Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

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Operating Systems and Networks
Assignment 6

1 Traceroute: Theory

Consult the man page for traceroute (`man traceroute` from the Linux command line or on the web at `http://linux.die.net/man/8/traceroute`). Consider the following traceroute output:

```
[davs@pyxis]:~$ traceroute -n ethz.ch
traceroute to ethz.ch (129.132.128.139), 30 hops max, 60 byte packets
 1  192.33.93.1  0.822 ms  0.856 ms  0.893 ms
 2  10.10.1.81  1.222 ms  1.267 ms  1.265 ms
 3  10.1.17.242  1.252 ms  0.988 ms  1.117 ms
 4  192.33.92.185  1.815 ms  1.891 ms  1.778 ms
 5  * * *
 6  * * *
```

Figure 1: Traceroute output

a) What does each of the three measurements next to each IP address on lines 1-4 mean?

b) Give one possible reason why hops 5 and 6 show "* * *"

2 Data Transmission

A direct Swiss flight between Zürich and New York takes 8h54m. You get on this flight, and take with you a 4 terabyte hard drive. Assume 4 terabytes is 32 terabits ($3.2 \cdot 10^{13}$ bits). Once you land in New York:

a) What was the data transmission rate (in Gigabits/s)?

b) What was the propagation delay?

c) How long would it take to transfer the same amount of data on a typical home fiber connection (assume a data transfer rate of 100 megabits/s)?

d) Since the flight time is constant for any amount of data (1 byte or 100 terabytes), up to how much data does it make sense to transfer over the fiber connection?

3 Bandwidth and delay

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 ($3 \cdot 10^8$ m/s)

a) Calculate the minimum delay 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 (25 MB). What is the minimum amount of time that will elapse between when the request for the data goes out and the transfer is finished?

4 Bandwidth

How much bandwidth is needed to send computer screen images through an optical fiber? Assume the screen is 1920x1080 pixels, and each pixel carries 24 bits. The framerate is 60 images per second.

5 Nyquist Theorem

We know that the Nyquist theory applies to copper wire. Does it also apply to optical fiber? Why? Why not?

6 Internet Checksum

A message `1001 1100 1010 0011` is transmitted using the Internet Checksum (using 4-bit words). What is the value of the checksum?

7 Hamming Code

A 12-bit hamming code whose hexadecimal value is `0xE4F` arrives at a receiver. What was the original value in hexadecimal? Assume that no more than 1 bit is in error.