CS 422 (Park) **Final** **May 7 (Sat.), 2011**

Remarks: Keep the answers compact, yet precise and to-the-point. Long-winded answers that do not address the key points are of limited value. Binary answers that give little indication of understanding are no good either. Time is not meant to be plentiful. Make sure not to get bogged down on a single problem.

PROBLEM 1 (36 pts)

(a) Why can the Slow Start component of TCP congestion control be considered a misnomer? Comparing Congestion Avoidance and Slow Start, is one more important than the other (or not) in real-world Internet environments?

(b) Suppose a UDP multimedia traffic flow has to traverse through 3 links with latencies D_1, D_2, D_3, bandwidths B_1, B_2, B_3, and packet loss rates P_1, P_2, P_3. What are the end-to-end latency, bandwidth, and packet loss rate experienced by the flow across the three links?

(c) Enumerate the network mechanisms/features that have prevented IPv4 address depletion in decreasing order of importance leading up to today's Internet. Explain your rationale behind the ordering. What are the key issues associated with deploying IPv6? Can you think of additional solutions to increase IPv4's effective address space that ISPs may be able to utilize?

(d) Although IEEE 802.11 WLANs employ CSMA to implement contention-based multi-user communication, below the CSMA MAC layer 802.11g/n use OFDM and 802.11b uses DSSS when transmitting frames. What is the role of OFDM and DSSS given that multi-user communication is handled by CSMA?

PROBLEM 2 (36 pts)

(a) Routing/forwarding of packets on the Internet is handled by three separate subsystems spanning LANs, intra-domain networks, and inter-domain networks. Explain how the three subsystems differ and how packet routing is carried out by each (algorithms, routing criteria, and protocols).

(b) We studied linear increase/exponential decrease, TCP's Congestion Avoidance method, in the context of pseudo-real-time multimedia streaming (Method B). In what way is Method B superior to Method A? In what way is Method B inferior to Method D? Where else in networks have we encountered protocols similar to Method B?

(c) IEEE 802.11g defines 8 data rates (6, 9, 12, 18, 24, 36, 48, 54 Mbps) that implement different levels of FEC to protect against channel noise. What is a popular data rate selection scheme used in today's WLAN NICs? How does the protocol work? What is its main weakness when deployed in real-world WiFi hot spots? Does the same issue arise in cellular networks that employ TDMA or CDMA in place of CSMA? Explain your reasoning.

(d) What is the 2-person consensus problem? Why is the problem relevant for TCP? Why does the problem not have a solution? How is the problem dealt with in practice during TCP connection tear-down? Given that TCP is forced to employ a "hack," what could potentially go wrong? In your assessment, how serious a problem is this?

PROBLEM 3 (14 pts)

How is pseudo-real-time multimedia streaming different from real-time multimedia communication such as teleconferencing or voice-over-IP? How might routers provide high quality of service to real-time multimedia flows? What IP header field may be used for this purpose? Although most modern routers possess such capabilities, they are disabled in operational networks. Why is providing QoS to real-time multimedia traffic not just a simple matter of turning on the existing router features? In what sense is pseudo-real-time multimedia streaming a producer/consumer problem encountered in operating systems? In what way are they different?

PROBLEM 4 (14 pts)

In BGP inter-domain routing, BGP update messages (AS-PATH) are the fundamental route advertisements through which autonomous systems convey reachability of IP prefixes to their neighbors following the CIDR convention. Using Purdue (AS 17), one of its providers INDIANAGIGAPOP (AS 29782), and one of AS 29782's providers Cogent

(AS 174) as examples, explain how reachability of one of Purdue's IP address blocks, say, 128.10.0.0/16, may be advertised to the global inter-domain Internet starting at AS 17. What feature of BGP might cause IP addresses belonging to the 128.10.0.0/16 block to be unreachable from some autonomous system, say, Univ. of Arizona (AS 1706)? Suppose a company based in Chicago, which is geographically not too far from Purdue, has its own AS number and is able to reach Purdue through one of its providers. Does geographic proximity imply that packets from the company in Chicago travel a short distance on their way to an IP address at Purdue? Explain your reasoning. Suppose Indiana Univ. (AS 87) submits a proposal to Purdue suggesting that we peer with each other. If you were asked to evaluate the merit of such a proposal, what would the criteria for determining your recommendation be? What would your recommendation be? If a peering relationship were established, is it in Purdue's interest to allow packets from the global Internet destined to IU to travel through Purdue to reach AS 87? What about Purdue's ISPs? Explain your reasoning. From a BGP route update perspective, what would have to happen for this to be technically possible? Is such forwarding compliant with BGP rules?

BONUS PROBLEM (10 pts)

Wireless mobiles devices with multiple air interfaces such as smartphones and tablets are becoming significant contributors of global Internet traffic. From a network programming perspective, what are unique challenges to building effective apps and services for these devices that may not be significant issues in wired network environments?