Chapter 2

Wireless Communication

2.1 Introduction

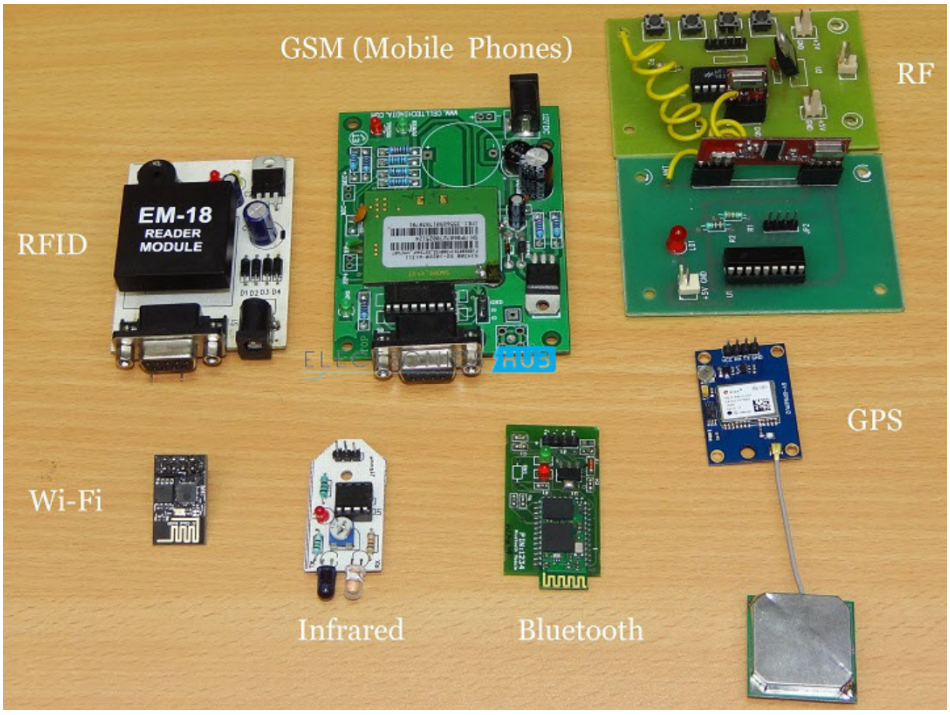
Communication Systems can be Wired or Wireless and the medium used for communication can be Guided or Unguided. In Wired Communication, the medium is a physical path like Co-axial Cables, Twisted Pair Cables and Optical Fiber Links etc. which guides the signal to propagate from one point to other. Such type of medium is called **Guided Medium**.

On the other hand, Wireless Communication doesn't require any physical medium but propagates the signal through space. Since, space only allows for signal transmission without any guidance, the medium used in Wireless Communication is called **Unguided Medium**.

2.1.1 Wireless Communication

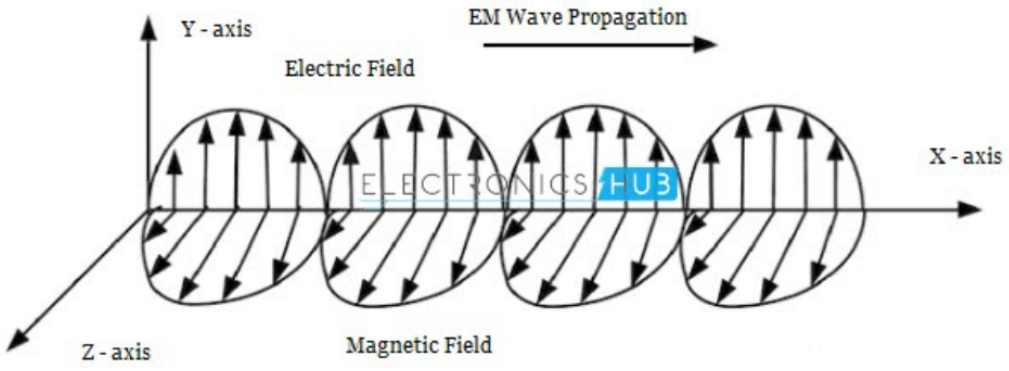
Wireless Communication is a method of transmitting information from one point to other, without using any connection like wires, cables or any physical medium. Generally, in a communication system, information is transmitted from transmitter to receiver that are placed over a limited distance. Wireless Communication doesn't require any physical medium but propagates the signal through space. With the help of Wireless Communication, the transmitter and receiver can be placed anywhere between few metres (like a T.V. Remote Control) to few thousand kilometres (Satellite Communication).

Some of the commonly used Wireless Communication Systems in our day – to – day life are: Mobile Phones, GPS Receivers, Remote Controls, Bluetooth Audio and Wi-Fi etc.



In unguided mechanism, communication is achieved by means of electromagnetic waves and the transmission and reception of signals is accomplished with Antennas. Antennas are electrical devices that transform the electrical signals to radio signals in the form of Electromagnetic (EM) Waves and vice versa. These Electromagnetic Waves propagates through space. Hence, both transmitter and receiver consists of an antenna. Electromagnetic Waves carry the electromagnetic energy of electromagnetic field through space. Common electromagnetic radiations are: X-ray, UV light, visible light,radio waves, microwaves, etc.

An Electromagnetic Wave consists of both electric and magnetic fields in the form of time varying sinusoidal waves. Both these fields are oscillating perpendicular to each other and the direction of propagation of the Electromagnetic Wave is again perpendicular to both these fields.



2.1.2 Advantages of Wireless Communication

Even though some draw backs are there, Wireless communication is advantageous in the following respects.

- Cost :- The cost of installing wires, cables and other infrastructure is eliminated in wireless communication and hence lowering the overall cost of the system compared to wired communication system.
- Mobility :- Mobility is the main advantage of wireless communication system. It offers the freedom to move around while still connected to network.
- Ease of Installation :- The setup and installation of wireless communication network's equipment and infrastructure is very easy as we need not worry about the hassle of cables.e.g. Setting a wi-fi network.
- Reliability :- Since there are no cables and wires involved in wireless communication, there is no chance of communication failure due to damage of these cables which may be caused by environmental conditions, cable splice and natural diminution of metallic conductors.
- Disaster Recovery :- In case of accidents due to fire, floods or other disasters, the loss of communication infrastructure in wireless communication system can be minimal.
- Viability :- In emergency situations and remote locations, where the setup of wired communication is difficult, wireless communication is a viable option.

2.1.3 Disadvantages

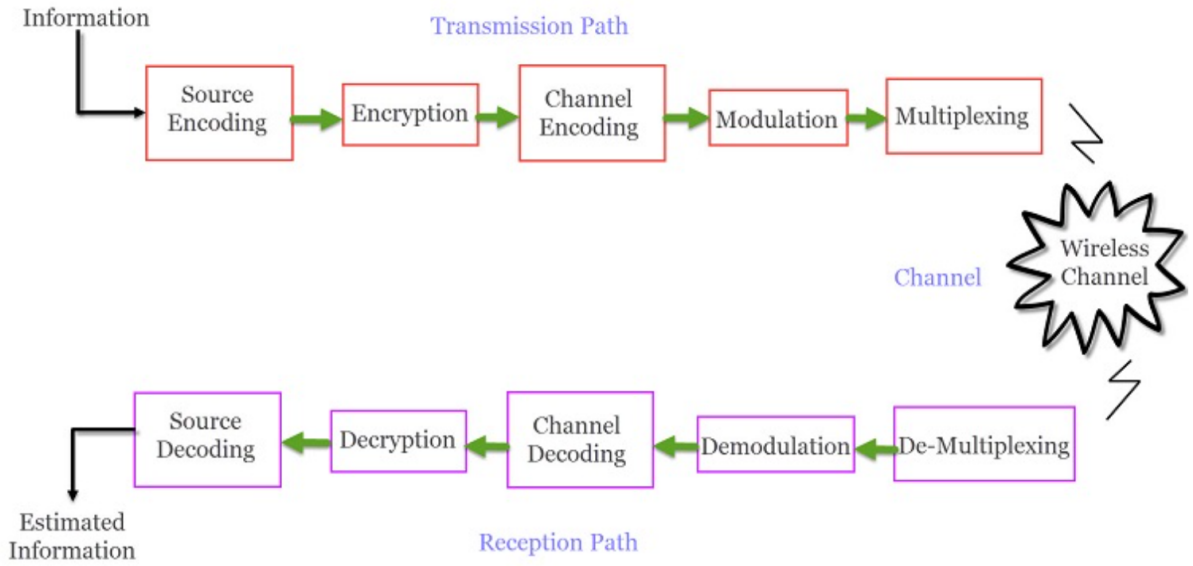
Wireless communication is advantageous in some respects but it has got some disadvantages also.

- Interference :- Since Wireless Communication systems use open space as the medium for transmitting signals, there is a huge chance that radio signals from one wireless communication system or network might interfere with other signals.

- Data security:- Since wireless signals are transmitted in open space, it is possible that an intruder can intercept the signals and copy sensitive information.
- Health Concerns :- Continuous exposure to any type of radiation can be hazardous. Even though the levels of RF energy that can cause the damage are not accurately established, it is advised to avoid RF radiation to the maximum.
- RF wireless communication systems have a transmitter and a receiver.
- Since the size of antenna has to be as large as one-fourth of the wavelength, the original signal (normally voice) cannot be transmitted without transferring it onto a higher frequency (smaller wavelength) that reduces size of the antenna.
- On the transmission side, the original signal (normally voice) is superimposed on a locally generated RF signal called a carrier – a process termed as modulation.
- The carrier signal containing the information, is then transmitted by the antenna; and then received at receiver where the information is extracted from the modulated carrier – a process called demodulation.
- During propagation of the signal in free space the signal becomes weaker and gets distorted due to noise and propagation effects like reflection, diffraction and scattering.
- Distortion effects are worse in mobile systems where the environment is changing from one moment to the other.
- The analogue and digital RF technologies are in fact used to enable the transmission and reception while reducing the problems of distortion during propagation.

2.1.4 Basic Elements

The essential components necessary for a wireless communication is shown in the figure.



2.2 Wireless Communication Systems

Important wireless communication systems are the following.

- Television and Radio Broadcasting
- Satellite Communication

- Radar
- Mobile Telephone System (Cellular Communication)
- Global Positioning System (GPS)
- Infrared Communication
- WLAN (Wi-Fi)
- Bluetooth
- Paging
- Cordless Phones
- Radio Frequency Identification (RFID)

Wireless Communication systems can be again classified as Simplex, Half Duplex and Full Duplex.

Simplex System

Simplex communication is one way communication. An example is Radio broadcast system.

Half Duplex

Half Duplex is two way communication but not simultaneous one. An example is walkie – talkie (civilian band radio).

Full Duplex

Full Duplex is also two way communication and it is a simultaneous one. Best example for full duplex is mobile phones.

2.2.1 Analog and Digital Access

In the initial stages wireless communication used analogue signals, but presently majority of the signals transmitted or sent is digital type.

Major Types of Signals

A signal is an electromagnetic or electrical current that carries data from one system or network to another. In electronics, a signal is often a time-varying voltage that is also an electromagnetic wave carrying information, though it can take on other forms, such as current.

There are two main types of signals used in electronics: **analogue** and **digital**l signals.

Analog Signal

An analogue signal is time-varying and generally bound to a range (e.g. +12V to -12V), but there is an infinite number of values within that continuous range. An analog signal uses a given property of the medium to convey the signal's information, such as electricity moving through a wire. In an electrical signal, the voltage, current, or frequency of the signal may be varied to represent the information. Analog signals are often calculated responses to changes in light, sound, temperature, position, pressure, or other physical phenomena.

Analog Signal - Representation

When plotted on a voltage vs. time graph, an analogue signal should produce a smooth and continuous curve. There should not be any discrete value changes.

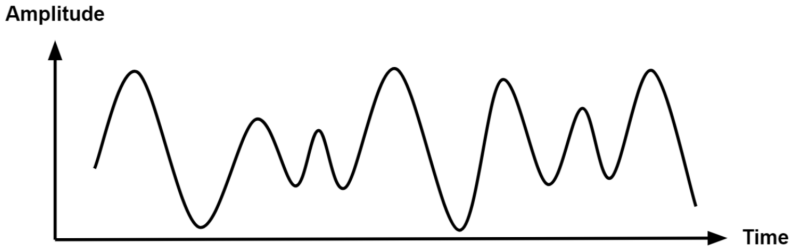


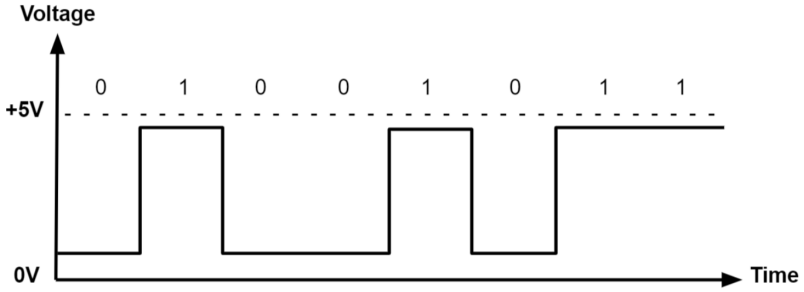
Figure 1: Analog Signal

Digital Signals

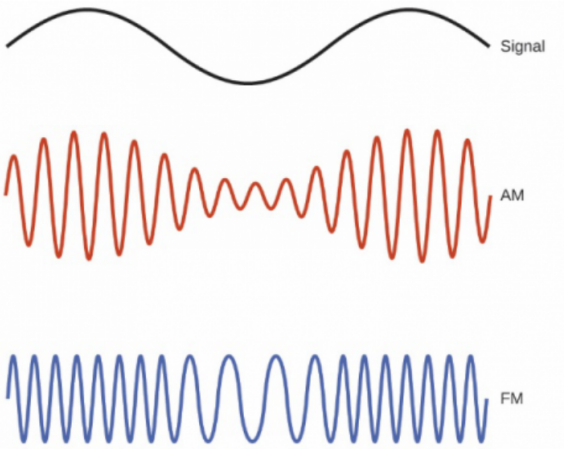
A digital signal is a signal that represents data as a sequence of discrete values. A digital signal can only take on one value from a finite set of possible values at a given time. With digital signals, the physical quantity representing the information can be many things:

- Variable electric current or voltage.
- Phase or polarization of an electromagnetic field.
- Acoustic pressure.
- The magnetization of a magnetic storage media.

When plotted on a voltage vs. time graph, digital signals are one of two values, and are usually between 0V and VCC (usually 1.8V, 3.3V, or 5V)



Analog signals are commonly used in communication systems that convey voice, data, image, signal, or video information using a continuous signal. There are two basic kinds of analogue transmission, which are both based on how they adapt data to combine an input signal with a carrier signal; amplitude modulation and frequency modulation.
Amplitude modulation (AM) adjusts the amplitude of the carrier signal. Frequency modulation (FM) adjusts the frequency of the carrier signal.



Analog transmission may be achieved via many methods:

- Through a twisted pair or coaxial cable.
- Through an optical cable.
- Through radio
- Through water.

Digital Wireless Technology

Digital signals are discrete (finite or limited set of values) in time and value and are represented by binary numbers, "0" or "1" (called a bit).

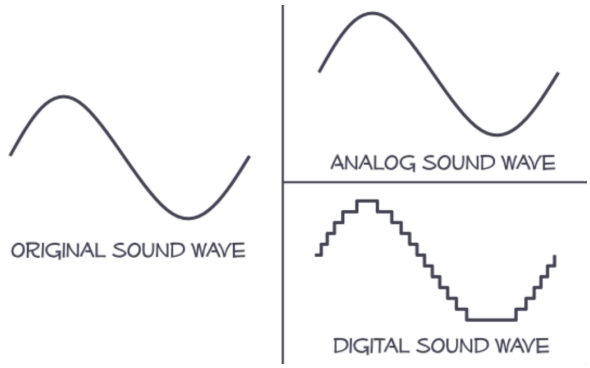


Figure 2.1: Analogue and digital sound wave

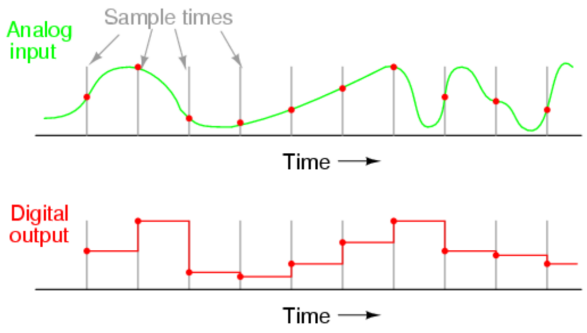


Figure 2.2: Analogue to digital Conversion

The digital signals can be generated by sampling of continuous (analogue) signal where the digital signal tries to approximate the values of analogue signal in small discrete steps.

2.3 Wireless Application Protocol(WAP)

2.3.1 Wireless Application Protocol

Wireless Application Protocol (WAP) is a technical standard for accessing information over a mobile wireless network. The wireless industry came up with the idea of WAP. The purpose of this standard is to show internet contents on wireless clients, like mobile phones, PDAs, etc. It is an open global specification that empowers mobile users with wireless devices to easily access and interact with internet information and services instantly. Features of WAP are as follows:

- WAP is an application communication protocol.
- It is used to access information and services through wireless devices.
- WAP is inherited from internet standards like IETF, RFC, etc.
- It designed for micro browsers.
- WAP enables creation of web applications for mobile services.
- It uses a markup language, WML and not HTML.
- it is defined as XML 1.0 application.
- WAP specifications continue to be developed by contributor members, who through interoperability testing have brought WAP into the Lime Light of the mobile data marketplace with fully functional WAP enabled devices.
- The basic aim of WAP is to provide a web experience on small portable devices like mobile phones and PDAs.
- The purpose of WAP is to enable easy fast delivery of relevant information and services to mobile users.
- Type of devices that use WAP are handheld digital wireless devices such as mobile phones, pagers, two-way radios, smartphones and communicators - from low end to high end.
- WAP works with most wireless networks such as CDPD, CDMA, GSM, PDC, PHS, TDMA, FLEX, etc.

2.3.2 Operating systems Compatible with WAP

- WAP is a communication protocol and an application environment.
- WAP is independent of OSS that means WAP can be implemented on any devices and OSs.
- It can be built on any operating system including palm OS, EPOC-32, Windows CE, FLEXOS, Java OS, etc.
- It provides service interoperability even between different device families.

2.3.3 Components Required for a WAP Service

1. WAP Device

WAP device that is used to access applications and content. It might be a PDA, handheld computer.

2. WAP Client

WAP client is an entity that receives content from internet via a WAP gateway. This is usually the web browser.

3. WAP Content/Origin/Application Server

It is the element in the network where the information or web/WAP application resides.

4. WAP Proxy

- WAP Proxy acts as both the client as well as a server in the network. It typically should have:
  - Protocol gateway :- translates request from the WAP protocol stack to www protocol stack.
  - Content encoders and decoders :- translate what can turn into a compact encoded formats to reduce the size of data over the network.
- It allows applications to be hosted on standard www servers and developed using proven www technologies such as CGI mapping.

5. WAP Gateway

WAP gateway is the intermediary element used to connect two different types of network. It receives request directly from the clients, as if it actually were the original server that clients want to receive the information form. The clients are usually unaware that they are speaking to the gateway.

6. WAP Browser

WAP browser is a software running on the WAP device that interprets the WAP content arriving from the internet and decides how to display it on a WAP device.

7. WML

- WML - wireless markup language formerly called HDML handheld devices markup language.
- It is a language that allows the text portions of web pages to be presented on cellular phones and personal digital assistants (PDAs) wireless access.
- WML is used for delivering data to WAP devices and is HTML like in its appearance.
- An alternative to WML is I-MODE's cHTML language

2.3.4 Applications

- Corporate applications :- Sales force automation where sales people use their WAP enabled handsets to get instant, direct access to the latest pricing, latest news, competitive information anytime anywhere.

- Online services.

  - Banking users can get their current balance, transfer funds between accounts and receive fax of a mini statement.
  - Electronic commerce :- subscribers can use their handset just like their PC to purchase products and services over the web.

- Tele services.

  - Prepaid services :- With a WAP enabled phone, prepaid subscribers can see the current balance in the press of a button.
  - By pressing another button they can also recharge their account by entering a credit card or voucher number into the handset.

- Personal productivity :- email : using WAP, users can keep track of their email, right from their handset.

- Others : include interactive chat, auctions games, etc.

2.3.5 Advantages

- Open standard, vendor independent.

- Network-standard independent.

- Transport mechanism - optimised for wireless data bearers.

- Application download from the server enabling fast service, creation and introduction are opposed to embedded software.

2.3.6 Disadvantages

- Small screens :- for web phones there is an incredibly small viewing area and top are barely better.

- Speed of access :- all devices have low slow access.

- Limited of fragmented availability ;- wireless web access is sporadic in many areas and entirely unavailable in other areas.

- Price many technology limitations are being addressed by higher end devices and services but the entry price for a good wireless web palmtop with a decent display, keyboard and speed is comparatively high not including monthly access.

- Lack of user habit it takes some patients and overcoming the learning curve to get - the hang of it, connecting putting in an address typing. Users just are not used to the idea and protocol yet.

2.4 Wireless LANs

2.4.1 Introduction

Definition

Wireless LANs are those Local Area Networks that use high frequency radio waves instead of cables for connecting the devices in LAN. Users connected by WLANs can move around within the area of network coverage.

A wireless LAN (WLAN) is a wireless computer network that links two or more devices using wireless communication to form a local area network (LAN) within a limited area such as a home, school, computer laboratory, campus, or office building.

- WLAN gives users the ability to move around within the area and remain connected to the network.
- Through a gateway, a WLAN can also provide a connection to the wider Internet.
- Wireless LANs have become popular for use in the home, due to their ease of installation and use.
- They are also popular in commercial properties that offer wireless access to their employees and customers.
- Most WLANs are based upon the standard IEEE 802.11 or WiFi.

2.4.2 Wireless LAN Requirements

- Same as any LAN: High capacity, short distances, full connectivity, broadcast capability.
- Throughput:- Efficient use of wireless medium.
- Number of nodes :- Hundreds of nodes across multiple cells.
- Connection to backbone LAN :- Use control module to connect to both type of LANs.
- Service area :- 100 to 300m .
- Low power consumption :- Need long battery life on mobile stations.
- Transmission robustness and security :- Interface prawn and easily eavesdropped.
- Collocated network operation :- Two or more wireless LANs in same area.
- Licence free operation then handoff/roaming move from one cell to another.
- Dynamic configuration :- Addition, deletion and relocation of end systems without disruption of users.

2.4.3 IEEE 802.11 Architecture

The components of an IEEE 802.11 architecture are as follows:

1.Stations(STA)

Stations comprise all devices and equipments that are connected to the wireless LAN. All stations are equipped with wireless network interface controllers (WNICs). Wireless stations fall into two categories: Wireless APs and Clients.

1a.Wireless access points(WAP)

Access points (APs), normally wireless routers, are base stations for the wireless network. They transmit and receive radio frequencies for wireless enabled devices to communicate with.

1b.Clients

Wireless clients can be mobile devices such as laptops, personal digital assistants, IP phones and other smartphones, or non-portable devices such as desktop computers, printers, and workstations that are equipped with a wireless network interface. Every BSS has an identification (ID) called the BSSID, which is the MAC address of the access point servicing the BSS.

There are two types of BSS:

- Independent BSS (also referred to as IBSS) :- An independent BSS (IBSS) is an ad hoc network that contains no access points, which means they cannot connect to any other basic service set. i.e. they are STAs configured in ad hoc (peer-to-peer)mode.
- Infrastructure BSS :- Infrastructure BSS devices communicate with other devices through access points.

2.Extended Service Set

An extended service set (ESS) is a set of connected BSSs. Access points in an ESS are connected by a distribution system. Each ESS has an ID called the SSID which is a 32-byte (maximum) character string.

3.Distribution System

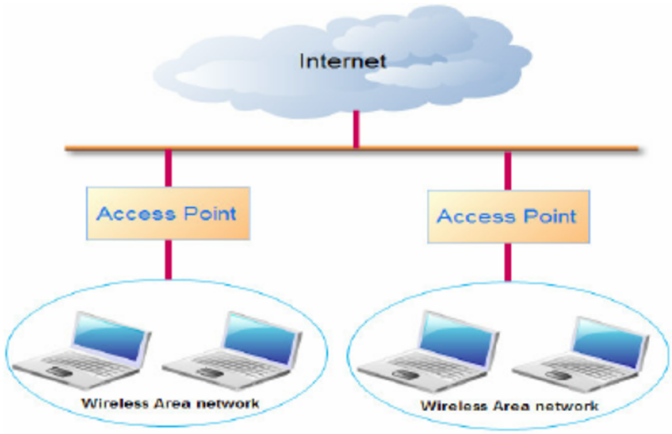
A distribution system (DS) connects access points in an extended service set. The concept of a DS can be used to increase network coverage through roaming between cells. DS can be wired or wireless. Current wireless distribution systems are mostly based on WDS or MESH protocols, though other systems are in use.

2.4.4 Types of Wireless LANs

WLANs, as standardized by IEEE 802.11, operates in two basic modes, infrastructure, and ad hoc mode.

- Infrastructure Mode − Mobile devices or clients connect to an access point (AP) that in turn connects via a bridge to the LAN or Internet. The client transmits frames to other clients via the AP.
- Ad Hoc Mode − Clients transmit frames directly to each other in a peer-to-peer fashion.

Infrastructure WLAN



Infrastructure WLANs are divided into two:

- Single Cell WLAN configuration
- Multi cell WLAN Configuration.

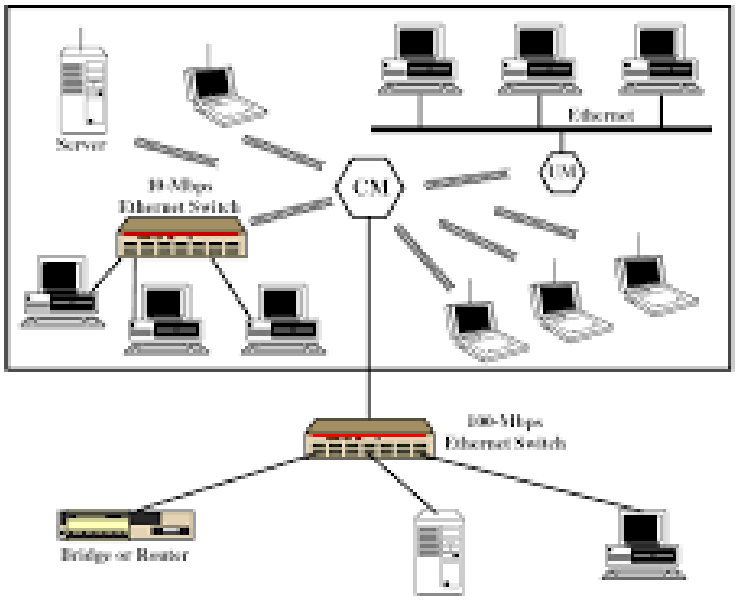
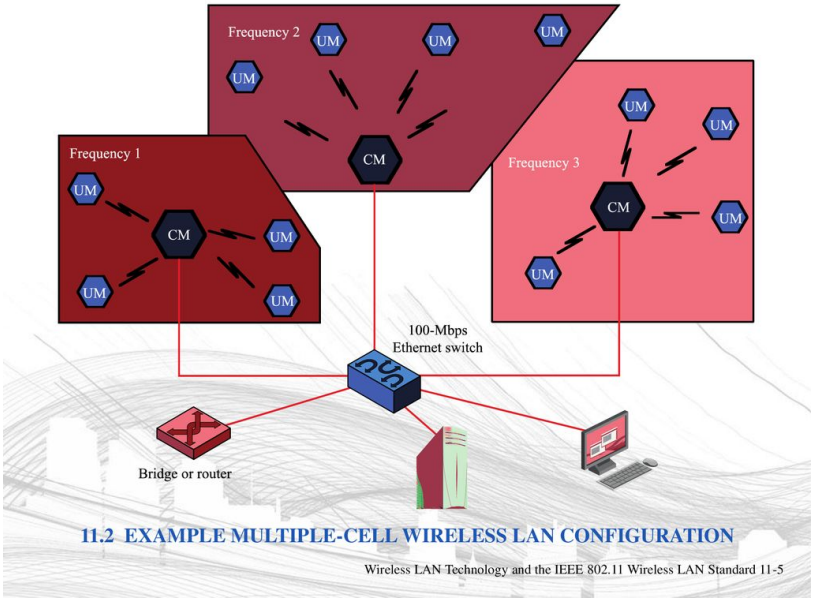


Figure 15.1 Example Single-Cell Wireless LAN Configuration



Adhoc WLAN

- Used mainly for peer to peer network.
- Set up temporarily to meet some immediate need.
- E.g. Group of employees, each with laptop or palm top.
- Network used only for the duration of meeting.

2.4.5 Applications

- Wireless LANs have a great deal of applications.
- Modern implementations of WLANs range from small in-home networks to large, campus-sized ones to completely mobile networks on airplanes and trains.
- Users can access the Internet from WLAN hotspots in restaurants, hotels, and now with portable devices that connect to 3G or 4G networks.
- Often times these types of public access points require no registration or password to join the network.

- Others can be accessed once registration has occurred or a fee is paid.
- Existing Wireless LAN infrastructures can also be used to work as indoor positioning systems with no modification to the existing hardware.

Advantages

- They provide clutter free homes, offices and other networked places.
- The LANs are scalable in nature, i.e. devices may be added or removed from the network at a greater ease than wired LANs.
- The system is portable within the network coverage and access to the network is not bounded by the length of the cables.
- Installation and setup is much easier than wired counterparts.
- The equipment and setup costs are reduced.

Disadvantages

- Since radio waves are used for communications, the signals are noisier with more interference from nearby systems.
- Greater care is needed for encrypting information. Also, they are more prone to errors. So, they require greater bandwidth than the wired LANs.
- WLANs are slower than wired LANs.

2.4.6 Classification of WLANs

Wireless LAN is divided into three types based on the unguided medium used for networking.

- Infra Red LAN :- connecting medium between the devices in the wireless network is Infra Red signals.
- Spread Spectrum LANs. :- Radio signals of definite bands. Most of these LAN techniques use ISM bands(Industrial, Scientific and Medical)
- Narrow Band Microwave LANs :- Microwave signals of lower wavelength but not spread spectrum.

Merits Infra Red LAN

- Spectrum for IR is virtually unlimited.
- Hence high data rates are possible.
- Infra Red spectrum unregulated.
- It is unregulated.
- Equipment is inexpensive and simple.
- Reflected by light coloured objects.i.e. ceiling reflection is enough to cover the whole room.
- Does not penetrate through walls. Hence better security from eavesdropping,and less interference from other rooms.

IR LAN Demerits

- Indoor environments experience interference from sun's IR radiations and IR emitted by other indoor light sources.
- These radiations appears as noise in the infra red receiver and hence
  - Transmitters of high power are required.
  - Range is limited.
  - High power transmitters affect eyesight and higher power consumption.

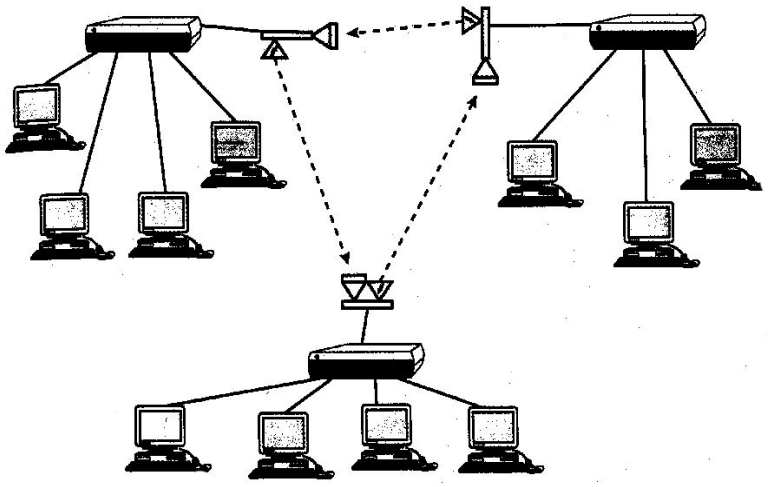
2.4.7 IR Data Transmission Techniques

There are three IR transmission techniques.

1.Directed Beam Infrared(Point to Point)

- The range depends on the emitted power and degree of focusing.
- The range can be in kms (for outdoor installation with LOS).
- The figure in next slide shows a token ring LAN.
- Work stations are connected to a hub which is connected to a transceiver.
- Used to create point-to-point links.
- Range depends on emitted power and degree of focusing.
- Focused IR data link can have range of kilometres
- Cross-building interconnect between bridges or routers.

Unidirectional Ring LAN



Token ring LAN using point-to-point infrared links

2.Omni Directional

- Have a single base station that is within LOS of all other stations.
- Usually the BS is mounted on the ceiling.
- The BS transmits omni directional signals while other stations transmit directional beam aimed at the ceiling base unit.
- Single base station within line of sight of all other stations on LAN.
- Station typically mounted on ceiling.
- Base station acts as a multiport repeater.
- Ceiling transmitter broadcasts signal received by IR transceivers.
- IR transceivers transmit with directional beam aimed at ceiling base unit.

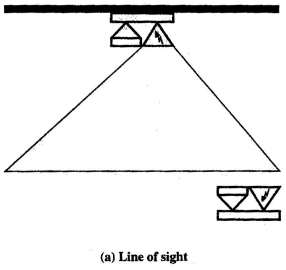


Figure 2.3: Omnidirectional IR LAN

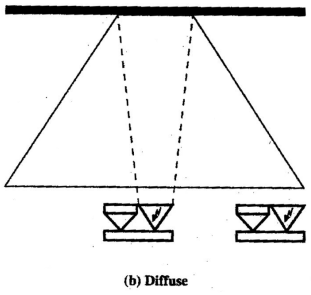


Figure 2.4: Diffused IR LAN

3. Diffused

- Here all IR transceivers are focused and aimed at a point on a diffusely reflecting ceiling.
- The signals strike the ceiling and are re-radiated or reflected omni directionally and picked up by all of the receivers in the area.
- All IR transmitters focused and aimed at a point on diffusely reflecting ceiling.
- IR radiation strikes ceiling, re-radiated omni directionally and picked up by all receivers.

2.5 Microwave LAN

2.5.1 Microwave LAN

A high frequency radio signal that can send wirelessly in the line of sight via transponders from 40 to 50 km in distance. Transponders receive a signal, amplify the signal, then send a signal to the next transponder. For this reason transponders need to be placed strategically and are usually set up on hire ground such as upon for buildings. Microwave is used by telephone network, internet service providers, as well as other companies for remote monitoring and management.

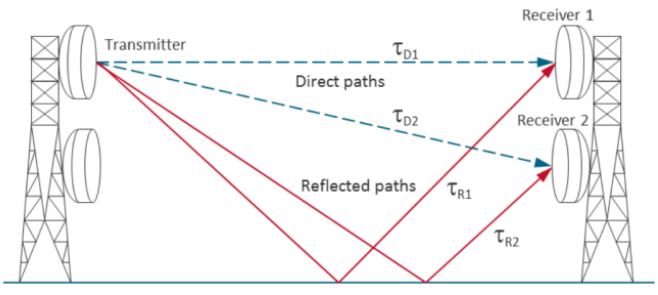


Figure 2.5: Microwave Transmission

Microwave Transmission makes use of satellites. Satellites are geostationary devices that receive signal from earth(uplinking) and transmit(relay) the signal to some other location on the earth at a different frequency(downlinking). GPS, radio and television broadcasts, mobile networks makes use of satellites. Geostationary satellites have the advantage that they are always in line of sight.

2.5.2 Microwave Communication

Microwave is a line-of-sight wireless communication technology that uses high frequency beams of radio waves to provide high speed wireless connections that can send and receive voice, video, and data information.

Microwave links are widely used for point-to-point communications because their small wavelength allows conveniently-sized antennas to direct them in narrow beams, which can be pointed directly at the receiving antenna. This allows nearby microwave equipment to use the same frequencies without interfering with each other, as lower frequency radio waves do.

Another advantage is that the high frequency of microwaves gives the microwave band a very large information-carrying capacity; the microwave band has a bandwidth 30 times that of all the rest of the radio spectrum below it. Microwave radio transmission is commonly used in point-to-point communication systems on the surface of the Earth, in satellite communications, and in deep space radio communications. Other parts of the microwave radio band are used for radars, radio navigation systems, sensor systems, and radio astronomy.

The higher part of the radio electromagnetic spectrum with frequencies are above 30 GHz and below 100 GHz, are called "millimetre waves" because their wavelengths are conveniently measured in millimetres, and their wavelengths range from 10 mm down to 3.0 mm. The electronic technologies needed in the millimetre wave band are also much more complex and harder to manufacture than those of the microwave band, hence cost of Millimetre Wave Radios are generally higher.

A microwave link is a communications system that uses a beam of radio waves in the microwave frequency range to transmit video, audio, or data between two locations, which can be from just a few feet or meters to several miles or kilometres apart. Modern Microwave Links can carry up to 400Mbps in a 56MHz channel using 256 QAM modulation and IP header compression techniques. Operating Distances for microwave links are determined by antenna size (gain), frequency band, and link capacity. The availability of clear Line of Sight is crucial for Microwave links for which the Earth's curvature has to be allowed.

Microwave signals are often divided into three categories:

- Ultra high frequency (UHF) (0.3-3 GHz)
- Super high frequency (SHF) (3-30 GHz) and
- Extremely high frequency (EHF) (30-300 GHz).

In addition, microwave frequency bands are designated by specific letters.

Lower Microwave frequencies are used for longer links, and regions with higher rain fade. Conversely, Higher frequencies are used for shorter links and regions with lower rain fade.

2.5.3 Uses of microwave LAN

- Backbone links and "Last Mile" Communication for cellular network operators.
- Backbone links for Internet Service Providers (ISPs) and Wireless ISPs (WISPs).
- Corporate Networks for Building to Building and campus sites.
- Telecommunications, in linking remote and regional telephone exchanges to larger (main) exchanges without the need for copper/optical fibre lines.
- Broadcast Television with HD-SDI and SMPTE standards.

2.5.4 Application of Microwave LAN

- Because of the scalability and flexibility of Microwave technology, Microwave products can be deployed in many enterprise applications including building-to-building connectivity, disaster recovery, network redundancy and temporary connectivity for applications such as data, voice and data, video services, medical imaging, CAD and engineering services, and fixed-line carrier bypass.
- Mobile Carrier Backhaul :- Microwave Links are a valuable tool in Mobile Carrier Backhaul: Microwave technology can be deployed to provide traditional PDH 16xE1/T1, STM-1 and STM-4, and Modern IP Gigabit Ethernet backhaul connectivity and Greenfield mobile networks.
- Microwave is far quicker to install and lower Total Cost of Ownership for Cellular Network Operators compared to deploying or leasing fibre optic networks.

- Low Latency Networks Cable Free Low Latency versions of Microwave links uses Low Latency Technology, with absolutely minimal delay between packets being transmitted and received at the other end, except the Line of Sight propagation delay.

- The Speed of Microwave propagation through the air is approximately 40% higher than through fibre optics, giving customers an immediate 40% reduction in latency compared to fibre optics.

- In addition, fibre optic installations are almost never in a straight line, with realities of building layout, street ducts and requirement to use existing telecom infrastructure, the fibre run can be 100% longer than the direct Line of Sight path between two end points.

2.6 Radio LAN

2.6.1 Radio LAN

- Radio transmission uses radio waves that can be in line of sight or wide area.

- WiFi networks, RFID(radio frequency identification), NFC(near field communication), Bluetooth, etc. makes use of radio signals.

- The devices used in this type of networks should have a wireless adaptor for translating data into and from radio signals.

2.6.2 Radio LAN

Radio LAN

A radio network is a collection of nodes communicating together through radio devices, using radio waves to carry the information exchanged.

It is sometime called a radio Ethernet, by analogy of the wired technology.

Most radio devices are a card (ISA, Pcmcia) to plug in a PC (or workstation), and interact directly with the standard networking stack on it (no need of PPP or any specific protocol stack).

A radio device is composed of two main parts.

- A radio Modem

- The MAC controller

Radio Modem

This is the part transmitting (modulating) the data onto the frequency and receiving other transmissions. It is composed of antenna(s), amplificators, frequency synthesisers, filters and other bits of magic. These are mainly analogue parts, and a bit of digital (in an ASIC, the Baseband). Usually it is encapsulated in metal case to protect the PC.

The modem main characteristics are the frequency band, the signalling rate, the modulation and the transmitted power. People building modems are also talking a lot of SNR and dB.

2. The MAC Controller

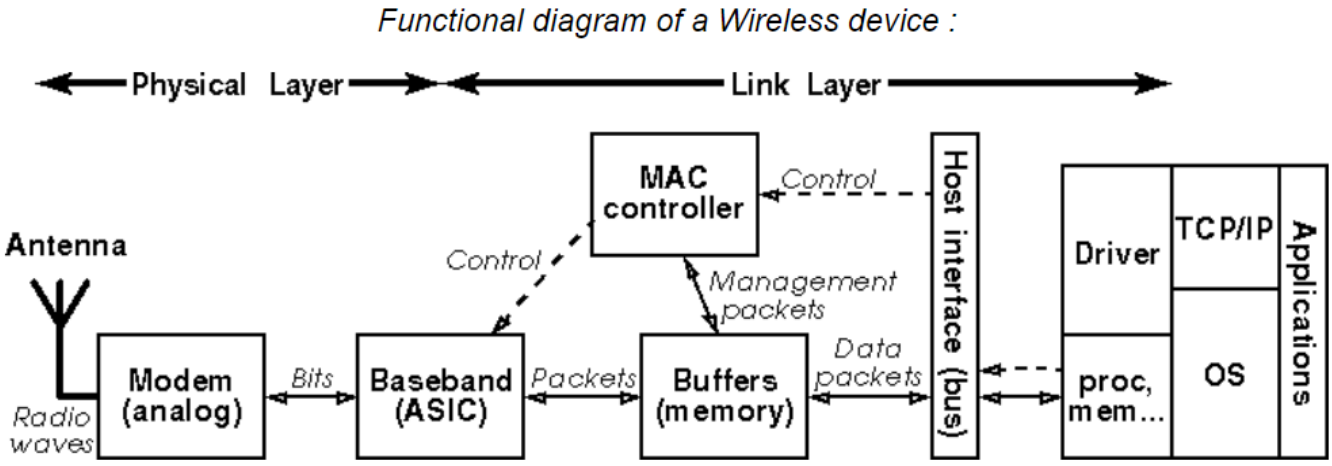
- The MAC[1] controller, responsible to run the MAC protocol.

- This is implemented mainly in an ASIC and/or a microcontroller on the card, but some functionalities of the MAC may be as well in the driver on the PC.

- The card also includes some memory for the MAC controller to store incoming and outgoing packets (buffers) and other data (configuration, statistics).

[1]Media Access Control

- Most of the time the few most time critical parts are handled in the radio modem ASIC (the baseband), the bulk of the MAC in a microcontroller and only some management functionality in the driver.
- But, the different manufacturers place the boundary between the different functionalities differently (cost/performance trade off), and some have implemented driver only MACs for lower cost.
- The main characteristics of the MAC are the packet format (size, headers), the channel access mechanisms and the network management features.
- The amount of on-board memory is also important, because the MAC may need a significant number of buffers to compensate the PC and interface latencies.



2.6.3 3. The Host Interface

- The card interface to the PC through one of its buses (ISA, PCI, Pcmcia...) or communication ports (serial, parallel, USB or Ethernet).
- This interface allows the software (mostly the driver) to communicate with the MAC controller and most of the time directly to the on board memory (the software writes packets to a specific location of it, then the controller reads them and sends them).
- The main characteristic of the interface is mainly the speed (i/o, shared memory or DMA) and the ability to process requests in parallel.
- The flexibility and functionality of it are usually more a concern for the person writing the driver.

4. The Driver

- With all modern operating systems, the end application doesn't access directly the hardware but use a standard API.
- The operating system needs a driver to interface the hardware to the network stack (TCP/IP, NetBeui, IPX...).
- The main function of the driver is to manage the hardware and to answer its request (to service interrupts).
- In most of the Wireless LANs, the driver also implements some parts of the MAC protocol.

Other Components

5. Wireless LAN Wireless LAN is necessary only when two different Radio LAN is interconnected as in the case of wireless bridges, wireless distribution systems and cable replacement, and they are quite different from local area networking.

6.Professional and Home Wireless LANs Wireless LANs are getting towards lower price, Wireless LAN manufacturers are no longer targeting mobile commercial users only but also the home market.

2.7 WLL Technologies

2.7.1 Wireless in Local Loop

Wireless local loop (WLL), is the use of a wireless communications link as the "last mile / first mile" connection for delivering plain old telephone service (POTS) or Internet access (marketed under the term "broadband") to telecommunications customers.

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.

2.7.2 WLL Technologies

The WLL system can be based on 4 major technologies. They are:

1. Satellite-Based Systems:

- These systems provide telephony services for rural communities and isolated areas such as islands.
- Satellite systems are designed for a Gaussian or Rician channel with K factor greater than 7 dB.

These systems can be of two types:

- Technology designed specifically for WLL applications :- offers quality and grade of service comparable to wireline access, but it may be expensive.
- Technology piggy backed onto mobile satellite systems as an adjunct service of these :- promises to be less costly but, due to bandwidth restrictions, may not offer the quality and grade of service comparable to plain old telephone service (POTS).

An example of a satellite based technology specifically designed for WLL is the HNS telephony earth station (TES) technology.

Advantages

- Low bit rate for voice and data.
- Low cost mobile terminals.
- It provides quality and grade of service for WLL applications.

Disadvantages

- The number of satellites and propagation delay put restrictions on the system design.
- Handover capability is needed e.g. LEO,MEO satellites are in motion relative to the earth's surface, so they need handover capability for all fixed and cellular applications.

Cellular-Based Systems

These systems provide large power, large range, median subscriber density, and median circuit quality WLL services. Cellular WLL technologies are primarily used to expand the basic telephony services.

This approach offers both mobility and fixed wireless access from the same cellular platform.

- For relatively sparsely populated rural and even urban settings, WLL technologies based on existing cellular systems can be economical and rapidly deployable.
- They include much sophisticated technology (and therefore overhead bandwidth) not necessarily required for the WLL application.
- The resultant limited user bandwidth represents a fundamental limitation of such systems for WLL.

Advantages

- They provide fixed wireless access and mobility.
- They can be rapidly deployed in rural and urban areas.
- They provide large power and operating range.
- They provide medium circuit and medium subscriber density.

Disadvantages

- They are not recommended for deployment indoors and in pico cells.
- Air interface is complex.
- The user bandwidth is limited.

2.7.3 Fixed Wireless Access Systems

- These systems are proprietary radio systems designed specifically for fixed wireless applications, which may or may not be extensible to PCS or cordless.
- The primary disadvantage of the cellular approach is its limitation on toll quality voice (new toll-quality vocoders designed for cellular technologies may eliminate this problem), and signalling transparency.
- The primary disadvantage of low-tier PCS and microcellular approaches is their range.
- FWA systems for zonal areas are designed to cover the local telephone area directly from the PSTN switches.
- The systems for rural areas provide connection at the remote ends of rural links to the end users.

Advantages

- Less expensive.
- It can be easily installed.
- The installation time need is less.
- Limitation on toll-quality and signalling transparency.

2.7.4 Low-Tier PCS or Microcellular-Based Systems

- These systems provide low power, small range, high subscriber density, and high circuit quality WLL services.
- These technologies are considered to facilitate rapid market entry and to expand the capacity of the existing infrastructure.
- They are typically operated at 800 MHz, 1.5 GHz, 1.8 GHz, and 1.9 GHz frequency bands.
- Compared with the cellular-based WLL, more base stations are required to cover the same service area.
- Operators may consider low-tier WLL technologies when an existing infrastructure is in place to support backhaul.
- For densely populated urban environments, WLL technologies based on existing low-tier PCS radio technologies.

Advantages

- High Subscriber density.
- Low power.
- High circuit quality.

Disadvantages

Transmission cost is more.

2.8 Evolution of Mobile Phone Technology

2.8.1 First Generation(1G)

- This term refers to the first generation cellular systems that were analogue telecommunications standards introduced in the 1980s.
- The voice channel typically used frequency modulation, and they used FDMA techniques.
- Examples: NMT (Nordic Mobile Telephone), used in Nordic countries, Switzerland, Netherlands, Eastern Europe and Russia, AMPS (Advanced Mobile Phone System) used in the United States and Australia, TACS (Total Access Communications System) in the United Kingdom, C-450 in West Germany, Portugal and South Africa.
- 1G types of phones was introduced in 1982 for the use of voice services and was based on technology known as Advanced Mobile Phone System (AMPS).
- The AMPS system was frequency modulated Features. The main Features are:
  - It is based on analogue system.
  - Poor voice quality and battery life.
  - Limited capacity.

2.8.2 Second Generation(2G)

- The term "Second Generation" refers to second forms of cellular telecommunications systems.
- The systems were digital and were oriented to voice with only low speed data services.
- Systems such as GSM and US-TDMA used a mixture of TDMA and FDMA techniques.
- IS-95/cdmaOne was the first CDMA system.
- 2G services are frequently referred as Personal Communications Services, or PCS, in the United States.
- 2G refers to the second generation and based on GSM.
- It was developed in late 1980s.
- It mainly focused of on digital signals.
- It provides services to deliver text and picture message at slow speed (in kbps).
- Main Features are:
  - It uses digital signals.
  - It supports or provides services such as text messages etc.

2.8.3 2.5G

This systems enable high-speed data transfer over upgraded existing 2G networks. Examples: EDGE, GPRS, CDMA2000 etc.

2.8.4 Third Generation (3G)

- The designation for systems following the 2G systems and they offer high speed data services in addition to the basic voice capability.
- Typically they use CDMA techniques and include UMTS (W-CDMA), CDMA2000 1xEV-DV, CDMA2000 1xEV-DO, and TD-SCDMA.
- 3G refers to the third generation and is based on WCDMA It provides various services like data services access to television/video.
- Main Features are:
  - It provides faster communication.
  - It has large capacities and broadband capabilities.
  - It send/receive large email messages.

3GPP

- It refers to "Third Generation Partnership Project".
- The group that was set up to produce globally applicable Technical Specifications and Technical Reports for a 3rd Generation Mobile System based on evolved GSM core networks.
- It produced the standards for W-CDMA (UMTS). Later the scope of the organisation was widened to include the maintenance and development of the GSM Technical Specifications and Reports.

3GPP2

It refers to "Third Generation Partnership Project 2". The organisation that is responsible for the specifications for the 3G developments for CDMA2000.

- 4G refers to the fourth generation which was introduced in year 2010.
- It enables same feature as 3G and also provides additional services.
- It provides mobile ultra-broadband Internet access.
- Both 3GPP and 3GPP2 are currently working on further extensions to 3G standards, named Long Term Evolution and Ultra Mobile Broadband, respectively.
- Being based on an all-IP network infrastructure and using advanced wireless technologies such as MIMO-OFDM, these specifications display features characteristic for IMT-Advanced (4G), the successor of 3G.
- However, falling short of the bandwidth requirements for 4G (which is 1 Gbit/s for stationary and 100 Mbit/s for mobile operation), these standards are classified as 3.9G or Pre-4G.
- 3GPP plans to meet the 4G goals with LTE Advanced.

2.8.5 Fifth Generation(5G)

5G refers to the fifth generation. Various types of advanced features are included in 5G. Features are:

- Interactive multimedia, voice, internet and others services are supported by 5G.
- It is more effective and attractive as compare to other generation.
- For 5G technology IMT 2020 vision has set the limit of peak data rate of 50 Gbps within a minimum latency of 1ms.
- This puts a requirement of design of advanced efficient channel coding technique in the physical layer to handle such a data rate with minimum BER and low power consumption.

Advantages of 5G

- It possess very high capacity and speed.
- 5G technology act as a backbone for multimedia, voice and internet.
- Global access and service portability is also provided by 5G.
- High resolution and bi-directional large bandwidth is offered by 5G.

Disadvantages of 5G

- In some parts of the world it is very difficult to get a high speed.
- Privacy and security problems needed to be improved in 5G.
- Old machines needed to be renovated so that they can support 5G technology.

2.8.6 The History of Cellular System

- The first commercial cellular network system, the Advanced Mobile Phone System(AMPS), was designed by researchers at Bell Laboratories in 1982.
- The cellular concept was first proposed by D H Ring and his Colleagues in an internal Bell Labs Memorandum in 1947.
- The notion of a 'cell' comes from the concept of frequency reuse that divide the geographical area into small hexagonal cells.
- A relatively low powered base station transceiver in each cell uses radio frequencies unused by its neighbouring cell to service cell phones within its own range.
- Those base station as well as other network components constitutes a cellular network infrastructure.
- Another key concept in cellular systems is 'hand off' which enables every mobile users to move across different cells without experiencing communication interruption.
- Some sophisticated hand of techniques are employed in a cellular system to allow almost unnoticed switching of base stations and frequencies.
- To increase the capacity of a cellular system, cell can be further split into smaller areas.
- Cellular communication between a mobile station and its associated base stations is in the form of two way radio, as the mobile station transmits and receives signals in two different frequencies to achieve full duplex communication.
- As a result, the capacity of a system, or the maximum number of cell phone users, a system can accommodate is largely determined by the allocated frequencies for the cells.
- The frequency spectrum generally considered a public asset; thus the government has to control the allocation of non governmental users of frequency bands and signal power to avoid interference.

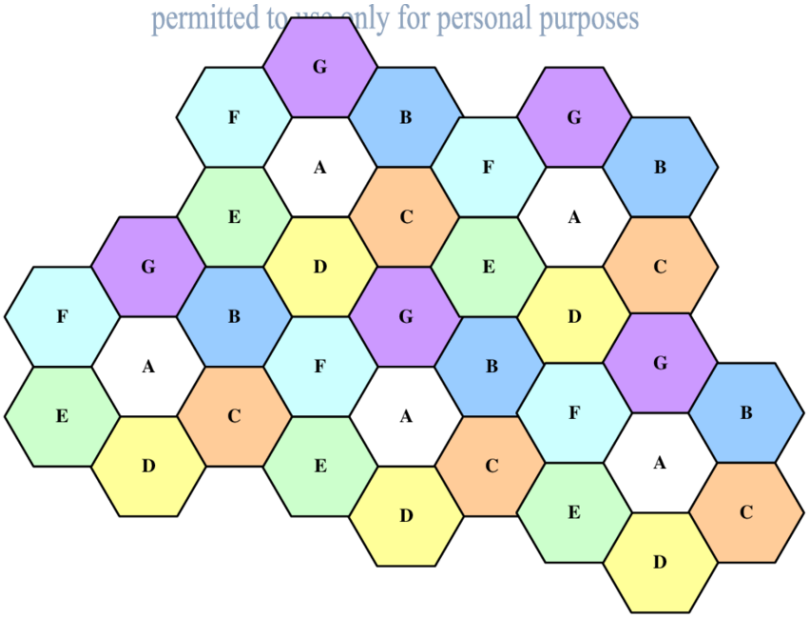


Figure 2.6: Hexagonal Cells which use frequency reuse

- The Improved Mobile Telephone System(IMTS), the first generation analogue cellular network using only 23 channels was approved by the FCC, in 1960.
- In 1982 AMPS went into operation. It utilised Frequency Division Multiplexing Access(FDMA)over as many as 832 channels in the 800MHz band, greatly improving the capacity.
- The first generation systems also included the Total Access Communication Systems also included in the UK and the Nordic Mobile Telephony (NMT) of Scandinavian nations.

2.8.7 The AMPS Technology

- Advanced Mobile Phone System (AMPS) was an analogue mobile phone system standard originally developed by Bell Labs and later modified in a cooperative effort between Bell Labs and Motorola which introduced in the Americas on October 13, 1983.
- AMPS is a first-generation cellular technology that uses separate frequencies, or "channels", for each conversation.
- It therefore required considerable bandwidth for a large number of users.
- In general terms, AMPS was very similar to the older "0G" Improved Mobile Telephone Service it replaced, but used considerably more computing power to select frequencies, hand off conversations to land lines, and handle billing and call setup.
- AMPS cellular service operated in the 850 MHz Cellular band. For each market area, the United States Federal Communications Commission (FCC) allowed two licensees (networks) known as "A" and "B" carriers.
- Each carrier within a market used a specified "block" of frequencies consisting of 21 control channels and 395 voice channels.
- In AMPS, the cell centres could flexibly assign channels to handsets based on signal strength, allowing the same frequency to be re-used in various locations without interference.
- This allowed a larger number of phones to be supported over a geographical area.
- AMPS pioneers coined the term "cellular" because of its use of small hexagonal "cells" within a system.
- AMPS suffered from many weaknesses compared to today's digital technologies. As an analogue standard, it was susceptible to static and noise, and there was no protection from 'eavesdropping' using a scanner.

Drawbacks of AMPS

- Cell Phone Roaming among different first generation systems was not possible.
- Lack of standardisation.
- Inadequate security and privacy.

2.8.8 Frequency Division Multiple Access

Each call is carried on a separate frequency channel. Provides multi-user access by separating the used frequencies.

- In FDMA, the entire allocated cellular frequency spectrum is divided into a number of 30-kHz channels.

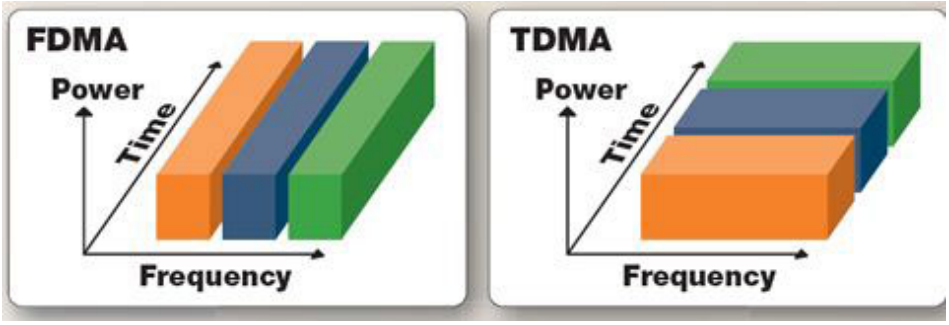


Figure 2.7: FDMA in Comparison with TDMA

- Each user on a different frequency.
- A channel is a frequency.
- The power transmitted by a cell is only large enough to communicate with mobile stations located near the edge of the cell's coverage area.
- The radius of a cell might be one mile or less- referred to as a small cell.
- The frequency reuse will be '7'

2.8.9 Time Division Multiple Access

Each frequency channel is further divided into a set of timeslots; each timeslot carries the data of a voice call. Provides multiuser access by chopping up the channel into sequential time slices.

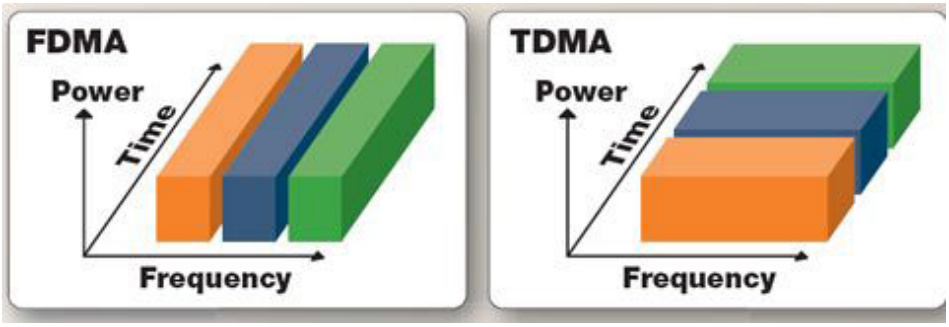


Figure 2.8: TDMA in Comparison with FDMA

2.8.10 D-AMPS

- IS-54 and IS-136 are second-generation (2G) mobile phone systems, known as Digital AMPS (D-AMPS), and a further development of the North American 1G mobile system Advanced Mobile Phone System (AMPS).
- This system is most often referred to as TDMA. That name is based on the abbreviation for time division multiple access, a common multiple access technique which is used in most 2G standards, including GSM, as well as in IS-54 and IS-136.
- D-AMPS uses existing AMPS channels and allows for smooth transition between digital and analogue systems in the same area.
- Capacity was increased over the preceding analogue design by dividing each 30 kHz channel pair into three time slots (hence time division) and digitally compressing the voice data, yielding three times the call capacity in a single cell.

- A digital system also made calls more secure in the beginning, as analogue scanners could not access digital signals.

- Calls were encrypted, using CMEA, which was later found to be weak.

- IS-136 added a number of features to the original IS-54 specification, including text messaging, circuit switched data (CSD), and an improved compression protocol. SMS and CSD were both available as part of the GSM protocol, and IS-136 implemented them in a nearly identical fashion.

- S-54 is the first mobile communication system which had provision for security, and the first to employ TDMA technology.

- IS-54 employs the same 30 kHz channel spacing and frequency bands (824-849 and 869-894 MHz) as AMPS.

- Capacity was increased over the preceding analogue design by dividing each 30 kHz channel pair into three time slots and digitally compressing the voice data, yielding three times the call capacity in a single cell.

- A digital system also made calls more secure because analogue scanners could not access digital signals.

- The IS-54 standard specifies 84 control channels, 42 of which are shared with AMPS.

- To maintain compatibility with the existing AMPS cellular telephone system, the primary forward and reverse control channels in IS-54 cellular systems use the same signalling techniques and modulation scheme (binary FSK) as AMPS so as to make use of either analogue AMPS phones or D-AMPS phones.

- The access method used for IS-54 is Time Division Multiple Access (TDMA), which was the first U.S. digital standard to be developed and was adopted by the TIA in 1992.

- TDMA subdivides each of the 30 kHz AMPS channels into three full-rate TDMA channels, each of which is capable of supporting a single voice call.

- Later, each of these full-rate channels was further sub-divided into two half-rate channels, each of which, with the necessary coding and compression, could also support a voice call.

- Thus, TDMA could provide three to six times the capacity of AMPS traffic channels. TDMA was initially defined by the IS-54 standard and is now specified in the IS-13x series of specifications of the EIA/TIA.

- The channel transmission bit rate for digitally modulating the carrier is 48.6 kbit/s. Each frame has six time slots of 6.67-ms duration.

- Each time slot carries 324 bits of information, of which 260 bits are for the 13-kbit/s full-rate traffic data.

2.8.11 Distinction B/W AMPS and D-AMPS

AMPS	D-AMPS
1.AMPS is Analogue Technology	1.D-AMPS is digital Technology
2.AMPS was the analogue technology used for the first generation (1G) of mobile networks	2.D-AMPS is the digital version of AMPS used for the second generation (2G) of mobile networks.
3.Lack of Security and Privacy	3.Increased Security and Privacy
4.Cell Phone Roaming among different first generation systems was not possible	4.Roaming is possible.
5. Lack of standardisation	5.Standardised and compatible with other systems like GSM.

2.8.12 GSM

- GSM is a digital cellular system developed by Group Special Mobile(presently Global System for Mobile Communications) of Conference Europeans des Postes et Telecommunications (CETP) and its successor European Telecommunication Standard Institute(ETSI).
- An important goal of the GSM development process was to offer compatibility of cellular services among European countries.
- GSM is a revolutionary technology that combines both the time division multiple access(TDMA) and frequency division multiple access(FDMA).
- With TDMA, the radio hardware in the base station can be shared among multiple users.
- In GSM, a frequency carrier is divided into eight time slots where the speech coding rate is 13 Kbps.

Frequency Reuse

- There are total 124 carriers in GSM.
- Each carrier has 8 timeslots and if 7 can be used for traffic then a maximum of 868 (124 X 7) calls can be made.
- This is not enough and hence frequencies have to be reused.
- The same RF carrier can be used for many conversations in several different cells at the same time.
- The radio carriers available are allocated according to a regular pattern which repeats over the whole coverage area.
- The pattern to be used depends on traffic requirement and spectrum availability.

Frequency Reuse

- In a GSM base station, every pair of radio transceiver-receiver supports eight voice channels, whereas an AMPS base station needs one such pair for every voice channel.
- The GSM MSs control their RF output power to maintain interference at low levels.
- The GSM air interface has been evolved into Enhanced Data Rate for GSM Evolution (EDGE) with variable data rate and link adaptation.

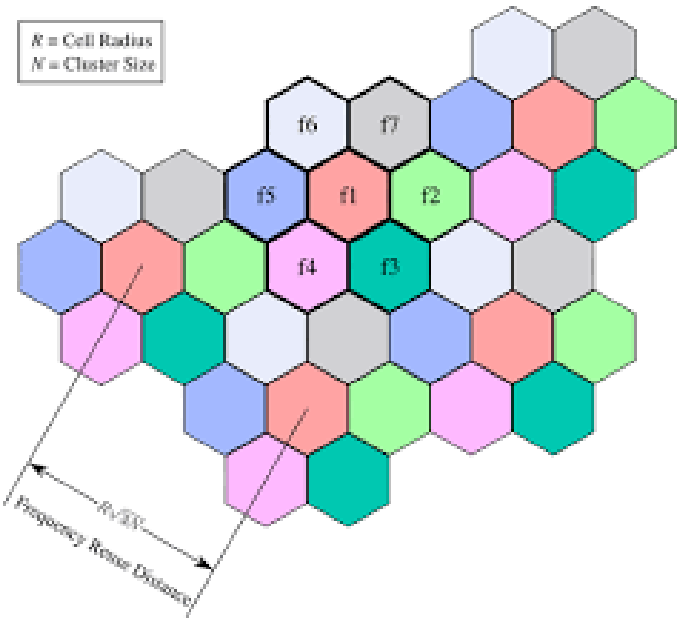


Figure 2.9: Hexagonal Cells which use frequency reuse

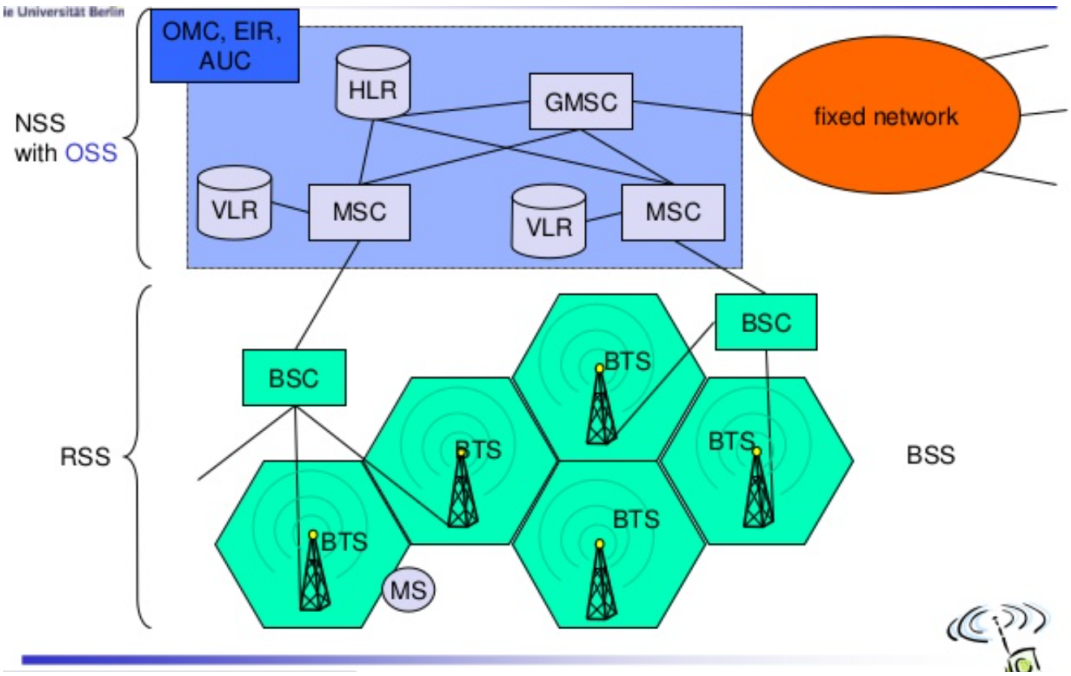
- EDGE utilizes highly spectrum-efficient modulation for bit rates higher than existing GSM technology.
- EDGE requires upgrade of existing base transceiver station, which supports high-speed data transmission in smaller cells and at short ranges within cells.
- EDGE does not support ubiquitous coverage; that is, it supports island coverage in indoor, pico, and micro cells.
- The GSM development process was similar to that of AMPS, except that no large-scale trial was conducted.
- The intellectual property rights of the GSM radio system from all vendors were waived, making GSM hugely popular.
- It took about four years to create the GSM specification.
- The GSM roaming management protocol is specified by GSM.
- Mobile Application Part (MAP), which provides similar functionality as IS-41.
- GSM features include most features a digital switch can provide:
  - Point-to- point short messaging.
  - Group addressing.
  - Call waiting.
  - Multiparty services, etc.

2.8.13 GSM System Architecture

Various Components of a GSM system architecture are:

- Mobile Station (MS)
  - Mobile Equipment(ME).
  - Subscriber Identity Module(SIM).

- Base Statio n Subsystem (BSS)
  - Base Transceiver Station(BTS).
  - Base Station Controller(BSC).
- Network Switching Subsystem(NSS):-
  - Mobile Switching Center(MSC).
  - Home Location Register(HLR).
  - Visitor Location Register(VLR).
  - Authentication Center(AUC).
  - Equipment Identity Register(EIR).



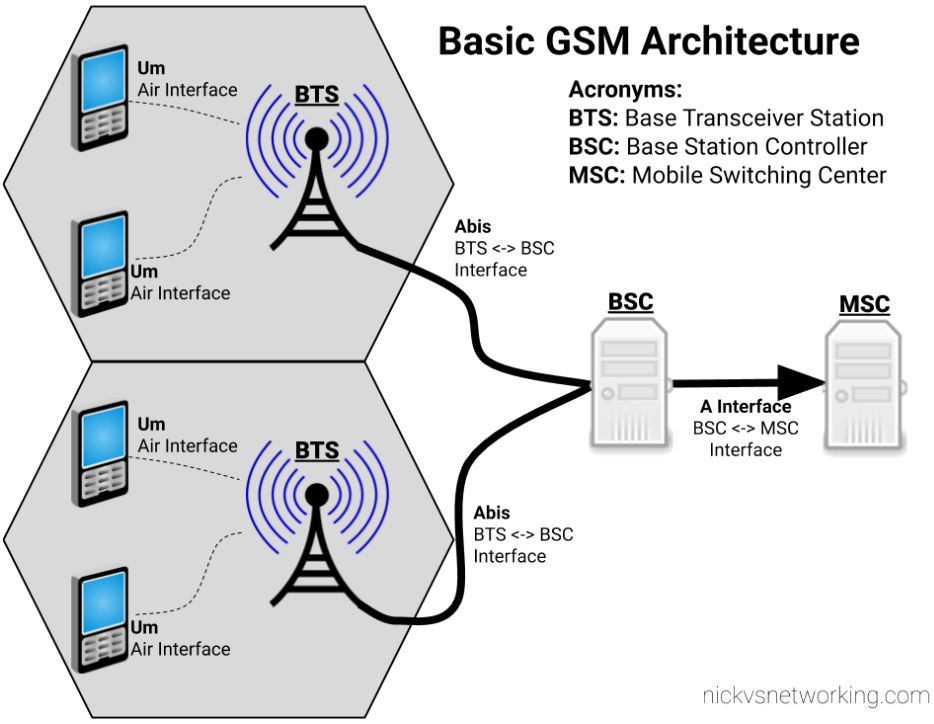
Features of GSM

Phase 1

- Telephony (full rate speech) - with some added features.
- Emergency calls.
- Data transmission at 2.4/4.8/9.6 kbps.
- Short message service (SMS).

Phase 2 Non-voice services like :-

- Advice of charge.
- Calling line identification.
- Call waiting.
- Call hold.
- Conference calling.
- Closed user groups and enriched telephony (half-rate speech).
- High-speed circuit-switched data (HSCSD)



Phase 2+

- Multiple service profiles.
- Private numbering plans.
- Access to Centrex services.
- Internetworking with GSM 1800, GSM 1900, Digital Enhanced Cordless Telecom (DECT)

Phase 2.5

- GPRS: Global packet radio system.
- Enhanced data rates for GSM (EDGE).

2.8.14 Mobile Station(MS)

- Subscriber Identity Module (SIM)
- Mobile Equipment (ME).
- Mobile Terminal (MT).

Subscriber Identity Module(SIM)

SIM is a removable smart card through which a user is authenticated via a Personal Identity Number (PIN). If PIN entered incorrectly, N times, then phone is locked for all but emergency calls, until you enter a PIN unblocking key (PUK). It contains subscriber information like preferred network provider(s), phone list, SMS messages, etc.

Mobile Station (MS)

Portable, vehicle mounted, hand held device. Uniquely identified by an IMEI (International Mobile Equipment Identity). Voice and data transmission. Monitoring power and signal quality of surrounding cells for optimum handover. Power level : 0.8W – 20 W. 160 character long SMS.

Mobile Equipment(ME)

The phone" itself - radio and radio interface, display, keyboard, etc. performs: radio transmission and reception, authentication, handover, encoding & channel encoding. note: ME without SIM can only make emergency (112) calls. Radios operate in one or more of the frequency bands GSM450, GSM480, GSM850, GSM900, GSM1800, GSM1900, for System Uplink (mobile station to base station) and Downlink(base station to mobile station).

2.8.15 Base Station Subsystem (BSS)

Base Station Subsystem is composed of two parts that communicate across the standardized Abis interface allowing operation between components made by different suppliers.

- One or more Base Transceiver Station (BTS) and
- Base Station Controller (BSC).

Base Transceiver Station (BTS)

- It performs: channel coding/decoding and encryption/decryption.
- BTS includes: radio transmitters and receivers, antennas, the interface to the PCM facility (i.e., backhaul for the voice and control to the BSC).
- About 1/2 the processing is associated with transcoding PCM encoded speech channel to/from GSM coding.

Base Station Controller (BSC)

- BTSs are connected to a BSC which manages the radio resources.
- Call maintenance using the received signal strength sent by mobile stations normally every 480ms.
- initiate handovers to other cells.
- Change BTS transmitter power.
- Network and Switching Subsystem(NSS):- It is responsible for keeping gateway to other networks, databases, etc.
- Mobile Switching Centre:- It acts as the heart of the network and Manages communication between GSM and Other Networks, Call setup function and basic switching, Call routing, Billing information and collection, Mobility management, Registration, Location Updating, Inter BSS and inter MSC call handoff, MSC does gateway function while its customer roams to other network by using HLR/VLR.
- Home Location Registers(HLR):- Permanent database about mobile subscribers in a large service area(generally one per GSM network operator)and Database contains IMSI, MSISDN, prepaid / postpaid, roaming restrictions, supplementary services.
- Visiting Location Register(VLR) :- Temporary database which updates whenever new MS enters its area, by HLR database, Controls those mobiles roaming in its area, Reduces number of queries to HLR, Database contains IMSI, TMSI, MSISDN, MSRN, Location Area, authentication key, etc.
- Authentication Center(AUC):- Generally it is associated with HLR, protects against intruders in air space and maintains authentication keys and algorithm to provide security.
- Equipment Identity Register(EIR):- It is a database used to track handsets using IMEI number. It consists of three subclasses, the whitelist, black list and gray list.

Comparison B/W AMPS and GSM

AMPS	D-AMPS
1.AMPS is Analogue Technology	1.GSM is digital Technology
2.AMPS has poor performance for data transfer	2.GSM is far better for data transfer.
3.AMPS uses 21 control channels	3.GSM uses only 3
4.AMPS is less secure	2.GSM is more secure.
5. In AMPS HLR holds user's personal data and phone settings 6. AMPS allows restricted roaming	5. GSM has the SIM smart card which holds the user's personal information and phone settings. GSM is more compatible towards roaming.
7. AMPS requires less power at the MS and at the BS. 8.AMPS has a cell radius 1.5km - 25km	7. GSM's power control attempts to minimize radio transmission power of the MS and BTS, thus, minimizes the amount of co-channel interference. GSM is more flexible with cell sizes.

Advantages of GSM over Analog System

- Capacity increases.
- Reduced RF transmission power and longer battery life.
- International roaming capability.
- Better security against fraud (through terminal validation and user authentication).
- Encryption capability for information security and privacy.
- Compatibility with ISDN, leading to wider range of services.

Applications of GSM

- Mobile telephony.
- GSM-R
- Telemetry System
- Fleet management
- Automatic meter reading
- Toll Collection.
- Remote control and fault reporting of DG sets.
- Value Added Services.

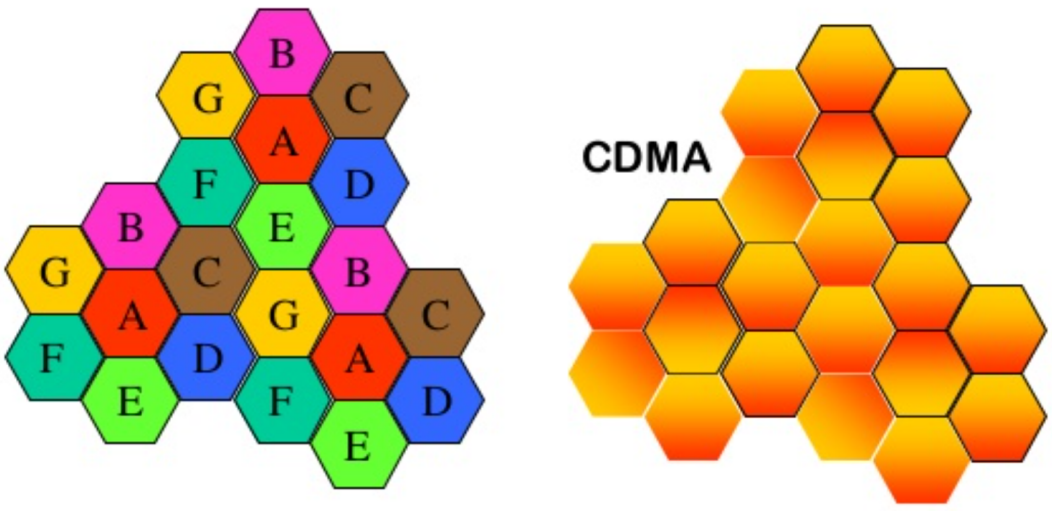
2.8.16 CDMA

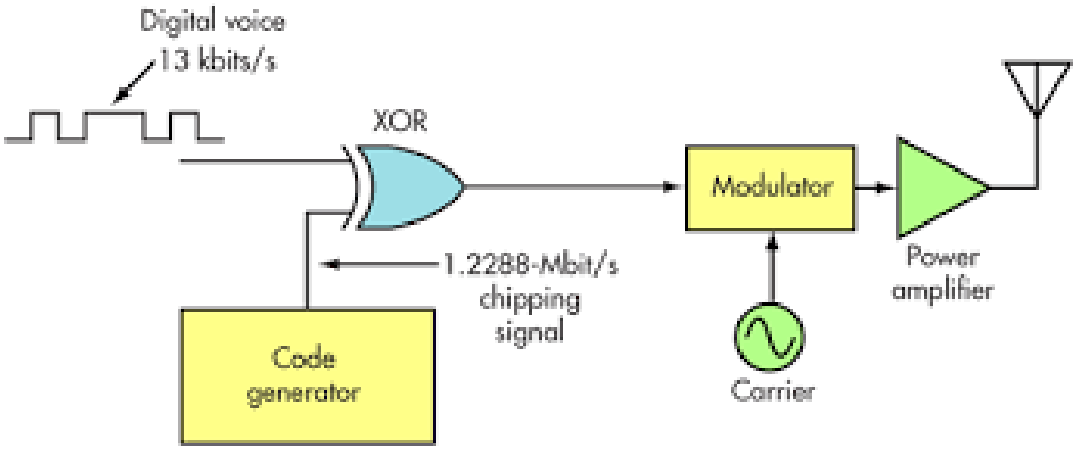
- Code-division multiple access (CDMA) is a channel access method used by various radio communication technologies.
- CDMA is an example of multiple access, where several transmitters can send information simultaneously over a single communication channel. This allows several users to share a band of frequencies (see bandwidth).
- To permit this without undue interference between the users, CDMA employs spread spectrum technology and a special coding scheme (where each transmitter is assigned a code).
- A channel is a unique code pattern – Each user uses the same frequency all the time, but mixed with different distinguishing code patterns.

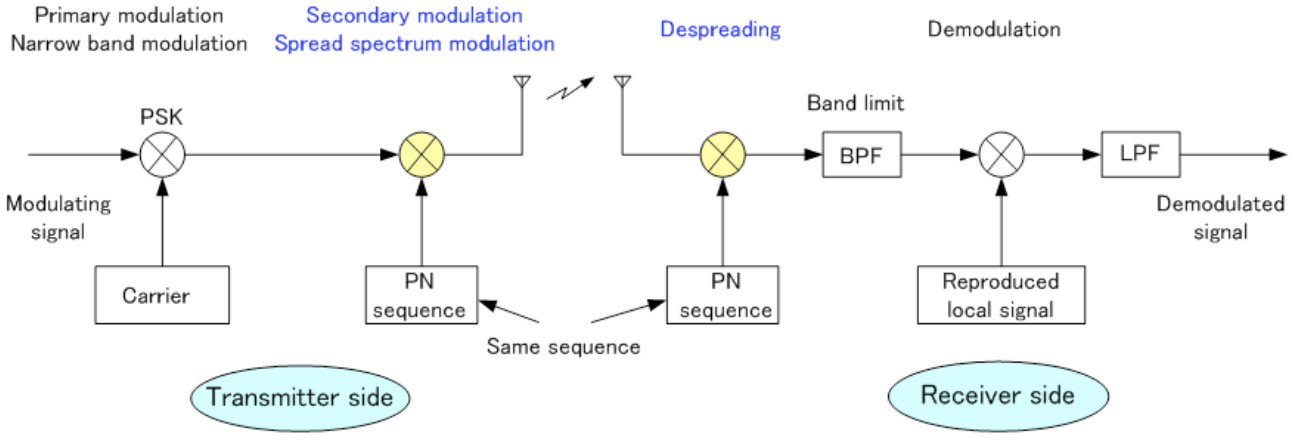
In CDMA, there exists a third dimension namely code, in addition to frequency and time and it will be provided by the operator for the user.

- In CDMA each user is assigned a unique PN code.
- Each user transmits its information by spreading with unique code.
- Direct Sequence spread spectrum is used.
- Users are separated by code not by time slot and frequency slot.
- The voice has to be digitalized (Pulse Code Modulation (PCM) then compressed)
- Each user is given a unique PN code.
- The Codes must have low cross-correlation.
- The transmitter multiplies the code by the data to get the coded massage (bit) and then transmitted with carrier signals through BTSs.
- In the receiver side, the received signal is demodulated, multiplied again by the same code that used in the transmitter so as to reproduce the transmitted message(bit).
- In CDMA the frequency reuse is '1'

Frequency Reuse of CDMA







Principle of CDMA

Comparison B/W GSM and CDMA

GSM	CDMA
1.In TDMA Band width available for transmission is small which leads to compromise in quality of transmission.	1.In CDMA systems entire spectrum is used which enhances voice quality.
2.In GSM every user is assigned a particular frequency	2. A unique PN code is assigned to user by the operator network and are allowed to use a collection of frequencies(a band).
3.In GSM the user is able to roam and switch the carrier without changing the instrument.	3.In CDMA the user has to switch the phone in order to switch the carrier.
4. In TDMA/FDMA, cell design requires more frequency planning which is tough job.	4.In CDMA frequency planning is minimal.
5. TDMA is Band limited system.	5.CDMA is Power limited system
6 GSM make use of SIM card	6. CDMA uses handsets without SIM card
7. Only single modulation is done in GSM	7. In addition to the primary modulation with carrier wave, a secondary modulation using the PN code is also carried out.
8. GSM operates at 900MHz and 1800MHz bands.	8.CDMA operates in the band 800MHz and 1900MHz.
9. Max. bandwidth available in GSM is 64 kbps	9. 64 to 2 Mbps available.
10.Voice clarity is poor	10. Good voice quality

Advantages of CDMA

- Capacity is CDMA's biggest asset. It can accommodate more users per MHz of bandwidth than any other technology(3 to 5 times more) than GSM.
- Increased cellular communications security.
- Simultaneous conversations.
- Increased efficiency, meaning that the carrier can serve more subscribers.
- Low power requirements, little cell-to-cell coordination needed by operators and covers large areas so cell size in CDMA is larger.
- Extended reach - beneficial to rural users situated far from cells.
- CDMA uses Soft Handoff, reducing the likelihood of dropped calls.

Disadvantages

- Due to its proprietary nature, all of CDMA's flaws are not known to the engineering community.
- CDMA is relatively not popular, and the network is not as mature as GSM.
- CDMA cannot offer international roaming, a large GSM advantage.

2.9 Personal Communication Service Systems(PCS)

2.9.1 Introduction

Personal Communication Service PCS (personal communications service) is a wireless phone service similar to cellular telephone. It is sometimes referred to as digital cellular. The term Personal Communication Service (enabling communication with a person at anytime, at any place, and in any form) include:

- Various Wireless Access.
- Personal Mobility Services.

Technologies used for PCS are

- TDMA
- CDMA
- GSM

The goals of PCS are to provide a mobile user with voice, data, and multimedia at any place, at any time, and in any format.

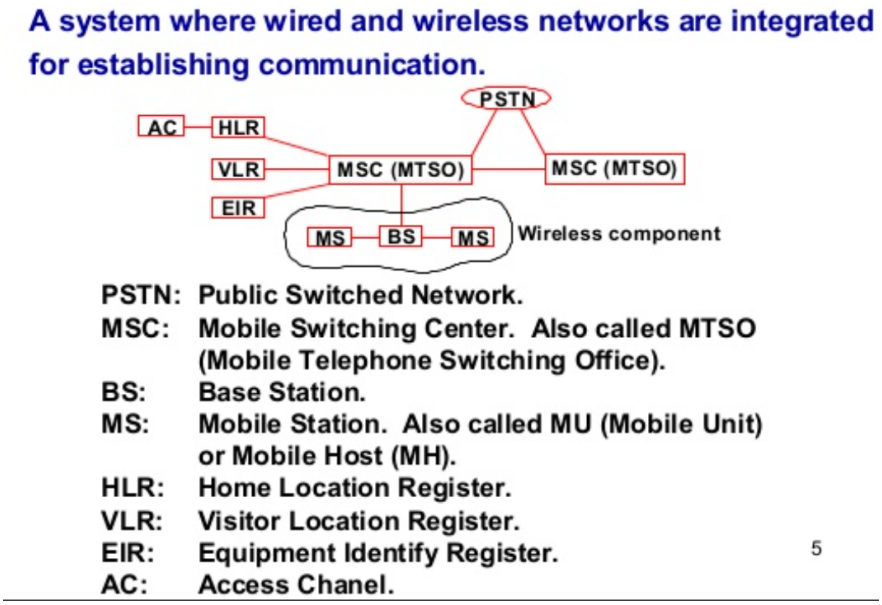
- PCS technologies have grown rapidly in the telecommunications industry.
- Two of the most popular are :
  - Cellular Telephony Cordless.
  - Low tier PCS technology.

  The basic architecture consist of two parts
  - Radio Network

– Wireline Transport Network

- PCS users carry mobile stations(MSs) to communicate with the base station in a PCS network.
- MS is also referred to as handset, mobile phone, subscriber unit or portable.
- The term subscriber unit is used when we describe wireless local loop.
- The term portable is used when we describe the low tier system such as PACS.
- The term mobile station is used when we describe the GSM system.
- The radio coverage of a base station or a sector in the base station is called a cell.
- For systems such as GSM and PACS, The base station system is partitioned into a controller and radio transmitters/receivers.
- Controller: (Base station controller in GSM and radio port control unit in PACS).
- Radio transmitters/receivers: (base transiever stations in GSM and radio ports in PACS).
- The base stations usually reach the wireline transport network via land links or dedicated microwave links.

2.9.2 PCS Architecture



- The mobile switching centre (MSC) connected to the base station is a special switch.
- The MSC is connected to the PSTN to provide services between the PCS users and wireline users.
- MSC also communicates with mobility databases to track the locations of mobile.

2.10 Smart Phone

A smartphone is a mobile device that combines cellular and mobile computing functions into one unit.

They have core phone functions such as voice calls and text messaging and are distinguished from feature phones by their

- Stronger hardware capabilities.
- Extensive mobile operating systems, which facilitate wider software, internet (including web browsing over mobile broadband),
- Multimedia functionality (including music, video, cameras, and gaming).

Smartphones typically contain

- A number of metal–oxide–semiconductor (MOS) integrated circuit (IC) chips
- Various sensors that can be leveraged by their software (such as a magnetometer, proximity sensors, barometer, gyroscope, or accelerometer), and
- Support wireless communications protocols (such as Bluetooth, Wi-Fi, or satellite navigation).

2.11 Feature Phone

A feature phone is a mobile phone that retains the form factor of earlier-generation phones, with button-based input and a small display. Feature phones are sometimes called dumbphones in contrast with touch-input smartphones.

- They tend to use an embedded operating system with a small and simple graphical user interface, unlike large and complex mobile operating systems like Android or iOS.
- Feature phones typically provide voice calling and text messaging functionality as well as basic multimedia and Internet capabilities and other services offered by the user's wireless service provider.

Feature phones often contain

- Hardware including a backlit LCD screen.
- A hardware notification LED,
- A micro USB port,
- Physical keyboard,
- A microphone,
- An SD card slot,
- A rear-facing camera to record video and capture pictures, and GPS.
- Some feature phones include a rudimentary app store that includes basic software such as mobile games, calendar and calculator programs.

2.12 Mobile OSs

- An Operating System(OS) is a very basic and essential software to operate a system.
- An operating system is the most important software that runs on a computer or mobile.
- It manage Mobile's memory, processes, and all of its software and hardware.
- Without an Operating System, a System(Computer/Mobile) is useless.
- A Mobile OS is a software platform which is designed specially for mobile to handle the devices like Smart Phone, Tablet, PDA with lot of features and facilities.

E.g. Android, iOS, Windows Mobile OS, Blackberry OS, Symbian OS etc.

2.12.1 Android OS

- Android from Google Inc.
- Free and open source.
- Android was purchased by Google in 2005.
- First released version in 2008.
- 52.0 % of the global Smartphone market share till April, 2013.
- Mobile Manufacture Companies- Intel, HTC, Samsung, Motorola and so on...
- The latest Android OS is Android 11.

2.12.2 iOS

- iOS from Apple Inc.
- Closed source, proprietary.
- First released version in 2007.
- Market Share 39.2% till April 2013.
- Such as iPhone, iPod touch, iPad and second gen. Apple TV.

2.12.3 Windows OS

- Windows Mobile OS from Microsoft.
- Closed source, proprietary.
- First released version in 2003.
- Market Share 3.0% till April 2013.
- Such as Nokia, Samsung , LG Optimus and HTC Titan, etc.

2.12.4 Smart Phone Applications

A mobile application, also referred to as a mobile app or simply an app, is a computer program or software application designed to run on a mobile device such as a phone, tablet, or watch.

Apps were originally intended for productivity assistance such as email, calendar, and contact databases, but the public demand for apps caused rapid expansion into other areas such as mobile games, factory automation, GPS and location-based services, order-tracking, and ticket purchases, so that there are now millions of apps available.

- Apps are generally downloaded from application distribution platforms which are operated by the owner of the mobile operating system, such as the App Store (iOS) or Google Play Store.
- Some apps are free, and others have a price, with the profit being split between the application's creator and the distribution platform.
- Mobile applications often stand in contrast to desktop applications which are designed to run on desktop computers, and web applications which run in mobile web browsers rather than directly on the mobile device.

2.12.5 First Generation Smart Phone Applications

First Generation smart phone applications are mostly natural extensions of PDA and cell phone functionality.

Fist generation smart phone applications are the following:

- Mobile Telephony:- Services like phone call, voice mail services, etc.
- SMS services
- Enhanced Message Service(EMS) and Multimedia Message Service(MMS).
- Cell Phone Positioning.
- Navigation systems with traffic information and Geographic Information Service(GIS).
- Instant Messaging(IM)
- Applications like E-mail, calendar, organiser, address book, notepad
- Wireless internet browsing
- Data synchronisation with computer or with other mobile,
- Information push service,
- Audio/Video/Television streaming service.

2.12.6 Second Generation Apps

The rapid advancements in wireless technologies put forward a broader spectrum of data-centric applications which requires significantly high data rates. They are

- Voice over IP (VoIP or VoWIP):- Comparatively cheap and have comparatively larger capacity.
- Mobile Commerce:- online shopping etc,
- Mobile Enterprise:- Companies with large number of field workers use cell phones for high productivity.
- Mobile gaming.

- Mobile music.
- Remote access.
- Remote monitoring.
- Mobile wallet, mobile banking and mobile ticketing.
- Mobile social networking.
- Mobile ID/Key.

2.12.7 Challenging Issues with Mobile Phone

In order to be universal, the following issues to be resolved.

- Power Consumption :- More hardware components will increase the power consumption of a smart phone. Mainly three types of battery is used as power source.
  - Nickel metal hydride battery
  - Lithium ion battery.
  - Lithium polymer battery.

  New battery technologies are to be discovered to cater the need.
- The form factor :- The form factor of smartphone makes it impractical to watch television or video on the small screen even if mobile broadband with sufficiently large band width.
- Memory Capacity :- Common use of flash memory on mobile device may even give rise to large capacity. Very large flash memory is not economically feasible due to its high cost depending up on the card to be used SD, MMC, SDIO, etc.
- Wireless interference:- It is a critical issue, as a smartphone will deal with heterogeneous wireless networks in different ranges.

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