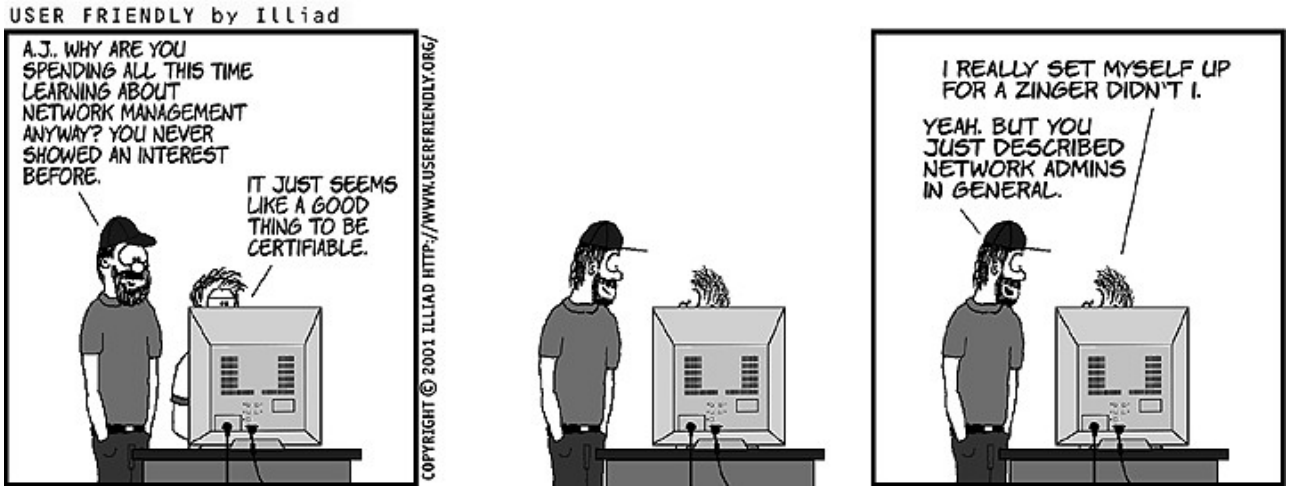
CSE 265: System and Network Administration



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

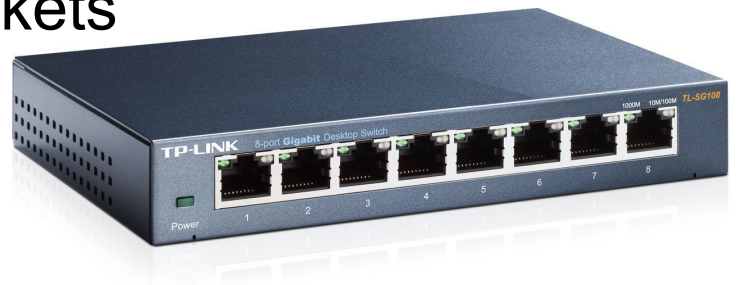
Networking hardware

- 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/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

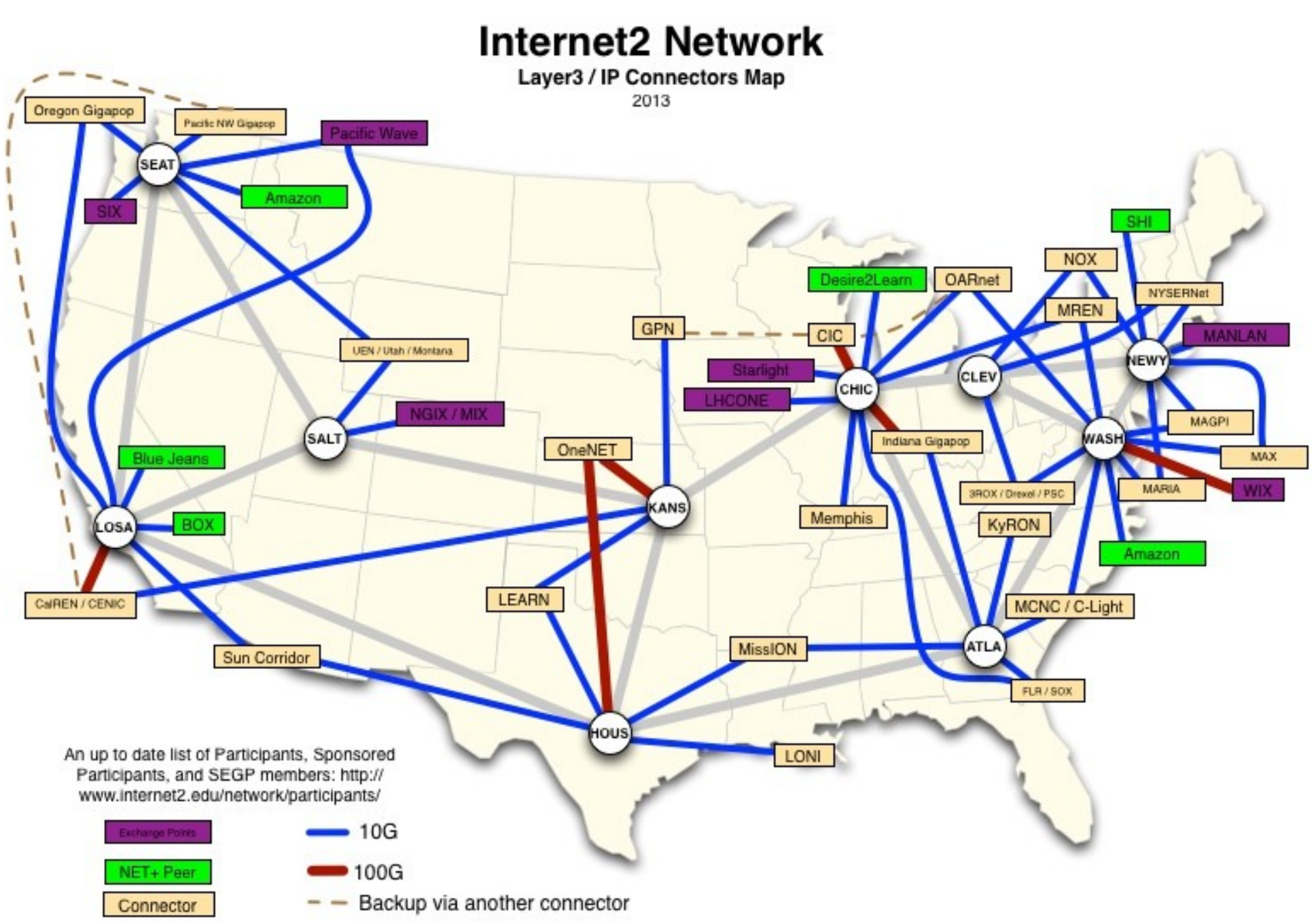
- Routing is static for most systems
  - Established when network card configured
- Additional static routes can be added using the route command
- Dynamic routing can be managed using quagga and xorp (ULSAH if interested)
  - routed and gated are obsolete

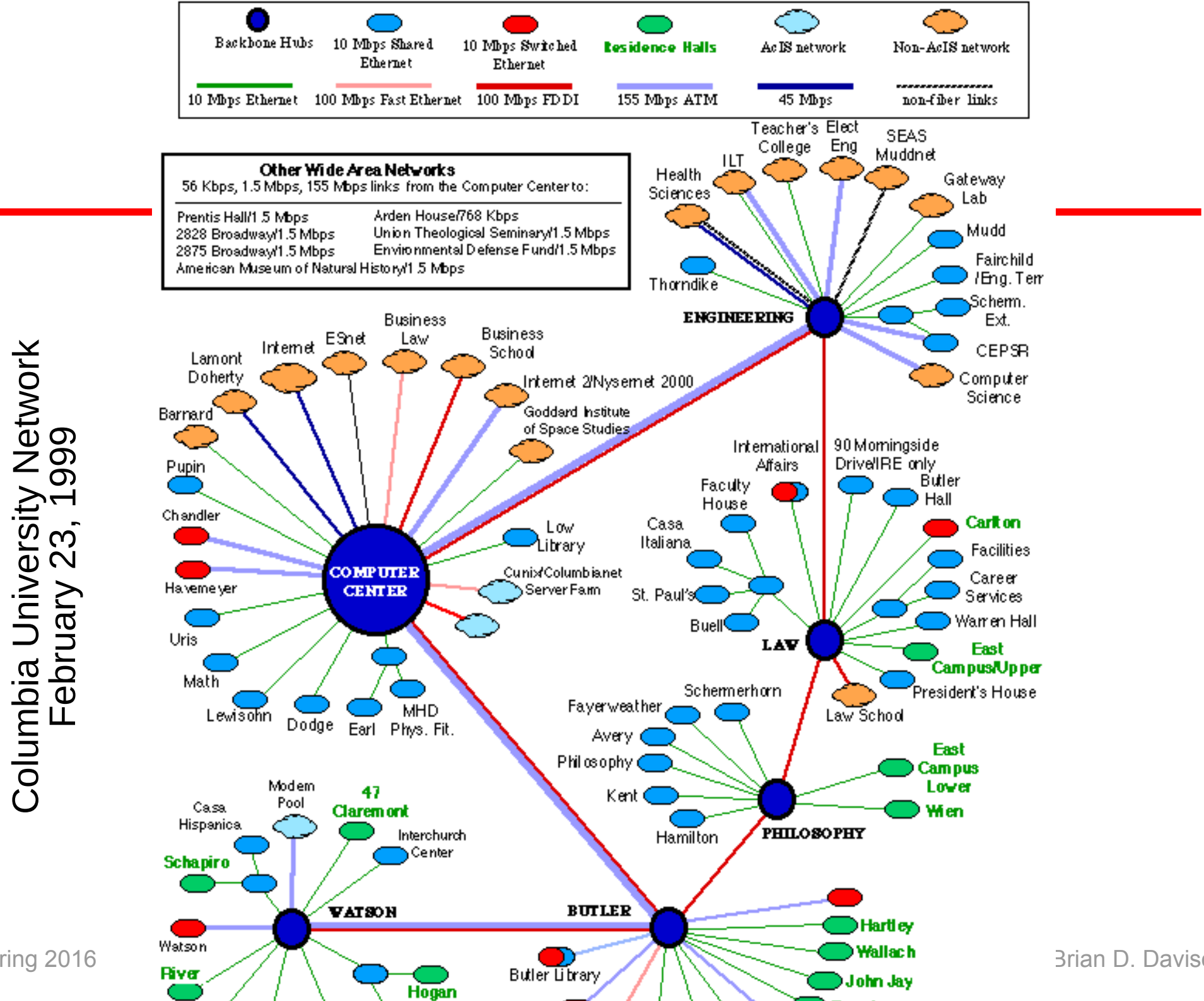
Connecting to the Internet

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

Network Topology

- Network architecture should
  - Be clean and simple
  - Provide for growth (new LAN segments, new remote offices)
  - Ensure reliability through redundancy
- Needs to consider both physical and logical topologies
- Typical logical forms: Star, Ring, Mesh
- Next are examples network topologies
  - Most are networks to which Lehigh is connected


Internet2 Network
Layer3 / IP Connectors Map
2013
Oregon Gigapop
Pacific NW Gigapop
Pacific Wave
SEAT
SIX
Amazon
UEN / Utah / Montana
NGIX / MIX
SALT
Blue Jeans
LOSA
BOX
CalREN / CENIC
Sun Corridor
GPN
OneNET
KANS
LEARN
HOUS
LONI
MissION
Desire2Learn
OARnet
CIC
Starlight
LHCONE
CHIC
Indiana Gigapop
Memphis
SHI
NOX
NYSERNet
MREN
MANLAN
CLEV
NEWY
MAGPI
WASH
MAX
MARIA
WIX
3ROX / Drexel / PSC
KyRON
Amazon
MCNC / C-Light
ATLA
FLR / SOX
An up to date list of Participants, Sponsored Participants, and SEGP members: http://www.internet2.edu/network/participants/
Exchange Points
NET+ Peer
Connector
10G
100G
Backup via another connector


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
Columbia University Network
February 23, 1999
COMPUTER CENTER
ENGINEERING
LAW
PHILOSOPHY
BUTLER
WATSON
Health Sciences
ILT
Teacher's College
Elect Eng
SEAS Muddnet
Gateway Lab
Mudd
Fairchild /Eng. Terr
Scherm. Ext.
CEPSR
Computer Science
Thorndike
Lamont Doherty
Internet
ESnet
Business Law
Business School
Internet 2/Nysernet 2000
Goddard Institute of Space Studies
Barnard
Pupin
Chandler
Havemeyer
Uris
Math
Lewisohn
Dodge
Earl
MHD Phys. Fit.
Low Library
Cunix/Columbianet Server Farm
International Affairs
90 Morningside Drive/IRE only
Butler Hall
Faculty House
Casa Italiana
St. Paul's
Buell
Carlton
Facilities
Career Services
Warren Hall
East Campus/Upper
President's House
Law School
Schermerhorn
Fayerweather
Avery
Philosophy
Kent
Hamilton
East Campus Lower
Wien
Modem Pool
47 Claremont
Casa Hispanica
Interchurch Center
Schapiro
Watson
River
Hogan
Butler Library
Hartley
Wallach
John Jay


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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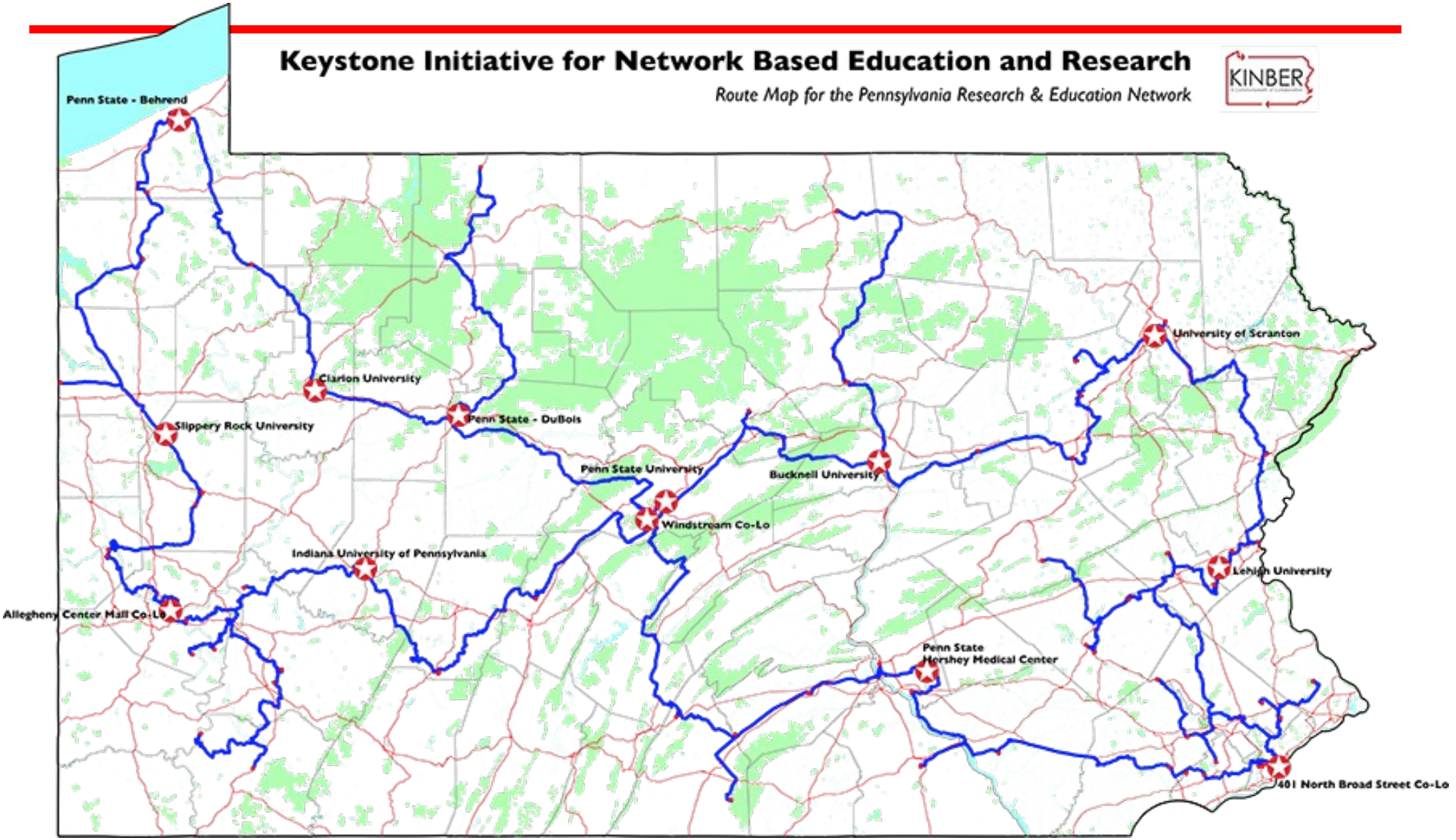
North America
PC-1
AAG
SC
PAC
SAC
MAC
HIBERNIA NORTH
AC-1
APOLLO NORTH
AC-1
AC-2
FLAG NORTH (FA-1)
FLAG SOUTH (FA-2)
APOLLO SOUTH
Albany
Worcester
Springfield
Boston
Framingham
Providence
Erie
Hartford
Stamford
Couderspport
Poughkeepsie
New London
Wilkes-Barre
Norwalk
New Haven
Punxsutawney
Williamsport
White Plains
Bridgeport
State College
Scranton
Brookhaven
Allentown
Indiana
Lebanon
Bellport
Altoona
Reading
Nassau
Pittsburgh
Carlisle
New York
Harrisburg
Newark
York
Edison
Lancaster
Princeton
Frederick
Trenton
Winchester
Baltimore
Philadelphia
Ashburn
Washington, D.C.
Harrisonburg
Fredericksburg
Harbour Pointe
Seattle
Bellvue
Spokane
Helena
Billings
Vancouver
Portland
Hillsboro
Salem
Eugene
Boise
Bandon
Casper
Medford
Redding
Ogden
Cheyenne
Salt Lake City
Fort Collins-Loveland
Greely
Boulder
Denver
Chico
Reno
Manchester
Roseville
Sacramento
Arden-Arcade
Grand Junction
Colorado Springs
San Francisco
Oakland
Sunnyvale
Modesto
San Mateo
San Jose
Fresno
Palo Alto
Salinas
Las Vegas
Grover Beach
San Luis Obispo
Bakersfield
Albuquerque
Lompoc
Santa Barbara
San Bernardino
Riverside
Los Angeles
Anaheim
Orange County
Carlsbad
Phoenix
San Diego
Tijuana
Tucson
Santa Teresa
El Paso
Minneapolis
Eagan
Eau Claire
Green Bay
Owatonna
Madison
Milwaukee
Omaha
Council Bluffs
Des Moines
Lincoln
Topeka
Kansas City
Wichita
St. Louis
Stratford
Amarillo
Tulsa
Oklahoma City
Lubbock
Wichita Falls
Fort Worth
Plano
Dallas
Abilene
Midland
Waco
Round Rock
Austin
Bryan
Houston
San Antonio
Sugar Land
Bay town
Laredo
Corpus Christi
Marlene
Harbinger
Monterrey
Mazatlan
Guadalajara
Mexico City
Chicago
Grand Rapids
Lansing
Troy
Livonia
Southfield
Kalamazoo
Detroit
Battle Creek
Dearborn
South Bend
Toledo
Elyria
Cleveland
Akron
Youngstown
Columbus
Indianapolis
Springfield
Dayton
Cincinnati
Louisville
Middletown
Lexington-Fayette
Bowling Green
Nashville
Johnson City
Tri-Cities
Memphis
Little Rock
Shelbyville
Manchester
Chattanooga
Greenville
Spartanburg
Atlanta
Birmingham
Macon
Augusta
Columbia
Jackson
Savannah
Charleston
Wilmington
Ferry Pass
Brent
Mobile
Baton Rouge
Tallahassee
Pensacola
New Orleans
Jacksonville
Gainesville
Ocala
Daytona Beach
Orlando
Titusville
Tampa
Winter Haven
Clearwater
Melbourne
Saint Petersburg
Lakeland
West Palm Beach
Sarasota
Boca Raton
Fort Myers
Deerfield Beach
Pompano Beach
Miami
Fort Lauderdale
Hollywood
Toronto
Rochester
Utica
Schenectady
Troy
Niagara Falls
Buffalo
Syracuse
Erie
Montreal
Burlington
Boston
New York
Philadelphia
Pittsburgh
Baltimore
Washington, D.C.
Charlottesville
Staunton
Lynchburg
Richmond
Roanoke
Danville
Norfolk
Chesapeake
Greensboro
Rocky Mount
Winston-Salem
Durham
Gastonia
Charlotte
Raleigh
Fayetteville

PennREN / KINBER



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 (saw in lab)

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 going past your network interface
  - 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)
```


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

