Principles of Communications Networks

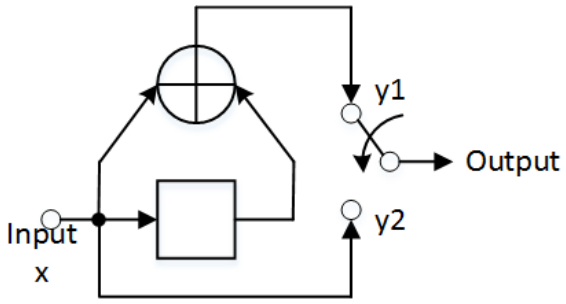
Final Exam

2020/6/17

1. [Lecture 2] (15%) Please briefly answer the following questions.
   (a) (2%) Every (*n*, *k*) linear block code with generator matrix **G** and parity-check matrix **H** has a dual code with parameters (*n*, *n*-*k*), generator matrix **H** and parity-check matrix **G**. In other words, $\mathbf{GH}^{\mathrm{T}}=\mathbf{0}$. Please prove this.
   (b) (2%) For a (7,4) Hamming code, its generator matrix is as below. What's the corresponding parity-check matrix?

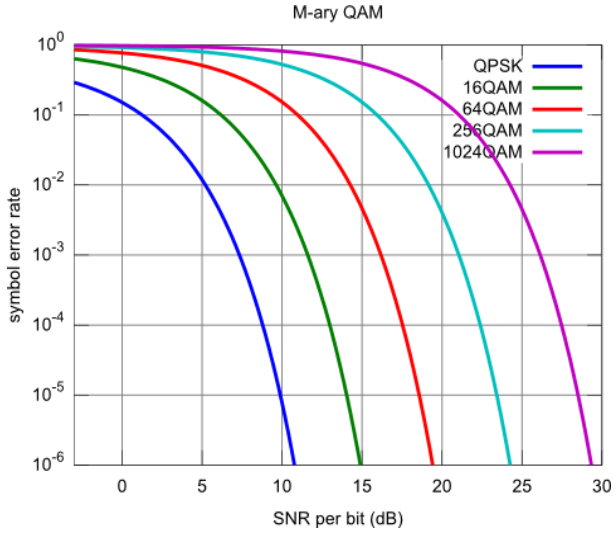
$$\mathbf{G}=\begin{bmatrix}1&1&0&1&0&0&0\\0&1&1&0&1&0&0\\1&1&1&0&0&1&0\\1&0&1&0&0&0&1\end{bmatrix}$$

   (c) (3%) Based on (b) and (c), please construct the 8 codewords in the dual code.
   (d) (2%) Please find the minimum distance of the dual code determined in (c).
   (e) (3%) Consider the rate r=1/2, constraint length K=2 convolutional encoder, which is shown below. Please find the encoder output produced by the message sequence 10111.



   (f) (3%) Assume the adopted coding scheme is linear block code (8, 4), and the ACK/NAK is error free. In addition, the distance from the transmitter to the receiver is 3 km, and the transmission data rate is 1Mbps. The retransmission is unlimited. Under what bit error rate setting that Go-Back-N ARQ scheme can perform better than Selective Repeat ARQ scheme in terms of transmission time? Please validate your answer.

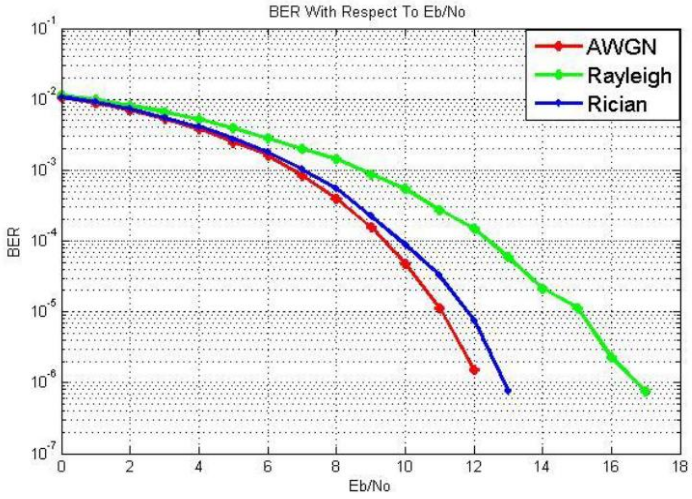
2. [Lecture 3] (6%) Please briefly answer the following questions.
   (a) (3%) The BER performance of various SNR values for different modulation techniques is shown below. If the BER threshold is 0.001, and the measured SNR value at different time instance is 34 dB, 30 dB, 28 dB, 20 dB, 18 dB, 10 dB, and 5 dB, respectively. What's the adopted modulation technique for each time instance?



(b) (3%) In an OFDM system, each subcarrier is modulated with a conventional modulation scheme. Assume the measured SNR values for the 4 utilized subcarriers are 15 dB, 20 dB, 23 dB, and 25 dB, and the BER threshold is still 10^{-3}. What are the adopted modulation techniques for these 4 subcarriers?

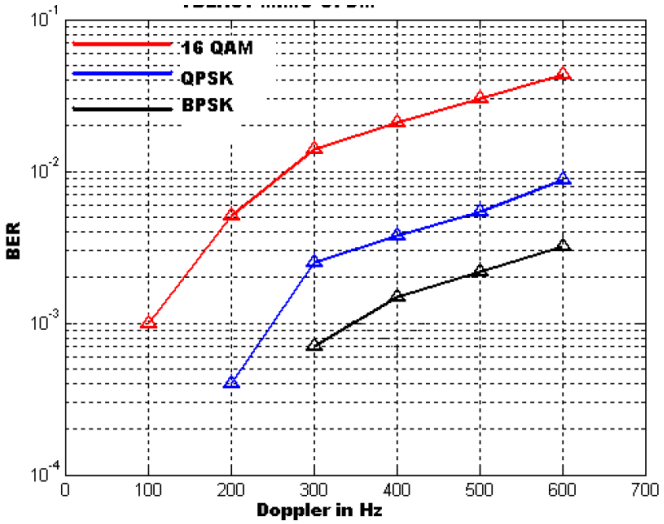
3. [Lecture 4] (10%) Please briefly answer the following questions.

(a) (3%) The bit error rate (BER) performance upon various E_b/N_0 (i.e., SNR) of AWGN, Rayleigh, and Rician channel models for QAM modulation technique is shown below. We found that, to achieve the same BER, the SNR thresholds of three channel models are $SNR_{AWGN}>SNR_{Rician}>SNR_{Rayleigh}$. Please briefly explain this.



(b) (3%) Assume the carrier frequency is 2 GHz, the wave velocity is light speed (3×10^8 m/s), the receiver moving speed is 5.15×10^{-5} m/s, and the source is static. What's the corresponding Doppler shift?

(c) (4%) The BER performance of different Doppler shift upon 15dB SNR for various modulation techniques is shown below. Based on the Doppler shift derived in (b), if the BER threshold is set to be 10^{-3} (i.e., the actual BER should be less than the predefined threshold), which modulation technique should the sender utilize?



4. [Lecture 5] (14%) Please briefly answer the following questions.
   (a) (4%) Please prove that $N=i^2+j^2+ij$.
   (b) (3%) During a busy hour, the number of calls per hour for each of the 12 cells of a cellular cluster is 2220, 1900, 4000, 1100, 1000, 1200, 1800, 2100, 2000, 1580, 1800, and 900. Assume that 75% of the car phones in this cluster are used during this period and that one call is made per phone. Please find the number of customers in the system.
   (c) (4%) Following (b), assume the average hold time of 60 seconds, what is the total Erlang value of the system?
   (d) (3%) Find the reuse distance D if R=5 km.

5. [Lecture 6] (12%) Please briefly answer the following questions.
   (a) (2%) Please describe the operations of CSMA/CA mechanism.
   (b) (2%) In a WiFi network consisting of multiple access points (APs), is it possible to occur hidden terminal problem? Please use an example to validate your answer.
   (c) (3%) Equipping smart antenna is a feasible solution to increase the system capacity. Smart antenna can be classified into two categories: switched beam and adaptive beam. What's switched beam smart antenna?
   (d) (5%) Following (b) and (c), when an WiFi AP equips a switched beam smart antenna, from your viewpoint, will the hidden terminal problem get worse, comparing with the scenario of equipping an omnidirectional antenna? And why? You can draw an example to validate your answer.

6. [Lecture 7] (9%) Please briefly answer the following questions.
   (a) (2%) For a 3G CDMA system, please design chip sequences to support 8 simultaneous transmissions.
   (b) (3%) Following (a), for these 8 simultaneous transmissions, we assume the transmitting binary bits are [0, 0, 1, 1, 1, 1, 0, 0]. Please using the 4^{th} transmitting bit as an example to show the coding and decoding procedure.
   (c) (2%) CDMA system would incur the near far problem, and power control is one of the feasible solutions. Please using free space propagation model as an example to illustrate how to perform power control.

(d) (2%) Please use an example to illustrate collision occurrence in a FHSS system.

7. [Lecture 8] (10%) Please briefly answer the following questions.
   (a) (3%) In a cellular system with 7-cell clusters, the average number of calls at a given time is given as follows:

Cell number	Average number of calls/unit time	Cell number	Average number of calls/unit time
1	900	5	1200
2	2000	6	1800
3	2500	7	1000
4	1100		

   If the system is assigned 49 traffic channels, how would you distribute the channels if static allocation is used based on traffic load?
   (b) (3%) Following (a) while adopting dynamic channel allocation scheme, how would you distribute the channels?
   (c) (4%) In a cellular system with 4 channels, one channel is reserved for handoff calls. What is the value of B_O and B_H , given $\lambda_O=\lambda_H=0.001$ and $\mu=0.0003$? What's the average number of occupied channels?

8. [Lecture 9] (9%) Please briefly answer the following questions.
   (a) (3%) Please draw the 2G cellular system infrastructure conceptually, and briefly describe the functions of each entity.
   (b) (2%) Based on the figure you draw in (a), please show the steps and message flow of MS (say MS_A) reattach procedure (i.e., reattach to the new nearest BS when moving).
   (c) (2%) Based on the figure you draw in (a) and (b), please show the steps and message flow when MS_B tries to make a phone call to MS_A (note that MS_A is currently out of its home MSC).
   (d) (2%) What's the difference between handoff and roaming?

9. [Lecture 10] (15%) Please briefly answer the following questions.
   (a) (3%) Please draw the 4G cellular system infrastructure conceptually, including control and data plane, and briefly describe the functions of each entity.
   (b) (2%) What's the major difference between 2G/3G core network and 4G core network?
   (c) (2%) When to use IMSI? When to use TMSI?
   (d) (2%) What were the two air interface implementations of UMTS? Please list the two major technical differences among the two implementations.
   (e) (3%) Please list three approaches adopted to increase the capacity of a 4G mobile communication system.
   (f) (3%) Please list and briefly explain three disruptive technology direction in 5G.