Mestrado em

Engenharia Electrotécnica e de Computadores

Redes Móveis e Sem Fios

Exame de Recuperação – 1ª parte

6 de Julho de 2018

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 with 4-symbol chip sequences, there are two mobile stations trying to transmit to a base station with keys S1= +1, +1, -1, +1, S2= +1, +1, +1, -1. The time of one bit corresponds to 4 chips and the keys of the stations are synchronized. Assume that the logical value "0" is represented by -1 and logic value "1" is represented by +1. The decoding thresholds are -1 and +1, respectively for logical "0" and logical "1". The sequence that was received at the base station was the following: 0, 0, +3, -2, +2, 0, -2, +2.

   a) Assuming that the noise was too low to destroy the data, calculate which data bits were received from S1 and S2. (1,5 val)

   b) Quantify the noise. (1,5 val)

   c) Do the used keys present good characteristics regarding the mitigation of multipath fading? Suggestion: Calculate maximum delay spread (measured as chip intervals) that will be eliminated during reception, considering the transmission of a single station. (2,0 val)

2) In a Wireless Sensor Network, the sensor nodes are equipped with radio transmitters that operate in the 868 MHz frequency band, using a 300 kHz wide RF channel. The sensor nodes perform temperature measurements and send them to a monitoring station nearby. The sensor nodes are very basic and have no battery. Instead, a small solar panel allows them to accumulate energy in a super-capacitor, just enough for the next packet transmission. The packet size is 10 bytes. The employed modulation is QPSK (roll-off factor is $\boldsymbol{r = 0}$) and the transmit power is 1 mW. The noise spectral density is -140 dBm/Hz. The receiver sensitivity is considered to be the received power at which a FER of 1% is attained without interference. Assume that both the sender and receiver antennas are isotropic and the deployment area is flat. Two-Ray propagation model is assumed with antenna height of 1 m.

   a) Assuming that there is no energy expenditure other than that due to the packet transmissions, calculate the power generated by the solar panel when the packet generation period is 6 seconds. (2,0 val)

   b) Calculate the receiver sensitivity. (2,0 val)

   c) Assuming that the sensor node is deployed at a distance from the base station about half of the maximum range, calculate the maximum tolerated interfering power in order to obtain the same performance achieved at maximum range without interference. (2,0)

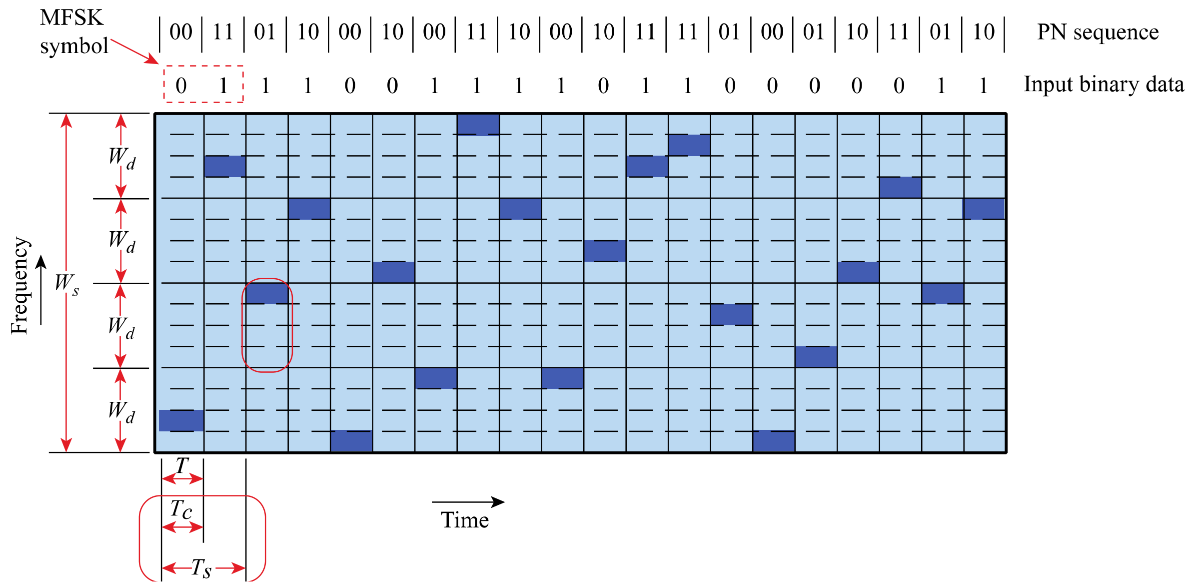
3) Consider a wireless technology operating in the 5 GHz frequency band, using MFSK (roll-off factor is $\boldsymbol{r = 1}$) and FHSS (see the figure). The effective bandwidth is 20 MHz.

   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 $\boldsymbol{B_{coherence} = 100\ MHz}$ and $\boldsymbol{T_{coherence} = 1 \mu s}$. (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 a MIPv6 system without optimizations or extensions, where the hop distances between the different entities are the following: CN→HA=30; HA→CN=33; HA→FA=70; FA→HA=80; FA→MN=7; MN→FA=7; MN→CN=90; CN→MN=80. The CN wishes to establish a Skype telephony session with the MN. Assume that the TTL field of the IP headers is always initialized with 100.

a) Is it possible to setup a Skype session between the CN and the MN? Justify. (2,0 val)

b) In a simple MIP setting (no reverse tunneling), consider that the relevant entities have the following IPv4 addresses: MN (193.154.3.10), HA (193.154.3.1), FA/CoA (195.137.10.2), CN (146.64.4.6). What are the source and destination IP addresses in IPv4 headers of packets exchanged between those entities, considering both inner and outer headers (when applicable)? Justify. (2,0 val)

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	$BER_{QPSK} = Q\left(\sqrt{\frac{2 \cdot E_b}{N_0}}\right)$

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		