Networking Area Qualifying Exam
Fall 2010

Please answer all six questions. Clearly state the assumptions you are making. Write legibly!

A. Defending Networks from Malicious Attacks

Despite concerted efforts by many, malicious activity in the Internet continues to grow. Standard methods for defending network infrastructure from malicious attacks include the use of devices that attempt to differentiate attack traffic from non-attack traffic.

1) Give two examples of network-based devices that are commonly used to defending networks and describe the basic mechanisms they use to identify attack traffic.

2) Considering the examples of network-based defensive devices you provided in part 1, describe how attackers are still able to be successful in their efforts to penetrate networks.

3) As we move from an Internet in which there is a relatively modest number of applications (e.g. web, email, etc.) to a very large number of apps (e.g. for handheld devices), how will this impact the task of defending network infrastructures from malicious attacks?

B. Muticast

The basic notion of multicast routing is simple and compelling, yet it's native deployment remains limited to enterprise networks due to concerns about manageability and scalability.

1) Describe how an end-system approach to multicast would work and how it might overcome some of the problems/concerns with native multicast.

2) As the size and popularity of content continues to grow, the notion of asynchronous and reliable multicast becomes a compelling option to standard TCP-based unicast. Describe how the Digital Fountain method can be used for asynchronous, reliable multicast.

C. TCP and Wireless

Traditionally, TCP is known to perform poorly over wireless links even though it is very effective as a congestion control protocol over the wired Internet.

a) Explain what new challenges come up when TCP operates on an end-to-end path consisting on a single-hop wireless link (usually the last hop).

b) Discuss possible approaches to mitigate each of these challenges.

c) What are the additional challenges when TCP operates over a multi-hop wireless path, e.g., the last path segment is a WiFi-based mesh network.
You can assume that each mesh node is equipped with a single wireless radio.

D. Mobility support

Mobile devices far outnumber static devices in the Internet today. The original Internet architecture did not have an explicit support for mobility. Describe some of the properties of existing Internet protocols

that impose some limitations in supporting mobility and how you can re-implement such protocols to fix them. Discuss them in the context of the following three protocol suites at different layers.

a) MACA protocol, originally proposed by Phil Karn.

b) Mobile IP.

c) TCP.

E. Queueing

Fair queuing has received a fair degree of attention in the networking community because of the provable guarantees it offers and because of its centrality to congestion control and network stability. However, fair queueing can impose significant resource requirements on routers in terms of memory (state that needs to be tracked) and per-packet computation. Over time, different proposals to fair queueing have attempted to address the challenges pertaining to overhead while retaining the overall theoretical benefits to an approximate extent.

(a) Describe the classical Fair Queueing (FQ) algorithm by Demers, Keshav and Shenker. Outline the memory and computation requirements of this algorithm.

(b) How does Shreedhar and Varghese's Deficit Round Robin (DRR) address the memory and computation challenges? Does it sacrifice performance guarantees relative to FQ in doing so? If so, describe in what sense DRR is inferior to FQ.

F. Network data structures

(a) The summary cache proposal relies on Bloom filters to summarize cache occupancy. However, Bloom filters need careful configuration to ensure correct and efficient operation. For a given size M of the cache (e.g., M could be the number of cached objects), describe how to configure the bloom filter in terms of selecting the size S of the filter and the number of hash functions to be used, H. In particular, comment on why there is an "optimal" H to be used for a given M and S.

(b) Traditional IP routing lookups relied on using Patricia tries. However, this data structure incurs too many memory lookups resulting in slowdown. Subsequent refinements have developed smarter data structures to speed up IP lookup. Briefly describe the Patricia Trie data structure and the lookup cost it incurs. Then outline the solution proposed by Valdvogel, Varghese et. al to improve the lookup cost. Note that just an outline of the key idea is sufficient. You don't have to describe the optimizations employed to deal with taking traffic conditions into account etc.