

Homework 3
CSE/EE 461, Winter 2000
Due: 6pm, Wednesday, Mar 8, 2000.

1. Packet-Pair

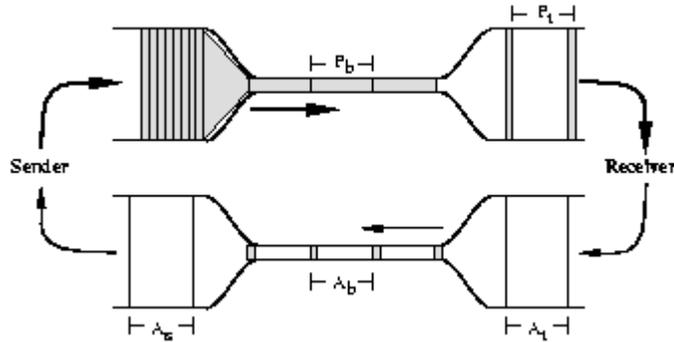


Figure 1: Packet Pair mechanism in action

One mechanism for estimating the bottleneck link bandwidth sends a pair of back-to-back packets into the network, and measures the time between the receipt of acknowledgements. As these packets traverse the bottleneck link, they stretch: taking more time because of the reduced bandwidth. When those packets find a high bandwidth link, they contract in time, but preserve the spacing they acquired because of the bottleneck link. Acknowledgements for these packets also preserve the same spacing. Because this scheme uses a pair of packets, it is referred to as "packet pair."

Assume that the source sends back-to-back 1500 byte packets, and that the space between received acknowledgements is 1ms. What is the bandwidth of the bottleneck link?

Note that, in practice, this scheme is considerably complicated by interference with other packets, especially between the acks on the return path, as well as difficulties taking accurate timings. You can ignore these issues.

2. TCP Transfer Times

Consider a TCP connection. 10Kbytes of data must be transferred and the TCP segment size is 1500 bytes. The one-way latency of the path is 50ms and the bandwidth of the path is 10Mbps. In the following questions, state any simplifying assumptions that you make.

- a) How long does it take to establish the TCP connection?
- b) How long does it take to transfer the data using slow-start, after connection establishment?
- c) How long does it take to close the TCP connection?
- d) To speed up the transfer, your boss suggests buying a faster Internet connection, a T3 line (45Mbps). How much will this reduce the total transfer time?

3. TCP Congestion Avoidance

Consider TCP along a network path where the bottleneck bandwidth is 1Mbps (one megabit per second) and the one-way latency is 5ms. The queue at the bottleneck link is 10 packets, and all packets sent are 1500 bytes.

- a) How many packets can be stored along this path?
- b) If the TCP sender is sending at the bottleneck rate (so that no loss will occur) and all packets are acknowledged immediately by the receiver, how large can cwnd be?
- c) During congestion avoidance, TCP increases its sending rate beyond that of the bottleneck link. This causes loss to occur. How large will cwnd grow before a loss is detected?