ASSIGNMENT - 1

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1) A network can be described as the interconnection of systems, people or things using communication media, while wireless communication employs electromagnetic waves to transmit & receive data or voice, with the electromagnetic spectrum

In today's world, wireless communication holds immense significance:

→ Wireless technology enables seamless connectivity for mobile devices, including tablets, smartphones, laptops & GPS devices, supporting communication on the go.

→ Networks like Wi-Fi & cellular provide universal access to the internet & communication services, fostering global connectivity & info exchange.

Advantages:

1) Users experience greater freedom of movement with wireless connectivity, ensuring flexibility.

2) It offers internet & communication access even in remote areas where laying physical cables is difficult.

3) Wireless networks can be easily expanded or adapted to accomodate more devices or cover large areas.

Limitations:

→ Wireless signals have a restricted reach compared to wired connections, potentially leading to coverage gaps or the need for additional infrastructure.

→ Many wireless devices rely on batteries or power sources, which can impact device lifespan & require maintenance.

(2) Signal propogation in wireless communication is governed by several key principles that are essential to understanding how information is transmitted & received in wireless networks.

Here are the fundamental principles of signal propogation in wireless communication.

→ Electromagnetic waves: Wireless communication relies on electromagnetic waves, which includes radio waves, microwaves & other forms of electromagnetic radiation. These waves travel through space & can carry information in the form of modulated signals.

-> **Propagation Loss**: As electromagnetic waves travel through space, they experience propagation loss, also known as path loss. This loss occurs due to factors like distance from the transmitter, signal frequency & interference. Path loss causes the signal strength to decrease with distance from the source.

Line-of-Sight: Line-of sight propagation occurs when there is a clear & unobstructed path between the transmitter and receiver. In this scenario, electromagnetic waves travel directly from the transmitter to the receiver without encountering obstacles or reflections.

Effects on Signal Strength & Quality:

Strong Signal Strength: LOS propagation typically results in strong signal strength since "-

there are minimal obstacles to attenuate or scatter the signal.

Low Signal Delay: Signal propagation in LOS conditions involves minimal delay because the waves follow a straight path.

Low Signal Attenuation: The signal experiences minimal attenuation in LOS conditions, resulting in a high quality, reliable connection.

Non-Line-of-Sight [NLOS] Propagation:

Non-line-of-sight propagation occurs when there are obstacles, such as buildings, trees, between the transmitter and receiver. In NLOS scenarios, the signal may experience reflections, diffraction, and scattering.

Effects on Signal Strength & Quality:

Reduced Signal Strength: NLOS propagation often leads to reduced signal strength due to signal attenuation caused by obstacles & reflections.

Signal Delay and Multipath Effects: Signals in NLOS conditions may experience delays and multipath effects because they take various paths as they bounce off obstacles. This can result in signal interference, known as multipath fading.

Signal Quality Variability: NLOS conditions can lead to signal quality variations, making the connection less reliable and subject to fluctuations.

(3) Fading in wireless communication refers to the variation or fluctuations in the strength & quality of a received signal as it travels from a transmitter to a receiver. These variations are caused by several factors, including the physical characteristics of the wireless channel and the environment through which the signal propagates. Fading can have a significant impact on the reliability & performance of wireless communication systems.

There are different types of fading in wireless communication, including path loss, shadowing and multipath fading:

1) Path Loss: Path loss, is a type of fading that occurs due to the natural spreading of electromagnetic waves as they travel through space.

Eg: Imagine a cellular tower transmitting a signal to a mobile phone. As the distance between the tower & the mobile phone increases, the signal strength decreases due to path loss. This is why mobile devices need to be within a certain range of the tower to maintain a "reliable connection.

2) Shadowing [Log-Normal Fading]:

Shadowing is caused by large objects in the single path that block the signal. These obstacles create areas of reduced signal strength or "shadows".

Eg: In an urban environment, tall building can cast shadows where the signal strength from a nearby base station is significantly weaker. This can result in uneven coverage & signal dropouts as a mobile device moves through the city.

3) Multipath Fading: Multipath ~~f~~ fading occurs when the transmitted signal takes multiple paths to reach the receiver due to reflections diffractions & scattering from various objects in the environment. These delayed & phase shifted signal components can interfere constructively or destructively, causing signal variations.

Eg:- Consider a Wi-Fi signal in a room with walls. The signal reaches a receiver not only directly from the router but also after reflecting off walls, leading to constructive interference or destructive interference at different locations within the room.

4) Fast Fading vs Slow Fading:

Fast fading refers to rapid & short-term variations in signal strength, typically occuring over a small fraction of a second.

Slow fading, on the other hand, involves gradual & long-term signal variations, which may occur ~~over~~ several seconds to minutes.

Eg: Fast fading: Mobile phones in a moving vehicle.
Slow fading: Building penetration with Wi-Fi.

(4) Multiple access in wireless communication is the method by which multiple users or devices shares a common communication channel or medium to transmit and receive data simultaneously. The goal of multiple access techniques is to efficiently allocate & manage the available resources to accomodate resources to accomodate the needs of various users or devices.

FDMA	TDMA	CDMA
→ Stands for Frequency Division multiple access	→ Stands for Time Division Multiple access.	→ Stands for Code Division multiple access.
→ Mode of data transfer is continuous signal.	→ Mode of data transfer is signal in bursts.	→ Mode of data transfer is digital signal.
→ Synchronization is not required.	→ Synchronization is required.	→ Synchronization is not required.
→ there is no need of any code word.	→ there is no need of any code word	→ Codeword is necessary.
→ It is little flexible	→ It is moderate flexible	→ Highly flexible.

(5) Given frequency $f = 2.4\ GHz$

$B.W = 20\ MHz$.

$SNR = 25\ DB$.

max achievable data rate = ?

Channel Capacity $C = B \log_2 (1 + SNR)$.

$\Rightarrow SNR = 25\ DB$.

$10 \log_{10}(S/N) = 25$

$$\log_{10}(S|N) = 2.5$$

$$S|N = 10^{2.5}$$

$$\Rightarrow \quad S|N = 316.277$$

$$\Rightarrow C = 20\times10^{6} \log(1+316.277)$$

$$C = 20\times10^{6}(8.31)$$

$$C = 16.62\times10^{7} \text{ bps}$$

$$C = 166.2 \text{ Mbps}$$

(6) $B.W = 4000\ Hz$.

Given that $\Rightarrow$ 4 levels.

Max achievable data rate $C = 2B\log_2 M$

$$C = 2(4000)^2 \log_2 4$$

$$\boxed{C = 16000}$$

(7) $BW = 20\ KHz$. [Noiseless channel]

We need to send 280 kbps $= C$

$$M = ?$$

$$C = 2B\log_2 M$$

$$280 \times 10^3 = 2(26 \times 10^3) \log_2 M$$

$$7 = \log_2 M$$

$$M = 2^7 \Rightarrow \boxed{M = 128}$$

(8) In dB, we have

$$P_r(dBM) = P_t(dBM) - 21.98 + 20\log_{10}(\lambda) - 20\log_{10}(d)$$

$$P_{loss} = L_p = P_t - P_r = 21.98 - 20\log_{10}(\lambda) + 20\log_{10}(d)$$

$$\lambda = c/f$$

Given $f = 2.4\ GHz$

transmission power $= 20\,dBM \rightarrow P_t$

receiver sensitivity $= -90\,dBM \Rightarrow P_r$

path loss component $= 3.5$

distance between T & R $= d = ?$

$$P_r = P_t = 21.98 + 20\log_{10}(\lambda) - 20\log_{10}(d)$$

$$-90 = 20 - 21.98 + 20\log_{10}\left(\frac{3 \times 10^8}{2.4 \times 10^9}\right) - 20\log_{10}(d)$$

$$20 \log_{10}(d) = 20 - 21.98 + 90 - 18.06$$

$$20 \log_{10}(d) = 69.96$$

$$\log_{10}(d) = 3.498$$

$$d = 10^{3.498}$$

$$d = 3147.74$$

∴ Maximum distance between transmitter receiver that allows successful communication

$$d = 3147.94$$