Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Spring Term 2014

ADVANCED COMPUTER NETWORKS
Assignment 1: Network Principles

Assigned on: **27 Feb 2014**
Due by: **06 March 2014**

Question 1:

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

Question 2:

Suppose a 100-Mbps point-to-point link is being set up between Earth and a new lunar colony. The distance from the moon to Earth is 385,000 km and data travels over the link at the speed of light, 3 x 10^8 m/s.

a) Calculate the minimum RTT for the link.

b) Calculate the bandwidth-delay product for the link.

c) A camera on the lunar base takes pictures of Earth and saves them in digital format to disk. Suppose Mission Control on Earth wishes to download the most current image (25MB). What is the minimum amount of time that will elapse between when the request for the data goes out and the transfer is finished?

Question 3:

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. 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 4:

For the following, assume that no data compression is used, even though this would almost never be the case in reality. For (a)-(c), calculate the bandwidth necessary for transmitting in real time.

a) HDTV high-resolution video at resolution of 1920*1080, 24 bits/pixel, 30 frames/second.

b) POTS (Plain Old Telephone Service) voice audio of 8-bits samples at 8 KHz.

c) GSM mobile voice audio of 260-bit samples at 50 Hz.

d) Assume a fax transmits an 8x10 inch black-and-white image at a resolution of 72 pixels per inch. How long would this take over a 14.4-Kbps modem?

Question 5:

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.

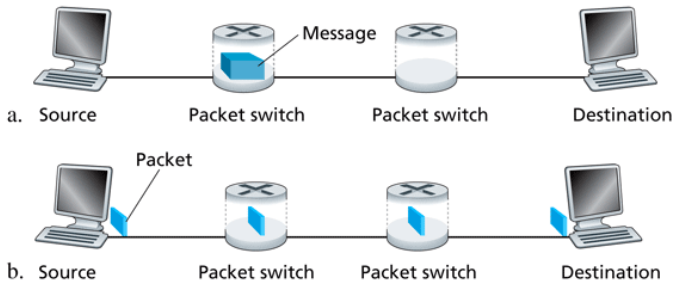

Figure 1: End-to-end message transport (a) without message segmentation; (b) with message segmentation

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 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.

d) Discuss the drawbacks of message segmentation.

Question 6:

What are the two observations about the naming of network objects (regarding form and bindings) made by Saltzer [2]?

Question 7:

Paper reading: "Resilient Overlay Networks" [1].

a) In a Resilient Overlay Network (RON), an overlay node may direct traffic through a single intermediate node to circumvent a performance or reachability problem on the direct path to the destination node. That is, RON decided to limit paths to two overlay hops. Why does RON impose this restriction? What is one advantage and one disadvantage of this design decision?

b) Routing overlays like Resilient Overlay Networks (RONs) can, by definition, be deployed without requiring the support of the underlying network. Yet, support from the underlying network could undoubtedly help RON run better. List two ideas for changes to the "underlay" to support RON.

Hand In Instructions

This is a paper exercise. Please hand it in during the exercise session on the due date.

References

[1] David Andersen, Hari Balakrishnan, Frans Kaashoek, and Robert Morris. Resilient overlay networks. In *Proceedings of the Eighteenth ACM Symposium on Operating Systems Principles*, SOSP '01, pages 131–145, New York, NY, USA, 2001. ACM.

[2] J. Saltzer. On the Naming and Binding of Network Destinations. *Internet RFCs*, RFC 1498, 1993.