

## Redes Móveis e Sem Fios

### Exame de Recuperação – 2ª parte

6 de Julho de 2018

Duração 1h30

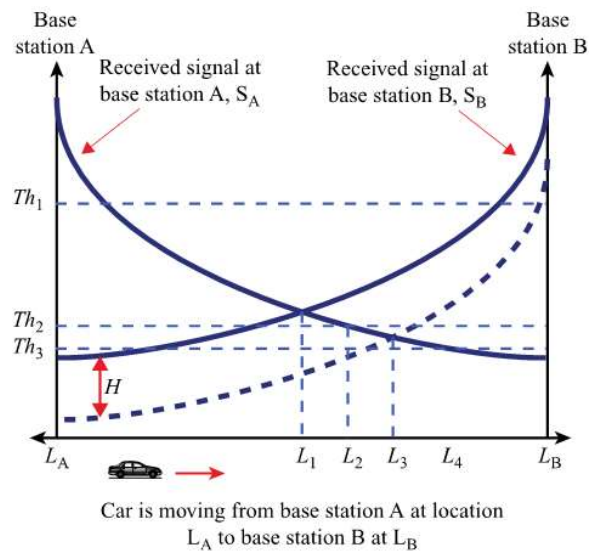
**In order to avoid grading mistakes, please answer each question on a different page, keeping the order as much as possible.**

- 1) Consider a Bluetooth piconet, comprising one master (mobile phone) and two slave devices (S1 and S2, an handfree auricular and PC, respectively). The master has established an SCO link with S1 for a voice call (64 kbit/s in each direction). In the meantime, S2 is sending data to the Internet through the master, using an ACL link.
  - a) Considering that the SCO link is using HV2 packets, how many slots can be assigned to the ACL link between the periodic SCO transmissions? (2,0 val)
  - b) What is the maximum data rate (in bits/s) that the PC can send to the Internet while the SCO link is active? (2,0 val)
  - c) Explain the purpose of the Park state of a node, as well as the 8-bit Parked Member Address. (1,0 val)
  
- 2) LoRaWAN is a Low Power Wide Area Network (LPWAN) technology, which is currently considered very promising from the point of view of Internet of Things (IoT) implementation.
  - a) The LoRaWAN architecture defines three main network side entities: the Gateway, the Network Server and the Application server. Succinctly explain the role of each of these entities. (2,0 val)
  - b) After an uplink (end device to network) transmission, the end device must wake-up in the receive windows (RX1 and RX2) that follow (see picture). Explain the function of those receive windows and how they are to be used. (2,0 val)
  - c) Indicate two management data items that must be configured in the end device after activation. (1,0 val)



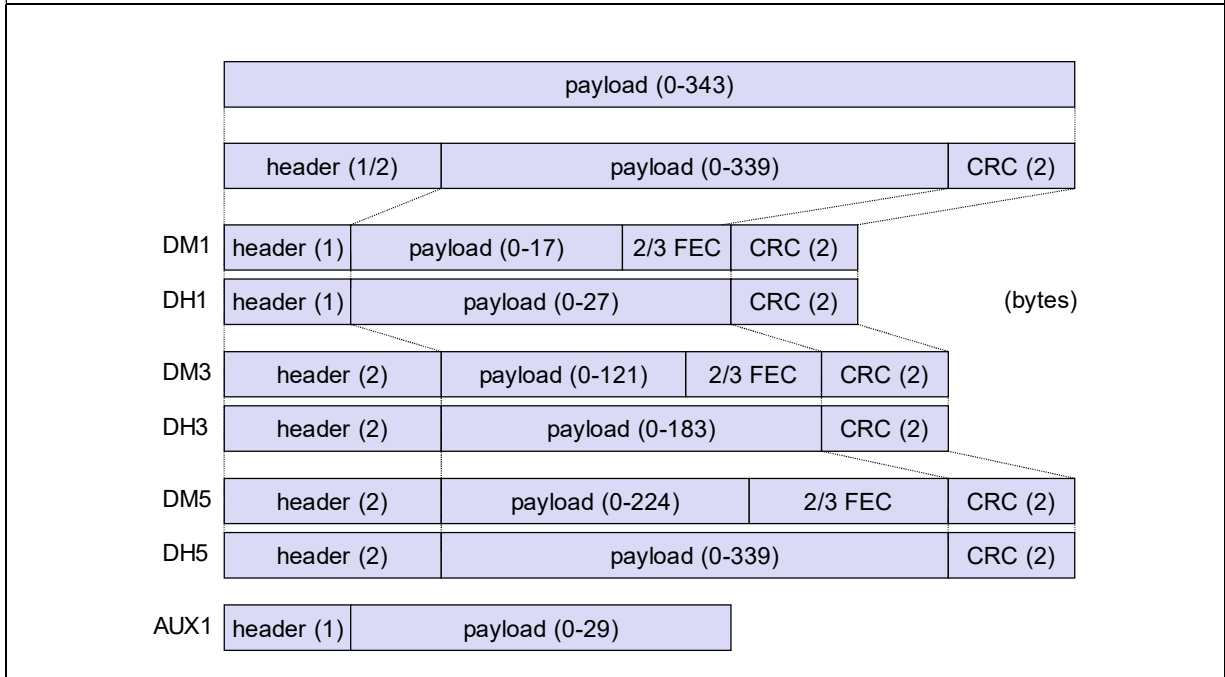
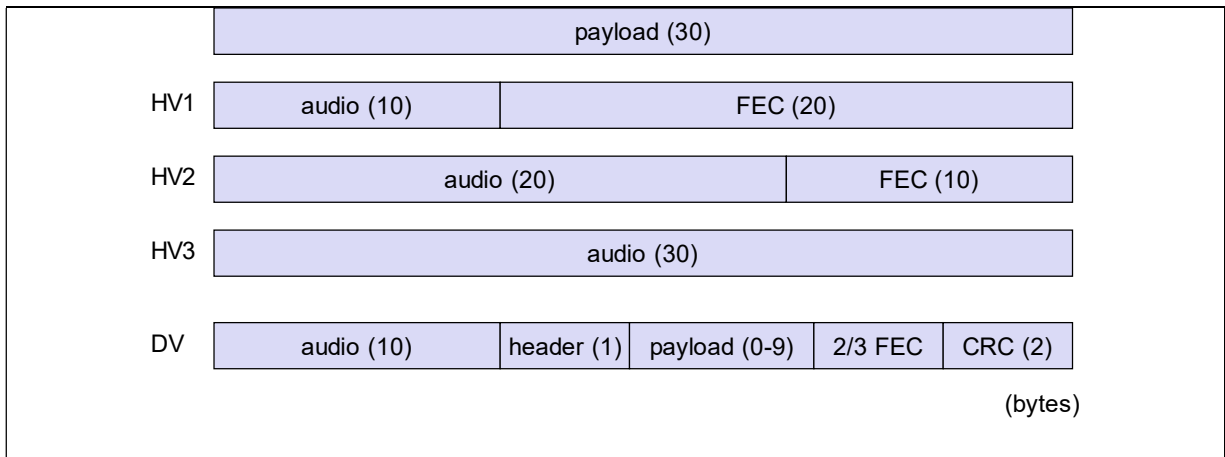
\* RX2 does not need to be present if reply is received in RX1

- 3) Consider a mobile cellular system. A mobile terminal is currently connected with Base Station A, and approaching Base Station B, as depicted in the following picture.



- a) Which handoff locations ( $L_A, L_1, L_2, L_3, L_4, L_B$ ) result from the following handover strategies:
- i) Relative Signal Strength. (1,0 val)
  - ii) Relative Signal Strength with Hysteresis. (1,0 val)
  - iii) Relative Signal Strength with Threshold  $Th_2$ . (1,0 val)
  - iv) Relative Signal Strength with Hysteresis and Threshold  $Th_3$ . (1,0 val)
- b) Explain the advantages and disadvantages of Open-Loop Power Control vs Closed-Loop Power control. (1.0)
- 4) Consider an experimental MEO satellite system operating in the 2 GHz frequency, with transmit power of 40 dBm. One of the functions of the satellite is to perform the echo of received signals. A ground station is located in the line that forms the projection of satellite's orbit. Each time the satellite passes right over it, the ground station transmits one sounding signal and receives its echo. The measured time interval between the transmission of the signal and the reception of the echo is 50 ms, which includes 10 ms of processing delay. The satellite and ground station antennas have similar characteristics, featuring a divergence angle of  $21,55^\circ$ . The atmosphere introduces an additional attenuation of 10 dB.
- a) Calculate the period of transmissions from the ground station, knowing that the satellite has an equatorial orbit and travels AGAINST the rotational movement of the Earth. (2,0 val)
  - b) Calculate the gain of the antennas. (1,0 val)
  - c) Knowing that the transmit power was chosen as to provide a 6 dB safety margin relative to the required minimum, calculate the receiver sensitivity. (2,0 val)

<b>Bluetooth</b>
<b>1 slot = 625us</b>
<b>SCO stream throughput = 64 kbit/s</b>



Satellite Systems	
$F_g = m \cdot g \cdot (R/r)^2$ $g = 9.81 \text{ m/s}^2$ $R = 6370 \text{ km}$	$F_c = m \cdot r \cdot \omega^2$
$L = \left( \frac{4 \cdot \pi \cdot r \cdot f}{c} \right)^2$	$\text{FootprintRadius} = \alpha_{div} \times d$
$G_{(1plane)} = 2\pi / (2 \cdot \alpha_{div})$	$A_{eff} = \eta \cdot A_{phy} = \frac{\lambda^2}{4\pi} G$
$P_r(\text{dBm}) = P_t(\text{dBm}) + 10 \cdot \log_{10} \left( \frac{G_t \cdot G_r \cdot \lambda^2}{(4 \cdot \pi \cdot d)^2} \right) - At$ $P_r(\text{dBm}) = P_t(\text{dBm}) - 10 \cdot \log_{10} \left( \frac{4 \cdot \text{FootprintArea}}{\pi^2 \cdot A_{eff}} \right) - At$	

$$\frac{R}{R+h} = \frac{\sin(\alpha)}{\sin\left(\theta + \frac{\pi}{2}\right)} =$$

$$\frac{\sin\left(\frac{\pi}{2} - \beta - \theta\right)}{\sin\left(\theta + \frac{\pi}{2}\right)} = \frac{\cos(\beta + \theta)}{\cos(\theta)}$$
  

$$\frac{d}{R+h} = \frac{\sin(\beta)}{\sin\left(\theta + \frac{\pi}{2}\right)} =$$

$$= \frac{\sin(\beta)}{\cos(\theta)}$$

$$d = \frac{(R+h) \cdot \sin(\beta)}{\cos(\theta)} = \frac{R \cdot \sin(\beta)}{\sin(\alpha)}$$

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$$\frac{a}{\sin(A)} = \frac{b}{\sin(B)} = \frac{c}{\sin(C)}$$

$$a^2 = b^2 + c^2 - 2 \cdot b \cdot c \cdot \cos(A)$$

$$b^2 = a^2 + c^2 - 2 \cdot a \cdot c \cdot \cos(B)$$

$$c^2 = a^2 + b^2 - 2 \cdot a \cdot b \cdot \cos(C)$$

<b>Cellular Networks and Traffic Engineering</b>	
<b>Hexagonal cell area:</b> $A_{cell} = 1.5 \times R^2 \times \sqrt{3}$	<b>Distance between hexagonal cell centers:</b> $d = \sqrt{3} \times R$
<b>Frequency reuse factor:</b> $RF = \frac{1}{G}$	<b>Cell cluster sizes:</b> $G = I^2 + J^2 + (I \times J)$ <i>st</i> $I, J = 0, 1, 2, \text{ etc.}$
<b>Traffic intensity:</b> $A = \lambda \cdot h$	<b>Traffic intensity:</b> $A = \rho \cdot N$
<b>Grade of service for <math>\infty</math> sources LCC:</b> $P = \frac{\frac{A^N}{N!}}{\sum_{x=0}^N \frac{A^x}{x!}}$	<b>Capacity of blocking system:</b> $C = A(1 - P)$