UNIT-I

Introduction to Wireless Networks:

A wireless network refers to a computer network that makes use of Radio Frequency (RF) connections between nodes in the network. Wireless networks are a popular solution for homes, businesses, and telecommunications networks. Thus, it reduces the equipment and setup costs.

Computer networks that are not connected by cables are called wireless networks. They generally use radio waves for communication between the network nodes. They allow devices to be connected to the network while roaming around within the network coverage.

Types of Wireless Networks:

Wireless LANs − Connects two or more network devices using wireless distribution techniques.
Wireless MANs − Connects two or more wireless LANs spreading over a metropolitan area.
Wireless WANs − Connects large areas comprising LANs, MANs and personal networks.

Advantages of Wireless Networks

1. Without wires/cable to transmit data from device to device
2. Accessing network devices from any location with in network coverage
3. Installing and setup of wireless networks are easy
4. Connect new device very simple
5. It reduces the equipment setup and cost.

Examples of wireless networks

1. Mobile phone networks
2. Wireless sensor networks
3. Satellite communication networks
4. Terrestrial microwave networks

Mobile Computing:

Mobile Computing is a technology that provides an environment that enables users to transmit data from one device to another device without the use of any physical link or cables. It is one of the fastest and most reliable sectors of the computing technology field. The concept of Mobile Computing can be divided into three parts:

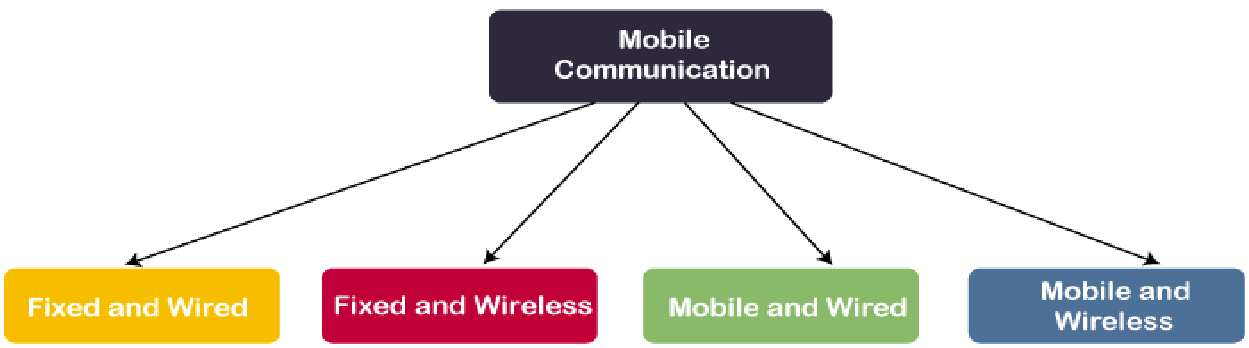
Mobile Communication
Mobile Hardware
Mobile Software

Mobile Communication

Mobile Communication specifies a framework that is responsible for the working of mobile computing technology. In this case, mobile communication refers to an infrastructure that ensures seamless and reliable communication among wireless devices. This framework ensures the consistency and reliability of communication between wireless devices. The mobile communication framework consists of communication devices such as protocols, services, bandwidth, and portals necessary to facilitate and support the stated services. These devices are responsible for delivering a smooth communication process.

Mobile communication can be divided in the following four types:

1. Fixed and Wired
2. Fixed and Wireless
3. Mobile and Wired
4. Mobile and Wireless



Fixed and Wired: In Fixed and Wired configuration, the devices are fixed at a position, and they are connected through a physical link to communicate with other devices.
For Example, Desktop Computer.
Fixed and Wireless: In Fixed and Wireless configuration, the devices are fixed at a position, and they are connected through a wireless link to make communication with other devices.
For Example, Communication Towers, WiFi router
Mobile and Wired: In Mobile and Wired configuration, some devices are wired, and some are mobile. They altogether make communication with other devices.
For Example, Laptops.
Mobile and Wireless: In Mobile and Wireless configuration, the devices can communicate with each other irrespective of their position. They can also connect to any network without the use of any wired device. **For Example**, WiFi Dongle.

Mobile Hardware:

Mobile hardware consists of mobile devices or device components that can be used to receive or access the service of mobility. Examples of mobile hardware can be smartphones, laptops, portable PCs, tablet PCs, Personal Digital Assistants, etc.

These devices are inbuilt with a receptor medium that can send and receive signals. These devices are capable of operating in full-duplex. It means they can send and receive signals at the same time. They don't have to wait until one device has finished communicating for the other device to initiate communications.

Mobile Software

Mobile software is a program that runs on mobile hardware. This is designed to deal capably with the characteristics and requirements of mobile applications. This is the operating system for the appliance of mobile devices. In other words, you can say it the heart of the mobile systems. This is an essential component that operates the mobile device.

History:

The first professional wireless network was developed under the brand ALOHAnet in 1969 at the University of Hawaii and became operational in June 1971. The first commercial wireless network was the WaveLAN product family, developed by NCR in 1986.

1973 – Ethernet 802.3.

Term	Stands for	Launch Year
1G	First Generation	1980
2G	Second Generation	1991
3G	Third Generation	2001
4G	Fourth Generation	2009
5G	Fifth Generation	2019

1991 – 2G cell phone network

June 1997 – 802.11 "Wi-Fi" protocol first release

1999 – 803.11 VoIP integration

1G:- Devices have only voice-oriented communication.

the first generation of wireless telephone technology, mobile telecommunications, which was launched in Japan by NTT in 1979.

2G:- 2G devices communicate voice as well as data signals.

-Came onto the market in 1988.

-Support data rates up to 14.4 kbps.

2.5G : -Support data rates up to 100 kbps.

3G:
-Higher data rates than 2G and 2.5G.
-Uses 2 Mbps or Higher for short distance transmission.
-Uses 384 Kbps for long distance transmission.
-Supports voice, data and multimedia streams.
-enable transfer of video clips and faster multimedia communication.
4G:
-Higher data rates than 3G.
-Support streaming data for video.
-Enables multimedia news paper, high resolution mobile TV.
-Support data rates up to 100 Mbps

4G Technology	5G Technology
It stands for Fourth Generation technology	It stands for Fifth Generation technology
The maximum upload rate of 4G technology is 500 Mbps	While the maximum upload rate of 5G technology is 1.25 Gbps
The maximum download rate of 4G technology is 1 Gbps	While the max download rate of 5G technolgy is 2.5 Gbps.
The latency of 4G technology is about 50 ms	While the latency of 5G technology is about 1 ms
4G offers CDMA	While 5G offers OFDM, BDMA

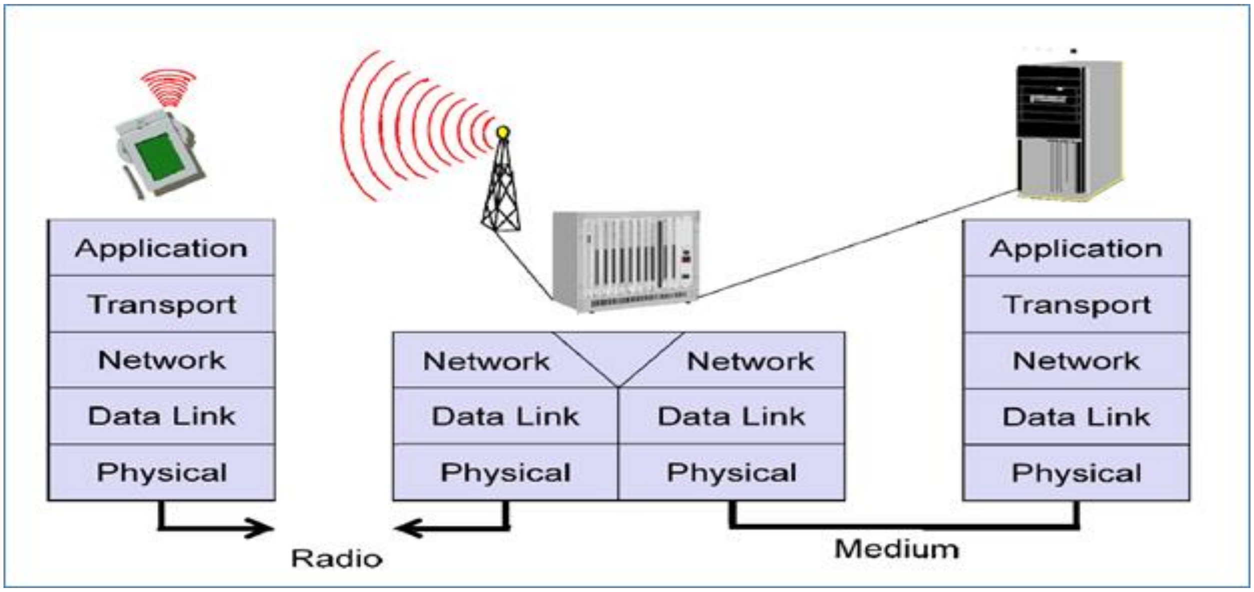
Applications of Wireless Networks
1. **Mobile Communication**
Cellular Networks: Mobile phones rely on wireless networks for voice calls, messaging, and internet services.
Mobile Internet: Technologies like 4G, 5G, and Wi-Fi hotspots enable high-speed wireless connectivity.
2. **Home and Office Networking**
Wi-Fi Networks: Used in homes, offices, and public places to connect devices like laptops, smartphones, printers, and smart TVs.
Smart Homes: Wireless networks connect IoT devices like smart lights, thermostats, and security systems.

3. **Internet of Things (IoT)**
Smart Cities: Wireless sensors monitor traffic, pollution, energy usage, and public safety.
Wearables: Fitness trackers, smartwatches, and healthcare devices connect wirelessly to smartphones or cloud servers.
Industrial IoT: Sensors and devices in factories communicate wirelessly to optimize production and monitor equipment.
4. Healthcare
Remote Patient Monitoring: Wearable sensors and wireless devices monitor patient health and send real-time data to doctors.
Telemedicine: Enables video consultations and remote diagnostics via wireless networks
5. **Education**

E-Learning: Wireless internet supports online classes, virtual labs, and interactive educational platforms.
Campus Wi-Fi: Universities provide campus-wide wireless connectivity for students and staff.
6. **Transportation**
Vehicle-to-Vehicle (V2V) Communication: Wireless networks allow cars to share traffic, location, and safety information.
In-Flight Connectivity: Passengers can access Wi-Fi services on airplanes.
Public Transport: Wi-Fi on buses, trains, and stations enhances passenger experience.
7. **Military and Defense**
Battlefield Communication: Wireless networks enable secure and reliable communication between troops, drones, and command centers.
Surveillance: Wireless sensors and drones monitor areas for security purposes.
8. **Banking and Finance**
Wireless ATMs: Some ATMs operate in remote areas using wireless communication.
Online Banking: Secure transactions via wireless networks enable financial activities from anywhere.
9. **Entertainment**
Streaming Services: Wireless networks support platforms like Netflix, YouTube, and gaming services.
Virtual Reality (VR) and Augmented Reality (AR): These technologies rely on low-latency wireless networks for an immersive experience.
10. **Environmental Monitoring**
Weather Sensors: Wireless networks transmit data from remote weather stations.
Wildlife Tracking: Sensors and GPS-enabled wireless devices monitor animal movement and habitats.

Simplified Reference Model

A simplified reference model for mobile communication can be used to illustrate how mobile device, such as personal digital assistant communicates with a base station and a computer. The model can show how the base stations radio transceiver and interworking unit connect the wireless link to the fixed link.



The figure shows the protocol stack implemented in the system according to the reference model. End systems (such as the PDA and computer) need a full protocol to handle the application layer, transport layer, network layer, data link layer, and physical layer. Applications on the end-systems communicate with each other using the lower layer services. Intermediate systems, such as the interworking unit, do not necessarily need all of the layers.
Physical layer: This is the lowest layer in a communication system and is responsible to convert the stream of bits into signals that can be transmitted on the sender side. The physical layer of the receiver then transforms the signals back into a bit stream. For wireless communication, the physical layer is responsible for frequency selection, generation of the carrier frequency, signal detection, modulation of data onto a carrier frequency and encryption.
Data link layer: The main task of this layer is to access the medium, multiplexing of different data streams, correction of transmission errors, and synchronization (i.e., detection of a data frame). Therefore, the data link layer is responsible for a reliable point-to-point connection
. Network layer: This third layer is responsible for routing packets through a network or establishing a connection between two entities over many other intermediate systems. Important functions are addressing, routing, device location, and handover between different networks.
• Transport layer: This layer is used in the reference model to establish an end-to-end connection
• Application layer: Finally, the applications are situated on top of all transmission oriented layers. Functions are service location, support for multimedia applications, adaptive applications that can handle the large variations in transmission characteristics, and wireless access to the world-wide web using a portable device.

Frequencies:

Frequency is expressed in Hertz and is the number of cycles per second. Mobile networks use radio communication which is carried out on a range of frequencies.For example, Wi-Fi networks use frequencies between 2.5 GHz and 5 GHz, while mobile networks use frequencies between 800 MHz and 2.5 GHz.

Signals:

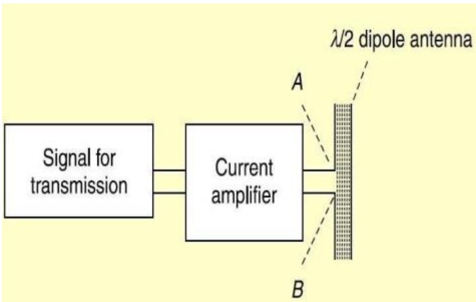
Signals are the physical representation of data that is transmitted through communication systems. Signal parameters like amplitude, frequency, and phase shift encode the data.

Signal propagation:

Signal propagation refers to the transmission of signals from one layer to another in a feed-forward network, such as in the case of perceptron-like networks. It involves the calculation of net inputs and the transformation of these inputs into output signals through transfer functions.

Antenna:

- Devices that transmit and receive electromagnetic radiations.
- Most antennae function efficiently for relatively narrow frequency ranges.
- If an antenna not properly tuned to the frequency band in which the transmitting system connected to it operates, the transmitted or received signals may be impaired.
- The forms of antennae used are chiefly determined by the frequency ranges they operate in and can vary from a single piece of wire to a parabolic dish.



Modulation:

Modulation means modification to original action so that the modification in the action is clearly presented.

For example, a professor's voice is modulated and reflects his command over the subject.

Similarly, electrical signals are modulated with information or electrical signals which is then communicated over long distances.

Types of modulation are, Analog signal modulation, Digital signal modulation, Amplitude modulation Amplitude shift keying, Frequency modulation, Frequency shift keying

Phase modulation, Phase shift keying, Binary phase shift keying, Gaussian minimum shift keying, Quadrature phase shift keying, Eight phase shift keying

Quadrature amplitude modulation (QAM). 64-QAM

Spread spectrum:

Direct-sequence spread spectrum in Wireless Networks is a technique that transmits a data signal over a range of frequencies, spreading it uniformly across the allocated spectrum. Direct-sequence spread spectrum is used to ensure that a particular frequency band is kept free from interference. This technique can be related to escaping the problem of co-channel interference (like two different wireless networks transmitting on the same frequency band) and cross-talk interference. Direct-sequence spread spectrum can also be used as an alternative approach to orthogonal frequency division multiplexing, where the baseband signal is encoded and transmitted across a quantity of fixed, predetermined channels.

Direct Sequence Spread Spectrum (DSSS) is a communication system that was developed in the 1980s. It divides the bandwidth of a radio channel into wide frequency bands and transmits these signals over separate frequencies. In this frequency-hopping process, each signal is assigned a different orthogonal sequence of frequencies.

All other radios in the range must gain each signal sequentially and then transmit it, which significantly reduces the risk of interference from outside sources or jamming. The time required for this process is proportional to the number of frequencies used for transmission. When security agencies need to be ready to communicate secretly, DSSS can be implemented so that their transmissions cannot be spied upon by other parties who are monitoring broadcasts on a shorter wavelength or through tapping devices.
For Example, the NIST specification for the Advanced Encryption Standard used in the Secure Electronic Transaction program defines a system that uses eight bits of data per transmitted symbol in an eight-bit wire transmission to transmit a 128-bit cryptographic key. A receiver would need to correlate eight different symbols to calculate a hash value.

Working:

In order for a direct-sequence spread spectrum to be used in wireless networks, it is necessary that each node of the network has a frequency synthesizer. This synthesizer is useful in determining the signals that are required to be transmitted and at which frequencies these signals need to be amplified in order to ensure that interference occurs. It is also important that each node has a means of receiving signals, which is usually accomplished with a corresponding means of demodulation that can cancel out the spreading function.
Direct-sequence spread spectrum is a particular scheme for signal-spreading, which includes two complementary schemes called direct-sequence spread spectrum and frequency hopping spread spectrum. In the direct-sequence spread spectrum, the spreading code is contained within the transmitted signal to be used for spreading.
The spreading code can be transmitted in multiple ways like Binary Phase Shift Keying (BPSK), Quadrature Phase Shift Keying (QPSK), or more complex modulation schemes like Quadrature Amplitude Modulation (QAM).

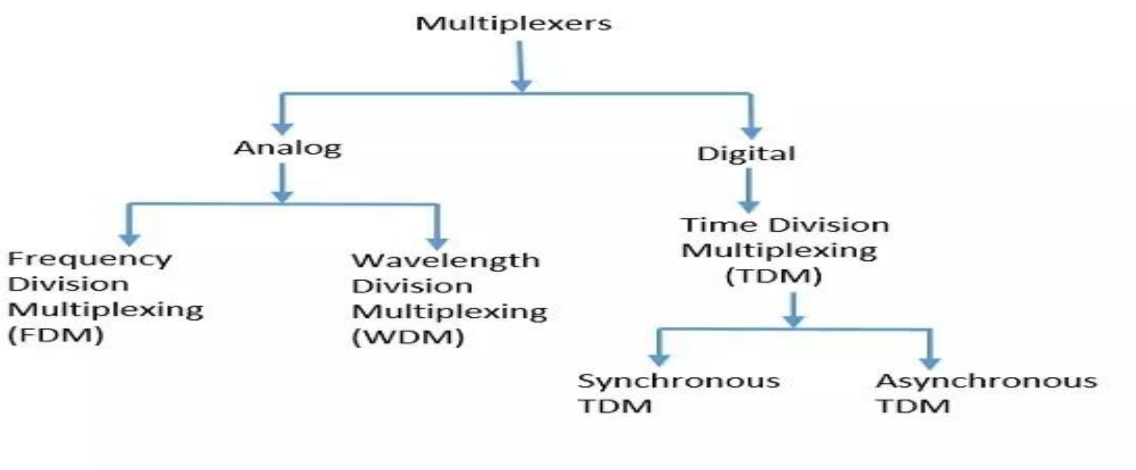
Multiplexing and its types:

Multiplexing is the process of combining multiple signals into one signal, over a shared medium. If analog signals are multiplexed, it is Analog Multiplexing and if digital signals are multiplexed, that process is Digital Multiplexing.

Multiplexing and Demultiplexing

Types of Multiplexers

There are mainly two types of **multiplexers**, namely **analog** and digital. They are further divided into **FDM**, **WDM**, and **TDM**.



Analog Multiplexing
The analog multiplexing techniques involve signals which are analog in nature. The analog signals are multiplexed according to their frequency (FDM) or wavelength (WDM).
Frequency Division Multiplexing (FDM)
In analog multiplexing, the most used technique is Frequency Division Multiplexing FDM. This technique uses various frequencies to combine streams of data, for sending them on a communication medium, as a single signal.
Example: A traditional television transmitter, which sends a number of channels through a single cable, uses FDM.

Wavelength Division Multiplexing (WDM)
Wavelength Division Multiplexing is an analog technique, in which many data streams of different wavelengths are transmitted in the light spectrum. If the wavelength increases, the frequency of the signal decreases.
Example: Optical fibre Communications use the WDM technique, to merge different wavelengths into a single light for the communication
Digital Multiplexing
The term digital represents the discrete bits of information. Hence the available data is in the form of frames or packets, which are discrete.
Time Division Multiplexing (TDM)
In TDM, the time frame is divided into slots. This technique is used to transmit a signal over a single communication channel, with allotting one slot for each message. Of all the types of TDM, the main ones are Synchronous and Asynchronous TDM.
Synchronous TDM
In Synchronous TDM, the input is connected to a frame. If there are ‘n’ number of connections, then the frame is divided into ‘n’ time slots. One slot is allocated for each input line. In this technique, the sampling rate is common to all signals and hence same clock input is given. The mux allocates the same slot to each device at all times.
Asynchronous TDM
In Asynchronous TDM, the sampling rate is different for each of the signals and the clock signal is also not in common. If the allotted device, for a time-slot, transmits nothing and sits idle, then that slot is allotted to another device, unlike synchronous.

PHASE SHIFT KEYING

Phase Shift Keying PSK is the digital modulation technique in which the phase of the carrier signal is changed by varying the sine and cosine inputs at a particular time. PSK technique is widely used for wireless LANs, bio-metric, contactless operations, along with RFID and Bluetooth communications. PSK is of two types, depending upon the phases the signal gets shifted. They are −

1. **Binary Phase Shift Keying BPSK**

This is also called as 2-phase PSK or Phase Reversal Keying. In this technique, the sine wave carrier takes two phase reversals such as 0° and 180°. BPSK is basically a Double Side Band Suppressed Carrier DSBSC modulation scheme, for message being the digital information.

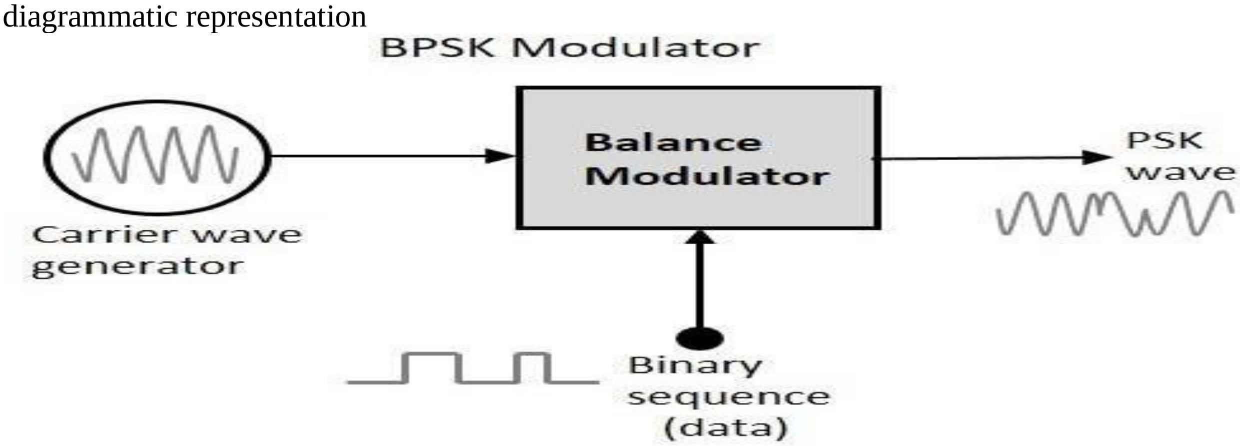
2. **Quadrature Phase Shift Keying QPSK**

This is the phase shift keying technique, in which the sine wave carrier takes four phase reversals such as 0°, 90°, 180°, and 270°.

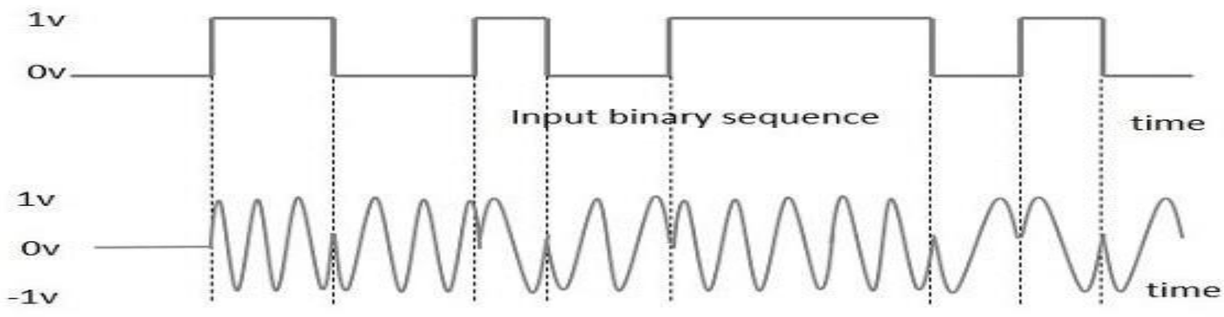
If this kind of techniques are further extended, PSK can be done by eight or sixteen values also, depending upon the requirement.

BPSK Modulator

The block diagram of Binary Phase Shift Keying consists of the balance modulator which has the carrier sine wave as one input and the binary sequence as the other input. Following is the diagrammatic representation



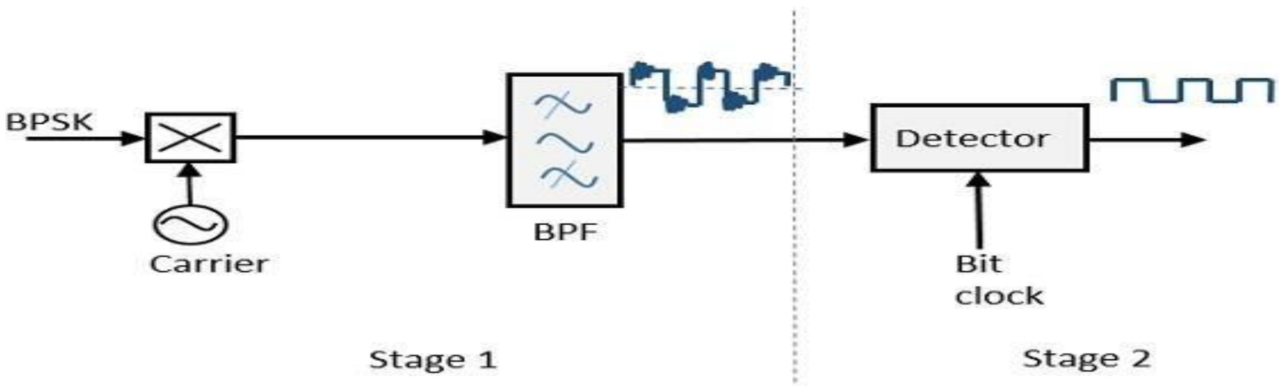
The modulation of BPSK is done using a balance modulator, which multiplies the two signals applied at the input. For a zero binary input, the phase will be **0°** and for a high input, the phase reversal is of **180°**. Following is the diagrammatic representation of BPSK Modulated output wave along with its given input.



BPSK Modulated output wave

The output sine wave of the modulator will be the direct input carrier or the inverted 180°phaseshifted180°phaseshifted input carrier, which is a function of the data signal.

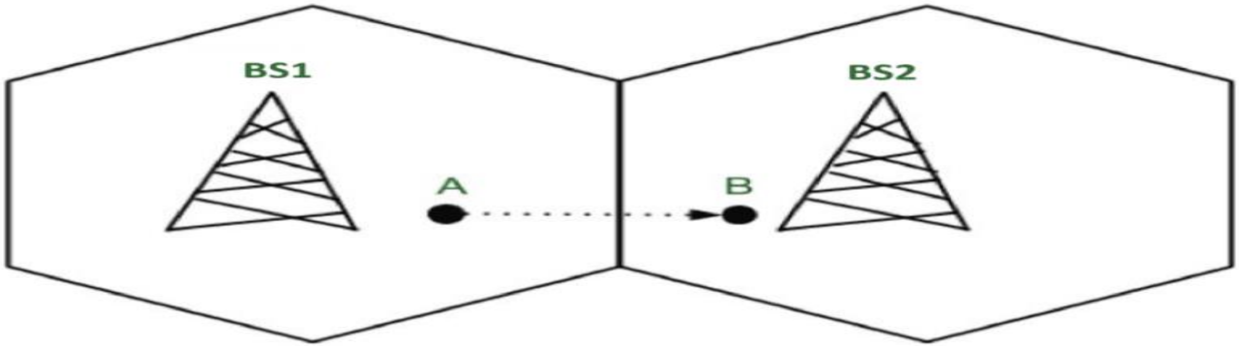
BPSK Demodulator



By recovering the band-limited message signal, with the help of the mixer circuit and the band pass filter, the first stage of demodulation gets completed. The base band signal which is band limited is obtained and this signal is used to regenerate the binary message bit stream.
In the next stage of demodulation, the bit clock rate is needed at the detector circuit to produce the original binary message signal. If the bit rate is a sub-multiple of the carrier frequency, then the bit clock regeneration is simplified. To make the circuit easily understandable, a decision-making circuit may also be inserted at the 2nd stage of detection

handover or handoff:

The terms handover or handoff refers to the process of transferring an ongoing call or data connectivity from one Base Station to another Base Station. When a mobile moves into a different cell while the conversation is in progress then the MSC (Mobile Switching Centre) transfers the call to a new channel belonging to the new Base Station.



When a mobile user A moves from one cell to another cell then BSC 1 signal strength loses for the mobile User A and the signal strength of BSC 2 increases and thus ongoing calls or data connectivity for mobile users goes on without interrupting.

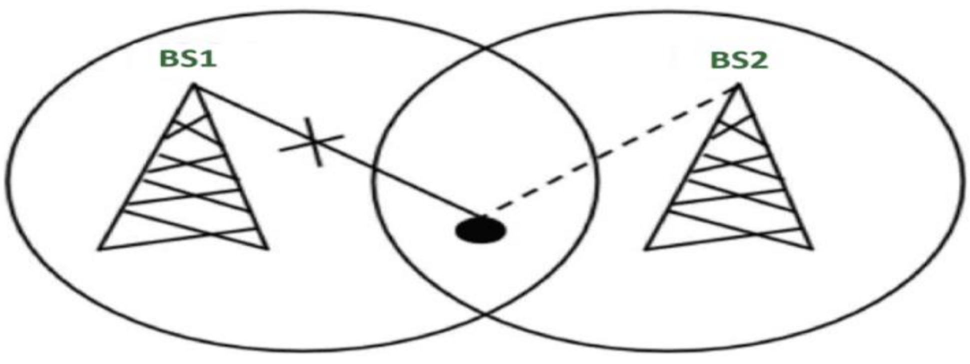
Types of Handoff

Hard Handoff
Soft Handoff
Delayed Handoff
Mobile-Assisted Handoff

Hard Handoff

When there is an actual break in the connectivity while switching from one Base Station to another Base Station. There is no burden on the Base Station and MSC because the switching takes place so quickly that it can hardly be noticed by the users. The connection quality is not that good. Hard H-andoff adopted the 'break before make' policy.

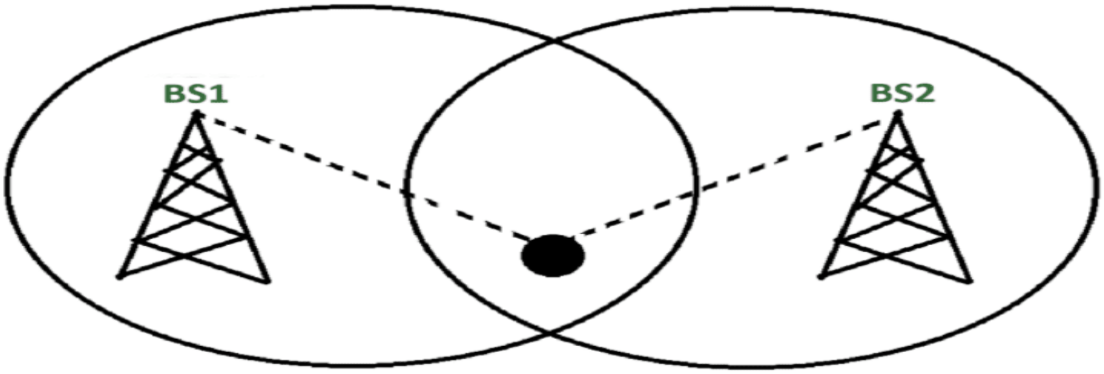
It is generally implemented in Time Division Multiplexing and Frequency Division Multiplexing when a user connects to the base station with a fluctuating radio frequency. Hard Handoff is cheaper in cost as compared to soft Handoff because only one channel needs to be active at a time. It is more efficient than soft handoff, that's why hard handoffs are widely implemented. Sometimes, a delay can be experienced while switching base stations.



Soft Handoff

Soft Handoff is a mechanism in which the device gets connected with two or more base stations at the same time. At least one of the links is kept when radio signals are added or removed to the Base Station. Soft Handoff adopted the 'make before break' policy. If a channel is in power loss then another channel will always be on standby mode so this makes it best in terms of quality as compared to Hard handoff. Soft handoffs are used in devices supporting CDMA/WDMA networks

High Transmission speed as more than one repeater can transmit signals.It has a very low delay in signals. It can’t be implemented on devices supporting GSM or LTE networks.



Delayed Handoff

Delayed handoff occurs when no base station is available for accepting the transfer. The call continues until the signal strength reaches a threshold, and after that, the call is dropped. Generally, it happens when the user is out of the network coverage area, or at some dead spots where network reach is very low.

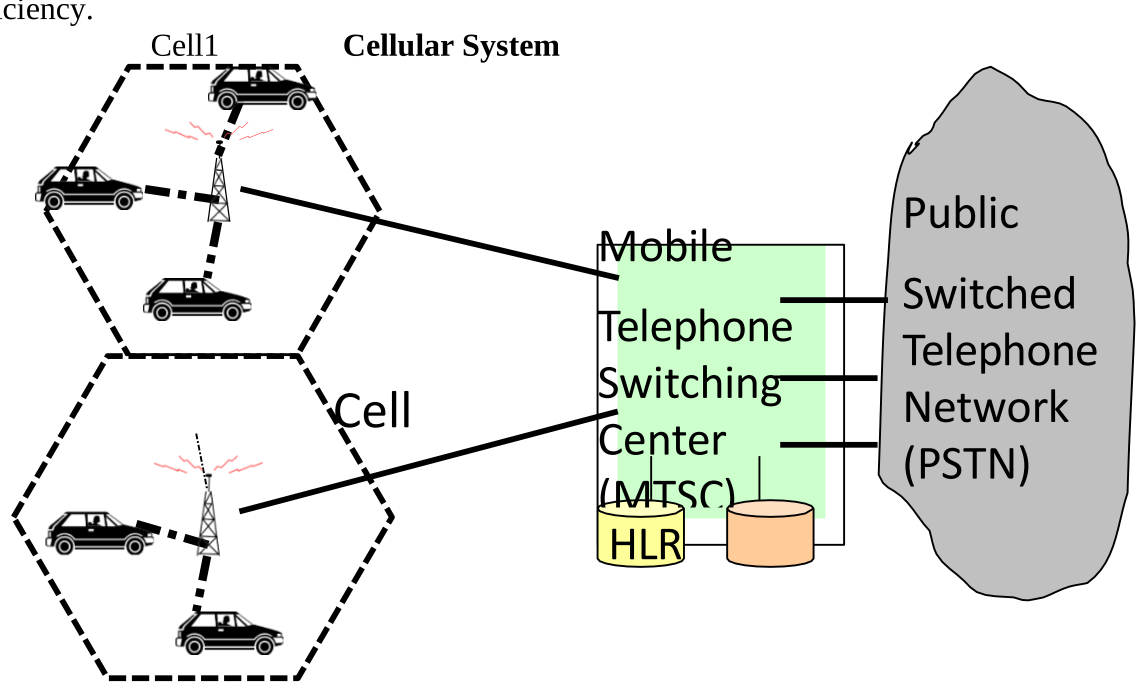
Mobile-Assisted Handoff

Mobile-Assisted handoff is generally used when a mobile phone helps a base station to transfer the call to another base station with better-improvised connectivity and more signal strength. This handoff is used in TDMA technique-based GSM devices.

Cellular System

A cellular system is a telecommunications network that divides a large area into smaller cells, each with a low-power transmitter, to allow for more subscribers and improve spectral efficiency.

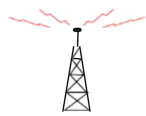
Cellular System



Mobile User

Cordless connection

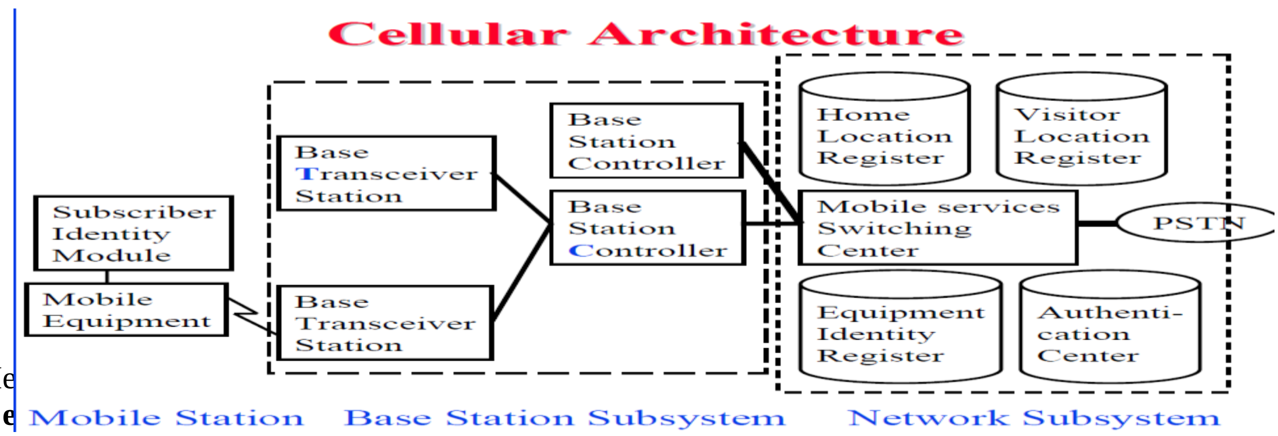
Wired connection



Base Transceiver Station (BTS)

HLR = Home Location Register

VLR = Visitor Location Register



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are served by at least one base transceiver station (BTS).

Base transceiver station (BTS): A BTS is located at the base of a cell tower and handles local radio communications with cellular phones. The BTS's transmitting power determines the size of the cell.

Mobile switching center (MSC): A component of a cellular system.

Radio network controller (RNC): A component of a cellular system.

Home and visitors (roamers) location register: A component of a cellular system.

Public switched telephone network (PSTN): A component of a cellular system.

Mobile telephone switching office (MTSO): A component of a cellular system that coordinates all cell sites.

Cellular systems use a principle called frequency reuse, where neighboring cells are assigned different frequencies to avoid interference and ensure quality service.

Frequency Management: The function of frequency management is to divide the total number of available channels into subsets which can be assigned to each cell either in a fixed fashion or dynamically (i.e., in response to any channel among the available channels). The terms "frequency management" and "channel assignment" often create some confusion. Frequency management refers to designating setup channels and voice channels (done by the FCC), numbering the channels (done by the FCC), and grouping the voice channels into subsets (done by each system according to its preference).

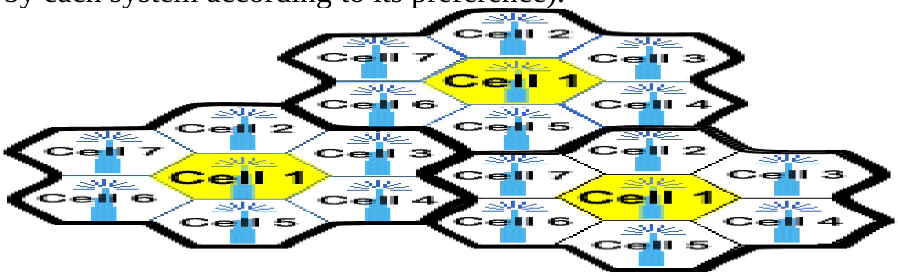


Fig.1.1. Frequency management chart

1A 2A 3A 4A 5A 1B 2B 3B 4B 5B 1C 2C 3C 4C 5C
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
21 22 23 24 25 26 26 27 28 29 30 31 32 33 34 35
21 Block A/Block B

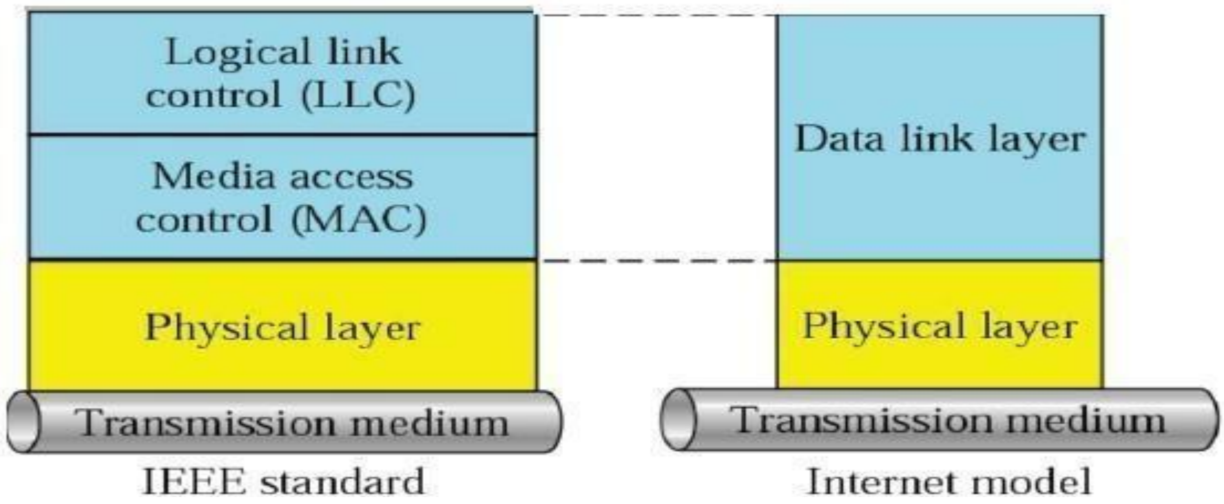
Channel assignment refers to the allocation of specific channels to cell sites and mobile units. A fixed channel set consisting of one more subsets is assigned to a cell site on a long-term basis. During a call, a particular channel is assigned to a mobile unit on a short- term basis. For a short-term assignment, one channel assignment per call is handled by the mobile telephone switching office (MTSO). Ideally channel assignment should be based on causing the least interference in the system. However, most cellular systems cannot perform this way. Numbering the channels: The total number of channels at present (January 1988) is 832. But most mobile units an systems are still operating on 666 channels. Therefore we describe the 666 channel numbering first. A channel consists of two frequency channel bandwidths, one in the low band and one in the high band. Two frequencies in channel 1 are 825.030 MHz (mobile transmit) 870.030 MHz (cell-site transmit). The two frequencies in channel 666 are 844.98 MHz (mobile transmit) and 898 MHz (cell-site transmit). The 666 channels are divided into two groups: block A system and block B system. Each market (i.e., each city) has two systems for a duopoly market policy. Each block has 333 channels, as shown in Fig.1.1. The 42 set-up channels are assigned as follows. Channels 313-333 block A Channels 334-354 block B The voice channels are assigned as follows. Channels 1-312 (312 voice channels) block A Channels 355-666 (312 voice channels) block B.

Fig.1.1. Frequency management chart

1A 2A 3A 4A 5A 1B 2B 3B 4B 5B 1C 2C 3C 4C 5C
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
21 22 23 24 25 26 26 27 28 29 30 31 32 33 34 35
21 Block A/Block B.

UNIT-II

MAC: The **Media Access Control** (**MAC**) data communication protocol sub-layer, also known as the Medium Access Control, is a sub-layer of the Data Link Layer specified in the seven-layer OSI model (layer 2). The hardware that implements the MAC is referred to as a **Medium Access Controller**. The MAC sub-layer acts as an interface between the Logical Link Control (LLC) sub layer and the network's physical layer. The MAC layer emulates a full-duplex logical communication channel in a multi-point network. This channel may provide unicast, multicast or broadcast communication service.



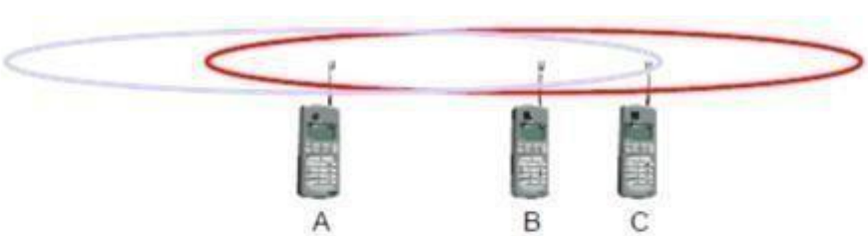
Motivation for a specialized MAC

One of the most commonly used MAC schemes for wired networks is carrier sense multiple access with collision detection(CD). In this scheme, a sender senses the medium to see if it is free. If the medium is busy, the sender waits until it is free. If the medium is free, the sender starts transmitting data and continues to listen into the medium. If the sender detects a collision while sending, it stops at once and sends a jamming signal.

The problems are:

1. Signal strength decreases proportional to the square of the distance
2. The sender would apply CS and CD, but the collisions happen at the receiver
3. It might be a case that a sender cannot “hear” the collision, i.e., CD does not work
4. Furthermore, C“ might not work, if for e.g., a terminal is “hidden.

Hidden and Exposed Terminals: Consider the scenario with three mobile phones as shown below. The transmission range of A reaches B, but not C (the detection range does not reach C either). The transmission range of C reaches B, but not A. Finally, the transmission range of B reaches A and C, i.e., A cannot detect C and vice versa.



1. A sends to B, C cannot receive A
2. C wants to send to B, C senses a “free” medium and starts transmitting
3. Collision at B occurs, A cannot detect this collision and continues with its transmission to B
4. A is “hidden” from C and vice versa

Exposed terminals

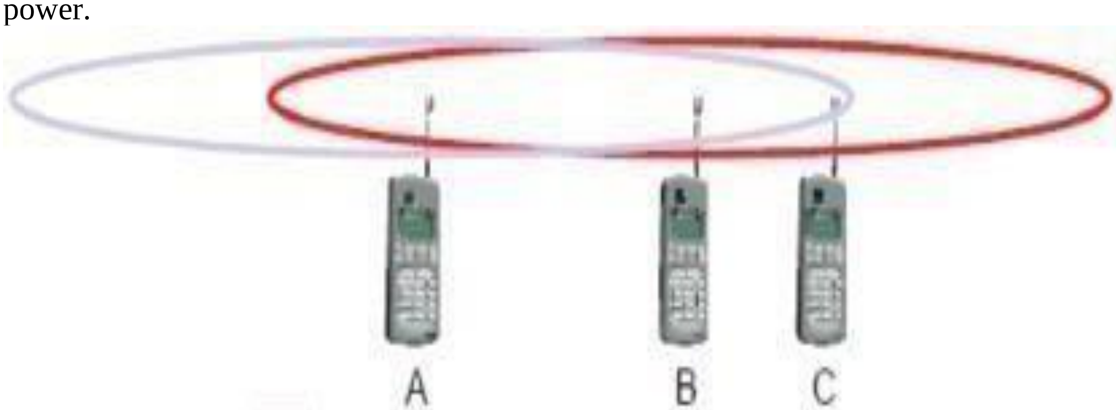
1. B sends to A, C wants to send to another terminal (not A or B) outside the range

2. C senses the carrier and detects that the carrier is busy.
3. C postpones its transmission until it detects the medium as being idle again
4. but A is outside radio range of C, waiting is **not** necessary
5. C is “exposed” to B

Hidden terminals cause collisions, where as Exposed terminals causes unnecessary delay.

<u>Near and far terminals</u>

Consider the situation shown below. A and B are both sending with the same transmission power.

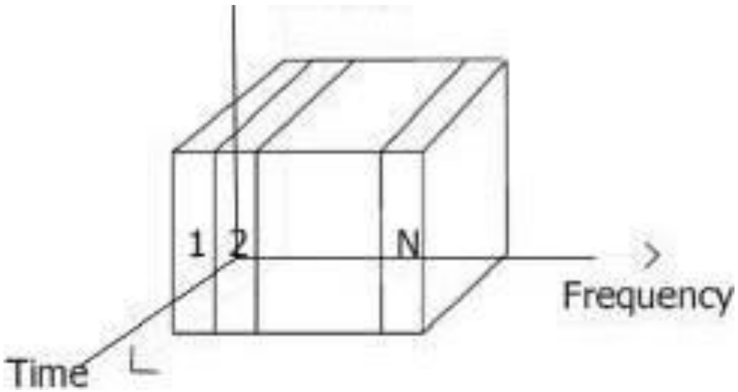


1.Signal strength decreases proportional to the square of the distance
2.“o, B’s signal drowns out A’s signal making C unable to receive A’s transmission
3. If C is an arbiter for sending rights, B drown out A’s signal on the physical layer making C unable to hear out A.

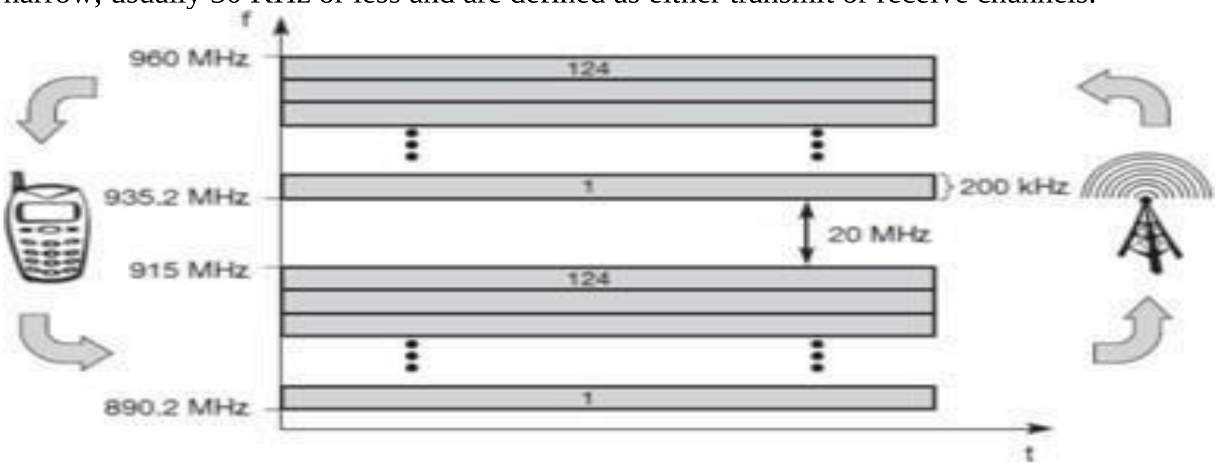
SDMA: stands for Space Division Multiple Access.
Space Division Multiple Access is used for allocating a separated space to users in wireless networks. No of application are assigning on base station to a mobile phone user. The mobile phone may receive several base stations with different quality. A MAC algorithm can decide which base station is best, taking into account which frequencies (FDM), time slots (TDM) or code (CDM) are still available. The SDMA algorithm is formed by cells and sectorized antennas which constitute the infrastructure implementing space division multiplexing (SDM). SDM has the unique advantage of not requiring any multiplexing equipment. It is usually combined with other multiplexing techniques to better utilize the individual physical channels

FDMA: Frequency division multiplexing (FDM) describes schemes to subdivide the frequency dimension into several non-overlapping frequency bands.

CODE



Frequency Division Multiple Access is a method employed to permit several users to transmit simultaneously on one satellite transponder by assigning a specific frequency with in the channel to each user. Each conversation gets its own, unique, radio channel. The channels are relatively narrow, usually 30 KHz or less and are defined as either transmit or receive channels.

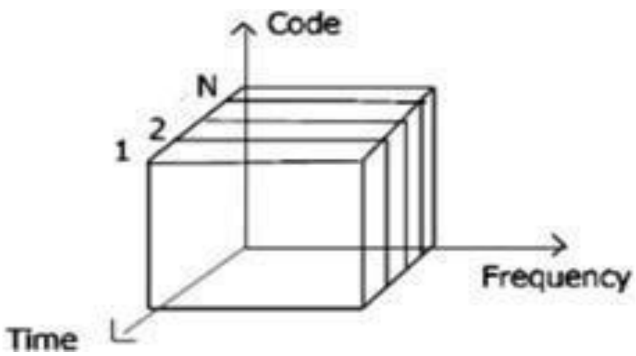


A full duplex conversation requires a transmit & receive channel pair. FDM is often used for simultaneous access to the medium by base station and mobile station in cellular networks establishing a duplex channel. A scheme called frequency division duplexing (FDD) in which the two directions, mobile station to base station and vice versa are now separated using different frequencies**.**

FDM for multiple access and Duplex The two frequencies are also known as uplink, i.e., from mobile station to base station or from ground control to satellite, and as downlink, i.e., from base station to mobile station or from satellite to ground control. The basic frequency allocation scheme for GSM is fixed and regulated by national authorities. All uplinks use the band between 890.2 and 915 MHz, all downlinks use 935.2 to 960 MHz. According to FDMA, the base station, shown on the right side, allocates a certain frequency for up- and downlink to establish a duplex channel with a mobile phone. Up and downlink have a fixed relation. If the uplink frequency is $f_u = 890 \text{ MHz} + n \cdot 0.2 \text{ MHz}$, the downlink frequency is $f_d = f_u + 45 \text{ MHz}$, i.e., $f_d = 935 \text{ MHz} + n \cdot 0.2 \text{ MHz}$ for a certain channel n. The base station selects the channel. Each channel (uplink and downlink) has a bandwidth of 200 kHz.
This scheme **also** has disadvantages. While radio stations broadcast 24 hours a day, mobile communication typically takes place for only a few minutes at a time. Assigning a separate frequency for each possible communication scenario would be a tremendous waste of (scarce)

frequency resources. Additionally, the fixed assignment of a frequency to a sender makes the scheme very inflexible and limits the number of senders.

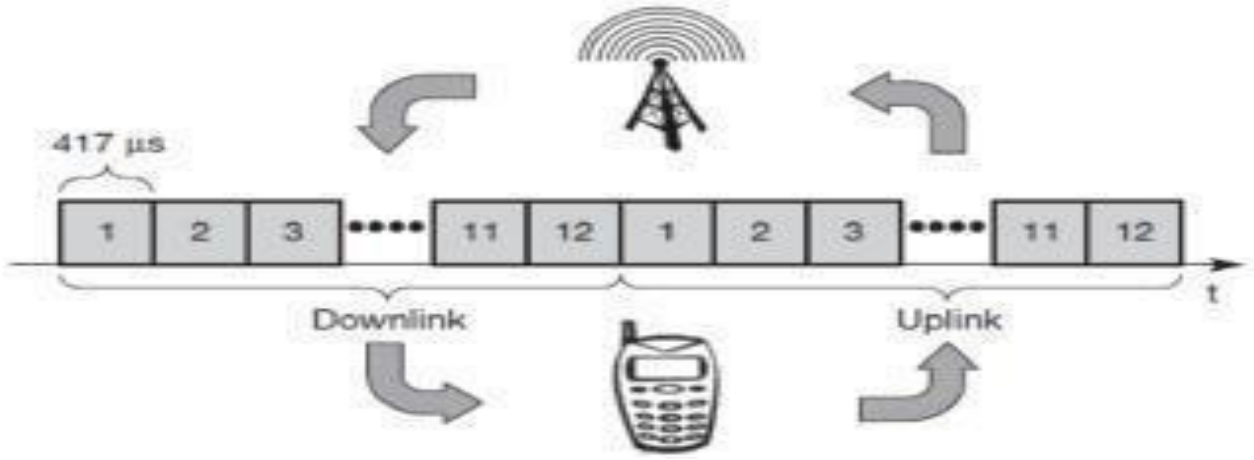
TDMA: A more flexible multiplexing scheme for typical mobile communications is time division multiplexing (TDM). Compared to FDMA, time division multiple access (TDMA) offers a much more flexible scheme, which comprises all technologies that allocate certain time slots for communication. Now synchronization between sender and receiver has to be achieved in the time domain. Again this can be done by using a fixed pattern similar to FDMA techniques, i.e., allocating a certain time slot for a channel, or by using a dynamic allocation scheme.



Listening to different frequencies at the same time is quite difficult, but listening to many channels separated in time at the same frequency is simple. Fixed schemes do not need identification, but are not as flexible considering varying bandwidth requirements.

Fixed TDM: The simplest algorithm for using TDM is allocating time slots for channels in a fixed pattern. This results in a fixed bandwidth and is the typical solution for wireless phone systems.

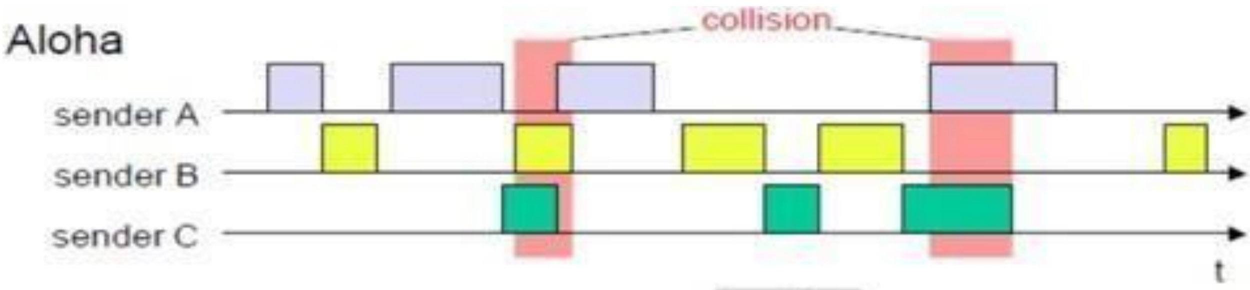
MAC is quite simple, as the only crucial factor is accessing the reserved time slot at the right moment. If this synchronization is assured, each mobile station knows its turn and no interference will happen. The fixed pattern can be assigned by the base station, where competition between different mobile stations that want to access the medium is solved.



The figure shows how these fixed TDM patterns areused to implement multiple access and a duplex channel between a base station and mobile station. Assigning different slots for uplink and downlink using the same frequency is called **time division duplex (TDD)**. As shown in the figure, the base station uses one out of 12 slots for the downlink, Up to 12 different mobile stations can use the same frequency without interference using this scheme. Each connection is allotted its own up- and downlink pair. This general scheme still wastes a lot of bandwidth. It is too static, too inflexible for data communication. In this case, connectionless, demand- oriented TDMA schemes can be used.

Classical Aloha

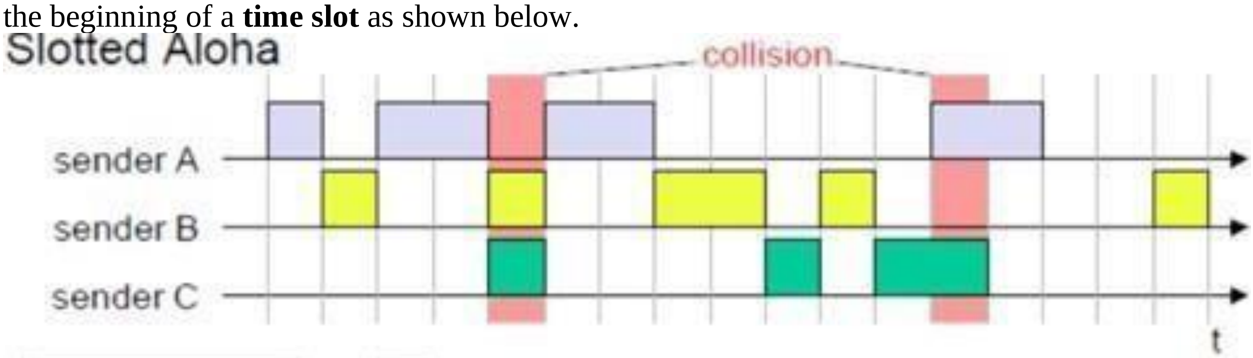
In this scheme, TDM is applied without controlling medium access. Here each station can access the medium at any time as shown below:



This is a random access scheme, without a central arbiter controlling access and without coordination among the stations. If two or more stations access the medium at the same time, a **collision** occurs and the transmitted data is destroyed. Resolving this problem is left to higher layers (e.g., retransmission of data). The simple Aloha works fine for a light load and does not require any complicated access mechanisms.

Slotted Aloha:

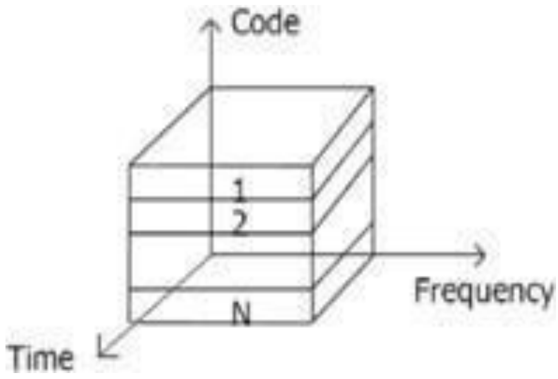
The first refinement of the classical Aloha scheme is provided by the introduction of time slots (**slotted Aloha**). In this case, all senders have to be **synchronized**, transmission can only start at the beginning of a **time slot** as shown below.



The introduction of slots raises the throughput from 18 per cent to 36 per cent, i.e., slotting doubles the throughput. Both basic Aloha principles occur in many systems that implement distributed access to a medium. Aloha systems work perfectly well under a light load, but they cannot give any hard transmission guarantees, such as maximum delay before accessing the medium or minimum throughput.

CDMA:

Code division multiple access systems apply codes with certain characteristics to the transmission to separate different users in code space and to enable access to a shared medium without interference.



All terminals send on the same frequency probably at the same time and can use the whole bandwidth of the transmission channel. Each sender has a unique random number, the sender XO‘s the signal with this random number. The receiver can “tune” into this signal if it knows the pseudo random number, tuning is done via a correlation function

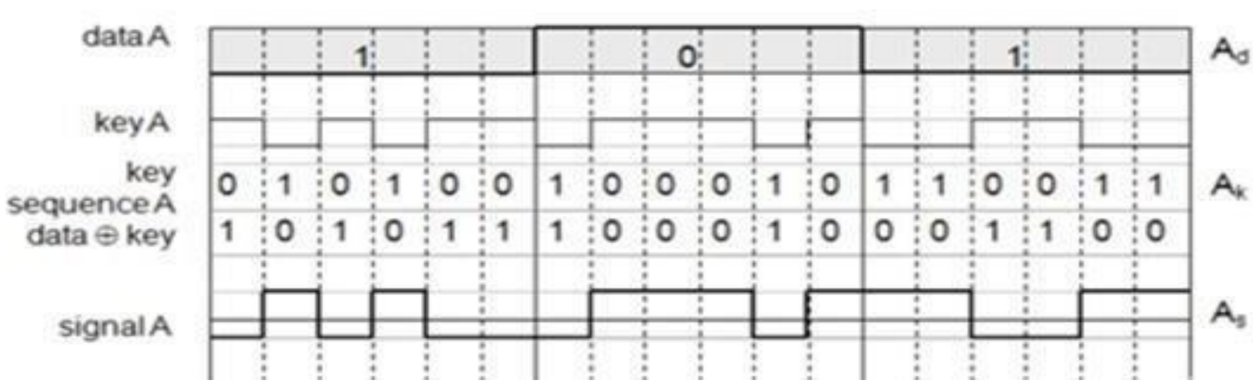
Advantages:

1. all terminals can use the same frequency, no planning needed
2. huge code space(eg. 2^{32}) compared to frequency space.
3. forward error correction and encryption can be easily integrated

- Sender A wants to transmit the bits 010011.
  – sends Ad = 1, key Ak = 010011 (assign: “0”= -1, “1”= +1)
  – sending signal As = Ad * Ak = (-1, +1, -1, -1, +1, +1)
- Sender B wants to transmit the bits 110101
  – sends Bd = 0, key Bk = 110101 (assign: “0”= -1, “1”= +1)
  – sending signal Bs = Bd * Bk = (-1, -1, +1, -1, +1, -1)
- Both signals superimpose in space as
  – As + Bs = (-2, 0, 0, -2, +2, 0)
- Receiver wants to receive signal from sender A
  - apply key Ak bitwise (inner product)
    – Ae = (-2, 0, 0, -2, +2, 0)

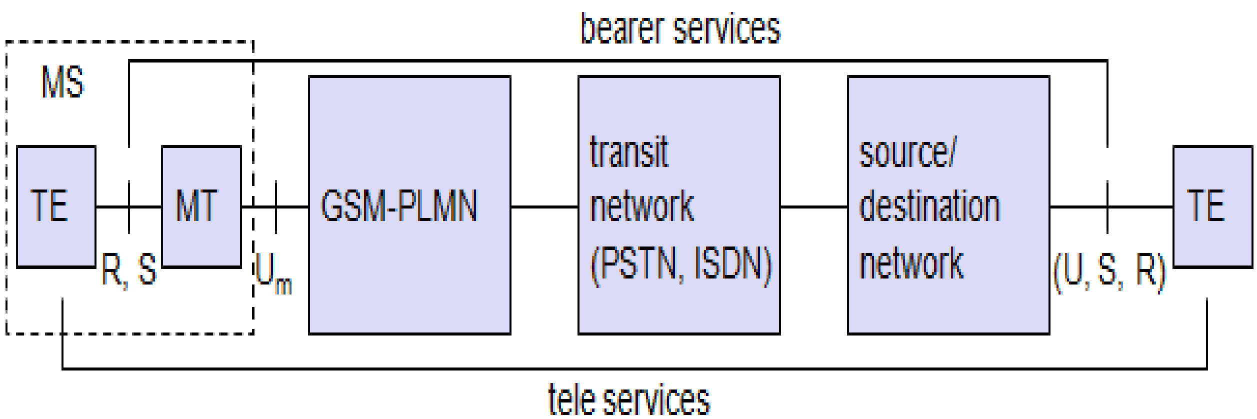
Be = (-2, 0, 0, -2, +2, 0)Bk = -2 + 0 + 0 - 2 - 2 + 0 = -6, i.e. “0”

The following figure shows a sender A that wants to transmit the bits 101. The key of A is shown as signal and binary sequence Ak. The binary “0” is assigned a positive signal value, the binary “1” a negative signal value. After spreading, i.e., XORing Ad and Ak, the resulting signal is As.



GSM Services: GSM is the digital mobile telecommunication system in the world today. It is used by over 800 million people in more than 190 countries. GSM permits the integration of different voice and data services and the interworking with existing networks. Services make a network interesting for customers. GSM has defined three different categories of services: bearer, tele and supplementary services.

Bearer services: GSM specifies different mechanisms for data transmission, the original GSM.



allowing for data rates of up to 9600 bit/s for non-voice services. Bearer services permit transparent and non-transparent, synchronous or asynchronous data transmission.

Transparent bearer services: Transfer of data using physical layer is said to be transparent when the interface for service uses only physical layer protocols. Physical layer is the layer which transmits or receives data after formatting or multiplexing or insertion of **forward error correction (FEC)** using a wired (fiber) or wireless (radio or microwave) medium.

Forward error correction (FEC) bits: The physical layer protocol in a GSM bearer service also provides for FEC. Bluetooth also provides FEC. The FEC bring out redundant bits along with the data to be transmitted. This redundant data allows the receiver to detect and correct errors.

Non-transparent bearer services use protocols of layers two and three to implement error correction and flow control. These services use the transparent bearer services, adding a **radio link protocol (RLP).**

This protocol comprise mechanisms of **high-level datalink control (HDLC**), and special selective-reject mechanisms to trigger retransmission of erroneous data.

Synchronous and asynchronous data transmission:

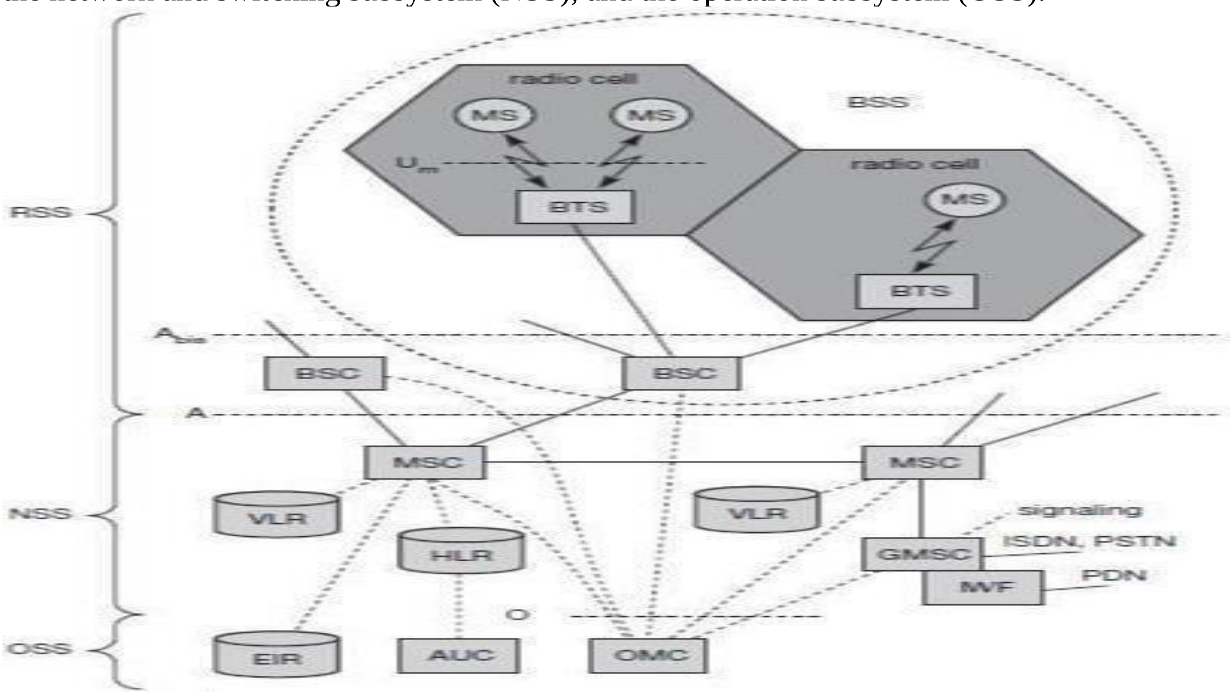
Synchronous means data is transmitted from a transceiver at a fixed rate with constant phase differences are maintained b/w two devices. It means establish a constant clock rate b/w receiver and sender. (i.e not using handshaking technique).

Asynchronous means data is transmitted by the transceiver at variable rate b/w two devices. It means, first set the bandwidth and provide the clock rate b/w two devices.

GSM specifies several bearer services for interworking with PSTN, ISDN, and packet switched public data networks (PSPDN) like X.25, which is available worldwide. Data transmission can be full-duplex, synchronous with data rates of 1.2, 2.4, 4.8, and 9.6 kbit/s or full-duplex, asynchronous from 300 to 9,600 bit/s.

Tele services: GSM mainly focuses on voice-oriented tele services. These services encrypted (such as voice transmission, message services, and basic data communication) with terminals and send to / received from the PSTN or ISDN (e.g., fax).
The primary goal of GSM was the provision of high-quality digital voice transmission. Special codes (coder/decoder) are used for voice transmission, while other codes are used for the transmission of analog data for communication with traditional computer modems used in, e.g., fax machines.
Another service offered by GSM is the **emergency number** (eg 911, 999). This service is mandatory for all providers and free of charge. This connection also has the highest priority, possibly pre-empting other connections, and will automatically be set up with the closest emergency center.

GSM Architecture: A GSM system consists of three subsystems, the radio sub system (RSS), the network and switching subsystem (NSS), and the operation subsystem (OSS).



Network Switching Subsystem: The NSS is responsible for performing call processing and subscriber related functions. The switching system includes the following functional units
Some location register (HLR): The HLR has a database that used for storage and management of subscriptions. HLR stores all the relevant subscriber data including a subscribers service profile such as call forwarding, roaming, location information and activity status.
Visitor location register (VLR): It is a dynamic real-time database that stores both permanent and temporary subscribers data which is required for communication b/w the coverage area of MSC and VLR.
Authentication center (AUC): A unit called the AUC provides authentication and encryption parameters that verify the users identity and ensure the confidentiality of each call.
Equipment identity register (EIR): It is a database that contains information about the identity of mobile equipment that prevents calls from stolen, unauthorized or defective mobile stations.

Mobile switching center (MSC): The MSC performs the telephony switching functions of the system. It has various other functions such as 1. Processing of signal. 2. Control calls to and from other telephone and data systems. 3. Call changing, multi- way calling, call forwarding, and other supplementary services. 4. Establishing and terminating the connection b/w MS and a fixed line phone via GMSC.

Radio Subsystem (RSS): The **radio subsystem (RSS)** comprises all radio specific entities, i.e., the **mobile stations (MS)** and the **base station subsystem (BSS)**. The figure shows the connection between the RSS and the NSS via the A **interface** (solid lines) and the connection to the OSS via the **O interface** (dashed lines).

Base station subsystem (BSS): A GSM network comprises many BSSs, each controlled by a base station controller (BSC). The BSS performs all functions necessary to maintain radio connections to an MS, coding/decoding of voice, and rate adaptation to/from the wireless network part. Besides a BSC, the BSS contains several BTSs.

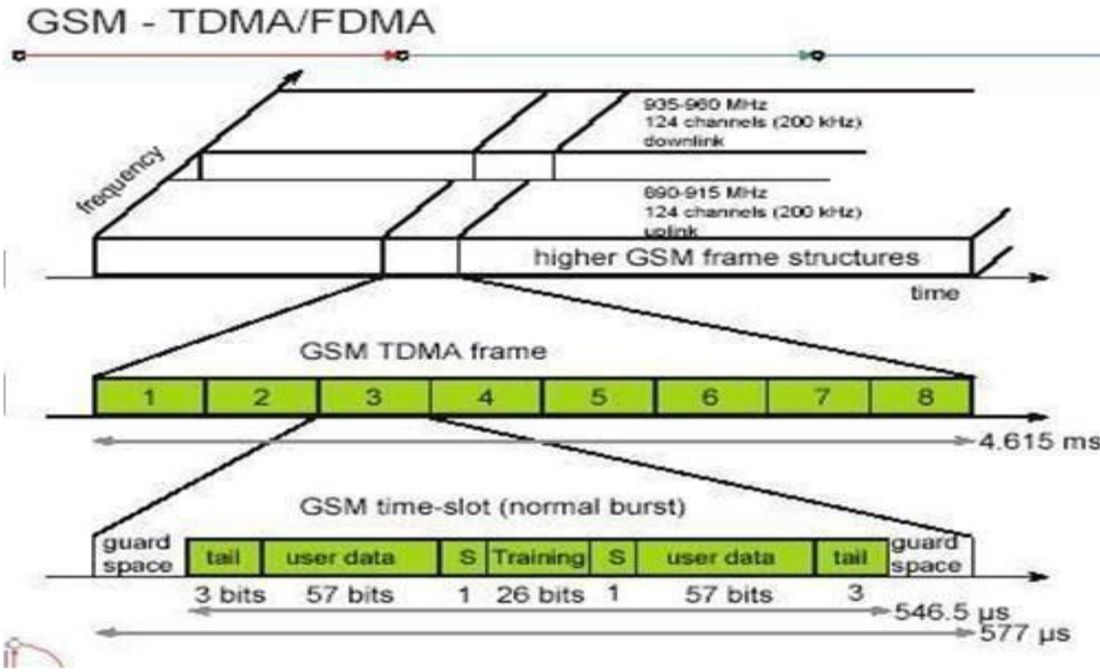
Base station controllers (BSC): The BSC provides all the control functions and physical links between the MSC and BTS. It is a high capacity switch that provides functions such as handover, cell configuration data, and control of radio frequency (RF) power levels in BT". A number of BSC's are served by and MSC.

Basetransceiver station(BTS):The BTS handles the radio interface to the mobile station. A BTS can form a radio cell or, using sectorized antennas, several and is connected to MS via the Um interface, and to the BSC via the A BTS interface. The Um interface contains all the mechanisms necessary for wireless transmission (TDMA, FDMA etc.). The BTS is the radio equipment (transceivers and antennas) needed to service each cell in the network. A group of BTS's are controlled by an BSC.

Radio Interface The most interesting interface in a GSM system is the radio interface, as it contains various multiplexing and media access mechanisms.

Electric signals are given to antenna. The antenna radiates the electromagnetic waves. Electromagnetic waves propagate b/w the transmitter and receiver. Two electrical signals of two sources are not have same frequency at the same time. GSM TDMA Frame, Slots and Bursts

In the below figure, the GSM implements SDMA using cells with BTS and assigns an MS to a BTS. The diagram shows GSM TDMA frame. A frame is again subdivided into 8 GSM time slots, where each slot represents a physical TDM channel and lasts for 577 μs. Each TDM channel occupies the 200 kHz carrier for 577 μs every 4.615 ms. Data is transmitted in small portions, called bursts. As shown, the burst is only 546.5 μs long and contains 148 bits. The remaining 30.5 μs are used as guard space to avoid overlapping with other bursts due to different path delays and to give the transmitter time to turn on and off.



The first and last three bits of a normal burst (**tail**) are all set to 0 and can be used to enhance the receiver performance. The **training** sequence in the middle of a slot is used to adapt the parameters of the receiver to the current path propagation characteristics and to select the strongest signal in case of multi-path propagation. A flag **S** indicates whether the **data** field contains user or network control data.

Wireless LAN/(IEEE 802.11)

The global goal of WLANs is to replace office cabling, to enable ether less access to the internet and, to introduce a higher flexibility for ad-hoc communication in, e.g., group meetings.

Advantages

● Flexibility: Within radio coverage, nodes can communicate without further restriction. Radio waves can penetrate walls, senders and receivers can be placed anywhere (also non-visible, e.g., with in devices, in walls etc.).

● Planning: Only wireless ad-hoc networks allow for communication without previous planning, any wired network needs wiring plans. As long as devices follow the same standard, they can communicate

● Design: Wireless networks allow for the design of small, independent devices which can for example be put into a pocket. Cables not only restrict users but also designers of small PDAs, notepads etc.

● Robustness: Wireless networks can survive disasters, e.g., earthquakes or users pulling a plug. If the wireless devices survive, people can still communicate. Networks requiring a wired infrastructure will usually break down completely.

● Cost: After providing wireless access to the infrastructure via an access point for the first user,adding additional users to a wireless network will not increase the cost. This is, important for e.g., lecture halls, hotel lobbies or gate areas in airports where the numbers using the network may vary significantly.

Dis-Advantages:

● Quality of service:
WLANs typically offer lower quality than their wired counterparts. The main reasons for this are the lower bandwidth due to limitations in radio transmission (e.g., only 1–10 Mbit/s user data rate instead of 100–1,000 Mbit/s).
● Proprietary solutions:
Due to slow standardization procedures, many companies have come up with proprietary solutions offering standardized functionality plus many enhanced features).
● Restrictions:
All wireless products have to comply with national regulations. Several government and non-government institutions worldwide regulate the operation and restrict frequencies to minimize interference.
● Safety and security:Using radio waves for data transmission might interfere with other high-tech
● Global operation:
WLAN products should sell in all countries so, national and international frequency regulations have to be considered

IEEE 802.11

The IEEE standard 802.11 (IEEE, 1999) specifies the most famous family of WLANs in which many products are available. As the standard's number indicates, this standard belongs to the group of 802.x LAN standards, e.g., 802.3 Ethernet or 802.5 Token Ring. This means that the standard specifies the physical and medium access layer adapted to the special requirements of wireless LANs, but offers the same interface as the others to higher layers to maintain interoperability. The primary goal of the standard was the specification of a simple and robust WLAN which offers time-bounded and asynchronous services. The MAC layer should be able to operate with multiple physical layers, each of which exhibits a different medium sense and transmission characteristic. Candidates for physical layers were infra red and spread spectrum radio transmission techniques. Additional features of the WLAN should include the support of power management to save battery power, the handling of hidden nodes, and the ability to operate worldwide. The 2.4 GHz ISM band, which is available in most countries around the world, was chosen for the original standard. Data rates envisaged forth standard were 1 Mbit/s mandatory and 2 Mbit/s optional.
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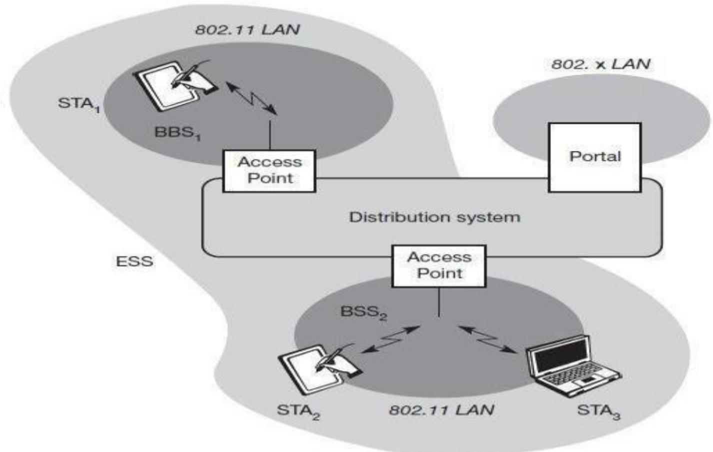
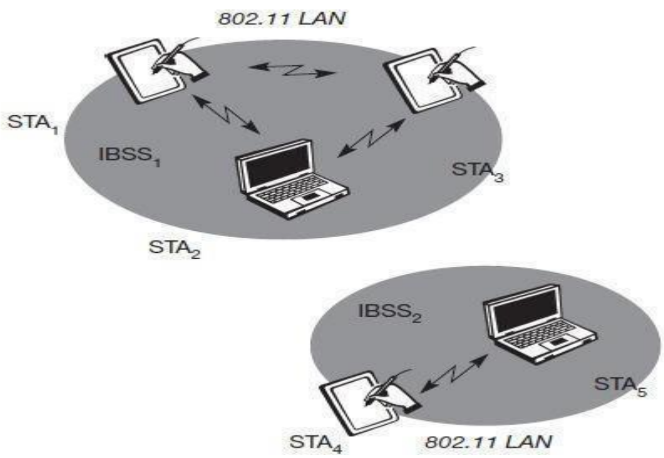
The following sections will introduce the system and protocol architecture of the initial IEEE 802.11 and then discuss each layer, i.e., physical layer and medium access. After that, the complex and very important management functions of the standard are presented. Finally, this subsection presents the enhancements of the original standard for higher data rates, 802.11a (up Wireless networks can exhibit two different basic system architectures as shown in infrastructure- based or ad-hoc. Figure shows the components.



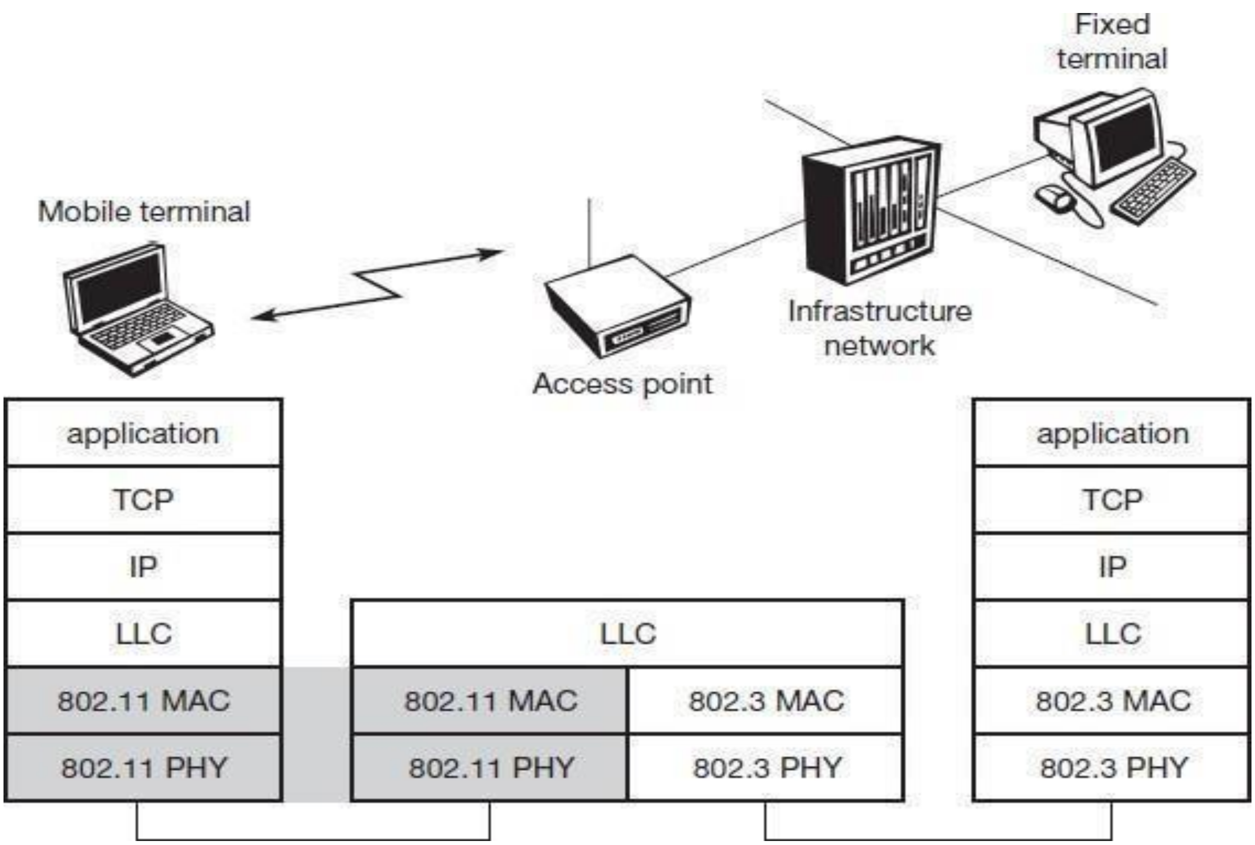
as specified for IEEE 802.11. Several nodes, called stations (STAi), are connected to access points (AP). Stations are terminals with access mechanisms to the wireless medium and radio contact to the AP. The stations and the AP which are within the same radio coverage form a basic service set (BSSi). The example shows two BSSs – BSS1 and BSS2 – which are connected via a distribution system. Figure: Architecture of an infrastructure

A distribution system connects several BSSs via the AP to form a single network and thereby extends the wireless coverage area. This network is now called an **extended service set (ESS)** and has its own identifier, the ESSID. The ESSID is the 'name' of a network and is used to separate different networks. Without knowing the ESSID (and assuming no hacking) it should not be possible to participate in the WLAN. The distribution system connects the wireless networks via the APs with a **portal**, which forms the interworking unit to other LANs. The architecture of the distribution system is not specified further in IEEE 802.11. It could consist of bridged IEEE LANs, wireless links, or any other networks. However, **distribution system services** are defined in the standard (although, many products today cannot interoperate and needs the additional standard IEEE 802.11f to specify an inter access point protocol. Stations can select an AP and associate with it. The APs support roaming (i.e., changing access points), the distribution system handles data transfer between the different APs. APs provide synchronization within a BSS, support power management, and can control medium access to support time-bounded service. These and further functions are explained in the following sections.

In addition to infrastructure-based networks, IEEE 802.11 allows the building of ad-hoc networks between stations, thus forming one or more independent BSSs (IBSS) as **shown in Figure**. In this case, an IBSS comprises a group of stations using the same radio frequency. Stations STA1, STA2, and STA3 are in IBSS1, STA4 and STA5 in IBSS2. This means for example that STA3 can communicate directly with STA2 but not with STA5. Several IBSSs can either be formed via the distance between the IBSSs or by using different carrier frequencies (then the IBSSs could overlap physically). IEEE 802.11 does not specify any special nodes that support routing, forwarding of data or exchange of topology information as, e.g., HIPERLAN 1 or Bluetooth.



Protocol architecture: ***Figure:*** *Architectu re of EEE 802.11 ad- hoc wireless LANs*



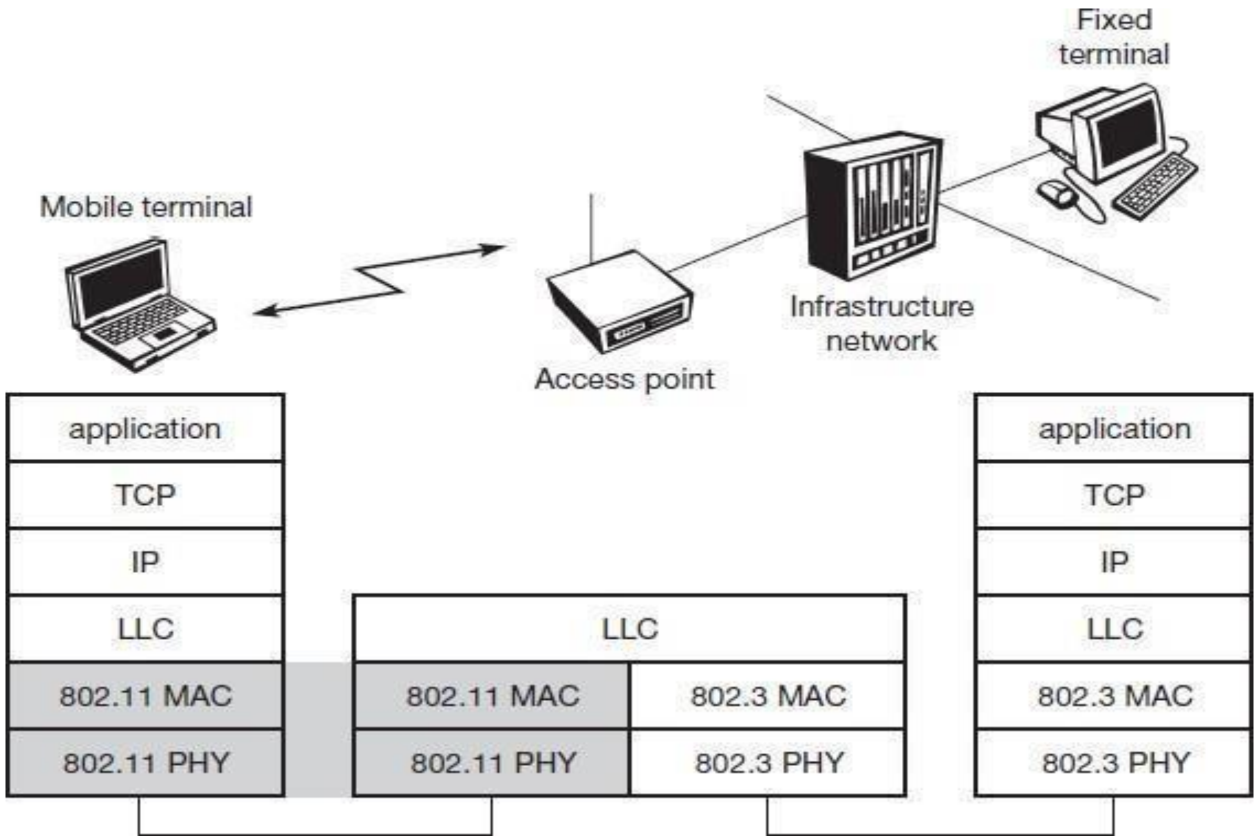


Figure: *IEEE 802.11 protocol architecture and bridging*

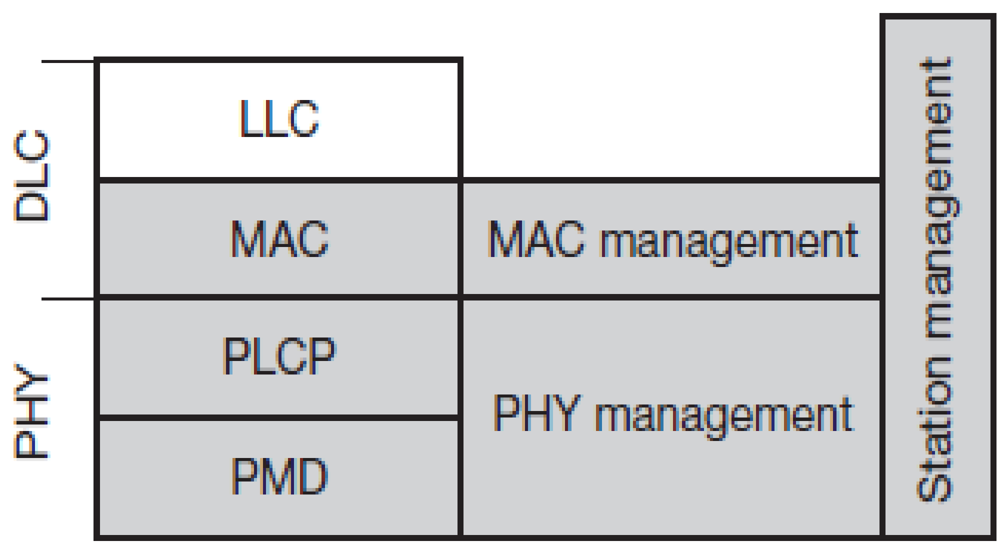


Figure*: Detailed IEEE 802.11* ***pr****otocol architecture and management*

As indicated by the standard number, IEEE 802.11 fits seamlessly into the other 802.x standards for wired LANs Figure shows the most common scenario: an IEEE 802.11 wireless LAN connected to a switched IEEE 802.3 Ethernet via a bridge. Applications should not notice any difference apart from the lower bandwidth and perhaps higher access time from the wireless LAN. The WLAN behaves like a slow wired LAN. Consequently, the higher layers (application, TCP, IP) look the same for wireless nodes as for wired nodes. The upper part of the data link control layer, the logical link control (LLC), covers the differences of the medium access control layers needed for the different media. In many of today’s networks, no explicit LLC layer is visible. Further details like Ether type or sub-network access protocol (SNAP) and bridging technology are explained in, e.g., Perlman (1992).