

## Homework 2

(Due Date: Sept 19th, 11:59PM, submit through eCampus)

You MUST use the provided latex template for writing your answers. You are free to use any Latex editor you wish. A free, friendly version is at [overleaf.com](https://overleaf.com). Upload the two latex files and you will be ready to edit them and produce a pdf.

## 1 Signals

- (a) Show that doubling the transmission frequency or doubling the distance between transmitting antenna and receiving antenna, attenuates the power received by 6dB. (5 pts)
- (b) Suppose a transmitter produces 50W of power. i) Express the transmit power in units of dBW and dBm; ii) If the transmit power is applied to a unity gain antenna with a 900MHz carrier frequency, what is the received power in dBm at a free space of 100m? iii) Repeat for a distance of 10km; iv) Repeat previous, but assume a receiver antenna gain of 2. (10 pts)
- (c) What is the range of path loss exponent that will satisfy the following requirements: Transmit power = 2W, Received power = -105dBm, Unity gain antenna for transmit and receive, Carrier frequency = 1.8GHz, Distance = 5.2km. (5 pts)

## 2 OFDM

- (a) OFDM creates several lower rate (i.e., longer symbol time) subcarriers. Why is that helpful? (5 pts)

## 3 Spread Spectrum

- (a) A FHSS system employs a total bandwidth of 400MHz and an individual channel bandwidth of 100Hz. What is the minimum number of PN bits required for each frequency hop? (5 pts)

## 4 Aloha

Answer the following questions about Aloha (3-5 sentences each):

- (a) What is the window of vulnerability? How does it affect the throughput (i.e., number of packets sent in unit time)? (5 pts)
- (b) Should the slot size in slotted Aloha be longer than L, where L is the transmission duration of a packet? Why? (5 pts)
- (c) Let's assume three nodes A, B and C, within communication range of each other try to access the wireless medium using slotted Aloha. Each node transmits in a slot with probability p. If we number the slots as 1, 2, 3, ..., then answer the following questions:

- (A) What is the probability that node A succeeds for the first time in slot 3? (5 pts)
- (B) What is the probability that some node (A, B or C) succeeds in slot 3? (5 pts)
- (C) What is the probability that the first success occurs in slot 3? (5 pts)

## 5 CSMA

Answer the following questions about CSMA (3-5 sentences each):

- (a) For Carrier Sense Multiple Access, how does the CS threshold impact spatial reuse and interference? (5 pts)
- (b) Explain the hidden and exposed terminal problems with an example. (5 pts)
- (c) Why is it difficult to use CSMA-CD in the wireless medium? (5 pts)
- (d) Using only physical carrier sense, can you avoid the hidden terminal problem? If so, how? If not, why? (5 pts)
- (e) Could there be problems with using only virtual carrier sense and no physical carrier sense? (5 pts)

## 6 MAC Layer

This problem will help you understand why you cannot achieve the physical layer rate at the multiple access layer in 802.11.

- 802.11 physical layer transmission rate = 54Mbps
- MAC layer data payload = 1452 bytes
- MAC header = 28 bytes
- ACK Frame Size = 14 bytes
- RTS Frame Size = 20 bytes
- CTS Frame Size = 14 bytes
- SIFS Time =  $16 \mu s$
- DIFS Time =  $34 \mu s$
- Average time spent in backoff =  $36 \mu s$

MAC layer throughput is defined as the number of bits sent by the MAC layer in a given period of time (1s). Answer the following questions:

- (a) If there are two stations exchange data using 802.11 DCF but without using RTS/CTS transaction, what is MAC layer throughput? (10 pts)
- (b) What is the throughput when RTS/CTS is used? (10 pts)

## 7 Wireshark

Study the provided “Wireshark Lab: 802.11”.

- (a) Please answer the 16 questions asked in the tutorial. [3pts each, 48pts total]

## 8 Submission Instructions

Please submit the PDF as obtained from the provided latex template. Name your submission as `<your lastname>.hw2.pdf` and submit it on ecampus.