networking 101

- what's a network
- the 7 layers
- Ethernet
- routing

Networks

- layers and interfaces
- encapsulation
- media and speed
- interconnects
- addressing

What's a network?

- media
- protocols
- service

Selection criteria:

- speed
- connectivity
- cost
- community of interest
- portability
- availability/reliability
- security

layers

- OSI's main contribution
- each layer offers a service to the layer above
- hides details from higher layer
- details of lower level can change
- well-defined interfaces between layers
- protocol is the interface between the same layer on two machines
- encapsulation – each layer may add an envelope

OSI layers

- physical – transmitting bits
- data link – framing, error checking, flow control
- network – addressing, routing
- transport – segmentation, sequencing, services, error checking, end-to-end
- session – establish/terminate sessions, restart (RPC)
- presentation – compression, encoding
- application – end user service

net speeds

1 Gbs	phone trunks (1.7 Gbs)
	Hippi (800 Mbs), OC3 (155 Mbs)
100 Mbs	FDDI (100 Mbs) ATM
	T3 (45 Mbs), token (16 Mbs)
10 Mbs	Ethernet (10 Mbs)
1 Mbs	T1 (1.5 Mbs) (class video)
100 Kbs	
	ISDN (64 Kbs) voice
10 Kbs	modem (9.6 Kbs)
	modem(2400 bps)
1 Kbs	
	modem (300 bps)
100 bs	human data rate (100 bps)

transfer times

Material	bytes	@2400	@T1	@1Gbs
page	2400	8s	.01s	1x10**-5s
report	7x10**4	4m	.4s	3x10**-4s
book	7x10**5	40m	4s	.003s
dictionary	6x10**7	2.3d	5.3m	.3 s
Encyclo.	2x10**8	5d	12h	.6 s
OR lib	7x10**10	7.4y	4d	5.5m
UT lib	7x10**11	74y	43d	55m
lib. Cong.	2x10**13	1900y	3y	23h

latency: OS overhead, queueing delays, speed of light

Interconnects

Out the interface, through the hub, over the bridge, off the router ... nothing but net.

- **repeaters** signal regeneration
- **hub** concentrator
- **bridges** filter, store & forward, media switching
- **switch** filter, parallel
- **routers** network-layer routing

Addressing

- Address: service, host, network
- name-to-number translation
- network to physical mapping

Addresses

```
                +--------+--------+
DECnet          |area(6)  host(10)|
                +--------+--------+
                     16 bits

                +----------------------------------+
ISO             |AFI|  IDI       |   DSP (20 min)   |
                +----------------------------------+
                            40 digits (max)

                +--------+--------+--------+--------+
IP     A        |0 net(7)|   host (24)               |
                +--------+--------+--------+--------+
                                32 bits
                +--------+--------+--------+--------+
       B        |10   net (14)    |     host (16)   |
                +--------+--------+--------+--------+
                +--------+--------+--------+--------+
       C        |110   net (21)            |host(8) |
                +--------+--------+--------+--------+
                +--------+--------+--------+--------+
       D        |1110     multicast (28)            |
                +--------+--------+--------+--------+

                +---+---+---+---+---+---+
Ethernet        | vendor(24)| local (24)|  broadcast: -1
                +---+---+---+---+---+---+
                          48 bits
```


IP addresses

- localhost 127.0.0.1
- broadcast 255.255.255.255
- subnet broadcast 192.12.68.255
- private A 10.*.*.*
- private B's 172.16-31.*.*
- private C's 192.168.0-254.*
- UT 128.169.*.*
- ORNL 128.219.*.*, 134.167.*.*, 192.31.96.*

Ethernet

a local area network

- Xerox, DEC, Intel, '76
- 10 million bits/sec (100, giga)
- CSMA/CD, half-duplex (later full)
- thick, thin, fiber, twisted pair, wireless
- min pkt (64)
- max pkt (1518)
- 6-byte address (vendor(3)+other(3))
- supports broadcast and multicast
- preamble(8),header(14),data(46-1500), checksum(4)
- connectionless, unreliable

Ethernet packet

```
 0     7 8    15 16   23 24   31 32   39 40   47
+-------+-------+-------+-------+-------+-------+
|             Destination address               |
+-------+-------+-------+-------+-------+-------+
|                Source address                 |
+-------+-------+-------+-------+-------+-------+
|    type       |    data  ...
+-------+-------+-------+--...
   ....

or for 802.3
+-------+-------+-------+-------+-------+-------+
|    length     |  DSAP   SSAP    data  ...
+-------+-------+-------+--...
```


CSMA/CD

- broadcast media (party line)
- half-duplex (newer, full)
- sense carrier
- max length of cable, min pkt size to assure collision detect
- if you collide, stop and do jam, exponential backoff
- minimum packet spacing 9.6us

see spec sheet and web refs

Ethernet addresses

- 6 byte address
- upper 3 bytes assigned to vendor
- broadcast destination, all 1's
- multicast destination 0x01 ....

Ethernet types

- length field bigger than 0x600, then type
- IP can be carried in 802.3 (LSAP= 06)

```
 hex
 800      IPv4
 806      ARP
 600      XNS
8137      Novell
8035      reverse ARP
86DD      IPv6
```

Ethernet interface

- card/chip takes care of CSMA/CD, encoding, packet spacing, preamble/CRC
- control: commands and status
- control
  - add/delete multicast address
  - enable/disable promiscuous
  - set MAC address (DECnet)
- status: collisions, interrupts, ready
- drops "bad" packets
- passes up own/broadcast/multicast pkts
- accepts header-data
- kernel driver is the interface
- driver passes up to type handler

address mapping

finding Ether address for host

- mapping or discovery
- DECnet maps DECnet address into MAC address for local net
- for IP, kernel determines if desination IP is a local address
- for local IP, look in ARP cache (20 minute lifetime)
- broadcast ARP – what is MAC for host w.x.y.z
- remote (proxy) responds with ARP reply
- *arp -a* list ARP cache

RFC 826 – ARP

fast Ethernet

- 100 Mbs
- Gigabit ether (fiber)
- full duplex
- auto-negotiate (watch out)

routing

getting to a not-directly attached host

- network layer
- source routing (hosta!hostb!hostx)
- route select: load, cost, distance, policy
- routing control

  static (*route* command)

  dynamic (distributed) (Internet)
- routing protocols
  RIP, OSPF, BGP
- more nets, bigger routing tables

routing on a host

- usually just default route
- static routes with *route*
  route add net 1.2.3.0 router 1.2.3.4
- *netstat -r* to view
- dynamic (RIP)
- host can be a router

routers

- protocols to advertise routes
- logic to select best route
- config commands (local nets, filters, trusted neighbors)
- interfaces, switching fabric, CPU, memory
- for IP, each packet may take a different route
- packets may be dropped

review

for network programming, why do we care about lower levels?

- understand data rates (latency/bandwidth), loading, errors
- broadcast/multicast
- routing – delay, loss, variability
- security

tool box

Commands

- telnet – port probe and protocol tester
- arp – ether to IP mapping
- ping – reachability and latency
- traceroute – route analyzer (1-way)
- netstat – route display, interface activity
- ifconfig – interface config
- route – static routing

assignment 2

next time

TCP/IP and sockets

```
Readings:
   class 3 readings (see web page)
```