1 Congestion control

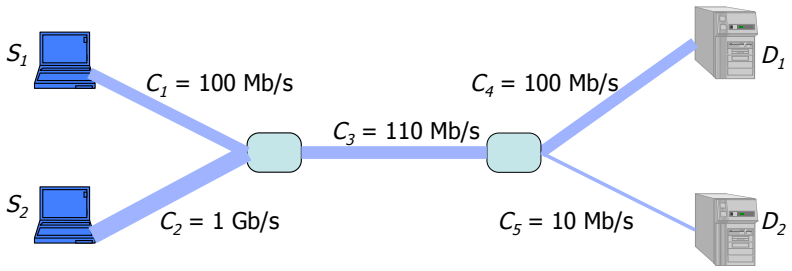

Figure 1: Example network

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 accordong to FIFO.

2. There is no congestion control (sources are like UDP) and routers schedule packets accordong 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 accordong to FIFO.

4. There is congestion control (sources are like TCP) that allocates rates to flows according to max-min fairness. Routers schedule packets accordong to Fair Queueing.

Solution:

1. FIFO:
   Router 1
   source at S1: 100/(100+1000)*110=1/11=10 Mb/s
   all sources at S2: 1000/(100+1000)*110=10/11=100 Mb/s, 1 source: 100/4=25 Mb/s

   Router 2 -links to destination
   source at S1: 10 Mb/s
   source at S2: 10 Mb/s

   thr = 20 Mb/s

2. FQ:
   Router 1

   source at S1: 110/5= 22 Mb/s
   sources at S2: 110/5= 22 Mb/s

   Router 2 -links to destination
   source at S1: 22 Mb/s
   sources at S2: 10 Mb/s

   thr = 32 Mb/s

3. max-min fairness:
   Router 1

   source at S1: 100 Mb/s
   source at S2: 10 Mb/s

   Router 2 -links to destination
   source at S1: 100 Mb/s
   sources at S2: 10 Mb/s

   thr = 110 Mb/s

1 Congestion control

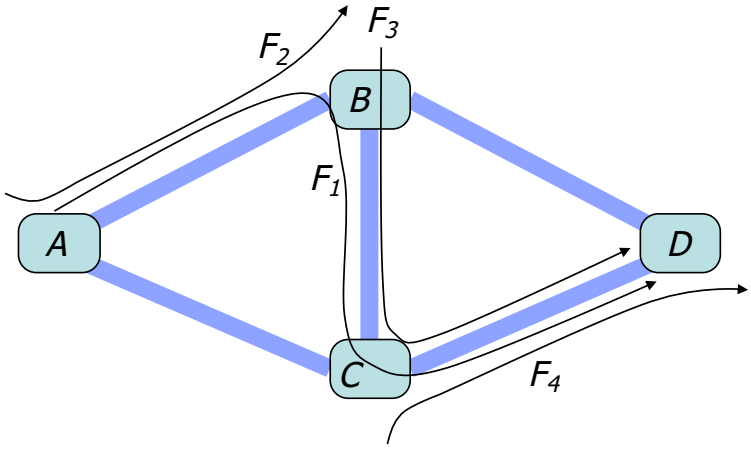

Figure 1: Example network

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.

Solution:

1. FIFO:

   Link 1: 1/2, 1/2 Link 2: 1/5, 2/5, 2/5 Link 3: 0.04, 0.08, 0.08, 0.2, 0.2, 0.2, 0.2

2. FQ:
   Link 1: 1/2, 1/2 Link 2: 1/3, 1/3, 1/3 Link 3: 1/7, 1/7, 1/7, 1/7, 1/7, 1/7, 1/7

3. TCP:
   F1 - 1/7 F2 - 6/7 F3 - 1/7 F4 - 1/7, ...

1 Congestion control

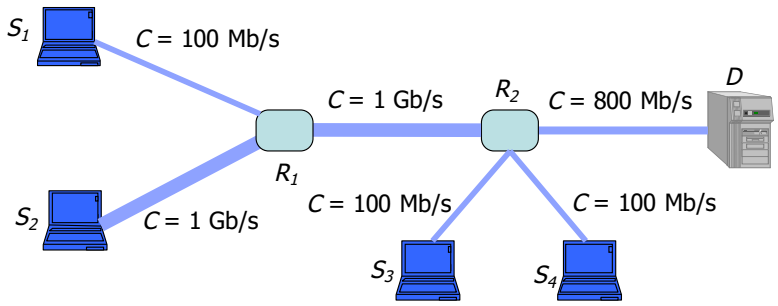

Figure 1: Example network

Consider an example network presented in Figure 1. Link capacity is indicated in the figure. Sources $S_i, i = 1, ..., 4$ 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?

   $R_1 - R_2$: S_1 gets 100/1100=91 Mb/s, S_2 gets 1000/1100=909 Mb/s

   $R_2 - D$: S_1 gets 91/1200*800=61 Mb/s, S_2 gets 909/1200*800=606 Mb/s, S_3–S_4 gets 100/1200*800=66 Mb/s each.

2. What is the flow rate on the links if the routers schedule packets according to Fair Queueing?

   $R_1 - R_2$, S_1 gets 100 Mb/s, S_2 gets 900 Mb/s

   $R_2 - D$: S_1 S_3–S_4 gets 100 Mb/s, S_2 gets 500 Mb/s.

3. What is the flow rate on each link if the sources adapt their rates according to max-min fairness.

   $R_1 - R_2$, S_1 gets 100 Mb/s, S_2 gets 500 Mb/s

   $R_2 - D$: S_1 S_3–S_4 gets 100 Mb/s, S_2 gets 500 Mb/s.

1. FIFO:

   Link 1: 1/2, 1/2 Link 2: 1/5, 2/5, 2/5 Link 3: 0.04, 0.08, 0.08, 0.2, 0.2, 0.2, 0.2

2. FQ:
   Link 1: 1/2, 1/2 Link 2: 1/3, 1/3, 1/3 Link 3: 1/7, 1/7, 1/7, 1/7, 1/7, 1/7, 1/7

3. TCP:
   F1 - 1/7 F2 - 6/7 F3 - 1/7 F4 - 1/7, ...