently has a data transfer rate of 9.6k.

Supplementary Services

- Supplementary services are additional services that are provided in addition to teleservices and bearer services.
- These services include caller identification, call forwarding, call waiting, multi-party conversations, and barring of outgoing (international) calls, among others.
- **Conferencing:-** It allows a mobile subscriber to establish a multiparty conversation.
- i.e, a simultaneous conversation between three or more subscribers to setup a conference call.
- **Call Waiting:-**This service notifies a mobile subscriber of an incoming call during a conversation.
- The subscriber can answer, reject, or ignore the incoming call.
- **Call Hold:-** This service allows a subscriber to put an incoming call on hold and resume after a while.
- **Call Forwarding:-** Call forwarding is used to divert calls from the original recipient to another number.
- It is normally set up by the subscriber himself.
- It can be used by the subscriber to divert calls from the Mobile Station when the subscriber is not available, and so to ensure that calls are not lost.
- **Call Barring:-** Call Barring is useful to restrict certain types of outgoing calls such as ISD or stop incoming calls from undesired numbers.
- **Number Identification:-** There are following supplementary services related to number identification
- **Calling Line Identification Presentation:-** This service displays the telephone number of the calling party on your screen.
- **Calling Line Identification Restriction:-** A person not wishing their number to be presented to others subscribes to this service.
- **Malicious Call Identification:-**The malicious call identification service was provided to combat the spread of obscene or annoying calls.

Radio interface in GSM

- GSM Network Interface connect between different elements in the GSM mobile communication network.
- The **Um interface** is the air interface for the GSM mobile telephone standard.
- It is the interface between the mobile station(MS) and the Base transceiver station(BTS).
- This **Air interface (RF Interface)** uses the Time Division Multiple Access(TDMA) technique to transmit and receive traffic and signaling information between the GSM's BTS and the GSM Mobile Station.
- The TDMA technique is used to divide each carrier into eight time slots.
- These time slots are then assigned to specific users, allowing up to eight conversations to be handled simultaneously by the same carrier.



- The **A interface** is used to provide communication between the BSS and the MSC.
- The interface carries information to enable the channels, timeslots.
- The messaging required within the network to enable handover etc to be undertaken is carried over the interface.
- **Abis interface** : This is a BSS internal interface linking the BSC and BTS, and it has not been totally standardized.
- The Abis interface allows control of the radio equipment and radio frequency allocation in the BTS.

MOBILE NETWORKS

(2G,3G,4G)

- "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.
- For e.g.. 1G offers 2.4kbps , 2G offers 64 kbps and is based on GSM, 3G offers 144kbps-2mbps where as 4G offers 100 Mbps – 1Gbps

Features	1G	2G	3G	4G	5G
Introduced	1979	1991	2001	2010	2019
Technology	AMPS, TACS	GSM	WCDMA	WiMAX, LTE	MIMO
Frequency	800-900 MHz	1.8 GHz	2 GHz	1800 MHz	24-47 GHz
Internet Service	Normal	Narrow band	Broad band	Ultra Broadband	Wireless World Wide Web
Net Speed	2.4 Kbps	64 Kbps	2 Mbps	1 Gbps	10 Gbps
Application	Voice call	Voice call, short message	Video call, GPS, MMS	Video call, GPS, mobile TV	HD video, robots.

1G – First Generation

- This was the first generation of cell phone technology.
- 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.
- 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 system (1G and 2G), is that the radio signals used by 1G network are analog, while 2G network are digital.
- The max speed of 2G with General Packet Radio Service(GPRS) is 50 Kbps or 1Mbps.
- It implemented the concept of CDMA and GSM. Provided small data service like SMS and MMS.

3G – Third Generation

- Web browsing, email, video downloading, picture sharing and other Smartphone technology were introduced in the third generation.
- This network combines aspects of the 2G network with some new technology and protocols to deliver a significantly faster data rate.
- 3G has Multimedia services.
- In 3G, Universal access and portability across different device types are made possible.

4G – Fourth Generation

- Its purpose is to provide high speed, high quality and high capacity to users.
- 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 max speed of a 4G network when the device is moving is 100 Mbps or 1Gbps.