CS144
An Introduction to Computer Networks

Worked Example

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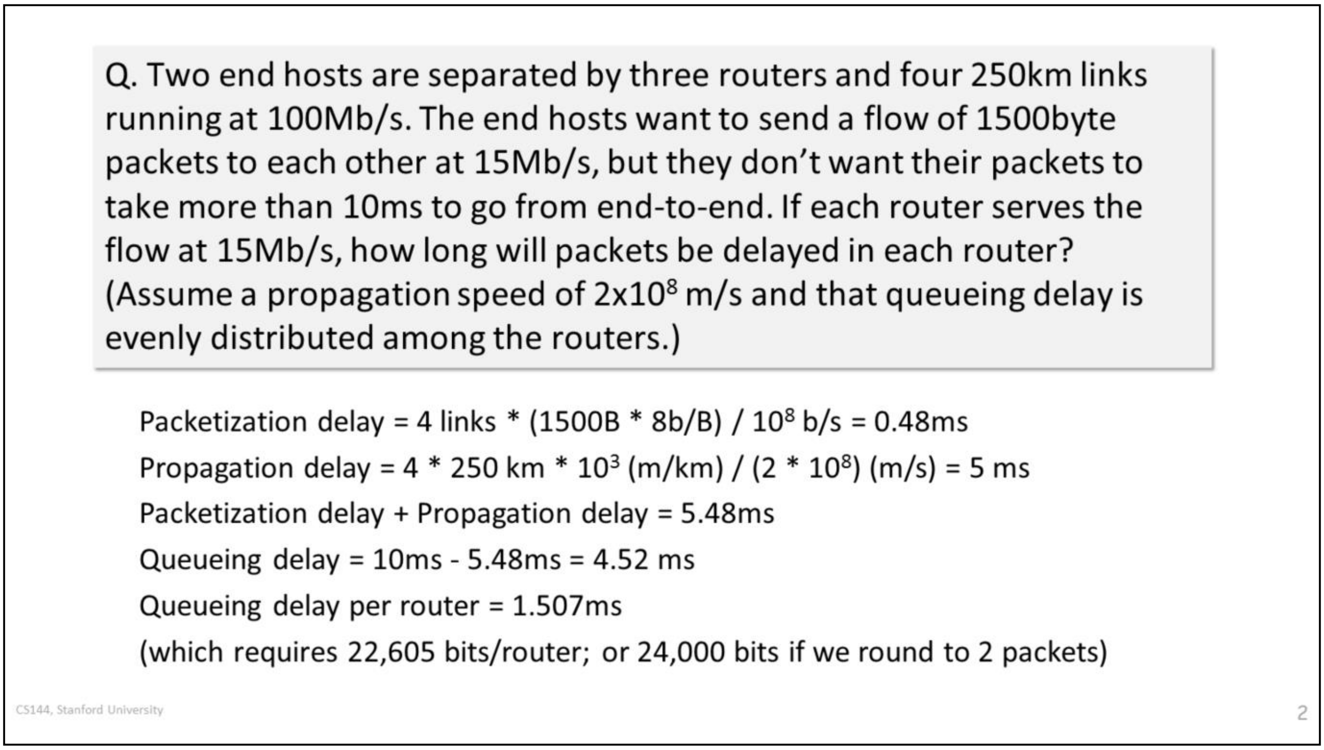
Let’s look at a worked example for delay guarantees.



Q. Two end hosts are separated by three routers and four 250km links running at 100Mb/s. The end hosts want to send a flow of 1500byte packets to each other at 15Mb/s, but they don’t want their packets to take more than 10ms to go from end-to-end. If each router serves the flow at 15Mb/s, how long will packets be delayed in each router? (Assume a propagation speed of $2x10^8$ m/s and that queueing delay is evenly distributed among the routers.)

From the question we know that a third of the queueing delay will be in each of the routers. So first, we need to figure out what the queueing delay is. The queueing delay will be the total delay, which is 10ms, minus the fixed delay, which is the sum of the packetization delay and the propagation delay.

Let's first calculate the packetization delay, which is the time to transmit a 1500byte packet onto each of the four links along the path. <click> For each link, the packetization delay is 1500bytes * 8bits/byte divided by 100Mb/s or 10 to the power of 8. This gives us a total packetization delay of 0.48ms.

Now let's calculate the propagation delay, which is the time taken for one bit to traverse all four links. <click> The time for each link is 250km times 1000m per km, divided by the speed of propagation. The total time will be 5ms across all four links. Our total fixed delay is therefore 5.48ms. This means the queueing delay is 10 – 5.48ms = 4.52ms, which we are told is divided equally among the three routers. Therefore, the queueing delay in each router can be no more than 1.507ms. The answer is therefore 1.507ms of delay per router.

We could go on and calculate the amount of buffering needed in each router to hold 1.507ms of data. Given that the queue is being served at 15Mb/s, this corresponds to 1.507ms * 15Mb/s = 22,605 bits. In practice, we'd round this up to at least two packets, which is 24,000 bits per router.