MONASH UNIVERSITY
DEPARTMENT OF ELECTRICAL & COMPUTER SYSTEMS ENGINEERING

Performance of Telecommunication Networks

Assignment: Performance of Scheduling Algorithms and Traffic Prioritization

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1 Overview

This assignment has two parts: In the first part, you will work on the theoretical analysis of a scheduling system. In the second part you will be writing a new queueing model for our packet switching network simulation system that you learned in your laboratory experiments and used for your routing algorithm assignment.

As part of their resource allocation mechanisms, each router implements a queueing discipline and scheduling algorithm to choose which packets to be transmitted. We discussed various scheduling algorithms in our lectures. In this assignment, we will investigate how a particular scheduling algorithm affect the traffic flows. We will especially focus on fairness, number of dropped packets, delay and delay variation statistics.

2 Procedure

2.1 Analytical Study: Scheduling Problem in a Switching System

In a communication network, data packets arrive at a switch S in an independent fashion from two servers S_1 and S_2. On average, S_1 and S_2 send $\lambda_1 = 10$ and $\lambda_2 = 20$ packets per second, respectively. The packets from S_1 and S_2 pile up at the buffers B_1 and B_2, respectively, before they are picked randomly from the switch S with probability p and $(1 - p)$, respectively. The packet length is exponentially distributed with a mean size of 400 bytes. Also, the speed of the output link from the switch is 128 kbps. (Hint: due to the different lengths of the packets, the processing time at the switch is exponentially distributed with the rate $\mu = 40$ packets per second)

1. Assuming that the sizes of the buffers B_1 and B_2 are infinite:
   (a) Compute the average waiting time for the packets in B_1 and B_2.
   (b) Plot the expected number of packets in B_1 and B_2 as a function of the variable p.
   (c) Find the values of p which minimize the sum of the average waiting times for a packet in B_1 and B_2.
2. Assuming each buffer can hold a maximum of two packets:
   (a) Write the state diagram for the waiting system (Hint: a state corresponds to the number of packets in the buffers B_1 and B_2).

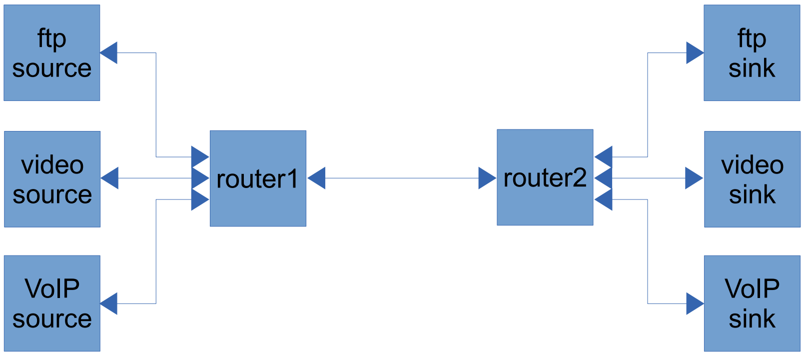

Figure 1: Network topology for comparing the scheduling algorithms

(b) At equilibrium, compute the probability that both the buffers are full (joint blocking probability). Find out the value of p which minimizes the blocking probability.

(c) Also compute the blocking probability for each buffer (individual blocking probabilities). Hint: note that the selection probability affects the service rate for the packets in each buffer.

2.2 Simulation Study: Performance of Scheduling Algorithms

In the *delay and queueing in packet switching networks* experiment [Şek06], we use a set of models to simulate a network of hosts and routers. The router model we have only has one queue per output interface, and we implement a strict FIFO policy for choosing a packet to transmit.

In this assignment, you will replace this with your own scheduling module to run the following scheduling algorithms and compare their performance: *Fair Queueing*, *Priority Queueing*, and *Bit-Rate Fair Queueing*.

You will need to create three different traffic sources to represent three applications: FTP (bursty and varying packet sizes), video (long packets, with varying size and intervals, representing a compressed video application) and VoIP (short packets that are generated in relatively regular intervals). You can model these sources by setting the `iATime` and `pkSize` parameters to appropriate values (please do a literature search to find about these values).

You need to set the `payloadType` field value to allow a router to distinguish the traffic type being carried in a packet.

You are now ready to work on the simulation part of your assignment. You can modify the network topology you used in your packet switching experiments[1] to create your network as shown in Figure 1.

Create your OMNeT++ simulation models that, when they are run, they should generate the following graphs for a given scheduling algorithm, and for a given traffic load (choose three traffic scenarios for the router-to-router link: lightly, moderately and heavily loaded, keep the video and VoIP traffic loads unchanged but increase the "FTP" traffic to increase the load on the link).

1. For each router queue, dropped packets Vs. time

[1] http://www.ecse.monash.edu.au/twiki/pub/InFocus/ANetworkOf4HostsAnd2PacketSwitches/pkswitch_net.ned

2. At the VoIP sink, voice packet end-to-end delay Vs. time and voice packet delay variation Vs. time

3. At the video sink, video packet end-to-end delay Vs. time and video packet delay variation Vs. time

Your aim is to compare the three queuing disciplines and explain their effect on the performance of the three applications.

3 Submission Requirements

Please pay attention to following points:

1. Please submit your analytical study work as a report (in PDF) through the Unit's Moodle site.

2. We will run your simulations in your assigned laboratory hour in Week 12 together and discuss your work and simulation results.

References

[Şek06] Y. A. Şekercioğlu. Delay and Queueing in Packet Switching Networks Experiment for the Performance of Telecommunication Networks Unit, 2006. (available online) http://titania.ctie.monash.edu.au/netperf/netperf-omnetpp-pkswitch.pdf.