ComNets
Institute of Communication Networks
TUHH

Exam Task for Module

Simulation and Modelling of Communication Networks

Summer Term 2016

0 Formalities and Time Schedule

- The report needs to be submitted by **August 23rd 2016, 11:59 AM** by **email** (to your tutors and CC to comnets@tuhh.de) and as **print-out** on the same day and the same time (to Ms Düring, room E 1.058 or by postal mail).
- The email should contain the report as PDF-file and a compressed archive (ZIP-file) with the simulation model (all .ned, .ini, .cc and .h-files etc.) and the scalar result files (.sca-files, but no vector result files). If the overall size of the attachments exceeds 10 MB, please use the file upload service[1] of the TUHH computer centre.
- Please do not just answer the questions. The submission should generally present and discuss the results of your investigation in the form of a coherent report.
- The report itself should be a document. You are free to choose your own template and structure. We expect something like 10 – 20 pages, but these are no hard limits as the size depends also very much on your style, template etc.
- For the subtasks the respective authors have to be indicated. The general parts however can be written cooperatively.

Presentation

- Your presentations are planned for September 5th to 8th. Time slots for each team will be assigned and announced on Stud.IP.
- The presentation should discuss the problem and your results, not the details of the implementation and configuration of your simulation model.
- Your presentation should be done as a team. Each team member must do parts of the presentation. The different subtasks need to be presented by the authors of the subtasks.
- The presentation must not exceed 30 minutes; 20 – 25 min. are recommended.
- After the presentation we will discuss with you about the presented results complemented by some questions about implementation details and the theoretical background learned in the lecture and exercises.

General comments

- Read the task description carefully!
- You are the consultant. For your customer, the implementation details and code are usually not that interesting, neither in the report nor in the presentation (but you should be able to answer questions about it).
- The task was designed for 1-2 weeks full time effort – if you seem to need much more, please get advice from us.
- Consultations: please use our offer of discussing with us and getting advice; a reasonable amount of discussion will rather give a positive than negative impression on our side.
- You can use the pool computers of the TUHH computer centre to run your simulations. This is also possible from remote (e.g. from your home) using secure shell (SSH). See the Stud.IP file section for a how-to document.

[1] http://upload.tuhh.de/ (be sure not to download your file yourself after uploading it, because the link will expire after one hour in this case so that we cannot download your solution)

1 Introduction

Near to a remote university building a construction site is set up. As the machinery used for the road work might accidentally cut cables and therefore the network connection of the building might break, a backup using a point-to-point radio link should be implemented.

Several services should be available at the remote university building: First of all, students should be able to use the Web. The professor is on a business trip at another university but nevertheless wants to give lectures himself via a video conference. The video conference is bi-directional to also allow questions from students and discussions. One student forgot to upload the solution for a final simulation task and is now uploading it using FTP. Last but not least, the entrance of the building is observed using a CCTV camera which is streamed to the porter's office on the main campus.

The Quality of Service of the video conference call should be maintained during all activities. The students (for HTTP web browsing and FTP file upload) and the video conference laptop use the same WLAN. Therefore it should be investigated how many students can use the WLAN for web browsing during the class. The CCTV camera is connected via Ethernet. All traffic should be then transmitted using the point-to-point radio link.

To evaluate the capabilities of the backup solution you as consultants are requested to simulate the whole network and determine the key characteristics of this setup.

Figure 1 shows a draft of the network. All wireless users are uniformly distributed in a 400 m^2 quadratic area around the WLAN access point. The students usually do not move with their laptops and 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". The CCTV camera is connected to the same router using Fast Ethernet as well. The "remote router" is connected to the "main router" via the point-to-point radio link. The CCTV monitoring station at the porter's office is connected to the "main router". A VDSL connection with a data rate of 100 Mbit/s connects the "main router" to the Internet and therefore HTTP server, and the FTP server. This Internet connection can be simplified assuming an exponentially distributed delay with a mean of 30 ms. The professor's laptop is connected to the DFN ("Deutsches Forschungsnetz) and therefore has a constant delay of only 5 ms. The point-to-point radio link can be modelled as a PPP connection with the parameters given in Figure 1.

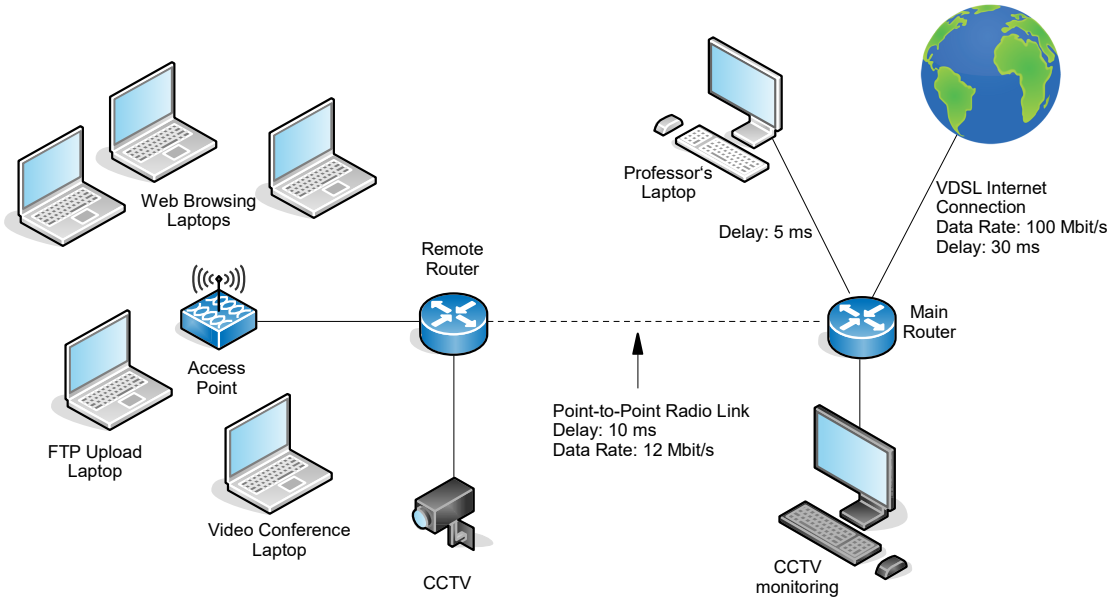

Figure 1: Proposed Network Setup With Point-to-Point Radio Link

To be able to analyse the scenario the computer centre captured statistics about the web browsing behaviour. The traffic caused by the students can be modelled as one HTTP request and response followed by some exponentially distributed reading time (see parameter sheet) before the next request is issued. **The requested size (in Byte) is recorded in a trace file.** You as the consultants 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.

The CCTV camera is constantly streaming a high quality video to the main campus. The stream is modelled as a constant UDP stream containing packets of size 10KB every 40 ms. Optionally the camera can be switched off.

Also both video conference stations send with a constant data rate of one packet every 40 ms. A video packet consists of 1388 Byte of payload plus protocol headers. The video 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 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 CCTV camera is streaming the video constantly, the upload from the student's laptop to the FTP-server is considered as one large file transfer lasting the whole simulation, and other students browse the Web. Each device uses only one application at a time. 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).

2 Task

You as consultants simulate the proposed network with the direct radio link. Your work should answer, but is not limited to the following questions:

- How many students can use the Web while the file is uploaded, the CCTV cam is streaming and the professor is giving the lecture using the video conference, so that the video QoS requirements (delay, loss rate) are still met?
- What are the expected average delays and loss rates for the video connection depending on the number of Web users?
- What is the average data rate of the FTP upload?
- What are the average download rates of the HTTP clients?
- Analyse the trace files with statistical methods to model the HTTP traffic in the simulation.
- How do the other applications influence the video call?
- Is the direct radio link rate sufficient? Is it required to pause the CCTV service during the video conference?
- Where are the main bottlenecks of each variant?
- Which further changes would you suggest to improve the QoS for the video call?

One team member should do the examination and discussion with the CCTV camera stream activated and the other one without.

3 Hints

- 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.
- Unspecified connection parameters can be assumed as being ideal or default.
- 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.
- The trace file and parameter sheet for your team can be found on Stud.IP in the documents section (check your group specific folder).