TLT-2756 Ad Hoc Networks

ns-2 assignment 2

General

The target of this exercise is to get acquainted with the TCP performance over wired and wireless network, by analyzing the throughput and *fairness index* as a function of the TCP packet size.

These simulations can be run using ns-2 software installed on Sun workstations of the Birdland (Lintula), but you can also download and install the ns-2 simulator on own computer. Note that installing ns-2 on your computer could take some time and effort, so in most cases it is more efficient to use Lintula installation. You can get the Birdland account from the room TC207.

This document contains some conceptual definitions, instructions for simulations, reporting, grading and returning of the report.

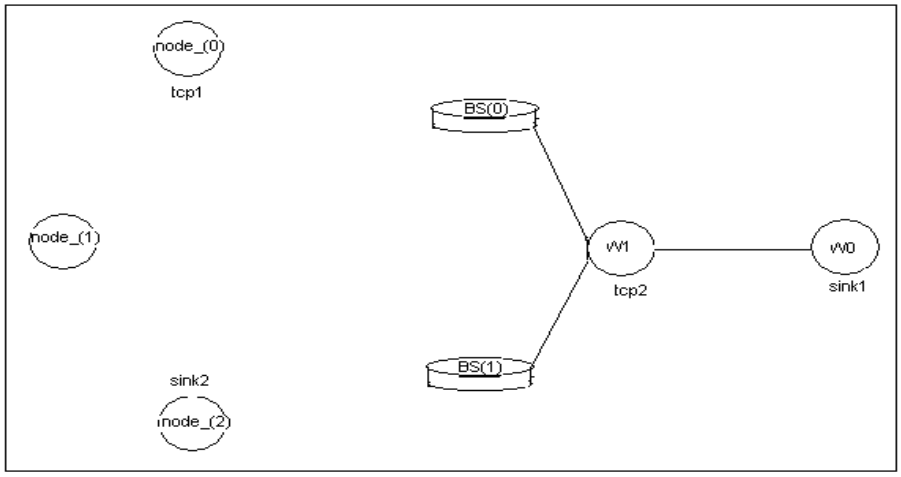
Using ns-2

"Ns is a discrete event simulator targeted at networking research. Ns provides substantial support for simulation of TCP, routing, and multicast protocols over wired and wireless (local and satellite) networks." (http://www.isi.edu/nsnam/ns)

ns-2 is an interpreter of OTcl language, which includes objects for simulating networks. Those objects are implemented using C++, but OTcl is an interface that can be used for calling methods of the objects.

Before starting this exercise it is absolutely essential for you to get acquainted with the excellent tutorial by Marc Greis. (http://www.isi.edu/nsnam/ns/tutorial/). Hence it is presumed in these instructions that **students know the basic terms related to ns-2**, such as creating nodes and links, and how to use protocol and software agents to create traffic in the network.

The network to be simulated



Nodes and links for above network

In the network topology shown above every circle represents a node, while lines represent links.

- The network consists of two TCP sources: wireless node_(0), and wired node W1.
- Two corresponding TCP destinations (sinks) W0 and node_(2) respectively.
- The wireless source node_(0) should be under the domain of the Base Station BS(0) and other wireless sink node_(2) under the domain of the Base Station BS(1).
- The wired nodes W0 and W1 come under the wired domain.
- BS1 and BS2 are linked to the node W1 and W1 connected to W0.

NOTE: node_(1) is a free node.

Transmission and application agents

Nodes node_(0) and W1 use Agent/TCP/Reno as the sending TCP agent and FTP traffic source. Nodes W0 and node_(2) are the receivers of FTP transfers respectively, and they use Agent/TCPSink as their TCP-agent.

The routing protocol used for the simulation scenario is ad hoc routing protocol Destination Sequenced Distance Vector (DSDV), MAC/PHY layer is IEEE 802.11.

Measuring the fairness

To quantitatively measure the fairness of the bandwidth, **fairness index *f*** is used. (see e.g. R.Jain *The Art of Computer Systems Performance Analysis: Technique for Experimental Design, Measurement, Simulation and Modelling*, John Wiley and Sons, Inc., 1991, s. 35-37)

$$f(x_1, x_2, \ldots, x_n) = \frac{\left(\sum_{i=1}^{n} x_i\right)^2}{n \times \sum_{i=1}^{n} x_i^2}$$

Here x_i is the throughput of the i^{th} flow, e.g. the amount of data that has been successfully transferred from the sender to the target in each flow, n is the number of throughputs. The closer fairness index is to the value 1, the better (more equally) the bandwidth is utilized during the traffic flows.

The targets of the simulation

In this simulation you will study how the fairness index and throughput changes when the amount of TCP packet size is varied. You must make 9 simulation experiments using different TCP packet sizes; all the other parameter values are kept constant. You should use the following TCP packet size values: 40, 44, 48, 52, 60, 552, 576, 628, 1420 and 1500. For each value you will get a different TCP traffic load in the wired link. After each simulation run you will have the throughputs values for different links, and based on these throughputs the fairness-index can be calculated. To smooth out the random variation, this fairness-index can be calculated as a mean value from several simulation runs for each packet size (e.g. 10 simulations per each TCP packet size), with random variation of starting time of different TCP flows e.g. small variation between 0 – 5 seconds. The easiest way to achieve that is to write a simple shell script that runs ns2 in a loop with different input parameters – for that implement a new input variable in your .tcl script – the FTP start time.

The duration of each simulation is 60 seconds. Since TCP flows act a little bit unstable in the beginning (slow start, rough estimates of round trip times, etc.), the throughput for each flow in the simulation will not be calculated using the whole time period. Instead, the first 10 seconds form the warm-up period, and the measuring will start when t = 10 seconds, i.e. the amount of data will be collected between 10 - 60 seconds simulated time. In this way the transient time in the beginning will be taken into account.

- Your task is to use (together with a simple shell script that you need to write) and modify the TCL script for ns-2-simulator provided in the course webpage (http://www.cs.tut.fi/kurssit/TLT-2756/assign.html), which creates the topology described earlier, runs the simulation for 60 seconds and calculates the throughputs of TCP-flows.

Note: the term *throughput* is usually referring to the average data transfer rate (bit/s), but since the observation time is the same for all the flows, it is reduced away in the formula of fairness and the values x_i simply mean the amount of transferred data.

- Write the logic inside the *assignment2.tcl* script that calculates the fairness index, with the shell script run ns2 in a loop, with 9 different packet sizes and 10 runs for each size (with random FTP start time). The script should calculate the average fairness values (for each TCP packet size) and create the graph using e.g. the Xgraph-program, where the **value of fairness index** is on the y-axis and the **value of** TCP packet size is on the x-axis.

Using ns-2 and nam (network animator) from ssh Secure shell in Windows

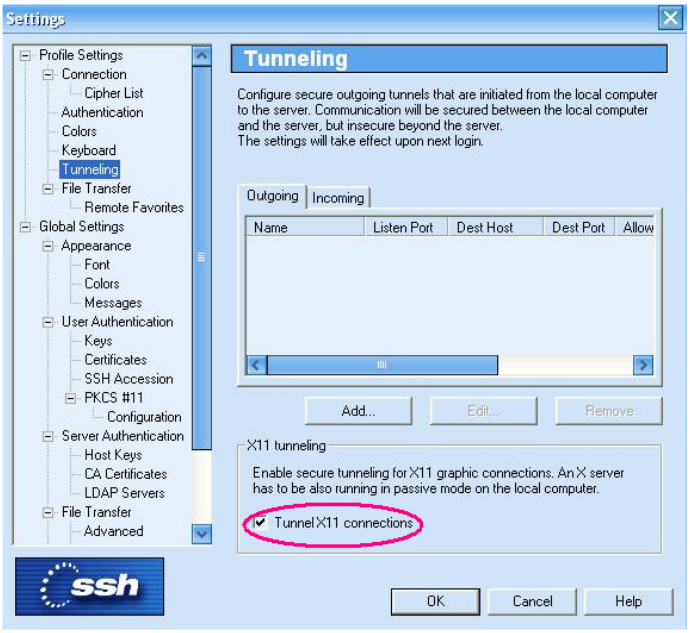
Use nam to demonstrate the network topology described, and experiment with the following example script assignment2.*tcl* *(http://www.cs.tut.fi/kurssit/TLT-2756/assign.html)* with the different TCP flows.

PATH settings for Lintula's UNIX machines (viherkiuru.cs.tut.fi)
Add */usr/local/contrib/bin/* to your PATH settings for Lintula's UNIX machines. For example, if you are using bash (ssh client), edit (or create) the *.bash_profile* file

$ emacs .bash_profile
and add the line *export PATH=$PATH:/usr/local/contrib/bin/* into it.
$ <Ctrl X S>, $ <Ctrl X C>, (for SAVE and EXIT emacs editor)
From this directory, now you'll find both ns nam and xgraph programs for Sun-workstations.

Viewing the xgraph and nam animator from ssh client

ssh Secure Shell Client, Edit, Settings, Tunneling
Click on the Tunnel X11 connections, *OK*



Then *ssh Secure Shell Client, File, Save Settings*

You also have to run the the Xserver in your computer during the simulation.
WinAxe, Xsession (in the university Computers)

The simulation can be started from your own working directory, where you have copied the final script. Then run the script, ns is started with the command:

$ ns assignment2.tcl <TCP_packet_size>

After the simulation, ns outputs the throughput for two different TCP flows and writes a trace files named *wired-and-wireless.tr* and *wired-and-wireless.nam,* which automatically launches the nam animator, which is an X-windows based graphical software that animates the traffic based on the traces in the out.nam file.

Similarly, the fairness graph can be plot using e.g. the xgraph-program, gnu plot, or you can import the values into Excel or Matlab, and use these tools to draw the graph.

Reporting

Write a compact description of the wired-and-wireless scenario based on ad hoc network. You may use the text, images and formulas from these instructions. Next you should present the graph describing the behavior of fairness index as a function of TCP packet size. The results must be commented. Also include a table with the throughput values per flow per simulation run for different TCP packet size.

Attachment required: the complete TCL and shell scripts **send it by email to jakubiak@cs.tut.fi**

About grading

The report will be graded using pass/fail. The following issues will be evaluated:

- The correctness and comparative analysis of the results
- The report presentation and clarity of script.

Submission of the report

Submit the report in the wooden **box #249** (Tietotalo, 2nd floor) by Dec 9th, 16:00. Email **only** the final *script_file* and the shell script, the name of the final TCL script file should be *lastname_studentnumber.tcl (e.g. smith_123456.tcl)*. The electronic versions of the report (sent via e-mail or by other means) will not be considered.

With questions regarding the assignment please contact jakubiak@cs.tut.fi