Mestrado em

Engenharia Electrotécnica e de Computadores

Redes Móveis e Sem Fios

2º Teste

20 de Junho de 2018

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>): <S1, DH3>, <S2, DM1>, <S2, DM5>. Regarding the ACL uplink traffic: S1 has two packets in the queue: DM5 and DH3; S2 has a single DM3 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), as well as the frequency in use in each slot. The diagram ends when the last ACL packet is transmitted. (2,0 val)

    b) In a piconet with only one master and one slave, which FEC-enabled packet types should be employed in each direction, so that the throughput from master to slave is maximized, while the throughput from slave to master is at least 350 kbit/s? Indicate the respective throughput values in each direction. Justify. (2,0 val)

    c) Explain the main mechanisms that minimize the interference between piconets operating within transmission range of each other. (1.0 val)

2) The Internet of Things enables the accessibility of smart objects through the Internet, allowing the development of applications that make decisions based on the measurements performed by smart objects, while also allowing dynamic smart object management and control.

    a) Compare the COAP and MQTT protocols regarding the implementation of a publish&subscribe IoT services. Justify. (1.5 val)

    b) Compare COAP and MQTT regarding the possibility of employing UDP as the transport protocol. Justify. (1.5 val)

    c) Draw the message diagram of a COAP GET request between a client and a server, indicating, for each message, the Type, Message ID, Token and contents. Assume that the first Message ID is 0x4567, and the first Token is 0x34, the resource being read is /humidity and the respective value measured by the server node is "134". Assume a piggy-backed confirmed response message model. (2.0 val)

3) A new mobile network operator wished to cover a small area in the downtown of Lisbon, which is still visited today by huge numbers of tourists, especially during the summer season. This was accomplished with one picocell. The expected number of session establishment attempts per minute was 5 and the expected session duration was 5 minutes, during peak times. Assume an Erlang B model (see table below).

    a) How many channels were needed in order to provide a blocking probability equal to 0.002? Justify. (2,0 val)

    b) After some time, the operator realized that an increase in the number of users had caused the service to degrade to a probability of blocking of 0.02. Which were the offered and carried traffic by then? If you did not answer to a), consider that the number of channels was 20. Justify. (2,0 val)

    c) Suggest two measures, which can be carried out by the mobile network operator in order to restore the grade of service, assuming that it is out of question to buy new channels? (1,0 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)***
10	***5.08***	***4.46***	***3.96***	***3.43***	***3.09***
20	***13.19***	***12.03***	***11.10***	***10.07***	***9.41***
24	***16.64***	***15.27***	***14.21***	***13.01***	***12.24***
40	***31.0***	***29.0***	***27.3***	***25.7***	***24.5***
70	***59.13***	***56.1***	***53.7***	***51.0***	***49.2***
100	***87.97***	***84.1***	***80.9***	***77.4***	***75.2***

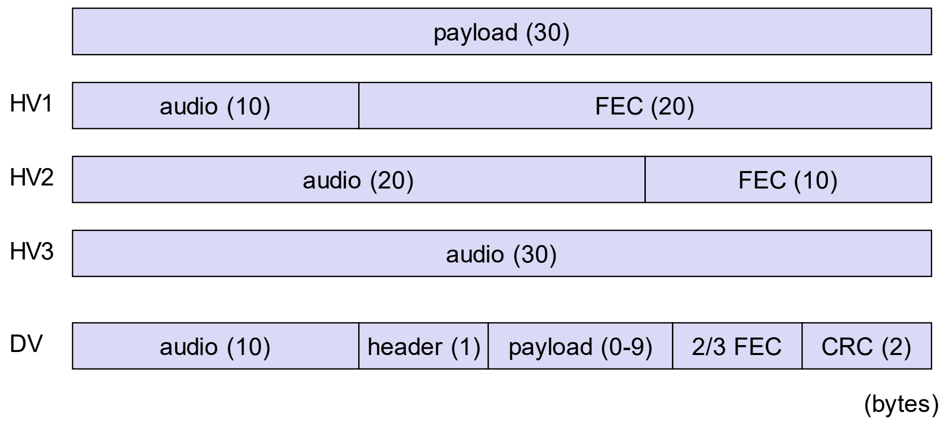
4) Consider a GEO satellite system operating in the 1 GHz frequency band. The minimum elevation that still allows communication with the satellite is 10º. The atmosphere introduces an additional attenuation of 10 dB.

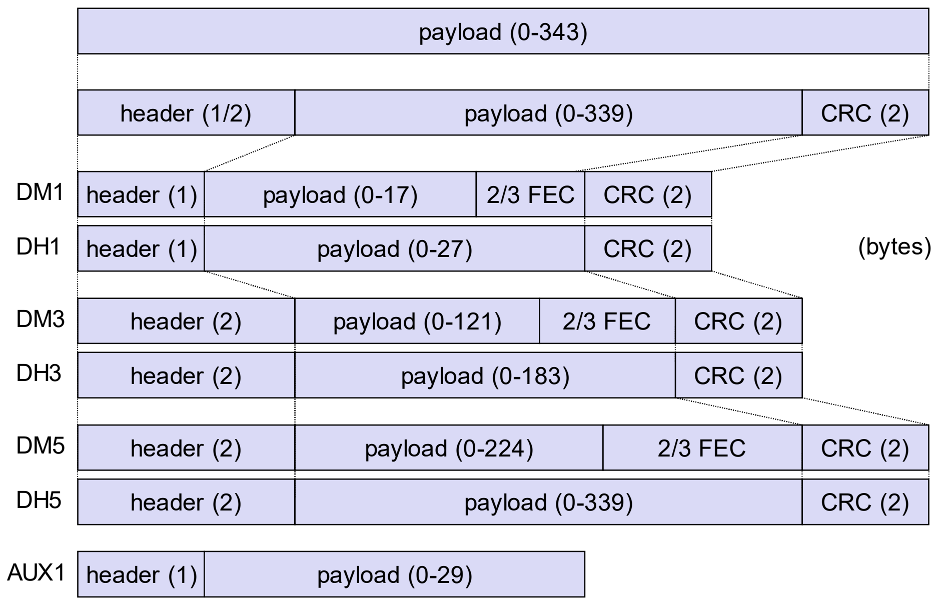
a) Calculate the altitude of the orbit. (2,0 val)

b) Assume that the elevation angle is the only limitation regarding footprint coverage. Calculate the maximum latitude where communication with the satellite is possible. Suggestion: take into account the $\boldsymbol{\alpha}$, $\boldsymbol{\beta}$, and $\boldsymbol{\theta}$ angle relationships associated to the respective figure. Note: in case you were unable to solve a), consider $\boldsymbol{h} = \mathbf{40000}\ \boldsymbol{km}$. (1,5 val)

c) Assuming that the Earth is a sphere, calculate the transmit power neded in order to allow communication at a latitude of 60º, knowing that the receiver sensitivity is -80 dBm and the antenna gains (satellite and Earth station) are 40 dBi. (1,5 val)

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

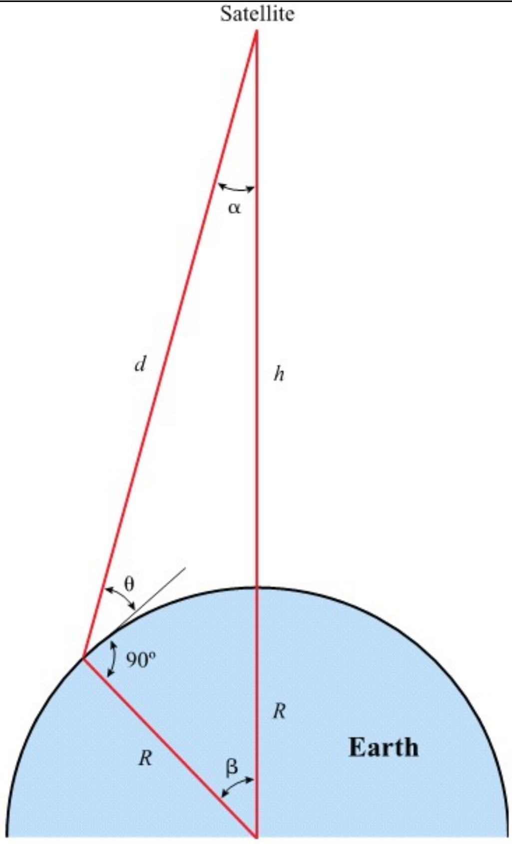




Satellite Systems	
$F_g = m \cdot g \cdot (R/r)^2$ $g = 9.81 m/s^2$ *(gravitational acceleration)* $R = 6370\ km$ *(radius of the Earth)*	$F_c = m \cdot r \cdot \omega^2$
$L = \left(\frac{4 \cdot \pi \cdot d \cdot f}{c}\right)^2$	$Footprint\ Diameter = 2 \times \alpha \times d$
$G_{(1plane)} = 2\pi/(2 \times \alpha)$	$A_{eff} = \eta \cdot A_{phy} = \frac{\lambda^2}{4\pi} G$

$$P_r(dBm) = P_t(dBm) + 10 \cdot log_{10}\left(\frac{G_t \cdot G_r \cdot \lambda^2}{(4 \cdot \pi \cdot d)^2}\right) - At$$

$$P_r(dBm) = P_t(dBm) - 10 \cdot log_{10}\left(\frac{4 \cdot Footprint}{\pi^2 \cdot A_{eff}}\right) - At$$



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

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

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

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

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

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