CS549: Performance Analysis of Computer Networks
Mini-Projects

Assigned: 26/8/2020 *Design Review: 31/8-2/9* *Due: 11:55 pm 10/9/2020*

There are 3 types of mini-projects: experimental, simulation and theory/analysis. You may also propose your own. Work in groups of 2. You must make a presentation highlighting your analysis, results, inferences (as applicable). The presentation must be submitted by due date. These must be self-made, *i.e.*, do not use sentences, plots, diagrams from any other sources. The presentations will go through a plagiarism check on Turnitin.

For the experimental mini-projects, setup virtual nodes on your laptop. Each node may be either a network namespace + MACVLAN or a Linux virtual machine on VirtualBox (or other hypervisor).

For the simulation mini-projects, use NS2. For an overview of NS2 architecture and installation instructions, see [1]. The NS2 manual [2] has detailed instructions and sample scripts.

In the experimental and simulation mini-projects, (1) start with design of experiments: list all the system parameters and the range over which you plan to vary each one. Estimate the total number of experiments to be run, and the time it will take you. (2) Sketch graphs showing the expected results. (3) Run the experiments. (4) Plot and analyse the results. Depending on the outcome, you may need to iterate over some more experiments. In all problems, you must explore sufficiently that you learn beyond the lectures and assignments.

1. Configure N+1 nodes on your laptop. Designate one node as the server and the other N nodes as clients. Choose any file transfer server such as `ftpd`, `sshd`. Vary the rate, loss and delay on the client MACVLANs to emulate some real network scenario. Have the clients generate requests to the server for this scenario. Measure the performance, analyse and draw inferences.
2. Similar to (1) except use Apache or other web server.
3. Similar to (1) except use MySQL or other database server.
4. Similar to (1) except write your own client-server code using TCP or UDP sockets.

In the simulation mini-projects, compare the simulation results with analytical results given in the textbooks, where available.

5. Using NS2, compare the performance of ALOHA, Slotted ALOHA and 1-persistent CSMA. Vary the number of nodes and the traffic rate from each node.
6. In linear incremental backoff (LIB) in which the number of slots is increased by a fixed amount on each successive collision. Using NS2, compare the performance of truncated binary exponential backoff (BEB) as used in Ethernet, and LIB. Vary the number of nodes and the traffic rate from each node.
7. Using NS2, change the backoff algorithm to give higher priority to some stations. Study the effect on elephant and mice flows. Vary the number of nodes and the traffic rate from each node.
8. Use NS2 to compare the performance of CSMA and Ethernet. Vary the number of nodes and the traffic rate from each node.
9. Destination Sequenced Distance Vector (DSDV) is a routing protocol that is based on the Bellman-Ford algorithm. Conduct simulations on NS2 to analyse DSDV. Choose various factors for parameters: number of nodes, movement of nodes, type of traffic etc. Record delay, throughput and packet loss and draw inferences from the results.
10. Repeat (9) for Ad-hoc On-demand Distance Vector (AODV) protocol.

11. Simulate an M/M/1/B queue in NS2. Compare the blocking probability and delay obtained from the trace files with the analytical results.
12. Using NS2 simulate a network of queues with 2 edge routers and 1 core router. The edge routers have service capacity of C_1 and C_2 Mbps, and serve N_1 and N_2 hosts. The access links connecting the hosts to the edge routers must handle a maximum rate X_i Mbps, such that $N_i x X_i > C_i$, say $X_i = 1.2C_i/N_i$. The core router must have a service capacity larger than each C_i but smaller than $C_1 + C_2$. For fixing the size of the router buffers (B), use the bandwidth-delay product rule B = CxRTT [3], where you may fix RTT as 250 ms. Choose three distinct combinations of N and X for each edge router that satisfy the above equation. Conduct simulations for each combination of (N,X), and record queue length, link utilization and packet drop probability.

The following are theory/analysis based miniprojects. For these, you are expected to do/repeat the analysis and extend the plots (if any) in the given references. You may extend the research in interesting directions.

13. IEEE 802.11ad specifies a hybrid MAC protocol that comprises contention- and non-contention-based mechanisms. A three-dimensional Markov chain model, for such a protocol, and its analysis are discussed in [4]. Repeat the modelling and analysis.
14. In order to improve the energy efficiency of the Internet researchers have proposed several modifications to routing protocols. These enhanced protocols work by powering off links during low-traffic period. The work in [5] proposes one such modification to the link state routing protocol OSPF. Repeat the modelling and analysis, propose improvements/ alternative ways of doing it.
15. Reference [6] analyses the delay in a TDMA channel. Repeat the analysis and the numerical example.
16. As the number of Internet hosts grows, so does the size of the routing table. This demands more memory and reduces the packet forwarding speed thereby increasing the end-to-end delay. The work in [7] discusses 4 factors that influence the growth of routing tables. Examine the contribution of each of these factors on the size of the routing table. Add your own illustrative examples (numerical or simulation results).
17. Revenue maximization is an important problem in network economics. ISPs often explore the profitability of various pricing schemes before fixing packet carriage prices. The work in [8] explores some simple pricing schemes and compares the revenue they offer to the maximum feasible revenue. Repeat the analysis.

Propose any mini-project of your own.

18. It must be related to PACN, the level of difficult must be similar to the above, and it must not be work that is submitted/to be submitted for any other course.

References

[1] Slides on “The Network Simulator 2”, borrowed from Communication Networks, Aug – Nov 2015, Department of Electrical Engineering, IIT Madras, available: https://students.iitmandi.ac.in/moodle/pluginfile.php/51002/mod_resource/content/1/Ns2_IntroSampleCode.pdf

[2] E. Altman and T. Jimenez, “NS Simulator for beginners,” Synthesis Lectures on Communication Networks, vol. 5.1, pp 1-184, 2012.

[3] G. Raina and D. Wischik, “Buffer sizes for large multiplexers: TCP queueing theory and instability analysis,” in Proc. of *Next Generation Internet Networks*, pp. 173--180, 2005.

[4] K. Chandra, R.V. Prasad and I. Niemegeers, "Performance analysis of IEEE 802.11 ad MAC protocol,” *IEEE communications letters,* vol. 21.7, pp. 1513–1516, 2017.

[5] A. Cianfrani, V. Eramo, M. Listanti, M. Marazza and E. Vittorini, "An energy saving routing algorithm for a green OSPF protocol", in proceedings of *IEEE Conference on Computer Communications Workshops (IEEE INFOCOM),* pp. 1---5), 2010.

[6] S.S. Lam, "Delay analysis of a time division multiple access (TDMA) channel," *IEEE Transactions on Communications,* vol. 25.12, pp. 1489–1494, 1977.

[7] T. Bu, L. Gao and D. Towsley, "On routing table growth," *ACM SIGCOMM Computer Communication Review*, vol. 32.1, pp. 77–88, 2002.

[8] S. Shakkottai, R. Srikant, A. Ozdaglar and D. Acemoglu, "The price of simplicity," *IEEE Journal on Selected Areas in Communications*, vol. 26(7), pp.1269–1276, 2008.