Final Task

Simulation and Modelling
of Communication Networks

Institute of Communication Networks, TUHH

Summer Term 2019
June 25

1 Introduction

You are hired as an expert in communication networks by a company which wants to extend its existing network.

In Section 2 you can find a detailed description of the network 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 out of it that are essential to the solution, as well as deciding which specific aspects you will look into in your modelling and simulation, how you will analyse, and how you can deduce a meaningful conclusion from your results.

2 Problem Description

A company has built its new factory site, which is around 1 km away from its current office building. They would like to extend their existing network to provide Internet access for staffs working at the factory.

Typical network usage at the factory is as follows. A computer continuously sends a large amount of collected sensor data to the cloud via an FTP connection. One worker needs to make a video conference call from time to time with a colleague located in another city. Other workers usually use web-based applications. All devices access the network via wireless LAN.

The networking department considers to extend their current network by using either a wireless link or a cable link for connecting the main router at the office building with a remote router at the factory. The wireless link has a cost advantage over the cable link but its Bit Error Rate (BER) is 10^{-6}, while the BER of the cable is only 10^{-9}.

Figure 1 shows a draft of the network. All users are randomly uniformly distributed in the coverage of the WLAN access point, which is a circle with a radius of 15m. 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 access point is connected via Fast Ethernet (IEEE 802.3, 100 Mbit/s) to the remote router. A VDSL connection with a data rate of 100 Mbit/s connects the main router to the Internet and therefore to the HTTP server, and the FTP cloud server. This Internet connection can be simplified assuming a uniformly distributed delay from 25ms - 35ms. The colleague at another city uses the company's VPN to make video conference calls,

FTP = TcpSessionApp or TcpBasicClientApp

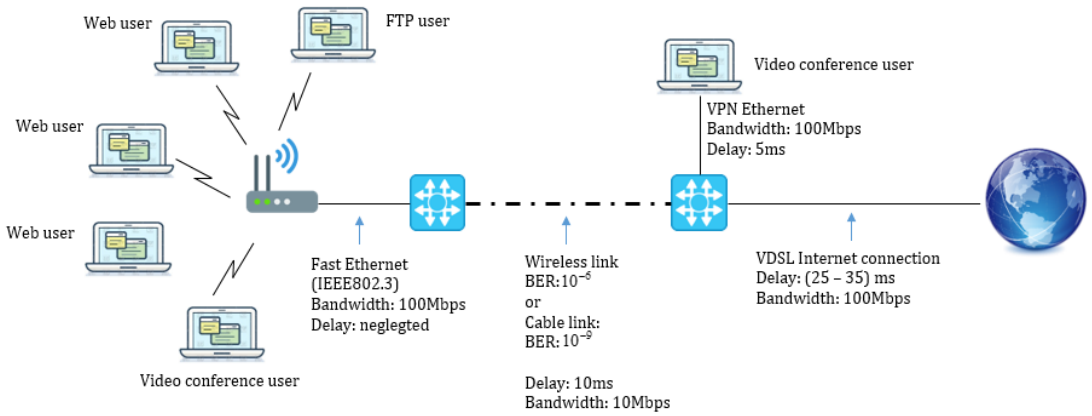

Figure 1: Overview of the network scenario

and therefore has a constant delay of only 5 ms to the main router. The connection between the main router and remote router, either a wireless or a cable link, can be simply modeled as a Point-to-Point link using PPP with the parameters shown in Figure 1.

To be able to analyse the scenario, the networking department captured statistics about the web browsing behaviour. The traffic caused by web users can be modeled as a HTTP request and response followed by an exponentially distributed reading time before the next request is issued. The average reading time is 5 s. The size of web pages (in Byte) is recorded in a trace file. You, as a consultant, need to identify the statistic behaviour of the HTTP requests by analysing the recorded traces. Assumptions on the statistical distribution should be validated by evaluating the goodness of fit. *chi-square test*

RTP Header size = 12 Bytes

Both video conference stations constantly send one packet every 40 ms. A video packet consists of 1388 Byte 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 100 ms, i. e. the time when the video data is required in the application of the receiver is at maximum 100 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 5%.

The sensor data can be simply modeled as a large file, and its transmission lasts the entire simulation

The operating systems' TCP/IP implementations 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 two options for connecting the main router and the remote router of the network scenario described in Section 2, and judging which solution is more suitable for the company's demands.

To do so, please abstract the described scenario into a simulation model, gather data through simulations, and analyse this data for the relevant aspects.

Make justified statements as to whether the proposed solutions support the company's demands

or why it does not if this is not the case. Should you find an alternative better solution, please describe in detail how it would benefit the system, make clear your expectations about the change, and if possible, implement your proposal and evaluate it through simulation. If you are not sure on how to continue, please consult your tutors.

An interview with the company's networking department has identified a number of key issues that should give a focus for your efforts:

- How can the web-traffic data packet sizes be modeled, based on the trace file?
- How many web users can be supported so that the QoS of video conferences is guaranteed?
- How does the existing of web and FTP users affect the QoS of video conference?
- How does the BER of the link affect the performance of all applications?
- Which changes do you suggest to improve the network performance?

The networking team emphasizes that they are still considering how to extend their network efficiently. This manifests in the few general questions above. The team are thankful for any help you can provide, especially regarding improvements upon their envisioned system that go beyond the general questions.

The two members in your team should divide the task as follows:

1. One member evaluates the network with a wireless link
2. The other member evaluates the network with a cable link.

4 Formalities

4.1 Time Schedule and Submission

- The submission deadline of the final task is **Sunday, August 11th 23:59**.
- 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 (**Sunday, August 11th 23:59**). After this time, your membership will be expired and you won't be able to upload your files to the repository 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.
- Please indicate how you divide the tasks between the team members, so that it becomes clear to the reader who does what. The general parts **should be written cooperatively**.

4.2 Presentation

- Presentations will be held on **Monday, August 19th** and **Tuesday, August 20th**. The specific time slot for your team is available at https://flint10.rz.tuhh.de/1565-nluy9j88/.
- Your presentation needs to be **emailed** to your tutors (Team 1-8: zeynep.vatandas@tuhh.de and Team 9-16: leo.krueger@tuhh.de), and to comnets@tuhh.de by **August 18th 23:59**
- 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 learned 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 advices.
- 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 **July 09, July 30 and August 6, from 10:00 to 11:00** in the institute seminar room `E1.022`.
- Please use our **Mattermost channel** to discuss with us and your peers problems that you have.
- You can use the TUHH pool computers to run your simulations. You can login via 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 Byte and this limits the size for the protocol data units (PDU) 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 (802.11) protocols are needed to discuss the simulation results.