COLLEGE OF ENGINEERING & TECHNOLOGY

Department : Graduate Studies
Electronics & Communications Engineering
Lecturer : Prof. Mohamed Essam Khedr
Course : Wireless Communications
Course Code : EC 744

Final Exam (Take home). Only lecture slides and textbooks, No Internet is allowed

Question one: (probability, Digital communications, Diversity)

I- Consider one of the two signals S_0=-1, S_1=1 is transmitted over the channel shown in figure one. The two noise random variables n_1, n_2 are statistically independent of the transmitted signal and of each other. The density functions are $p_{n_1}(\alpha) = p_{n_2}(\alpha) = 0.5e^{-|\alpha|}$

a. Draw the signal space and find the optimum decision regions for equally likely messages
b. What is the minimum probability of error

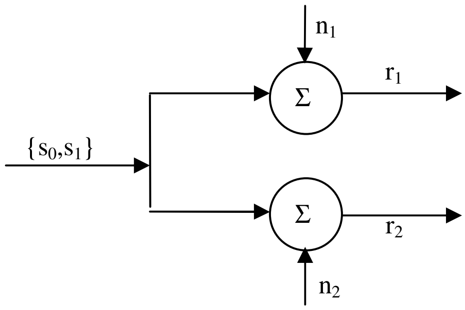

Figure 1

II- In the communication system shown in figure 2, the transmitted signal S, and the noises N_1, N_2 are S.I

Assume $P[m_1]=P[m_0]=0.5$

N_1, N_2 are Gaussian noise with zero mean and σ^2 variance

$S_1=-S_0$

a. Show that the optimum receiver is as shown in figure 3 where "a" is an appropriately chosen constant
b. What is the optimum value of "a"
c. What is the optimum threshold setting
d. Express the resulting P[e] in terms of Q
e. By what factor would E_s have to be increased to yield this same probability of error if the receiver were restricted to observing only r_1

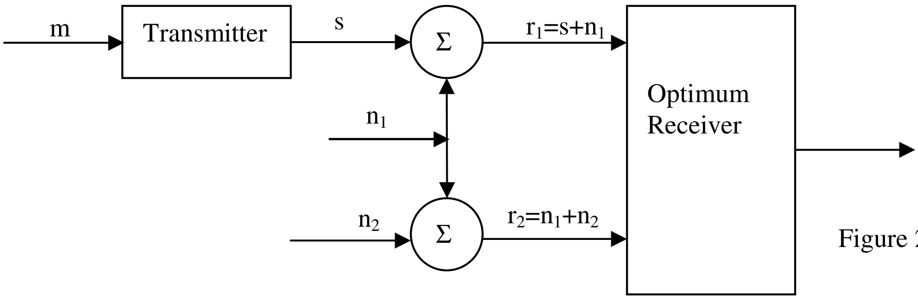

Figure 2

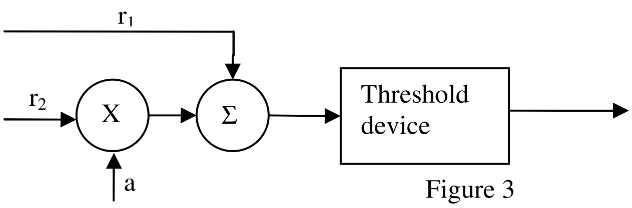

Figure 3

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Question Two: (Multipath)

Consider the multipath communication model shown in figure 4a for equally likely messages. Assume that the three paths are characterized as follows

Constant attenuation	a_1=0.2	a_2=0.4	a_3=0.6
Constant delay	t_1=1ms	t_2=1.5ms	t_3=2ms
White noise PSD	0.002	0.006	0.004

The three noises are Gaussian and S.I of each other and the signal transmitted. The signal transmitted is defined by

$$S_1(t) = -S_0(t) = \begin{cases} 5\cos(2\pi 10^3 t) & 0 \le t \le 3\times10^{-3} \\ 0 & elsewhere \end{cases}$$

a. Show that the optimum receiver can be realized in the form illustrated in figure 4b determine $h_1(t)$, T_1, and the specifications of the decision device and the P[e]
b. Assume that the receiver has access to the three multipath outputs individually. Demonstrate that in this case, the optimum receiver can be realized as shown in figure 5
c. Determine the values of Δs, α'S, $h_2(t)$ and T_2 and the specifications of the decision device and the P[e]

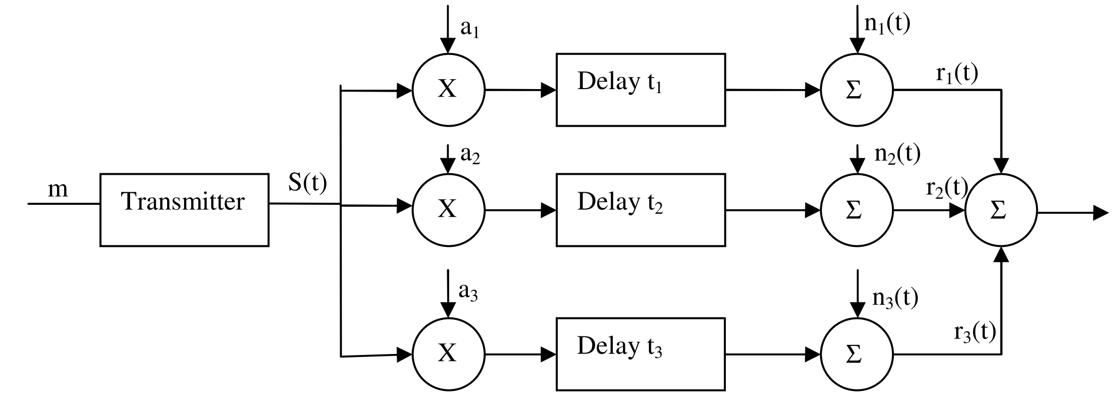

Figure 4a

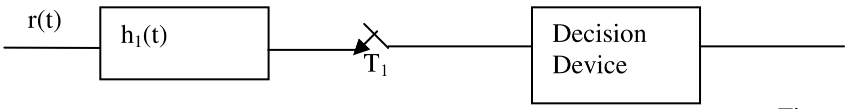

Figure 4b

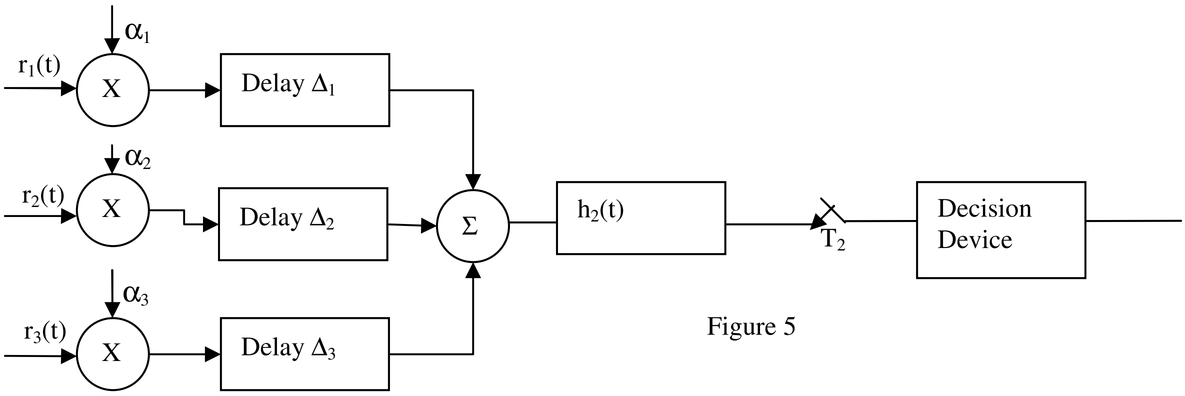

Figure 5

Question three: (Diversity)

Consider a two branch diversity system using BPSK with coherent detection. The channel gain in each branch is 1.0 with probability 0.9 and 0.05 with probability 0.1. The additive noise in each branch is white Gaussian noise with PSD N0/2. the two branches have independent channel gains. Calculate the probability of error as a function of the receiver SNR for selective diversity and equal gain combining.

Question Four: (OFDM, MC-CDMA, OVSF)

I- Assume the maximum delay spread in an IEEE 802.11g system is 800ns and the cyclic prefix overhead is desired to be less that 20%.

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a. Calculate the total duration of the OFDM symbol as well as its useful part T
b. What is the subcarrier frequency spacing?
c. Let the available BW is 20 MHz. Calculate the number of subcarriers in an OFDM symbol X? Note: actual number of useful subcarriers is X-12.
d. To transmit 54Mbps, how may bits are available for useful data transmission during OFDM symbol
e. Using 64 QAM for each subcarrier & channel code rate is 3/4, how may carriers will be used for data transmission?

II. Using slide number 75 in the CDMA lecture, draw similar figure if the parallel bits were 1 -1 -1 1 and the frequency spread is 1 -1 1 and the time spread is -1 1 -1 and explain the figure.

III. Using the same OVSF tree in slide 56 in the CDMA lecture, show how to assign four $2R_b$ users on the tree using random, left most, crowded first code, crowded first space

Question Four: (WLAN)

1. Using the following network scenario shown in figure 6

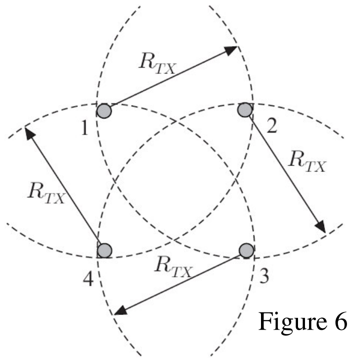

Figure 6

a. Explain the hidden terminal problem that arises in wireless mobile networks.
b. Explain how the RTS/CTS function "resolves" the hidden terminal problem
c. Explain the exposed terminal problem that arises in wireless mobile networks.

2. Consider the scenarios shown in Figures 7a), 7b) and 7c). Two IEEE 802.11b nodes A and B that continuously send traffic through the Access Point (AP); the nodes operate in the DCF mode. Moreover, nodes A and B have an infinite backlog of packets to be sent via the AP. The scenarios presented in Figure 3 differ only in the location of node B. As node B moves farther away from the AP, the signal-to-noise ratio at both node B and the AP decreases, resulting in a decreased raw data rate at which node B and the AP can communicate. Figure 7(d) shows how the raw data rate varies with the distance between the given node and the AP. Assume that the average backoff time for both nodes A and B is 160 µsec, assume there are no collisions. The DIFS interval is 50 µsec, the SIFS interval is 10 µsec, the ACK frame is 14 bytes long, the RTS frame is 20 bytes long and the CTS frame is 14 bytes long.

   Using the timeline of successful transmission shown in figure 9, calculate the average ("useful") throughput RA seen by node A for the scenarios shown in Figures 7(a), 7(b) and 7(c). Assume that nodes A and B use data frames (packets) of the same length L = 1500 bytes. Plot your results in Figure 8.
   Deduce the throughput as a function of number of nodes and draw the equation for the different scenarios shown.

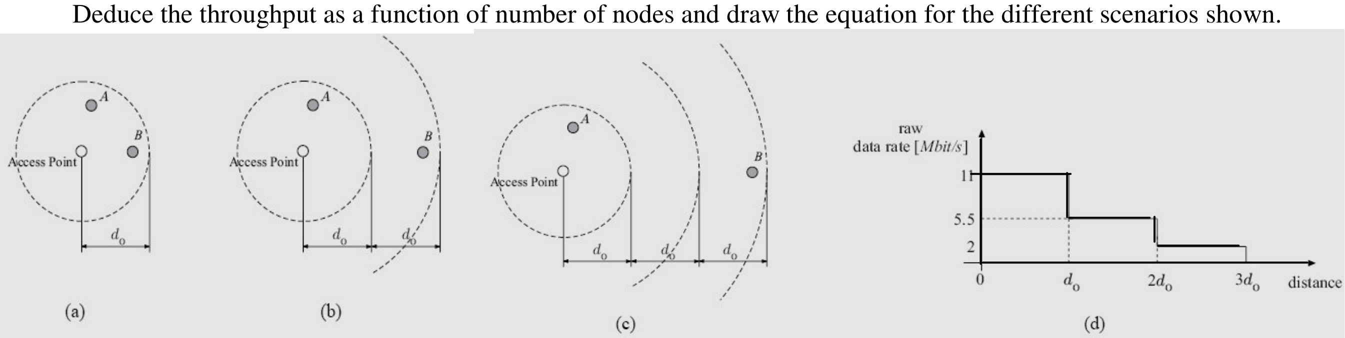

Figure 7

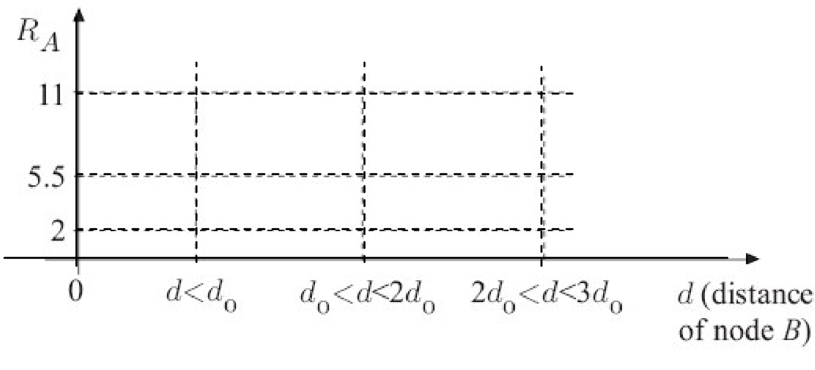

Figure 8

Figure 9 time of Successful transmission

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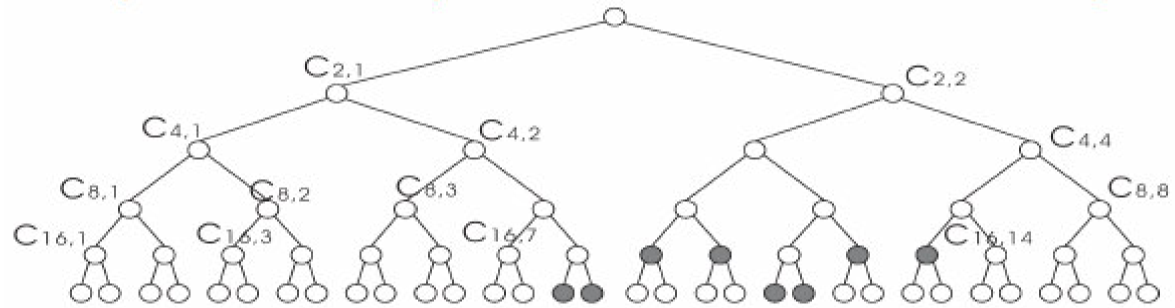
Code assignment example (multi-code)

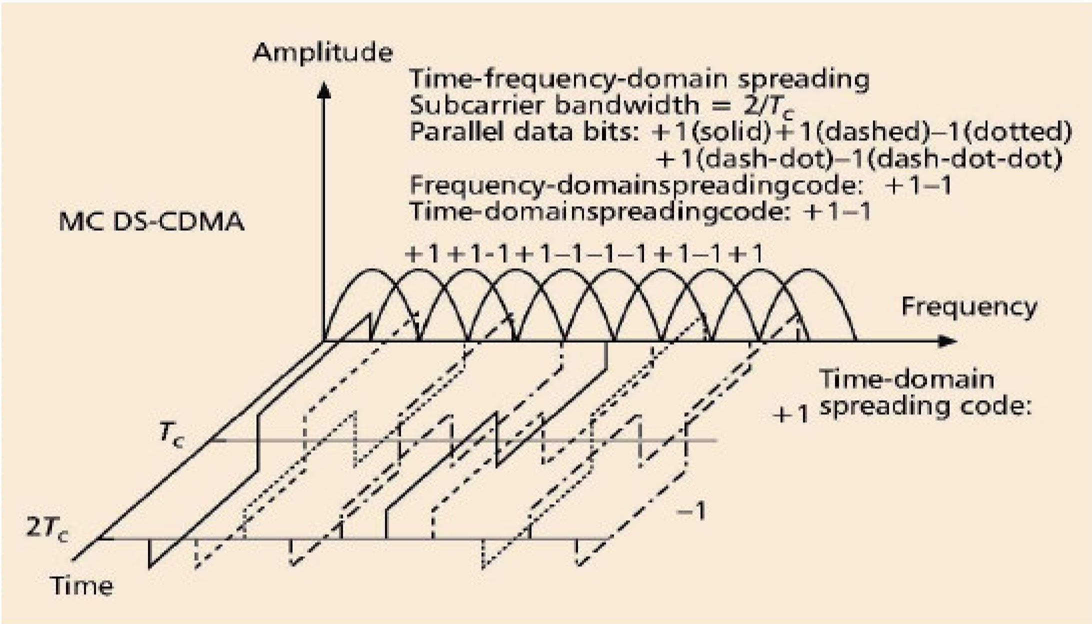
Suppose two codes can be assigned to a user.
A request $6R_b$ arrives (two codes, $4R_b$ and $2R_b$, are needed).



united assignment, decreasing order

- Leftmost
  - $\{C_{8,1}, C_{16,3}\}$
- Crowded-first-space
  - $\{C_{8,8}, C_{16,14}\}$
- Crowded-first-code
  - $\{C_{8,3}, C_{16,7}\}$

2.6 MC DS-CDMA Illustration



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