Mestrado em

Engenharia Electrotécnica e de Computadores

Redes Móveis e Sem Fios

Exame de Recurso – 1ª parte

28 de Junho de 2016

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 with 8-symbol chip sequences, there are three mobile stations trying to transmit to a base station with keys S1= + 1, - 1, + 1, + 1, + 1, + 1, - 1, - 1, S2= - 1, - 1, + 1, - 1, + 1, - 1, + 1, + 1 and S3=- 1, + 1, + 1, - 1, + 1, + 1, + 1, - 1. The time of one bit corresponds to 8 chips. Assume that the logical value "0" is represented by -1 and logic value "1" is represented by +1. The sequence that was received at the base station was the following: +1, +2, +2, +1, +1, +3, -1, -3. The transmissions are affected by the following noise pattern: 0, +1, +1, 0, 0, 0, 0, 0. The decoding thresholds are -3 and +3, respectively for logical "0" and logical "1".

   a) Which data bits were received from S1, S2 and S3? (2,0 val)

   b) Calculate the data received from S2 when no signal arrives from S3 and the signal from S1 arrives with four times the amplitude of the signal from S2. Explain the results. Note: the amplitude of the target signal from S2 does not change relative to the one considered in a). (2,0 val)

   c) Explain the relationship between DSSS and CDMA. (2,0 val)

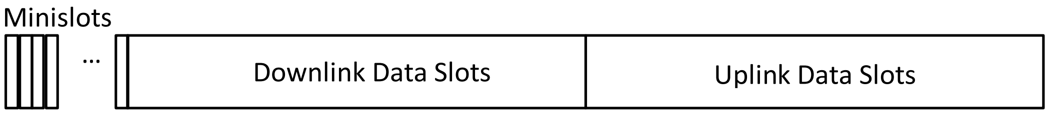
2) In a Wireless Sensor Network, the sensor nodes are equipped with radio transmitters that operate in the 868 MHz frequency band, using a 300 kHz wide RF channel. The sensor nodes perform temperature measurements and send them to a monitoring station nearby. The sensor nodes are very basic and have 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. (1,0 val)

   b) Calculate the receiver sensitivity. (1,5 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. (1,5)

3) Consider a satellite communication system with one satellite and 10 ground stations, which employs a reservation-TDMA MAC scheme, whose superframe (depicted in the figure) has a fixed duration. The ground stations send their data concurrently to the satellite in the uplink portion of the superframe. The ground stations only communicate with the satellite and the satellite only communicates with ground stations. There are 20 uplink data slots and 20 downlink data slots. Uplink data slots are equally divided among the ground stations. Besides the data slots that are assigned to it, a ground station can contend (with probability 40%) for one of the data slots left free (i.e., not reserved) by other ground stations based on ALOHA contention. Each reservation minislot occupies 8 bytes plus one guard interval of 1 ms, and each data slot occupies 500 bytes plus one guard interval of 1 ms. The 500 bytes of the data slot include a header of 8 bytes. The data rate is 300 kbit/s.



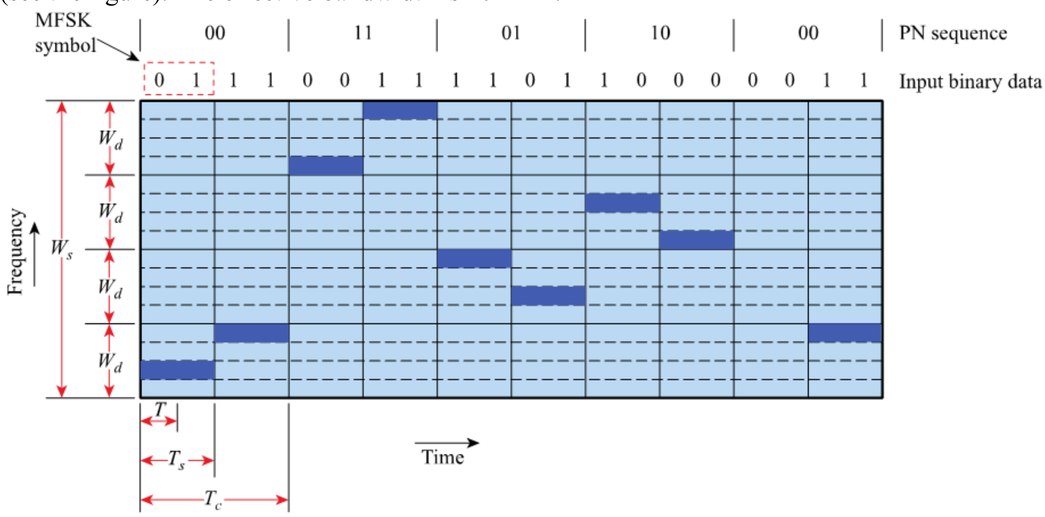
a) How many reservation minislots are needed? (1,0 val)

b) Calculate the duration of the superframe – in case you did not provide an answer to a), consider 5 minislots. (1,0 val)

c) Calculate the average uplink throughput achieved by the LLC of a single ground station when all data slots are reserved by the respective owners. (1,5 val)

d) Repeat b) now considering that there is exactly one free slot and that the ground station under analysis needs it. Also consider that the remaining ground stations need exactly their own uplink slots, thus not competing for the free slot. (1,5 val)

4) 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 $\boldsymbol{B_{coherence} = 500\ MHz}$ and $\boldsymbol{T_{coherence} = 1\mu s}$. (1,0 val)

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

Propagation Models	
Fresnel Zone Radius	$r(F_n) = \sqrt{\dfrac{n \cdot \lambda \cdot d_1 \cdot d_2}{d_1 + d_2}}$
Friis Model	$P_r = P_t \cdot \dfrac{G_t \cdot G_r \cdot \lambda^2}{(4 \cdot \pi \cdot d)^2}$
Two-Ray Model	$P_r = P_t \cdot \dfrac{G_t \cdot G_r \cdot (h_t \cdot h_r)^2}{d^4}$ $d_c = \dfrac{4 \cdot \pi \cdot h_t \cdot h_r}{\lambda}$

Maximum Channel Capacity	
Shannon-Heartley Theorem	$C = B \cdot log_2\left(1 + \dfrac{S}{N}\right)$
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	$B = \left(\dfrac{1 + r}{log_2(M)}\right) \cdot R_b$
M-FSK	$B = \left(\dfrac{(1 + r) \cdot M}{log_2(M)}\right) \cdot R_b$

Modulation Performance (BER)	
BASK	$BER_{ASK} = Q\left(\sqrt{\dfrac{E_b}{N_0}}\right)$
BFSK	$BER_{BFSK} = Q\left(\sqrt{\dfrac{E_b}{N_0}}\right)$
DBPSK	$BER_{DBPSK} = 0.5 \cdot e^{-\frac{E_b}{N_0}}$
BPSK **QPSK**	$BER_{BPSK} = Q\left(\sqrt{\dfrac{2 \cdot E_b}{N_0}}\right)$
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		