Networking Qualifying Examination
Fall 2017

A. TCP

1. Describe three ways in which a TCP connection can violate the "packet conservation" principle: A new packet isn't put into the network until an old packet leaves.

2. TCP's slow start mechanism addresses one of the above three ways for a connection violating packet conservation. Explain how.

3. TCP's AIMD congestion avoidance and control mechanism addresses another way a connection can violate packet conservation. Explain why AIMD -- as opposed to MIMD or AIAD or MIAD -- is the right choice for TCP to ensure that packet conservation is satisfied.

B. High speed routers

1. Switch crossbars can use two approaches to service multicast traffic: "no fanout-splitting" in which all of the copies of a packet must be sent at the same time. If the packet does not win access to all of the outputs that it desires, it is not copied to any of them, and must try again in the next slot. The second discipline is "fanout-splitting" in which packets may be delivered to output ports over any number of slots. What are the trade-offs of the two approaches? Which approach is employed by modern high speed routers and why?

2. i. As a function of the number of packets currently enqueued, describe how much state must be maintain and the amount of per-packet computation that must be performed by a switch implementing traditional fair queuing.

2.ii. Explain how deficit round robin improves on both accounts. What does DRR trade-off to achieve these improvements?

C. Application Layer Services

Internet applications and their needs for performance, security, reliability and availability continue to be one of the primary catalysts for new protocols and technologies. When user interest in particular applications grows, opportunities emerge for new services that can be used by applications directly to enhance functionality. We refer to these as "application layer services".

1) Give two examples of application layer services that enhance performance. Describe how applications function with and without the service and how performance is enhanced with the service.

2) Give two examples of application layer services that enhance security and/or privacy. Describe how applications function with and without the service and how security and/or privacy are enhanced with the service.

3) Give one example of application layer services that enhances resiliency and/or reliability. Describe how applications function with and without the service and how resiliency and/or reliability is enhanced with the service.

D. Simulation-based Evaluation of Network Protocols

Developing and deploying new Internet Protocols is a time consuming and challenging process. One way to evaluate the potential value, risks and impact of new protocols is through simulation-based evaluation.

1) Give three reasons why simulation is a preferred method of developing and evaluating new protocols vs. other methods such as analytic modeling or evaluation in a testbed.

2) Give three basic requirements for a network simulation system and describe how these requirements can be addressed (feel free to refer to an existing network simulator in your description).

3) How do wireless environments present unique challenges in network simulation and how can these challenges be addressed?

E. Wireless communication

1. Ethernet and other wired communication systems have traditionally relied on collision detection methods to identify simultaneous transmissions in the medium and to abort transmissions. Why is this mechanism not considered suitable in wireless environments?

2. In 802.11-based systems, the MAC layer typically implements methods such as backoff and re-transmissions when sending unicast data. However, when MAC layer broadcast is used, backoffs and re-transmissions are not useful. Explain why.

3. Some of the new results in wireless communication system design shows how one can allow for full-duplex communication, where two nodes, A and B, can transmit data simultaneously and would still be able to decode each other's signals. Traditionally the ability to do full-duplex communication was considered a major challenge. What high level mechanisms do you think would be necessary to implement full-duplex communication, where node A can decode node B's transmission and node B can decode node A's transmission, both of which are transmitted simultaneously.

F. Networking principles

1. Describe the key differences between traditional telephone networks and IP networks on which the Internet is based upon.

2. A layered protocol stack is usually considered a good modular design. Provide two examples where some "violation" of layering can lead to improved performance (make sure what performance metric you are considering).
3. Consider three end-hosts, A, B, and C and the direct Internet paths between them --- defined as the path that would be taken by data packers if forwarded using standard routing/forwarding in the Internet. Let us denote these paths ass AB, AC, and CB. Is it possible that the end-to-end latency on path AB can be consistently higher than the sum of end-to-end latencies of AC and CB, i.e., can it be the case that if we send packets directly from A to B, the end-to-end latency is consistently higher than the case when we send packets from A to C, and then from C to B. Explain with illustrations, why or why not.