

## National University of Computer and Emerging Sciences

# Assignment 01

## Chapter 01

CS-3001 Computer Networks – Spring 2026

Section: BSE-6B1

Max Marks: 50

**Instructions:**

- **Show all work.** Full credit is only given for deriving the correct final expressions and values.
- Assume  $1 \text{ kbps} = 10^3 \text{ bps}$ ,  $1 \text{ Mbps} = 10^6 \text{ bps}$ , unless otherwise stated.
- **Answer all questions.** Partial credit may be awarded if your reasoning is clear, even if the final answer is incorrect.
- **Use neat and organized work.** Clearly label all steps, diagrams, and equations.
- **Units matter.** Always include appropriate units in your answers.
- **Academic Integrity:** Students are expected to submit their own original work. Plagiarism, copying from others, or sharing solutions is strictly prohibited and may result in zero marks and disciplinary action.
- **Submission Guidelines:** Submit your assignment by the deadline in the format specified by the instructor. Late submissions may be penalized unless prior permission is granted.

Question	Max Marks	Obtained
1	20	
2	15	
3	15	
<b>Total</b>	<b>50</b>	

## Question 1: Textbook Problems (20 Marks)

### Part A: Review Questions (4 + 4 = 8 Marks)

- R12.** What advantage does a circuit-switched network have over a packet-switched network? What advantages does TDM have over FDM in a circuit-switched network?
- R19.** Suppose Host A wants to send a large file to Host B. The path from Host A to Host B has three links, of rates  $R_1 = 500$  kbps,  $R_2 = 2$  Mbps, and  $R_3 = 1$  Mbps.
- (a) Assuming no other traffic in the network, what is the throughput for the file transfer?
  - (b) Suppose the file is 4 million bytes. Dividing the file size by the throughput, roughly how long will it take to transfer the file to Host B?
  - (c) Repeat part (a) and part (b), but now with  $R_2$  reduced to 100 kbps.

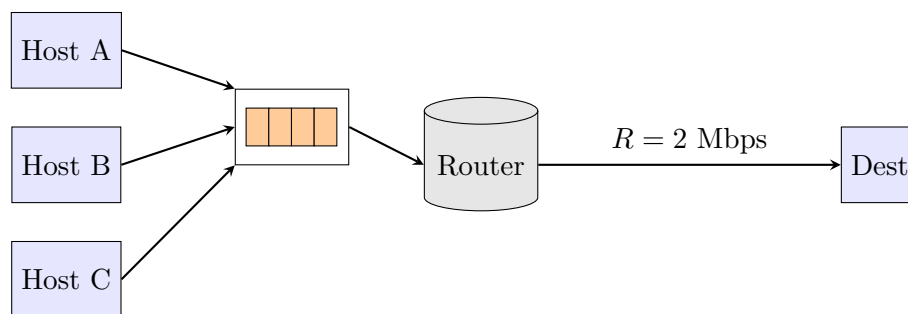
### Part B: Problems (4 + 4 + 4 = 12 Marks)

- P3.** Consider an application that transmits data at a steady rate (for example, the sender generates an  $N$ -bit unit of data every  $k$  time units, where  $k$  is small and fixed). Also, when such an application starts, it will continue running for a relatively long period of time. Answer the following questions, briefly justifying your answer:
- (a) Would a packet-switched network or a circuit-switched network be more appropriate for this application? Why?
  - (b) Suppose that a packet-switched network is used and the only traffic in this network comes from such applications as described above. Furthermore, assume that the sum of the application data rates is less than the capacities of each and every link. Is some form of congestion control needed? Why?
- P6.** This elementary problem begins to explore propagation delay and transmission delay, two central concepts in data networking. Consider two hosts, A and B, connected by a single link of rate  $R$  bps. Suppose that the two hosts are separated by  $m$  meters, and suppose the propagation speed along the link is  $s$  meters/sec. Host A is to send a packet of size  $L$  bits to Host B.
- a. Express the propagation delay,  $d_{\text{prop}}$ , in terms of  $m$  and  $s$ .
  - b. Determine the transmission time of the packet,  $d_{\text{trans}}$ , in terms of  $L$  and  $R$ .
  - c. Ignoring processing and queuing delays, obtain an expression for the end-to-end delay.
  - d. Suppose Host A begins to transmit the packet at time  $t = 0$ . At time  $t = d_{\text{trans}}$ , where is the last bit of the packet?
  - e. Suppose  $d_{\text{prop}}$  is greater than  $d_{\text{trans}}$ . At time  $t = d_{\text{trans}}$ , where is the first bit of the packet?
  - f. Suppose  $d_{\text{prop}}$  is less than  $d_{\text{trans}}$ . At time  $t = d_{\text{trans}}$ , where is the first bit of the packet?
  - g. Suppose  $s = 2.5 \times 10^8$  m/s,  $L = 1500$  bytes, and  $R = 10$  Mbps. Find the distance  $m$  so that  $d_{\text{prop}}$  equals  $d_{\text{trans}}$ .
- P10.** Consider a packet of length  $L$  that begins at end system A and travels over three links to a destination end system. These three links are connected by two packet switches. Let  $d_i$ ,  $s_i$ , and  $R_i$  denote the length, propagation speed, and transmission rate of link  $i$ , for  $i = 1, 2, 3$ . The packet switch delays each packet by  $d_{\text{proc}}$ . Assuming no queuing delays:
- (a) In terms of  $d_i$ ,  $s_i$ ,  $R_i$  ( $i = 1, 2, 3$ ),  $L$ , and  $d_{\text{proc}}$ , what is the total end-to-end delay for the packet?
  - (b) Suppose now the packet is 1,500 bytes, the propagation speed on all three links is  $s_i = 2.5 \times 10^8$  m/s, the transmission rates of all three links are  $R_i = 2.5$  Mbps, the packet switch processing delay is  $d_{\text{proc}} = 3$  ms, the length of the first link is  $d_1 = 5,000$  km, the length of the second link is  $d_2 = 4,000$  km, and the length of the last link is  $d_3 = 1,000$  km. For these values, what is the end-to-end delay?

## Question 2: Traffic Intensity & Buffer Overflow (15 Marks)

**Scenario:** Consider a router buffer preceding a bottleneck link. Traffic arrives in "bursts" rather than a smooth flow.

- The output link capacity is  $R = 2$  Mbps.
- The router has a finite buffer that can hold exactly **4 packets** (excluding the one currently being transmitted).
- Three hosts (A, B, and C) are connected to this router.
- At time  $t = 0$ , Host A, Host B, and Host C **simultaneously** send a burst of 2 packets each.
- Each packet size is  $L = 10,000$  bits.
- Assume the input links are infinitely fast (packets arrive instantly at the buffer at  $t = 0$ ).

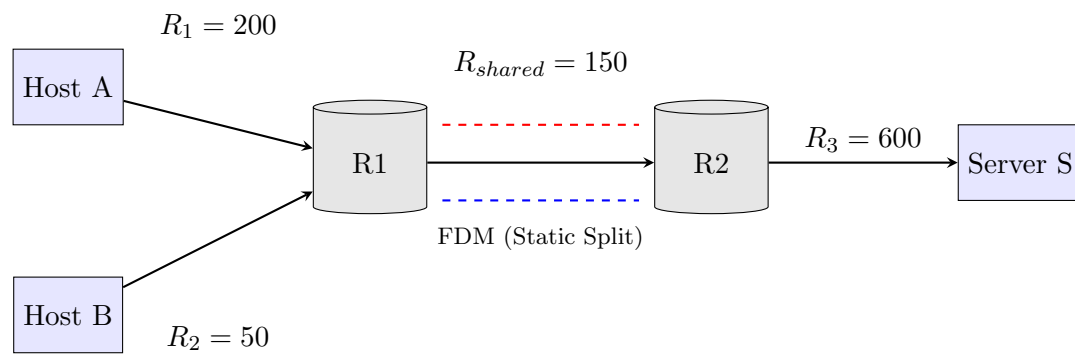


- Calculate the total Traffic Intensity ( $I$ ) relative to the buffer capacity at the instant  $t = 0$ .
- How many packets are dropped (lost) due to buffer overflow?
- Calculate the Queuing Delay for the **last** packet that is successfully transmitted.
- What is the total Nodal Delay for that last successful packet? (Assume processing delay  $d_{proc} = 2$  ms and propagation delay  $d_{prop} = 5$  ms).

## Question 3: Throughput & Heterogeneous Networks (15 Marks)

**Scenario:** Consider the network topology below.

- Host A sends a large file to Server S.
- Host B sends a large file to Server S simultaneously.
- The shared link (R1-R2) uses **Frequency Division Multiplexing (FDM)** and splits the bandwidth evenly into 2 static channels.
- $R_1 = 200$  Mbps (Access link for A)
- $R_2 = 50$  Mbps (Access link for B)
- $R_{shared} = 150$  Mbps (Shared backbone link)
- $R_3 = 600$  Mbps (Server access link)



- Because FDM is used on the shared link,  $R_{shared}$  is split into two dedicated channels of 75 Mbps each. Determine the End-to-End Throughput for Host A.
- Determine the End-to-End Throughput for Host B.
- Calculate the total network utilization efficiency of the shared link. (i.e., What percentage of the 150 Mbps is actually carrying data?).
- If the network administrator switches from FDM to **Packet Switching** (statistical multiplexing), what would be the maximum theoretical throughput for Host A (assuming Host B stops transmitting)?