

## Homework 2

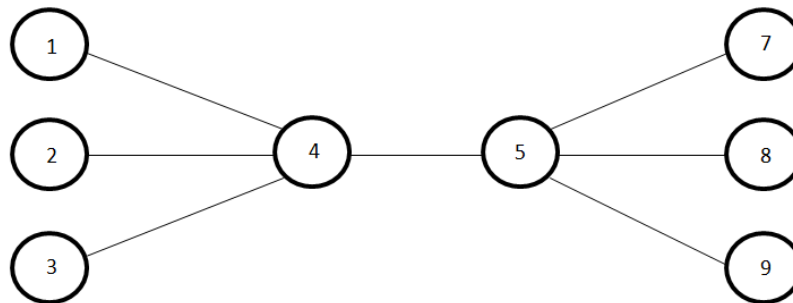
Please email your answers/report in **PDF format** to Mr. Baki “baki@ce.sharif.edu” and CC me at “kharrazi@sharif.edu”. The HW file name should be “**Your Lastname-693-HW-2**”. It should be used as the subject of your email, too. In order for us not to miss your homework please follow the formatting. This homework is due by **Aban 10th, 11:59 PM**. You are also supposed to have a face-to-face delivery.

In this assignment, we’ll use the network simulator (NS-2) to understand the working mechanisms of transport layer protocols; TCP and UDP. In the first part, you are expected to learn and understand the NS-2. Then, in the second part, you will use a simple simulation model to understand why the AIMD algorithm is being used. In the third part you will go after the wireless simulation capabilities of NS-2 and get familiar with its error models.

### Part I

In this part of the assignment, the goal is to become familiar with NS traces and be able to write simple scripts to process such data. Please follow the below steps:

1. Write a simulation script which generates the following topology:



With the following characteristics:

- Establish a TCP connection between node 1 and node 7 and a second between node 3 and node 9 (use TCP Tahoe),
- Establish a UDP connection between node 2 and node 8,
- Set the packet size to 1024 bytes,
- Set the UDP source to send packets at the rates of 10, 20, . . . , 100 packets per second (in 10 independent experiments),
- Set the maximum advertised window size of the TCP flow to 32 packets,

- Both the UDP and TCP sources start at 0.0 seconds and run for the whole duration of the simulation,
  - Run the simulation for 30 seconds.
2. The script file posted on the course webpage measures the throughput (the ratio of the total number of packets received to the total number of packets sent) of UDP flow. Modify it to also measure the throughput of TCP flows. Or you can write your own script and use it as a parser. The parser script can be run by typing: `gawk -f parser.awk out.tr` The script should be able to measure:
    - UDP throughput
    - TCP throughput
  3. Run the parser script and store the results in a log file.
  4. Change the version of TCP to TCP Reno and repeat steps 2-3.
  5. Plot graphs of (using the data from the 2 log files)
    - UDP throughput vs UDP packet rate
    - TCP throughput vs UDP packet rate
    - TCP goodput vs UDP packet rate
  6. The bandwidth of all links should be set at 5Mbps and also the delay on all links should be set at 5ms. Write a script and find the utilization of the link between node 4 and node 5.

#### Observations to be made:

- Comment on the difference in the average bandwidths available to the different versions of TCP. Explain the difference in terms of congestion control mechanisms of these versions. Which version would you like to adopt for your network?
- Comment on the bandwidth share of TCP and UDP. Do you think that UDP traffic is suppressing the bandwidth share of TCP traffic? If yes, can you suggest a way to stop that?

## Part II

In this part of the assignment, you will change the simple UDP flow of previous part to behave more fairly in respect to TCP flows. Please follow the below steps:

1. Write a script in TCL based on your script from the previous part considering these changes:
  - The script should accept N arguments  $t_1, t_2, \dots, t_n$  indicating N times which a loss may occur,
  - Start UDP flow with rate 10, 20,  $\dots$ , 100 packets per second (in 10 independent experiments),
  - At each second and/or each one of  $t_i$  times, change/update the sending rate of CBR traffic producer for the UDP flow between node 2 and node 8 based on:
    - AIMD (add sending rate as much as one packet per second and halve it if you reach one of loss time instants which you got through your script arguments),
    - AIAD (add sending rate as much as one packet per second and decrease it as much as one packet per second too if you reach one of loss time instants),
    - MIMD (multiply sending rate by two and halve it if you reach one of loss time instants),

- MIAD (multiply sending rate by two and decrease it as much as one packet per second if you reach one of loss time instants),
  - Run the TCL script without any argument, parse its output, obtain the times which a loss was occurred at them, run the TCL script again, this time with found loss time instants as the script arguments, and repeat this process for 100 times. After each run, the loss time instants will be found more precisely and the simulation output will estimate the AIMD/AIAD/MIMD/MIAD UDP flow behavior more closely.
2. Plot 4 graphs for AIMD/AIAD/MIMD/MIAD cases. In each case, plot the one UDP flow's throughput and throughput of two TCP flows vs the initial UDP flow rate (10 values from 10 experiments),
  3. Note on the fairness of changed UDP flow vs TCP flows having different initial sending rates. What can you say about AIMD/AIAD/MIMD/MIAD cases?

### Part III <sup>1</sup>

We will use NS-2 to study the throughput of a single hop IEEE 802.11 network. There are several factors that affect the throughput, 1) number of nodes, 2) the back-off mechanism for contention resolution, 3) use of ACK and 4) packet size and use of RTS/CTS, etc. The purpose of this assignment is to evaluate the impact of some of these factors. Construct a simulation scenario with  $m$  nodes in a single hop network. A constant bit rate (CBR) source on top of UDP transport is used as traffic source. Adjust the rate of the CBR source such that the loss rate is controlled below 5% (Don't parametrized your simulation environment in such a way that the loss rate is more than 5%). Choose any routing protocol as you wish. Throughput is defined as the ratio of the total number of application layer bits received to the total number of application layer bits sent. Measure the throughput and single-hop delay with respect to the following parameters (while fixing the other parameters).

1. Vary the number of sender/receiver pairs (with all sources transmitting at the same rate). Use 2 pairs, 5 pairs, and 8 pairs while the RTS/CTS is disabled.
2. Repeat the above, this time having the RTS/CTS enabled.

Note that some of the simulations may require minor modification of source codes. Repeat each experiment 5 times with a different random seed and compute the average to get the final results. [hint: locate the mac-802.11 related codes in the ns-2 source tree first and then start with a single pair of sender and receiver scenario.] Summarize your findings and comment on whether the use of routing protocols would have an impact on the results and how.

### What to turn in:

- All of the TCL scripts used for your simulations,
- The parsing scripts for calculating the required parameters,
- The required graphs (plotted using gnuplot, xgraph, excel, etc.). Handmade graphs will not be accepted,
- Detailed observations and conclusions,
- A report file with clear instructions to run your simulations and parse the trace files. You should clearly specify the functionality and purpose of each file. NOTE: Please DO NOT send the trace files. All files should be contained in a directory which is zipped into a single file and must follow the naming conventions as specified earlier (Lastname-693-HW-2.zip).

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<sup>1</sup>Parts of this assignment are obtained from other courses. Acknowledgments are available on the course website.