

Time available for solving the exam: 1 hour and 20 minutes

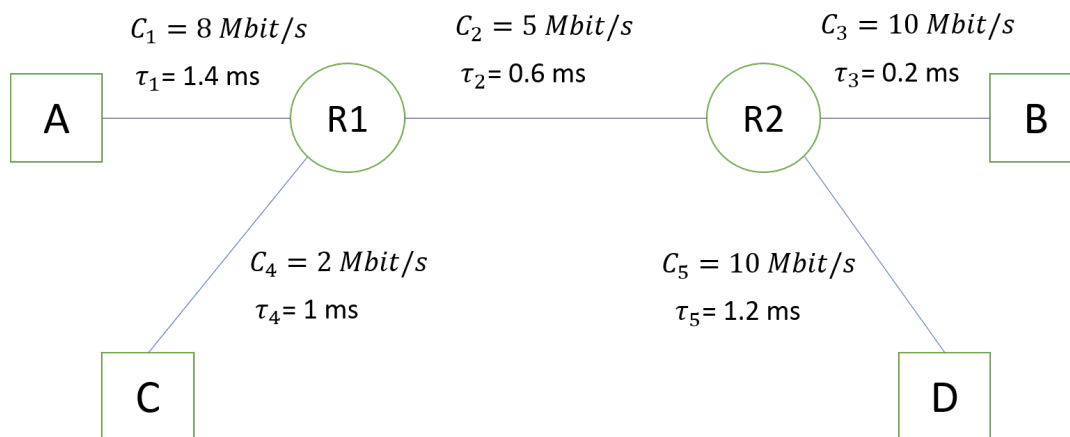
Attention: please report on any single sheet your name, surname and “matricola”

Exercise 1

Let us consider the network topology illustrated in the Figure below (where besides each link we can find the link capacity in Mbit/s and the propagation delay in ms). Let us assume that an HTTP client in B needs to download a webpage available at server A. The link capacity between B and A is limited because of the link that acts as bottleneck in the network, which is shared with 3 interfering, long-lived flows (file transfers), between C and D. The webpage is composed of an HTML page of 9000 [bytes] and 3 images of 1200 [kbytes] each. You need to calculate the time necessary to download the webpage:

- a) when the HTTP connection is persistent for the HTML document as well as the images (transmitted serially), and
- b) when non-persistent connections are used (first for the HTML document, then for the 3 images with parallel connections).

We assume that the messages used to open the TCP connection as well as the HTTP GET message are negligible in terms of size.



Exercise 2

- a) Calculate the efficiency of the Roll-Call Polling protocol, used for example by Bluetooth, when the total number of Slaves is equal to 9, but only 4 of these always have packets to transmit.

The packets are 1200 bits in size, and the token is 120 bits. The propagation delay between each station and the Master is 15 μs , the channel capacity is 600 kbit/s.

- b) Determine the minimum number of Slaves that must be active and with packets to be transmitted so that the efficiency of the protocol is equal to at least 75%. All other parameters are the same as above for point (a).

c1) Calculate the efficiency of the Hub-Polling protocol, where the token is therefore exchanged in this order: Master $\rightarrow$ S1 $\rightarrow$ S2 $\rightarrow$ S3 ... $\rightarrow$ S9 $\rightarrow$ Master ...

The propagation delay between each station and the following one (including the Master) is now 10 μ s, All other parameters are the same as in point a) (i.e., packet size = 1200 bits , token = 120 bit, channel capacity = 600 kbit/s), the total number of Slaves is equal to 9, but only 4 of these always have packets to transmit.

c2) Compare the efficiency computed in point (a) to the one computed in point (c1), commenting why this result is expected.

Exercise 3

3.1) Two sources, transmitting at 64 kbit/s, and three other sources transmitting at 192 kbit/s are multiplexed using Time Division Multiplexing (TDM). Let us assume that multiplexing is performed at the level of a single octet (byte, 8 bit).

You need to find:

- 1) the structure of the frame having minimal duration
- 2) the duration of such frame
- 3) the transmission rate of the multiplexer (expressed in kbit/s)

3.2) Now answer to the same questions above (1, 2 and 3) in the case where multiplexing is performed at the level of a single bit (1 bit).

Exercise 4

Let us dimension a cluster for a cellular system which adopts *frequency reuse*.

a) Calculate the minimum K value (K being the inverse of the Frequency reuse efficiency, as defined during the course), assuming that the system tolerates a minimum SIR (SIR_{min}) = 20 dB, and the path-loss exponent η is equal to 4. Assume that the cellular system does NOT use sectorial antennas, but only omnidirectional antennas.

b) Calculate again the minimum K value, as in point a), this time assuming that the cellular system DOES use sectorial antennas, with 3 sectors.

Question 1:

Describe clearly and precisely in what consists the *exposed terminal* problem within wireless networks that use the 802.11 protocol.

Question 2:

Describe clearly and precisely in what consists and the functioning of the *ICN (Information Centric Networks)* paradigm and what are its key features and novelties.