



Masterkurs Rechnernetze / Master Lecture on Computer Networks (IN2907) — Tutorial

Class Assignment No. 4, WS 2009/2010

2nd Project

Abgabedatum / To be handed in by: 2010-01-29, 10h

This assignment is intended to practically evaluate the concepts of bandwidth measurements. Recapitulate **assignment 2** in preparation for the following exercises. If you are new to Linux, you may consider the step-by-step tutorial provided on the lecture webpage.

Hints on grading:

- The completion of both regular exercises results in a grading of *4.0*. However, you can improve your grading by putting more effort into your answers or address some of the advanced exercises.
- Additional credits for higher grading are indicated with circles.
- Grading of this project will take into account the quality of your approach to setup the measurements, to organize the measured data, to evaluate the measurements (e.g. to apply statistical analysis such as confidence intervals), to document the results (e.g. by using different diagrams), and to interpret the results (how do you explain the results)!

Exercise 13 — VPS probing

Goal: bandwidth measurement, hop-by-hop link capacities, practical relevance

The outcome of this exercise will be some kind of European “internet map”. A graphical template can be found on the lecture webpage.

a) Use the tool `traceroute` to obtain detailed routing information for the following webservers:

<code>www.fu-berlin.de</code>	<code>www.uzh.ch</code>	<code>www.cam.ac.uk</code>	<code>www.ccssu.crimea.ua</code>
<code>www.univ-montp2.fr</code>	<code>www.uam.es</code>	<code>www.unifg.it</code>	<code>www.ntnu.no</code>
<code>www.ntua.gr</code>	<code>www.sote.hu</code>	<code>www.ue-varna.bg</code>	<code>www.ut.ee</code>
<code>www.ucv.ro</code>	<code>www.uj.edu.pl</code>	<code>www.su.se</code>	<code>www.phnet.fi</code>
<code>www.univ.kiev.ua</code>	<code>www.bsu.by</code>	<code>www.ut.ee</code>	<code>www.ucd.ie</code>

- Mark your personal location on the map.
 - Determine the longest common prefix in the `traceroute` paths for the webservers listed above. Mark its last hop on the map, it represents your access router to the internet’s backbone networks.
Note: You can map IP addresses to geographic locations at <http://www.geoiptool.com/>.
 - Identify groups of hops which are presumably routing within the same location (e.g. *router aliases*). Mark the corresponding cities on the map.
- b) Use the tool `pchar` (see lecture webpage) to measure the city-to-city link capacities to the webservers. Visualize the links and bandwidths on the map (e.g. with lines of different color or thickness).
Note: `pchar` offers options for reducing the required time as well as for skipping certain hops.

- ② Repeat this exercise from another location (e.g. at your home or at university).
- ② Repeat this exercise from an *amazon EC2* virtual machine (see guide on lecture webpage).
- ③ Analyze a certain link over a fixed period of time (e.g. one day).
Draw diagrams on bandwidths and router queueing lengths.

Exercise 14 — PP probing

Goal: bandwidth measurement, end-to-end link capacity, practical relevance

- a) Download the Python script `pp.py` from the lecture webpage. Make yourself familiar with implementation details and try to run the script.
 - *What is your bandwidth estimation to the default server (`www.in.tum.de`)?*
 - Repeat the measurements at different networks (e.g. WLAN, DSL, university LAN).
What are your conclusions?
 - Try to increase the number of packet pairs and target different servers (e.g. `www.google.de`).
How would you explain the observed behaviour?
- b) Improve the script to reliably provide results for arbitrary webservers.
 - Try to send pairs of TCP SYN packets (dport 80) and listen for the corresponding ACKs. Test the script with a webserver of your choice.
Hint: parallel TCP connections have to originate from different source ports.
 - For obtaining significant results, SYN packets are too small. Fill the packets with arbitrary data and rerun the measurement.
Note: this is conform to RFC 793 (TCP), see page 29 for details.
 - Measure at least one webserver per continent.
What are your results? Interpret briefly.
- ① Experiment with larger packet trains (time difference between first and last packet) and try to improve your results.

Implement a technique for measuring bandwidth to internet backbone routers. Determine an open port where the previous approach of TCP SYN+data packets apply, and test your implementation (e.g. for 62.40.124.33).
- ① Measure the end-to-end link capacities for the webservers in **exercise 13** and compare your results. Note: broadband internet access (≥ 100 Mbit) or an *amazon EC2* virtual machine is recommended.
- ② Measure bandwidths to the same destination over a fixed period of time (e.g. one day) and draw the corresponding graph. *Are there any irregularities noticeable? Discuss.*
- ③ Analyze layer 2 influences: Realize packet pair probing with variable packet sizes (60-1460 Byte) and analyze arbitrary links with 1-2 hops (e.g. DSL, WLAN, Bluetooth).
Try to identify framing thresholds for ATM cells (DSL) or WLAN/Bluetooth!
- Expert
④ Implement cartouche probing, try to measure bandwidth bottlenecks for subpaths of a link (e.g. eliminating the effect of slow internet access) and compare to corresponding pchar results. See <http://www.cs.bu.edu/fac/byers/pubs/bb.pdf>, section IV for further details.