# Networking Qualifying Examination
## Computer Sciences
## Fall 2011

Please answer all six questions below.

## A. Transport protocols

TCP is the dominant transport protocol in the Internet today. Its operation is end-to-end in nature, i.e., all adaptation decisions are made solely by the endpoints.
However, an alternative design could have been to make intermediate points (such as, routers) more stateful. This question explores some of the tradeoffs in such designs.

a) Consider a long-running FTP transfer between two endhosts (A and B) separated by a multi-hop Internet path with many routers (R1, R2, ..., Rn). Compare the end-to-end throughput achievable for this FTP transfer when using the following two transport mechanisms:

> i) End-to-end TCP transport between A and B as it exists today in the Internet, and
> ii) A hop-by-hop variant, where we run a separate instance of TCP across each hop. More specifically, the flow is a composition of n+1 TCP flows,
> A - R1, R1 - R2, R2 - R3, ...., Rn - B.

Please focus on specific properties and path parameters that allow you to explain which of the two methods achieve a higher throughput in general.

b) Consider a short web content download, where end-to-end download latency is the critical metric of optimization. Among end-to-end TCP and the above described hop-by-hop variant, which method will lead to a lower end-to-end latency for such short downloads.

## B. Wireless medium access

a) Carrier sensing is not considered to be a useful method in wireless environments. Why?

b) Does the 802.11 standard solve the exposed terminal problem? If yes, explain how it solves the problem. If no, explain how exposed terminals are prevented from simultaneous communication.

c) In the Opportunistic Auto Rate adaptation protocol, if the achievable data rates of two backlogged clients, A and B, are 11 Mbps and 1 Mbps respectively, what is the actual data throughputs achieved by each client when they are the only active wireless transmitters in the system. Make any necessary simplifying assumptions. Why is this an improvement over the basic 802.11standard.

## C. Measuring End-to-end Path Characteristics

The series of nodes and links that comprise end-to-end paths between source and destination hosts in the Internet play a central role in the performance realized by applications. Because of this, understanding the characteristics of end-to-end paths through measurement is of both intrinsic and practical interest.

a) Name three characteristics of end-to-end paths that are objectives of measurement. What is the standard approach for measuring these end-to-end properties? What are the challenges in measuring these properties and how can they overcome?

b) End-to-end path properties are a central component in Service Level Agreements (SLA) between providers and their customers. How might a customer ensure that they are receiving the level of service they are paying for?

## D. IPv4 vs. IPv6

Internet architecture is commonly described as having a "narrow waist" meaning that there is a single unifying protocol - the Internet Protocol - that enables world-wide communication. However, since the early 1990's limitations in IPv4 led to the development of a new specification for the Internet Protocol - IPv6.

a) What are the key differences between the IPv4 and IPv6 and IPv6 specifications?

b) Why has it taken so long for IPv6 to roll out? Should we expect IPv6 to dominate IPv4 any time soon?

c) How do IPv4 and IPv6 co-exist in the Internet today? Should one expect any performance differences between packets that are transferred via IPv4 versus packets transferred via IPv6 in the Internet today?

## E. Multicast

a) The original IP multicast scheme from Cheriton and Deering was proposed for an intra-domain setting. Several attempts were made to extend IP multicast to the wide-area/inter-domain settings.

    i) Describe two reasons why the vision of inter-domain IP multicast was never realized.

    ii) Overlay-based multicast systems have been proposed to realized inter-domain multicast. Describe two downsides to realizing multicast using purely end host-

based mechanisms.

b) In reliable multicast, any datum transmitted by a source should be delivered to all group members reliably. Which of the two schemes, native IP multicast or end-host multicast, is more amenable to implementing reliability semantics? Why?

**F. Security**

a) Describe two aspects that make securing enterprises more challenging than securing an tier-1 ISP network.

b) Several papers have argued that fundamentally new network architectures are needed to address enterprise security needs.

i) Why do we need new network architectures? Why are existing IP-based network architectures insufficient?

ii) Many of these proposals require the enterprise network (i.e., routers and switches) to play an active role in security, e.g., in implementing filtering and access controls. An alternative is to realize all security functions purely at end-hosts. Name two advantages and two disadvantages of adopting a purely end-based approach to enterprise security.