DEPARTAMENTO DE ELETRÓNICA, TELECOMUNICAÇÕES E INFORMÁTICA

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ASSIGNMENT GUIDE NO. 4

PERFORMANCE ESTIMATION OF PACKET SWITCHED NETWORKS

Simulator 1

Using MATLAB, develop an event driven simulator, named Simulator 1, to estimate the performance of a point-to-point IP link between a company router and its ISP (Internet Service Provider) router. The simulator should be a MATLAB function following the input and output formats as specified in Appendix A.

Consider only the packet flow in the downstream direction, *i.e.*, from ISP to the company, usually the direction with highest traffic load. The link has a capacity of 10 Mbps. Consider that the queuing discipline in router is FIFO (*First-In-First-Out*) and that the queue is of size *f* bytes.

Consider the packet arrivals as a Poisson process with data throughput *r* (in bps). Consider also the packet size as a random number of bytes between 64 and 1518 bytes (which includes the layer 2 overhead) with the following probabilities: 19% for 64 bytes, 48% for 1518 bytes and all other values with equal probability.

Input parameters of Simulator 1:

- *r* – data throughput (in bps)
- *f* – size of the queue (in Bytes)
- *S* – number of seconds of a simulation run

Performance parameters to be estimated:

- Average packet loss (percentage of packets discarded due to buffer overflow)
- Average packet delay (in milliseconds)
- Transmitted throughput (in Mbps)

Simulator stopping criteria:

- When the simulated time reaches *S* seconds.

SUGESTIONS: Take as reference the diagram in Appendix B where:

Events: ARRIVAL (the arrival of a packet), DEPARTURE (the termination of a packet transmission) and TERMINATE (the termination of the simulation).

State variables: STATE (binary variable indicating if the link is free or busy with a packet transmission), QUEUEOCCUPATION (total number of bytes of the queued packets) and QUEUE (structure with (i) the arrival time and (ii) the size of each queued packet).

Statistical counters: TOTALPACKETS (number of packets arrived to the system), LOSTPACKETS (number of packets discarded due to buffer overflow), DELAYS (sum of the delays of all transmitted packets), TRANSMITTEDPACKETS (number of transmitted packets) and TRANSMITTEDBYTES (total number of transmitted bytes).

Auxiliary variables: INSTANT (arrival time instant of the packet that is being transmitted) and SYZE (size, in bytes, of the packet that is being transmitted).

With the proposed statistical counters, the performance parameters are determined at the end of the simulation as:

- Average packet loss = 100% × LOSTPACKETS / TOTALPACKETS
- Average packet delay = 1000 × DELAYS / TRANSMITTEDPACKETS
- Transmitted throughput = 8 × TRANSMITTEDBYTES × 10^{-6} / *S*

a) Consider a stopping criteria of S = 1000 seconds. Using Simulator 1, estimate the performance parameters for the cases defined in Table I. Run the simulator 10 times for each case and present the 90% confidence intervals.

Table I

Case	r (Mbps)	f (Bytes)	Avg. Packet Loss (%)	Avg. Packet Delay (msec.)	Transmitted Throughput (Mbps)
A	6	150000			
B	8	150000			
C	9	150000			
D	9.5	150000			
E	9.75	150000			
F	10.0	150000			
G	6	15000			
H	8	15000			
I	9	15000			
J	9.5	15000			
K	9.75	15000			
L	10	15000			

b) With the previous results, draw some conclusions concerning the performance of the link for the different input values of packet throughput (r) and queue size (f).

c) For the cases in Table I with null average packet loss, determine the theoretical values of the average packet delay assuming first the $M/M/1$ queuing model and, then, the $M/G/1$ queuing model (determine the appropriate values from the packet size statistics used in the simulator). Compare the theoretical values with the simulation results. Justify the observed differences and determine which model better approximates the system performance.

d) For the cases in Table I such that the packet loss is not null, determine the theoretical values of average packet delay and average packet loss assuming the $M/M/1/X$ model (on each case, choose the most appropriate value of X). Compare the theoretical values with the simulation results. Justify the observed differences and determine the cases for which this model is still adequate.

To be completed…

APPENDIX A – SIMULATOR 1 FUNCTION

The input and output parameters of the MATLAB function implementing Simulator 1 must follow the following example:

```
par.r= 6000000; %bps
par.f= 150000;  %Bytes
par.S= 1000;    %seconds

out = simulator1(par);

fprintf("Average Packet Loss (%%)= %f\n",out.AvgPacketLoss);
fprintf("Average Packet Delay (ms)= %f\n",out.AvgPacketDelay);
fprintf("Transmitted Throughput (Mbps)= %f\n",out.TransThroughput);
```

APPENDIX B – SIMULATOR 1 PROPOSED DIAGRAM