Chapter 1

Note//الرسمة او اي رسمة انت مش مطالب بيها بس الموضوع مطالب بيه

Wireless Communications

Wireless communications is a type of data communication that is performed and delivered wirelessly. // connecting and communicating between two or more devices using a wireless signal through wireless communication technologies and devices.

Broadband Wireless Technology

In communications broadband is a wide bandwidth data transmission with an ability to simultaneously transport multiple signals and traffic types.

Note// The medium can be coaxial cable, optical fiber, radio or twisted pair.

- **Higher data rates obtainable with broadband wireless technology**
  - Graphics, video, audio
- **Shares same advantages of all wireless services: convenience and reduced cost**
  - Service can be deployed faster than fixed service.
  - No cost of cable plant.
  - Service is mobile, deployed almost anywhere.

Wireless Communication Forms

1. Satellite Communication
2. Mobile Communication
3. Wireless Network Communication
4. Infrared Communication
5. Bluetooth Communication

Wireless Network

Wireless Network is a network setup by using radio signal frequency to communicate among network devices.

// E.g. Home networks - Office networks - IoT networks - adhoc networks

Wireless versus Wired Networking

- **Wireless connections are slower.**
  This difference is the big reason why most larger networks still depend on wired Ethernet for the bulk of their connections.
- **Wireless hardware is more expensive.**
  Depending on the standard supported by your wireless hardware, you pay significantly more for wireless hardware than you do for wired hardware.
- **Wireless networks require no hubs or switches.**
  Most wireless base stations and WAPs (wireless access points), can provide connections for up to 253 simultaneous users, so a larger wireless network (with 50 PCs or more) requires far less hardware.

The two **main components** of the wireless networks are Wireless Router or Access Point and Wireless Clients.

Access Point

In a wireless local area network (WLAN), an access point is a station that transmits and receives data. An access point connects users to other users within the network and also can serve as the point of interconnection between the WLAN and a fixed wire network.

Note// Each access point can serve multiple users.

Note// as people move beyond the range of one access point, they are automatically handed over to the next one.

Wireless Networks SWOT

1. Strengths

- **Convenience**: access your network resources from any location within your wireless network's coverage area.
- **Mobility**: You're no longer tied to your desk, as you were with a wired connection.
- **Deployment**: easy to setup, Installation can be quick and cost-effective.
- **Productivity**: Wireless access to the Internet and to your company's key applications and resources helps your staff get the job done and encourages collaboration.
- **Expandable**: Expand wireless networks with existing equipment
- **Cost**: Because wireless networks eliminate or reduce wiring costs, they can cost less to operate than wired networks.

2. Weaknesses

- **Security**: All data is transmitted as Radio Frequency on the air, it can be captured by enemies.
  - So, encrypted the data it's one of the solutions
- **Range**: The rang between transmitter(Tx) and receiver (Rx) is determined by physical characteristics and environmental conditions.
- **Complexity**: understanding well with wavelengths, channels, bands, spectrum, …etc.
- **Speed**: not that much, but it's improved.

3. Opportunities

- Improved Speed: 802.11ac and 802.11ad.
- Improved security

4. Threats

Security threats

- Denial of Service (DoS) attacks
- Rogue WAPs attacks
- Unwell configured server or router
- Sniffing : Captured data packets through the air.
- Wireless Driver Attacks
  - make some changes to the actual driver that is controlling our wireless access cards and our user devices.

Wireless Network types

1. **WiFi**

- Wireless Fidelity
- LAN Protocol
- IEEE 802.11
- Standars: a,b,g,n,ad and so on.
  - Different frequency
  - Different speed
- work in **ISM band**
- Uses 2.4GHz and 5GHz
- Frequency band divided into channels
- Governed by Wi-Fi Alliance.
- Concerned with the 2 lower layers of TCP/IP:
  - Data Link Layer
    - Logical Link Control (LLC)
    - Medium Access Control (MAC)
  - Physical Layer
    - Physical Layer convergence procedure (PLCP)
    - Physical Medium Deoendent (PMD)

2. **WiMAX**

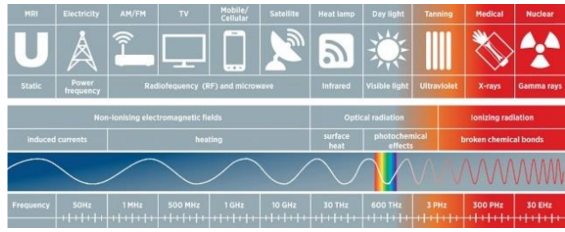
- Worldwide Interoperability for Microwave Access (**WiMAX**)
- WAN Technology
- IEEE 802.16
- Competing with LTE
- Managed by WiMAX forum
- Provides triple play communication (data-voice-vedio)
- Is similar to Wi-Fi. Both creates hot spots, but while Wi-Fi can cover several hundred meters, WiMAX has a range of 40 to 50 km.

3. **Bluetooth**

The Bluetooth following the **802.15 standard**. The concept behind Bluetooth is to provide a **universal short-range wireless** capability. **Key attributes are robustness, low power consumption, and low cost**. Using the **2.4 GHz band**, available globally for unlicensed low-power uses. Two Bluetooth devices within **10 m** of each other can share up to **2.1 Mbps or 24 Mbps of capacity**. A Bluetooth system uses a **frequency-hopping** scheme. Susceptible to barriers and wall.

Chapter 2

How Wireless Works



Medium

The medium is the method that's used to propagate the data out into the world without using wires.

Note// The wireless networks utilize the (RF) radio frequency medium.

The Radio Frequency waves travel in a portion of the electromagnetic spectrum.

The signals of the wireless networks are part of the electromagnetic spectrum. Which means the electromagnetic spectrum is the basis for all wireless transmission.

What is the electromagnetic spectrum?

It's the range of all possible electromagnetic radiation extends.

Note// The waves of the electromagnetic spectrum can travel through matter or space.

The transmitter (Access Point) transmits RF Signal in a particular wavelength.

The characteristics of the wavelength and the environment determines how far it travels and delivers data.

The physical layer technologies used in Wireless Networks, is called unguided media (wireless communication).

Electromagnetic spectrum

Any electromagnetic signal can be shown to consist of a collection of periodic analog signals (sine waves) at different amplitudes, frequencies, and phases. It is the basis for all wireless transmission.

- The radio, microwave, infrared and visible light portions of the spectrum can all be used for transmitting information by modulating the wave's amplitude, frequency or phase.
- The higher frequencies, that is, ultraviolet light, X-rays and gamma rays, would give better results, but are normally not used because they are difficult to produce and modulate, do not propagate well through buildings and are harmful to humans.

Radio Frequency Signal Characteristics

RF characteristics are defined by the physics laws.

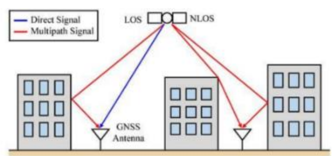
- ❑ characteristics of the RF
  - ✓ **Analog signal**
  - ✓ **Digital signal**
  - ✓ **Periodic signal**
  - ✓ **Aperiodic signal**
- ❑ Main characteristics of the RF
  - ✓ **Wavelength**
  - ✓ **Frequency**
  - ✓ **Amplitude**
  - ✓ **Phase**

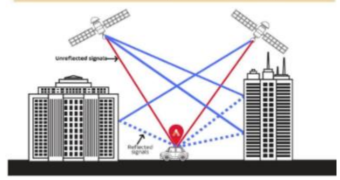
- **Analog signal**
  signal intensity varies in a smooth fashion over time.
- **Digital signal**
  signal intensity maintains a constant level for some period of time and then changes to another constant level.
- **Periodic signal**
  analog or digital signal pattern that repeats over time.
- **Aperiodic signal**
  analog or digital signal pattern that doesn't repeat over time.
- **Period (T)**
  amount of time it takes for one repetition of the signal.
  $T = 1/f$
- **Wavelength (λ)**
  The distance between two points of corresponding phase of two consecutive cycles.
  // The cycle is a one oscillates from positive (peak or crest) to negative (trough or valley)

$$Wavelength(\lambda) = \frac{velocity(V)}{frequency(f)}$$

- **Frequency**
  Frequency is a number of cycle or oscillate per second.
  // Measured in Hertz (Hz)
  Note// Inverse relationship between Wavelength and Frequency.
- **Amplitude (A)**
  maximum value or strength of the signal over time; typically measured in volts.
- **Phase (ϕ)**
  Measure of the relative position in time within a single period of a signal
  // Or, the position of a point in time on a complete cycle.
  - In Phase between two signal, if the position of the two points are in exact alignment.
  - Out of Phase between two signal, if the position of the two points are not in exact alignment.
  - If two signals in phase due to grater signal strength, and If two signals out of phase due to canceled each other.

Multipath signals





Components affect wireless networks.

- **Frequency**: (2.4 GHz or 5 GHz)
- **Environment**: (sandstorm, Humidity, fog)
- **Radio Frequency interference**: (2.4 GHz) range could be shared by mobiles, microwave.
- **Electrical interference**: Computers, lighting .. etc.
- **Obstacles**: Physical objects
- **Signal delivery** : FHSS, DSSS, OFDM

Data Communication Terms

- **Data** - entities that convey meaning, or information.
- **Signals** - electric or electromagnetic representations of data
- **Transmission** - communication of data by the propagation and processing of signals

Examples of Analog and Digital Data

1. **Analog**
   - Video
   - Audio
2. **Digital**
   - Text
   - Integers

Analog Signals

A continuously varying electromagnetic wave that may be propagated over a variety of media, depending on frequency

Examples of media:

- Copper wire media (twisted pair and coaxial cable)
- Fiber optic cable
- Atmosphere or space propagation

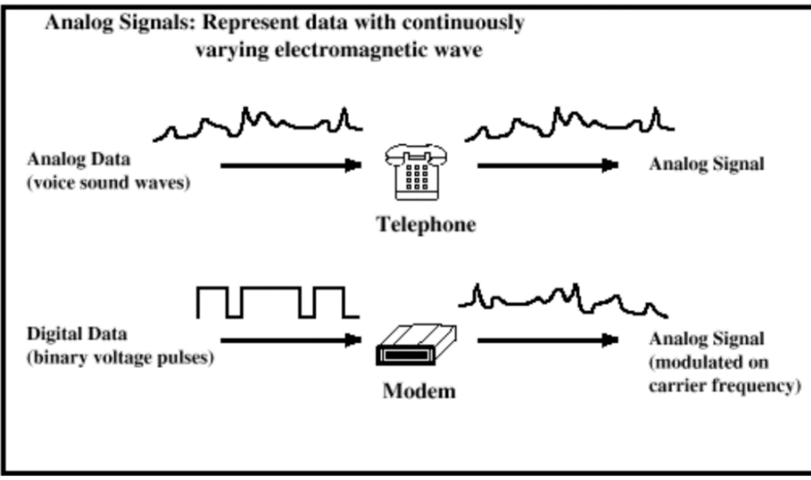
Note// Analog signals can propagate analog and digital data.

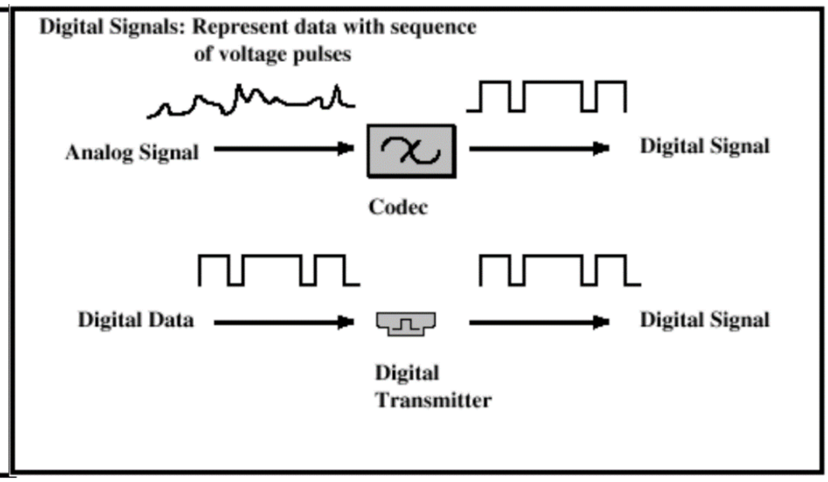
Digital Signals

A sequence of voltage pulses that may be transmitted over a copper wire medium

- Generally cheaper than analog signaling
- Less susceptible to noise interference
- Suffer more from attenuation

Note// Digital signals can propagate analog and digital data.





Reasons for Choosing Data and Signal Combinations

- **Digital data, digital signal**
  Equipment for encoding is less expensive than digital-toanalog equipment.
- **Analog data, digital signal**
  Conversion permits the use of modern digital transmission and switching equipment.
- **Digital data, analog signal**
  Some transmission media will only propagate analog signals λ Examples include optical fiber and satellite.
- **Analog data, analog signal**
  Analog data easily converted to analog signal.

Analog Transmission

Transmit analog signals without regard to content.

Attenuation limits length of transmission link
Cascaded amplifiers boost signal's energy for longer distances but cause distortion.

- Analog data can tolerate distortion.
- Introduces errors in digital data.

Digital Transmission

Concerned with the content of the signal.

Attenuation endangers integrity of data.

Digital Signal

- Repeaters achieve greater distance.
- Repeaters recover the signal and retransmit it.

Analog signal carrying digital data.

- Retransmission device recovers the digital data from analog signal.
- Generates new, clean analog signal.

Channel Capacity

Channel Capacity is the maximum rate at which data can be transmitted over a given communication path, or channel, under given conditions.

Concepts Related to Channel Capacity

- **Data rate** - rate at which data can be communicated (bps)
- **Bandwidth** - the bandwidth of the transmitted signal as constrained by the transmitter and the nature of the transmission medium (Hertz)
- **Noise** - average level of noise over the communications path
- **Error rate** - rate at which errors occur.
  - **Error** = transmit 1 and receive 0; transmit 0 and receive 1

Relationship between Data Rate and Bandwidth

The greater the bandwidth, the higher the information-carrying capacity

- Any digital waveform will have infinite bandwidth.
- BUT the transmission system will limit the bandwidth that can be transmitted.
- AND, for any given medium, the greater the bandwidth transmitted, the greater the cost.
- HOWEVER, limiting the bandwidth creates distortions.

Nyquist Bandwidth

- For binary signals (two voltage levels)
  - $C = 2B$
- With multilevel signaling
  - $C = 2B \log_2 M$
    - M = number of discrete signal or voltage levels

Signal-to-Noise Ratio

Ratio of the power in a signal to the power contained in the noise that's present at a particular point in the transmission.

// Typically measured at a receiver

- Signal-to noise ratio(SNR, or S/N)
  - $(SNR)_{dB} = 10 \log_{10} \frac{\text{signal power}}{\text{noise power}}$
- A high SNR means a high-quality signal, low number of required intermediate repeaters
- SNR sets upper bound on achievable data rate

Shannon Capacity Formula

- Equation:
- $C = B \log_2 (1+SNR)$
- *Spectrum of a channel between 3 MHz and 4 MHz;* $(SNR)_{dB} = 24\ dB$
- B= 4 MHz – 3 MHz = 1 MHz
- $(SNR)_{dB}$ = 24 dB = $10 \log_{10}(\text{SNR})$;
  SNR = 251
- Using Shannon's formula
  $C = 10^6 * \log_2 (1 + 251) \approx 10^6 * 8$ = 8 Mbps
- How many signaling levels are required?
  $C = 2B \log_2 M$

Classifications of Transmission Media

Transmission Medium

Physical path between transmitter and receiver

- **Guided Media**
  Waves are guided along a solid medium
  E.g., copper twisted pair, copper coaxial cable, optical fiber
- **Unguided Media**
  Provides means of transmission but does not guide electromagnetic signals.
  Usually referred to as wireless transmission
  E.g., atmosphere, outer space

BASIS FOR COMPARISON	GUIDED MEDIA	UNGUIDED MEDIA
Basic	The signal requires a physical path for transmission.	The signal is broadcasted through air or sometimes water.
Alternative name	It is called wired communication or bounded transmission media.	It is called wireless communication or unbounded transmission media.
Direction	It provides direction to signal for travelling.	It does not provide any direction.
Types	Twisted pair cable, coaxial cable and fibre optic cable.	Radio wave, microwave and infrared.

Unguided Media

Transmission and reception are achieved by means of an Antenna.

Configurations for wireless transmission

- Directional
- Omni-directional

General Frequency Ranges

Microwave frequency range

- 1 GHz to 40 GHz
- Directional beams possible
- Suitable for point-to-point transmission
- Used for satellite communications.

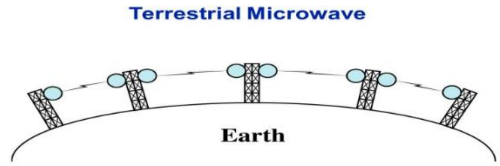
Radio frequency range

- 30 MHz to 1 GHz
- Suitable for omni-directional applications

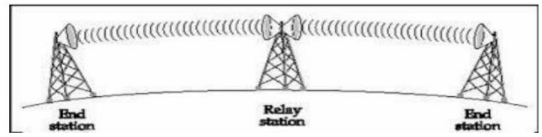
Infrared frequency range

- Roughly, $3x10^{11}$ to $2x10^{14}$ Hz
- Useful in local point-to-point multipoint applications within confined areas

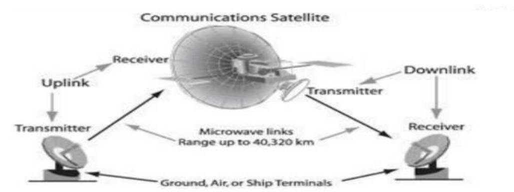
Terrestrial Microwave

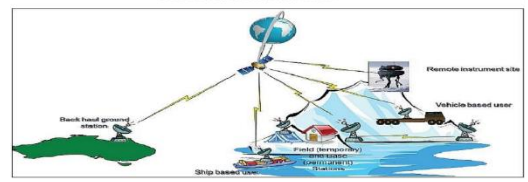


- **Description of common microwave antenna**
  - Parabolic "dish", 3 m in diameter
  - Fixed rigidly and focuses a narrow beam
  - Achieves line-of-sight transmission to receiving antenna
  - Located at substantial heights above ground level
- **Applications**
  - Long haul telecommunications service
  - Short point-to-point links between buildings



Satellite Microwave





- **Description of communication satellite**
  - Microwave relay station
  - Used to link two or more ground-based microwave transmitter/receivers
  - Receives transmissions on one frequency band (uplink), amplifies or repeats the signal, and transmits it on another frequency (downlink)
- **Applications**
  - Television distribution
  - Long-distance telephone transmission
  - Private business networks

Broadcast Radio

- **Description of broadcast radio antennas**
  - Omni-directional
  - Antennas not required to be dish-shaped
  - Antennas need not be rigidly mounted to a precise alignment
- **Applications**
  - Broadcast radio
    - VHF and part of the UHF band; 30 MHZ to 1GHz
    - Covers FM radio and UHF and VHF television

Multiple Access

Multiple Access schemes are used to allow many mobile users to share a finite amount of radio spectrum.

Note// The sharing of spectrum is required to achieve high capacity by simultaneous allocating the bandwidth.

Constraint: there should not be severe performance degradation.

Chapter 3

Spread Spectrum (SS)

SS is a form of wireless communications in which the frequency of the transmitted signal is deliberately varied. This results in a much greater bandwidth than the signal would have if its frequency were not varied.

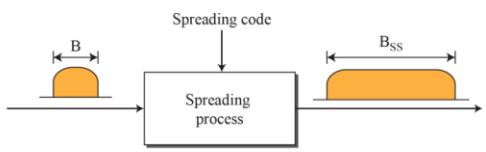
// SS **Spreads** data over wide **bandwidth.**

In **spread spectrum (SS)**, we combine signals from different sources to fit into a larger bandwidth, but our goals are to prevent **eavesdropping** and **jamming**. To achieve these goals, spread spectrum techniques add **redundancy**.

// SS Makes **jamming** and **interception** harder

// In SS signals from **different sources** are also **combined** to fit into larger bandwidth

Bandwidth required by station =B
Bandwidth spread by SS is B_{ss}
$B_{ss} >> B$



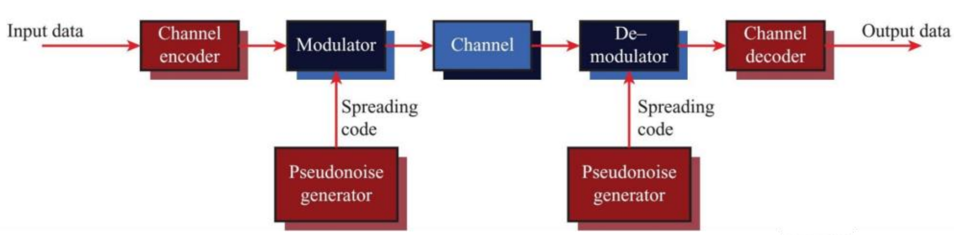
SS Signal vs Normal Signal

1. This signal occupies a larger bandwidth than that of a normal signal.
2. The spread spectrum signal invariably uses some kind of coding. The code word associated with an SS signal is independent of the information carried by a signal.
3. **The most important point is that the SS signal is "pseudorandom" in nature. This makes it appear like "random noise".** // Therefore the **normal receiver cannot** demodulate the SS signal. Only a **specially designed receiver** can demodulate it to recover the information.

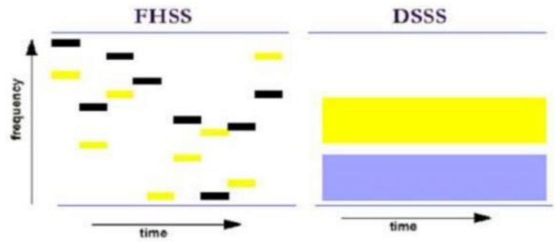
Spread Spectrum Advantages

- The signals gain immunity from various kinds of noise and multipath distortion.
- The earliest applications of spread spectrum were military, where it was used for its immunity to jamming.
- It can also be used for hiding and encrypting signals. Only a recipient who knows the spreading code can recover the encoded information.
- Several users can independently use the same higher bandwidth with very little interference. This property is used in cellular telephony applications, with a technique known as code division multiplexing (CDM) or code division multiple access (CDMA).

General Model of Spread Spectrum System



Techniques of Spread Spectrum



1. Frequency Hopping Spread Spectrum(FHSS)

is a method of transmitting radio signals by rapidly switching a **carrier** among many frequency **channels**, using a **pseudorandom** sequence known to both **transmitter and receiver**.

// Eavesdroppers hear unintelligible blips. Jamming on one frequency affects only a few bits.

- **Bandwidth Sharing in FHSS**

  // **FHSS** is similar to **FDM**

  It can use **Multiple FSK (MFSK)**

  Let number of hopping frequencies be **M**. we can multiplex **M** channels into one by using the same **B_{ss}**

  – In FDM, each station uses 1/M of bandwidth but allocation is fixed.

  – In FHSS, each station uses 1/M of bandwidth but allocation changes at every hop.

- **Multiple Frequency-Shift Keying (MFSK)**

  More than two frequencies are used. More bandwidth efficient but more susceptible to error.

$$s_i(t) = A\cos 2\pi f_i t \qquad 1 \le i \le M$$

  - $f_i = f_c + (2i - 1 - M)f_d$
  - f_c = the carrier frequency
  - f_d = the difference frequency
  - M = number of different signal elements = 2^L
  - L = number of bits per signal element

- **Disadvantages Of FHSS**

  – It has a relatively **low transfer limit**.

  – no built-in redundancy or **error checking**. Too many bits come out corrupted.

  – It takes a **significant time**, to establish sync between the receiver and transmitter.

  – **Complex** and **expensive** digital frequency synthesizers are required to be used.

2. Direct Sequence Spread Spectrum(DSSS)

Is a technique that expands the bandwidth of the original signal. Each bit is assigned a code of n bits, called chips, where the chip rate is n times that of the data bit.

- One method:

  – Combine input with spreading code using XOR

  – Input bit 1 inverts spreading code bit

  – Input zero bit doesn't alter spreading code bit

  – Data rate equal to original spreading code

- Performance similar to FHSS

- **Advantages Of DS-SS Systems**

  – The interference caused by the multipath reception is minimized successfully.

  – The performance of DS-SS system in presence of noise is superior to other system such as FH-SS system.

  – This system combats the intentional interference (jamming) most effectively.

- **Disadvantages Of DS-SS Systems**

  – DSSS systems are slow.

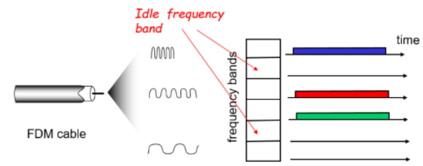
  – The channel bandwidth required is very large.

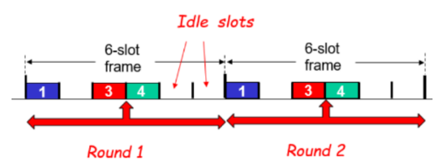
  – The synchronization is affected by the variable distance between the transmitter and receiver.

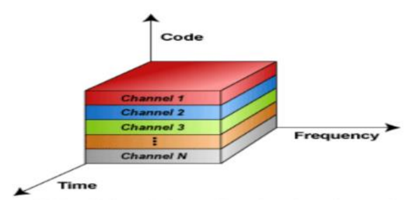
Multiple-access schemes

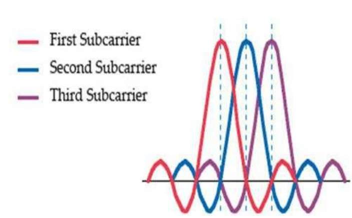
In a wireless environment, there is a need to address the issue of simultaneous multiple access by many users or mobile stations (MSs) in the transmission range between the BS and themselves. Users are able to receive signals transmitted by others in the system.
To provide **simultaneous**: two-way communications (duplex communication), a forward (downlink) channel from BS to MS and a reverse (uplink) channel from MS to BS are necessary.

Three basic ways in which many channels can be allocated within a given bandwidth (**Channel partitioning MAC protocol**) :

1. **(FDMA) - Frequency division multiple access**
   channel spectrum divided into frequency bands. each station assigned fixed frequency band. unused transmission time in frequency bands go **idle**.
   

   Channels can be assigned to the same frequency at all times, that is, pure FDMA, or change frequencies according to a certain pattern, that is, FDMA combined with TDMA.
   The latter is done in many wireless systems to circumvent narrowband interference at some frequencies, known as frequency hopping. The sender and the receiver agree on a hopping pattern, so that the receiver can tune to the right frequency.
   // example of FDMA, global system for mobile communication (GSM) standard for 900 MHz.
2. **(TDMA) -Time division multiple access**
   access to channel in "**rounds**". each station gets fixed length slot (like one packet in each round). unused slots go **idle**.
   

   // TDMA offers a much more **flexible** scheme as compared with FDMA.
   In TDMA, synchronization between receiver and sender has to be achieved in the time domain. This can be done either by using a fixed pattern or by using a dynamic allocation.
   // Many systems like IS-54, IS-136, GSM and digital European cordless telecommunications (DECT) use TDMA with fixed allocation.
3. **(CDMA) - Code division multiple access**
   // CDMA is basis for the 3G mobile systems
   

   CDMA in which each channel is assigned a unique code which is orthogonal to codes used by other users.
   CDMA is completely different from FDMA and TDMA.
   Instead of dividing the allowed frequency range into a few hundred narrow channels, CDMA allows each station to transmit over the entire frequency spectrum all the time.
   // Multiple simultaneous transmissions are separated using codes.
   In CDMA we **extract** only the desired signal and **reject** everything else as random noise.
   // each bit time is subdivided into m short intervals called chips.
   - **Advantage**
     – Good protection against interference and tapping.
   - **Disadvantages**
     – Receiver must be precisely synchronized with the transmitter to apply the decoding correctly.
     – Receiver must know the code and must separate the channel with user data from the background noise composed of other signals and environmental noise.
4. **(OFDM) - Orthogonal Frequency Division Multiplexing**
   OFDM uses multiple carrier signals at different frequencies, sending some of the bits on each channel.
   

   // OFDM-based techniques that have created great expansion in the capacity of wireless networks.
   // OFDM uses to move from third to fourth generation cellular.
   // OFDM also allowed the expansion of IEEE 802.11 data rates.

Chapter 4

How do Satellites Work

Two Stations on Earth can use a satellite as a relay station for their communication.

- One Earth Station **sends** a transmission **to** the **satellite**. This is called a **Uplink**.
- The satellite Transponder converts the signal and **sends** it down **to** the second earth **station**. This is called a **Downlink**.

Advantages of Satellites

- The coverage area of a satellite greatly exceeds that of a terrestrial system.
- Transmission cost of satellite is independent of the distance from the center of coverage area.
- Satellite to Satellite communication is very precise.
- Higher Bandwidths are available for use.

Disadvantages of Satellites

- Launching satellites into orbit is costly.
- Satellite bandwidth is gradually becoming used up.
- There is larger propagation delay in satellite communication than in terrestrial communication.

Factors in satellite communication

1. **Elevation Angle**
   The angle of the horizontal of the earth surface to the center line of the satellite transmission beam.
2. **Coverage Angle**
   A measure of the portion of the earth surface visible to a satellite taking the minimum elevation angle into account.
3. **Other impairments to satellite communication**
   - The distance between an earth station and a satellite.
   - **Satellite Footprint**: The satellite transmission's strength is strongest in the center of the transmission, and decreases farther from the center as free space loss increases.
   - Atmospheric Attenuation caused by air and water.

Ways to Categorize Communications Satellites

1. **Coverage area**
   - Global, Regional, National
2. **Service type**
   - Fixed service satellite (**FSS**), Broadcast service satellite (**BSS**), Mobile service satellite (**MSS**)
3. **General usage**
   - Commercial, military, amateur, experimental

Fixed service satellite (FSS)

Is a type of satellite used for services such as **telephone calls**, and **television signals** for **broadcasting**.

Fixed service satellite generally have a low power output and larger dish-style antennas are required for reception. Fixed service satellites have less power.

Mobile service satellite (MSS)

provide two-way voice and data communications to global users who are on the go or in remote locations.

// terminals range in size from handheld to laptop-size units.

// Terminals can be mounted in vehicle, with communications maintained while the vehicle is moving.

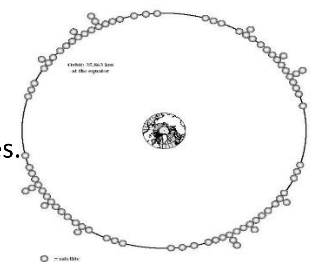
Broadcast service satellite (BSS)

Broadcasting service satellite is a type of satellite used for consumer services such as the transmission of radio and television programs. A broadcasting satellite is similar to a fixed service satellite (FSS) however it offers a higher power output requiring smaller antennas for receiving the signal.

Classification of Satellite Orbits

1. **Circular or elliptical orbit**
   - Circular with center at earth's center
   - Elliptical with one foci at earth's center
2. **Orbit around earth in different planes**
   - Equatorial orbit above earth's equator
   - Polar orbit passes over both poles
   - Other orbits referred to as inclined orbits.
3. **Altitude of satellites**
   - **Geostationary orbit (GEO)**
   - **Medium earth orbit (MEO)** or "Middle-earth" orbit
   - **Low earth orbit (LEO)**

Geostationary Earth Orbit (GEO)



These satellites are in orbit 35,863 km above the earth's surface along the equator.

Objects in Geostationary orbit revolve around the earth at the same speed as the earth rotates. means GEO satellites remain in the same position relative to the surface of earth.

Advantages of the GEO orbit

1. No problem with frequency changes
2. Tracking of the satellite is simplified
3. High coverage area
4. Good for broadcasting TV because of large area covered by frequencies

Disadvantages of the GEO orbit

- Weak signal after traveling over 35,000 km
- Polar regions are poorly served
- Signal sending delay is substantial

Low Earth Orbit (LEO)

LEO satellites are much closer to the earth than GEO satellites, ranging from 500 to 1,500 km above the surface.

Note// LEO satellites **don't** stay in fixed position relative to the surface, and are only **visible** for **15** to **20 minutes** each pass.// Orbit period range from 1.5 to 2 hours// Diameter of coverage is about 8000 km // **Round-trip** signal propagation delay **less than 20 ms**

A network of LEO satellites is necessary for LEO satellites to be useful.

- Little LEOs
  - Frequencies below 1 GHz
  - 5MHz of bandwidth
  - Data rates up to 10 kbps
  - Aimed at paging, tracking, and low-rate messaging
- Big LEOs
  - Frequencies above 1 GHz
  - Support data rates up to a few megabits per sec
  - Offer same services as little LEOs in addition to voice and positioning services (ie. Globalstar)

Advantages of the LEO orbit

5. A LEO satellite's proximity to earth compared to a GEO satellite gives it a better signal strength and less of a time delay, which makes it better for point to point communication.
6. A LEO satellite's smaller area of coverage is less of a waste of bandwidth.

Disadvantages of the LEO orbit

- A network of LEO satellites is needed, which can be costly
- Atmospheric drag effects LEO satellites,

Medium Earth Orbit (MEO)

A MEO satellite is in orbit somewhere between 5,000 km and 12,000 km above the earth's surface, Circular orbits.

// MEO satellites have a larger coverage area than LEO satellites. Diameter of coverage is 10,000 to 15,000 km.// MEO satellites are **visible** for much longer periods of time than LEO satellites, usually between **2 to 8 hours.**// **Round trip** signal propagation delay **less than 50 ms**

// MEO satellites are similar to LEO satellites in functionality.

Advantages of the MEO orbit

7. A MEO satellite's longer duration of visibility and wider footprint means fewer satellites are needed in a MEO network than a LEO network.

Disadvantages of the MEO orbit

– A MEO satellite's distance gives it a longer time delay and weaker signal than a LEO satellite, though not as bad as a GEO satellite.

Satellite Link Performance Factors

- Distance between earth station antenna and satellite antenna.
- For downlink, terrestrial distance between earth station antenna and "**aim point**" of satellite.
- Atmospheric attenuation (Affected by oxygen, water, angle of elevation, and higher frequencies)

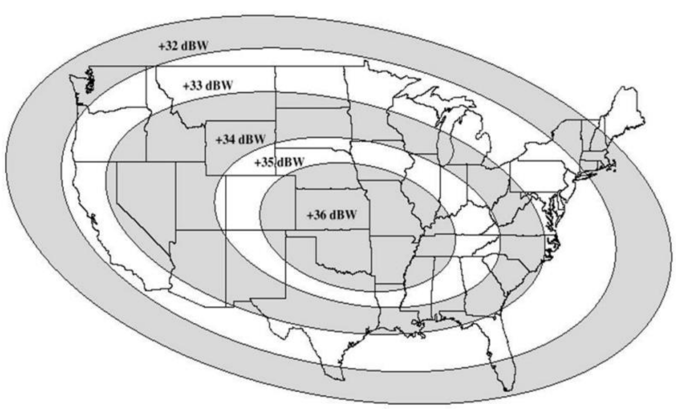
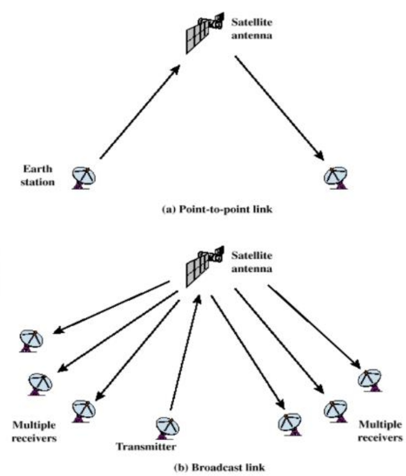


Figure 9.6 Typical Satellite Footprint



Capacity Allocation Strategies

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

Chapter 5

What is Mobile IP

Mobile IP is a standard communications protocol that is designed to allow mobile device users to move from one network to another while maintaining a permanent IP address.

// The Mobile IP allows for location-independent routing of IP datagrams on the Internet. Each mobile node is identified by its home address disregarding its current location in the Internet. While away from its home network, a mobile node is associated with a care-of address which identifies its current location and its home address is associated with the local endpoint of a tunnel to its home agent.

- Mobile IP protocols provide mobility support for IP network.
- It allows transparent routing of IP datagrams to mobile nodes in the Internet.
- In mobile IP , each mobile node is always identified by its home address, regardless of 'its current point of attachment to the Internet.
- Every mobile node is associated with a care-of address, which provides information about its current point of attachment to the Internet.
- Is a communication protocol that allows mobile devices to move from one n/w to another while maintaining permanent IP address.

Mobile IP Goals

- To continue to work with the existing TCP/IP protocol suite.
- To provide Internet-wide mobility, allowing a host the same IP address, called 'home address'.
- To optimize local area mobility without sacrificing performance or functionality of general case.
- To leave the transport layer and higher protocols untouched.
- To ensure that no application needs to change in order to run on or to change in order to run on or to be used from mobile hosts (MHs).

Mobile IP Uses

Enable devices to maintain Internet connectivity while moving from one Internet attachment point to another

- **Mobile** – user's point of attachment changes dynamically and all connections are automatically maintained despite the change
- **Nomadic** - user's Internet connection is terminated each time the user moves and a new connection is initiated when the user dials back in. // New, temporary IP address is assigned

Capabilities of Mobile IP

- **Discovery**
  Mobile node uses discovery procedure to identify prospective home and foreign agents.
- **Registration**
  Mobile node uses authenticated registration procedure to inform home agent of its care-of address.
- **Tunneling**
  Used to forward IP datagrams from a home address to a care-of address.

The Requirements For Physical Mobility

Wireless Communication

Mobile computers require both wireless and wired network access. Communication delays are more frequent due to retransmissions, timeouts and error-control processing. The wireless connection can also be lost or degraded by mobility if the enters high-interference areas.

1. **Wireless Networks**
   Wireless networks deliver much lower bandwidth than wired ones.
2. **Mobility**
   Address migration: As people move, their mobile computers will have to use different **network service access points**(NSAPs).
3. **Portability**
   handheld devices need to have wristwatch properties they need to be small, light and water resistance and have long battery life.

Cellular Communication

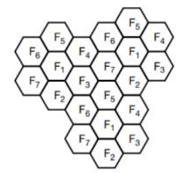
Cellular communication is the foundation of mobile wireless communications and supports users in locations that are not easily served by wired networks.

// Cellular communication is the underlying technology for **mobile telephones**, **smartphones**, **tablets**, **wireless Internet** and **wireless applications**, and much more.

// Cellular communication has subject to many generations, in which the communication bandwidths and data speeds have continuously increased. This has given rise to many applications that have benefited mobility.

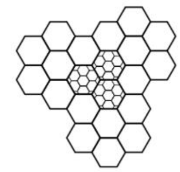
Cells

- The system architecture is such that a geographic region is divided into cells. The size of the cells is about **10–20 km**.
- Each cell uses some set of frequencies not used by its neighbors.
- Transmission frequencies are reused in nearby but not adjacent cells, to reduced the interference.
- Figure 2.4a illustrates the concept of frequency reuse. The cells are normally circular but are shown as hexagonal for ease of drawing
- If the area is overloaded, the power is reduced and the overloaded cells are split into smaller microcells Figure 2.4b.



(a)

Figure



(b)

Figure 2.4(b) Microcells add more users

Handoff

If a call is in progress, the mobile is asked to switch to the new channel used in that adjacent cell. This process is called **handoff or handover**. A BS is only a radio relay.

- Handoffs can be either soft or hard:
  - In a **soft handoff**, the mobile is acquired by the new BS before the old one signs off. Thus, there is no loss of continuity. But it requires the mobile to be able to tune to two frequencies at the same time. **Neither first- nor second-generation** devices can do this. **3G CDMA systems** provide soft handover
  - In a **hard handoff**, the old BS drops the mobile before the new one acquires it. The call is disconnected abruptly if there is no available frequency with the new BS, or there is a call drop till the new frequency is received. This is noticeable by the user but is typically of very short duration of about 60 ms in GSM systems.

1. **The first generation (1G): 1980**

   // Analog cellular systems is the first generation of mobile telephone communication systems. They used analog frequency modulation for **only voice (speech) transmission**.

   - The various systems that fall in this category are:
     - AMPS (Advanced Mobile Phone Service) (USA)
     - Nordic Mobile Telephone (NMT)-900 (Sweden)
     - Cellular Digital Packet Data (CDPD)

2. **The second generation (2G):1992**

   the second generation is digital.

   - The various advantages of digital cellular are as follows:
     1. It is more robust as it displays resistance to noise and has efficient error correction.
     2. It exhibits the intelligence of the digital network.
     3. It is more flexible and can be integrated with the wired digital network.
     4. Reduced RF transmission power is needed.
     5. Encryption can be provided for communication privacy.
     6. System complexity is reduced.
     7. User capacity is increased.

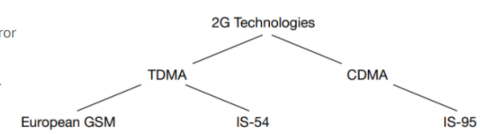
   

   Figure 2.5 The 2G Technologies

   2) **The second generation (2.5G):1996**

      Enhanced data rates for GSM evolution (EDGE) is a 2.5G system, with a data rate of 384 kbps, which is higher than GSM.

      // GPRS (general packet radio service) is another 2.5G scheme

3. **The third generation (3G): 2000+**

   The objective of the third generation of wireless communication is to provide fairly **high-speed** wireless communications to support **multimedia**, **data**, and **video** in addition to **voice**.

   Its goals:
   1. Support high mobile velocity (300–500 km/hour), compared with less than 100 km/hour in GSM.
   2. Support global roaming, as opposed to district and country in GSM.
   3. Support multimedia service, especially Internet service, 144 Kb/s (outdoor and higher velocity), 384 Kb/s (from outdoor to indoor, lower velocity)
   4. Convenience for transition and evolvement or innovation, compatibility of services with various fixed/mobile networks.
   5. More efficient use of the available spectrum in general.

4. **The fourth generation (4G):2002+**

   - 4G systems provide ultra-broadband Internet access for a variety of mobile devices including laptops, smartphones, tablets, and device-to-device communications.
   - 4G networks support Mobile Web access and high bandwidth applications such as high-definition mobile TV, mobile video conferencing, and gaming services.
   - Be based on an all-IP packet-switched network.
   - Support data rates of up to 100 Mbps for high-mobility mobile access and up to 1 Gbps for low-mobility access such as local wireless access.
   - Dynamically share and use network resources to support more simultaneous users per cell.

Chapter 6

Overview

- A wireless LAN uses wireless transmission medium
- Wireless LANs (WLANs) play an important role in the local area network market
- wireless LANs are vital to traditional wired LANs: for mobility, ad hoc networking, and coverage of locations difficult to wire.
- Popularity of wireless LANs has grown rapidly
- wireless devices use WLANs as replacement for cellular coverage when in range (indoors)

Motivation

- **Cellular data offloading**: The spectrum available in mobile cellular networks is limited and costly to consumers. Mobile devices such as smartphones, laptops, and tablets can use higher capacity WLANs. This is especially helpful in high density locations such as shopping malls, enterprises, universities.
- **Sync/file transfer**: Multi-gigabit Wi-Fi (Wireless Fidelity) allows synchronization between devices 10 times faster than previous Wi-Fi.
- **Internet Access**: Multi-gigabit Wi-Fi enables faster Internet access, eliminating any significant bottlenecks from the WLAN.
- **Multimedia Streaming** :Streaming uncompressed video can require 3 Gbps, and streaming of compressed video has issues of quality and latency. Wi-Fi is suitable because of its larger deployment, user awareness, support for IP networking, ease of connection, and standardized security mechanism.

Single-Cell WLAN Configuration

- Connection to backbone LAN.
  - (such as Ethernet): supports servers, workstations, routers to link with other networks
- Use control modules to connect to both types of LANs.
  - The control module includes either bridge or router functionality to link the wireless LAN to the backbone
- Each control module supports a number of wireless end systems within its transmission range.
  - For example, with IEEE 802.11ad WLAN, transmission is limited to a single room due to its use of 60 GHz frequencies

Multiple-Cell WLAN Configuration

In this case, there are multiple control modules interconnected by a wired LAN. Each control module supports several wireless end systems within its transmission range.

For example, with an infrared LAN, transmission is limited to a single room; therefore, one cell is needed for each room in an office building that requires wireless support

Applications – Ad Hoc Networking

- Peer-to-peer network-(no centralized server)
- Set up **temporarily** to meet some immediate need.
- **E.g.** group of employees, each with laptop or palmtop, in business or classroom meeting
- Network for duration of meeting

Wireless LAN Requirements

- High capacity, short distances, full connectivity, broadcast capability
- Throughput
- Number of nodes
- Connection to backbone LAN
- Service area
- Low power consumption
- Transmission robustness and security
- Collocated network operation
- License-free operation
- Handoff/roaming
- Dynamic configuration