

# 1 Congestion control

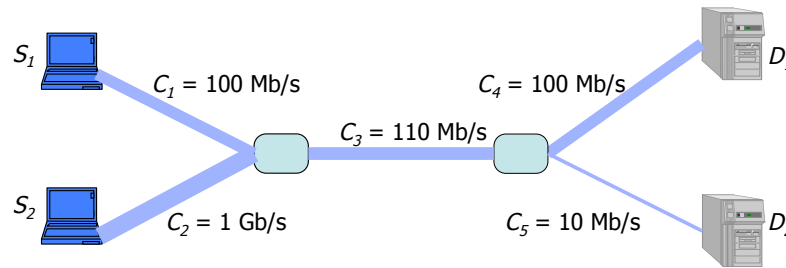


Figure 1: Example network

Consider the network presented in Figure 1 and the following flows:

- on  $S_1$  there is 1 source sending packets to  $D_1$ ,
- on  $S_2$  there are 4 sources sending packets to  $D_2$ .

Link capacity are in the figure. Analyze the four cases below and answer the questions: what is the throughput of each flow on each link? what is the total network throughput?

1. There is no congestion control (sources are like UDP) and routers schedule packets according to FIFO.
2. There is no congestion control (sources are like UDP) and routers schedule packets according to Fair Queueing.
3. There is congestion control (sources are like TCP) that allocates rates to flows according to max-min fairness. Routers schedule packets according to FIFO.
4. There is congestion control (sources are like TCP) that allocates rates to flows according to max-min fairness. Routers schedule packets according to Fair Queueing.

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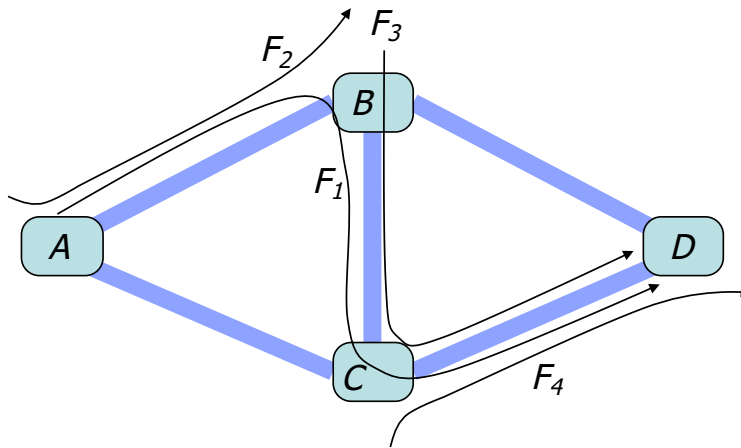


Figure 1: Example network

Consider an example network consisting of four routers A, B, C, and D presented in Figure 1. All links are of capacity 1 Mb/s. Several types of flows ( $F_1$ ,  $F_2$ ,  $F_3$ ,  $F_4$ ) take different routes shown in the figure and each source can transmit at a speed of 1 Mb/s. There is 1 flow of type  $F_1$  and  $F_2$ , 2 flows of type  $F_3$  and 4 flows of type  $F_4$ . Assume that all the flows are UDP with packets of the same size (unless specified otherwise).

1. What is the flow rate on each link if the routers schedule packets according to FIFO?
2. What is the flow rate on each link if the routers schedule packets according to Fair Queueing?
3. What is the flow rate on each link if the sources adapt their rates according to max-min fairness.

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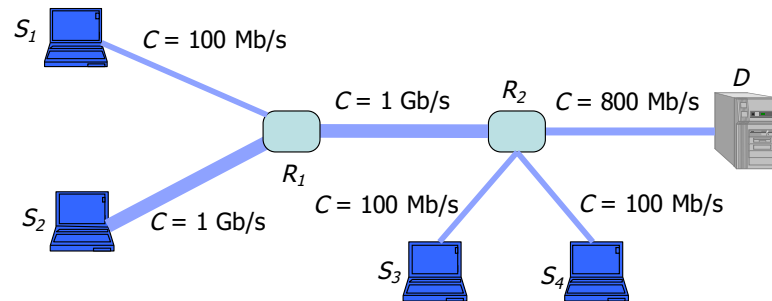


Figure 1: Example network

Consider an example network presented in Figure 1. Link capacity is indicated in the figure. Sources  $S_i, i = 1, \dots, 4$  generate flows to destination  $D$ . Assume that all the flows are UDP with packets of the same size (unless specified otherwise).

1. What is the flow rate on links  $R_1 - R_2$  and  $R_2 - D$  if the routers schedule packets according to FIFO?
2. What is the flow rate on the links if the routers schedule packets according to Fair Queueing?
3. What is the flow rate on each link if the sources adapt their rates according to max-min fairness.