15-441: Computer Networks
Homework 2

Assigned: September 28, 2006
Due: Oct 5, 2006

1. The program *traceroute* allows you to find the path (i.e., sequence of routers) that a packet follows to a specific destination. The routers along the path are often identified by name, which means that you can learn the identity of ISPs that your packet traversed through. For this problem, use *traceroute* (in /usr/sbin) to record the path taken by a CMU host to

   - www.lcs.mit.edu
   - www.freebsd.org
   - www.cam.ac.uk

   (a) Can you identify the Autonomous System number for each router? Attach a printout of the traceroute output and mark which routers belong to which AS, if the AS can be identified. (Hint: you can use the command "whois -h whois.arin.net *ASN*" or "whois -h radb.ra.net *IPaddr*" or visit http://www.arin.net/whois/ for more information.)

   (b) Can you identify the ISPs used in the above queries. On the above printout also mark the ISPs that each router belongs to (Hint: Router names can be quite informative!)

   (c) Try to classify the ISPs as local, regional, or backbone

2. How could Harry modify traceroute to estimate the latency of a particular link in the network (i.e. **not** the entire path to that distance)

3. Route servers (e.g. those available at `http://www.traceroute.org/#Route%20Servers`) are BGP speaking routers with a publicly accessible interface. In other words, you can telnet to these routers and access their full BGP tables.

   `route-views.oregon-ix.net` is one such route server hosted at the University of Oregon. One use of this route server is that you can potentially get the route(s) from any AS X to any AS Y at an AS path level. You can also get the routes that *almost* any AS X would take to reach a given address prefix P.

   For this exercise, we have provided a subset of a particular snapshot of the routing table entries from the RouteViews server at `http://www.cs.cmu.edu/ srini/15-441/F06/HW2-RouteViews.txt`. Use this snapshot to answer the following questions.

   (a) CMU owns the address block `128.2.0.0/16`. Using this information, can you figure out the ISP CMU uses (the AS number of the ISP)? Using the `whois` service at `http://www.arin.net/whois/`, determine who this AS number actually corresponds to (the name of the ISP).

   (b) Print the best AS route from the route server to CMU.

   (c) What is the AS number of MIT? List all providers of `mit.edu` that you can infer from the table.

   You can get more information if you log into this route server by executing `telnet route-views.oregon-ix.net`. Run `sh ip bgp` at the prompt, and lo!, you get the entire BGP table, shown one screen after another (much like when you execute `more`). In general you can type `sh ip BGP ?` for help on the possible extensions to the `sh ip bgp` command. For example, you can use the help to figure out that `sh ip bgp 12.0.0.0` will give you all the routes from `oregon-ix` to `12.0.0.0/8`.

4. Suppose host A is sending to a multicast group; the recipients are leaf nodes of a tree rooted at A with depth N and with each non-leaf node having k children; there are thus k^N recipients.
   (a) How many individual link transmissions are involved if A sends a multicast message to all recipients?
   (b) How many individual link transmissions are involved if A sends unicast messages to each individual recipient?
   (c) Suppose A sends to all recipients, but some messages are lost and retransmissions are necessary. To what fraction of the recipients is unicast retransmissions equivalent to a multicast retransmission to all recipients in terms of individual link transmissions?