Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Spring Term 2017

ADVANCED COMPUTER NETWORKS
Assignment 1: Network Principles

Assigned on: **22 Feb 2017**
Due by: **1 Mar 2017**

Question 1:

Define bandwidth-delay product in the context of network performance. What is the importance of the bandwidth-delay product for networks? Does the bandwidth-delay product equally affect all protocols? Give an example of a system that has a large bandwidth-delay product.

Question 2:

Assume that TCP implements an extension that allows window sizes much larger than 64 KB. Suppose that you are using this extended TCP over a 1-Gbps link with a RTT of 100ms to transfer a 10 MB file, and the TCP receive window is 1 MB. The initial window size on the sender side is 1 packet. If TCP sends 1-KB packets:

a) How many RTTs does it take to send the file?

b) If the time to send the file is given by the number of required RTTs multiplied by the RTT, what is the effective throughput for the transfer?

c) What would be the effective throughput if TCP had another extension that allowed receive window sizes much larger than 1 MB?

Question 3:

We define the throughput as:

$$Throughput = \frac{TransferSize}{RTT + TransferSize/Bandwidth}$$

Assume you have a network link with a bandwidth of 1Gb/s and you are transferring a 16MB file. Calculate the throughput. How does RTT effect file transfers? Draw a graph that shows the dependency between RTT and Throughput.

Question 4:

In packet switching networks, the source host segments long application layer messages (for example an image or a music file) into smaller packets and sends the packets into the network. The receiver re-assembles the packets back into the original message. Figure 1 illustrates the end-to-end transport of a message with and without segmentation. Consider a $7.5 * 10^6$ bits long message that is to be sent from the source to the destination as shown in the figure. Suppose that each link in the figure is 1.5 Mbps. Ignore propagation, queuing and processing delays. You can assume that you do not have to wait for ACKs when sending the message with segmentation.

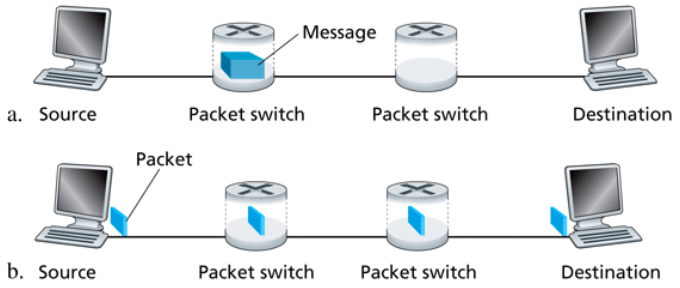

Figure 1: End-to-end message transport (a) without message segmentation; (b) with message segmentation

a) Consider sending the message from source to destination without message segmentation. How long does it take to move the message from the source host to the first packet switch? Keep in mind that each packet switch uses a store and forward packet switching. What is the total time to move the message from the source host to the destination host?

b) Now suppose that the message is segmented into 5,000 packets, with each packet being 1500 bits long. How long does it take to move the first packet from the source host to the first packet switch?

c) How long does it take to move the file from the source host to the destination host when message segmentation is used? Compare with part A and comment.

Question 5:

The network fairness can be defined in multiple ways. Depending on the fairness strategy, users can observe different quality of service.

a) Construct an example where flow fairness does not lead to per-sender fairness. Do not use more than 4 nodes including senders and receivers.

b) Can per-sender fairness be implemented end to end without network support? Explain the answer.

We are happy to give individual feedback in person on request.