Homework -1

1. Define wireless communication and explain its importance in today's world. Discuss the advantages and limitations of wireless communication.

It is known as transmission of data between two user’s without using any physical medium like wires. In wireless communication it uses electromagnetic waves like frequency, microwave, infrared rays for sending data, voice and video over distance.

Importance:-

Wireless communications plays a vital role in today’s world and has become a integral part of our day to day life due to following reasons:

* Connectivity: It helps in connecting people and their devices to connect across the world.
* Efficiency: It enhances efficiency by enabling people to work remotely from any where and any time.
* Emergency services: It play a important role in emergency services by providing quicka and reliable communication during emergencies like natural disasters and personal emergencies.

Advantages:

* Mobility: Easy to carry around when required and very convenient for every one.
* Cost: making or maintaining involves very less cost and makes it viable option for mass usage.
* Scalability: Is to scale up or down depending on our requirements like adding a wifi extender for increasing wifi range.
* Flexibility: Easy to configure and make changes to the network communication like setting up the password for the wifi.

Limitations:

* Security: Wireless network communication are prone to security risks both from physical and network side like DDOS attacks, MIM attack and stealing the hardware.
* Bandwith: Due to it’s compatible in size routers have limited bandwith capacity and range limitations.

2. Signal Propagation:

Im wireless communication the transmission is done using the electromagnetic waves through the air to transfer data/ information.

* Wavelength and frequency of the EM wave determine the how strong or weak a wave is.
* Relection from signals is caused by the signal bouncing off from the surfaces like walls , buildings, trees etc..,
* Diffraction occurs when a signal encounters obstacles with sharp edges like pyramids, mountains sky scrapper etc.., the signal diffract around these type of obstacles enabling them to reach areas that would otherwise be in shadow.

Line of Sight(LOS):

In Los conditions, the transmitter and receiver have an clear in sight and are visible to eachother without any obstacles in between. It is characterized by minimal signal attenuation which in turn results in strong signal strength and high-quality communication.

A close-up of a computer screen

Description automatically generated

Non line of sight (NLOS):

In NLOS conditions, the obstacles obstruct the path between the tranmisster and the receiver resulting in no direct path between them. In NLOS propagraion the signal attenuation, scattering and multipath effect which leads to decrease in signal strength and signal degradation resulting in low quality or noise signal at the receiver end.

The NLOS is commonly seen in ubran areas has they have many tall buildings which block the direct path.

A group of pyramids with snow on top

Description automatically generated

Effects on Signal Strength and quality:

* Signal Strength(Attenuation): In Los conditions, Signal strength is typically high, and attenuation is minimal.
* Signal quality: In LOS, the signal quality is generally excellent with minimal fading and interference where in NLOS the multipath propagationcan cause fading, which can result in signal distortion and less quality signal.
* Rate : In LOS, it will have higher data rates because of the direct path between transmitter and receiver resulting in strong signal and minimal interference.
* REliabiliy: LOS conditions are more reliabel for wireless communication because of the consistent signal strength and quality.

These principals along with different signal propagation techniques are very important in desgining and iptimising the wireless network to get the desired output.

3. Fading in Wireless communications:

Fading can be defeind as a common phenomenon in wireless communications that results from variations in the received signal strength or quality over time and space. It can be significantly affect the reliability and performance of the wireless communication system, including cellular networks and radio communications

There are different types of fading such as path loss, shadowing and multipath fading.

PathLoss: It is also known as free-space path loss, occurs as a wireless signal travels through space and speraads out causing it to be weaker as the distance increases from the source or transmitter. The signal power diminishes in proportion to the square of the distance between the transmitter and receiver. As the result the received signal power will be very less compared to the transmitted signal.

Example: A wifi in home network will have more signal strength and speed when the user and the router are in the same room and nearer to each other. But the signal and sterenth and speed drastically drops when we move from that to other room due to distance and obstacales in between.

Shadowing: Shadowing, it is also known as log-normal shadowing, which is caused by osbstruction from buildings , trres, mountains etc.., It is often characterized by the log-normal distribution of signal variations which means signal strength follows a statistical pattern.

Example: When we are using the mobile phone in a city, the signal strength can vary significantlyas you move through areas with tall buildings. This buildings will create shadow signal regions where signals are weak leading to call drops.

Multipath Fading:- The Multipath fading occurs when a wireless signal takes multiple path to reach the receiverdure to reflections, diffractions and scatiering off objects in its path. These different signal paths can interfere constructively with at the receiver, resulting in signal variations, including deep fades and signal enhancements.

Example:

When you listen to a FM radio station while bigen in moving car, you may experience signal fading caused by multipath reflections from nearby buildings or hills. As you car moves the relative phases of the reflected signals changes, Leading to fading and interference.

In general, fading in wireless communication refers to the variation in signal strength and quality caused by factors like distance, obstacles and multipath propagation.

4. Multiple Access in Wireless Communications:-

Multiple access is a fundamental concept in wireless communications that allows multiple users or communications that allows multiple users or devices to use the same transmission medium like radio frequency, Infrared rays in organized and efficient manner. There are different types of multiple access techniques depends on various factors likes bandwidth available , system requirements and interference.

Difference between TDMA, FDMA and CDMA

|  |  |  |  |
| --- | --- | --- | --- |
|  | TDMA | FDMA | CDMA |
| Allocation methods | Allocates frequency to users based on time slots. | Allocates independent frequency channels to users | Assigns unique code to users. |
| Interference Handling | For data transmission it uses separate time solts, so interference occurs in the time domain. | It tranmits data using separate frequency bands. So, Interference occurs in frequency domain as it may result in collision | It can transmit simultaneously, but interference is controlled using unique codes and signal processing techniques. |
| Bandwidth Efficiency | It may lead to underutilization of bandwidth if users do not fully occupy their allocated slots or channels | It may lead to underutilization of bandwidth if users do not fully occupy their allocated slots or channels | It uses bandwidth much effiecent when compared to other two as users can transmit concurrently, utilizing the entire bandwidth |
| System Flexibility | It is suited for sytems with fixed number of users and channels | It is suited for sytems with fixed number of users and channels | It is more flexible and can accommodate a variable number of users |
| Suited Environments | It can used where time synchronization can be achieved | It can be used when we have less users or more bandwidth available to use it. | It can easily handle multipath fading and signal less effect due to interference. |

The three multiple access techniques used in wireless communication to enable efficiently sharing the communication medium between different users.

5. A wireless communication system operates at a frequency of 2.4GHz and has a bandwidth of

20MHz. If the signal-to-noise ratio (SNR) is 25dB, determine the maximum achievable data rate using

Shannon's equation.

Ans:

**Given Values**:

* + Frequency: 2.4 GHz
  + Bandwidth: 20 MHz = 20 x 106 Hz.
  + Signal-to-Noise Ratio (SNR in dB): 25 dB.

SNR=10SNRdb/10

= 1025/10 = 102.5 = 316.22776 = 316.23

R = B log2 (1+SNR)

* + - * 20 \* 106 log2(1+316.23)
      * 166.187 \* 106 bps
      * 166.2 Mbps

Maximum Data Rate= 166.2 Mbps

6. A communication system uses a bandwidth of 4000Hz and is transmitting a signal with four levels.

Determine the maximum achievable data rate using Nyquist's formula.

Ans:

**Given Values:**

* Bandwidth (*B*) = 4000 Hz,
* Number of levels (*M*) = 4.

R = 2\*B\* log2​(*M*)

* 2 \*4000\* log2 4
* 2 \*4000\* log2 22
* 2 \*4000\*2\* log2 2
* 4\*4000\*1
* 16000 bps
* 16 Kbps

Maximum data rate = R= 16 Kbps

7. Consider a noiseless channel with a bandwidth of 80KHz. We need to send 1120Kbps over a channel. How many signal levels are required?

Ans:

**Given Values:**

* Bandwidth (*B*) = 80 KHz
* Data Rate (*R*) = 1120 Kbps

M = 2 R/(2\*B)

* 21120\*1000/2\*80\* 1000
* 2112/16
* 27
* 128

8. A wireless communication system operates at a frequency of 2.4GHz and has a transmission power of 20dBm. The receiver sensitivity is -90dBm. The path loss exponent for the environment is measured to be 3.5. Calculate the maximum distance between the transmitter and receiver that allows successful communication, assuming free space path loss model.

Ans:

* Transmission Power = (Pt) = 20 dBm
* Receiver Sensitivity = -90 dBm
* Path Loss Exponent (n) = 3.5
* Frequency = f = 2.4 GHz = 2.4 109 Hz

Path loss Exponent

Pt =Pr + 20\* log10 (d) - 20\* log10 (λ ) - 21.98

= 20\* log10 (d) = Pt – Pr + 21.98 +20\*log10 (3\*108/2.4 \* 109)

20\*log10­(d) =PL -21.98 – 18.06

20\*log10(d) = 110- 21.98 –18.06

20 \* Log10(d) = 69.96

Log10(d) = 3.498

d= 103.498 = 3147.74

9. Suppose that a CDMA system has four orthogonal codes as follows:

v1 = (1, -1, 1, -1)

v2 = (-1, -1, 1, 1)

v3 = (1, 1, 1, -1)

v4 = (1, -1, -1, 1)

Sender 1 and receiver 1 data is encoded with v1, sender2 and receiver2 with v2, and so on.

Suppose that the following data signals are to be transmitted simultaneously:

Sender 1 => 0 1 0 1 0 1

Sender 2 => 1 1 0 0 1 1

Sender 3 => 0 0 0 1 0 0

Sender 4 => 1 1 1 0 0 0

Show by means of a diagram the encoding of the individual data signals, the generation of the composite signal, and how each receiver interprets the correct signal.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 0 | | | | 1 | | | | 0 | | | | 1 | | | | 0 | | | | 1 | | | |
|  | -1 | 1 | -1 | 1 | 1 | -1 | 1 | -1 | -1 | 1 | -1 | 1 | 1 | -1 | 1 | -1 | -1 | 1 | -1 | 1 | 1 | -1 | 1 | -1 |
|  | -1 | -1 | 1 | 1 | -1 | -1 | 1 | 1 | 1 | 1 | -1 | -1 | 1 | 1 | -1 | -1 | -1 | 1 | 1 | 1 | -1 | -1 | 1 | 1 |
|  | -1 | -1 | -1 | 1 | -1 | -1 | -1 | 1 | -1 | -1 | -1 | 1 | 1 | 1 | 1 | -1 | -1 | -1 | -1 | 1 | -1 | -1 | -1 | 1 |
|  | 1 | -1 | -1 | 1 | 1 | -1 | -1 | 1 | 1 | -1 | -1 | 1 | -1 | 1 | 1 | -1 | -1 | 1 | 1 | -1 | -1 | 1 | 1 | -1 |
| Total | -2 | -2 | -2 | 4 | 0 | -4 | 0 | 2 | 0 | 0 | -4 | 2 | 2 | 2 | 2 | -4 | -4 | 2 | 0 | 2 | -2 | -2 | 2 | 0 |

Diagram:

