Network Technology and Programming Lab
Assignment 1

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Deadline: 10/03/2025 23:59

February 27, 2025

Know your lab!

As this is the introductory assignment, the goal is for you to become familiar with the Netlab and its network. Examine the network - carefully and without tampering with the connections! - and take a close look at the networking devices i.e. the routers, the switches, the hub, and the connections between them. At the start of the assignment, please make sure you remember the state of the cabling at the networking devices (all Ethernet cables originating from the computers and labeled comm1e to comm10e, are plugged on the 24-port switch), and before you leave, plug the cables at their original ports so that the next groups that will use the lab, start from the same basis as you.

On the control panel of the lab you will find 6 routers (Ubiquity EdgeRouter X) and 2 switches (EdgeSwitch 24, EdgeSwitch 8). You have full access on the R2-R6 and on the EdgeSwitch 8. Access on the R1 and on EdgeSwitch24 is read-only and no configuration is allowed. For your convenience, a DHCP server runs on the LAN that will assign a proper IP address on the plugged host automatically. You can plug a PC on any of the switch ports and access the LAN without any further configuration.

The management ports are the *eth0* for the routers. In order to save time and possible problems due to misconfiguration, never change the configuration of these ports. If you do, please reset the device and upload the default configuration, so other teams can access them easily. The assignments will not require you to configure the management ports. At the end of your session, re-upload the default configuration on the devices and reset any changes in the interface parameters of the Comm hosts.

The IP addresses for accessing the WebUI of each device are listed in the table below:

Device	**Address**
R1	192.168.4.1
R2	192.168.4.2
R3	192.168.4.3
R4	192.168.4.4
R5	192.168.4.5
R6	192.168.4.6
EdgeSwitch 24	192.168.4.8
EdgeSwitch 8	192.168.4.9

The username for the devices with full access is *hy435* and the password *hy435@csd*. For the R1 and the EdgeSwitch 24, a read only account with username *student* and password *hy435@csd* exists.

The lab also has 10 Linux workstations. In the table below you can see that all of them are operational and what their corresponding IP address is:

Host	Address
comm1e	192.168.4.51
comm2e	192.168.4.52
comm3e	192.168.4.53
comm4e	192.168.4.54
comm5e	192.168.4.55
comm6e	192.168.4.56
comm7e	192.168.4.57
comm8e	192.168.4.58
comm9e	192.168.4.59
comm10e	192.168.4.60

These hosts have the SSH service enabled and can be accessed using the command:

```
ssh -l <teamlogin> <ip>
```

Feel free to play with the available equipment! Just remember to revert to the initial state whatever you play with!

Exercise 0: Check connectivity

All of the Ethernet cables from the computers should be plugged on the 24-port switch. Make sure this stands. Also check that the hosts comm1e to comm10e mentioned in the table above are available. [Tip] Be patient when turning on the PCs!

(i) First you can inspect and see if the IP addresses on the table correspond with the actual ones. Label four nodes A, B, C and D. **Report** which node was assigned each label.

(ii) Check the connectivity between your 4 nodes. How will you check if there is connectivity between them?

You can always use the command *ethtool* to get more information about the link capabilities.

Exercise 1: Single-Server Switch Topology

In this task you will generate traffic between the nodes A and B. For this purpose you will use the **iperf3** tool. Go through the man page of the tool to see the available arguments and their use. Four different scenarios will be used to evaluate the performance of the network:

1. Generate TCP traffic letting the protocol adapt to the network conditions
2. Generate UDP traffic with a bitrate of 5% of the link's theoretical maximum
3. Generate UDP traffic with a bitrate of 50% of the link's theoretical maximum
4. Generate UDP traffic with a bitrate of 99% of the link's theoretical maximum

Those scenarios will be tested across the following topologies:

(i) Run iperf3 as server on node B , and as client on node A . Run each of the above scenarios between the two nodes for 60 seconds. The setup is depicted in Figure 1.

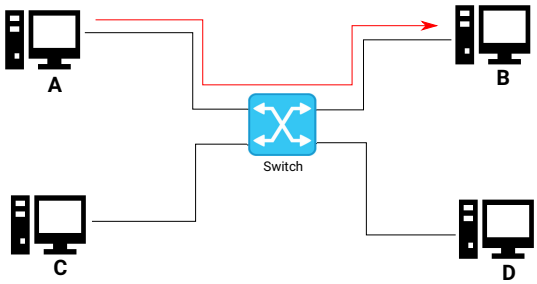

Figure 1: Single-server, single-flow scenario

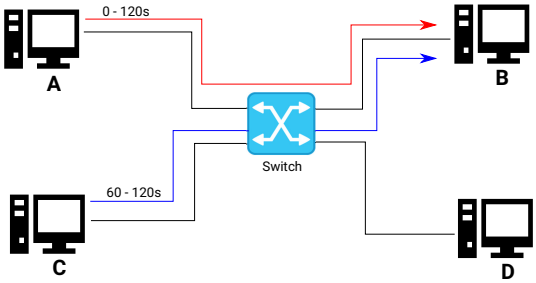

Figure 2: Single-server, multiple-flow scenario

(a) Plot the results. TCP plots should contain the throughput, along with the congestion window size and the re-transmissions. On the other hand, for the UDP plot the throughput, along with the jitter and the packet loss percentage.

(b) Report your findings.

(c) For the TCP experiments, compare the re-transmissions and the size of the congestion window. What do you observe?

(d) For the UDP experiments, compare the throughput the jitter and packet loss. What do you observe?

(ii) For the next task you will also utilize node C. Run iperf3 as client on node A and on node C, and as server on node B. For each of task 1's scenarios, do the following: Execute the scenario between nodes A and B for 60 seconds. Then, and without killing the first flow, run the scenario for 60 more seconds between nodes C and B. The rationale behind this task is to observe what happens when a single flow is generated versus two simultaneous flows, and how the bitrate varies. Report the values observed and compare with the above task. The setup is depicted in Figure 2.

(iii) Older versions of iperf did not provide the bandwidth option for TCP flows. Can you provide a possible explanation for that design decision?

Exercise 2: Single-Server Hub Topology

In this task you will use the hub instead of the switch. Unplug nodes A, B and C from the switch, and plug them on the hub. Notice however that there is no DHCP server running on the hub. As a result, this time you have to set your own IP address on each of the hosts. Use the **ip** tool to assign addresses in the 192.168.4.0/24 subnet. **Be careful:** unplugging the devices resets the configuration. Repeat the experiments (i), (ii) of Exercise 1 and report your findings. Furthermore, comment on the differences you observed between the different topologies and explain them.

Exercise 3: Multiple-Server Topology

In this task you will repeat the above scenarios, only this time we will also use the fourth node:

1. Plug again all nodes on the switch. This time, run iperf3 as client on nodes A and C, and as server on nodes B and D. For each of task 1's scenarios, do the following: Execute the scenario between nodes A and B for 60 seconds. Then, and without killing the first flow, run the scenario for 60 more seconds between nodes C and D. The setup is depicted in Figure 3.

2. Now plug all nodes on the hub and repeat the above scenario.

Plot the results and report your findings. What is the difference of this topology compared to the star topology of the two first tasks?

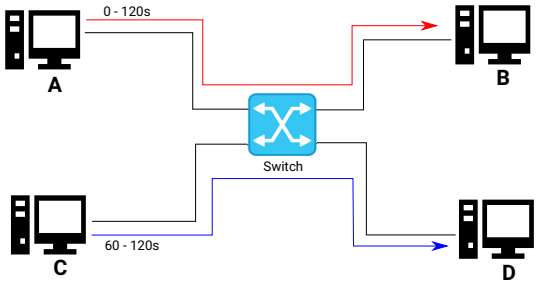

Figure 3: Multiple-server, multiple-flow scenario

Exercise 4: Communication in a network segment

This task will help you understand how two hosts communicate when in the same network segment. Give as much detail as you think is necessary (e.g. source/destination address, OSI layer, protocol). For this assignment, you are going to need at least three hosts/nodes. In this experiment we are only interested about the IPv4 communications. Remember, some packets may appear that are not useful for the communication (e.g. some running services, discovery protocols). It is your job to keep only what is useful.

1. Make sure that all hosts are plugged on the switch except nodes A and B. For nodes A and B verify that the eno1 interface is down.

2. Start Wireshark on all nodes, connect the nodes to the switch and observe the DHCP exchange. What do you observe? How many packets are exchanged, what is their functionality? Who can see which packet, are there some that are visible on all hosts? Why? Report your findings and include screenshots.

3. Clear the ARP cache from nodes A and B. Then, try pinging one host from the other. Watch Wireshark on all computers. What are the packets exchanged? Who

can see which packet, are there some that are visible on all hosts? Why? Report your findings and include screenshots.

4. Some hosts might not make an ARP request. Why? How do they learn the information that would be requested without it?

*** When leaving the lab remember to shutdown the PCs and restore everything to the state you first found it!**

Reporting

Your reports should include your answers to the above questions as well as the plots/screenshots of the observed results. For the first three tasks you are expected to show the variation of the bitrate of each node in time using plots. You can use the plotting tool of your choice for this purpose. For example you can find (and/or imporve if you want) implementations of iperf plotter on Github. Your reports should be in pdf format. For the last task, you are expected to answer the questions and include all relevant screenshots.
Pay attention on the quality of your report. Plots should be easily readable and you are expected to comment on your findings.
If something is wrong with your experiment, justify the approach you followed and provide possible reasons for the abnormal situation.

Submission

The submission of the assignments will be done through the **turnin** process. If needed, more info will be sent to the list prior to the deadline. You can turnin this assignment until **Monday 10/3 23:59**. Use the command below:
turnin assignment1@hy435 <dir>

Oral Examination

All the students who have submitted their exercises are requested to attend the oral exam session, in order to present their solutions. A short quiz will also take place during that time. More details will be sent to you via email.

Attention

- Each team will only be examined during the timeslot chosen.
- During this session both the Assignments 1 and 2 will be examined.
- Both the timely submission and the oral exam session will contribute to the grading of the assignments.