University of Glasgow | School of Computing Science

Assessed Coursework

Course Name	**Networked Systems (H)**			
Coursework Number	**Exercise 1**			
Deadline	**Time:**	**4:00pm**	**Date:**	**27 February 2025**
% Contribution to final course mark	**20%**			
Solo or Group ✓	**Solo**	✓	**Group**	
Anticipated Hours	**20**			
Submission Instructions	**Submit via Moodle**			
Please Note: This Coursework cannot be Re-Assessed				

Code of Assessment Rules for Coursework Submission

Deadlines for the submission of coursework which is to be formally assessed will be published in course documentation, and work which is submitted later than the deadline will be subject to penalty as set out below.

The primary grade and secondary band awarded for coursework which is submitted after the published deadline will be calculated as follows:

(i) in respect of work submitted not more than five working days after the deadline
   a. the work will be assessed in the usual way;
   b. the primary grade and secondary band so determined will then be reduced by two secondary bands for each working day (or part of a working day) the work was submitted late.

(ii) work submitted more than five working days after the deadline will be awarded Grade H.

Penalties for late submission of coursework will not be imposed if good cause is established for the late submission. You should submit documents supporting good cause via MyCampus.

Penalty for non-adherence to Submission Instructions is 2 bands

You must complete an "Own Work" form via https://studentltc.dcs.gla.ac.uk/ for all coursework

Networked Systems (H) 2024-2025 – Exercise 1

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13 February 2025

Introduction

An important problem for transport protocols is congestion control: how to adapt the speed of transmission to match the available network capacity. Lecture 6, and the material in laboratory exercise 5, discuss this topic. Complete that lab exercise, and review the lecture material, then answer the following questions about TCP congestion control.

This is an assessed exercise that is worth 20% of the marks for this course.

The goal is primarily to test your understanding of the TCP protocol and its congestion control algorithm. The exercise further tests your ability to write code to work with, and extract and visualise information about, network packet traces as might be useful when understanding or debugging network protocols and their performance.

Feedback will comprise a breakdown of your mark by question, along with brief written justification for the marks assigned.

Assessed Exercise 1

TCP Connection Establishment

Review and complete Section 3 of laboratory exercise 5 ("TCP Connection Handshake") and answer the following:

Question 1: In the `lab05.pcap` file, what IP address and source port are used by the client that is opening the connection? What is the host name of the server to which the client is connecting? [2 marks]

Question 2: In the `lab05.pcap` file, what is the initial sequence number chosen by the client? What is the initial sequence number chosen by the server? [2 marks]

Question 3: In the `lab05.pcap` file, what is the initial round-trip time from the client to the server? That is, what is the difference between the timestamp recorded when the first packet was sent and when the second packet was received (each line of the `tcpdump` output starts the timestamp of the event). [1 mark]

Question 4: The first two packets sent in `lab05.pcap` both include the option `sackOK`. This indicates that both the client and server are willing to use the TCP Selective Acknowledgements (SACK) option. Do some background reading and, in your own words, describe what is indicated by an acknowledgement in TCP, what is a TCP selective acknowledgement, and how do selective acknowledgements change what is acknowledged by TCP. Explain why selective acknowledgements are useful. [10 marks]

Question 5: The `tcpdump` output for the first packet in the `lab05.pcap` file contains a specification of the receive window ("`win 28960`") and the window scaling option ("`wscale 7`"). Do some background reading and explain what is the TCP receive window and what is the impact of window scaling on the receive window. State also the size of the receive window, in bytes, that will be used by the client in this connection. [5 marks]

Question 6: Explain the difference between the receive window and the congestion window in a TCP connection. Which is the limiting factor in TCP throughput? [5 marks]

TCP Data Transfer

Review and complete Section 4 of laboratory exercise 5 ("TCP Data Transfer") and answer the following questions:

Question 7: Submit the first of the two plots you prepared to show the behaviour of the TCP data transfer, plotting TCP sequence number on the y-axis against the arrival timestamp on the x-axis, for the entire connection. [4 marks]

Question 8: The slope of the curve in the plot indicates the transmission rate of the TCP connection, with a steeper curve showing a faster transmission rate. Discuss the shape of the curve you see in your graph. Is the transmission rate constant? Explain why, or why not. [4 marks]

Question 9: Submit the second plot you prepared, showing the behaviour of the first 300ms of the connection. [2 marks]

Question 10: The plot you submitted for Question 7 should show packets being sent in four distinct bursts separated by idle periods. By inspection of the plot and the `lab05-timeseq.dat` file you prepared, state approximately how many TCP segments were sent in each of these four bursts. What aspect of TCP behaviour is seen here? What is the initial congestion window used by the sender? [6 marks]

Question 11: What is the total number of bytes of application data transferred over the TCP connection from the server to the client? How long did the connection take

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to send this data? What is the average download rate? Explain how you calculated these values. [4 marks]

TCP Congestion Control

Question 12: A TCP connection is used to transmit a file containing 1024 kilobytes of data. The connection traverses a network that has a path maximum transmission unit (MTU) large enough to allow each TCP segment to deliver one kilobyte of payload data, plus any necessary header data. Consider:

a. If no packets are lost, and the initial congestion window is 1 kilobyte, what will be the duration of the TCP connection, measured in multiples of the network round-trip time? Explain your working. [7 marks]

b. Assuming the round trip time is 30ms and the TCP/IP headers sent in are each packet 40 bytes in size, what is the maximum bit rate at which the above described connection will send data within a single round trip. [4 marks]

c. Discuss whether it is possible that this connection was traversing a link with 100Mbps capacity. [4 marks]

Submission

You should submit a single report, in PDF format, answering the ten questions given above. A mark out of 60 will be assigned to your submission, weighted as noted earlier. This mark will be converted to a percentage, then used to assign a band on the University's 22 point scale.

Prepare your PDF file formatted for A4 paper, in two columns, using the Times Roman/Times New Roman font in 11pt, with 1.5cm margins, and with the exercise title, your GUID (matriculation number and initial letter of your surname), and the date at the top of the first page (i.e., using a format that matches the last two pages of the handout). If you use LaTeX to prepare your document, the following structure will format your submission appropriately:

```
\documentclass[11pt,a4paper,twocolumn]{article}
\usepackage[cm]{fullpage}
\usepackage{newtxtext}
\usepackage{newtxmath}
\begin{document}
\title{Networked Systems (H) Exercise 1}
\author{GUID goes here}
\maketitle
\section*{Question 1}
...your text here...
\end{document}
```

You are not required to use LaTeXwhen preparing your report. Your report must not exceed three pages in length, including all figures, tables, and any references. **Length is not an indication of merit**. If you can answer the questions in less than three pages, then please do so.

You must submit your report before 4:00pm UK time on 27 February 2025. Following the code of assessment, late submissions will be accepted for up to 5 working days beyond this due date. Late submissions will receive a two band penalty for each working day, or part thereof, the submission is late. Submissions that are received more than five working days after the due date will be awarded a band of H.

Submissions must be made via Moodle. This problem set is worth 20% of the mark for this course. You must submit a single PDF file, `ns-ex1-`*`GUID`*`.pdf`, replacing *GUID* with your GUID (your student number followed by the first letter of your surname). **Submissions that are formatted incorrectly, that have the wrong filename, or that otherwise do not follow the submission instructions will be given a two band penalty. Such penalties will be strictly enforced.**

If you are ill, or have other circumstances that may affect your submission, then you may contact the Student Support Team **before** the deadline to request an extension, following the usual procedure.

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