

Fall 2012 Networking Area Qualifying Exam

1. Answer all questions
2. Provide sufficient detail in your answers, but avoid unnecessary verbosity
3. Clearly state all the assumptions you are making

A. DHTs

Chord is one of the most famous DHT protocols. The following questions are about Chord's performance and applications.

- a. Does Chord's lookup performance get impacted under scenarios where multiple nodes join or leave the system? When is it most impacted, and when is it least impacted? Explain your answer.
- b. Chord was originally designed to support peer-to-peer file-sharing systems. However, Chord, and for that matter all other DHTs did not see much adoption in the P2P file-sharing space. Explain why. List one setting other than P2P file sharing where the bar to adopting DHTs is much lower.

B. Fairness and TCP

One possible way of defining fairness between competing flows of network traffic is by giving each TCP connection that is above a certain threshold an equal share of the network capacity: per-TCP-flow max-min fairness at each router.

- a) Present three alternate definitions of fairness that can be used for allocating network capacity when congestion occurs. For each of the definitions proposed present an argument about why or under what conditions it is preferable to use per-TCP-flow max-min fairness at each router.
- b) If long-lived TCP flows compete at a router that uses a FIFO drop-tail queue is the resulting allocation max-min fair? If yes explain how fairness is achieved, if no explain the differences between the actual and the fair allocation and what causes them.
- c) Describe one fair queuing algorithm that achieves max-min fairness even when the traffic contains flows that do not implement TCP's congestion control algorithm.

C. Network Security and Measurement:

Bloom Filters are widely employed to summarize large data sets.

1. Describe how to derive the false positive rate of a Bloom filter as a function of the filter size (m), number of elements summarized (n) and the number of hash functions (k).
2. Bloom filters have interesting applications in networking as they support effective lookup. One such class of applications lies in network security. Describe how Bloom filters can be used to implement network traceback to identify sources of network DoS attacks.

D. TCP over Mobile and Wireless Systems

TCP as a protocol was designed to be independent of underlying link layer technologies. While the proposed protocol and its variants are known to be quite efficient in most general settings, certain optimizations are possible when the last hop on the end-to-end path is wireless based.

a) Split-TCP and Snoop-TCP are different approaches to improving TCP performance over a wireless path. What are the advantages and disadvantages of each approach?

b) The "end-to-end argument for system design" paper proposes that any mechanism be implemented at the most suitable layer where the mechanism is really necessary. Hence, TCP's choice of implementing a re-transmission mechanism at this transport layer seems quite suitable. However, IEEE 802.11 standard also incorporates a link layer re-transmission to recover some of these losses. Is this a contradiction to the end-to-end argument? Explain why or why not.

E. Network Architecture

The Internet's architecture can be defined as a layered design with a narrow waist. Historically, this architecture was not initially clear, but rather emerged over time, and is now recognized as fundamental enabling the Internet to scale to evolve into the massive, multi-function, high performance infrastructure that it is today.

a) While the layered design is useful for many things, it is not necessarily clear on others. Name and describe an associated design principle, *other than the end-to-end argument* that has played a key role in improving performance in the Internet.

b) The "narrow waist" of the Internet's architecture means that there is a single protocol at the network layer. Why has this "narrow waist" been important and what are two of the key challenges at this layer in the future?

c) The notion of "virtualized networks" have been discussed over the past several years. Describe how a network might be "virtualized" and what benefits such a capability might provide. Are there any examples of virtualized networks in use today?

F. Router Design and Implementation

Routers play a central role in enabling end-to-end connectivity in the Internet. All routers have similar functionality at a basic level, but details vary from vendor to vendor.

a) Name the two basic design components of routers and how these two components interact with each other in routers that are deployed in live networks. Also name at least two challenges that vendors are addressing in the development of each of these components over time.

b) One of the biggest challenges in the design and implementation of new routers is heat dissipation due to the increasing amounts of power that are required by the devices. Give three examples of how power demands might be reduced in future router designs.