Mestrado em

Engenharia Electrotécnica e de Computadores

# Redes Móveis e Sem Fios

## 1º Teste

30 de Abril de 2021

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 there are two mobile stations (A and B) whose separation is done using CDMA. Chip modulation is BPSK. Station A has the following spreading code: +1, -1, +1, -1, -1, +1, -1, +1. Station B has the following spreading code: +1, +1, +1, +1, -1, -1, -1, -1. The decoding thresholds are ≤-4 and ≥+4, respectively for logical "0" and logical "1". At the time instant in question, impulsive noise from a nearby radar affects station A and station B equally, with pattern 0, 0, -2, -1, 0, 0, 0, 0. The base station is transmitting with SF4 to station A, emitting the following sequence: -1, +1, -1, +1, +1, -1, +1, -1.

   a) If the bitrate transmitted by the base station to station A is 2 Mbit/s, what is the chip rate? Justify. (1,0 val)

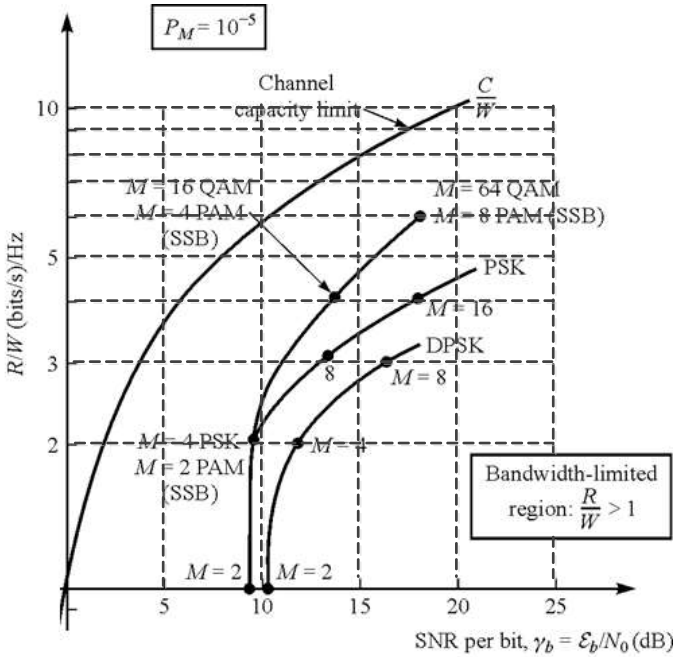
   b) Assuming the conditions in a), what is the approximate bandwidth of the transmitted signal when the roll-off is 0, with and without spreading? (1,0 val)

   c) What is the data interpreted by station B, assuming that B knows the SF of the transmission? (1,0 val)

   d) Consider that, at the same time that the base station transmits to station A, it also transmits bit value '1' to station B with SF8. What is the sequence received by station B before DSSS processing? Justify. (1,5)

   e) In the considered system, chips are encoded using BPSK modulation. Draw the constellation diagram of this modulation, assuming that one of the symbols corresponds to a phase of 90º. (0,5 val)

2) Consider the chart below, which relates bandwidth efficiency and $\frac{E_b}{N_0}$ for different signal encoding techniques, for a symbol error rate $P_M = 10^{-5}$. In the chart, $R$ represents the achieved bitrate, $W$ represents the required bandwidth and $C$ represents the maximum bitrate capacity according to the Shannon-Heartley theorem.



a) What is the maximum bitrate that can be achieved with 12 MHz of bandwidth, using DPSK modulation at $\frac{E_b}{N_0} = \mathbf{15}$ dB? Note: round values to the closest integer. (1,5 val)

b) With $\frac{E_b}{N_0} < \mathbf{15\ dB}$, what is the maximum bandwidth efficiency that can be achieved with QAM modulation? How many symbols are used in that case? Note: round values to the closest integer (2,0 val)

c) What is the symbol error rate achieved with 8-PSK when the bit error rate is $\boldsymbol{BER = 10^{-5}}$? Assume that bit errors are independent, and the probabilities of changing 1 for 0 and 0 for 1 are the same (BSC channel). Suggestion: take into account the number of bits per symbol. (1,5 val)

3) Consider a point-to-point radio link operating in a 6 MHz wide frequency range centered at 3.5 GHz. Within that frequency range, FDD is employed with bandwidth divided equally among the two directions, with a guard band of 100 kHz between directions. The link connects two buildings of the same company in a city, which are located 2 km apart. The path loss measured at 100 m is 103 dB. Beyond that distance, a path loss exponent of 3 was estimated. The endpoint antennas stand 1 m high at the top of the buildings, featuring gains of 13 dBi in both cases. The employed radio technology has four modes of operation achieved with different combinations of channel coding and modulation, whose bitrates and respective sensitivities are the following: <6Mbit/s, -95 dBm>, <12Mbit/s, -93 dBm>, <18Mbit/s, -91 dBm>, <24Mbit/s, -89 dBm>. The transmit power is 400 mW. The noise power spectral density is -170 dBm/Hz.

a) What is the theoretical capacity limit of the channel in each direction? (1,5 val)

b) Assuming that the endpoints always communicate at the maximum possible bitrate, what is that bitrate? (1,0 val)

c) Calculate the physical area of the antennas, knowing that the antenna efficiency is 80%. (1,5 val)

d) Calculate the spectral efficiency of each mode of operation when the error probability is negligible. (1,0 val)

4) Consider a MIPv6 system without optimizations or extensions, where the hop distances between the different entities in direct routes are the following: CN→HA=25; HA→CN=93; HA→FA=80; FA→HA=80; FA→MN=7; MN→FA=7; MN→CN=90; CN→MN=80. The CN wishes to establish an HTTP session with the MN. Assume that the TTL field of the IP headers is always initialized with 100.

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

*b)* In a MIP setting with 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)

*c)* Explain succinctly the role of the Foreign Agent in MIPv6, and how that role differs from MIPv4. (1,0 val)