Advanced Computer Networks
Assignment 3 – Queuing in a Packet Switch
Assignment given on: 7th Oct 2023
Due Date: 20th Oct 2023

(1% Penalty per 24-hour period)

The objective of this assignment is to understand the basic concepts of the working of an input queue, an output queue and ISLIP protocol which uses the concepts of Virtual Output Queue (VOQ).

1. Input

The command line will specify the following parameters:

$ routing -N switchportcount -B buffersize -p packetgenprob -queue INQ | KOUQ | ISLIP -K knockout -out outputfile -T maxtimeslots

- All packets are taken to be of the same length. Further, slotted time is assumed, where one time slot equals the transmission time of one packet.
- The switch is assumed to have N input and N output ports. The ports are numbered 0 through N - 1; Default value of 8.
- Each port will hold up to B fixed-length packets; Default value of B is 4.
- *packetgenprob* denotes the probability that an input port will generate a packet in a given slot; Default value is 0.5.
- The '-queue' argument specifies the queue type; the output file will contain the output generated by the program. Default is: INQ.
- The *maxtimeslots* argument specifies the simulation time, in slots; Default value is : 10,000.

2. Switch Operation

The (simulator) program will consist of three phases, repeated in a loop until termination: Phase 1 corresponds to traffic generation, Phase 2 corresponds to packet scheduling, and Phase 3 corresponds to packet transmission. All the three phases will take place at the beginning of each time slot.

Initially, all the packet queues are assumed to be empty.

2.1 Traffic Generation

In this phase, each port will generate a packet with probability *packetgenprob*. The destination port for each packet is randomly selected, with uniform probability, from the set of all output ports. Let *t* denote the current time slot. The start time of each packet is randomly set between $t + 0.001$ and $t + 0.01$. For delay purposes, ignore this offset and assume that the arrival time is *t*.

2.2 Scheduling

In this phase, the packets generated in the previous phase are handled.

INQ: For each packet generated, if there is no contention for its desired output port, it is selected for transmission and placed in the corresponding output port's buffer. For packets contending for the same output port, one of the packets is randomly selected for transmission and placed in the corresponding output port's buffer; the other packets are queued at the corresponding input port.

KOUQ: A maximum of K packets (per output port) that arrive in a given slot are queued (based on packet arrival time) at the corresponding output port. If two or more packets have the same arrival time, the packets can be queued in any order. If more than K packets arrive in a slot for a particular output port, then K packets are randomly selected for buffering, and the remaining packets are dropped. The default value is K = 0.6N.

ISLIP: Implement the iSLIP scheduling algorithm for use with a Virtual Output Queuing (VOQ) system, as described in "The iSLIP Scheduling Algorithm for Input Queued Switches", IEEE/ACM TRANSACTIONS ON NETWORKING, VOL. 7, NO. 2, APRIL 1999.

2.3 Transmission

At each output port, the packet at the head of the queue is transmitted. Note that, in the case of KOUQ, the packet at the head of the queue will have the lowest arrival time. Packet delay is calculated as the difference between transmission completion time and the packet arrival time.

3. Outputs

The performance metrics to be measured are as follows:

- **Average Packet Delay:** This value represents the mean of packet delay computed for all transmitted packets.
- **Average Link Utilization:** For each link, the link utilization is defined as the fraction of the time that the link has been used for transmitting a packet, with respect to the entire simulation duration. The average link utilization is the mean value of all link utilizations.
- **KOUQ Drop Probability:** The probability, per slot, that more than K packets were generated for an output port. For example, if in a given slot, more than K packets were generated for 3 out of 8 outports, then the probability for that slot is 0.375. Report the average probability over all slots for the simulation duration.

Output format: The program, upon termination, will output a line with the following values (separated by tabs), that will be appended to the specified output file.

N	P	Qtype	Avg PD	Std. Dev of PD	Avg LU

A technical report (in PDF) that compares the performance of the above four schemes needs to be generated. The report will consist of: performance graphs comparing average packet delay and average link utilization for different values of N, L in {2,3,4} and K in {0.6; 0.8; 1.0} x N. N can be varied from 4 until as high as possible, i.e. the simulator code terminates in a reasonable amount of time. The quality of the report is very important, i.e. correct English sentences, easily viewable performance graphs and technically detailed explanation of graphs (include comparison to known theoretical switch utilization values).

4. What to Submit

Please submit a tar-gzipped file including the source code files, sample output files, make file, technical report, README and COMMENTS files.

5. Grading Criteria

- INQ: 10 points
- KOUQ: 25 points
- ISLIP: 45 points
- Report and Readme file: 20 points

6. Hints

- The use of random variables and related functions will be needed.
- You can use graph drawing packages based on Excel, gnuplot, R, matlab, xgraph, etc. to generate the performance graphs.
- Start your work early.

Submission Details:

1. Please read the questions carefully and complete them.

2. Make a directory with name <Your_Roll_Number> and copy your all program (source code) and output file to that folder.

3. You can implement it using either C/C++/Python or Java.

4. Please copy your output and paste it to a related program at the end of source code(please comment it)/ if necessary you can take a screenshot, name it with its question number and put it in the same Folder.

5. Test well before submission. Follow some coding style uniformly. Provide proper comments in your code.

6. Submit only through moodle and well in advance. Any hiccups in the moodle/Internet at the last minute is never acceptable as an excuse for late submission. Submissions through email will be ignored.

7. Please zip your folder and submit through moodle within **20-10-2023 (23:50 PM)**.