ICSI 445/660 Fall 2016 – Homework 1
Due October 4, 2016 11:59PM via Blackboard

September 20, 2016

1 Requirements and policies

Students enrolled in 660 should complete this assignment individually. Students enrolled in 445 can work in pairs. Your turn-in is due on Blackboard and each student should submit individually (even if you've worked as a pair). Note that there is a fair amount of software installation to be completed before you can answer the questions below. This will take time and will raise questions, so start early and come to office hours to discuss any issues. **Late submissions will not be accepted**.

2 Assignment overview

The purpose of this assignment is to familiarize you with ns-3[1] network simulator and remind you of how to use Wireshark[2]. To complete this assignment you must install ns-3. Note that ns-3 runs only under Linux, so if you don't have access to a Linux machine, you can do one of the following: (i) create a dual-boot machine, (ii) install Linux in a virtual machine or (iii) use a Linux environment like Cygwin. The directions for installing ns-3 can be found on the following URL `https://www.nsnam.org/docs/tutorial/html/getting-started.html`.

The assignment consists of two parts. In the first part you will get familiar with the simulator and the modules it includes. In the second part you will run some basic simulations and analyze the results.

3 Part 1: Getting familiar with ns-3

At this point you should have successfully installed the ns-3 simulator on your computer. Navigate in your installation to answer the following questions.

1. What wireless network modules are available in ns-3? Consider Data Link Layer (i.e. MAC protocol modules) and Network Layer (i.e. routing protocol modules). In what directories are they located?

2. OLSR and DSR are two mobile network routing protocols. Refer to [1] and briefly (in one paragraph) describe their similarities and differences.

3. What mobility models are included in ns-3? In what directory are they located? Lookup online and briefly describe what is the *random waypoint* mobility model. Go on GoogleScholar and find one highly-cited paper on random waypoint mobility. List the paper title, authors, venue and year of publication.

4. In part 2 of the assignment we will run a ns-3 example called `csma-ping` provided through the ns-3 code base. The example code can be found in `ns-3.25/src/csma/examples/csma-ping.cc`. Following our in-class discussion of `ns-3.25/examples/tutorial/third.cc` draw the network architecture that `csma-ping` creates and also draw the block-diagram of the `csma-ping.cc` implementation. Who pings whom in this example?

[1] https://www.nsnam.org/
[2] https://www.wireshark.org/

4 Part 2: Running a simulation and analyzing the results

In this part you will learn how to run a simulation and analyze the results. We will work with an example called `csma-ping` provided through the ns-3 code base. Run the `csma-ping` example using `waf`[3] and note where the program stores the output pcap files. Once you fully understand how to run the example and where to find the output you can proceed to the actual measurements.

For your measurements, you will execute `csma-ping` five times using the default parameters and saving the pcap files for each execution. Note that when running simulations, you should never draw conclusions based on a single execution of an experiment. In order to obtain statistically-significant results you need to run an experiment multiple times and then present results across these runs.

Once you have the pcap files saved, you will analyze them using Wireshark and its command-line equivalent Tshark[4]. (If you haven't already) you will need to install Wireshark and Tshark on your computer. For more information and installation instructions visit `https://www.wireshark.org/` and the Wireshark User's Guide `https://www.wireshark.org/docs/wsug_html_chunked/`.

After running the five simulations, use Wireshark to examine the packet traces and answer the following questions.

1. How many of ICMP requests/replies were sent in each ping session?
2. Did you notice any protocols that were not ICMP-related? Why were they necessary?
3. Were there any packet losses?

Compute the average round-trip time (RTT) across all runs for each pair of hosts. This is where you can use `tshark` to convert your pcap file to a textual file and automate your computations. In order to do this you can issue the following `tshark` command

```
tshark -r <ping-output.pcap> -T fields -e frame.number -e frame.time_epoch -e eth.src -e
eth.dst -e ip.src -e ip.dst -e icmp.type -E separator=, > <ping-output.csv>
```

substituting the .pcap and .csv file names as appropriate. This command reads the already collected .pcap file and applies filters to it in order to extract the frame number (frame.number), frame unix timestamp (frame.time_epoch), source and destination MAC and IP addresses and ICMP packet type (icmp.type)[5]. You can learn more about all the filters you can apply to a .pcap file here `https://www.wireshark.org/docs/dfref/`. The information produced by the above `tshark` command is saved in a .csv file, which you can post-process to calculate the RTT.

Your calculations should produce three values of average RTT – one for each node pair. Note these values in your submission. Now let's compare the results from simulated ping measurements with these from a real Internet ping. Execute `ping` from your machine to a server on the University at Albany network (say our web server at `www.albany.edu`). Here is how it looks like if I send 3 ping requests from my PC to the university web server:

```
mariya@shasta ~$ ping www.albany.edu -c 3
PING www.albany.edu (169.226.1.110) 56(84) bytes of data.
64 bytes from www.albany.edu (169.226.1.110):  icmp_seq=1 ttl=254 time=0.742 ms
64 bytes from www.albany.edu (169.226.1.110):  icmp_seq=2 ttl=254 time=0.768 ms
64 bytes from www.albany.edu (169.226.1.110):  icmp_seq=3 ttl=254 time=0.755 ms
--- www.albany.edu ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2000ms
rtt min/avg/max/mdev = 0.742/0.755/0.768/0.010 ms
```

Do you see a difference in the average RTT from your simulation and in a real Internet scenario? Comment on your findings.

[3] If you are unsure how to do this, follow the "Running a script" instructions on the Getting Started page `https://www.nsnam.org/docs/tutorial/html/getting-started.html`

[4] `https://www.wireshark.org/docs/man-pages/tshark.html`

[5] ICMP type 8 is the code for ICMP request and ICMP type 0 is the code for ICMP reply.

5 Turn in

This homework is due by 11:59PM on Tuesday, October 4, 2016. The turn-in consists of the answers to the questions in part 1 and 2 (in a single PDF) and the script(s) you wrote to compute the average RTT in part 2. Turn in your work through Blackboard as two files – the first file is your PDF with answers and the second file is a zip archive with your script(s). You can use the submission template below to format your answers.

References

[1] Charles E. Perkins Samir R. Das and Elizabeth M. Royer. Performance comparison of two on-demand routing protocols for ad hoc networks. In *IEEE INFOCOM 2000*, Tel Aviv, Israel, March 2000.

ICSI 445/660 Fall 2016 – Homework 1 Submission Template
Due October 4, 2016 11:59PM via Blackboard

September 20, 2016

1 Part 1: Getting familiar with ns-3

1. Answer 1
2. Answer 2
3. Answer 3
4. Answer 4

2 Part 2: Running a simulation and analyzing the results

1. Answer 1
2. Answer 2
3. Answer 3

Average RTT calculations from the simulation.

Comparison of simulation and real RTT measurements.