# **Final Task**
# Simulation and Modelling of Communication Networks

Institute of Communication Networks, TUHH

Summer Term 2020
July 28

## 1 Introduction

Considering the scenario of virus spread in the region, all on-campus activities are halted and people are in self-isolation. To continue with the teaching activities, many lectures are held online using a video conferencing system provided by the university. You are hired as an expert on communication networks by the university because both, students and lecturers, had technical problems with the online lectures. You are supposed to identify possible bottlenecks in the system and to propose a feasible solution.

In Section 2, you can find a detailed description of the scenario. Section 3 follows with the task you are hired to do. The description and task are a general formulation of the problem. It is up to you to retrieve those pieces of information that are essential to the solution, as well as to decide which specific aspects you will look into in your modeling and simulation, how you will analyze, and how you can deduce a meaningful conclusion from your results.

## 2 Problem Description

Both, students and lecturers, report technical problems with the online lectures. During an online lecture, the typical network usage is as follows. A lecturer is giving the lecture via the video conferencing system that is provided by the university and students are attending it from their homes. During the lecture, the students are asked to upload their assignments to the lecturer's FTP server at home, so the lecturer can access it. Consider the case of a student attending the lecture from their student's dormitory, while the other dormitory tenants are browsing the web to watch Netflix or YouTube videos. All devices in the dormitory access the Internet via Wireless Local Area Network (WLAN). An overview of the scenario is given in Figure 1.

For simplicity, assume that all students in the dormitory are uniformly distributed in the coverage area of the WLAN Access Point (AP), which is a rectangular area of $30\,\mathrm{m} \times 250\,\mathrm{m}$. The AP is positioned at the center of the rectangular area. The users usually do not move with their laptops, and hence, can be considered stationary. The WLAN is based on IEEE 802.11g with 54 Mbit/s and the AP is connected via Fast Ethernet (IEEE 802.3, 100 Mbit/s) to the dormitory's router. A Very High Speed Digital Subscriber Line (VDSL) connection with a downlink data

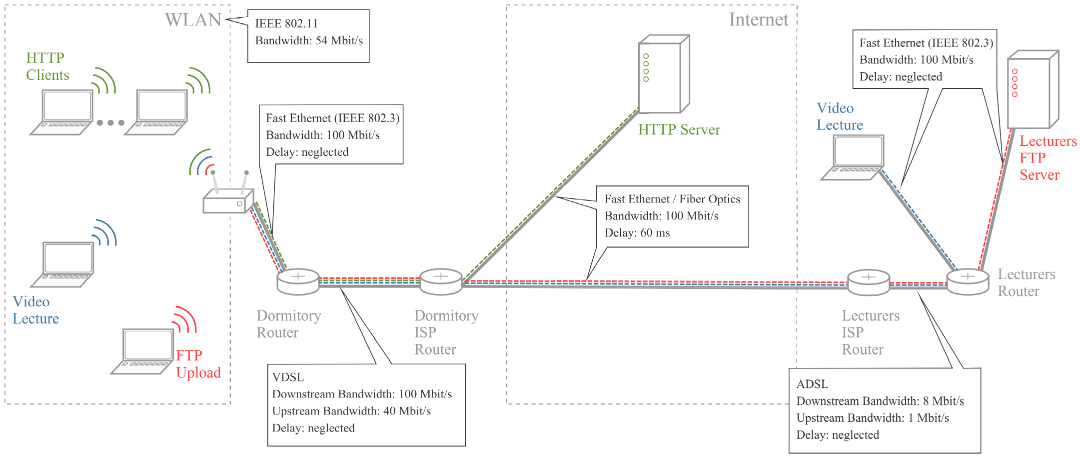


Figure 1: Overview of the scenario

rate of 100 Mbit/s and an uplink data rate of 40 Mbit/s connects the dormitory's router to the dormitory Internet Service Provider (ISP). The lecturer lives on the countryside where only a slow Internet connection via Asymmetric Digital Subscriber Line (ADSL) with a downlink data rate of 8 Mbit/s and an uplink data rate of 1 Mbit/s is available. To ensure the best possible connection quality, the notebook of the lecturer is connected to the lecturer's router via Fast Ethernet. The connections between the ISPs and to the Hypertext Transfer Protocol (HTTP) server can be modeled as Fast Ethernet links that introduce a constant delay of 60 ms.

To help you out with analyzing the problem, the networking department of the dormitory captured statistics of the web browsing (Netflix, YouTube, etc.) behavior of the students. The traffic can be modeled as a HTTP request and response followed by a constant waiting time before the next request is issued. As there are several HTTP response sizes and waiting times to be analyzed, the different parameter sets are assigned to different student teams. The size of the HTTP responses (in Bytes) is recorded in a trace file and the waiting time is stated in the name of the trace file. You, as a consultant, need to identify the statistical behavior of the HTTP responses by analyzing the recorded trace. Assumptions on the statistical distribution should be validated by evaluating the goodness of fit. The HTTP request size is noted as 254 B. Each request/response pair is transmitted using a seperate Transport Control Protocol (TCP) connection.

The student and the lecturer both send one video packet every 40 ms. A video packet consists of 1400 B of payload plus protocol headers. The video conference call application uses the Real-Time Transport Protocol (RTP) over User Datagram Protocol (UDP) over Internet Protocol version 4 (IPv4). For a good Quality of Service (QoS) of the video conference connection, the maximum acceptable end-to-end delay is 150 ms, i.e., the time when the video data is required in the application of the receiver is at maximum 150 ms after the packet is generated at the sender. Encoding and decoding delays are neglected. If a packet arrives too late, it will be considered as lost. The acceptable packet loss rate is at most 10%.

The student who is attending the lecture put a lot of effort into their assignment resulting in a really large file. Therefore, the upload of the file via File Transfer Protocol (FTP) to the lecturer's server lasts the entire period of investigation.

The TCP/IP implementations of the operating systems are based on TCP New Reno and the receiver side advertises a receive window of 1000 times the Maximum Segment Size (MSS).

# 3 Task

You, as a network consultant, are tasked with evaluating the bottlenecks in the system. To do so, please abstract the described scenario into a simulation model, gather data through simulations, and analyze this data for the relevant aspects. An interview with the university's and dormitory's networking departments has identified a number of key issues that you should give focus in your efforts:

- How can the web traffic data packet sizes be modeled based on the trace file?
- How does the presence of the web users and the FTP traffic affect the QoS of the video conference at both sides?
- How does the number of web users influence the QoS of the video conference?

The networking departments emphasize that they are still considering how to improve the quality of the system. This manifests in the few general questions above. The teams are thankful for any help you can provide, especially regarding improvements upon their system that go beyond the general questions.

# 4 Formalities

## 4.1 Time Schedule and Submission

- The submission deadline of the final task is **Tuesday, September 1st 23:59 CEST**.
- The submission including a report (as a **pdf file**) and the simulation model (all `.ned`, `.ini`, `.cc`, `.h`, ... files) as well as result scalar files (not vector files) must be uploaded to your repository on GitLab by the deadline (**Tuesday, September 1st 23:59 CEST**). After this time, your repository membership will be expired and you won't be able to upload your files anymore.
- We generally expect a discussion of the results, and a presentation of your approach in the form of a **coherent report**. Please do not simply answer the given questions one by one.
- We provide a LaTeX report template to you, but using Word or another text editor and layout is up to you.
- We expect between 10 to 20 pages, but **this is not a hard limit**!
- Please clean up your codes for the final submission.

## 4.2 Presentation

- Presentations and the final exam will be held on **9th, 10th and 11th of September, 2020**. The specific time slot for your team is available here.
`https://www3.tuhh.de/e-4/Teaching/SimCN/SimCN-exercises/`

- Your presentation needs to be **emailed** to your tutors **plus** to `comnets@tuhh.de` by **September 8th 23:59 CEST**.
- The presentation should show and discuss the problem that you have investigated, how you have investigated it and your results. Details of your implementation and the configuration of your simulation model **should not** be part of the presentation.
- The presentation should be held by all members of your team. Each member should present some part, and individual tasks done by specific members need to be presented by the respective author.
- The presentation **must not exceed** 30 min; 20 to 25 min are recommended.
- You can expect a discussion and possibly follow-up questions on the presented results, about implementation details and about all the theoretical background taught in the lecture and exercises. Please prepare accordingly.

### 4.3 Comments

- Read the task description carefully! Ask us if anything is not clear.
- You are a consultant. The customer has no interest in implementation details and codes, and so your report and representation should contain as little of those as required. However, you must still be able to answer questions on them.
- The task is designed for 1 to 2 weeks of full-time effort – if you seem to require more time than this, please contact us to get advice.
- Please make use of our offer of consultation, if anything is not clear. A reasonable amount of discussion will give us a positive impression!
- Official consultation hours are on **August 11, 18 and 25, from 10:00 to 12:00 CEST** on the virtual zoom room of the lecture.
- Please use our **SimCN 2020 Mattermost channel** to discuss with us and your peers about problems that you have.
- You can use the TUHH pool computers to run your simulations. You can login via Secure Shell (SSH) from home as well.

### 4.4 Hints

- Unspecified connection parameters can be assumed as being ideal or default.
- For Ethernet, the Maximum Transmission Unit (MTU) is 1500 B and this limits the size for the Protocol Data Units (PDUs) of the upper layers. However, the PDUs of upper layers (e.g., TCP) should be as large as possible to reduce protocol overhead.
- Keep in mind that WLAN stations have to associate with the access point before they can transmit data.
- Give indications for the confidence of your simulation results.
- Please keep in mind that we expect a discussion of your proposals and that implies a justification as well.

- Sound knowledge of TCP/IP, UDP and WLAN (IEEE 802.11) protocols are needed to discuss the simulation results.