Instructor: Subir Biswas

Introduction to Communication Networks
ECE-442 / 842
Project #2
Assigned: October 15th, 2023
Due: October 31st, 2023

Directions:

Your report must contain:
- A cover page with
    - Your name and PID
    - Project #
    - Submission date

- No hand-written content; everything should be typed

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Project #2: Delay and Performance Analysis of Network Queuing Systems

Objectives:

- To understand how network queues behave in different load, service, and queue conditions
- To understand how to dimension buffers for accommodating user-specified packet drop rates
- To understand how simulation length affects performance accuracy

Queues to be analyzed:

- M/M/1/Θ
- M/D/1/Θ
- D/M/1/Θ
- M/M/1/K

D: stands for deterministic

Introduction to Qsim:

QSim is a queue simulator that is capable of simulating all the above types of queues.

Simulation Setup (for Windows):

1. Create a directory by the name of "sim" on C drive (important: don't create it under any subdirectories)
2. Copy the simulation executable file QSim (from D2L) in that directory

How to use the Simulator:

Input Parameters:

- Packet arrival rate (packets/second)
- Packet arrival distribution (p: poisson or c: constant/deterministic)
- channel capacity (bits/second)
- packet size (bits)
- packet size distribution (p: poisson or c: constant/deterministic)
- Queue Length (# of packets)
- Simulation time (seconds)

Output Parameters:

- Utilization
- Average packet Delay (seconds)
- Number of packets in the system
- Packet Drop Rate

Command line example:

$ Qsim.exe 10 p 10000 750 c 20000 10000

10: packet arrival rate (packets/second)
p: arrival rate is poisson distributed
10000: channel capacity (bits/second)
750: packet size (bit)
c: packet size in constant/deterministic distribution
20000: queue length (# of packets)
10000: simulation time (second)

Experiments:

Each simulation should be run for 10,000 seconds unless specified otherwise:

Experiment #1:

Consider a transmission line of capacity 100Kbps is connected at a port of a router. The router generates packets for that port at the average rate of 10 packets per second with a Poisson distribution. For a queue of length 10^6, if the average packet size is 800 bytes and the packet size is Poisson distributed then:

a) Compute the average transmission line utilization, total number of packets in the system (Population in the buffer plus in the server), and the total packet delay (waiting delay + service delay) for the packets. Also, compute the theoretical values for these quantities. Provide your results in the following format.

	Utilization	Population	Delay
Theoretical values			
Simulation time: 10s			
Simulation time: 100s			
Simulation time: 1000s			
Simulation time: 10000s			

Explain the differences between theoretical and practical values.

Experiment #2:

For the above system, experimentally measure and plot:

a) Population with varying packet arrival rate
b) Delay with varying packet arrival rate.

For both the plots, use packet arrival rate values 1, 4, 7, 10, 13 and 15 (packets per second).

c) If for this system, the allowable delay is 400ms, find the maximum packet generation rate

Experiment #3:

For the same system, plot the delay values with packet arrival rate 1, 4, 7, 10, 13 and 15 (packets per second) for the following systems.

a) M/D/1/Θ
b) D/M/1/Θ
c) D/D/1/Θ
d) Explain and interpret the delay differences between part-b of Experiment #2 and parts a, b and c in this experiment.

Experiment #4:

In the system in Experiment #1, reduce the buffer size from 10^6 to smaller values. Assuming it to be an M/M/1/K queue, plot:

a) Packet drop rate for K = 1, …, 10 (all 10 values)
b) Average delay for K = 1, …, 10 (all 10 values)

Now set K = 10 and vary packet arrival rate 1, 4, 7, 10, 13, 16, 19, 22 and 25 (packets per second). Plot:

c) Packet drop rate for all those values of arrival rate
d) Average delay for all those values of arrival rate