INSTITUTO SUPERIOR TÉCNICO

Mestrado em

Engenharia Electrotécnica e de Computadores

Redes Móveis e Sem Fios

1º Teste – 1ª parte

12 de Abril de 2019

Duração 1h30

In order to avoid grading mistakes, please answer each question <u>on a different page</u> and keeping the order as much as possible.

1) In a mobile network using CDMA, there are two mobile stations (A and B) trying to transmit to a common base station. Station A is transmitting a logical "1" bit as +1, -1, +1, -1, -1, +1, -1, +1. Station B is simultaneously transmitting bit sequence "00" as +1, -1, -1, +1, +1, -1, -1, +1. The decoding thresholds are -2 and +2, respectively for logical "0" and logical "1".

   a) Which keys are being used by each station? (1,0 val)

   b) Assuming that the coding sequences are perfectly synchronized at the base station and that the received signal is +1, -2, 0, 0, +2, 0, -2, +2, verify if the transmissions from A and B are correctly received. Present all calculations. (1,5 val)

   c) Quantify the noise present in the signal received in b). Justify. (1,5 val)

   d) Considering DBPSK modulation, draw a sketch of station A's signal in the time domain, assuming that each chip corresponds to one cycle. (1,0 val)

2) Consider the control system of an automated factory facility. The propagation environment is quite harsh, with the path loss increasing with the 4th power of distance. The decay measured at 1 meter distance from the transmitter is 15 dB. There are 4 robots and a common access point in the center of the installation, equidistant from the robots. The MAC is based on TDMA/TDD and each robot is allocated its own timeslot for uplink transmission. There is a single downlink timeslot, with the same size, in the beginning of the TDMA superframe. Each timeslot is just enough for a packet of 80 modulation symbols, where only 70 symbols effectively constitute the data frame (the rest corresponds to a guard interval). The RF channel is 200 kHz wide and the center frequency is 868MHz. The modulation is QPSK and the roll-off factor is 1.0. The noise spectral density is -110 dBm/Hz. The antennas are isotropic. The transmit power is 20 mW and the receiver sensitivity is -60 dBm.

   a) Calculate the maximum range between the access point and the robots. (1,0 val)

   b) Calculate the FER when the access point is located at 15 m from the robots. (1,0 val)

   c) Considering a FER of 0.1, calculate the effective throughput capacity in the uplink direction, for each robot. (2,0 val)

   d) Which would the physical area of the antenna required to achieve a 2 dBi gain, considering an antenna efficiency of 50%? (1,0 val)

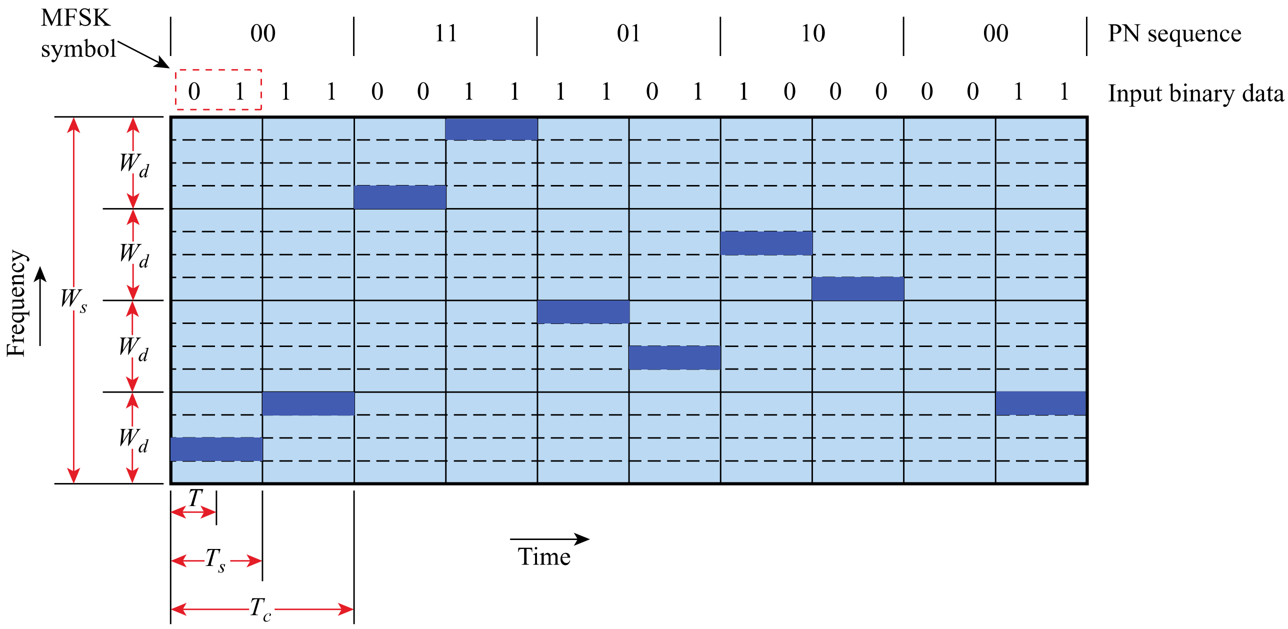
3) Consider a wireless technology operating in the 2.4 GHz frequency band, using MFSK (roll-off factor is $\mathbf{r = 1}$) and FHSS (see the figure). The effective bandwidth is 40 MHz.

   a) Calculate $\mathbf{T_c}$ and $\mathbf{T_s}$. (1,5 val)

   b) Does the system employ slow of fast FHSS? Justify. (1,5 val)

   c) From the point of view of this technology, classify the channel with regard to multipath fading effects, when $\mathbf{B_{coherence} = 500\ MHz}$ and $\mathbf{T_{coherence} = 1\mu s}$. (1,0 val)

   d) Consider that the system is attacked by a jamming signal whose interfering power at the receiver is $\mathbf{P_I}$. Compare the average SNIR with that attained by a narrowband (i.e., without spreading) MFSK system of bandwidth $\boldsymbol{W_d}$. (1,0 val)



4) Consider the IPv4 network represented in the picture below, as well as the routing tables of each router and host. Host H wishes to access a webpage at server S.

   a) Host H has no IP address at its current subnetwork location. Which mechanism can be used by host H to obtain such IP address? Give an example of a suitable IP address. (1.0 val)

   b) Host H does not know the IP address of server S, but it knows its logical name. Which service should it use to get the IP address of the server? (1,0 val)

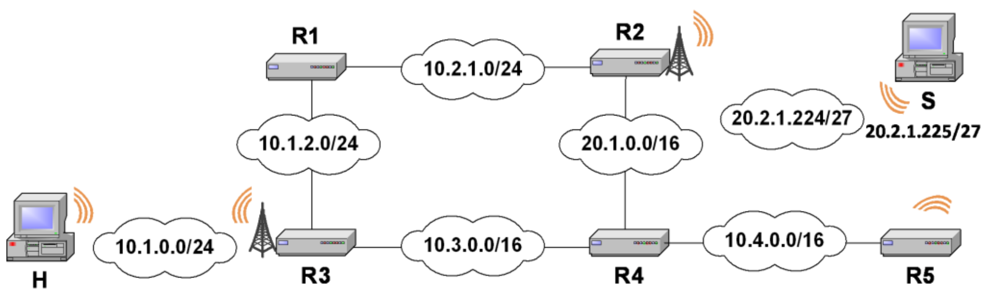
   c) Draw the message diagram at the transport and application protocol levels, once station A knows the IP address of server B. (1,0 val)

   d) What is the path followed by a packet transmitted by H towards S? Justify. (2,0 val)

Destination	Next Hop
10.1.0.0/24	R3
10.1.2.0/24	direct
10.2.1.0/24	direct
10.3.1.0/24	R3
20.2.1.0/24	R2
30.1.1.0/28	R2

Destination	Next Hop
10.1.0.0/24	R1
10.1.2.0/24	R1
10.2.1.0/24	direct
10.3.1.0/24	R4
20.1.0.0/16	direct
20.2.1.224/27	direct
20.2.0.0/16	R4

Destination	Next Hop
10.1.0.0/24	R2
10.1.2.0/24	R2
10.2.1.0/24	R2
10.3.1.0/24	R2
20.1.0.0/16	R2
20.2.1.224/27	direct
10.4.0.0/16	R5



Destination	Next Hop
10.1.0.0/24	direct
10.1.2.0/24	R3
10.2.1.0/24	R3
10.3.1.0/24	R3
20.1.0.0/16	R3
20.2.1.0/28	R3
default	R3

Destination	Next Hop
10.1.0.0/24	direct
10.1.2.0/24	direct
10.2.1.0/24	R4
10.3.1.0/24	direct
10.4.0.0/16	R4
20.2.1.192/26	R1
20.2.0.128/25	R4

Destination	Next Hop
10.1.0.0/24	R3
10.1.2.0/24	R3
10.2.1.0/24	R2
10.3.1.0/24	direct
20.1.0.0/16	direct
20.2.0.0/24	R2
default	R5

Destination	Next Hop
10.1.0.0/24	R4
10.1.2.0/24	R4
10.2.1.0/24	R2
10.3.0.0/16	R4
10.4.0.0/16	direct
20.2.1.0/28	direct

Propagation Models	
Antenna Apperture and Gain	$A_{eff} = \eta \cdot A_{phy} = \frac{\lambda^2}{4\pi} G$
Log-distance Model	$P_r\ [dBm] = P_t\ [dBm] - PL_0 + G_t\ [dBi] + G_r\ [dBi] - 10 \cdot \alpha \cdot log_{10}\ (d / d_0\ )$
Friis Free Space Model	$P_r = P_t \cdot \frac{G_t \cdot G_r \cdot \lambda^2}{(4 \cdot \pi \cdot d)^2}$
Two-Ray Model	$P_r = P_t \cdot \frac{G_t \cdot G_r \cdot (h_t \cdot h_r)^2}{d^4}$ $d_c = \frac{4 \cdot \pi \cdot h_t \cdot h_r}{\lambda}$
Fresnel Zone Radius	$r(F_n) = \sqrt{\frac{n \cdot \lambda \cdot d_1 \cdot d_2}{d_1 + d_2}}$

Maximum Channel Capacity	
Shannon-Heartley Theorem	$C = B \cdot log_2 \left(1 + \frac{S}{N}\right)$
Nyquist Rate (applicable in baseband)	$C = 2 \cdot B \cdot log_2(M)$

Modulation Performance (B)

ASK	$B = (1 + r) \cdot R_b$
M-PSK	$B = \left(\frac{1 + r}{log_2(M)}\right) \cdot R_b$
M-FSK	$B = \left(\frac{(1 + r) \cdot M}{log_2(M)}\right) \cdot R_b$

Modulation Performance (BER)	
BASK	$BER_{ASK} = Q\left(\sqrt{\frac{E_b}{N_0}}\right)$
BFSK	$BER_{BFSK} = Q\left(\sqrt{\frac{E_b}{N_0}}\right)$
DBPSK	$BER_{DBPSK} = 0.5 \cdot e^{-\frac{E_b}{N_0}}$
BPSK	$BER_{BPSK} = Q\left(\sqrt{\frac{2 \cdot E_b}{N_0}}\right)$
QPSK	$BER_{QPSK} = Q\left(\sqrt{\frac{2 \cdot E_b}{N_0}}\right)$
M-PSK	$BER_{MPSK} = 2Q\left(\sqrt{\frac{2 \cdot E_b}{N_0}} \cdot sin\left(\frac{\pi}{M}\right)\right)$
Q function	$Q(k) = P(X > \mu + k\sigma) = \frac{1}{\sqrt{2\pi}} \int_k^{+\infty} e^{-\lambda^2/2} d\lambda$

Probabilities
$\sum_{i=1}^{+\infty} i \cdot (1-p)^{i-1} \cdot p = \frac{1}{p}$

$$\sum_{i=0}^{+\infty} i \cdot (1-p)^{i} \cdot p = \frac{p-1}{p}$$

TABLE OF THE Q FUNCTION

0	5.000000e–01	2.4	8.197534e–03	4.8	7.933274e–07
0.1	4.601722e–01	2.5	6.209665e–03	4.9	4.791830e–07
0.2	4.207403e–01	2.6	4.661189e–03	5.0	2.866516e–07
0.3	3.820886e–01	2.7	3.466973e–03	5.1	1.698268e–07
0.4	3.445783e–01	2.8	2.555131e–03	5.2	9.964437e–06
0.5	3.085375e–01	2.9	1.865812e–03	5.3	5.790128e–08
0.6	2.742531e–01	3.0	1.349898e–03	5.4	3.332043e–08
0.7	2.419637e–01	3.1	9.676035e–04	5.5	1.898956e–08
0.8	2.118554e–01	3.2	6.871378e–04	5.6	1.071760e–08
0.9	1.840601e–01	3.3	4.834242e–04	5.7	5.990378e–09
1.0	1.586553e–01	3.4	3.369291e–04	5.8	3.315742e–09
1.1	1.356661e–01	3.5	2.326291e–04	5.9	1.817507e–09
1.2	1.150697e–01	3.6	1.591086e–04	6.0	9.865876e–10
1.3	9.680049e–02	3.7	1.077997e–04	6.1	5.303426e–10
1.4	8.075666e–02	3.8	7.234806e–05	6.2	2.823161e–10
1.5	6.680720e–02	3.9	4.809633e–05	6.3	1.488226e–10
1.6	5.479929e–02	4.0	3.167124e–05	6.4	7.768843e–11
1.7	4.456546e–02	4.1	2.065752e–05	6.5	4.016001e–11
1.8	3.593032e–02	4.2	1.334576e–05	6.6	2.055790e–11
1.9	2.871656e–02	4.3	8.539898e–06	6.7	1.042099e–11
2.0	2.275013e–02	4.4	5.412542e–06	6.8	5.230951e–12
2.1	1.786442e–02	4.5	3.397673e–06	6.9	2.600125e–12
2.2	1.390345e–02	4.6	2.112456e–06	7.0	1.279813e–12
2.3	1.072411e–02	4.7	1.300809e–06		