TÉCNICO LISBOA

Mestrado em

Engenharia Electrotécnica e de Computadores

Redes Móveis e Sem Fios

Exame de Recuperação – 2ª parte

28 de Junho de 2016

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 an IPv6 IoT sensor network operating over IEEE 802.15.4 with 6LoWPAN adaptation and RPL routing allowing multihop operation. The sensor network is connected to the Internet via an Edge Router. The global prefix of the sensor network is 2001:300a:1::/64.

   a) Explain why the 6LoWPAN adaptation to IPv6 is needed in this kind of network. (1,0 val)

   b) Assuming stateless header compression, as defined in RFC4944, how many bits of the source and destination network prefixes and how many bits of the source and destination interface identifiers must be sent in the 6LoWPAN header when sensor 2001:300a:1::3 sends a packet to sensor 2001:400d:1::5? Justify. (2,0 val)

   c) Reconsider your response to b) in case context-based compression is used instead. (1,0 val)

2) Consider an ad-hoc network formed by 4 nodes A, B, C and D in a linear topology. Node A generates data packets whose destination is D. The routing protocol supported in this network is DSR.

   d) DSR is a reactive routing protocol. Explain the advantages and disadvantages of reactive routing protocols in comparison with proactive routing protocols. (2,0 val)

   e) Draw the message diagram of route establishment between A and D, identifying unicast and broadcast transmissions and the main message fields. (2,0 val)

   f) Explain which mechanisms can be implemented in DSR in order to reduce the route establishment delay. (1,0 val)

3) GSM is a mobile cellular technology which employs both FDMA and TDMA for multiple access. In GSM900 (890.2 MHz – 960 MHz), 124 bi-directional frequency channels are defined, each with a bandwidth of 200 kHz. In each frequency channel, time is divided in frames of 4.615 ms divided into 8 timeslots. The duplexing scheme is TDD, so that a call occupies one uplink timeslot in one of the lower frequency channels (central frequency $\boldsymbol{f_u} \in [\mathbf{890.3\ MHz}, \mathbf{914.9\ MHz}]$), with the corresponding downlink timeslot being allocated in the frequency channel that has center frequency $\boldsymbol{f_d = f_u + 45MHz}$. In the countryside, GSM cells are allowed to have a radius up to 35 km.

   a) In your opinion, why were the uplink channels assigned lower frequencies? (1,0 val)

   b) Consider a deployment of 32 GSM base stations in the countryside. Which should be the area of the cell in order to achieve maximum coverage, assuming that there is only one antenna per base station? (2 val)

   c) It is desirable to minimize as much as possible the interference between adjacent cells. A GSM900 operador, who owns 16 of the available frequency channels, wishes to calculate a suitable cell cluster size among three possibilities: 3, 4 and 7. Assuming an Erlang B model (infinite sources, Lost Calls Cleared) as represented in the table below, which cluster size should be chosen so that each cell can support a traffic intensity of at least 12 Erlangs with $\boldsymbol{P = 0.01}$? (2 val)

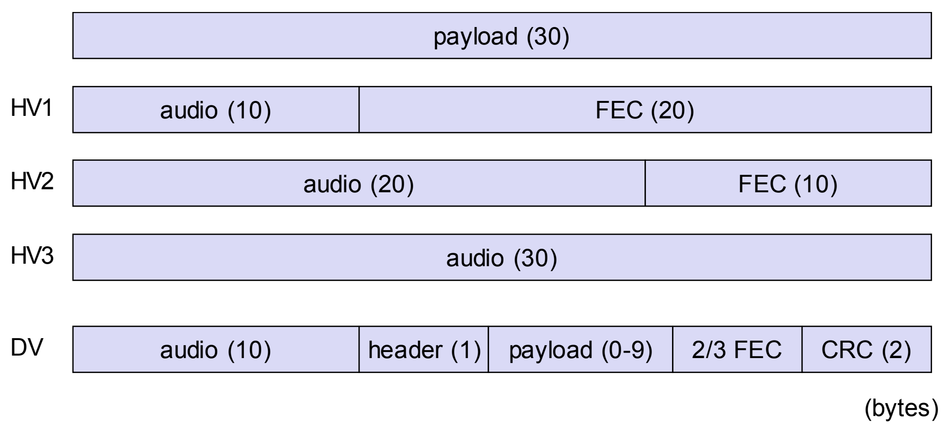
Capacity (Erlangs) for Grade of Service of					
Number of Servers (*N*)	**P=0.02 (1/50)**	**P=0.01 (1/100)**	**P=0.005 (1/200)**	**P=0.002 (1/500)**	**P=0.001 (1/1000)**
17	10.65	9.65	8.80	7.9	7.35
20	13.19	12.03	11.10	10.07	9.41
30	21.9	20.3	19.0	17.6	16.65
40	31.0	29.0	27.3	25.7	24.5
100	87.97	84.1	80.9	77.4	75.2
124	111.30	106.75	103.05	99.10	96.50
248	233.80	226.40	220.45	214.13	210.05

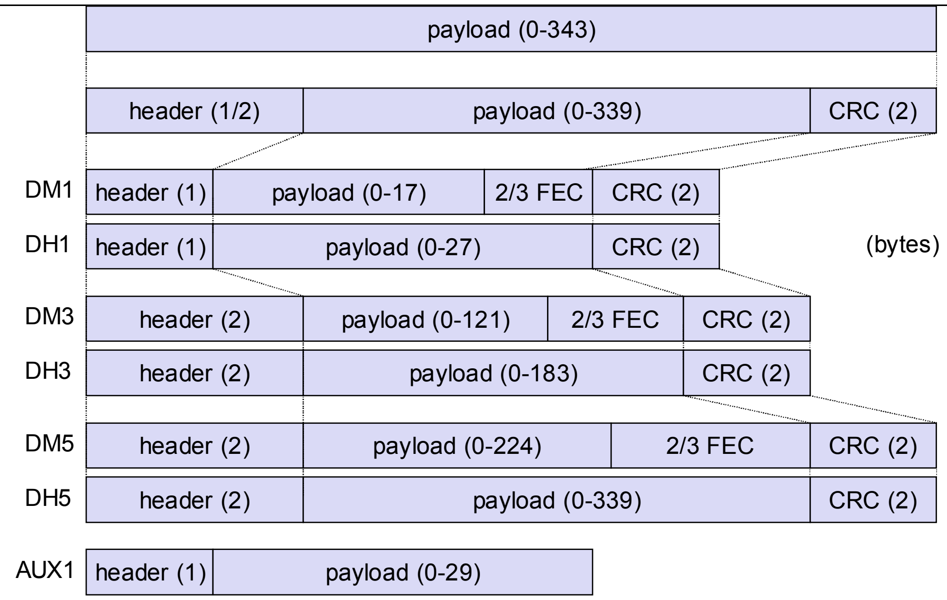
4) Consider one of the orbital planes of a LEO satellite system operating in the 2 GHz frequency. The altitude of the satellites is 1500 km, with the footprint of each satellite equal to $\mathbf{4.845 \times 10^{11} m^2}$. The satellite and ground station antennas have similar characteristics.

a) Calculate the divergence angle of the antennas. (2,0 val)

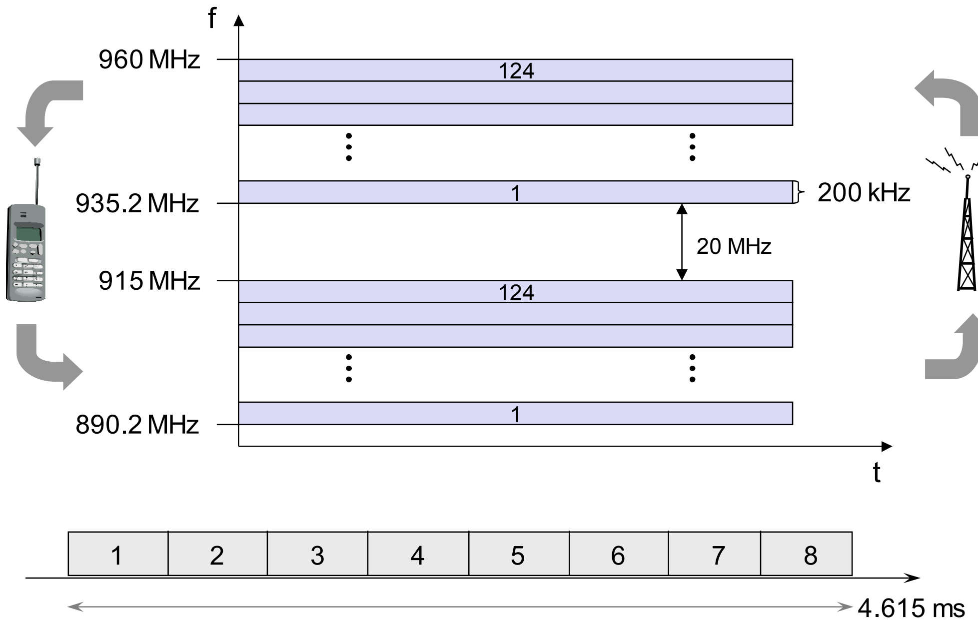
b) Calculate the gain of the antennas. (2, 0 val)

c) What is the maximum time interval during which a ground station can maintain connectivity with the same satellite, assuming that the minimum elevation is 10º? Note: assume that the rotational speed of the Earth is negligible compared with the rotational speed of the satellite. Note2: assume that the ground station is located on the line that corresponds to the projection of the satellite's orbit on the Earth's surface. Note: $\boldsymbol{r} = \sqrt[3]{\frac{\boldsymbol{g \cdot R^2}}{\boldsymbol{\omega^2}}}$ with the following constants: $\boldsymbol{g = 9.81 m/s^2}$ (gravitational acceleration), $\boldsymbol{R = 6370\ km}$ (radius of the Earth), $\boldsymbol{r}$ is the distance of the satellite to the center of the Earth. (2,0 val)

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




GSM



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

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:** $C = A(1 - P)$