15-441:Networking

Homework 2 - Solutions

Homework 2 is due Friday March 3, 2006, 5pm. Solutions must be submitted electronically, similar to homework 1.

Solutions for homework 2 will be posted that same evening so you can prepare for the midterm. Thus there will be no late days, i.e. late handins will not be accepted!!!

Problem 1: CIDR

Here is short forwarding table:

Mask	Network Number	Outgoing Interface
255.0.0.0	128.0.0.0	1
255.240.0.0	128.208.0.0	3
default	-	15

Or, equivalently:

Number bits	Subnet Number	Outgoing Interface
8	10000000	1
12	100000001101	3
default	-	15

(a) 128.3.208.23 - Interface 1 (only the first mask results in a match)

(b) 123.34.206.9 - Interface 15 (neither the first nor second mask result in a match so we use the default)

(c) 128.209.98.9 - Interface 3 (both the first and second masks result in matches, but we need to go with the longest prefix match)

(d) 128.240.98.126 - Interface 1 (only the first mask results in a match)

Problem 2: Link state routing

Figure 1 shows a network consisting of routers and hosts. Distances between routers are labeled. Interfaces on the routers are also labeled in smaller font. Assume that all these routers are running the Dijkstra algorithm. *You will only show what is going on at router R1.*

For your answer, please use the format used in class. For each iteration, list the nodes in the "Done" set with their cost and next hop information, list the nodes in the "Horizon" set with their cost and next hop information, and identify the node that will be moved from the Horizon set to the Done set.

Figure 1: *Network of routers and hosts.*

The format of the tables is (destination, cost, next-hop), and we show both router id for the next hop and the interface that should be used to get there. The node that is moved from the Horizon set to the Done set is marked in boldface.

Step	Done	Horizon
1	(R1,0,-)	-
2	(R1,0,-)	(R2,10,2/R1) **(R3,2,3/R3)**
3	(R1,0,-) (R3,2,3/R3)	(R2,10,2/R2) **(R5,5,3/R3)**
4	(R1,0,-) (R3,2,3/R3) (R5,5,3/R3)	**(R2,9,3/R3)** (R4,10,3/R3)
5	(R1,0,-) (R3,2,3/R3) (R5,5,3/R3) (R2,9,3/R3)	**(R4,10,3/R3)**
6	(R1,0,-) (R3,2,3/R3) (R5,5,3/R3) (R2,9,3/R3) (R4,10,3/R3)	-

Problem 3: Why traceroute?

The program *traceroute* allows you to find out the path (i.e. sequence of routers) that a packet will follow to a specific destination. The routers along the path are often identified by name, which means that you can learn the identity of the various ISPs your packets travel through.

This problem is very open-ended. Do the best you can. Use the Web. The purpose of this problem is to explore and learn.

For this problem, use *traceroute* to record the path taken by packets from a CMU host to

- www.cs.stanford.edu

- www.cisco.com

- www.rug.ac.be

a) Can you identify the ISPs used in the above queries. (Hint: the router names either contain the ISP's name, or you can find a web site with a similar name, e.g. www.xyz.net, or you can use a search engine).

```
linux2-prs 6 > /usr/sbin/traceroute www.cs.stanford.edu
traceroute to cs.stanford.edu (171.64.64.64), 30 hops max, 38 byte packets
 1  GIGROUTER.NET.CS.CMU.EDU (128.2.223.254)  0.346 ms  0.274 ms  0.239 ms
 2  POD-A-CYH-VL930.GW.CMU.NET (128.2.35.193)  0.363 ms  0.417 ms  0.239 ms
 3  CORE0-VL914.GW.CMU.NET (128.2.0.155)  0.363 ms  0.303 ms  0.240 ms
 4  HYPER-VL501.GW.CMU.NET (128.2.33.225)  0.364 ms  0.302 ms  0.364 ms
 5  bar-cmu-ge-4-0-0-2.3rox.net (192.88.115.185)  0.365 ms  0.310 ms  0.365 ms
 6  beast-bar-pc1-1.3rox.net (192.88.115.77)  0.364 ms  0.326 ms  0.369 ms
 7  abilene-psc.abilene.ucaid.edu (192.88.115.124)  9.975 ms  12.306 ms  9.982 ms
 8  atlang-washng.abilene.ucaid.edu (198.32.8.65)  25.722 ms  39.887 ms  29.722 ms
 9  hstnng-atlang.abilene.ucaid.edu (198.32.8.33)  45.336 ms  45.406 ms  45.336 ms
10  losang-hstnng.abilene.ucaid.edu (198.32.8.21)  77.068 ms  77.015 ms  77.067 ms
11  hpr-lax-gsr1--abilene-LA-10ge.cenic.net (137.164.25.2)  77.444 ms  77.939 ms  77.961 ms
12  svl-hpr--lax-hpr-10ge.cenic.net (137.164.25.13)  84.759 ms  85.382 ms  84.761 ms
13  hpr-stan-ge--svl-hpr.cenic.net (137.164.27.162)  84.958 ms  85.185 ms  84.961 ms
14  bbr2-rtr.Stanford.EDU (171.64.1.133)  85.564 ms  85.774 ms  85.560 ms
15  Gates-rtr.Stanford.EDU (171.64.1.178)  85.760 ms  85.585 ms  85.160 ms
16  CS.Stanford.EDU (171.64.64.64)  85.558 ms  85.986 ms  85.560 ms
```

- Pittsburgh Gigapop (PSC) - regional

- Cenic.net - California regional provider

- Abilene - backbone (NSF funded research network)

```
x2-prs 7 > /usr/sbin/traceroute www.cisco.com
traceroute to www.cisco.com (198.133.219.25), 30 hops max, 38 byte packets
 1  GIGROUTER.NET.CS.CMU.EDU (128.2.223.254)  0.326 ms  0.274 ms  0.240 ms
 2  POD-A-WEH-VL931.GW.CMU.NET (128.2.35.201)  0.363 ms  0.445 ms  0.240 ms
 3  CORE0-VL915.GW.CMU.NET (128.2.0.161)  0.365 ms  0.325 ms  0.241 ms
 4  HYPER-VL501.GW.CMU.NET (128.2.33.225)  0.365 ms  0.463 ms  0.366 ms
 5  bar-cmu-ge-4-0-0-1.3rox.net (192.88.115.181)  0.368 ms  0.458 ms  0.365 ms
 6  grill-ge-0-0-0-0.3rox.net (192.88.115.6)  0.864 ms  1.090 ms  0.860 ms
 7  12.118.191.37 (12.118.191.37)  7.367 ms  7.252 ms  7.362 ms
 8  gbr1-p70.phlpa.ip.att.net (12.123.137.22)  74.446 ms  96.332 ms  74.696 ms
 9  tbr1-p012501.phlpa.ip.att.net (12.122.12.97)  72.820 ms  72.886 ms  73.485 ms
10  tbr1-cl8.n54ny.ip.att.net (12.122.2.17)  74.983 ms  73.790 ms  75.485 ms
11  tbr1-cl14.cgcil.ip.att.net (12.122.10.2)  73.482 ms  72.793 ms  72.983 ms
12  tbr1-cl1.sffca.ip.att.net (12.122.10.6)  72.984 ms  74.795 ms  73.484 ms
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13  gbr5-p100.sffca.ip.att.net (12.122.11.74)  69.983 ms  77.781 ms  80.983 ms
14  gar1-p360.sj2ca.ip.att.net (12.122.2.253)  78.484 ms  72.790 ms  72.983 ms
15  12.127.200.82 (12.127.200.82)  72.486 ms  72.865 ms  72.984 ms
16  sjck-dmzbb-gw1.cisco.com (128.107.239.9)  72.483 ms  72.324 ms  72.484 ms
17  sjck-dmzdc-gw1.cisco.com (128.107.224.65)  73.991 ms  72.333 ms  72.488 ms
18  * * *
19  * * *
20  * * *
21  * * *
22  * * *
23  * * *
24  * * *
25  * * *
26  * * *
27  * * *
28  * * *
29  * * *
30  * * *
```

- Pittsburgh Gigapop (PSC) - regional

- AT&T - global

```
linux2-prs 8 > /usr/sbin/traceroute www.homepagina.be
traceroute to www.homepagina.be (213.132.196.245), 30 hops max, 38 byte packets
 1  GIGROUTER.NET.CS.CMU.EDU (128.2.223.254)  0.307 ms  0.251 ms  0.238 ms
 2  POD-A-CYH-VL930.GW.CMU.NET (128.2.35.193)  5.235 ms  2.444 ms  0.614 ms
 3  CORE255-VL918.GW.CMU.NET (128.2.255.155)  0.364 ms  0.290 ms  0.239 ms
 4  HYPER-VL501.GW.CMU.NET (128.2.33.225)  0.487 ms  0.319 ms  0.365 ms
 5  bar-cmu-ge-4-0-0-1.3rox.net (192.88.115.181)  0.363 ms  0.453 ms  0.364 ms
 6  minime-ge-0-1-0-0.3rox.net (192.88.115.5)  0.865 ms  0.690 ms  0.739 ms
 7  so-2-1-1.ar3.JFK1.gblx.net (208.50.254.45)  22.852 ms  22.811 ms  22.725 ms
 8  so0-0-0-2488m.ar1.EWR2.gblx.net (67.17.75.66)  22.975 ms  23.094 ms  23.102 ms
 9  sparkle-1.ar1.EWR2.gblx.net (208.50.13.46)  22.973 ms  22.974 ms  23.101 ms
10  ge6-0-ams7-amsa.ams.seabone.net (195.22.213.6)  109.924 ms  110.498 ms  109.799 ms
11  * * *
12  ams-tc2-nlhosting.ge1-0-0.vlan-25.netholding.nl (81.23.248.6)  148.738 ms  103.337 ms  10
13  webguru07.webguru.nl (213.132.196.245)  103.426 ms  104.820 ms  103.179 ms
```

- Pittsburgh Gigapop (PSC) - regional

- Global Crossing - global

- Seabone/Sparkle Telecom - global/regional

- Netholding - regional

- Webguru - local

b) Try as best you can to classify the above ISPs as local, regional, or backbone.
See above.

c) What is the name of the local ISP for CMU?
Pittsburgh Gigapop

d) Observe that CMU uses different backbone ISPs depending on the destination. Experiment with different destinations (academic, commercial, national, international, etc.) and see if you can come up with any observations about which backbone CMU routes through for different types of destinations.
Abilene is used for traffic to other research institutations that are members of Abilene. AT&T is the used for traffic in the US, while Global Crossing is used for international traffic.

Problem 4: Distance-Vector

We are using a distance vector routing algorithm for the network shown above. Assume that all routers boot at the same time, at time unit 0. Assume that steps are synchronous. Step 1 consists of discovering your distance to all your neighbors. Each subsequent step consists of each router sending an update to all its neighbors and receiving a routing update from all its neighbors.

a) Show the contents of each router's routing table at the end of step 2 by filling in the tables below. The routing table for R1 has been filled out as an example. Each routing table entry consists of a destination address, next hop router and estimated cost for the path to that router.

b) How many steps does it take for the algorithm to converge? Please explain.
The algorithm will converge in 3 steps because the longest shortest path between any two nodes in the network is three hops.

c) If router R3 crashes at the end of time unit 17 and is rebooted at the end of time unit 18, at the end of what time unit, will it have a complete routing table, i.e. one that contains routing information on how to reach all other routers? Please explain.

R3 will have a complete routing table at time 19 since its neighbors have complete routing tables and it will only 1 iteration for R3 to receive these tables.