

Please show the intermediate steps and explain them.

1. Assume that you have two nodes with a 4000 km distance from each other. There is a connection through the network, with a bottleneck link of 10 Mbps, and the signal propagates at $2 \cdot 10^8$ m/s.
 - (a) Calculate a lower bound for the round-trip time for data by omitting all delays in the network equipment.
 - (b) Calculate the bandwidth-delay-product (BDP) for the connection. Explain the significance of BDP.

Target: The student understands some of the fundamental restrictions in communications and network control.

2. Acquaint yourself with the tools `ping` and `traceroute`. You can use the `man` command in the UNIX machines for information. For logging your actions use the tool `script` and return the relevant parts of the resulting file as a part of your answer. Don't forget to explain your reasoning.
 - (a) Select an Internet host approximately 4000 km away from your computer. Measure the round-trip time to the host, and compare the result with the result from 1a. Explain.
 - (b) Find out the route used to reach the host used in 2a. Try to find out where the different network nodes are located, and the organizations they belong to. Describe your findings.
 - (c) Explain how the tools work (what protocol messages are sent, and how they are treated, among others).

Target: The student gets a hands-on experience on network topology.

3. Suppose your company uses the following protocol stack in its network:

TCP
IPv4
PPP over Sonet
STM-1

Assume that you send a series of messages of 1024 byte TCP payload. Calculate the approximate percentage of overhead to the amount of data sent. Feel free to use different sources to find out about the protocols.

Remember to cite your sources properly.

Target: The student understands some of the costs induced by layers.