Networking 101

CSEE W4840

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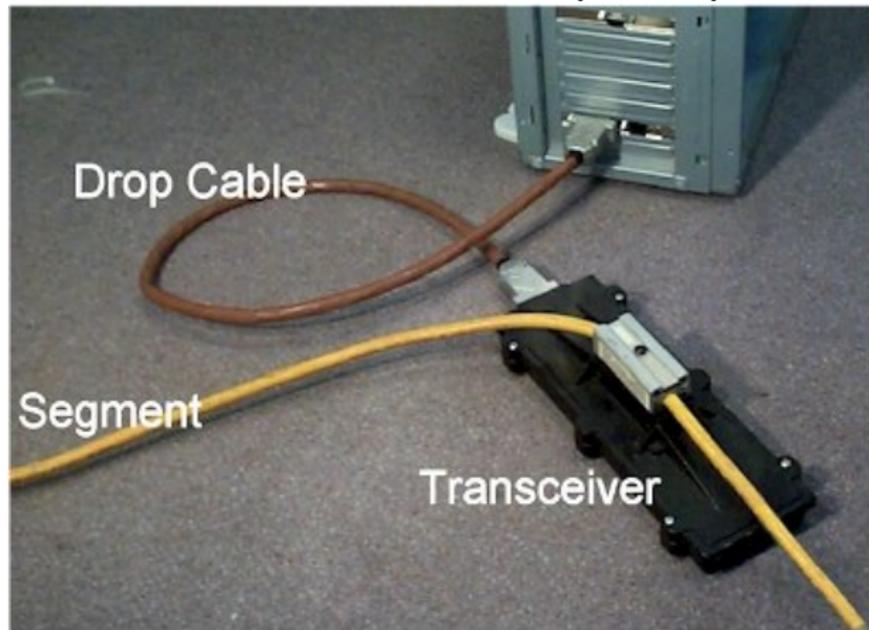
Ethernet

Started in about 1976 at Xerox PARC

IEEE Standard 802.3

Carrier-sense multiple access/carrier detect protocol:

1. Listen to the cable
2. If nobody's there, start talking
3. If someone interrupts, stop, and retry after a random time

10Base-5 "Thicknet"

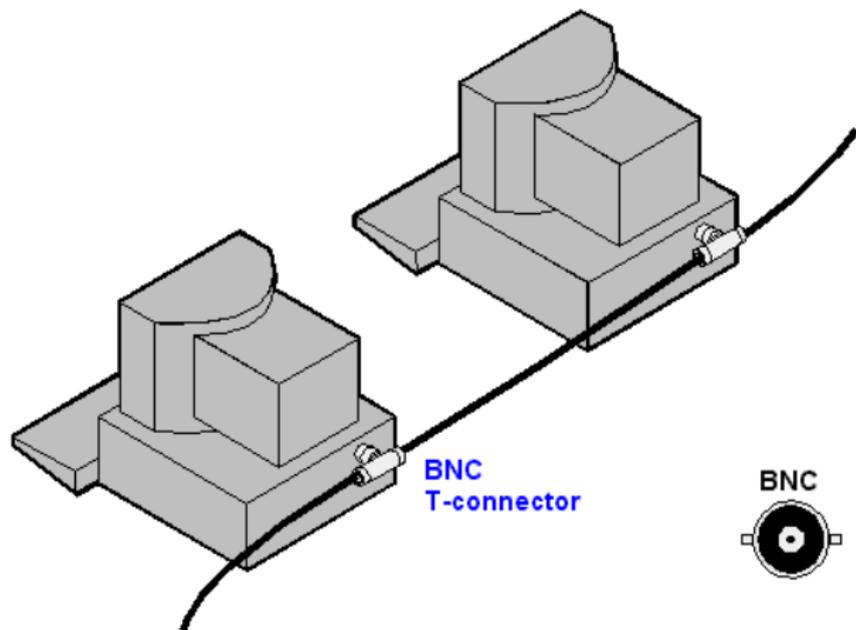Shared coax bus with "vampire tap" tranceivers

Yellow color suggested by the 802.3 standard

10Base-2 "Thinnet"

50-Ohm coax segments with BNC "T" connectors

**BNC
T-connector**

BNC

Coax invariably black

10Base-T and 100Base-T

Put the shared medium in a hub: a star topology.
Everybody uses it now.

Workstations
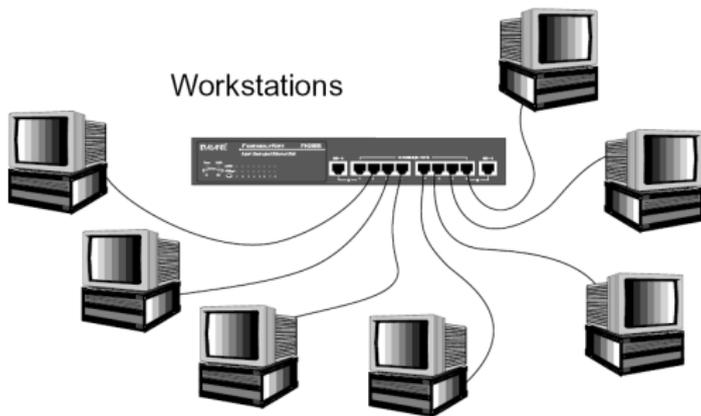
Star topology

Choice of colors

100Base-TX wiring (CAT 5)

Pair of twisted pairs, one pair for each direction.

Uplink or MDI port

Straight-through twisted pair cable

Normal or MDI-X port

Tx
1
2

Rx
1
2

Rx
3
6

Tx
3
6
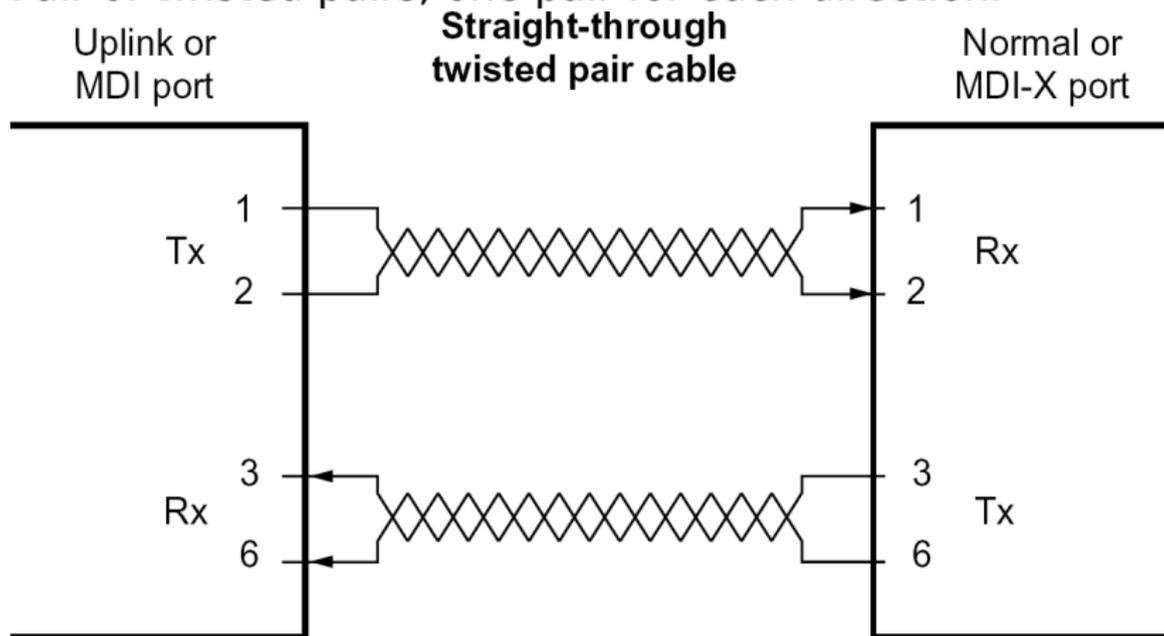
Hub-to-computer cable is straight-through.
Computer-to-computer cable is a "crossover."

From the Netgear EN104TP 4-port hub manual off of Amazon.com

An Ethernet Frame

| 7 bytes | 1 | 6 | 6 | 2 | 46–1500 | 4 |
| Preamble | SOF | Dest. | Src. | Type | Payload | Checksum |

SOF   Start of Frame
Dest.   Destination address
Src.   Source address
Type   Type of packet or length of data field
        0x0800 for IP, 0x0806 for ARP, etc.

Bytes sent LSB first

Minimum packet length: 64 (6 + 6 + 2 + 46 + 4)

Lengths > 1500 indicate packet type

Ethernet (MAC) addresses

48 bits ≈ 281 trillion (world population: 6.5 billion)

Bits 48–24: Vendor code

Bit 41: 0=ordinary, 1=group (broadcast) address

Bits 23–0: Serial number

On my desktop:

$ ifconfig eth0
eth0 Ethernet HWaddr 00:08:74:23:CC:AB

OUI (Organizationally Unique Identifier):

00:08:74 is Dell Computer

Address FF:FF:FF:FF:FF:FF is broadcast

An Ethernet Packet

00d006269c00	Destination MAC address (router)
00087423ccab	Source MAC address (my desktop)
0800	Type = IP packet
45	IPv4, 5 word (20-byte) header
00	Normal service
0028	Total length = 40 bytes
c31c	Identification (unique)
4000	"Don't Fragment"
40	64 hops to live
06	TCP protocol
3ff1	Header checksum (one's complement)
803b1372	Source IP 128.59.19.114 (desktop)
40ec6329	Destination IP 64.236.99.41

deac 0050 bf49 9ba6 a1a4 8bed 5010 ffff 1093 0000

IP Header Checksum Computation

One's complement addition on 16-bit elements
16-bit carry out becomes carry in
Computed on elements of IP header:

Computing	**Checking**
4500	4500
0028	0028
c31c	c31c
4000	4000
4006	4006
0000 ← checksum hole	3ff1 ← checksum
803b	803b
1372	1372
40ec	40ec
+6329	+6329
2c00c (two's complement)	2fffd (two's complement)
c00e (one's complement)	0000 (one's complement—OK)
3ff1 (inverted)	

IP Header

31		28	27		24	23						16	15		13	12										0
Version = 4			Words in Header			Type of Service (typically 0)							Total number of bytes in the IP packet													
Identification Number (which packet)												Flags - DF MF			Fragment Offset (which fragment)										
Time-to-Live (hops left)						Protocol 6=TCP, 17=UDP						Header checksum (one's complement sum)													
Source IP Address																									
Destination IP Address																									

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Options and padding
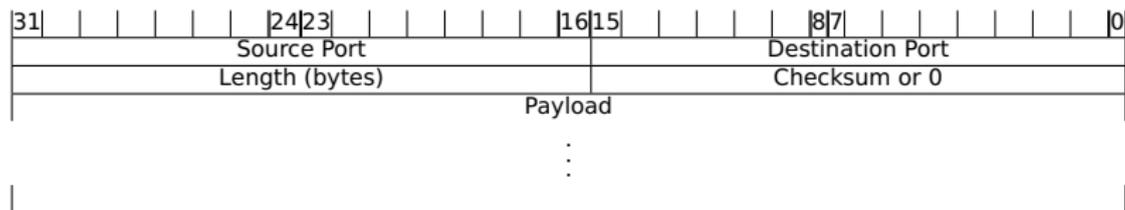
IP Addresses

32 bits ≈ 4 billion (world population: 6.5 billion)

First n bits indicate network (n = 8, 16, 24)

For example, columbia.edu
owns 128.59.0.0 – 128.59.255.255

Magical addresses:

127.0.0.1	"Me"
192.168.x.x	Never assigned worldwide
10.x.x.x	Never assigned worldwide
255.255.255.255	Broadcast

UDP Packets

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31|   |   |   |   |   |24|23|   |   |   |   |   |16|15|   |   |   |   |8|7|   |   |   |   |   |   |0
                Source Port              |              Destination Port
                Length (bytes)           |              Checksum or 0
|                                    Payload
                                       ⋮
|
```

Dumb packet protocol: unreliable, danger of
out-of-order delivery