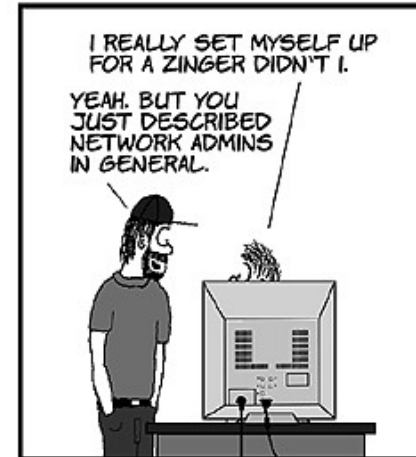
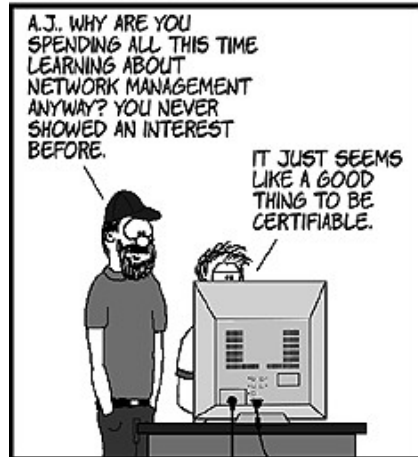


CSE 265: System and Network Administration

USER FRIENDLY by Illiad



- 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/ac



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

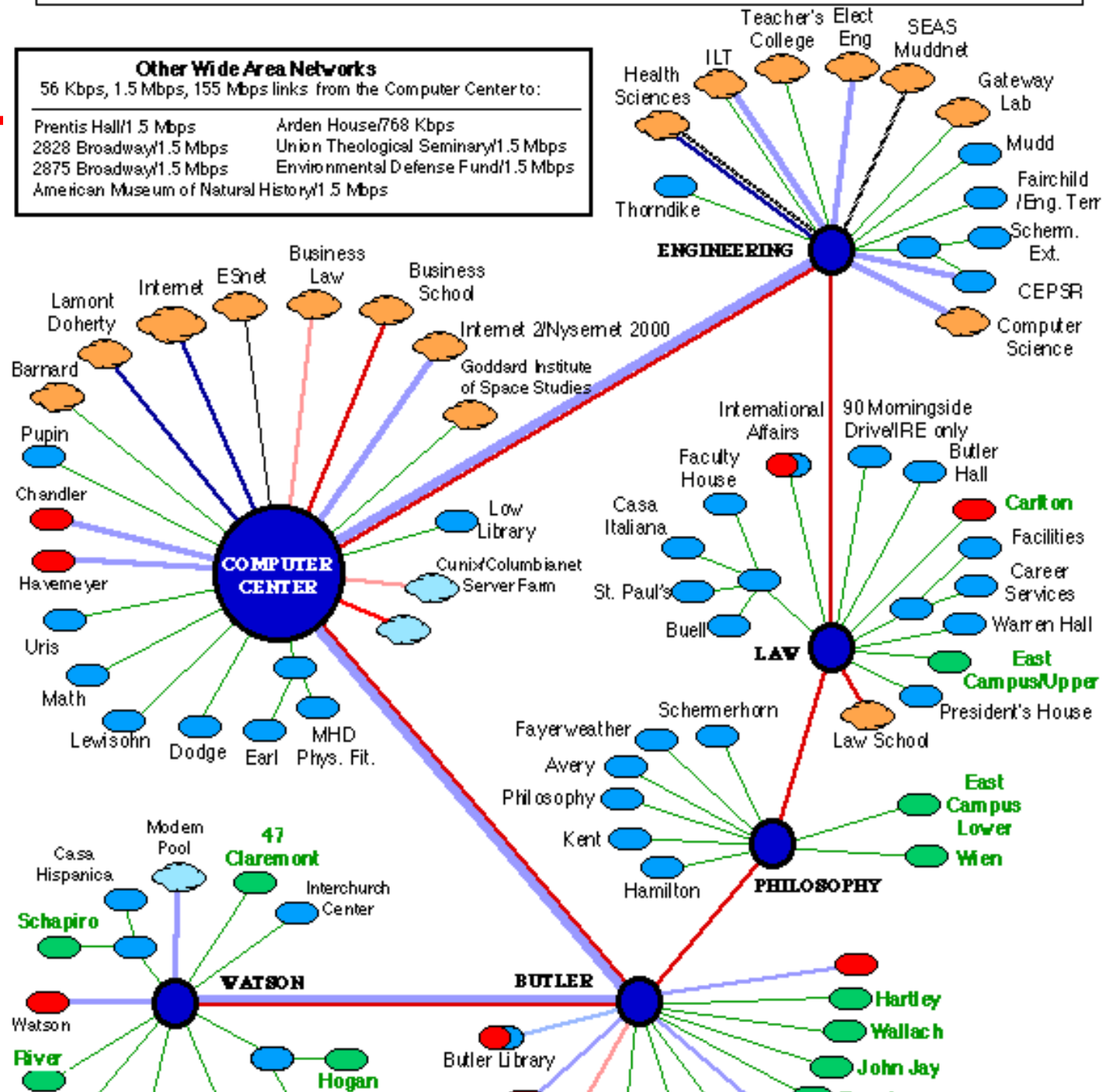
- Network architecture should
 - Be clean and simple
 - Provide for growth (new LAN segments, new remote offices)
 - Ensure reliability through redundancy
- Need to consider both physical and logical topologies
- Typical forms: Star, Ring, Mesh

Columbia University Network February 23, 1999



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

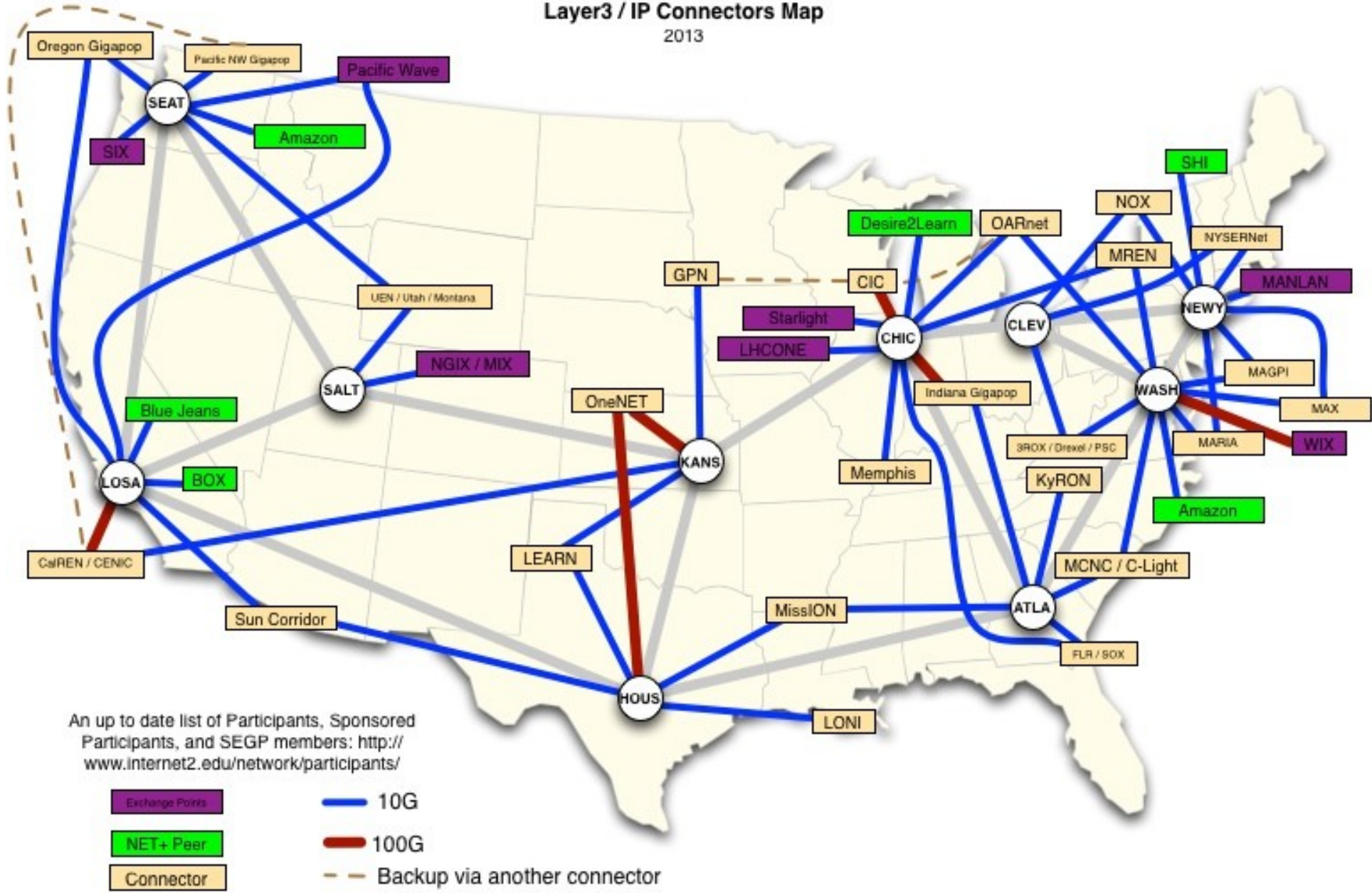
Prentiss Hall/1.5 Mbps	Arden House/768 Kbps
2828 Broadway/1.5 Mbps	Union Theological Seminary/1.5 Mbps
2875 Broadway/1.5 Mbps	Environmental Defense Fund/1.5 Mbps
American Museum of Natural History/1.5 Mbps	

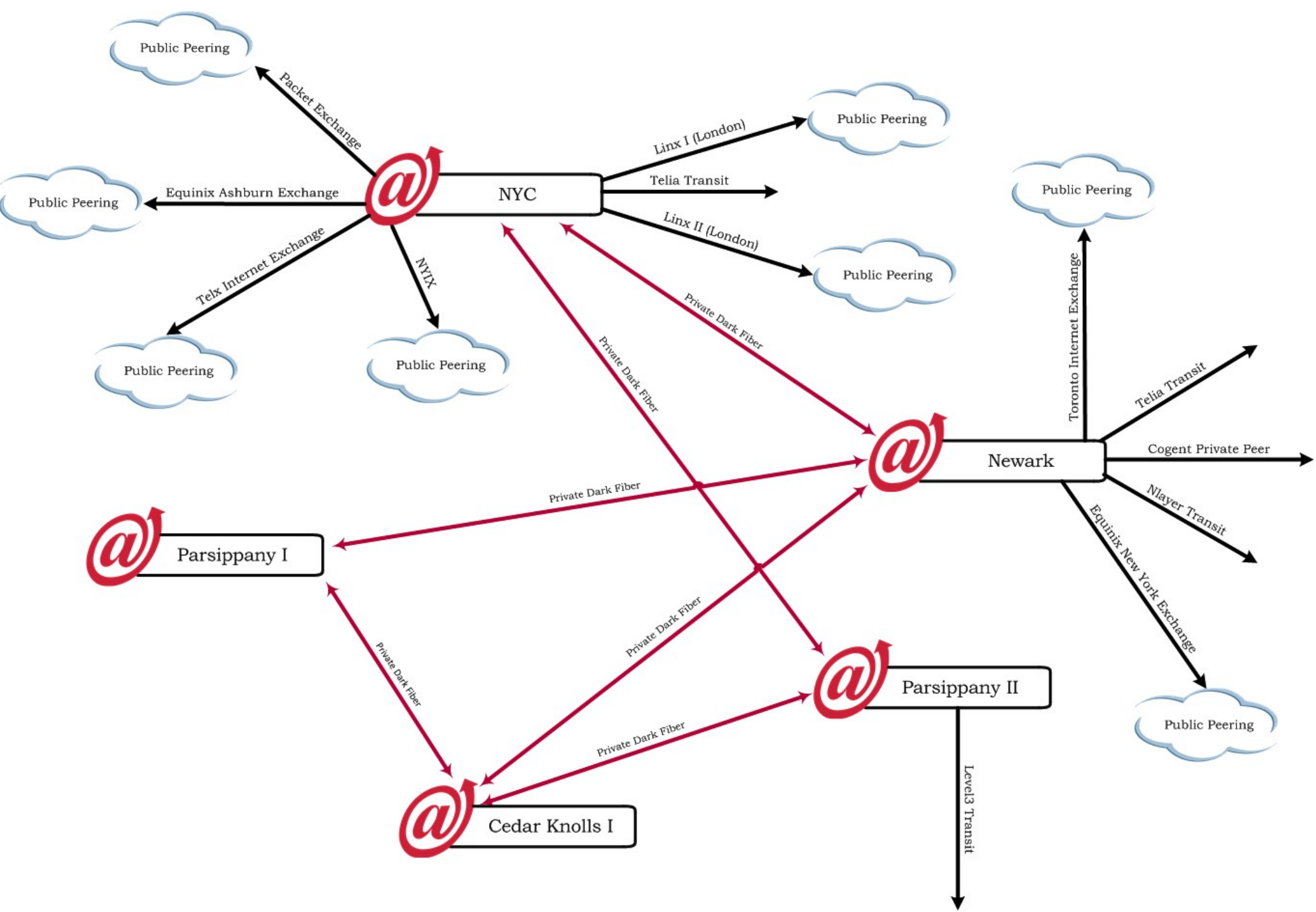


Internet2 Network

Layer3 / IP Connectors Map

2013







Level 3®



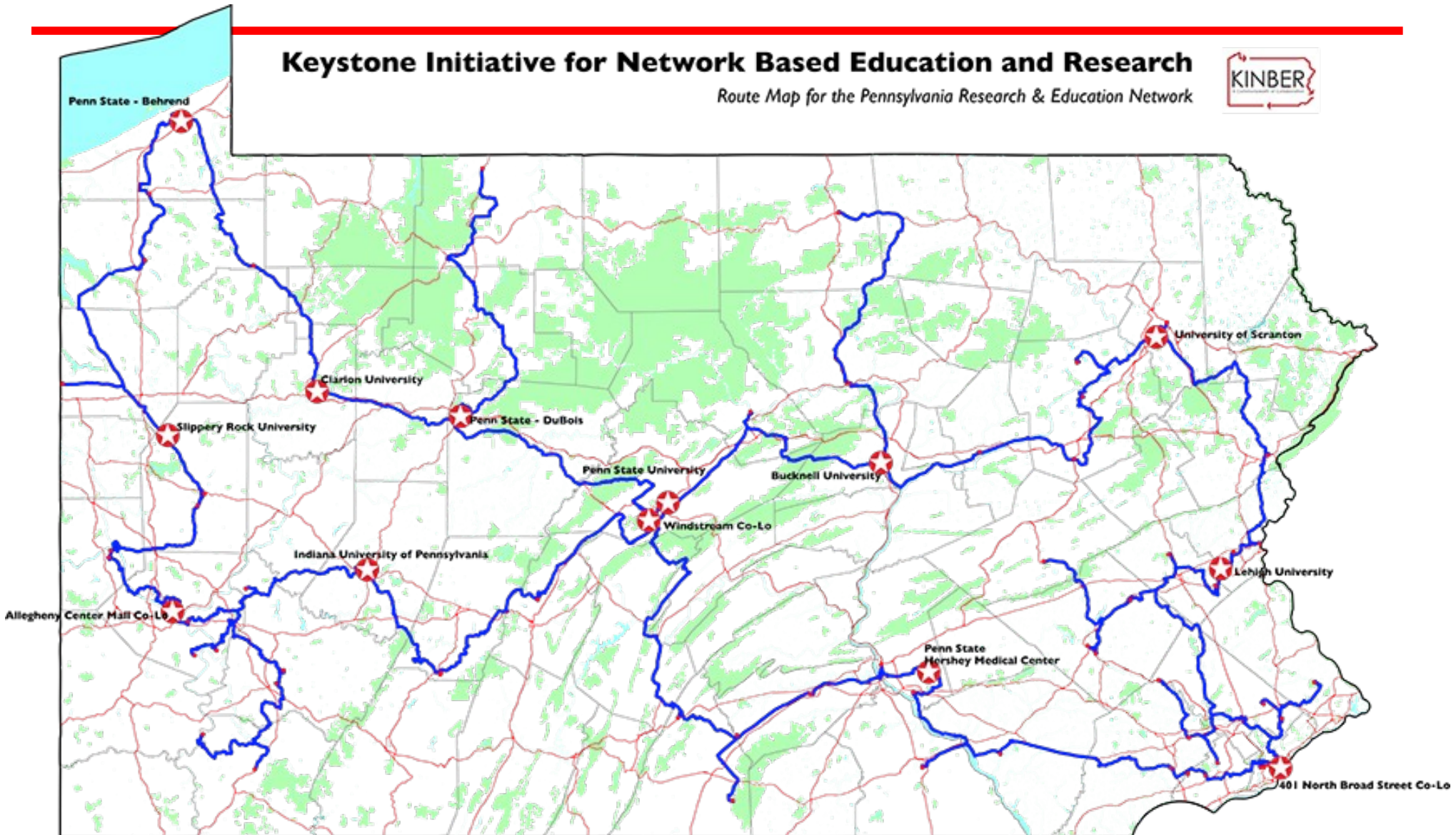
THE LEVEL 3 NETWORK

- ON-NET MARKET WITH METRO NETWORK (DATA CENTER = ■)
- ON-NET MARKET (DATA CENTER = ■)
- OWNED NETWORK
- LEASED NETWORK

PennREN / KINBER

Keystone Initiative for Network Based Education and Research

Route Map for the Pennsylvania Research & Education Network



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)
```