Department of Electrical Engineering
Final-Assignment
Date: 22/06/2020

Course Details

Course Title:	Advance Computer Networks	**Module:**	3^{RD}
Instructor:	NAEEM AHMED JAN	**Total Marks:**	50

Student Details

Name:	SAAD UR REHMAN	**Student ID:**	15608

Q1.	(a)	The Advanced Mobile Phone System (AMPS) uses two bands. The first band, 800 to 850 MHz, is used for sending; and 860 to 910 MHz is used for receiving. Each user has a bandwidth of 60 KHz in each direction. The 3-KHz voice is modulated using FM, creating 60 KHz of modulated signal. How many people can use their cellular phones simultaneously?	Marks 6
	(b)	Express a period of 1 ms in microseconds, and express the corresponding frequency in kilohertz and A sine wave is offset one-fourth of a cycle with respect to time zero. What is its phase in degrees and radians?	Marks 4
Q2.	(a)	Explain wave division multiplexing and it's applications?	Marks 5
	(b)	Nine channels, each with a 99-KHz bandwidth, are to be multiplexed together. What is the minimum bandwidth of the link if there is a need for a guard band of 13 KHz between the channels to prevent interference?	Marks 5
Q3.	(a)	A constellation diagram consists of sixteen equally spaced points on a circle. If the bit rate is 4800 bps, what is the baud rate?	Marks 5
	(b)	Given a bandwidth of 7000 Hz for a 128-PSK signal, what are the baud rate and bit rate?	Marks 5
Q4.		Explain wireless propagation methods & wireless transmission waves? We need to send 265kbps over a noiseless channel with a bandwidth of 20KHz. How many signal levels do we need?	Marks 10
Q5.		What is the difference between Shannon & Nyquist Capacity? Consider a noiseless channel with a bandwidth of 3000 Hz transmitting a signal with 4 signal levels, the maximum bit rate can be ?	Marks 10

Q1 (a) The Advanced Mobile Phone System (AMPS) uses two bands. The first band, 800 to 850 MHz, is used for sending; and 860 to 910 MHz is used for receiving. Each user has a bandwidth of 60 KHz in each direction. The 3-KHz voice is modulated using FM, creating 60 KHz of modulated signal. How many people can use their cellular phones simultaneously?

Each band is 50 MHz

If we divide 50 MHz into 60 KHz,

Note:

Mega = 10^6

Kilo = 10^3

= 50*10^6 / 60*10^3

=50000000/60000

We get

833.33.

In reality, the band is divided into 832 channels.

42 of these are used for control which means only 790 channels available for cellular phone users.

Q1(b) Express a period of 1 ms in microseconds, and express the corresponding frequency in kilohertz and A sine wave is offset one-fourth of a cycle with respect to time zero. What is its phase in degrees and radians?

As we know that

Mili second = 10^{-3} S

Micro second = 10^{-6} S

Kilo = 10^{3}

So

1 ms = 1 x 10^{-3} S

We can also write

= $10^{-3} * 10^{3} * 10^{-3}$ s

= $10^{3} * 10^{-6}$ S

= 10^{3} µs

1 ms = 10^{3} µs

As 1 ms = 10^{-3} S

As f =1 / t

So

f = 1 / 10^{-3} Hz

f = 10^{3} Hz

f= 1000 Hz

f = 1 KHz

A sin wave is offset one fourth of a cycle with respect to time zero its phase in degree is:

As Complete cycle is 360°

Therefore ¼ cycles is

¼ * 360 = 90°

a sin wave is offset one fourth of a cycle with respect to time zero its phase in radian is :

$90° * \frac{2\pi}{360} = \frac{\pi}{2} =$ **1.5708 radian**

Q2 (a) Explain wave division multiplexing and its applications?

Wavelength Division Multiplexing

Wavelength division multiplexing (WDM) is a technology or technique modulating numerous data streams, i.e. optical carrier signals of varying wavelengths (colors) of laser light, onto a single optical fiber. WDM enables bi-directional communication as well as multiplication of signal capacity.

WDM is actually frequency division multiplexing (FDM) but referencing the wavelength of light as opposed to the frequency of light. However, since wavelength and frequency have an inverse relationship (shorter wavelength means higher frequency), the WDM and FDM terms actually describe the same technology – light in optical cable used to carry data and communication signals.

Wavelength division multiplexing systems can combine signals with multiplexing and split them apart with a DE multiplexer. And with the proper fiber cable, the two can be done simultaneously; moreover, these two devices can also function as an add/drop multiplexer (ADM), i.e. simultaneously adding light beams while dropping other light beams and rerouting them to other destinations and devices. Formerly, such filtering of light beams was done with etalons, devices called Fabry–Pérot interferometers using thin-film-coated optical glass. The first WDM technology was conceptualized in the early 1970s and realized in the laboratory in the late 1970s; but these only combined two signals, and many years later were still very expensive.

As of 2011, WDM systems can handle 160 signals, which will expand a 10 Gbit/second system with a single fiber optic pair of conductors to more than 1.6 Tbit/second (i.e. 1,600 Gbit/s).

Uses of Wavelength Division Multiplexing:

WDM multiply the effective bandwidth of a fiber optic communications system

A fiber optic repeater device called the erbium amplifier can make WDM a cost-effective and it is the long-term solution.

This reduces the cost and increases the capacity of the cable to carry data.

Wavelength Division Multiplexing (WDM) uses multiple wavelengths (colors of light) to transport signals over a single fiber.

It uses light of different colors to create a number of signal paths.

It uses Optical prisms to separate the different colors at the receiving end and optical prisms does not require power source.

These systems used temperature stabilized lasers to provide the needed channels count.

Q2(b) Nine channels, each with a 99-KHz bandwidth, are to be multiplexed together. What is the minimum bandwidth of the link if there is a need for a guard band of 13 KHz between the channels to prevent interference?

9 Number of Channels we have
Each have 99Khz Bandwidth
As for 9 Channels we require 8 Guard Band
Guard band =13 KHz
So,
For Nine channels, we need at eight guard bands.
This means that the required bandwidth is at least
$9 \times 99 + 8 \times 13$
= 995 kHz

Q3 (a) A constellation diagram consists of sixteen equally spaced points on a circle. If the bit rate is 4800 bps, what is the baud rate?

$16 = 2^4$

4 bits are transmitted with each signal unit

Baud rate is:

<u>Formula:</u>

Bit rate/bits per signal

4800/4

= 1200 baud rate

Q3 (b) Given a bandwidth of 7000 Hz for a 128-PSK signal, what are the baud rate and bit rate?

For PSK the baud rate is the same as the bandwidth, which means the baud rate is 7000, but in 128 – PSK the bit rate is 7 times the baud rate

Bit rate = 7 x 7000
=49000 bps

Q4 (a) Explain wireless propagation methods & wireless transmission waves? We need to send 265kbps over a noiseless channel with a bandwidth of 20 KHz. How many signal levels do we need?

Wireless Propagation:

The wireless channel causes the transmitted signal to lose power as it propagates from the transmitter to the receiver. Reflections, diffraction, and scattering create multiple propagation paths between the transmitter and the receiver, each with a different delay. The net result is that wireless propagation leads to a loss of received signal power as well as the presence of multipath, which creates frequency selectivity in the channel. In this section, we provide an introduction to the key mechanisms of propagation. Then we rationalize the need for developing models and explain the distinction between large-scale models and small-scale models In this section, we briefly describe important factors affecting propagation in wireless channels to explain the need for several different channel models.

Wireless Propagation Methods:

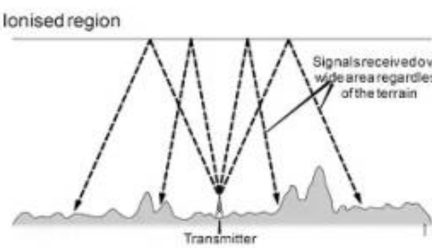
- Ground – radio waves travel through lowest portion of atmosphere, hugging the Earth
- Sky – higher-frequency radio waves radiate upward into ionosphere and then reflect back to Earth
- Line-of-sight – high-frequency signals transmitted in straight lines directly from antenna to antenna

Ground wave:

Used for a low-frequency range transmission, mostly less than 1 MHz. This type of propagation employs the use of large antennas order of which is equivalent to the wavelength of the waves and uses the ground or Troposphere for its propagation. Signals over large distances are not sent using this method. It causes severe attenuation, which increases with increased frequency of the waves.

SkyWave Propagation:

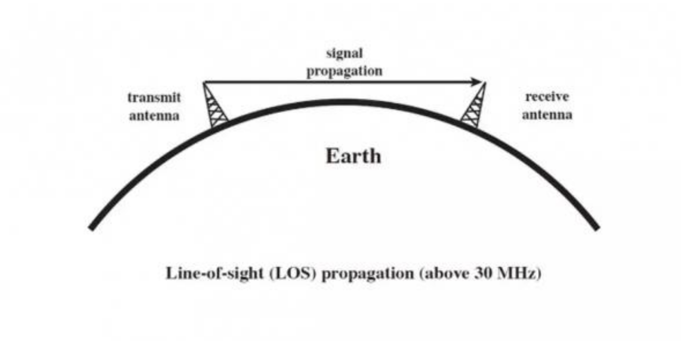
- Sky wave propagation is preferred when the wave has to travel a longer distance. Here the wave is projected onto the sky and it is again reflected back to the earth.



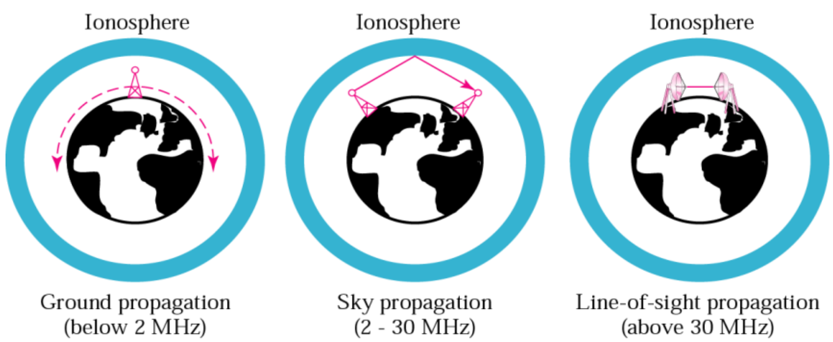
- The sky wave propagation is well depicted in the above picture. Here the waves are shown to be transmitted from one place and where it is received by many receivers. Hence, it is an example of broadcasting.
- The waves, which are transmitted from the transmitter antenna, are reflected from the ionosphere. It consists of several layers of charged particles ranging in altitude from 30-250 miles above the surface of the earth. Such travel of the wave from the transmitter to the ionosphere and from there to the receiver on Earth is known as Sky Wave Propagation. The ionosphere is the ionized layer around the Earth's atmosphere, which is suitable for sky wave propagation.

Line of sight Propagation:

Frequencies above 30 MHz fall in this category of propagation. Here signal above 30MHz are not reflected by ionosphere and here it is transmitted based on line-of-sight concept. For satellite application, it is transmitted from earth station antenna to the satellite antenna. for ground based wireless link, communication happens when both the transmit(TX) and receive(Rx) antennas are in the line of sight of each other. Typical applications include VHF/UHF television, FM broadcast, optical communication, Infrared LANs, terrestrial wireless link, radar, cellular telecom, PCS, WLL and more.



Propagation Methods:



Wireless transmission waves:

Wireless transmission is a form of unguided media. Wireless communication involves no physical link established between two or more devices, communicating wirelessly. Wireless signals are spread over in the air and are received and interpreted by appropriate antennas.

When an antenna is attached to electrical circuit of a computer or wireless device, it converts the digital data into wireless signals and spread all over within its frequency range. The receptor on the other end receives these signals and converts them back to digital data.

A little part of electromagnetic spectrum can be used for wireless transmission.

Radio Wave Transmission:

- **Frequency ranges: 3 KHz to 1 GHz**
- **Omnidirectional**
- **Susceptible to interference by other antennas using same frequency or band**
- **Ideal for long-distance broadcasting**
- **May penetrate walls**
- **Apps: AM and FM radio, TV, maritime radio, cordless phones, paging**

Radio frequency is easier to generate and because of its large wavelength it can penetrate through walls and structures alike. Radio waves can have wavelength from 1 mm – 100,000 km and have frequency ranging from 3 Hz (Extremely Low Frequency) to 300 GHz (Extremely High Frequency). Radio frequencies are sub-divided into six bands.

Radio waves at lower frequencies can travel through walls whereas higher RF can travel in straight line and bounce back. The power of low frequency waves decreases sharply as they cover long distance. High frequency radio waves have more power.

Lower frequencies such as VLF, LF, MF bands can travel on the ground up to 1000 kilometers, over the earth's surface.

Radio waves of high frequencies are prone to be absorbed by rain and other obstacles. They use Ionosphere of earth atmosphere. High frequency radio waves such as HF and VHF bands are spread upwards. When they reach Ionosphere, they are refracted back to the earth.

Microwave Transmission:

Electromagnetic waves above 100 MHz tend to travel in a straight line and signals over them can be sent by beaming those waves towards one particular station. Because Microwaves travels in straight lines, both sender and receiver must be aligned to be strictly in line-of-sight.

Microwaves can have wavelength ranging from 1 mm – 1 meter and frequency ranging from 300 MHz to 300 GHz. Microwave antennas concentrates the waves making a beam of it. As shown in picture above, multiple antennas can be aligned to reach farther. Microwaves have higher frequencies and do not penetrate wall like obstacles.

Microwave transmission depends highly upon the weather conditions and the frequency it is using.

- Frequencies between 1 and 300 GHz
- Unidirectional
- Narrow focus requires sending and receiving antennas to be aligned
- Issues:
    - ➡ Line-of-sight (curvature of the Earth; obstacles)
    - ➡ Cannot penetrate walls

Infrared Transmission:

Infrared wave lies in between visible light spectrum and microwaves. It has wavelength of 700-nm to 1-mm and frequency ranges from 300-GHz to 430-THz.

Infrared wave is used for very short range communication purposes such as television and it's remote. Infrared travels in a straight line hence it is directional by nature. Because of high frequency range, Infrared cannot cross wall-like obstacles.

- Frequencies between 300 GHz and 400 THz
- Short-range communication
- High frequencies cannot penetrate walls
- Requires line-of-sight propagation
- Adv: prevents interference between systems in adjacent rooms
- Disadv: cannot use for long-range communication or outside a building due to sun's rays.

Light Transmission:

Highest most electromagnetic spectrum which can be used for data transmission is light or optical signaling. This is achieved by means of LASER.

Because of frequency light uses, it tends to travel strictly in straight line. Hence the sender and receiver must be in the line-of-sight. Because laser transmission is unidirectional, at both ends of communication the laser and the photo-detector need to be installed. Laser beam is generally 1mm wide hence it is a work of precision to align two far receptors each pointing to lasers source.

Laser works as TX (transmitter) and photo-detectors works as Rx (receiver).

Lasers cannot penetrate obstacles such as walls, rain, and thick fog. Additionally, laser beam is distorted by wind, atmosphere temperature, or variation in temperature in the path.

Laser is safe for data transmission as it is very difficult to tap 1mm wide laser without interrupting the communication channel.

Numerical

We can use nyquist formula

Nmax = 2 * B * Log2L

265000 = 2 * 20000 * Log2L

265000 = 40000 * Log2L

Log2L = 265000/40000

Log2L = 6.625 L = 26.625 = 98.7 levels

Q5. What is the difference between Shannon & Nyquist Capacity? Consider a noiseless channel with a bandwidth of 3000 Hz transmitting a signal with 4 signal levels, the maximum bit rate can be?

A very important consideration in data communications how fast we can send data. in bits per second, over a channel.
Data rate depends on three factors

(i) The band width available
(ii) The level of the signals we use
(iii) The quality of the channel (the level noise).

Two theoretical formulas were developed to calculate the data rate- one by Nyquist for a no1seless channel, another by Shannon for a noisy channel.

Noiseless Channel: Nyquist Bit Rate –

For a noiseless channel, the Nyquist bit rate formula defines the theoretical maximum bit rate r = 2 X B X log2 L In this formula, B is the bandwidth of the channel, L is the number of signal levels used to represent data, and r is the bit rate in bits per second. According to the formula, we might think that, given a specific bandwidth, we can have any bit rate we want by increasing the number of signal levels. Although the idea is theoretically correct, practically there is a limit. When we increase the number of signal levels, we impose a burden on the receiver. If the number of levels in a signal is just 2, the receiver can easily distinguish between a 0 and a 1. If the level of a signal is 64, the receiver must be very sophisticated to distinguish between 64 different levels. In other words, increasing the levels of a signal reduces the reliability of the system.

Noisy Channel: Shannon Capacity

In reality, we cannot have a noiseless channel; the channel is always noisy. In 1944, Cloudeshannon introduced a formula called the Shannon capacity, to determine the theoretical highest data rate for a noisy Channel. C = B x log2(1 + SNR) In this formula B is the bandwidth of the channel, SNR is the signal-to noise ratio, and C is the capacity of the channel in bits per second. Note that the Shannon formula there is no indication of the signal level, which means that no matter how many levels we have. We cannot achieve a data rate higher than the capacity of the channel. In other words, the formula defines a characteristic of the channel, not the method of transmission. 10 In conclusion, we can say for channel capacity that the Shannon capacity gives us the' upper limit while the Nyquist formula tells us how many signal levels we need.

Numerical

As Bit Rate = 2 * Bandwidth * log2 L

Bit rate = 2 *3000* log2 4

Bit rate = 12000 bps

………