

**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:**

a) Calculate the efficiency of the Roll-Call Polling protocol used by Bluetooth, in the event that the total number of Slaves is equal to 6, but only 2 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  $\mu$ s, the channel capacity is 800 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).

c) Then calculate the maximum time necessary for a Slave (for example, Slave 1) to access the channel and be able to transmit its packet to the Master. Assume, in this case, that all 6 slaves have packets to transmit. All other parameters are the same as above for point (a).

**Exercise 2:**

Two 64 kbit/s signals, one 32 kbit/s, two 128 kbit/s signals and one of 96 kbit/s are all multiplexed together in time division.

Assuming that the minimum multiplexing unit is *one byte* (octet), determine:

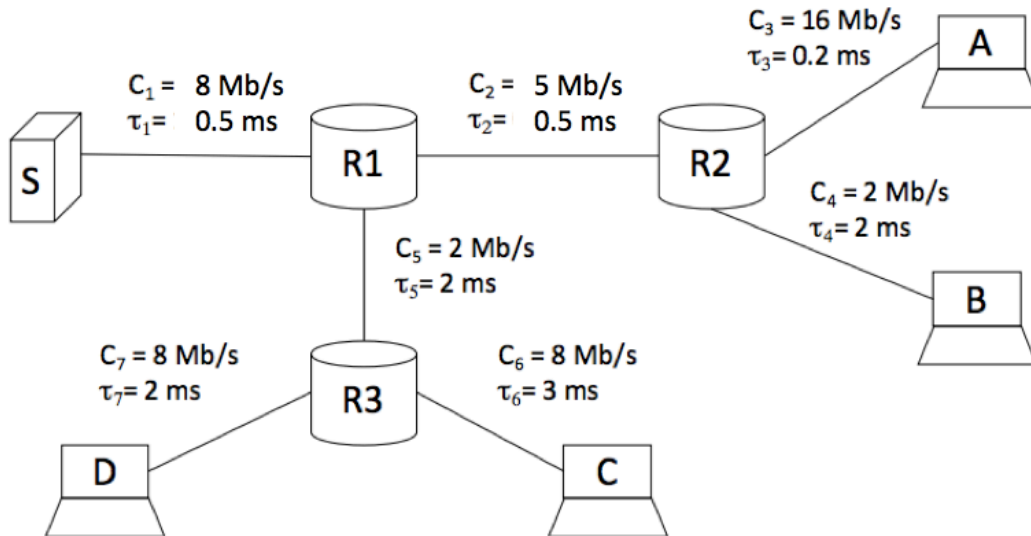
- a) the frame structure of minimal duration
- b) its duration
- c) the transmission speed of the multiplexer.

-> Answer the same questions a), b) and c) above, in case the minimum multiplexing unit is now equal to *one bit*.

**Exercise 3**

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 A needs to download a webpage available at server S. The link capacity between S 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), 2 between D and B and 1 between C and B. The webpage is composed of an HTML page of 300 [bytes] and 7 images of 1 [Mbyte] 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, and
- b) when non-persistent connections are used (first for the HTML document, then for the 7 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.



**Question 1:**

Describe clearly and precisely what the so-called *hidden terminal problem* consists of and how this can be solved within the 802.11 protocol.

**Question 2:**

Describe clearly and precisely the main novelties and features, compared to previous versions of this protocol, introduced in HTTP/2.