



# Operating Systems and Networks

## Assignment 3

Assigned on: **6th Mar 2014**  
Due by: **14th Mar 2014**

### 1 Network Performance

#### 1.1 Delays

Given a 1Gbps point to point copper wire (propagation speed  $200\text{m}/\mu\text{s}$ ) with a length of 3km. Ignoring the acknowledgements,

- what is the transmission time for a 16 MB file?
- what is the propagation delay?

#### 1.2 Throughput

What is the throughput when retrieving a 4MB file across a 1Gbps network with a round trip time of 150msec, again ignoring ACKs?

#### 1.3 Total Time

Calculate the total time required to transfer a 1'000 KB file in the following cases, assuming an RTT of 100 ms, a packet size of 1-KB data, and an initial 2 x RTT of "handshaking" before data is sent.

- The bandwidth is 1.5 Mbps, and the packets can be sent continuously.
- The bandwidth is 1.5 Mbps, but after we finish sending each data packet, we must wait one RTT before sending next.
- The bandwidth is "infinite", meaning that we take transmit time to be zero, and up to 20 packets can be sent per RTT.
- The bandwidth is infinite, and during the first RTT we can send one packet ( $2^{1-1}$ ), during the second RTT we can send two packets ( $2^{2-1}$ ), during the third we can send four ( $2^{3-1}$ ), and so on.

#### 1.4 Transmission Time

How long does it take to transmit x KB over a y Mb/s link?  
Give your answer as a ratio of x and y.

## 2 Network Characteristics

### 2.1 *Width* of a Bit

Determine the *width* of a bit on a 10 Gbps link. Assume a copper wire, where the speed of propagation is  $2.3 * 10^8$  m/s.

### 2.2 Transport media

You have the task to deliver a large data set from Zurich to Chicago (Distance: 6500km) and a choice of different transport media. The first option is a fiber-optical transatlantic link with a bandwidth of 100 Gbps. The signal propagation in the optical fiber is 200'000 km/s. The second option is a Boeing 747 plane with a capacity for delivering 120 tonnes of hard disks with a speed of 800 km/h from Zurich to Chicago. The weight of a hard disk is 600 grams and the capacity is 2TB.

- a) If your task was to broadcast a soccer match from Zurich to Chicago in real time, which of the properties of the two transport links would be dominating? Which transport would be your choice? Explain your arguments with numbers.
- b) If your task was to transfer a full backup of all ETH server disks (total capacity  $\sim 2$  PB) to Chicago, which parameters would then be most important and what is the numerical size? Where is the crossover point so that choosing the Boeing plane is preferable over the transatlantic link?
- c) Consider a third location on a ship 2000 km away from Zurich. The link to the computer on the ship is through a geostationary satellite half way between the ship and Zurich and in an altitude above ground of 36'000 km. Let the signal propagation be the speed of light ( $\sim 300'000$  km/s). If you try to send a ping to the computer in Chicago connected through the fiber-optical link and to the computer on the ship at the same time, which one will be the first to respond? Which of the parameter has the main impact?

## 3 Network tools

In this exercise you will see useful tools: `ping`, `traceroute`, `curl`, and `Wireshark`.

### 3.1 `ping`

`ping` is a tool which can be used to test whether a computer in the internet is “alive”. It sends a request packet to the target and expects a reply packet back. Additionally it measures the time between sending the packet to the target and receiving the reply. On Linux, `ping` continuously sends requests to the target. You can stop it by pressing Ctrl-C.

- a) `ping` and RTT
  - (a) Use `ping` to test whether `www.sf1.tv` and `www.inf.ethz.ch` are alive.
  - (b) Look at the output. `ping` is telling you the RTT. This value seems easy to measure. Why?
  - (c) Why is `ping` not telling you the latency?
- b) Calculate the bandwidth using `ping`
  - (a) Develop a formula to calculate the bandwidth  $R$  between two hosts using ping packets of different sizes  $L$ . Write down your formula. It might be dependent on the packet sizes  $L$  and RTTs  $Z$ .

- (b) Look up `ping`'s manual page (`man ping`) and find out how you can vary the packet sizes.
- (c) Calculate the bandwidth between your computer or a computer in the lab and the server `www.joke.com.au` using `ping` and your formula. Always use packets smaller than 1400 bytes! We will see later in the course, why we can't use larger packets.

### 3.2 traceroute

`traceroute` (`tracert` on Windows machines) is a tool for determining the path that a packet takes through the network. Some networks at ETH are firewalled and `traceroute` does not work. In this case, you can `ssh` into `optimus.ethz.ch` where `traceroute` works fine.

- a) Determine the number of hops located in Switzerland that a request to `www.joke.com.au` takes.
- b) Try to find a machine in the Internet that is the same number of hops away from your machine and print the path to this machine.
- c) What is the effect of the parameter `-t` (`-i` on Windows) of `ping`? How can you determine the distance (number of hops) to a given machine using `ping`?
- d) Give an explanation how `traceroute` could work internally. Explain how `traceroute` can be simulated using `ping`.

### 3.3 curl

`curl` is a tool that is available for almost every platform. For Windows, you probably have to download and install it whereas your Linux machine very likely has it in its package tree.

- a) Do `curl -v http://www.netsec.ethz.ch/about/index` and describe the result.
- b) Do the same with `curl -v http://google.com/`. What is the difference?

### 3.4 Wireshark

`Wireshark` is used to capture and examine a packet trace. A packet trace is a record of traffic at a location on the network, as if a snapshot was taken of all the bits that passed across a particular wire. The packet trace records a timestamp for each packet, along with the bits that make up the packet, from the lower-layer headers to the higher-layer contents. `Wireshark` runs on most operating systems, including Windows, Mac and Linux. It provides a graphical UI that shows the sequence of packets and the meaning of the bits when interpreted as protocol headers and data. It color-codes packets by their type, and has various ways to filter and analyze packets to let you investigate the behavior of network protocols.

- a) Download from `www.wireshark.org` if it is not already installed on your computer.
- b) Watch the 5 minute video "Introduction to Wireshark" that is on the site.