



Mestrado em  
Engenharia Electrotécnica e de Computadores

## Redes Móveis e Sem Fios

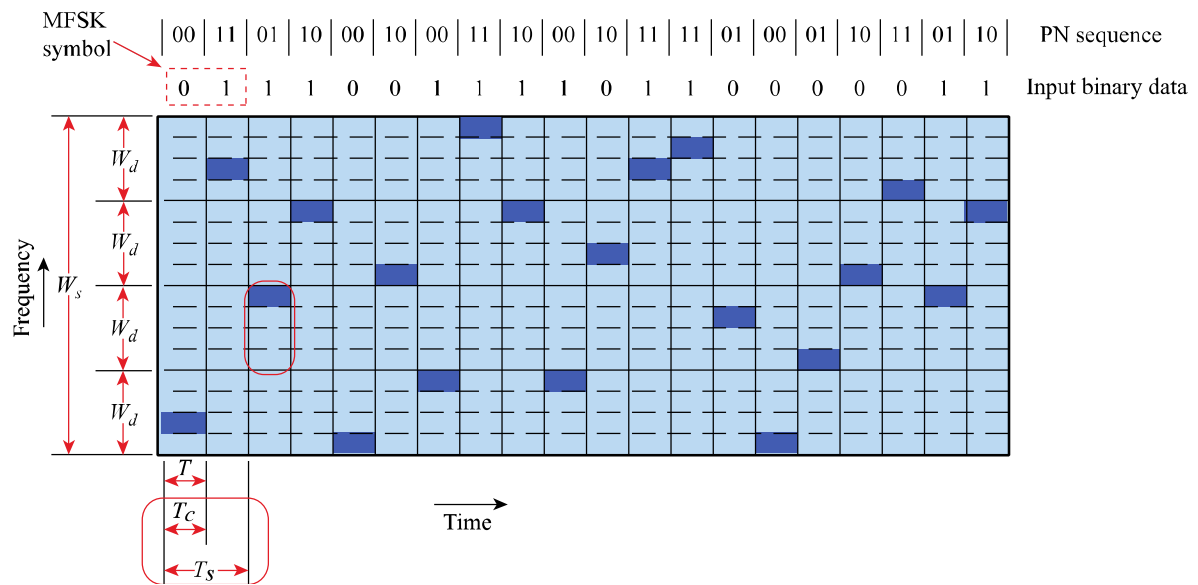
1º Teste – 1ª parte

21 de Abril de 2017

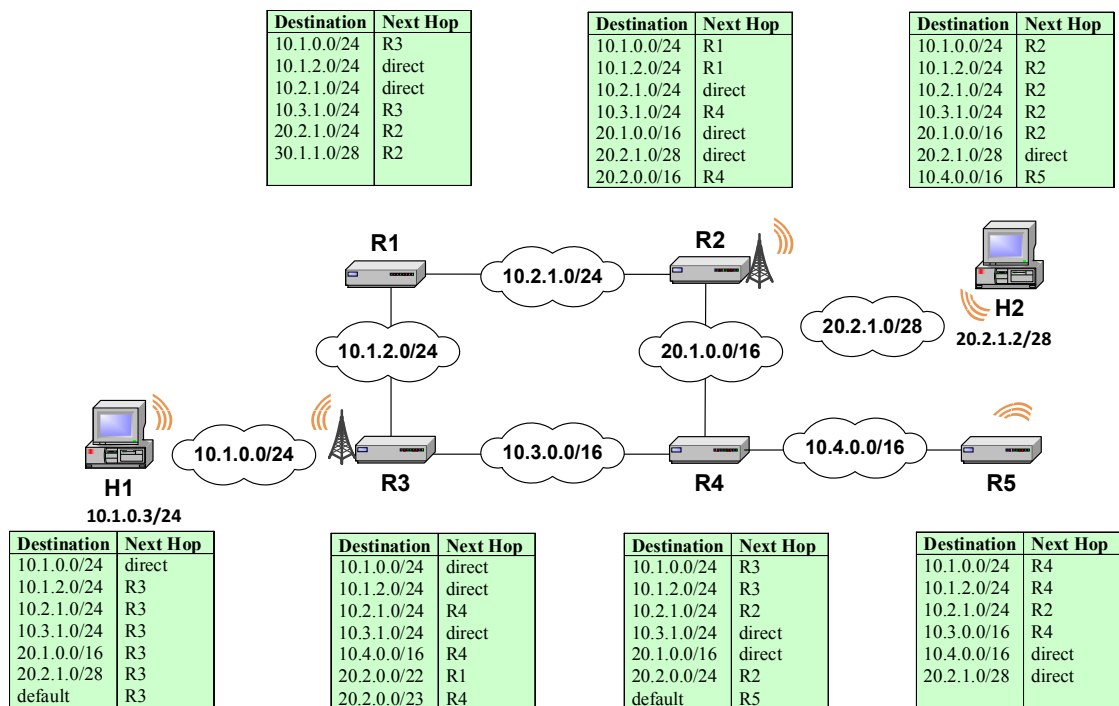
Duração 1h15

**In order to avoid grading mistakes, please answer each question on a different page 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  $r=1$ , 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 4<sup>th</sup> 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  $r = 1$ ) and FHSS (see the figure). The effective bandwidth is 20 MHz.
  - a) Calculate  $T_c$  and  $T_s$ . (1,5 val)
  - b) Does the system employ slow or 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  $B_{coherence} = 100 \text{ MHz}$  and  $T_{coherence} = 1\mu\text{s}$ . (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.
- What is the path followed by a packet transmitted by H1 towards H2? Justify. (2,0 val)
  - 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)



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-08
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		