CS 456 - Assignment 3

1. You have a 50 byte message from an application that you want to send through the Internet to another user. Each layer of the protocol stack includes headers and trailers as follows:
   Application – 4 byte header
   Transport – 20 byte header
   Network – 20 byte header
   Datalink – 24 byte header, 4 byte trailer
   a. What is the size of the frame/packet that is transmitted over the channel?
      Size of the frame/packet transmitted = sum the size of the message, headers, and trailers at each layer.
      Application Layer = 50 + 4 = 54 bytes
      Transport Layer = 54 + 20 = 74 bytes
      Network Layer = 74 + 20 = 94 bytes
      Datalink Layer = 94 + 24 + 4 = 122 bytes
      So, the total size of the frame/packet transmitted over the channel is 122 bytes.

   b. How long does it take to transmit this message over a 100 Mbit channel, assuming the maximum bit rate can be achieved?
      Frame Size in bits = 122 × 8 = 976 bits
      The channel speed is 100,000,000 bits per second
      The transmission time $= \frac{Frame\ size}{Channel\ speed}$
      $= \frac{976\ bits}{100{,}000{,}000\ bits/s}$
      = 0.00000976 seconds = 9.76 microseconds

   c. In the case of a wireless channel, describe at least 3 things that can slow the bit rate.
      Signal Interference: Other electronic devices, networks, or physical obstructions can interfere with the signal.
      Distance and Attenuation: As the distance between the transmitter and receiver increases, the signal weakens and bit rate decreases due to the need for reduced modulation schemes.
      Multipath Fading: Signals can reflect off walls, buildings, and other objects, causing multiple copies of the signal to arrive at different times, leading to data corruption and slower transmission speeds.
   d. Does the access point change the frame or just pass it on?
      The Access Point does not change the frame and only operates as a relay, forwarding the frame from one device to another. It might modify certain aspects

of the frame like the MAC address, or add its own header when performing encryption, but it does not alter the actual message content.

2. If you have a 40 MHz wifi channel that is measuring a -67 dBm signal and -91 dBm noise, what is the theoretical maximum capacity of the channel? If the SNR was cut in half, how much would the capacity of the channel degrade?

Shannon's law: $C = B \times \log_2(1 + S/N)$

$$\frac{S}{N} = 10^{\frac{S-N}{10}} = 10^{\frac{(-67)-(-91)}{10}} = 10^{2.4} = 251.19$$

Capacity $= 40 \times 10^6 \times \log_2(1 + 251.19) = 40 \times 10^6 \times 7.98$
$= 319134690$ bps $= 319.13$ Mbps

If the SNR was cut in half, the new SNR becomes 125.6
And Capacity $= 40 \times 10^6 \times \log_2(1 + 125.6) = 40 \times 10^6 \times 6.98$
$= 279365343$ bps $= 279.37$ Mbps
Capacity Degradation $= ((319.13 - 279.37) / 319.13) \times 100 = 12.46\%$

3. You are provisioning an Access Point that will use the U-NII-3 band and have the choice of using an 80 MHz channel or a 40 MHz channel. Provide an argument for and against each configuration.

When provisioning an Access Point in the U-NII-3 band, the choice between using an 80 MHz channel or a 40 MHz channel depends on the environment. An 80 MHz channel offers higher potential throughput, which provides faster data transmission rates and better support for modern devices. However, the wider channel can lead to increased interference, especially in crowded environments with multiple networks. This can reduce overall performance and may also reduce the range of the Access Point since the wider channel requires more power to maintain a stable connection.

On the other hand, a 40 MHz channel, while offering lower throughput, is less prone to interference because it uses less of the spectrum, making it ideal for crowded environments with other networks. It also provides better range and more stable connections over longer distances/through obstacles. The downside of a 40 MHz channel is that it may not be sufficient for certain environments, as the available bandwidth can become a bottleneck for applications requiring high data rates.
Ultimately, the decision depends on the balance between the need for speed and importance of a stable connection.

4. Go to the FCC website (fcc.gov), use the Licensing and Databases page and do an FM Radio Station Search on the city of Chicago. Create a table with all of the college radio stations (Including IIT's) showing the name of the college/university, radio station frequency, effective radiated power (erp), Antenna type (Directional/Non-Directional), Antenna radiation center Height Above Average Terrain (HAAT), Antenna radiation center Height Above Mean Sea Level (AMSL) and Antenna radiation center Height Above Ground Level (AGL). Take a look at the antenna pattern if there is one shown. Summarize your findings. What did you find interesting? Which station has the most powerful transmitter?

College/ University	Station Name	Frequency (MHz)	erp (kW)	Antenna Type	HAAT (Meters)	AMSL (Meters)	AGL (Meters)
Columbia College	WCRX	88.1	0.1	Directional	71	250	69
Illinois Institute Of Technology	WIIT	88.9	0.003	Non-Directional	74	254	73
Loyola University Of Chicago	WLUW	88.7	0.1	Non-Directional	70	253	77
Northeastern Illinois University	WZRD	88.3	0.1	Non-Directional	22	209	29
St. Xavier University	WXAV	88.3	0.25	Directional	34	224	34
University Of Chicago	WHPK	88.5	0.16	Directional	44.7	224.6	43.9

Summary and Interesting Findings:

- St. Xavier University's WXAV has the most powerful transmitter at 0.25 kW of Effective radiated power.
- Columbia College, St. Xavier University, and the University of Chicago use Directional antennas, meaning the signal is focused in certain directions for coverage. The others use Non-Directional antennas, which broadcast the signal evenly in all directions.
- The Antenna HAAT ranges from 22 meters all the way to 74 meters.
- Loyola University of Chicago has the highest AGL at 77 meters.
- The stations with Directional antennas tend to have higher heights, likely to ensure that their signal covers a larger area in specific directions.
- WZRD from Northeastern Illinois University has the lowest HAAT and AGL, which could limit its coverage range compared to the others.
- WIIT at IIT has the lowest ERP at 0.003 kW, which is significantly less powerful than others. This is possibly due to its non-commercial, low-power operation compared to others.