New Mexico State University
Dept. of Computer Science
Computer Networks Qualifying Examination
Fall 2008

This examination is open book, open notes. Answer all questions.

1. (a) Consider query flooding in a P2P file sharing application such as Gnutella. Suppose that each peer is connected to at most N neighbors in an overlay network. Also suppose that the node-count field is initially set to K. Suppose Alice makes a query. Find an upper bound on the number of query messages that are sent into the overlay network. Explain why it is difficult to derive an expression for the exact number query messages flooded into the network. [6 points]

   (b) What is the advantage of using a distributed lookup protocol such as "Chord" over query-based search as implemented by Gnutella? [5 points]

   (c) Suppose Alice discovers through querying that a peer named Bob has a file that she wants to download. Also suppose that Bob is behind a NAT whereas Alice is not. Explain, with a hypothetical NAT table at a NAT router, why this poses a problem. [8 points]

   (d) What steps are to be taken if a participating host to the Chord network must be placed behind a NAT middlebox? [6 points]

2. Let A be the number of autonomous systems (AS) in the Internet, and let D (for diameter) be the maximum AS path length.

   (a) Suggest a topology model for which D is of the order of $\log A$ and another for which D is of the order of $\sqrt{A}$. [6 points]

   (b) Assuming each AS number is 2 bytes and each network number is 4 bytes, give an estimate for the amount of data a BGP speaker must receive to keep track of the AS path to every network. Express your answer in terms of A, D and the number of networks N. Compare the answer for the above two topologies. [6 points]

   (c) Consider the spectrum of the graph representing the AS-level topology of the Internet (each AS is a node in the graph representation of the network). Recall that the spectrum of a graph is the set of eigenvalues of its adjacency matrix. Mention a set of graph properties related to its spectrum that are useful in characterizing network performance. [5 points]

   (d) Suppose you wish to advocate the choice of spectrum as the definitive metric for constructing scaled-down Internet look-alike synthesized topologies for experiments on testbeds or simulation platforms (e.g., from BGP, traceroute, or WHOIS dumps). What research problem must you solve to strengthen your advocacy for the use of spectrum ?

(Hint: Consider why many researchers favor joint degree distribution instead, even though it lacks richness in comparison to spectrum.) [8 points]

3. (a) Consider the design space where network applications running on end-hosts need to exchange message reliably to complete a transaction (RPC serves as a good example). UDP is a good choice if both the request and response fit in a single datagram, and the requested operation for the transaction is idempotent. If the reply is large, sequencing and retransmission is to be reconstructed over UDP, while TCP implements these mechanisms. Using TCP is unattractive due to its high overhead (at least nine segment exchanges between the client and the server) for a short request and a short response. Show these nine segment exchanges in a diagram, showing two parallel time axes for the two end hosts extending vertically. How many extra segments will be exchanged in the worst case? [8 points]

   (b) An experimental version of TCP known as T/TCP (Transactional TCP) as proposed in RFC 1379 and 1644, puts the payload onto the three-way handshake for connection establishment. Construct the minimal sequence of segment exchanges using a similar diagram. You do not need to refer to the aforementioned RFCs to answer this question. [8 points]

   (c) Consider the interaction of TCP congestion control with temporary failure of a router and which a TCP connection is routed. First, some segments are lost when the link fails. On loss detection, TCP cuts down the congestion window size. Routing protocols eventually adapt to the failed link (that was on the shortest path) by routing through another path (likely to be longer than the failed path). Describe qualitatively the expected behavior of TCP connection when the old (and shorter) route comes back up. Consider the case where TCP window size is such that the communication pipe between the sender and receiver on the longer path is filled with segments. For simplicity, assume the same data rate on all links. [9 points]

4. (a) Explain the hidden terminal problem in the context of wireless MAC protocol design using CSMA/CD. [5 points]

   (b) The RTS/CTS scheme introduced in CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance) is known to solve the hidden terminal problem. However, the RTS frames are equally susceptible to hidden terminal problem as ordinary data frame transmissions. Explain how the scheme remains robust. [7 points]

   (c) Explain why RTS/CTS exchanges are not made mandatory in the IEEE 802.11 infrastructure mode. When is it meaningful to deliberately skip the RTS/CTS exchanges? [5 points]

   (d) The Ethernet frame accommodates two 48-bit MAC addresses, namely that of the source and destination interfaces (adapters). Why two addresses are not sufficient for IEEE 802.11 infrastructure mode frame format. Explain showing the steps of a frame's transmission through an access point, using the necessary address fields. [8 points]