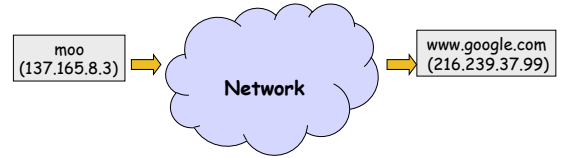


Network Routing

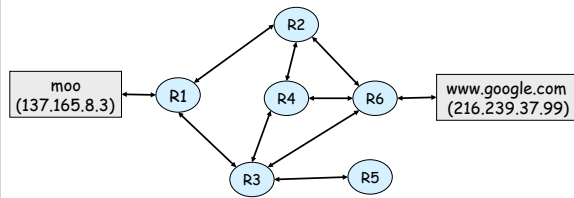
Stephen Freund
CSCI 134

The Network



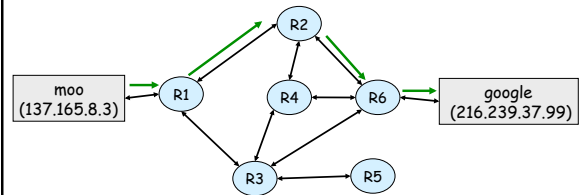
Message: 137.165.8.3 216.239.37.99 "Search for ..."

Gateways and Routers

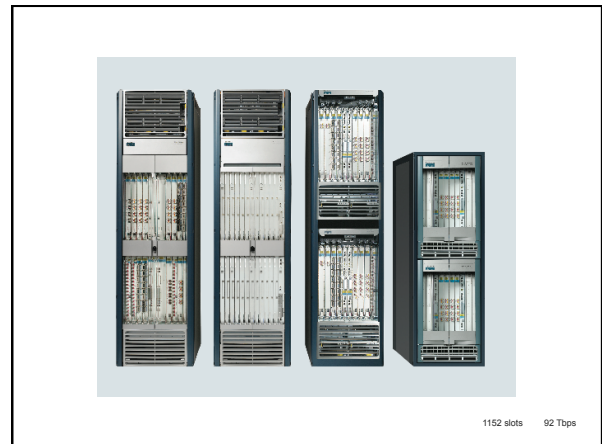


Message: 137.165.8.3 216.239.37.99 "Search for ..."

Routers

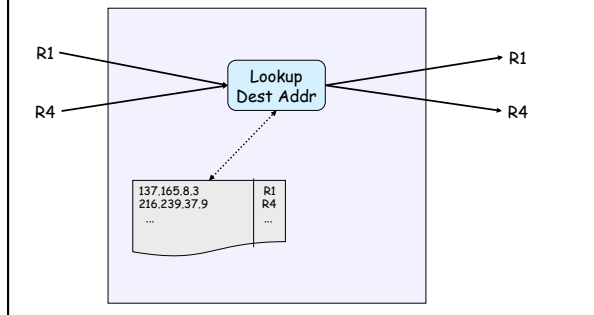


- Routing Algorithm
1. Receive message
 2. Look up Destination Address
 - a) Deliver message to Dest
 - b) Forward to next Router



1152 slots 92 Tbps

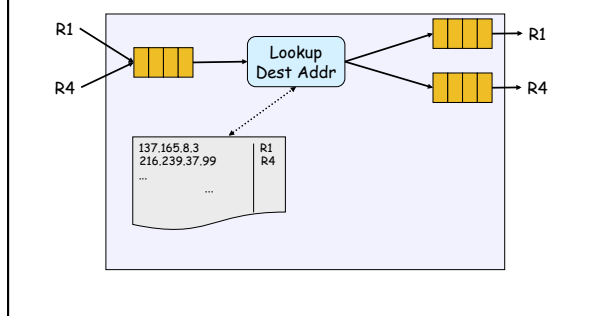
Router Internals



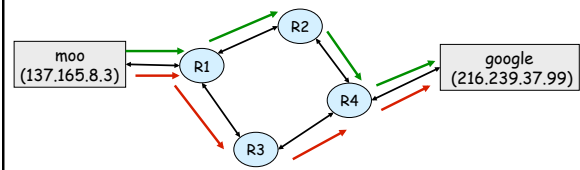
Buffering Messages

- There may be delays
 - router receives messages faster than it can process and send
 - some links are slower than others
 - common speeds: 10 Mbs, 100Mbs, 1Gbs.
 - wireless, satellite, infra-red, telephone line, ...
 - hardware problems
- Want to be able to handle short-term congestion problems

Router Internals



Choosing The Best Route



Choosing Routes

- Routers exchange information periodically
 - attempt to route on "best" path to destination
 - not easy to determine:
 - network congestion varies (evening vs. morning)
 - hardware added/removed or failures
- Dijkstra's algorithm (136)
- Look at www.traceroute.org

```

facadmins-MacBook-Pro:~/other/svn134-f12) traceroute www.globedom.com
traceroute to www.globedom.com (212.126.66.8), 64 hops max, 52 byte packets
 1 10.0.1.1 (10.0.1.1)  2.574 ms  1.431 ms  0.953 ms
 2  cpe-74-67-0-1.nycap.res.rr.com (74.67.0.1)  33.016 ms  22.785 ms  24.
 3  tge0-0-19.nadma0101h.northeast.rr.com (24.29.44.65)  171.841 ms  21.
 4  24.58.34.124 (24.58.34.124)  14.478 ms  14.942 ms  15.600 ms
 5  be26.albnyyf01r.northeast.rr.com (24.58.32.56)  20.117 ms  17.447 ms
 6  bu-ether36.nycmny837aw-bcr00.tbone.rr.com (107.14.19.100)  77.383 ms
 7  bu-ether26.nycmny837aw-bcr00.tbone.rr.com (107.14.19.26)  28.208 ms
 8  bu-ether46.nycmny837aw-bcr00.tbone.rr.com (107.14.19.102)  25.224 ms
 9  bu-ether11.nwrknjmd67w-bcr00.tbone.rr.com (66.109.6.26)  27.245 ms
10  0.ae3.pr0.nyc30.tbone.rr.com (107.14.17.169)  83.123 ms
    0.ae1.pr0.nyc30.tbone.rr.com (66.109.6.161)  24.900 ms
    0.ae3.pr0.nyc30.tbone.rr.com (107.14.17.169)  23.460 ms
11  ae10.edge3.newark1.level3.net (4.68.63.121)  26.324 ms * 26.397 ms
12  ae-6-6.car1.viennal.level3.net (4.69.135.33)  127.461 ms  127.292 ms
13  212.73.203.90 (212.73.203.90)  127.098 ms  128.039 ms  132.415 ms
14  www.globedom.com (212.126.66.8)  126.603 ms  127.861 ms  127.695 ms
    
```

```

facadmins-MacBook-Pro:~/other/svn134-f12] traceroute www.telstra.net
traceroute to www.telstra.net (203.50.5.178), 64 hops max, 52 byte packets
 1 10.0.1.1 (10.0.1.1) 3.186 ms 1.091 ms 1.024 ms
 2 cpe-74-67-0-1.nycap.res.rr.com (74.67.0.1) 33.970 ms 12.201 ms 18.7
 3 tge0-0-19.nadmma0101h.northeast.rr.com (24.29.44.65) 28.771 ms 32.63
 4 24.58.34.124 (24.58.34.124) 17.539 ms 14.303 ms 19.772 ms
 5 be26.albnyyf01r.northeast.rr.com (24.58.32.56) 20.736 ms 18.014 ms
 6 bu-ether26.nycmny837aw-bcr00.tbone.rr.com (107.14.19.26) 26.553 ms
 7 0.ae0.pr1.nyc20.tbone.rr.com (107.14.17.216) 26.092 ms
 66.109.1.59 (66.109.1.59) 23.534 ms
 0.ael.pr1.nyc20.tbone.rr.com (107.14.17.218) 22.682 ms
 8 ix-ae-16-0.tcore1.n75-new-york.as6453.net (66.110.96.81) 24.254 ms 2
 9 i-0-0-1-3-peer.ny8a02.pr.telstraglobal.net (134.159.48.37) 26.168 ms
10 i-0-4-0-9.ny8a-core01.bi.telstraglobal.net (202.84.252.49) 93.403 ms
i-0-3-0-8.eqnx-core01.bi.telstraglobal.net (202.40.149.198) 97.754 ms 94
12 i-13.sydp-core03.bx.telstraglobal.net (202.84.136.78) 307.316 ms 307
13 bundle-ether3.pad-gw10.sydney.telstra.net (203.50.13.85) 307.702 ms
14 bundle-ether3.chw-core10.sydney.telstra.net (203.50.6.56) 307.204 ms
15 bundle-ether8.exi-core10.melbourne.telstra.net (203.50.11.125) 306.96
16 gigabitethernet5-0.exi-service1.melbourne.telstra.net (203.50.80.7) 3

```

```

traceroute to cow.cs.williams.edu (137.165.8.107), 64 hops max, 5
 1 10.0.1.1 (10.0.1.1) 4.658 ms 1.558 ms 1.716 ms
 2 cpe-74-67-0-1.nycap.res.rr.com (74.67.0.1) 3136.117 ms 614.
 3 tge0-0-19.nadmma0101h.northeast.rr.com (24.29.44.65) 32.772
 4 24.58.34.124 (24.58.34.124) 15.265 ms 13.977 ms 16.466 ms
 5 be26.albnyyf01r.northeast.rr.com (24.58.32.56) 17.190 ms 2
 6 bu-ether46.nycmny837aw-bcr00.tbone.rr.com (107.14.19.102) 30
 bu-ether36.nycmny837aw-bcr00.tbone.rr.com (107.14.19.100) 26
 bu-ether46.nycmny837aw-bcr00.tbone.rr.com (107.14.19.102) 30
 7 0.ae0.pr1.nyc20.tbone.rr.com (107.14.17.216) 23.736 ms 22.4
 66.109.1.59 (66.109.1.59) 66.899 ms
 8 v702.core1.nyc4.he.net (209.51.175.37) 30.374 ms 37.568 ms
 9 tvc-albany-inc.10gigabitethernet5-4.core1.nyc4.he.net (216.66
10 66-109-52-41.tvc-ip.com (66.109.52.41) 42.870 ms 32.112 ms
11 66-109-52-166.tvc-ip.com (66.109.52.166) 31.680 ms 33.677 m
12 williams-college.tvc-ip.com (66.109.38.50) 43.302 ms 40.598
13 * * *
14 cow.cs.williams.edu (137.165.8.107) 35.288 ms 36.740 ms 35

```

(2016)

```

~] traceroute moo.cs.williams.edu
traceroute to moo (137.165.8.108), 64 hops max, 40 byte packets
 1 cpe-69-205-62-16.nycap.res.rr.com (69.205.62.16)
 2 * * *
 3 gig4-2.albnylee-rtr01.nyroc.rr.com (24.29.39.217)
 4 gig2-1-1.albnywav-rtr01.nyroc.rr.com (24.29.38.177)
 5 ge-1-0-0.albnywav-rtr03.nyroc.rr.com (24.24.7.21)
 6 ae-5-0.cr0.nyc30.tbone.rr.com (66.109.6.74)
 7 ae-1-0.pr0.nyc20.tbone.rr.com (66.109.6.163)
 8 * * te2-1.mpd01.jfk05.atlas.cogentco.com (154.54.13.185)
 9 vl3495.ccr04.jfk02.atlas.cogentco.com (154.54.6.45)
10 te2-2.mpd01.bos01.atlas.cogentco.com (154.54.6.1)
11 gi2-0-0.core01.bos01.atlas.cogentco.com (154.54.2.213)
12 po5-0.core01.alb02.atlas.cogentco.com (66.28.4.110)
13 vl3801.na21.b019505-1.alb02.atlas.cogentco.com (38.112.38.70)
14 38.104.52.10 (38.104.52.10)
15 ge-1-9.cr2.alb1.tvc-ip.com (66.109.38.161)
16 66-109-38-234.tvc-ip.com (66.109.38.234)
17 williams-college.tvc-ip.com (66.109.38.50)
18 moo.cs.williams.edu (137.165.8.108)

```

(2011)