CSE 232 Section B, Computer Networks; Programming Assignment 4: NS3 based Simulation of a computer network

Instructions:

a. Due date: WED, Nov 27, 2024, midnight,
b. To be done in groups of 2,
c. The institute plagiarism policy applies,
d. Simulation tool: (preferably) NS3
e. If required you may program in C, C++ or Python,
f. Platform: Linux OS,
g. Grading will be done based on submitted material, plus face-to-face interaction with TAs,
h. The submission will consist of 3 parts, suitable zipped with a name that contains the roll nos. of both students:
    1. 2-to-4 page document describing your system (including all assumptions you have made),
    2. the code(s) as separate file(s), and
    3. 8-to-10 slides that you will use to present your work before TAs. This must include screenshots from execution of code for the two data link entities, together with
        a. topology, traffic, link capacities, routing tables of the network under simulation,
        b. the observed performance and stats concerning:
            i. End-to-end one-way delays,
            ii. Packet drops – to be tabulated in the form of a source-destination matrix,
            iii. Queue lengths at each of the outgoing links in routers, and
            iv. Traces of a few packets.

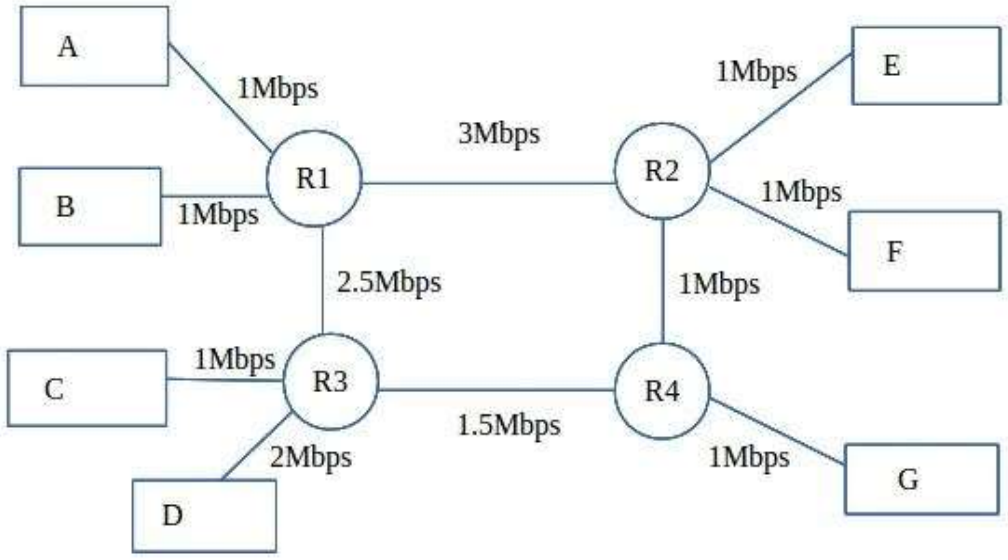
The assignment: Simulate a computer network using a simulator called NS3 and thereby evaluate the performance of the network.

The network consists of several nodes which are connected to each other using point to point data links. A node is either a workstation or a server or an intermediate router (node capable of routing packets). A workstation/server typically generates or consumes data packets, while intermediate nodes simply route packets received from other nodes. Sometimes packets will be dropped for one of many reasons. The data links (of fixed capacity) may be noisy. They also incur certain propagation delays.

The assignment requires that you simulate such a network consisting of 9 to 12 nodes of which 4 to 5 are switches or routers (you decide on the exact numbers). You also decide what the topology (interconnections) is going to be. **A sample topology** is given below (**but use your own topology**).

Here are various parameters that will help specify the network:

1. **Topology**: No. Of routers: 4 to 5 – **in the example below**, there are 4 routers, R1 through R4. Further, the no. of workstations/servers: 5 to 8 – **in the example** there are 7 workstations/servers, A to G.



2. **Packet length**: Workstations/servers generate or consume packets of size 2048 bits (or if you prefer packet size to be 4096 bits, but note that you will need to half the number of packets generated by workstations/servers).
3. **Traffic**: Decide on the AVERAGE no. of packets generated by workstations/servers and write that down in the form of matrix. For **example**, see the one given below in Table 1. **Note the traffic is not necessarily symmetric.**

   Packets generated follow the Poisson distribution, the average no. of packets generated being given by the matrix.

Table 1: Example traffic from/to workstations/servers

source workstation / server	End workstation/server						
	A	B	C	D	E	F	G
A	0	40	50	204	44	29	67
B	33	0	40	50	34	44	29
C	29	78	0	100	54	98	26
D	120	19	144	0	67	95	65
E	34	88	91	54	0	23	11
F	40	50	34	44	29	0	45
G	34	70	13	88	89	65	0

4. **Routing**: for the topology you have chosen, determine a routing table, a sample of which is given in Table 2.

Table 2: Routing table.

Source	Destination										
	A	B	C	D	E	F	G	R1	R2	R3	R4
A	-	R1	R1	R1	R1	R1	R1				
B	R1	-	R1	R1	R1	R1	R1				

C	R3	R3	-	R3	R3	R3	R3				
D	R3	R3	R3	-	R3	R3	R3				
E	R2	R2	R2	R2	-	R2	R2				
F	R2	R2	R2	R2	R2	-	R2				
G	R4	R4	R4	R4	R4	R4	-				
R1	A	B	R3	R3	R2	R2	R2	-	R2	R3	R2
R2	R1	R1	R1	R1	E	F	R4	R1	-	R1	R4
R3	R1	R1	C	D	R1	R1	R4	R1	R1	-	R4
R4	R2	R2	R3	R3	R2	R2	G	R2	R2	R3	-

5. **Link capacities**: Specify the Link capacities. **An example of that is given Table 3** for the specific topology we have picked.

Table 3: Example link capacities. Note all links are bi-directional with link capacity in forward and reverse direction being equal.

Links	Capacity
A-R1	1 Mbs
B-R1	1 Mbs
C-R3	1 Mbs
D-R3	2 Mbps
E-R2	1 Mbs
F-R2	1 Mbs
G-R4	1 Mbs
R1-R2	3 Mbs
R1-R3	2.5 Mbs
R3-R4	1.5 Mbs
R2-R4	1 Mbs

6. **Propagation delay**: Assume that propagation delay is 1 ms on each link – you have to literally force it.
7. **Packet drop rate**: Also assume that the links drop packets due to noise or buffer overflow at a given rate – – you have to literally force it. Choose a drop rate (or probability) between 0.5% to 1%.
8. **Simulation time: 1 minute**. That is packets are generated and moved through the network for 1 minute. Note that this will be significantly different from the lapse of time on your computer.

You need to observe and record:

a. End-to-end one-way delays – average and variance – to be tabulated in the form of a source-destination matrix,
b. Packet drops – to be tabulated in the form of a source-destination matrix,
c. Queue lengths at **each of the outgoing links in routers** (and not workstations/servers).

Can you trace the path by a packet as it travels from source to destination workstation/server and through the network. Do so for one packet from each A, B, C, or D to either E, F, or G. That is trace the path followed by these 12 packets.