DAT 610 – Wireless Communications
Final Exam – December XX, 2020

No printed or written means are allowed. A definite, basic calculator is allowed. Exam duration is 4 hours. Please answer the questions in English. If you think that you need additional parameters for answering a question, you can make assumptions and explain your assumptions in your answers.

PAST EXAM QUESTIONS

Suppose that the bandwidth of a channel is 1 MHz and SNR_{dB}=24 dB.

a. **(5 points)** Find out the theoretical capacity limit of this channel by using Shannon's formula.

b. **(5 points)** How many signaling level is required according to Nyquist formulation to reach this theoretical limit?

c. **(5 points)** Suppose that the distance between the transmitter and the receiver does not change and is equal to 500 meters, and the transmission power also stays the same. If the frequency of the used channel was moved from the central frequency of 450 MHz to 900 MHz, what would be the theoretical capacity limit of the same channel?

Shannon Formula: $C=B\log_2(1+SNR)$

Nyquist Formula: $C=2B\log_2 M$

$SNR_{dB}=10\log_{10}(SNR)$

$$L_{dB} = 10\log\left(\frac{P_t}{P_r}\right) = 20\log\left(\frac{4\pi fd}{c}\right) = 20\log(f) + 20\log(d) - 147.56\ dB$$

(10 points) Explain the differences between convolutional codes and turbo codes?

(15 points) Write a subroutine in any programming language for CSMA/CA? Your subroutine will be called by the following line. Once called, the subroutine will continuously check the frame queue to which the frames are inserted by another function, and transmits the frames by using the medium. The address of medium and frame queue are passed to your subroutine as input parameters.

void CSMACA(int medium, int frameQueue)

Please use the following functions in your subroutine (You do not need to develop them, just call them as you need in your subroutine.):

Frame getFrame(int frameQueue) //returns the frame if there is a frame to send in the queue
BOOL isMediumFree(int medium) //returns TRUE if the medium is free
BOOL sendFrame(int medium, Frame frame) //returns TRUE if successfully sends the frame
BOOL receiveFrame(int medium, Frame frame, int time) //waits until receiving a frame or time
// milliseconds, returns TRUE if successfully receives a frame

(13 points) You have a sensor network for reading temperature and humidity with 1.000.000 nodes? It is a fixed network, and each node is 100 hops away from the data collecting node (i.e., the average distance to the data collecting node from a node divided by the average transmission range of a node is 100) The average frequency that a node sends data is 1 per second. Average

link failure rate is 10^{-2} per second. Discuss the strengths and weaknesses of AODV and DSR for such a network?

(10 points) Explain three dynamic location registration schemes. What are their weaknesses and strengths comparing to each other?

(10 points) Explain distance based dynamic location registration. What are its weaknesses and strengths comparing to time based registration?

(12 points) Explain two different ways based on time difference of arrival for measuring the distance to a beacon node? What are the weaknesses and strengths of these techniques comparing to each other?

a. **(9 points)** Explain three main reasons why conventional TCP does not fit to wireless networks. Introduce three techniques from the literature to tackle these issues of the conventional TCP in its employment in wireless.
b. **(6 points)** Explain negative, positive and selective acknowledgement schemes for end to end reliability.

(10 points) Explain the main differences between 1^{st}, 2^{nd}, 3^{rd}, 4^{th} and 5^{th} Generation Wireless Broadband High Tier Mobile Communication Systems?

(10 points) Explain the techniques to avoid ping pong effect due to handoff scheme?

(10 points) Explain low density parity check (LDPC)? How is it different from hamming code?

(15 points) Is inter symbol interference (ISI) higher of lower in OFDM? Explain by using a figure why?

10 points) Explain selective paging. What are its weaknesses and strengths comparing to blanket paging?

(12 points) List and explain the techniques that can be used to find out the distance to a beacon node for multilateration? What are the weaknesses of these techniques?

(10 points) Explain and compare handoff with hysteresis and handoff with threshold?

(10 points) Suppose that the spectrum of a channel is between 3 MHz and 4 MHz and SNR_{dB}=24 dB.

a. Find out the theoretical capacity limit of this channel by using Shannon's formula.

b. How many signaling level is required according to Nyquist formulation to reach this theoretical limit?

Shannon Formula: $C=Blog_2(1+SNR)$

Nyquist Formula: $C=2Blog_2M$

(10 points) List and briefly explain the transmission impairments for wireless media. Discuss multipath fading? Are these transmission impairments avoidable?

(15 points) Explain CSMA/CA approach? How does it differ from CSMA/CD? Why does not CSMA/CD fit the requirements in ad hoc networks?

(10 points) Why does not IP suffice when the nodes are mobile?

(10 points) What are the differences between AODV and DSR protocols? Which one does have less security weaknesses?

(10 points) Explain location registration and paging in mobile networks. Why there is a trade off between the costs of paging and location registration. Explain three different paging schemes and compare them.

(10 points) List and explain the techniques that can be used to find out the distance to a beacon node for multilateration? What are the weaknesses of these techniques?

(15 points) A TCP connection is established through 10 wireless hops in an acoustic underwater ad hoc network. Assume that each hop is 100 meter in the average, acoustic signals travel 1500 meter per second, 10 kilobit data can be sent per second over a link, the source node has one megabyte of data to send, the receiver window size is 64 kilobytes, the maximum segment size is 1 kilobyte and the average processing delay for routing at each node is one millisecond. Assume also that the following segments do not reach the destination: 67, 112, 137. What would be the average utilization of the links for this connection if there is not another communications through them? Explain an alternative approach to increase the bandwidth utilization?

(10 points) Explain sink hole, black hole and selective forwarding attacks? Compare them.

a. (5 points) What are hidden terminal and exposed terminal problems?

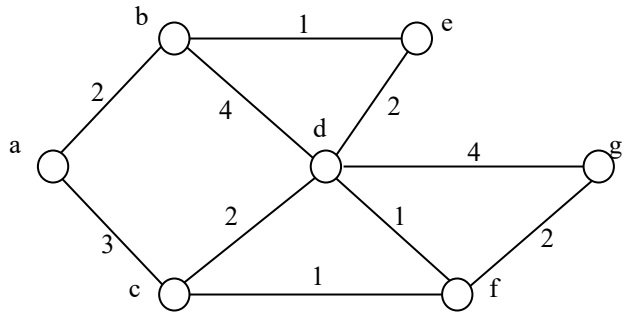
b. (5 points) Explain CSMA/CA approach?

Assume that the Hamming Code is used for the transmission of n=12 bit blocks. Note that the blocks include the redundant bits.

a. (4 points) What are the number of check bits, minimum Hamming distance, maximum number of bits in error that can be detected and the maximum number of bits in error that can be corrected?

b. (6 points) If the following bit stream is received: "001111001111". Is there any error in this bit stream? If there is, what should be the correct bit stream?

a. **(5 points)** In a network that has the following topology, Node *b* initially has the routing table shown in Figure 6.b. Later Node *e* broadcasts its routing table, which is in Figure 6.c. After receiving the Node e's routing table, how does the routing table of Node b change? Please use the Table at Figure 6.d for your answer.



a. Example network.

destination	next	cost
a	a	2
c	a	5
d	d	4
e	e	1
f	d	5
g	d	8

b. Initial routing table of *b*.

destination	next	cost
a	b	3
b	b	1
c	d	4
d	d	2
f	d	3
g	d	5

c. Routing table of *e*.

destination	next	cost

d. Updated routing table of *b*.

Figure 6: The topology and the routing tables

b. (**5 points**) Explain the count to infinity problem.

c. (**5 points**) Does AODV also have the count to infinity problem? Explain why or why not?

(10 points) Explain the relations among capacity, bandwidth, noise, distance and frequency.

(10 points) What is analog to digital modulation used for? Explain pulse code modulation (PCM) and delta modulation (DM). Discuss about the sampling rate and it's impact on PCM and DM.

(15 points) What are the difference between CSMA/CA and SMAC. What are hidden and exposed terminal problems? How do these protocols tackle with the hidden terminal problem?

(15 points) Explain AODV algorithm? Does it fit to wireless sensor networks? Why?

(10 points) Assume that the maximum cell radius in a cellular W-CDMA network is 15.6 km. The chip rate is 3.6864 Mcps. The size (the number of bits) of the maximal length code generator *n* is 15 bits. How many nodes can be assigned with a unique pseudonoise by using the code sequence generated by this maximal length code generator? Uniqueness of the pseudonoise should be guaranteed at the base station regardless of the location of the node that sends it. Assume that the signal travels with speed of light.

maximum length of a sequence $p=2^n-1$

(15 points) Assume that congestion window threshold value is 32 KB, receive window given by the destination host is always 64 KB, RTT is always 570 msec, and line speed is 128 Kbps.

- **a.** If we use TCP slow start mechanism where our initial congestion window size is 1 KB, what will be the maximum throughput after 5 minutes? What is the channel utilization for this 5 minutes? Assume congestion does NOT occur.
- **b.** Discuss alternative TCP mechanisms that aim to increase the utilization for wireless networks

(10 points) A sensor network operates at 900 Mhz. One of the nodes has two routes to send its packets to the collecting node. One of the routes has 10 hops of 100 meter. The other route has five hops of 200 meter. Because of the low lying antenna, the path loss exponent is four. Assume that the nodes do not consume energy for processing the packets to be relayed. Which route is more power efficient?

$$L_{dB} = 10\log\frac{P_t}{P_r} = \gamma 10\log\left(\frac{4\pi fd}{c}\right)$$

(10 points) Explain the properties that a good CDMA pseudo-noise sequence should show? Explain linear maximal length sequence generator. Generate an example sequence by using a four bit generator and prove that the generated sequence has the required properties.

(10 points) Explain dynamic source routing (DSR) algorithm? Does it fit to wireless sensor networks? Why?

(15 points) You are designing a data link layer protocol. Your frame length is 512 bits. You have a BEC scheme, which uses 8 bits to detect any number of bit errors in these frames. You also

have a FEC scheme, which uses 16 redundant bits to correct 2 bit errors and detect any number of bit errors in these frames. If BER is 10^{-3} and distributed randomly according to uniform distribution, would you prefer BEC or FEC. Answer the same question also for BER=10^{-6}?

(10 points) Explain the main differences among IEEE 802.11.a, IEEE 802.11.g, IEEE 802.11.n and IEEE 802.11.p standards.

(15 points) What are hidden and exposed terminal problems? How does CSMA/CA tackle these problems? When is the approach used in CSMA/CA NOT (negative) applied for ad hoc networks?