Birla Institute of Technology & Science, Pilani
Department of Computer Science and Information Systems
First Semester 2023-24
Advanced Computer Networks (CS G525)
COMPREHENSIVE EXAM (CLOSE BOOK)

Duration: 3.0 Hrs. Date: 12-12-2023 2:00 – 5:00 PM Weightage: 35% MM: 70

Note: Answer sub-parts of a question (if any) at one place in the sequence.

Q.1 a) A multicast application distributes data among 1000 participants using Internet Indirection Infrastructure (i3) overlay. The sender **S** sends data with an identifier **M** into the Chord overlay that maps to a node with an identifier **X** of the overlay. Each receiver $\mathbf{R_i}$ (where i = 0 to 999) inserts a trigger **(M,** $\mathbf{R_i}$**)** into the overlay to receive the multicast data. You can observe that node **X** is responsible for sending data to all receivers; hence, the multicast transmission mechanism discussed above is not scalable.
Design a scalable multicast data transmission scheme using an i3 overlay where each overlay node can handle a maximum of 100 multicast receivers. **[5M]**

Q.1 b) A web service provider deployed 16 servers (i.e., S_0, S_2, …., S_{15}) for a web service to fulfill the load requirement. The provider wants to run its service for the clients using Internet Indirection Infrastructure (i3) overlay for balancing traffic load among the servers.
Design an i3 overlay-based solution for balancing traffic load among the servers and explain the process of redirecting the client request to the least loaded server in your designed solution. **[5M]**

Q.2 To answer this question, consider the paper discussed in the class "Understanding TCP Fairness Over Wireless LAN by Saar Pilosof." **[2+3+1=6M]**
Consider a typical 802.11-based wireless LAN network where the mobile hosts access the network through a Base Station (BS).

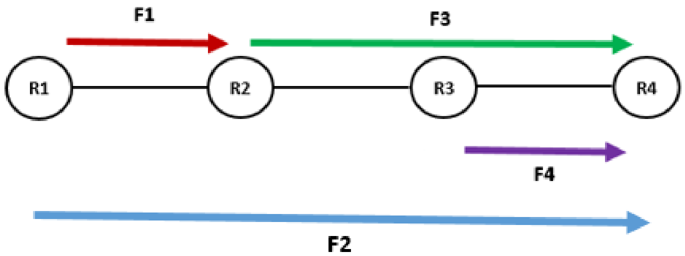
a) Consider a scenario where one mobile sender and three mobile receivers interact with the wired network through BS. What should the bandwidth share be between up and down TCP flows according to the 802.11 MAC protocol?
b) What causes the bandwidth share deviation between up and down TCP flows from the expected bandwidth share according to the 802.11 protocol? Explain.
c) What are the factors/parameters on which the unfair share observed in (b) depends?

Q.3 Consider two TCP flows transmit data through a common bottleneck link. The receiver for flow-1 is on a wired network, whereas the receiver for flow-2 is connected through a wireless access point (WAP). The senders for both flows are on the wired network. A snoopy agent is deployed at WAP, which suppresses the duplicate ACKs from the sender and does local retransmissions. [**5M]**
Compare the bandwidth-share of flow-1 and flow-2 on the bottleneck link for the following two cases:
Case-1: The bottleneck link is connected to a FIFO+DropTail router.
Case-2: The bottleneck link is connected to a RED router.
Assume buffer sizes of both routers are equal, the wireless receiver is not mobile, and senders have sufficient data to send.

Q.4 a) Consider an MPTCP packet scheduler algorithm in which you have a single transmit queue of size B for packets arriving from the application. A master scheduler divides these packets into two subflows in proportion to the capacity left in their congestion windows. Assume that initially, both paths have equal capacity available in their congestion windows. Analyze the master scheduler when both subflows have equal RTT and when one subflow RTT is twice the other subflow RTT. **[3M]**

b) Suppose we use the Additive Increase Multiplicative Decrease (AIMD) algorithm for the congestion control with the same multiplicative decreasing factor (b_D) for user-1 and user-2. However, the additive increasing factor (a_I) of user-1 is half that of user-2. Show the resource allocation convergence process with the help of a two-phase plot similar to the one discussed in class. Calculate the fairness value for the algorithm. **[3M]**

Q.5 The network shown in the below figure comprises four routers. Each link has a capacity of 2 Mbps. The network has four flows labeled F1, F2, F3, and F4, which pass through the routers as indicated in the figure. All flows are carrying constant bit rate UDP traffic at 2 Mbps. **[2+2+2= 6M]**



What would be the resulting rate (throughput) for each flow if -

a) Routers use FIFO + DropTail queuing.
b) Routers use Fair Queuing (FQ).
c) Routers use Weighted Fair Queuing (WFQ), where each flow is assigned a weight equal to its number (i.e., flow F1 gets weight 1, Flow F2 gets weight 2, and so on).

Q.6 Suppose a router has three input flows and one output. It receives the packets listed below at about the same time, in the order listed, during a period in which the output port is busy, but all queues are otherwise empty.

a) Give the order in which the packets are transmitted for the following Fair Queuing approaches: **[6+2=8M]**

i. Send the packet that has the shortest finish time.
ii. Send the packet that has the largest finish time.
iii. Send the packet that has the smallest start time.

Packet	Size	Flow
1	200	1
2	200	1
3	160	2
4	120	2
5	160	2
6	210	3
7	150	3
8	90	3

b) Compare the fair queuing approaches given in (a) in terms of fairness.

Q.7 Given the following topology of wireless nodes **A**, **B**, **C,** and **D**. The transmission range of a node is shown by a dotted circle surrounding it as a center of the circle. **[2 x 4=8M]**

[redacted]

a) If C sends an RTS packet to B, how does A know that not to transmit?
b) If B sends data to C, how does D know not to transmit? Assume the nodes use RTS/CTS MAC.
c) Using the above topology, give an example of the hidden terminal (if it exists; otherwise, explain that there is no possibility of a hidden terminal). Assume the nodes use the CSMA protocol for medium access control.
d) Give an example of an exposed terminal problem if it exists; otherwise, explain there is no possibility of an exposed terminal. Assume that the nodes use CSMA protocol for medium access control.

Q.8 Answer the following questions: **[2.5 x 6 = 15M]**

a) One of the most important goals for Internet architecture design was "To Achieve Survivability." It means the communication service should continue despite the networks and gateways failing. How has it been achieved in the Internet design? Is the "Survivability" goal valid in today's Internet? Explain.

b) One of the solutions proposed to deal with the tussles in the Internet in the paper titled "Tussle in Cyber Space" is design for choice. Give two examples in favor of it. Explain the "tussle" and the design choice for each example.

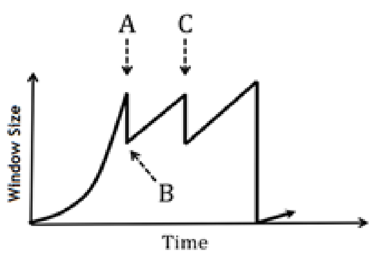
c) The data names are assumed unbounded (no length restrictions) for Name Data Networking (NDN) architecture. How do we handle the forwarding table size for unbounded names?

d) The traffic flow expiration can be achieved in an OpenFlow-based Software Defined Network (SDN) by either soft or hard timeout value. The flow-sense algorithm discussed in the class measures network utilization using flow expiration notification. Which type (soft or hard timeout) of notification provides a more accurate measurement for flow-sense?

e) Accurate estimation of bottleneck bandwidth is the key to working the BBR protocol correctly. For this purpose, we measure the delivery rates over a window of six to ten RTTs and consider the maximum delivery rate value for bottleneck bandwidth estimation. Why do we take the maximum value of the delivery rate over a time window? Explain.

f) What is retransmission ambiguity in TCP? How does QUIC protocol deal with it? Explain.

Q.9 Consider the graph of TCP throughput (**NOT DRAWN TO SCALE**) shown below, where the y-axis describes the TCP window size of the sender. **[2 x 3 = 6M]**



a) Assume that the network has an MSS of 1000 bytes. If point A occurs 1 second after the sender begins its transfer, and the sender has transferred 15,000 bytes to the network by that time, what is the round-trip-time (RTT) of the network? Assume that at time 0, the sender attempts to open the connection. Also, assume that the sender can instantaneously transmit a full window.

b) What is the sender's window size (in bytes) at point B?

c) If point C occurs 2 seconds after point B, what is the sender's window size (in bytes) at point C?

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