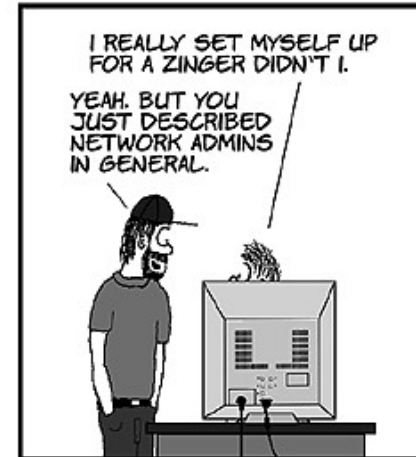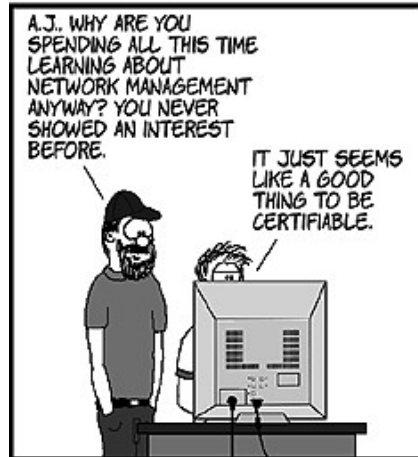# CSE 265:
System and Network Administration

- Network Architecture
  - Hardware
  - Routing
  - Getting connected
  - Centralization/decentralization
  - Network topology
  - Network debugging tools

Networking hardware

- Ethernet is the core of most networks
  - 10 Mbit 10Base2, 10BaseT
  - 100 Mbit 100BaseTX
  - 1 Gbit 1000BaseT
  - 10 Gbit 10GBase-T
- Many competing LAN technologies
  - ATM, Token Ring, FDDI
- Wireless
  - 802.11b/a/g/n

Connecting ethernets

– Hub/repeater (physical layer)

- Retimes and reconstitutes Ethernet frames to all ports
- Single collision domain

– Switch (link layer)

- Learns locations of MAC addresses, selectively forwards frames
- Receives, buffers, and retransmits packets
  - Separate collision domains
  - Required for GbE and 10GbE

– Router (IP/network layer)

- Connects separate ethernet networks
- Can connect different LAN/WAN technologies

Routing

- Given a packet, on which of multiple network interfaces should it be sent?

- UNIX kernel keeps routing table (netstat -rn)
  - Sample from dual-homed host

```
Kernel IP routing table
Destination       Gateway             Genmask            Iface
128.180.98.128    0.0.0.0             255.255.255.128 eth0
192.168.0.0       0.0.0.0             255.255.0.0        eth1
127.0.0.0         0.0.0.0             255.0.0.0          lo
0.0.0.0           128.180.98.248      0.0.0.0            eth0
```

Routing continued

- Routing is static for most systems

  - Established when network card configured

- Additional static routes can be added using the route command

- Dynamic routing can be managed using quagga and xorp (ULSAH if interested)

  - routed and gated are obsolete

Connecting to the Internet

- How can you connect your network to the Internet?

Connecting to the Internet

- How can you connect your network to the Internet?
  - Dialup
  - Wireless (cellular, satellite, point-to-point)
  - xDSL
  - Cable
  - ISDN
  - Frame relay
  - T1, T3, OC3, etc.

Remote access

- Connecting users to the organization
  - Check email, access data when traveling
  - Work from home
  - Remote facilities (e.g., stationed at customer site) but need access to organization network regularly
- Different needs, different support requirements
  - Establish an SLA
  - Worry about authentication, security, performance, costs
  - Consider centralization of authentication
  - Consider outsourcing changing technologies

Centralization/Decentralization

- Centralization – one focus of control

    – Regardless of the number of servers

- Decentralization – distribute control

    – Among many people/organizations

- Neither is always best

Applies to networks, services, personnel

Centralization

- Improve efficiency with economies of scale (purchasing and personnel)
- New technologies often bring opportunities for centralization
    - e.g., web-based instead of paper forms handling
- Often ideal for commodity services
- Simpler, consistent architecture
- Fewer systems to manage, house, service, etc.
- Consolidate expertise

Decentralization

- Improve speed and flexibility with local control

- On-hand support

- Customization

- Meet customers' needs

- Fault-tolerance
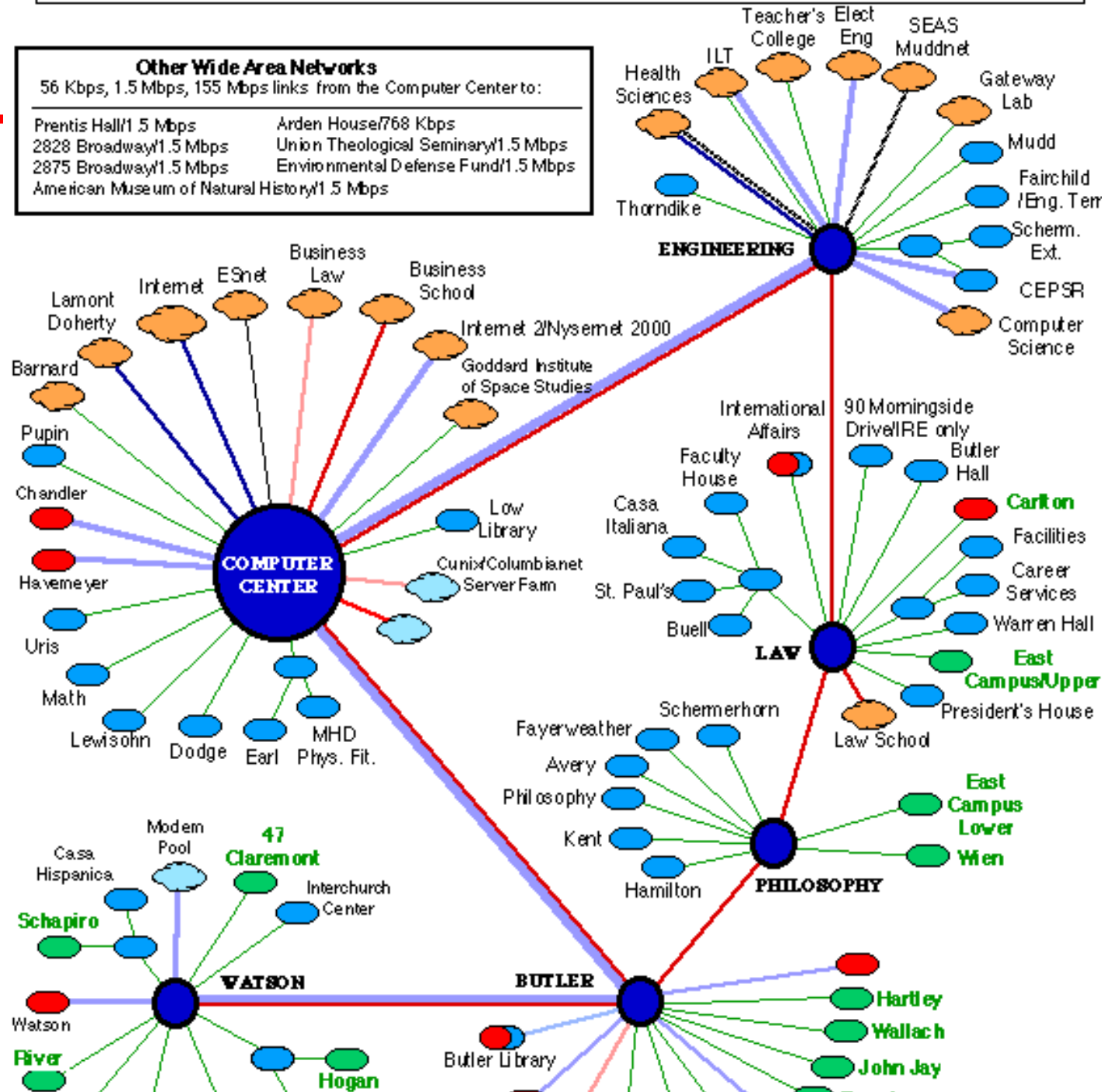
Network Topology

- Network architecture should
  - Be clean and simple
  - Provide for growth (new LAN segments, new remote offices)
  - Ensure reliability through redundancy
- Need to consider both physical and logical topologies
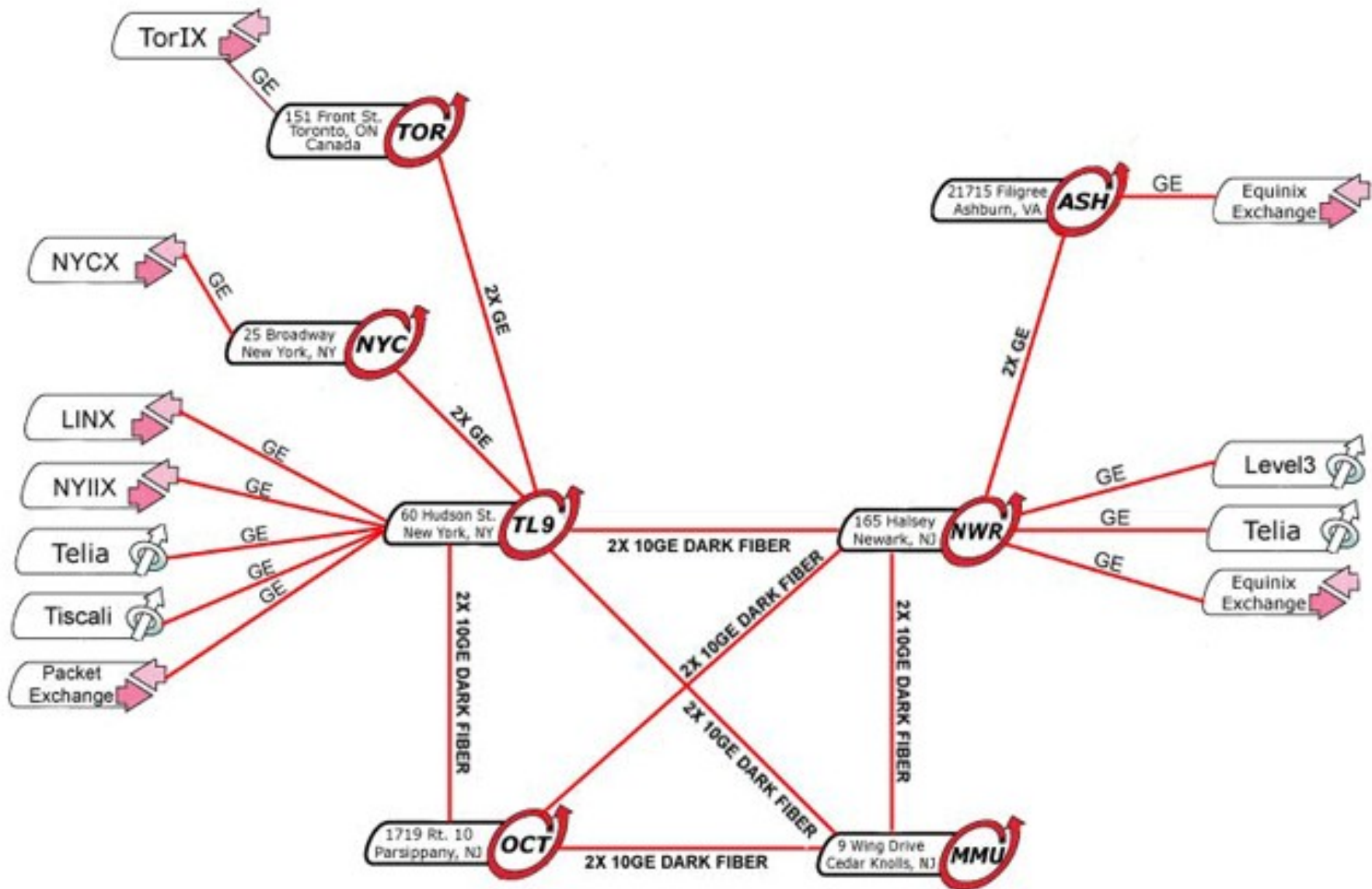- Typical forms: Star, Ring, Mesh

Columbia University Network
February 23, 1999

Legend:
- Backbone Hubs
- 10 Mbps Shared Ethernet
- 10 Mbps Switched Ethernet
- Residence Halls
- AcIS network
- Non-AcIS network
- 10 Mbps Ethernet
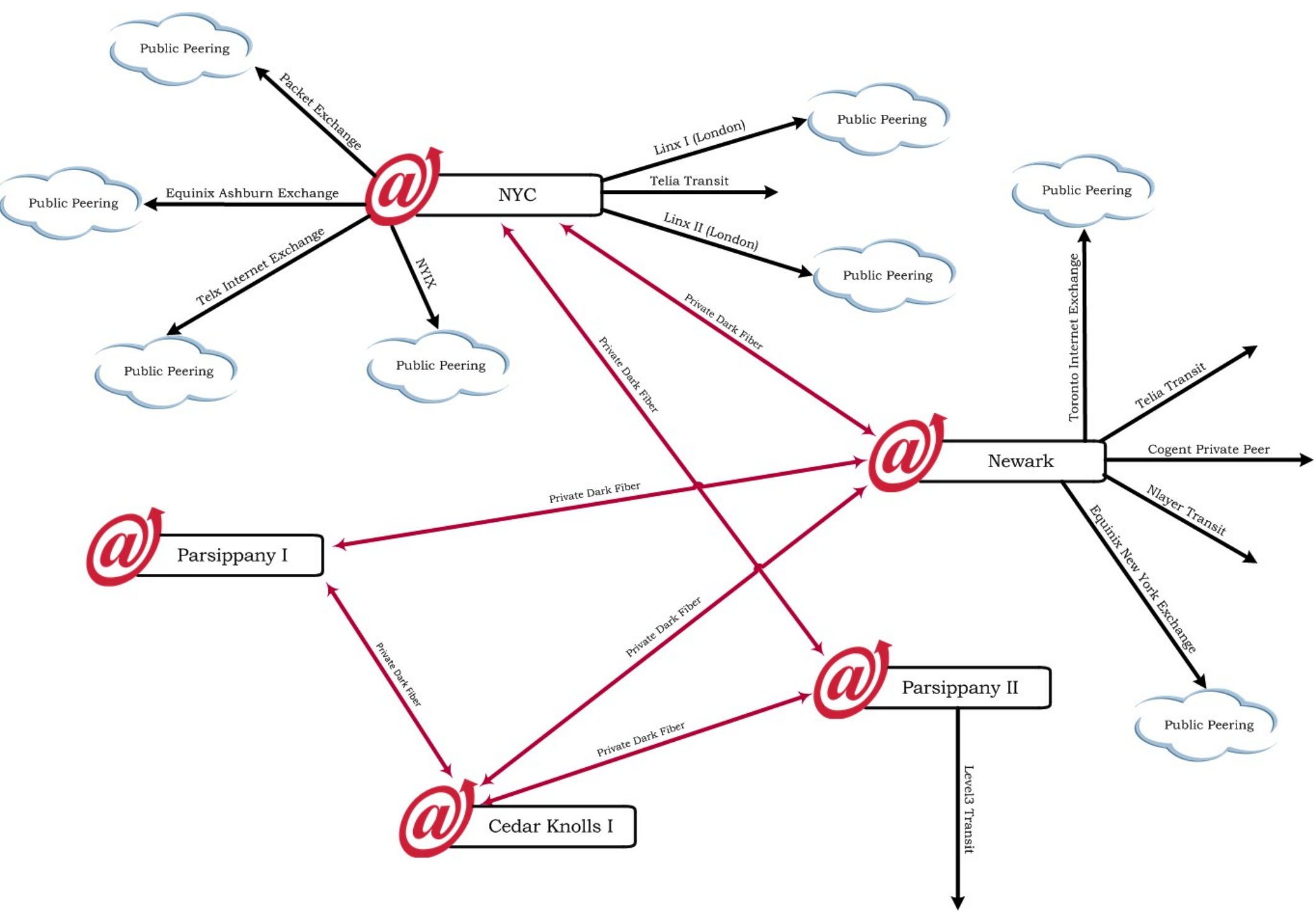- 100 Mbps Fast Ethernet
- 100 Mbps FDDI
- 155 Mbps ATM
- 45 Mbps
- non-fiber links

Other Wide Area Networks
56 Kbps, 1.5 Mbps, 155 Mbps links from the Computer Center to:

Prentis Hall/1.5 Mbps
2828 Broadway/1.5 Mbps
2875 Broadway/1.5 Mbps
American Museum of Natural History/1.5 Mbps
Arden House/768 Kbps
Union Theological Seminary/1.5 Mbps
Environmental Defense Fund/1.5 Mbps

Brian D. Davison

TorIX

GE

151 Front St.
Toronto, ON
Canada **TOR**

2X GE

ASH 21715 Filigree
Ashburn, VA

GE

Equinix
Exchange

NYCX

GE

25 Broadway
New York, NY **NYC**

2X GE

2X GE

LINX

GE

NYIIX

GE

Telia

GE

Tiscali

GE

Packet
Exchange

GE

60 Hudson St.
New York, NY **TL9**

2X 10GE DARK FIBER

165 Halsey
Newark, NJ **NWR**

GE Level3

GE Telia

GE Equinix
Exchange

2X 10GE DARK FIBER

2X 10GE DARK FIBER

2X 10GE DARK FIBER

2X 10GE DARK FIBER

1719 Rt. 10
Parsippany, NJ **OCT**

2X 10GE DARK FIBER

9 Wing Drive
Cedar Knolls, NJ **MMU**

last updated 2009

Level(3)

THE LEVEL 3 NETWORK

- 🔴 ON-NET MARKET WITH METRO NETWORK (DATA CENTER = 🟥)
- 🟡 ON-NET MARKET (DATA CENTER = 🟨)
- 🟧 OWNED NETWORK
- 🟨 LEASED NETWORK

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North America

Keystone Initiative for Network Based Education and Research

Outside Plant Construction Status for the Pennsylvania Research & Education Network

February 23, 2012
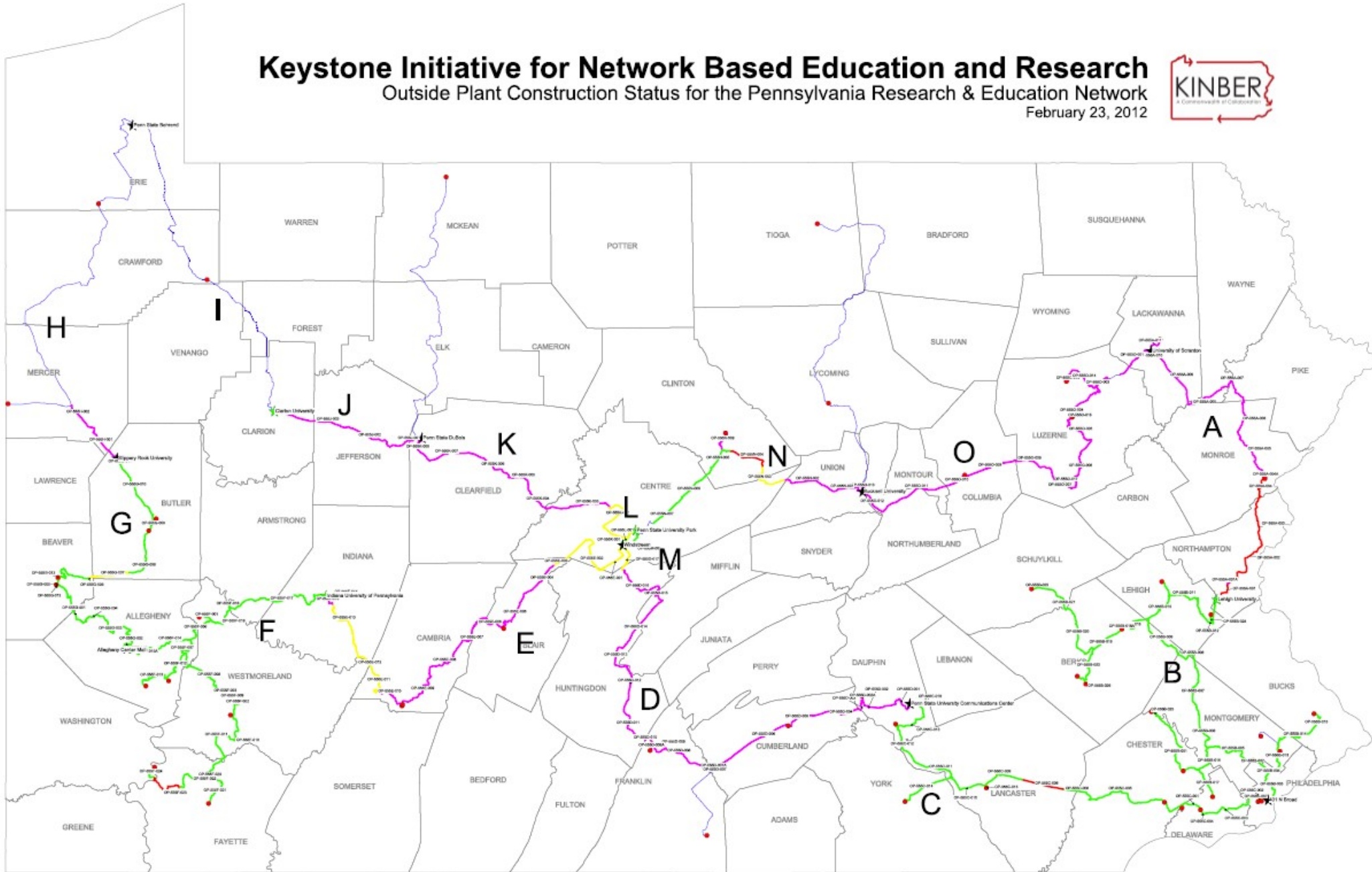
KINBER

SUNESYS

PennREN

Network debugging

– Questions to ask

- Do you have physical connectivity and a link light?
- Is your interface configured properly?
- Is DNS configured properly?
- Do your ARP tables show other hosts?
- Can you ping the localhost address (127.0.0.1)?
- Can you ping other local hosts by IP address?
- Can you ping other local hosts by hostname?
- Can you ping hosts on another network?
- Do high-level commands like telnet and ssh work?

Network tools

- ping

- traceroute

- netstat

- arp (saw earlier)

- tcpdump/wireshark

ping

- If ping works, networking between hosts is likely to be working

- It does not test availability of services

- Some firewalls filter ICMP messages

```
# ping www.lehigh.edu
PING www.lehigh.edu (128.180.2.14) from 128.180.98.216: 56(84) bytes
64 bytes from ws1.CC.Lehigh.EDU (128.180.2.14): icmp_seq=1 time=0.859 ms
64 bytes from ws1.CC.Lehigh.EDU (128.180.2.14): icmp_seq=2 time=0.685 ms
64 bytes from ws1.CC.Lehigh.EDU (128.180.2.14): icmp_seq=3 time=0.648 ms
64 bytes from ws1.CC.Lehigh.EDU (128.180.2.14): icmp_seq=4 time=0.751 ms
64 bytes from ws1.CC.Lehigh.EDU (128.180.2.14): icmp_seq=5 time=0.667 ms
64 bytes from ws1.CC.Lehigh.EDU (128.180.2.14): icmp_seq=6 time=1.00 ms
64 bytes from ws1.CC.Lehigh.EDU (128.180.2.14): icmp_seq=7 time=0.725 ms
64 bytes from ws1.CC.Lehigh.EDU (128.180.2.14): icmp_seq=8 time=0.655 ms
64 bytes from ws1.CC.Lehigh.EDU (128.180.2.14): icmp_seq=9 time=0.663 ms
64 bytes from ws1.CC.Lehigh.EDU (128.180.2.14): icmp_seq=10 time=0.724 ms

--- www.lehigh.edu ping statistics ---
10 packets transmitted, 10 received, 0% loss, time 9091ms
rtt min/avg/max/mdev = 0.648/0.738/1.006/0.109 ms
```

traceroute

- Finds the sequence of gateways traveled
- Works by increasing the TTL of the packet sent
- traceroute -n skips DNS

```
ariel% traceroute www.princeton.edu
traceroute to hulk.princeton.edu (128.112.128.15), 30 hops max, 40 byte
packets
 1 128.180.123.254 (128.180.123.254) 3.406ms  0.940ms 0.676ms
 2 ewfmB-GBE-A.CC.Lehigh.EDU (128.180.18.4) 0.407ms 0.465ms 0.640ms
 3 ewfmd-ewfmb.CC.Lehigh.EDU (128.180.128.82) 0.952ms 0.649ms 0.830ms
 4 ewfmc-ewfmd.CC.Lehigh.EDU (128.180.128.89) 1.005ms 1.687ms 1.464ms
 5 local.lehigh1.magpi.net (198.32.42.145) 5.148ms 4.810ms 4.721ms
 6 phl-02-08.backbone.magpi.net (198.32.42.197) 4.277ms 4.895ms 4.362ms
 7 remote.princeton.magpi.net (198.32.42.66) 33.474ms 20.958ms 20.399ms
 8 gigagate1.Princeton.EDU (128.112.12.21) 25.451ms 9.580ms 20.908ms
 9 hulk.Princeton.EDU (128.112.128.15) 11.067ms * 34.043ms
```

netstat

– Tons o' network statistics

```
# netstat | more
Active Internet connections (w/o servers)
Proto Recv-Q Send-Q Local Address       Foreign Address       State
tcp       0      0 someserver:www      td9091978.adsl.ter:1819 ESTABLISHED
tcp       0      0 someserver:www      td9091978.adsl.ter:1817 TIME_WAIT
tcp       0      0 someserver:www      unknown.servercen:53522 TIME_WAIT
tcp       0      0 someserver:www      lj1157.inktomisea:49477 TIME_WAIT
tcp       0      1 someserver:1248     218.15.192.166:smtp     SYN_SENT
tcp       0      0 someserver:www      cable200-75-67-206:3307 FIN_WAIT2
tcp       0      0 someserver:1224     mx02.osn.de:smtp        ESTABLISHED
tcp       0      0 localhos:x11-ssh-offset localhost:57893     ESTABLISHED
tcp       0   4209 localhost:6023      localhost:34263         FIN_WAIT1
```

– Can also show

• interface configurations, routing tables, counter values

Packet sniffers

- Show you what is really on the network
- Not as useful in a switched environment
- Examples: tcpdump, wireshark

```
# tcpdump
tcpdump: listening on eth0
19:05:08 220.168.28.55.http > wume1.cse.lehigh.edu.64207: P
1001579411:1001579684(273) ack 3591949882 win 65300 <nop,nop,timestamp
64538628 1686086162> (DF)
19:05:08 wume1.cse.lehigh.edu.36560 > G.ROOT-SERVERS.NET.domain:  7131
[1au] PTR? 55.28.168.220.in-addr.arpa. (55) (DF)
19:05:08 G.ROOT-SERVERS.NET.domain > wume1.cse.lehigh.edu.36560:  7131-
% 0/4/2 (164) (DF)
19:05:08 wume1.cse.lehigh.edu.36560 > l.gtld-servers.net.domain:  24184
A? NS1.APNIC.NET. (31) (DF)
19:05:08 wume1.cse.lehigh.edu.36560 > ns.ripe.net.domain:  12092 [1au]
PTR? 55.28.168.220.in-addr.arpa. (55) (DF)
```

CSE 265: System and Network Administration