Mestrado em

Engenharia Electrotécnica e de Computadores

Redes Móveis e Sem Fios

2º Teste

21 de Junho de 2017

Duração 1h30

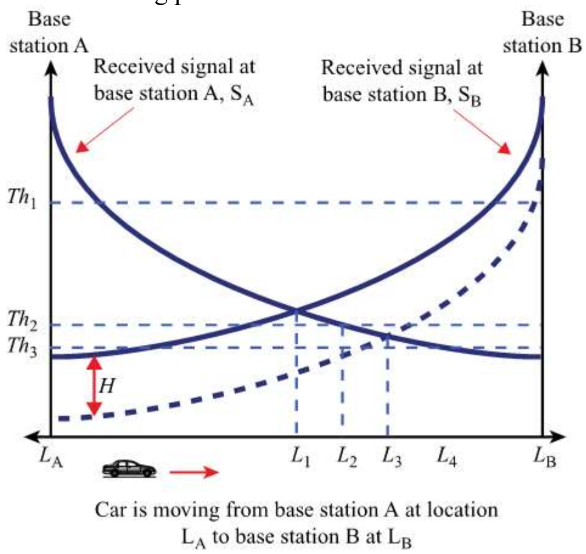
In order to avoid grading mistakes, please answer each question <u>on a different page,</u> keeping the order as much as possible.

1) Consider a Bluetooth piconet, comprising one master and two slave devices (S1 and S2). The master device has the following ACL packets in its transmission queue, which are ordered as follows (format is <destination, packet>): <S2, DM1>, <S1, DH5>, <S2, DM3>. Regarding the ACL uplink traffic: S1 has two packets in the queue: DH3 and DM1; S2 has a single DH1 packet in the queue.

   a) Draw the timeline diagram of packet transmissions, clearly indicating the timeslot assignment (for each packet, indicate the type, the occupied slots, the sender and the receiver). The diagram ends when the last ACL packet is transmitted. (2,5 val)

   b) In case there is an SCO session going on simultaneously, assuming that it employs HV2 packets, can the ACL traffic considered above be dispatched? Justify. (1,5 val)

2) 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 with Hysteresis and Threshold, with threshold *Th1*. (1,0 val)

      ii) Relative Signal Strength with Threshold, with threshold *Th1*. (1,0 val)

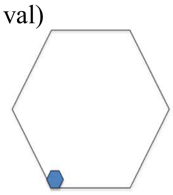
      iii) Relative Signal Strength with Hysteresis. (1,0 val)

   b) Explain the importance of the signal strength hysteresis in the context of handoff strategies. (1.0)

3) Consider an LTE-A system with 100 Resource Blocks (RBs), and one cell with radius $\boldsymbol{R_1 = 4\ km}$. Each active session is assigned 1 Resource Block. In the beginning, the mean rate of sessions was $\boldsymbol{\lambda = 2\ session/s}$ and the average duration of one session was $\boldsymbol{h = 38,7\ s}$.

a) Calculate the session blocking probability when the LTE-A service had just started in that area. (1,0 val)

b) As time passed, the density of users in one part of the cell has increased to a point that forced the operator to split the initial cell, creating a small cell with radius $\boldsymbol{R_2 = 500\ m}$, in addition to the originating cell (see picture). The small cell reuses all the 100 RBs of the bigger cell. What is now the supported capacity of the system in Erlangs, for the same area (i.e, the total area of the big cell) and grade of service? Note: assume that only users located inside the small cell connect the new eNB, while only users located in the remaining part of the big cell connect to the original eNB. (1,0 val)



c) Considering that all the users have similar behavior in all parts of the big cell, and assuming that the small cell is prepared to support an average user density of 1 user per 200 m^2, calculate the user density that the remainder of the big cell is prepared to support. (2,0 val)

d) How many RBs would be needed to provide the same capacity (i.e., the one calculated in b)) without cell splitting, considering only the values presented in the table? In case you didn't answer to b), consider a traffic intensity of 140 and a call blocking probability of 0,002. (2,0 val)

4) Consider one of the orbital planes of a LEO satellite system operating in the 1 GHz frequency, with transmit power of 40 dBm. The angular speed is 0.82 mrad/s. The satellite and ground station antennas have similar characteristics, featuring a divergence angle of 43°. The atmosphere introduces an additional attenuation of 10 dB.

a) Calculate the altitude of the orbit, knowing that $\boldsymbol{r} = \sqrt[3]{\frac{g \cdot R^2}{\omega^2}}$ is the distance of the satellite to the center of the Earth, with the following constants: $\boldsymbol{g = 9.81 m/s^2}$ (gravitational acceleration), $\boldsymbol{R = 6370\ km}$ (radius of the Earth). (2,0 val)

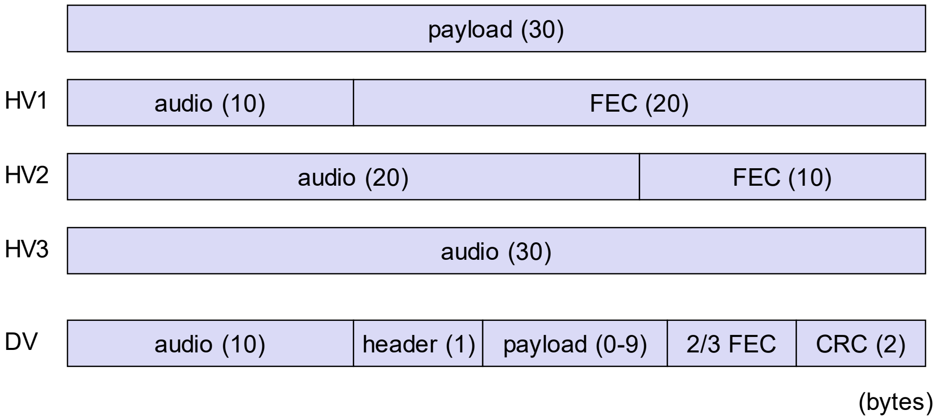
b) Calculate the gain of the antennas. (2, 0 val)

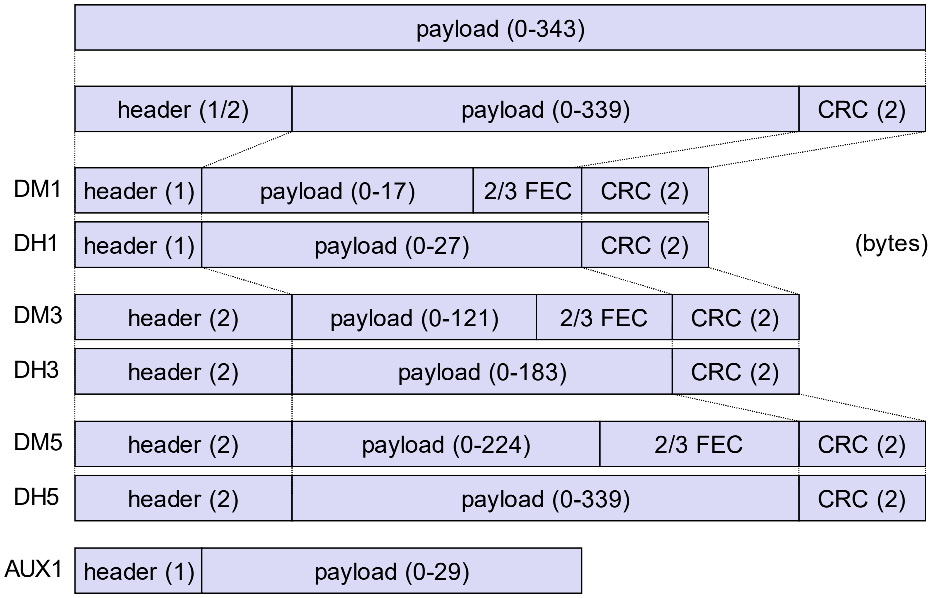
c) Knowing that the transmit power was chosen as to provide a 6 dB safety margin relative to the required minimum, calculate the receiver sensitivity. (2,0 val)

Bluetooth

1 slot = 625us

SCO stream throughput = 64 kbit/s





Satellite Systems	
$F_g = m \cdot g \cdot (R/r)^2$	$F_c = m \cdot r \cdot \omega^2$
$L = \left(\frac{4 \cdot \pi \cdot r \cdot f}{c}\right)^2$	$Footprint\ Diameter = \theta_{div} \times d$
$G_{(1plane)} = 2\pi/\theta_{div}$	$A_{eff} = \eta \cdot A_{phy} = \frac{\lambda^2}{4\pi} G$
$P_r(dBm) = P_t(dBm) - 10 \cdot log_{10}\left(\frac{4 \cdot Footprint}{\pi^2 \cdot A_{eff}}\right) - At$	

Erlang-B Capacity (Erlangs) for Grade of Service of					
Number of Servers (*N*)	***P*=0.02 (1/50)**	***P*=0.01 (1/100)**	***P*=0.005 (1/200)**	***P*=0.002 (1/500)**	***P*=0.001 (1/1000)**
20	**13.19**	**12.03**	**11.10**	**10.07**	**9.41**
30	**21.9**	**20.3**	**19.0**	**17.6**	**16.65**
40	**31.0**	**29.0**	**27.3**	**25.7**	**24.5**
100	**87.97**	**84.1**	**80.9**	**77.4**	**75.2**
115	**102.50**	**98.20**	**94.70**	**90.95**	**88.50**
125	**112.30**	**107.70**	**104.00**	**100.00**	**97.40**
150	**136.80**	**131.55**	**127.35**	**122.85**	**119.90**
175	**161.40**	**155.55**	**150.90**	**145.90**	**142.65**
200	**186.16**	**179.74**	**174.64**	**169.15**	**165.62**

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