Networking Qualifying Examination
Computer Sciences
Fall 2016

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. Improving Web Performance

Since it's invention over 25 years ago World Wide Web has grown and evolved in many ways.

1) Describe the basic operation of the Hyper Text Transfer Protocol (HTTP) and how it has evolved to facilitate better performance over the years.

2) Like many aspects of computing and communication, caching plays an important role in web performance. Give three examples of how caching is used in the web.

3) Most users interact with the web via browsers. Describe how browsers and their implementation can have an impact on performance.

D. Inter-domain Routing

Inter-domain routing, facilitated by Border Gateway Protocol (BGP), can be considered the glue that holds the Internet together. Service providers that wish to exchange packets with other networks typically use BGP. Despite its importance, BGP has many shortcomings that make it an on-going focus for research.

1) Describe the goals, protocols and basic operation of BGP.

2) BGP is referred to as an exterior gateway protocol. Contrast it with standard interior gateway protocols in terms of goals and operation. Also explain why BGP is sometimes used for routing within an autonomous system.

3) As IPv6 gains in prevalence, how might it affect or have an impact on inter-domain routing?

E. Quality-of-Service

1. Explain how a network can ensure that packets belonging to an end-to-end flow experience delay no more than d seconds. In answering this question assume there are many flows with such tight delay requirements. Your solution must indicate all the mechanisms needed at both the network edge and network core (hint: you need fair queueing in the core), as well as the signaling/communication protocols need to configure the mechanisms (hint: RSVP-like).

2. In this question, your goal is to answer whether the following performance guarantees can be provided to network flows, *without* any inherent support for per-flow fair queueing *anywhere* inside the network. Provide explanations for your answers.

a. flow loss rate < x% always
b. flow jitter < x ms always
c. flow throughput > x Mbps always

F. Internet measurements

1. Suppose you are to find routes that traverse a particular link A1-A2 in the Internet topology (A1 and A2 are ASes). Explain how you would go about doing this.

2. Suppose further that you are to measure attributes of such routes, such as delay, available capacity, and loss rate. Explain how you would go about doing this.