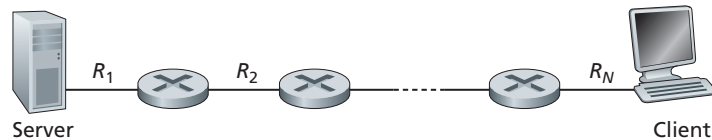


## CS5222 Computer Networks and Internets

### Tutorial 2

1. Suppose that you click a link within a web browser to retrieve a webpage. Suppose that the web page associated with that link contains 8 objects. Let RTT denote the round trip time between the local host and the server containing the base HTML and all 8 objects. Suppose that the transmission time of the base HTML file and the objects is negligible. How long does it take before the host can receive all objects?
  - a) Assume **non-persistent HTTP** and suppose we **do not use parallel connections**.
  - b) Assume **persistent HTTP** with **pipelining**.
2. Consider the figure below. Suppose that each link between the server and the client has a packet loss probability  $p$ , and the packet loss probability for these links are independent.
  - a. What is the probability that a packet (sent by the server) is successfully received by the client?
  - b. If a packet is lost in the path, then the server will eventually re-transmit the packet. On average, how many times will the server have to transmit a packet until the client successfully receives the packet?



3. A packet switch receives a packet  $P$  and determines the outbound link to which the packet should be forwarded. When packet  $P$  arrives, one other packet is halfway done being transmitted on this outbound link and four other packets are waiting to be transmitted. Packets are transmitted in order of arrival. Suppose all packets have length 1,500 bits and the transmission rate of the outbound link is 2 Mbps. What is the queueing delay for packet  $P$ ?
4. **[Harder]** Consider a sequence of  $N$  packets, each having a length of  $L$  bits and a router with an outbound link that has transmission rate  $R$ . Suppose that, at time 0, the first  $N/2$  packets arrive simultaneously at the router and, after  $(L/R)$  seconds, the remaining  $N/2$  packets arrive. Apart from these  $N$  packets, no other packets are currently being queued or transmitted by the router. (You can assume that  $N$  is even, i.e.,  $N/2$  is an integer.)
  - a.) What is the queueing delay for the  $i$ -th packet, if  $i \leq N/2$ ?
  - b.) What is the queueing delay for the  $i$ -th packet, if  $i > N/2$ ?
  - c.) What is the average queueing delay for these  $N$  packets?