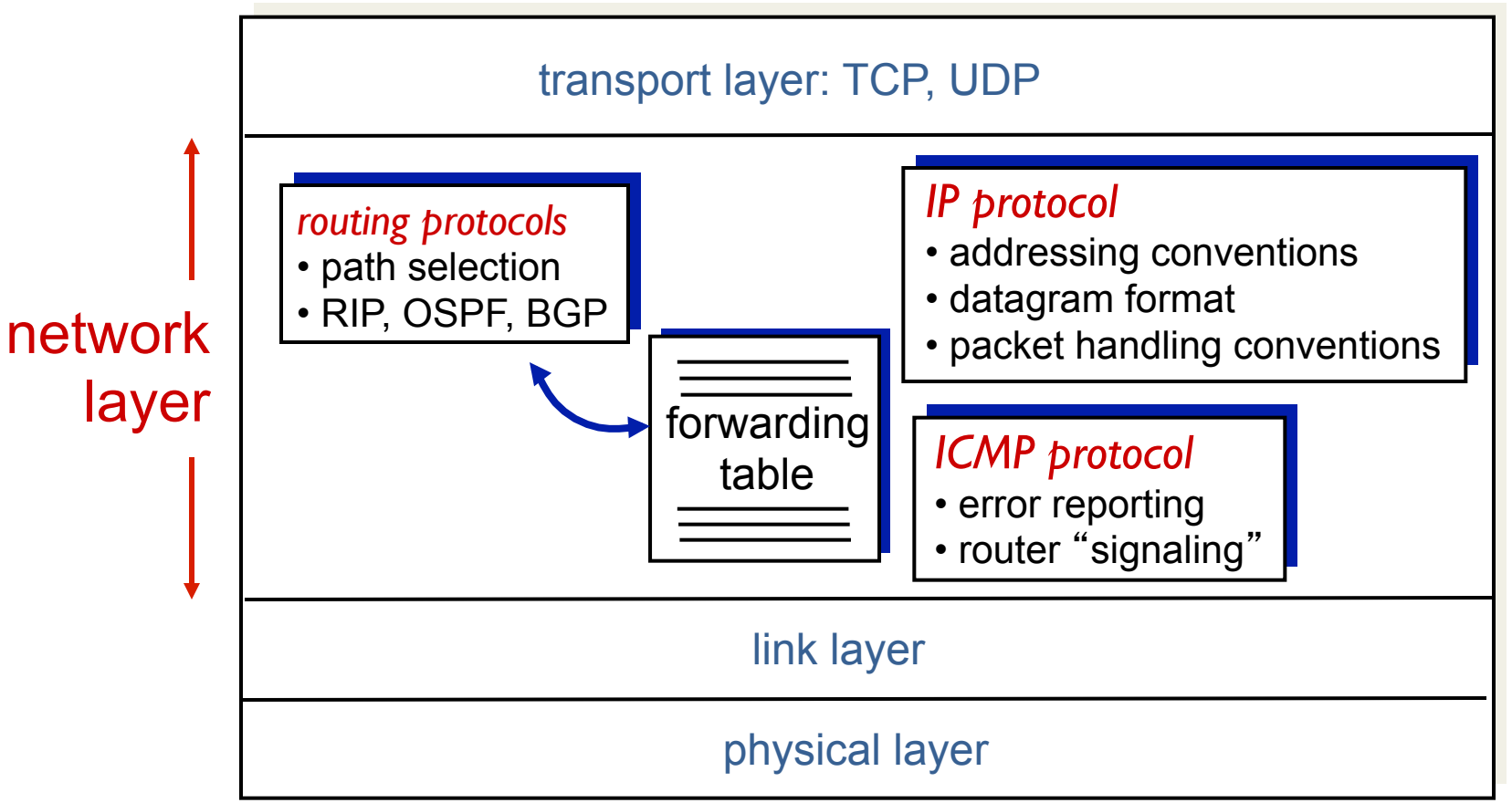
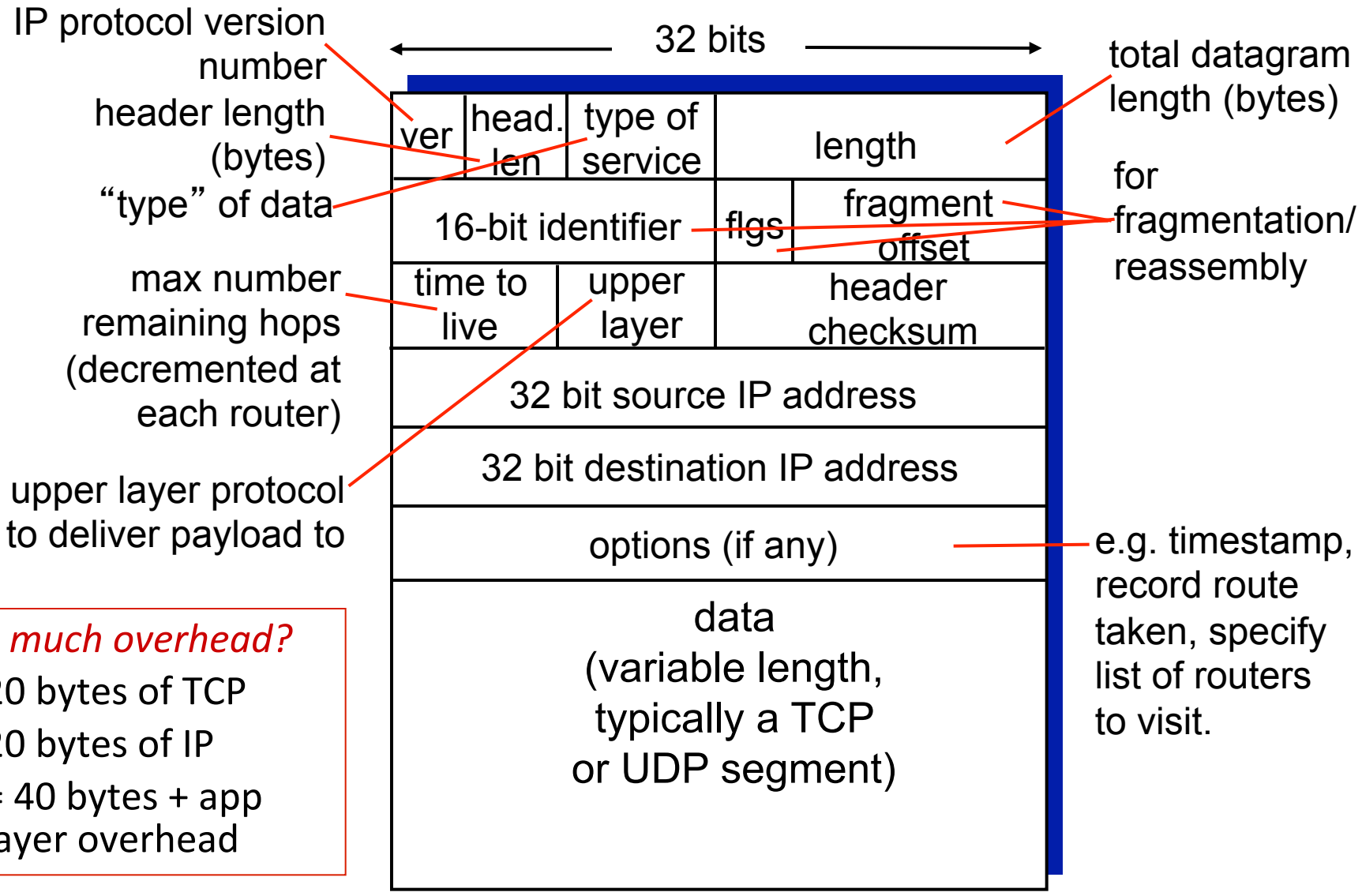
The Internet network layer

host, router network layer functions:



IP datagram format



how much overhead?

- 20 bytes of TCP
- 20 bytes of IP
- = 40 bytes + app layer overhead

What fields are not in an IP datagram header?

A. Port number

B. Fragment offset

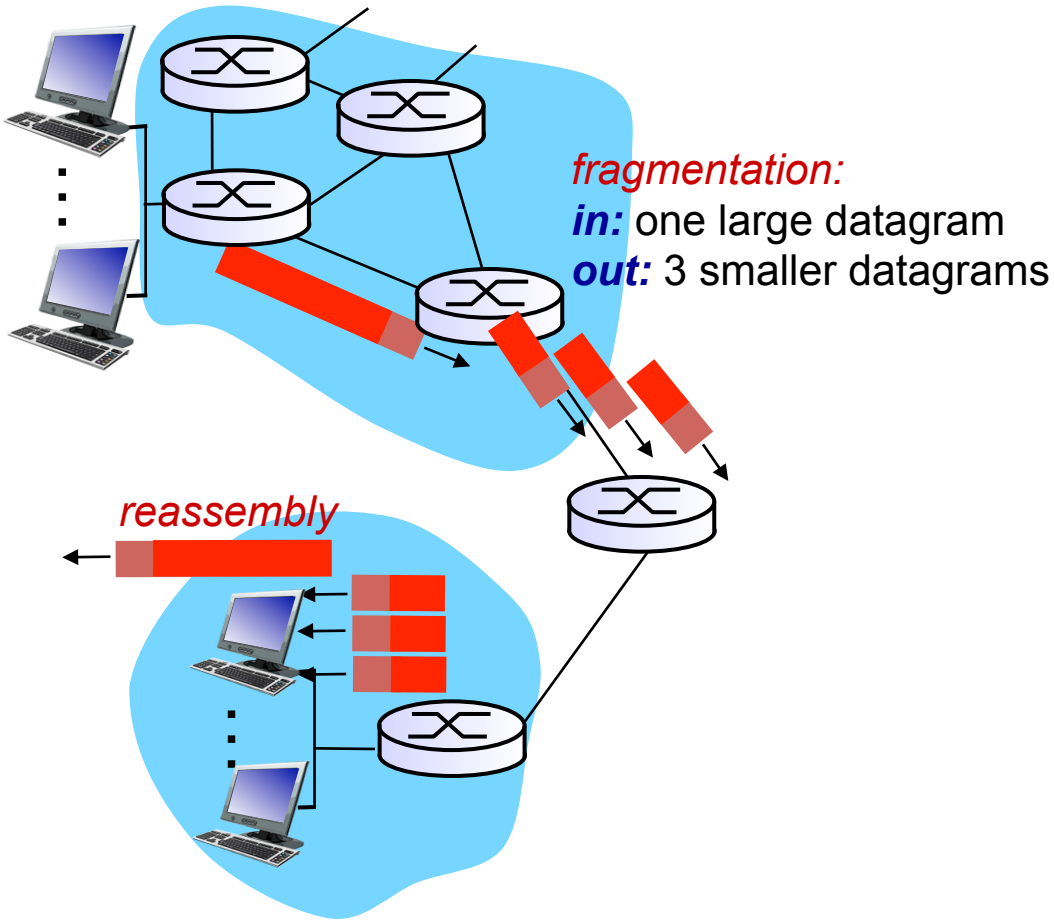
C. Header checksum

D. A and B

E. A, B and C

IP fragmentation, reassembly

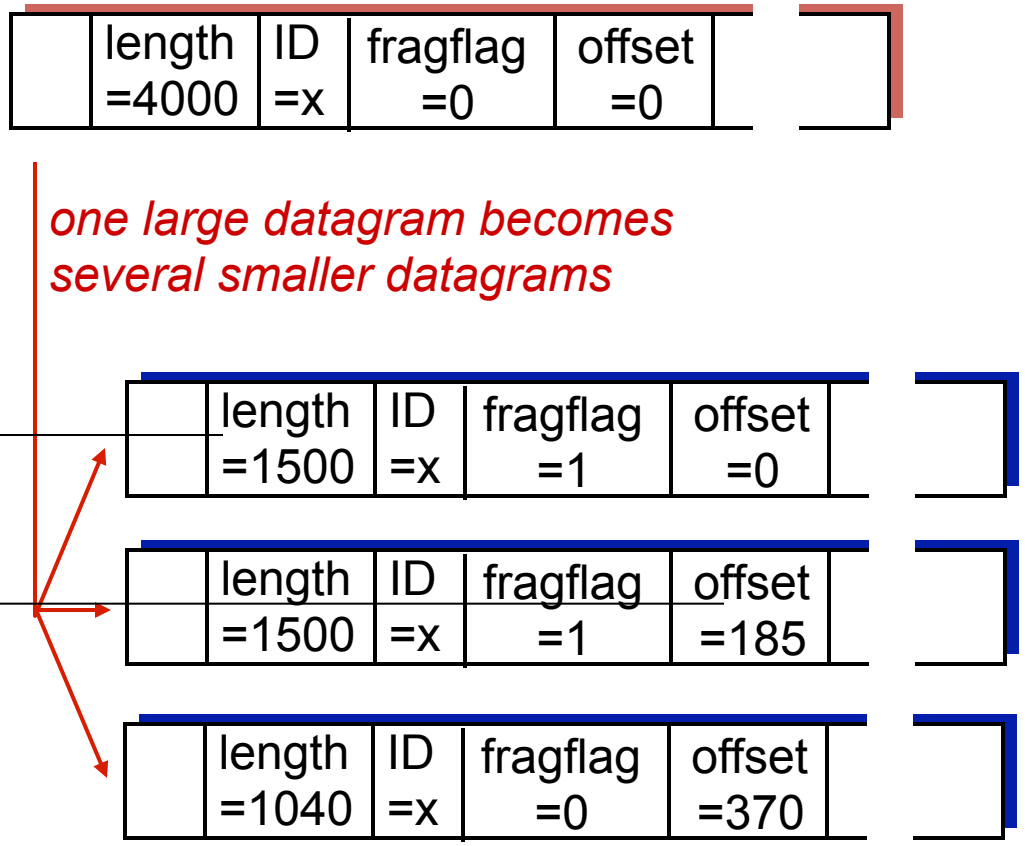
- network links have MTU (max transmission unit) - largest possible link-level frame
  - different link types, different MTUs
- large IP datagram divided ("fragmented") within net
  - one datagram becomes several datagrams
  - "reassembled" only at final destination
  - IP header bits used to identify, order related fragments



IP fragmentation, reassembly

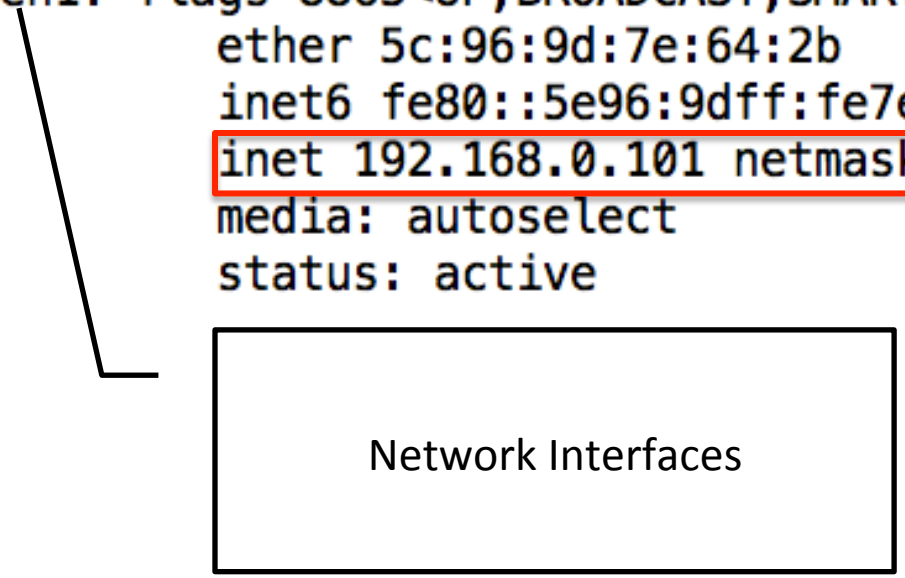
example:

- 4000 byte datagram
- MTU = 1500 bytes



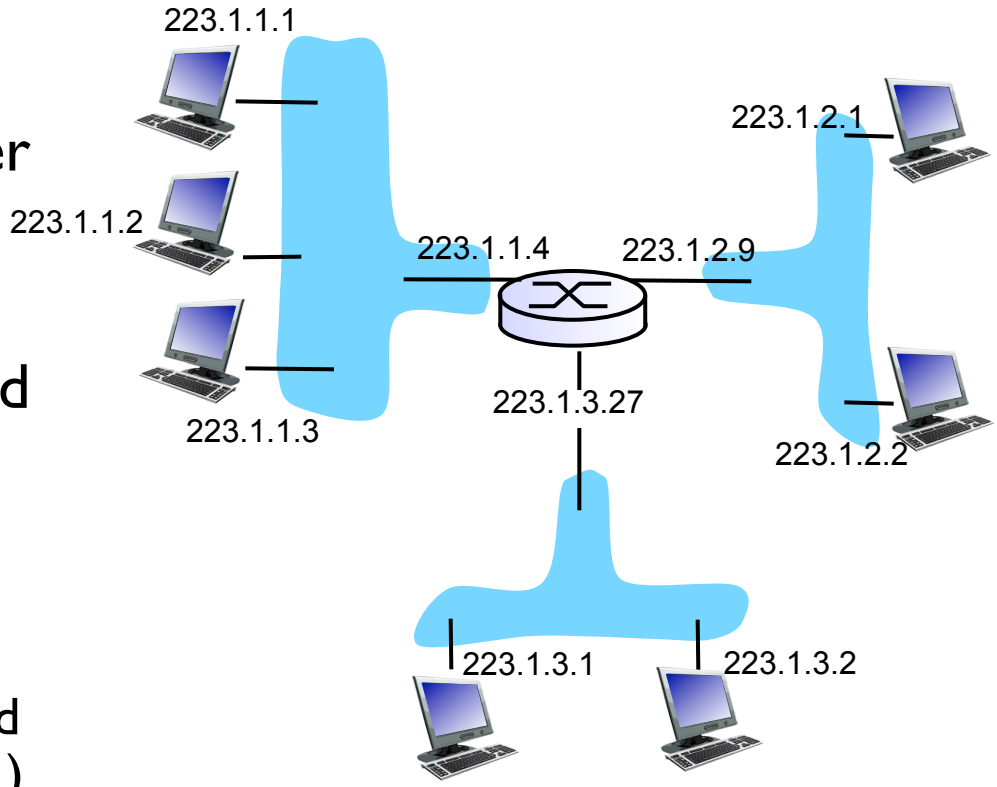
Example

```
en0: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        options=2b<RXCSUM,TXCSUM,VLAN_HWTAGGING,TSO4>
        ether a8:20:66:3e:54:a1
        media: autoselect (none)
        status: inactive
en1: flags=8863<UP,BROADCAST,SMART,RUNNING,SIMPLEX,MULTICAST> mtu 1500
        ether 5c:96:9d:7e:64:2b
        inet6 fe80::5e96:9dff:fe7e:642b%en1 prefixlen 64 scopeid 0x5
        inet 192.168.0.101 netmask 0xffffff00 broadcast 192.168.0.255
        media: autoselect
        status: active
```



IP addressing: introduction

- *IP address:* 32-bit identifier for host, router *interface*
- *interface:* connection between host/router and physical link
  - router's typically have multiple interfaces
  - host typically has one or two interfaces (e.g., wired Ethernet, wireless 802.11)
- *IP addresses associated with each interface*

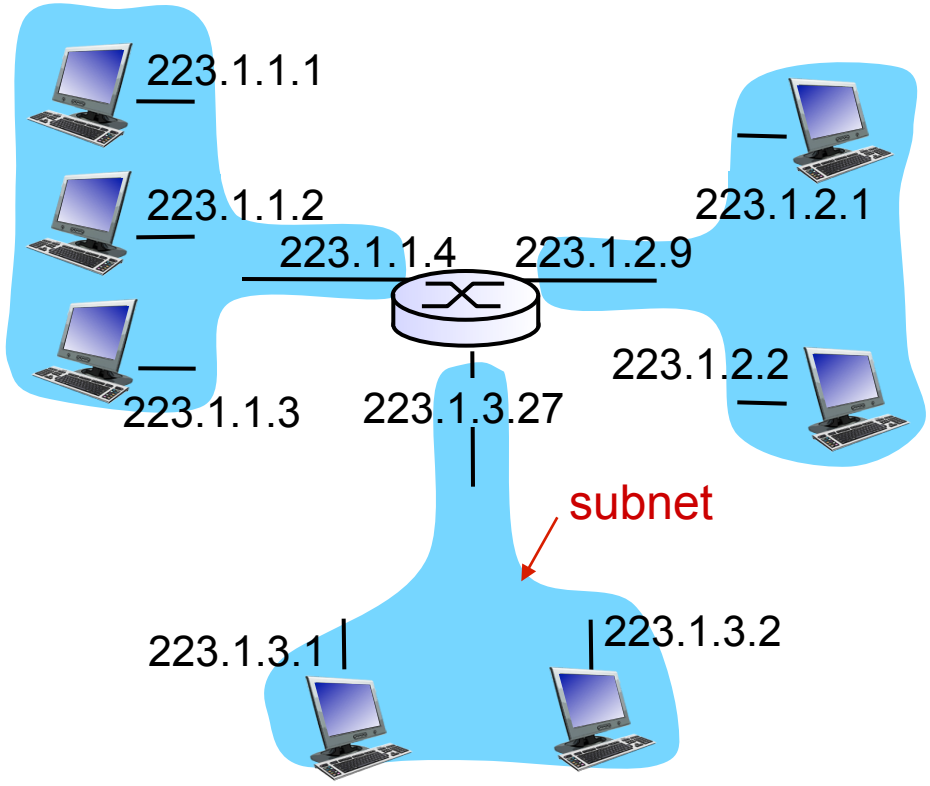


223.1.1.1 = 11011111 00000001 00000001 00000001

223 1 1 1

Subnets

- IP address:
  - –subnet part - high order bits
  - –host part - low order bits
- *what's a subnet ?*
  - –device interfaces with same subnet part of IP address
  - –can physically reach each other *without intervening router*

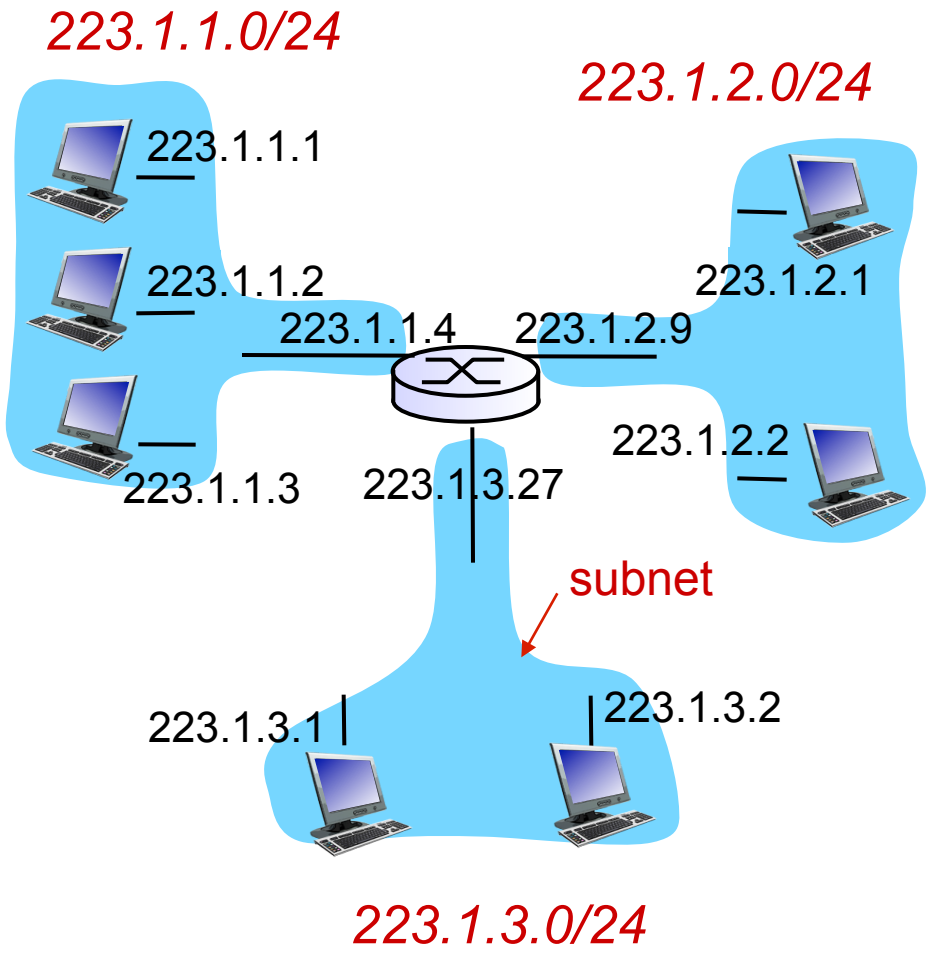


network consisting of 3 subnets

Subnets

recipe

- to determine the subnets, detach each interface from its host or router, creating islands of isolated networks
- each isolated network is called a *subnet*



subnet mask: /24

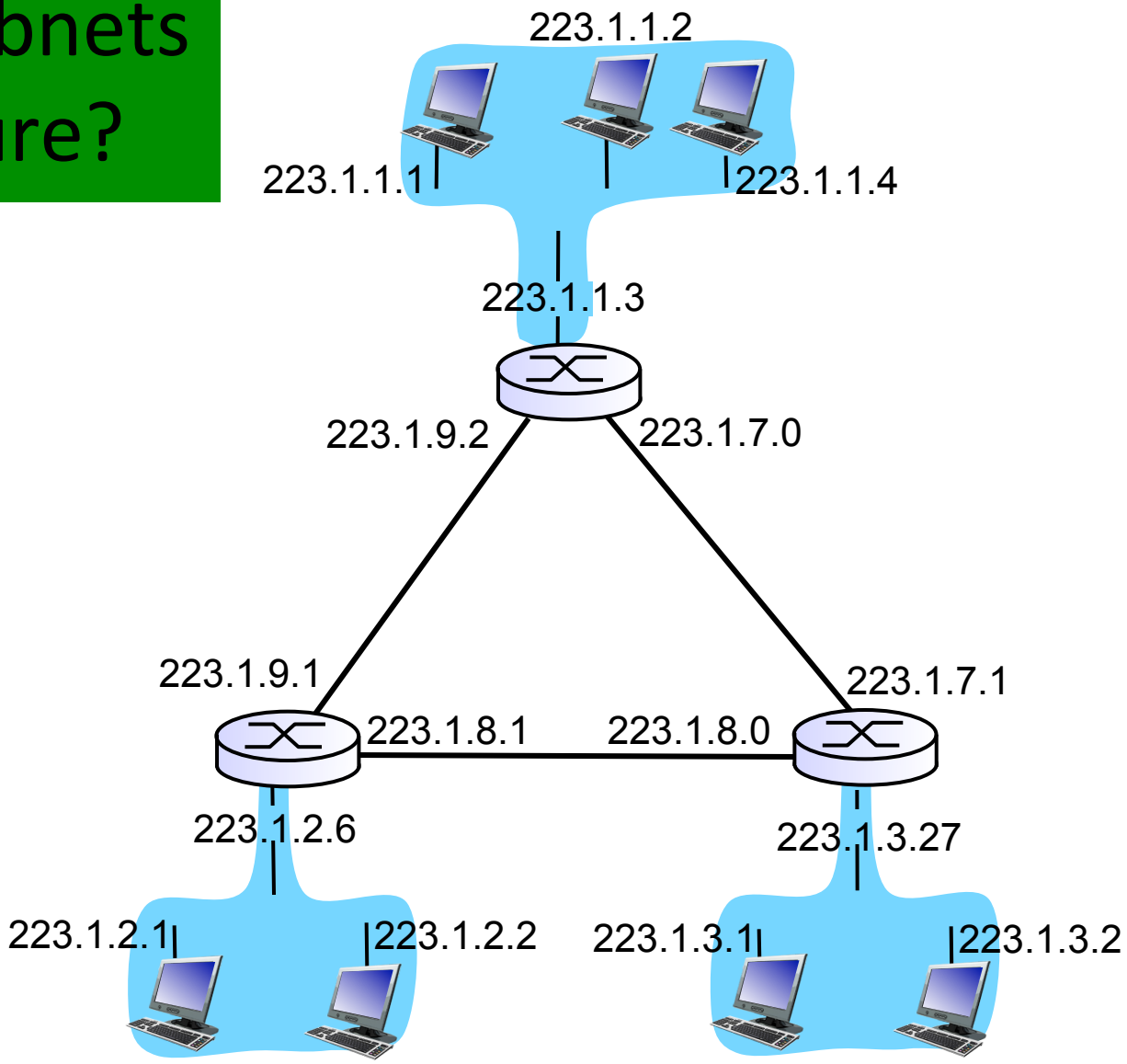
How many subnets in this figure?

A. 3

B. 6

C. 7

D. 10



Classful network addressing (Old standard)

Class	Leading bits	Size of *network number* bit field	Size of *rest* bit field	Number of networks	Addresses per network	Start address	End address
Class A	0	8	24	128 (2^7)	16,777,216 (2^{24})	0.0.0.0	127.255.255.255
Class B	10	16	16	16,384 (2^{14})	65,536 (2^{16})	128.0.0.0	191.255.255.255
Class C	110	24	8	2,097,152 (2^{21})	256 (2^8)	192.0.0.0	223.255.255.255

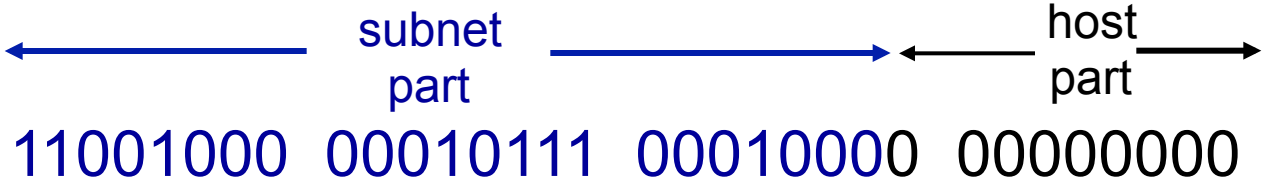
Class C is too small for an organization while class B is too large

Replaced by Classless Inter-Domain Routing (CIDR), starting 1993

IP addressing: CIDR

CIDR: Classless InterDomain Routing

- subnet portion of address of arbitrary length
- address format: a.b.c.d/x, where x is # bits in subnet portion of address



200.23.16.0/23

The number of hosts in a subnet a.b.c.d/x = 2^(32-x).
E.g. x=23 => The # hosts = 2^9 = 512

How many number of hosts for this network a.b.c.d/24?

A. 8

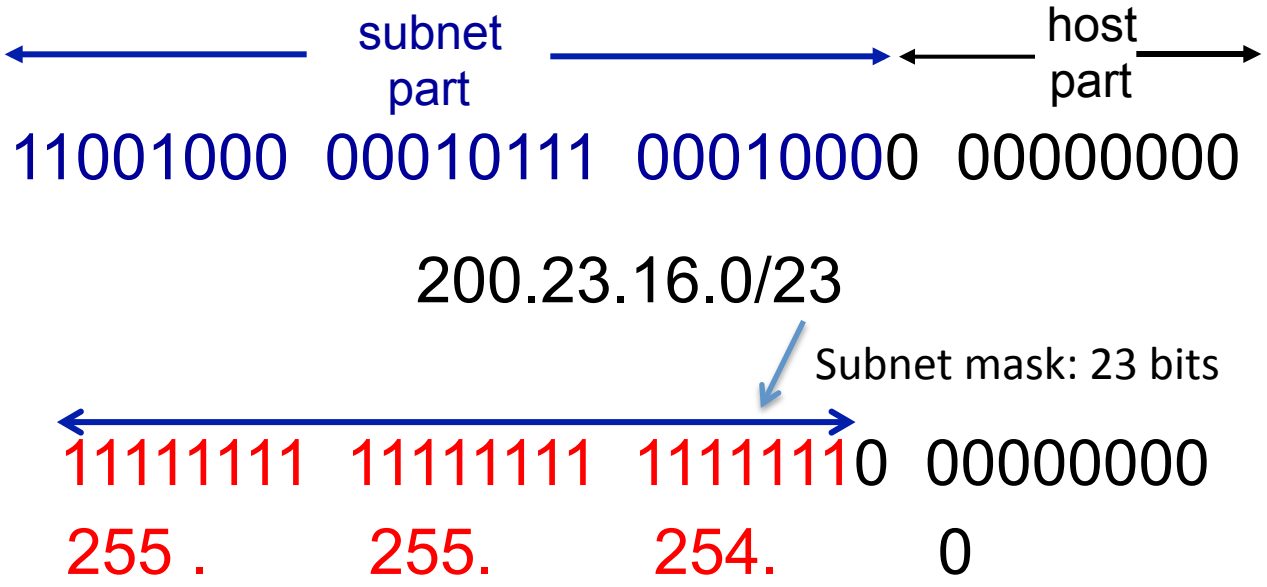
B. 24

C. 254

D. 256

Subnet mask

- Define the subnet part in # high order bits
  - Packets will be sent within the subnet without going to a router



The subnet mask of 255.255.255.224 (11111111.11111111.11111111.11100000) correspond to?

A. a.b.c.d/22

B. a.b.c.d/24

C. a.b.c.d/27

D. a.b.c.d/28

E. a.b.c.d/30

IP addresses: how to get one?

Q: How does a *host* get IP address?

- Manually assigned by users/administrators
- DHCP: Dynamic Host Configuration Protocol: dynamically get address from as server
  - "plug-and-play"

DHCP: Dynamic Host Configuration Protocol

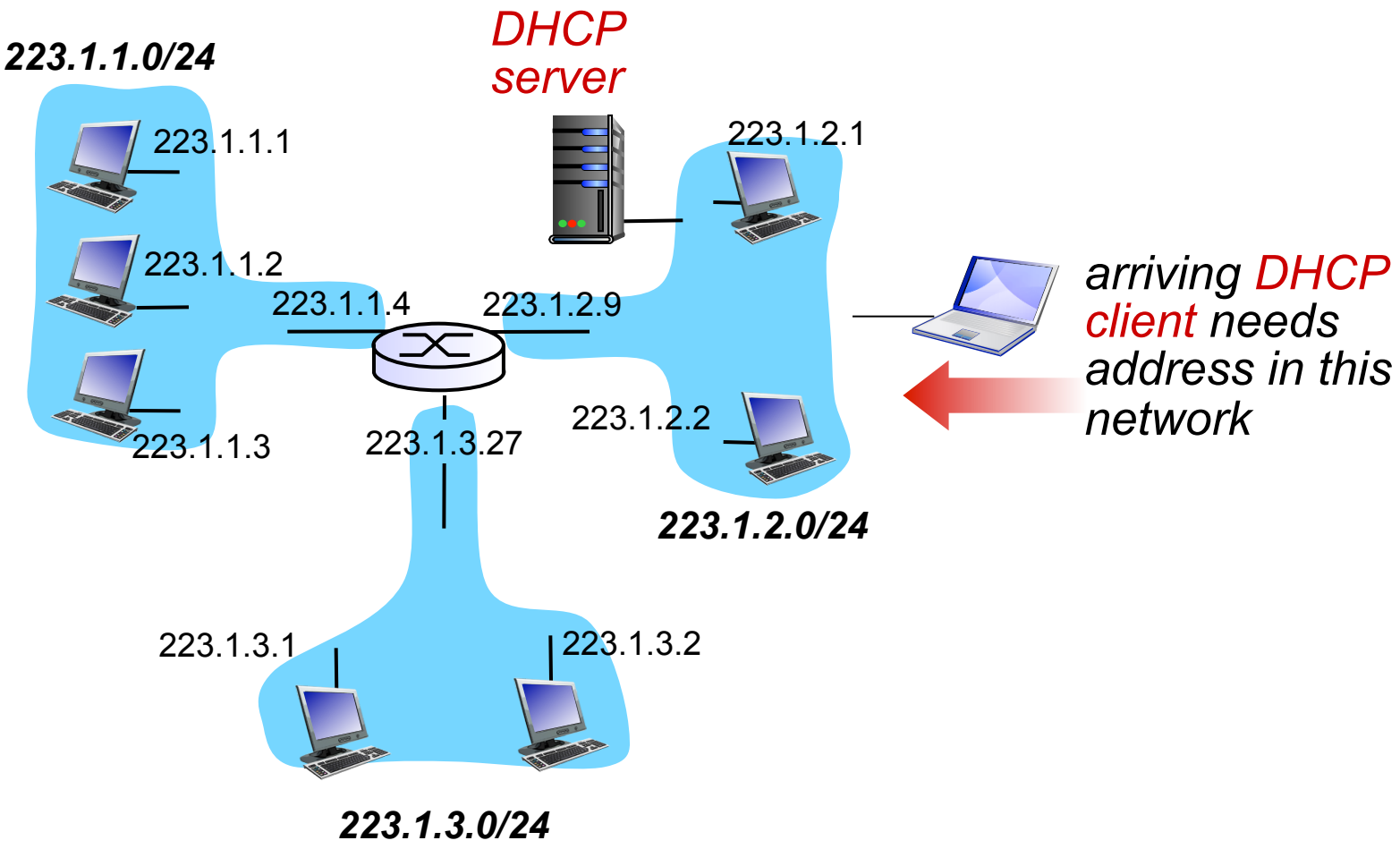
goal: allow host to *dynamically* obtain its IP address from network server when it joins network

- can renew its lease on address in use
- allows reuse of addresses (only hold address while connected/"on")
- support for mobile users who want to join network (more shortly)

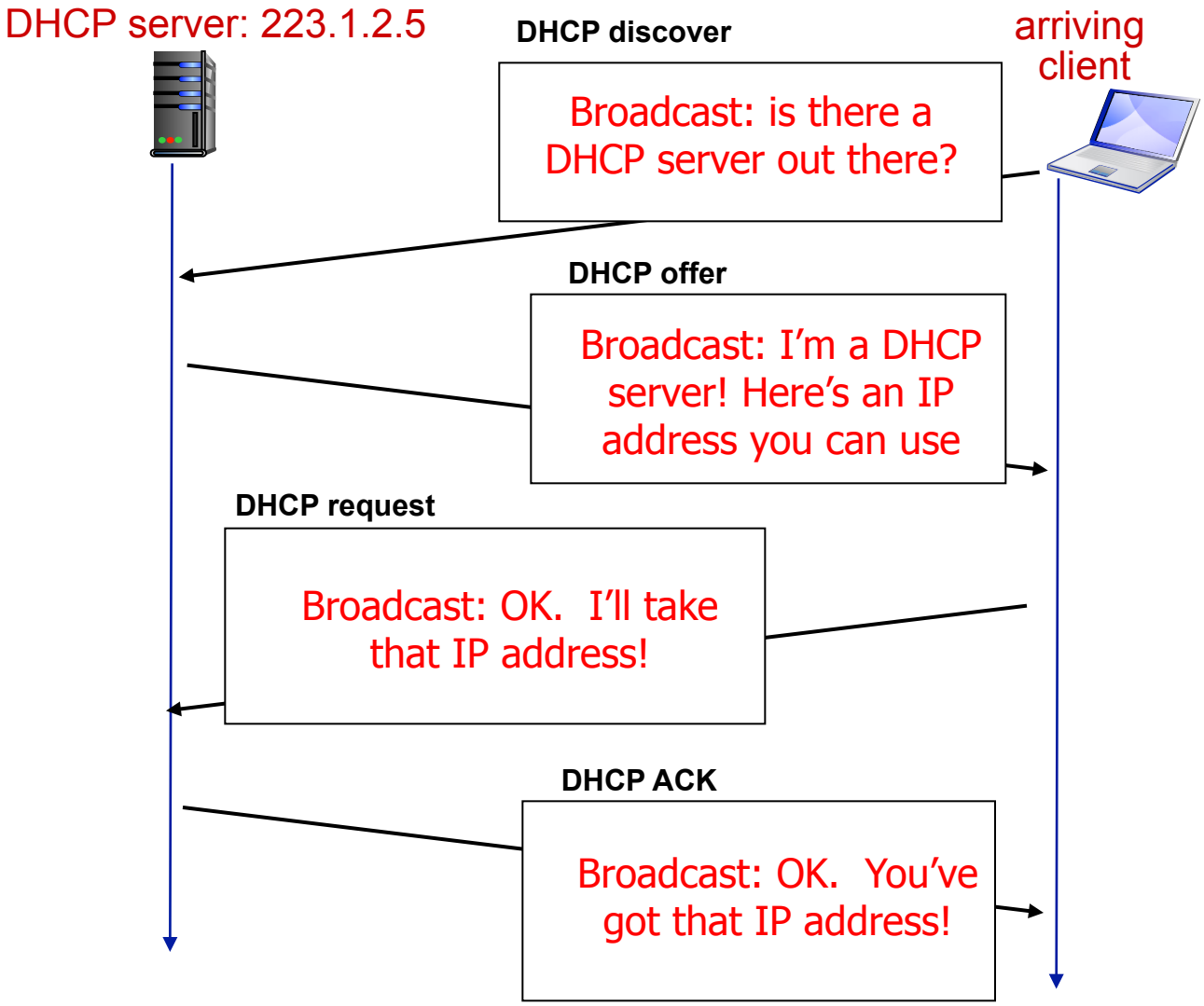
DHCP overview:

- host broadcasts "DHCP discover" msg [optional]
- DHCP server responds with "DHCP offer" msg [optional]
- host requests IP address: "DHCP request" msg
- DHCP server sends address: "DHCP ack" msg

DHCP client-server scenario



DHCP client-server scenario



DHCP: more than IP addresses

DHCP can return more than just allocated IP address on subnet:

- address of first-hop router for client
- name and IP address of DNS sever
- network mask (indicating network versus host portion of address)

IP addresses: how to get one?

Q: how does *network* get subnet part of IP addr?

A: gets allocated portion of its provider ISP's address space

ISP's block	11001000 00010111 00010000	00000000	200.23.16.0/20
Organization 0	11001000 00010111 00010000	00000000	200.23.16.0/23
Organization 1	11001000 00010111 00010010	00000000	200.23.18.0/23
Organization 2	11001000 00010111 00010100	00000000	200.23.20.0/23
...	.....	....	....
Organization 7	11001000 00010111 00011110	00000000	200.23.30.0/23

IP addressing: the last word...

Q: how does an ISP get block of addresses?

A: ICANN: Internet Corporation for Assigned Names and Numbers http://www.icann.org/

- allocates addresses
- manages DNS
- assigns domain names, resolves disputes

Assignment 4 progress

A. Almost done/submitted

B. >=75%

C. >=50%

D. >=25%

E. Something else

Next lecture

- Midterm exam discussion
- Assignment 4 demo