

Computer Networks Qualifying Exam

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Note: Please attempt all questions. Justify all your answers. This examination is open book and notes.

[1.] All the sub-questions relate to the application layer of the TCP/IP stack. [30 pts: 10 pts + 10 pts + 5 pts + 5 pts]

- a. Draw a graph with the asymptotic number of messages sent between nodes in a DHT for search on the Y-axis and the average degree of nodes in the network on the X-axis, where the number of nodes are 1000. Assume for each value of degree you can use all the edges in the topology and can use the best possible topology. *What can you infer from the graph?*

Ans: The graph is a heavy tailed graph with the graph starting at (1, 1000), (3, 3), and terminating at (1000, 1). Shows that increase in the node degree beyond $\mathcal{O}(\log n)$ does not add much to the reducing the message complexity for the search.

- b. Assume that you create a VoIP system consisting of one or more servers and several clients logged in at the same time from their own network to perform video/voice/text chat. Given that all clients are connected from within their network using a NAT/Firewall and cannot be accessed from outside, how do two clients in separate networks connect and communicate? Explain the set-up and the protocol clearly.

Ans: With the help of the servers, who work as relays. That is why you need to have more than one server in the system.

- c. If you know the canonical name of the website you want to connect to and ONLY your local DNS server is down, can you connect to the website through your browser? Please explain your answer.

Ans: No. Don't have access to higher level DNS.

- d. Is there a way to perform a denial of service attack with the help of a DNS server? Please support your answer with detailed explanation.

Ans: Yes. Making the DNS server send too many DNS replies to the host.

[2.] All the sub-questions relate to the transport layer of the TCP/IP stack.

- a. Which protocol TCP/UDP do you think is used in the Internet for a large majority of the multimedia traffic? Please comment on the suitability of use of this protocol for such traffic including: If it is TCP, what about congestion control reducing throughput? If it is UDP, what about unfettered transmission causing network congestion? [10 pts]

Ans: It is TCP. We manage because the Internet is over-provisioned to a large extent, hence we do not see throughput degradation.

- b. Explain how TCP congestion control can be inherently wasteful and under-utilize network resources. [10 pts]

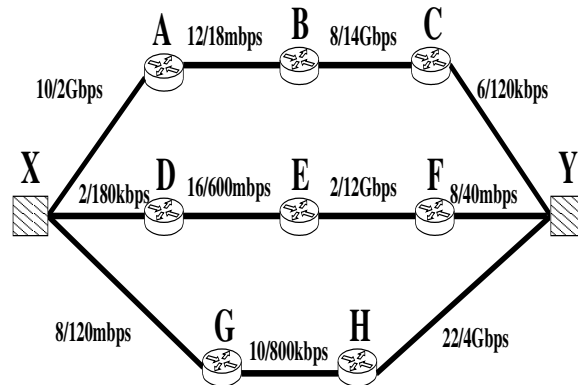
Ans: Congestion control causes oscillation in the send window of the sender (the window is halved in the event of a congestion). If the congestion is momentary, TCP still takes quite long to recover and get back to the levels pre-congestion because of the additive increase functionality. Thus, under-utilizing system bandwidth.

- c. Present an explicit congestion control mechanism that can be implemented at the routers in a network. Detail the complete mechanism of how congestion control can be performed using this mechanism. [10 pts]

Ans: Use a congestion notification bit in the packet. A router that notices congestion can set the bit in the packet, the destination checks the bit and informs the source about congestion.

[3.] All the sub-questions relate to the network layer of the TCP/IP stack.

- a. In the figure below, the edges have two values, the delay (in msec) on the left and the bandwidth on the right. What is a) the least delay path from X to Y (name the path by following the nodes on it); b) the highest bandwidth path from X to Y; and c) the total bandwidth of data-flow from X to Y? [10 pts]



Ans: a) $X \rightarrow D \rightarrow E \rightarrow F \rightarrow Y$; b) $X \rightarrow G \rightarrow H \rightarrow Y$ – 800 kbps; c) 1100 kbps.

- b. Consider a network where each link l_i has an associated bandwidth b_i and delay d_i , respectively, for a given source s and destination t , design an algorithm to find a path in the network from s to t with bandwidth at least B and with minimum delay. Explain your algorithm. [15 pts]

Ans: This problem can be solved using the bisection method. Sort the bandwidth values in increasing order. Start at the median value (bisecting the bandwidth block in two), remove all edges in the network with bandwidth less than the chosen value, see if you can find a path. Yes → Bisect the upper bandwidth block and re-try to find a path. Keep going until you can find no higher. No → Bisect the lower bandwidth block and re-run the algorithm. Keep going until you find the least bandwidth that allows a path.

- c. Consider a network where each link l_i has an associated cost b_i and delay d_i , respectively, for a given source s and destination t , Can you design a polynomial time algorithm to find a path in the network from s to t with minimum cost and with minimum delay? Comment. [15 pts]

Ans: This is an NP-hard problem. There is no polynomial time solution to solve the problem. Approximation algorithms can be designed though.