Networking 101

CSEE W4840

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Ethernet

Started in about 1976 at Xerox PARC

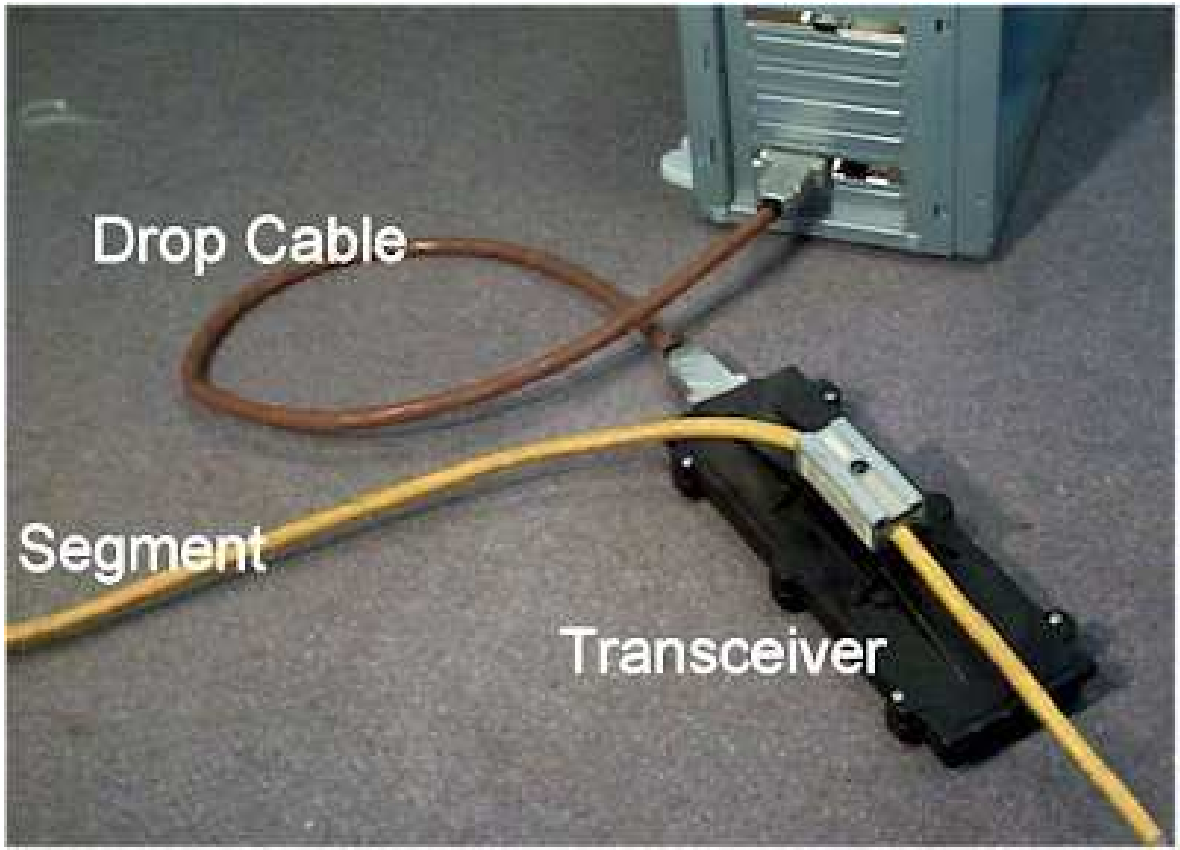
IEEE Standard 802.3

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

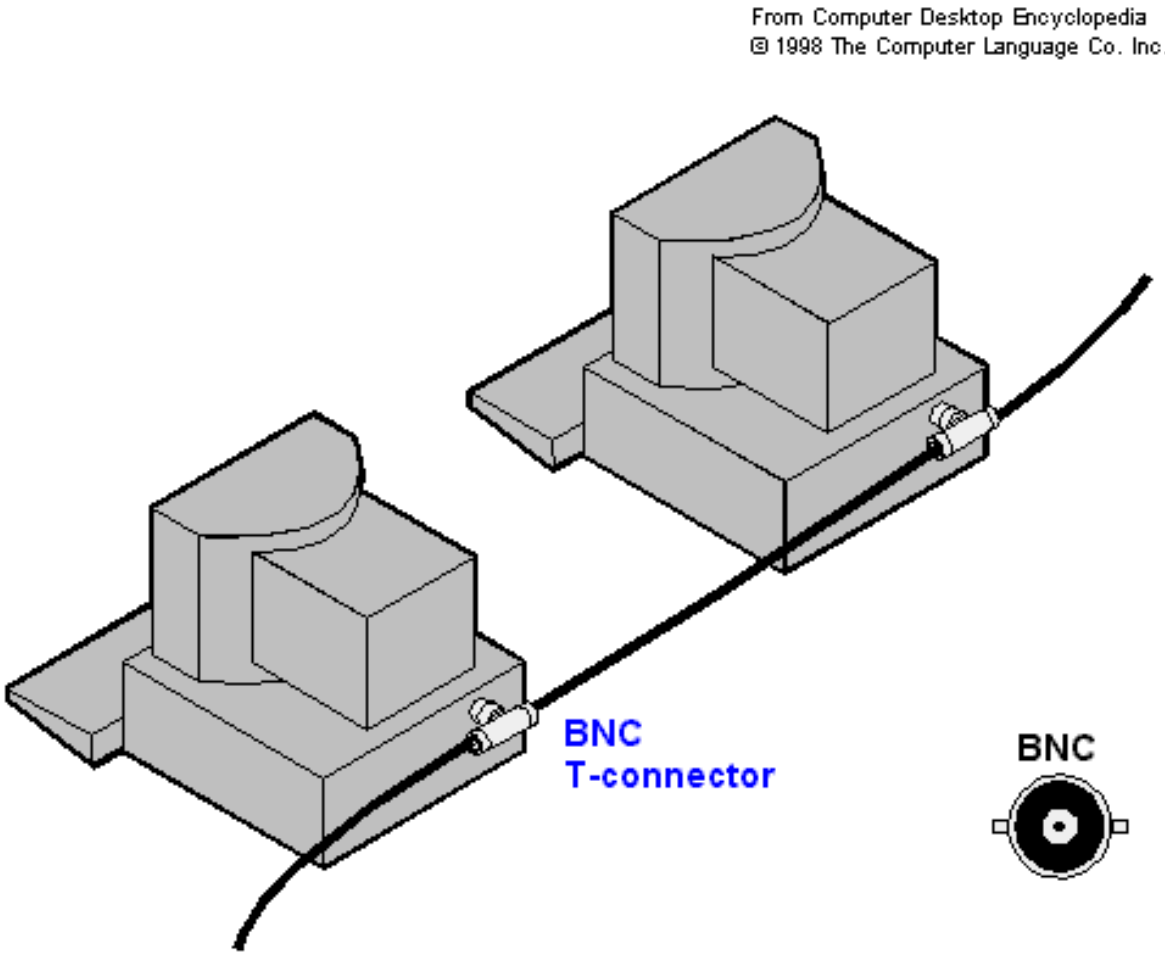


Yellow color suggested by the 802.3 standard

From http://www.turkcenet.org/yerel_htm/10base5.htm

10Base-2 “Thinnet”

50-Ohm coax segments with BNC “T” connectors

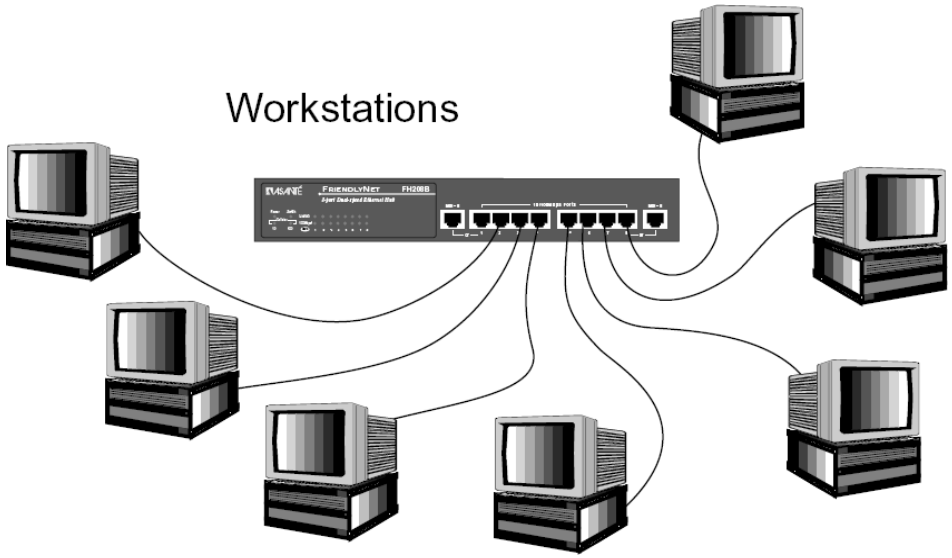


Coax invariably black

From http://www.answers.com/topic/10base2

10Base-T and 100Base-T

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



Star topology

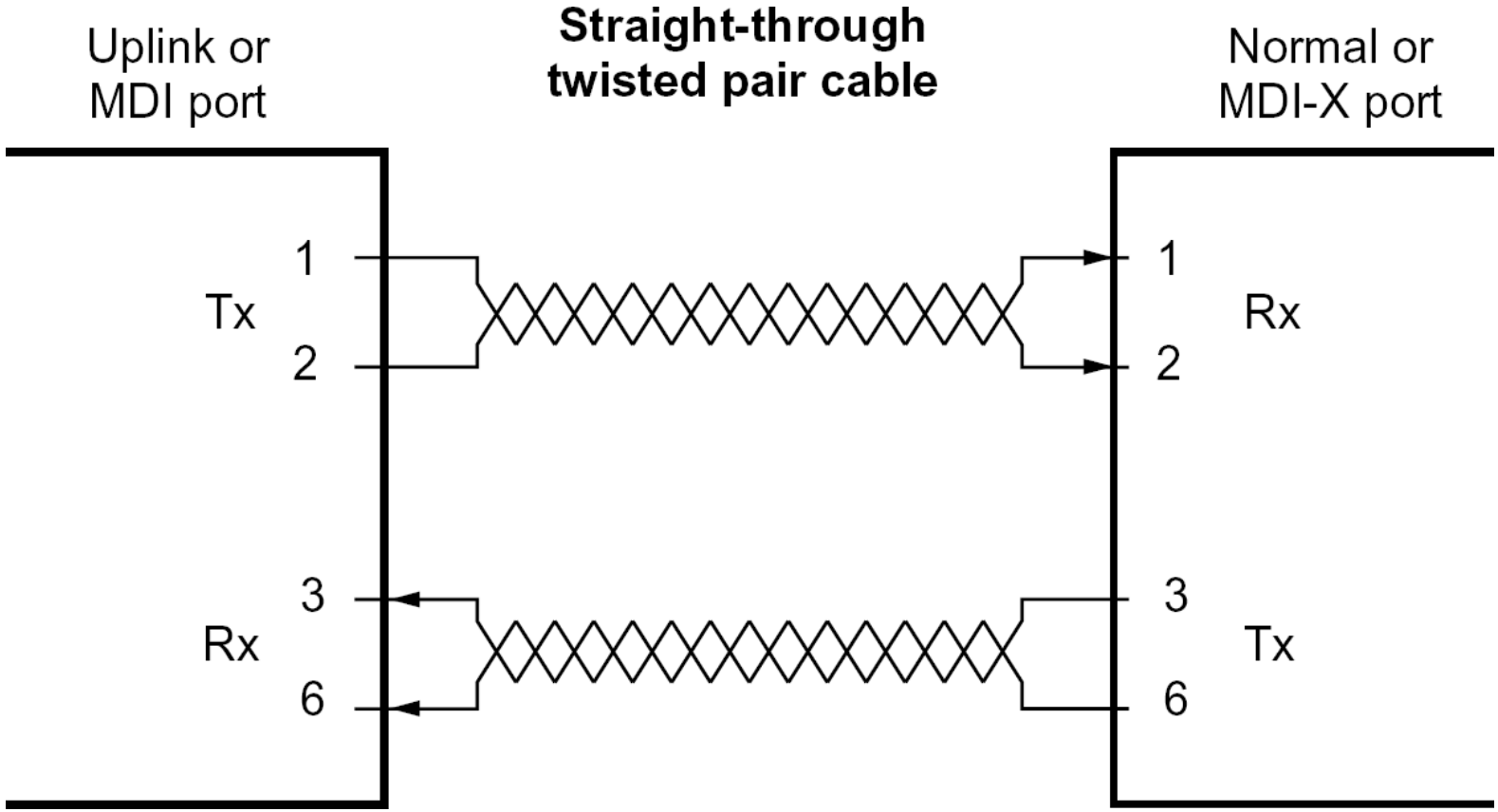
Choice of colors

From http://www.asante.com/downloads/legacy/fh200bugra.pdf and

http://www.connectworld.net/cables_u/patch-cable-manufacturer.html

100Base-TX wiring (CAT 5)

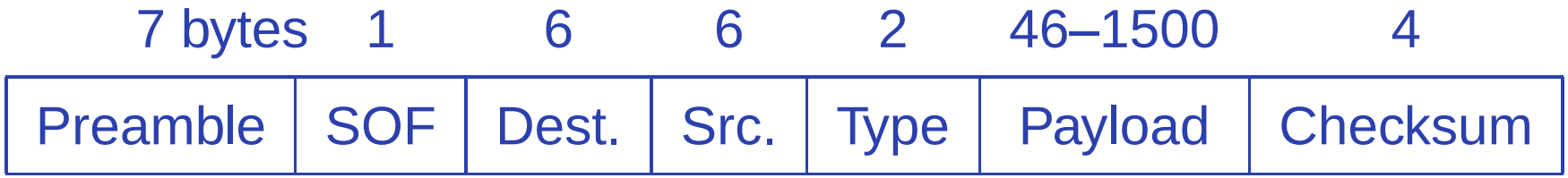
Pair of twisted pairs, one pair for each direction.



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



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 $\approx$ 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

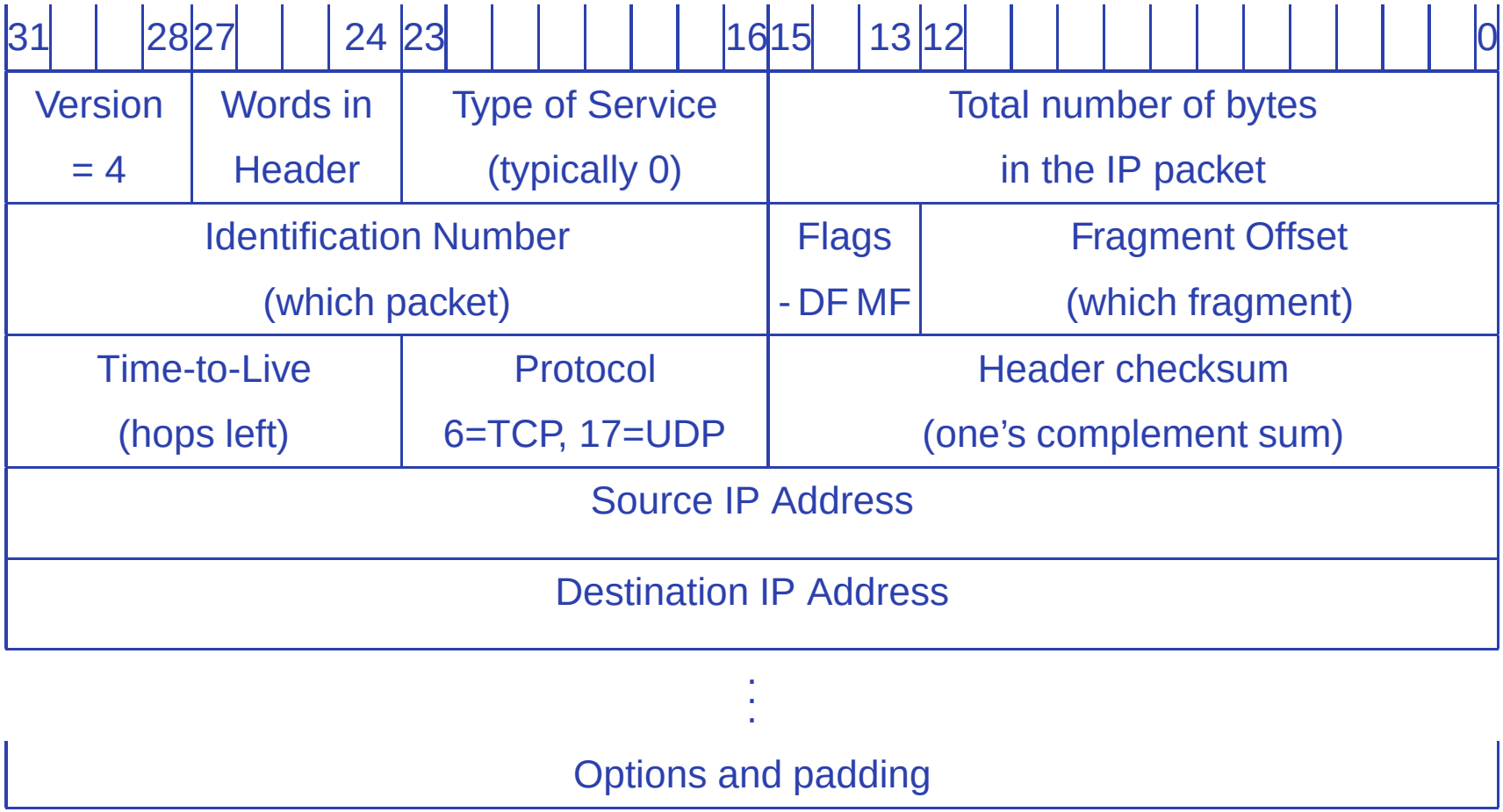
IP Header Checksum Computation

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

```
Computing:                          Checking:

  0x4500                              0x4500
  0x0028                              0x0028
  0xc31c                              0xc31c
  0x4000                              0x4000
  0x4006                              0x4006
  0x0000 <-- checksum hole            0x3ff1 <-- checksum
  0x803b                              0x803b
  0x1372                              0x1372
  0x40ec                              0x40ec
+ 0x6329                            + 0x6329
--------                            --------
 0x2c00c (two's complement sum)      0x2fffd (two's complement sum)
 0x c00e (one's complement sum)      0x 0000 (one's complement sum OK)
 0x 3ff1 (complement thereof)
```

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
Options and padding

IP Addresses

32 bits $\approx$ 4 billion (world population: 6.5 billion)

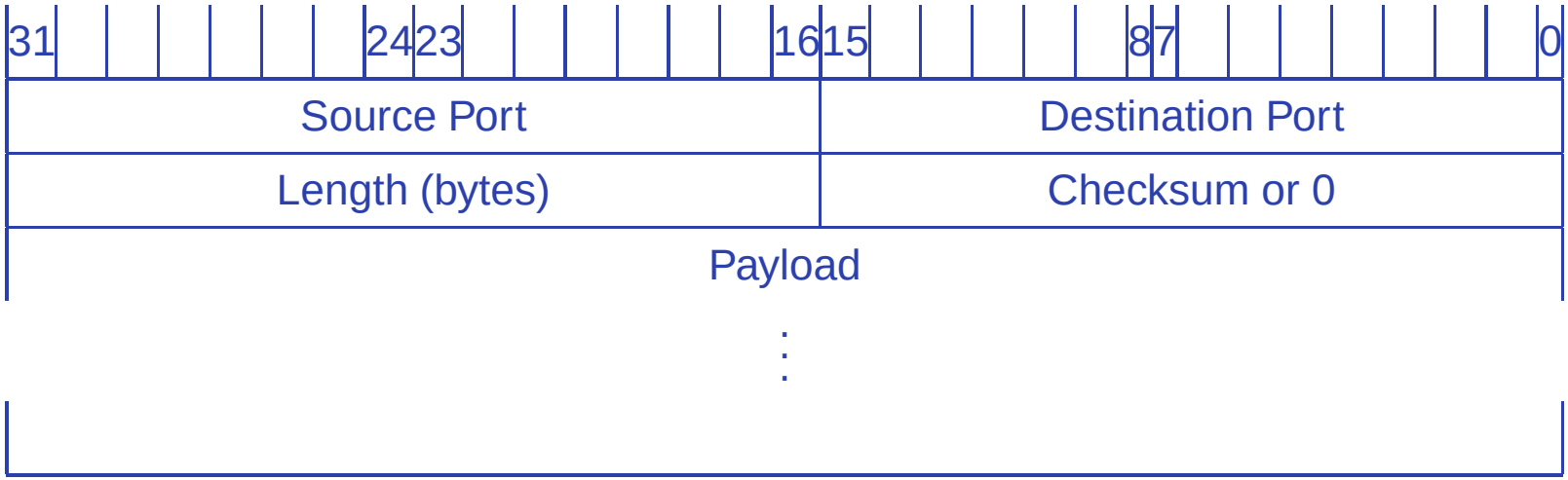
First n bits indicate network (n = 8, 16, 24)

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



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