Computer Networks Qualifying Exam
Fall-end 2014

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

[1.] All the sub-questions relate to the application layer of the TCP/IP stack. [**25 pts:** 5 pts + 5 pts + 15 pts]

a. Please draw the DNS hierarchy. Clearly mark the parts. If your DNS server does not have the IP address for a server's canonical name, then what is the server from which it can get it?

b. How can a DoS/DDoS attack be mounted on the DNS system? Explain in detail.

c. You are given two choices for distributed hash table topology for your P2P network: *i)* a topology with each node having a degree of $\mathcal{O}(\log\log n + k)$, where $2 > k > 1$ is a small constant, and a topology with each node having a degree of $\mathcal{O}(\log n)$. Assume the connections between the nodes are done randomly. Compare and contrast in detail the networks from the perspective of the average message complexity of a query. Which network topology would you prefer to reduce the message complexity?

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

a. The amount of unacknowledged data in TCP is limited by three quantities: the congestion window size, the receive window size (flow control), and the RTT-bandwidth product. [**10 pts:** 5 pts + 5 pts]

   i. Is it possible for TCP Reno (the commonly used version) to reach a state with congestion window size much larger than RTT $\times$ bandwidth? Why? How likely is it?

   ii. Is it possible for TCP Reno (the commonly used version) to reach a state with congestion window size much larger than the receive window? Why? How likely is it?

b. Why is TCP unsuitable for high bandwidth (say 1 Gbps) data transfer scenarios over the network? Explain clearly. Can you propose improvements to TCP to make TCP applicable in this scenario? (**Hint**: Consider explicit congestion notification.) [**15 pts**]

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

a. In a network represented by a graph $G(V, E)$, where V is the set of nodes and E is the set of edges between the nodes, each edge $\{(u, v)|u, v \in V\}$ has a bandwidth given by $b(u, v) > 0$. Design the most efficient polynomial time algorithm to find a path in the graph between two nodes s and t, whose bandwidth is greater than $B > 0$. [**20 pts**]

b. The standard Dijkstra's algorithm has an "edge-relaxation step," please explain what is done in this step. Why is it called edge-relaxation? [**10 pts**]

[4.] All the sub-questions relate to the data link layer of the TCP/IP stack.

a. A network administrator discovers that one of the hosts connected to the gigabit Ethernet LAN has been compromised and converted to a rogue station. Every time any host transmits a frame over its Ethernet interface, the rogue station sabotages the transmission by beginning a competing transmission as soon as it hears the beginning of the transmitted frame, causing a collision. He needs your help to estimate the approximate distance (in terms of cable length, in meters) of the rogue station from one or more probing hosts. On one of these probe stations, you notice that the collision is detected during the transmission of its 8th byte on the wire (including any preamble, etc.). Given that the speed of the signal in the wire is 2×10^8 meters/second, how far away is the rogue station from your machine? [**10 pts**]

b. Suppose you have installed an aware networking protocol stack as part of a new experimental OS kernel on your Wi-Fi capable PDA. On the PDA, you typically use one primary network application at a time, and traffic due to application mixes is not a very important consideration. You have a choice of three user selectable MAC protocols to be associated with each network application program, namely TDMA, CSMA/CA with RTS/CTS disabled, and full CSMA/CA (with RTS/CTS). Assume that the access points support on-the-fly negotiation of MAC choices with each individual mobile station. For each of the following three applications, select the MAC protocol you would like to associate explaining your reasons: [**10 pts** = 3 pt + 3 pt + 4 pt]

   i. VoIP phone calls:

   ii. MPEG mobile TV streaming:

   iii. Instant Messenger chat: