National University of Computer and Emerging Sciences

FAST School of Computing   Spring-2024   Islamabad Campus

CS-3001: Computer Networks

Serial No:

Sessional Exam-1

Total Time: 1 Hour

Total Marks: 45

Tuesday, 27th February, 2024

Course Instructors

Dr. Abid Rauf

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Signature of Invigilator

Student Name	Roll No.	Course Section	Student Signature

DO NOT OPEN THE QUESTION BOOK OR START UNTIL INSTRUCTED.

Instructions:

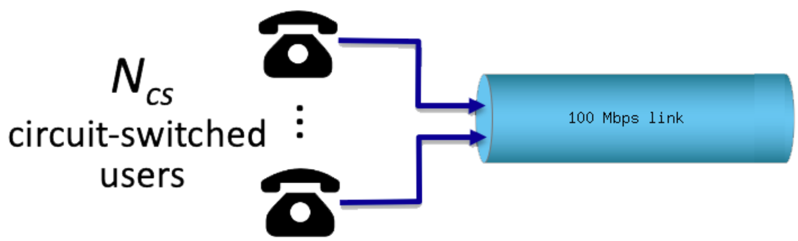
1. Attempt on question paper. Attempt all of them. Read the question carefully, understand the question, and then attempt it.
2. No additional sheet will be provided for rough work. Use the back of the last page for rough work.
3. If you need more space write on the back side of the paper and clearly mark question and part number etc.
4. After being asked to commence the exam, please verify that you have **eight (8)** different printed pages including this title page. There is a total of **3** questions.
5. Calculator sharing is strictly prohibited.
6. Use permanent ink pens only. Any part done using soft pencil will not be marked and cannot be claimed for rechecking.

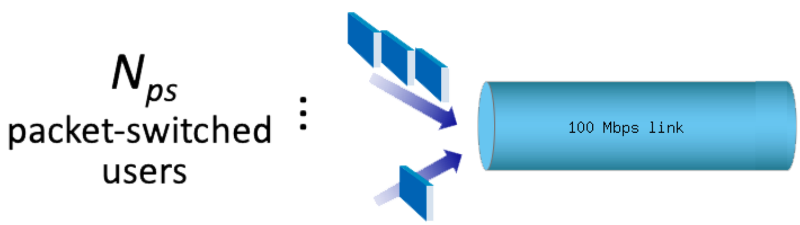
	Q-1	Q-2	Q-3	Q-4	Total
Marks Obtained					
Total Marks	**08**	**08**	**09**	**10**	**35**

QUESTION 1 [08 Marks]
QUANTITATIVE COMPARISON OF PACKET SWITCHING AND CIRCUIT SWITCHING

Consider the two scenarios below:

- A circuit-switching scenario in which N_{cs} users, each requiring a bandwidth of 10 Mbps, must share a link of capacity 100 Mbps.
- A packet-switching scenario with N_{ps} users sharing a 100 Mbps link, where each user again requires 10 Mbps when transmitting, but only needs to transmit 20 percent of the time.





a) When circuit switching is used, what is the maximum number of users that can be supported? [1]

1. When circuit switching is used, at most 10 users can be supported. This is because each circuit-switched user must be allocated its 10 Mbps bandwidth, and there is 100 Mbps of link capacity that can be allocated.

b) Suppose packet switching is used. If there are 19 packet-switching users, can this many users be supported under circuit-switching? Yes or No. Give reason. [2]

2. No. Under circuit switching, the 19 users would each need to be allocated 10 Mbps, for an aggregate of 190 Mbps - more than the 100 Mbps of link capacity available.

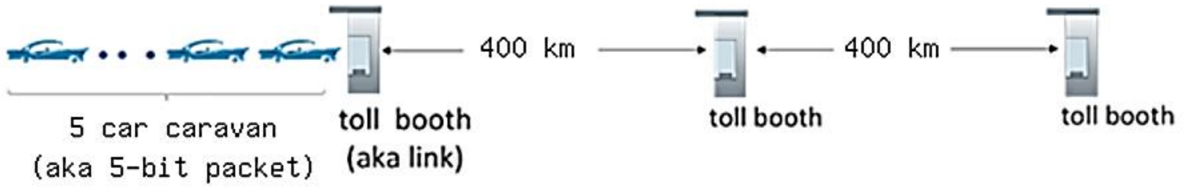
c) With 10 users, what is the probability that more than 4 users are transmitting at the same time? [5]

$P(X > 4) = 1 - P(X <= 4) = 1 – 0.96721 = 0.03279 = 3.3\%$

QUESTION 2 [08 Marks]

CAR - CARAVAN ANALOGY

Consider the figure below, which draws the analogy between store-and-forward link transmission and propagation of bits in packet along a link, and cars in a caravan being serviced at a toll booth and then driving along a road to the next tollbooth.



Suppose the caravan has 5 cars, and that the tollbooth services (that is, transmits) a car at a rate of one car per 2 seconds. Once receiving serving a car proceeds to the next tool both, which is 400 kilometers away at a rate of 10 kilometers per second. Also assume that whenever the first car of the caravan arrives at a tollbooth, it must wait at the entrance to the tollbooth until all of the other cars in its caravan have arrived, and lined up behind it before being serviced at the toll booth. (That is, the entire caravan must be stored at the tollbooth before the first car in the caravan can pay its toll and begin driving towards the next tollbooth).

a) Once a car enters service at the tollbooth, how long does it take until it leaves service? [1]

Service time is 2 seconds

b) How long does it take for the entire caravan to receive service at the tollbooth (that is the time from when the first car enters service until the last car leaves the tollbooth)? [2]

It takes 10 seconds to service every car, (5 cars * 2 seconds per car)

c) Once the first car leaves the tollbooth, how long does it take until it arrives at the next tollbooth? [1]

. It takes 40 seconds to travel to the next toll booth (400 km / 10 km/s)

d) Once the last car leaves the tollbooth, how long does it take until it arrives at the next tollbooth? [1]

Just like in the previous question, it takes 40 seconds, regardless of the car

e) Once the first car leaves the tollbooth, how long does it take until it enters service at the next tollbooth? [2]

. It takes 48 seconds until the first car gets serviced at the next toll booth (5-1 cars * 2 seconds per car + 400 km / 10 km/s)

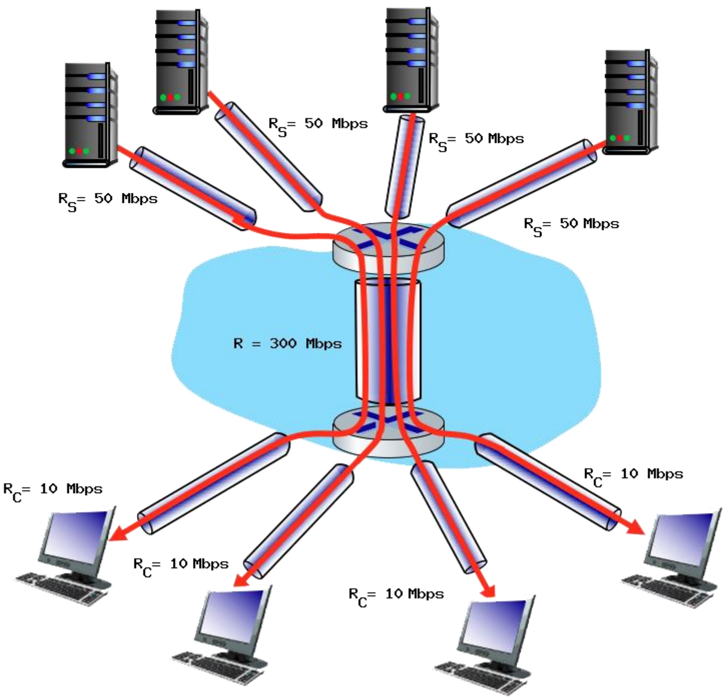
f) Are there ever zero cars in service at the same time, i.e., the caravan of cars has finished at the first toll both but not yet arrived at the second tollbooth? Answer Yes or No [1]

No, because cars can't get service at the next tollbooth until all cars have arrived

QUESTION 3 [09 Marks]

END TO END THROUGHPUT AND BOTTLENECK LINKS

Consider the scenario shown below, with four different servers connected to four different clients over four three-hop paths. The four pairs share a common middle hop with a transmission capacity of R = 300 Mbps. The four links from the servers to the shared link have a transmission capacity of R_S = 50 Mbps. Each of the four links from the shared middle link to a client has a transmission capacity of R_C = 10 Mbps.



a) What is the maximum achievable end-end throughput (in Mbps) for each of four client-to-server pairs, assuming that the middle link is fairly shared (divides its transmission rate equally)? [2]

The maximum achievable end-end throughput is the capacity of the link with the minimum capacity, which is 10 Mbps

b) Which link is the bottleneck link? Format as Rc, Rs, or R. [2]

The bottleneck link is the link with the smallest capacity between R_S, R_C, and R/4. The bottleneck link is Rc.

c) Assuming that the servers are sending at the maximum rate possible, what are the link utilizations for the server links Rs client links Rc, and shared link R? Answer as a decimal. [5]

The server's utilization = $R_{bottleneck}$ / R_S = 10 / 50 = 0.2

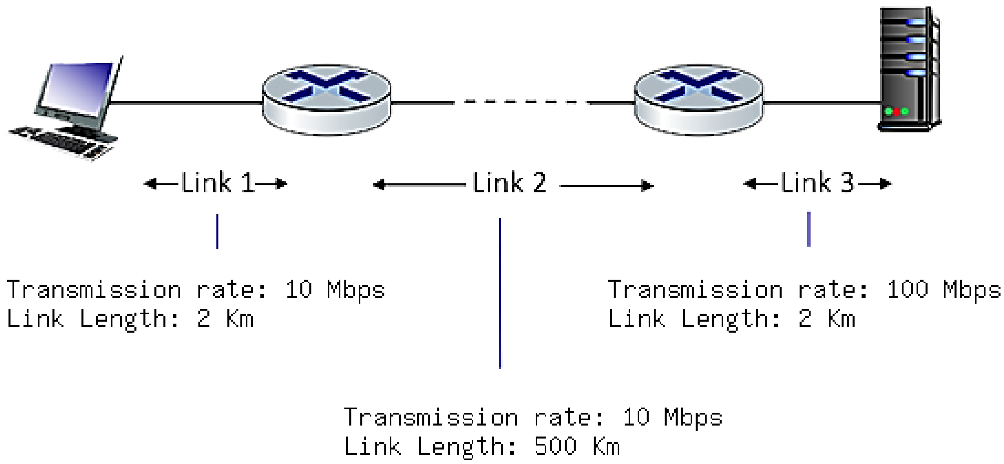
The client's utilization = $R_{bottleneck}$ / R_C = 10 / 10 = 1

The shared link's utilization = $R_{bottleneck}$ / (R / 4) = 10 / (300 / 4) = 0.13

QUESTION 4 [10 Marks]

COMPUTING END-END DELAY (TRANSMISSION AND PROPAGATION DELAY)

Consider the figure below, with three links, each with the specified transmission rate and link length.



Assume the length of a packet is 4000 bits. The speed of light propagation delay on each link is 3x10^8 m/sec. Round your answer to two decimals after leading zeros.

a) What is the transmission delay of link 1, link 2 and link 3 respectively? [3]

Link 1 transmission delay = L/R = 4000 bits / 10 Mbps = 0.0004 seconds

Link 2 transmission delay = L/R = 4000 bits / 10 Mbps = 0.0004 seconds

Link 3 transmission delay = L/R = 4000 bits / 100 Mbps = 4.00E-5 seconds

b) What is the propagation delay of link 1, link 2 and link 3 respectively? [3]

Link 1 propagation delay = d/s = ()2 Km) * 1000 / 3*10^8 m/sec = 6.67E-6 seconds

Link 2 propagation delay = d/s = ()500 Km) * 1000 / 3*10^8 m/sec = 0.0017 seconds

c) What is the total delay of link1, 2 and 3 respectively? [3]

Link 1 total delay = d_t + d_p = 0.0004 seconds + 6.67E-6 seconds = 0.00041 seconds

Link 2 total delay = d_t + d_p = 0.0004 seconds + 0.0017 seconds = 0.0021 seconds

Link 3 total delay = d_t + d_p = 4.00E-5 seconds + 6.67E-6 seconds = 4.67E-5 seconds

d) What is the total delay? [1]

The total delay = d_L1 + d_L2 + d_L3 = 0.00041 seconds + 0.0021 seconds + 4.67E-5 seconds = 0.0025 seconds