Mestrado em

Engenharia Electrotécnica e de Computadores

Redes Móveis e Sem Fios

1º Teste – 1ª parte

21 de Abril de 2017

Duração 1h15

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 the bit sequence "01" with spreading factor 4, using key +1, +1, -1, -1. Station B is transmitting simultaneously a single bit "1" with spreading factor 8. The chip rate is the same for both stations. **The used convention is to represent "0" as +1 and "1" as -1**. The decoding thresholds are +1 and -1, respectively for logical "0" and logical "1".

   a) Which of the following keys should be used by station B: +1, -1, +1, -1, -1, +1, -1, +1 or -1, -1, +1, +1, -1, -1, +1, +1? (1,5 val)

   b) Check if the data from station A is correctly received if station B is using the key -1, +1, +1, -1, -1, +1, +1, -1, the noise is +2, -1, 0, 0, +1, 0, 0, 0 and the signals are received with the same power. (1,5 val)

   c) Assuming that the modulation is 4-FSK with an effective signal bandwidth of 2 MHz and filter roll-off factor $\boldsymbol{r}$=1, calculate the chip rate and the bit rate of stations A and B. (2,0 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 20 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 fixed 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 44 modulation symbols, where only 40 symbols effectively constitute the data frame (the rest corresponds to a guard interval). The RF channel is 100 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. (2,0 val)

   b) Calculate the FER when the access point is located at 12 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) Calculate the gain of the antennas that would be required to duplicate the maximum range. (1,0 val)

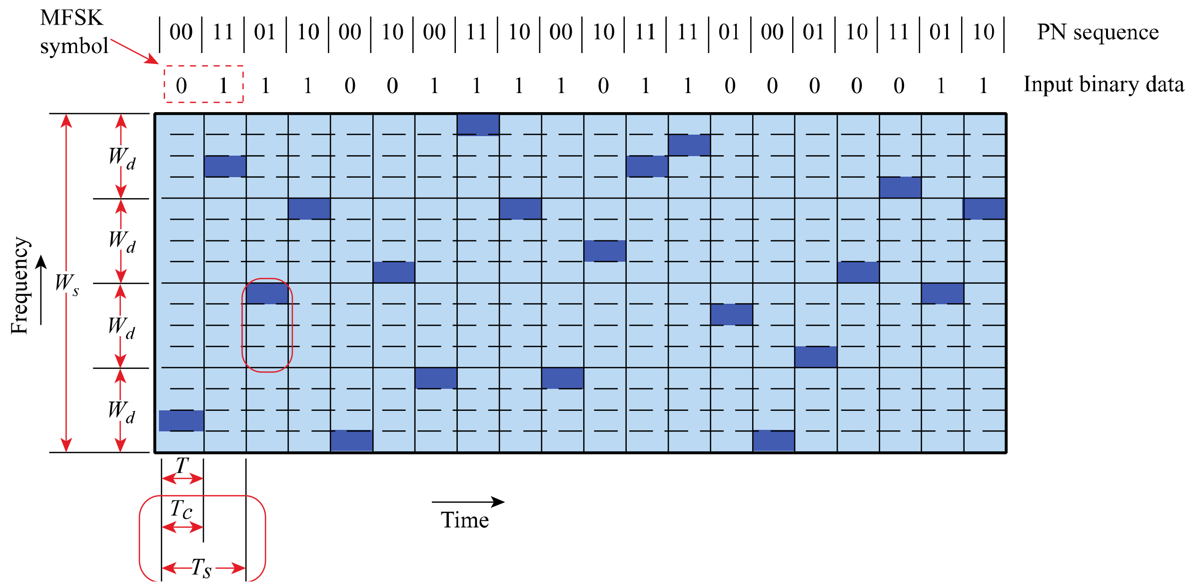
3) Consider a wireless technology operating in the 5 GHz frequency band, using MFSK (roll-off factor is $\boldsymbol{r} = \mathbf{1}$) and FHSS (see the figure). The effective bandwidth is 20 MHz.

   a) Calculate $\boldsymbol{T_c}$ and $\boldsymbol{T_s}$. (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 $\boldsymbol{B_{coherence}} = \mathbf{100}\ \boldsymbol{MHz}$ and $\boldsymbol{T_{coherence}} = \mathbf{1}\boldsymbol{\mu s}$. (1,0 val)

   d) What is the theoretical maximum bandwidth efficiency of the system, as achieved by the best possible modulation and coding techniques when the SNR is 10 dB? (1,0 val)



4) Consider the IPv4 network represented in the picture below, as well as the routing tables of each router and host.

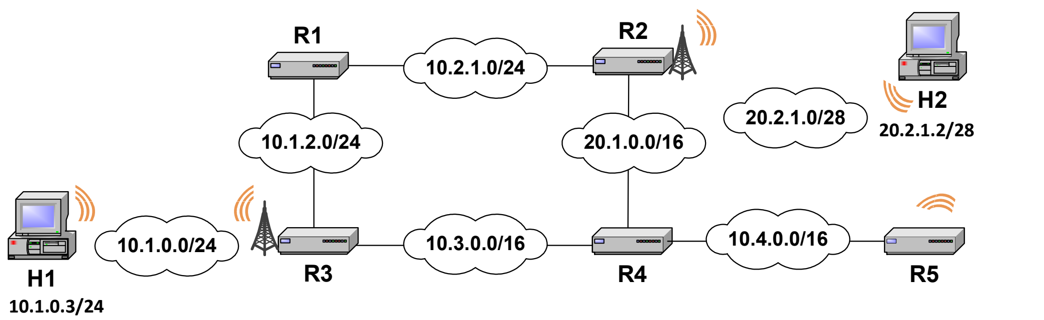
a) What is the path followed by a packet transmitted by H1 towards H2? Justify. (2,0 val)

b) Traffic generated by a host destined to an address outside the subnet where it is attached must be transmitted through a router attached to the host's subnet. Which protocol allows a host to find routers in the subnet where it is located? (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
20.2.1.0/28	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
20.2.1.0/28	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
20.2.0.0/22	R1
20.2.0.0/23	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	
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	$BER_{QPSK} = Q\left(\sqrt{\frac{2 \cdot E_b}{N_0}}\right)$
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		