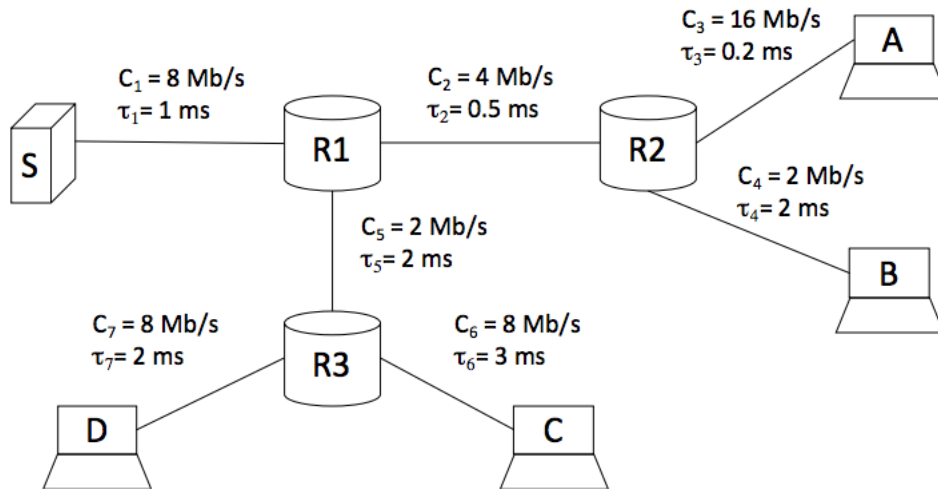


Exercise 1

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 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 2 interfering, long-lived flows (file transfers) between D and B and between C and B. The webpage is composed of an HTML page of 100 [bytes] and 8 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 8 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.



Solution

a) As for the persistent connection case, the fair/equal sharing between the 2 interfering flows and the HTTP flow between S and A leads for this latter to a data rate $R=2$ [Mbit/s] on the bottleneck R1- R2. In fact, be careful to the fact that the 2 interfering flows are actually limited to a total bandwidth of 2 [Mbit/s] (for both of them, which means 1 Mbit/s for each of them) since they pass through link R3-R1 (this latter link is, in fact, the limiting bottleneck for these 2 interfering flows”); hence, on link R1-R2 4 [Mb/s] – 2 [Mb/s] = 2 [Mb/s] are left free, and are hence used by the flow between S and A.

$$RTT = 2(\tau_1 + \tau_2 + \tau_3) = 3.4 \text{ [ms]}$$

$$T_{html} = 100 \cdot 8 \text{ [bit]} / 2 \text{ [Mbit/s]} = 0.4 \text{ [ms]}$$

$$T_{obj} = 8 \cdot 10^6 \text{ [bit]} / 2 \text{ [Mbit/s]} = 4 \text{ [s]}$$

$$T_{tot} = T_{open} + T_{get} + T_{html} + 8(T_{get} + T_{obj}) = RTT + RTT + T_{html} + 8(RTT + T_{obj}) = 32.0344 \text{ [s]}$$

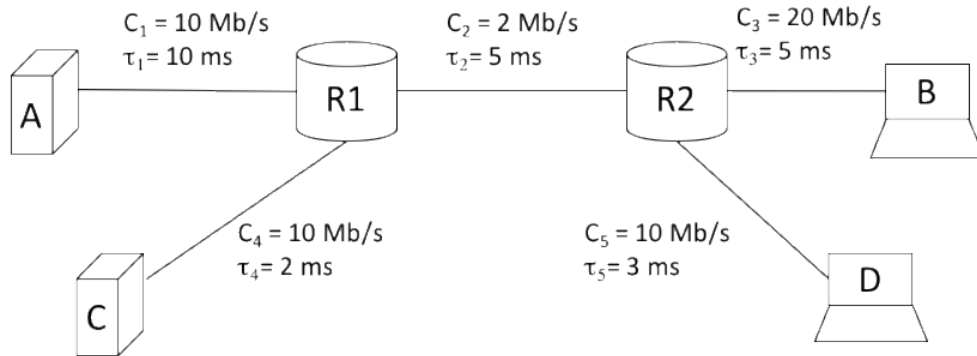
b) In case of non-persistent connection, and parallel connections, the part related to the HTML page does not change; for the other objects, the fair-share rate now becomes equal to 0.4 Mbit/s (4Mbit/s are in fact shared between 10 flows: 2 interfering ones + 8 images transmitted in parallel). Please note that in this case link R1-R2 is also the bottleneck for the 2 interfering flows (it is, indeed, the bottleneck for ALL 10 flows in the network). Hence:

$$T_{obj} = 8 \cdot 10^6 \text{ [bit]} / 0.4 \text{ [Mbit/s]} = 20 \text{ [s]}$$

$$T_{tot} = T_{open} + T_{get} + T_{html} + T_{open} + T_{get} + T_{obj} = 2RTT + T_{html} + 2RTT + T_{obj} = 20.014 \text{ [s]}$$

Exercise 2

Let us consider the network illustrated in the following Figure, with an HTTP server A and an HTTP client B. We need to transfer an HTML document of size $L_{html} = 100$ [kbyte] and 9 images of size $L_{obj} = 5$ [Mbyte] in the presence of 1 interfering flow between C and D. Calculate the necessary time assuming an RTT equal to 46.5 [ms] and an average transmission rate (R_{html} and R_{obj}) equal to the fair-share value (equal sharing of bandwidth, that is, the capacity of link 2 divided by the number of flows that pass through it) in case of persistent HTTP connections as well as non-persistent HTTP connections (with transmissions in parallel of the images).



Solution:

Persistente:

$$R_{html} = R_{obj} = \frac{C_2}{2} = 1 \text{ Mbps (Condivisione equa del flusso http e del flusso interferente)}$$

$$\begin{aligned} T_{tot} &= T_{open} + (T_{GET} + T_{html}) + 9(T_{GET} + T_{obj}) \\ &= T_{open} + \left(RTT + \frac{L_{html}}{R_{html}}\right) + 9\left(RTT + \frac{L_{obj}}{R_{obj}}\right) = 361.305 \text{ [s]} \end{aligned}$$

Non-persistente:

$$R_{html} = \frac{C_2}{2} = 1 \text{ Mbps (Condivisione equa del flusso http e del flusso interferente)}$$

$$R_{obj} = \frac{C_2}{10} = 0.2 \text{ Mbps (Condivisione equa dei 9 flussi http e del flusso interferente)}$$

$$\begin{aligned} T_{tot} &= (T_{open} + T_{GET} + T_{html}) + (T_{open} + T_{GET} + T_{obj}) \\ &= \left(T_{open} + RTT + \frac{L_{html}}{R_{html}}\right) + \left(T_{open} + RTT + \frac{L_{obj}}{R_{obj}}\right) = 200.973 \text{ [s]} \end{aligned}$$