Indian Institute of Technology Hyderabad

Department of Computer Science and Engineering

Course: CS50060 Mid-Term Duration: 3 Hrs October 14, 2023 **75 Marks**

Roll No: Name:

Notes: All questions are compulsory. Crisp and compact writing fetches 3 Grace Marks! Use illustrations wherever necessary to explain it better.

1. **True/False.** Determine whether each of the following statements is true or false with proper justification (1 or 2 lines). **[3 Marks]**
   a. The bandwidth-delay product of a link is how long it takes to send a packet to the other side and get a response back.
   b. Circuit switching offers delay and throughput guarantees.
   c. SMTP is used for sending email messages from mail clients and mail servers.
   d. The stop-and-wait protocol is highly inefficient when there is a short distance between source and destination and the transmission rate is large.
   e. Digital Subscribe Line (DSL) access network uses Frequency Division Multiplexing (FDM) and Time Division Multiplexing (TDM).
   f. The transfer of an html file from one host to another is loss-intolerant and time insensitive.
2. Indicate whether TCP or UDP (or both or neither) provide the following services to applications and explain the reason (1 or 2 lines). **[3 Marks]**
   a. Reliable data transfer between processes.
   b. Minimum throughput guarantees between processes.
   c. Congestion-controlled data transfer between processes.
   d. A guarantee that data will be delivered within a specified amount of time.
   e. Preserve application-level message boundaries.
   f. Secure data transfer between processes.
3. Consider a new peer Alice that joins BitTorrent without possessing any chunks. Without any chunks, she cannot become a top-four uploader for any of the other peers. How then will Alice get her first chunk? **[2 Marks]**
4. Consider two hosts, A and B having N links along the path, each with a link of rate ***R*** bps. Suppose the length of each link is ***M*** meters and the propagation speed along the link is ***S*** meters/sec. Host A wants to send **P** packets of **L** bits each to host B using store-and-forward switching in the following two ways. Assume that there are no packet losses, length of ACK packet is **A** bits and ignore nodal processing and queuing delays. **[6 Marks]**

   Case 1 (Stop-and-wait protocol): Host A cannot send the next packet until the preceding packet is acknowledged by host B.

   Case 2 (Back-to-back protocol): Host A continuously sends P packets and host B acknowledges each packet as and when it's received.

   a. Obtain expressions for the end-to-end delay for cases 1 and 2 described above.
   b. Suppose host A begins to transmit a packet at time t=0. At time t=2*L/R + D/S where is the last bit of 1st and 2nd packets in Cases 1 and 2? Show through illustrations.
   c. Suppose s = $2.5 * 10^8$ m/s, L=120 bits, and R = 50 Mbps. Find the distance m for which 120 bits of the packet occupy the entire length of the link.

5. Consider the following chain topology: A ----- B ------ C -------- D ------- E. Host A is sending packets to E using a reliable transport protocol. Each link in the chain can transmit one packet per second. There are no queues or other sources of delays at the nodes (except the transmission delays at each host). **[10 Marks]**
   a. What is the end-to-end between hosts A and E?
   b. What is the throughput of a stop-and-wait protocol at host A in the absence of any losses at the nodes in the chain?
   c. If host A decides to run a sliding window protocol (SR), what is the optimum window size (OWS) it must use? What is the throughput achieved when using this optimum window size?
   d. Consider a sliding window protocol (SR) running at the optimum window size (OWS) found in part(c) above. Suppose some intermediate host in the chain drops every 3rd packet sent from host A to host E, however no ACKs from host E to host A are dropped in the chain. The SR starts numbering packets with increasing sequence numbers starting with 1 like 1, 2, …, n where n is very large (infinity). Assume that host A uses a timeout of 10 seconds for unacknowledged packets. The receiver (E) buffers out-of-order packets until it can deliver them in-order to the application. Draw message flow diagram between A and E till the first OWS number of packets are successfully delivered at host E. Clearly show progression in sliding windows at hosts A and E and label packets as S1, S2, …. and ACKs as A1, A2, …., and highlight timeouts, losses and retransmissions.
6. Suppose Alice wants to check her bank balance by logging in at www.onlinesbi.sbi from her browser. Suppose Alice has configured her browser to use Cloudflare's public resolver (1.1.1.1) which does not contain anything matching in its cache and it follows iterative approach for name resolution. For simplicity, assume that RTTs are the same between every pair of entities involved in DNS hierarchy and Alice & the bank's webserver. Furthermore, assume no packet loss in the network and ignore transmission, processing and queuing delays. **[10 Marks]**
   a. You are asked to employ DNS over HTTPS (DoH) and DNSSEC for boosting security during name resolution. Where do you enable DoH and DNSSEC in the scenario given above. How do they help in improving DNS security?
   b. How many DNS messages get exchanged for name resolution i.e., before Alice starts sending HTTP GET message to the bank's webserver? List out the messages exchanged.
   c. How much time elapsed (in terms of RTTs) since Alice entered www.onlinesbi.sbi in the browser till she gets "200 OK" HTTP response from the bank's webserver?
   d. Answer part(b) assuming that TCP is used instead of UDP for name resolution and DNS query/responses fit inside one MSS of TCP.
   e. Answer part(c) assuming TCP is used instead of UDP for name resolution.

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7. In this problem, we study the performance of HTTP, comparing non-persistent HTTP with persistent HTTP in the presence of a CDN server from a webserver. Suppose the base HTML file (exam-results.html) your browser wants to download from the webserver is small (i.e., transmission delay of 1ms) and it references 12 similarly small sized embedded objects (with file names O1, O2, …, O5) which are kept at a CDN server for ensuring faster response time. The browser (client) and the webserver are separated by 10 hops, each having a RTT of 20ms. The CDN is positioned at 3 hops away from the browser, again with the RTT of 20ms per hop. You can assume zero transmission time for HTTP GET messages and TCP 3-way handshake messages at the respective senders. This means that you need to account only for propagation delays for these HTTP GET and TCP handshake packets exchanged in the network. Make sure you describe the various components that contribute to the response times while answering the following questions. Draw message flow diagrams by showing important network entities to justify your answers. **[10 Marks]**
   a. Non-persistent HTTP with 5 parallel connections: How long is the response time – the time from the when you request the base HTML file by entering its URL in the browser to the point in time when the HTML page and its embedded objects are downloaded and ready for rendering by the browser?
   b. Now suppose persistent HTTP with pipelining is used. What is the response time?
   c. Suppose a web proxy is deployed at one-hop away from the web clients by your ISP. Alice wants to visit the same exam-results page immediately after you have visited. What is the response time experienced by Alice for parts (a) and (b) above.
8. In his haste in writing the code for the exponential weighted moving average (EWMA) to estimate the smoothed RTT (srtt) for setting TCP timeouts, Mr. Bob writes it as follows:

   $srtt = alpha * r + alpha * srtt$;

   where r is the sample RTT and $0 < alpha < 1$. For what values of *alpha* does this buggy EWMA over-estimate the intended *srtt*? You may answer this question assuming any convenient non-zero sequence of RTT samples, r. **[2 Marks]**
9. In a Go-Back-10 protocol, the oldest transmitted segment without ACK has a sequence number equal to 100. The sender has already sent 5 packets from its transmission windows. If the timeout expires for packet 100, which packets the sender should retransmit? **[2 Marks]**

10. You are hired to design a reliable byte-stream protocol that uses a sliding window like TCP for keeping the pipe full. This protocol is meant to be deployed over a 1 Gbps network. The RTT of the network is 100 ms, and the maximum segment life-time is 120 secs (i.e., no segment stays in transmit for more than 120 secs in the network). How many bits would you recommend for the *AdvertisedWindow* (*a.k.a. Receive Window*) and *SequenceNumber* fields of your protocol header? Justify. **[3 Marks]**
11. Consider IITH domain iith.ac.in which is used for web services and mail services. Show a sample of resource records (RRs) present at *ac* DNS server and the authoritative DNS of the IITH (dns.iith.ac.in). **[2 Marks]**
12. Suppose host A sends five TCP segments back-to-back to host B over an existing TCP connection with does not have any unacknowledged segments in the pipe. The first segment has sequence number of 100 and the second and subsequent ones have sequence numbers of 150, 250,400,600. Draw message flow diagram by labeling packets and acks with sequence numbers and acknowledgment numbers. **[3 Marks]**
    a. How much application data is in the first segment?
    b. Suppose the first segment is lost but the second and other segments arrived at host B. In the acknowledgements that host B sends to host A, what will be the acknowledgement numbers?
    c. When will host A retransmit the lost first segment? Assuming it has been received this time at host B, what will be the acknowledgment number in the ACK packet?
13. Describe how TCP SYN flood attacks can be launched on a webserver? Suggest a measure to mitigate or prevent it. **[4 Marks]**
14. Name 4 applications or application layer protocols that run on the top of UDP? Justify why they chose to use UDP over TCP. **[4 Marks]**
15. Describe small-packet problem and silly window syndrome associated with TCP sessions? Suggest a fix to address these problems. **[4 Marks]**
16. Draw FSM machine of Go-back-N Sender and Go-back-N Reciever discussed in the class which is ACK-based, but NAK-free. **[4 Marks]**