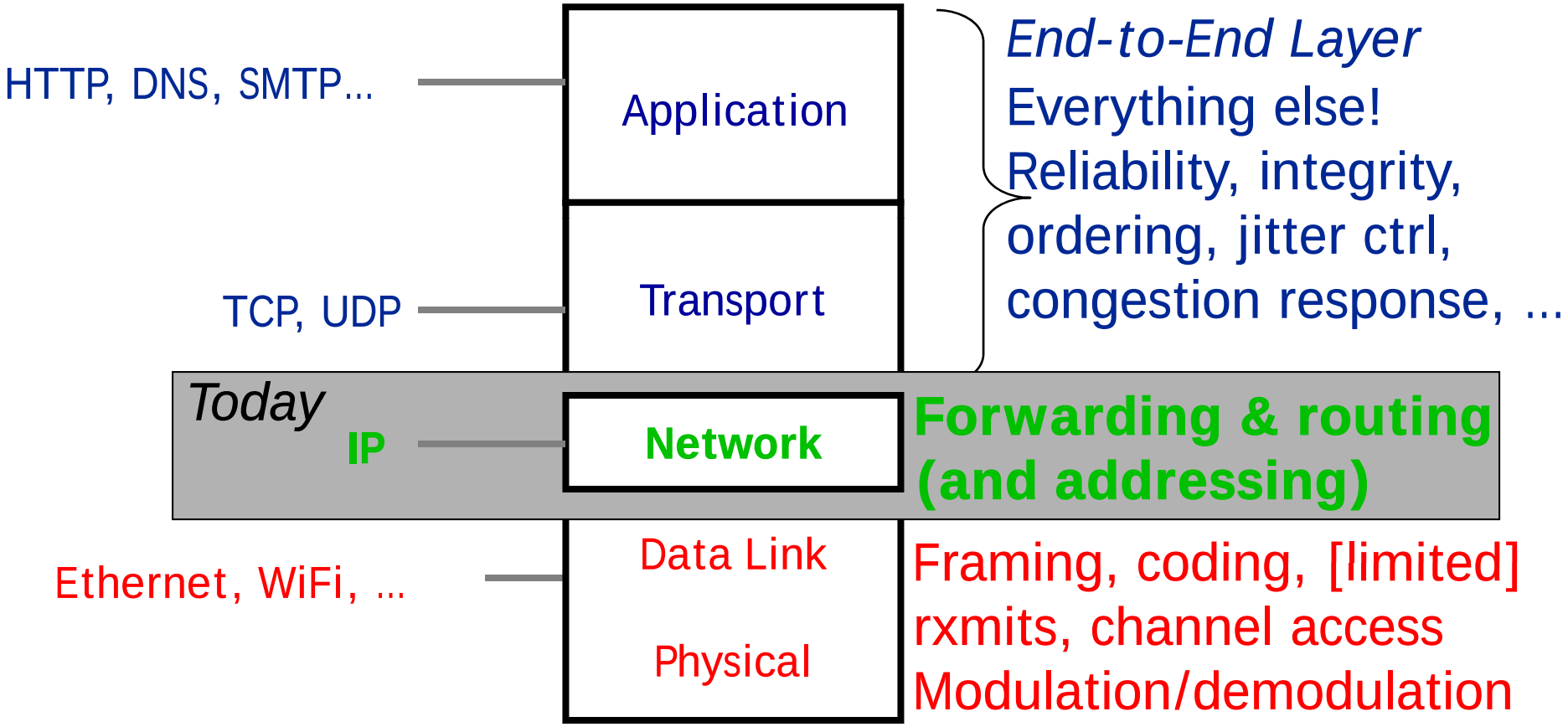
Network Layer I

Lecture 20

- Network layer functions
- forwarding and routing
- IP addresses

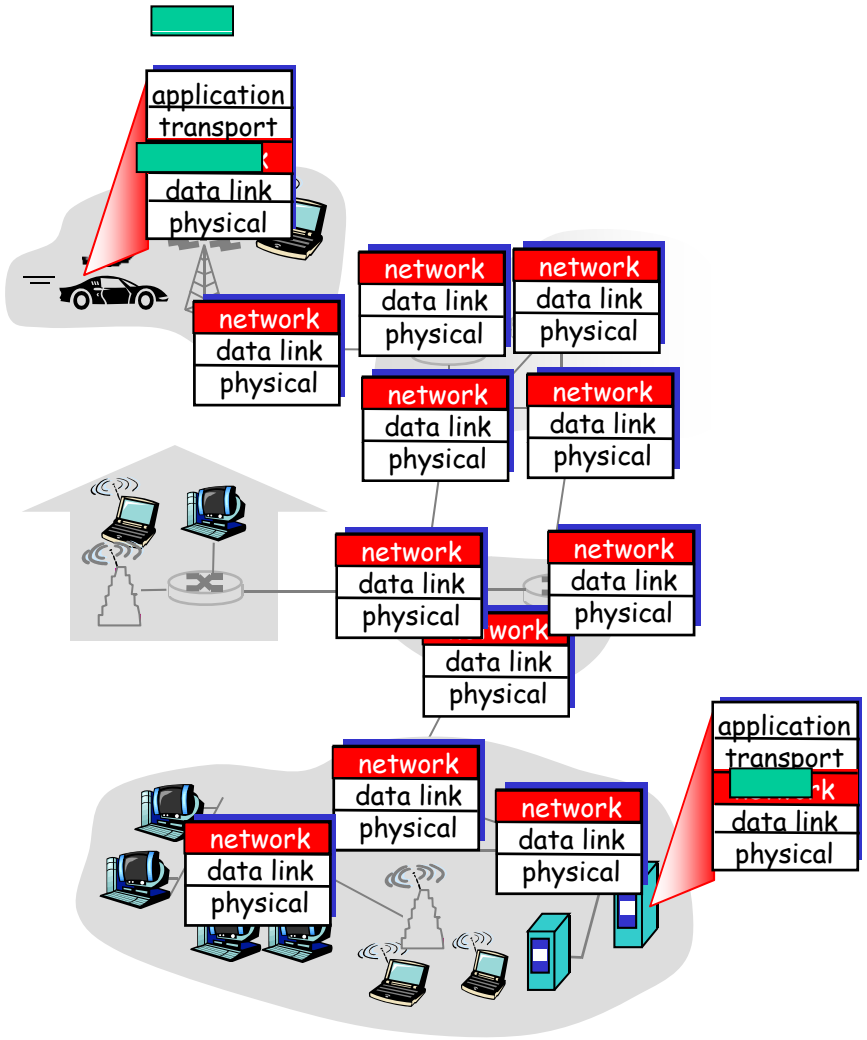
**The slides are adapted from ppt slides (in substantially unaltered form) available from "Computer Networking: A Top-Down Approach," 4th edition, by Jim Kurose and Keith Ross, Addison-Wesley, July 2007. Part of the materials are also adapted from MIT 6.02 course notes.*

Layering in the Internet



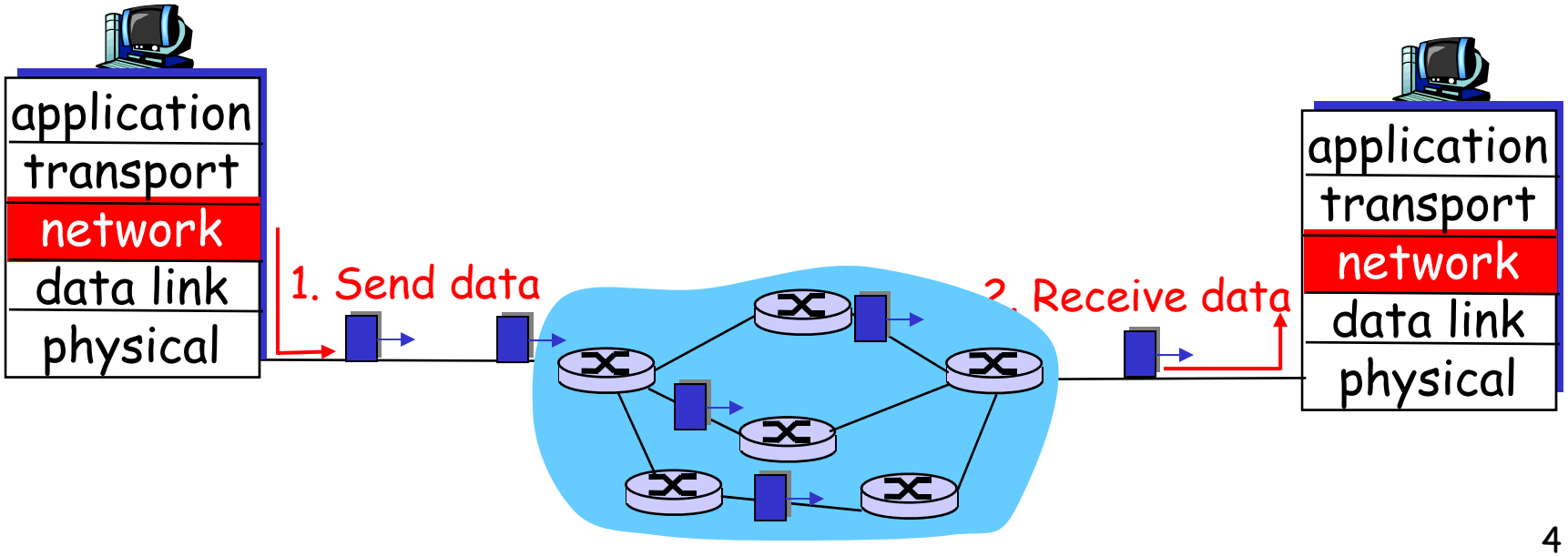
Network layer

- deliver "transport segment" from sending to receiving host
- on sending side encapsulates segments into datagrams
- on rcving side, passes segments to transport layer
- network layer protocols in hosts and routers
- router examines header fields in all datagrams passing through it



Datagram networks (e.g., Internet)

- no call setup at network layer
- packets forwarded using destination host address
  - packets between same source-dest pair are handled independently and may take different paths
- Internet Protocol (IP) – Network Layer of Internet
  - IP datagram or IP packet is the unit of transfer



Two Key Network-Layer Functions

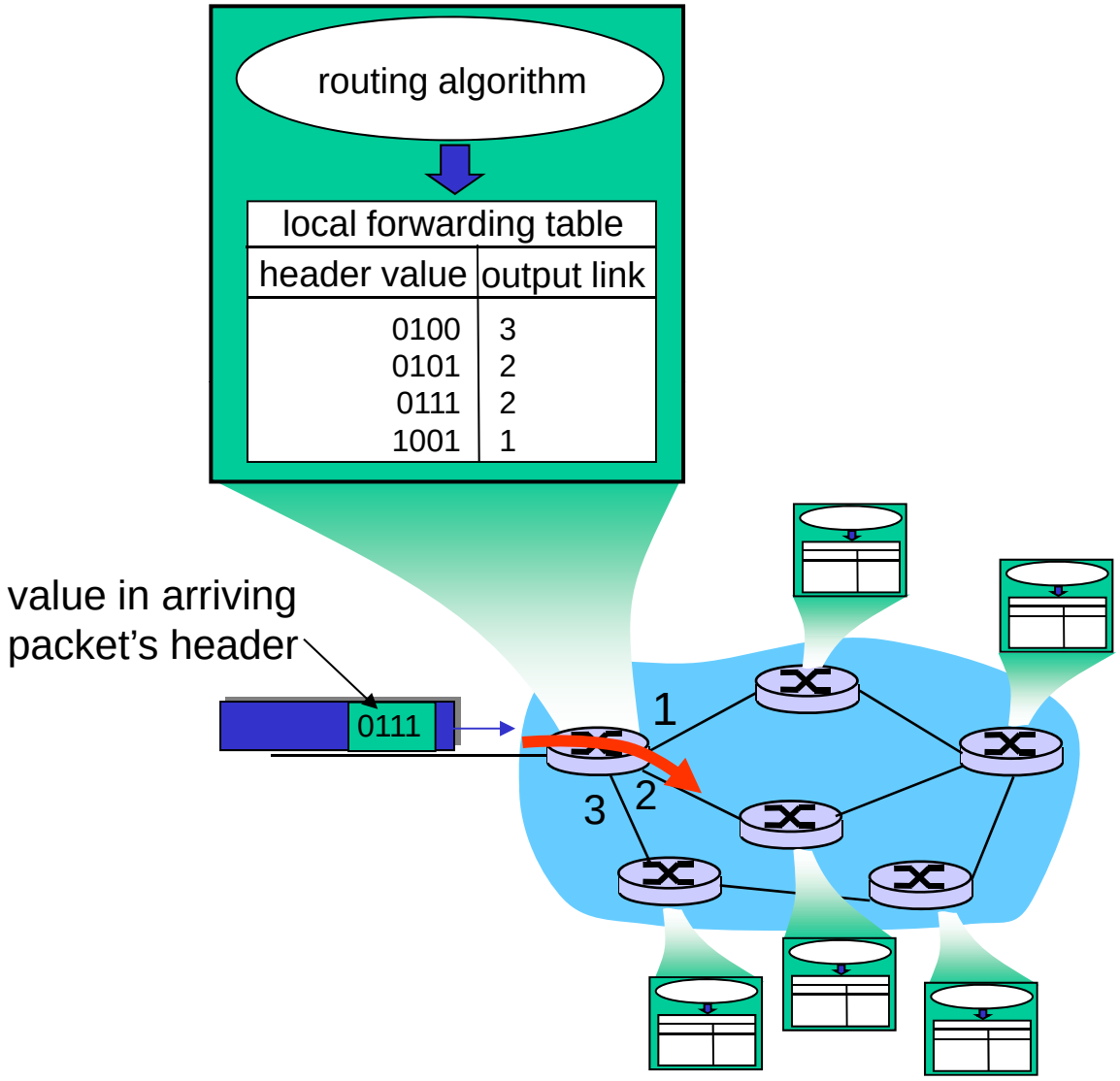
- *routing:* determine route taken by packets from source to dest.
  - *different routing algorithms*
- *forwarding:* move packets from router's input to appropriate router output

analogy:

- routing: process of planning trip from source to dest
- forwarding: process of getting through single interchange

Interplay between routing and forwarding

- *forwarding:* move packets from router's input to appropriate router output
- *routing:* determine route taken by packets from source to dest.
  - *routing algorithms create the forwarding table*



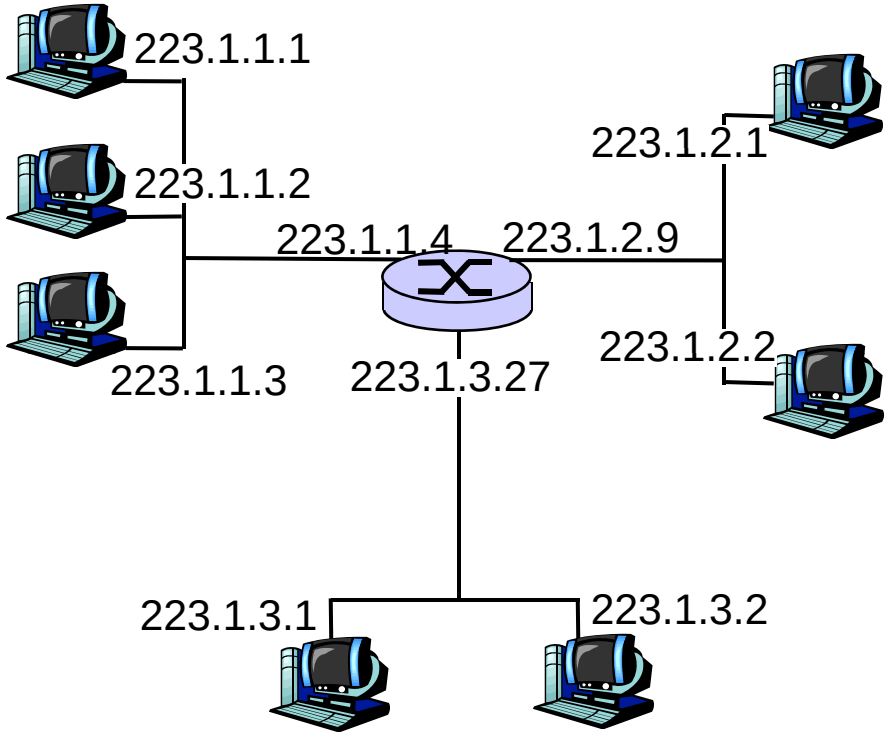
What is an IP Address?

- An IP address is a unique global address for a network interface

- An IP address:
  - is a **32 bit long** identifier
  - encodes a network number (**network prefix**) and a **host number**

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 interface
  - IP addresses associated with each interface

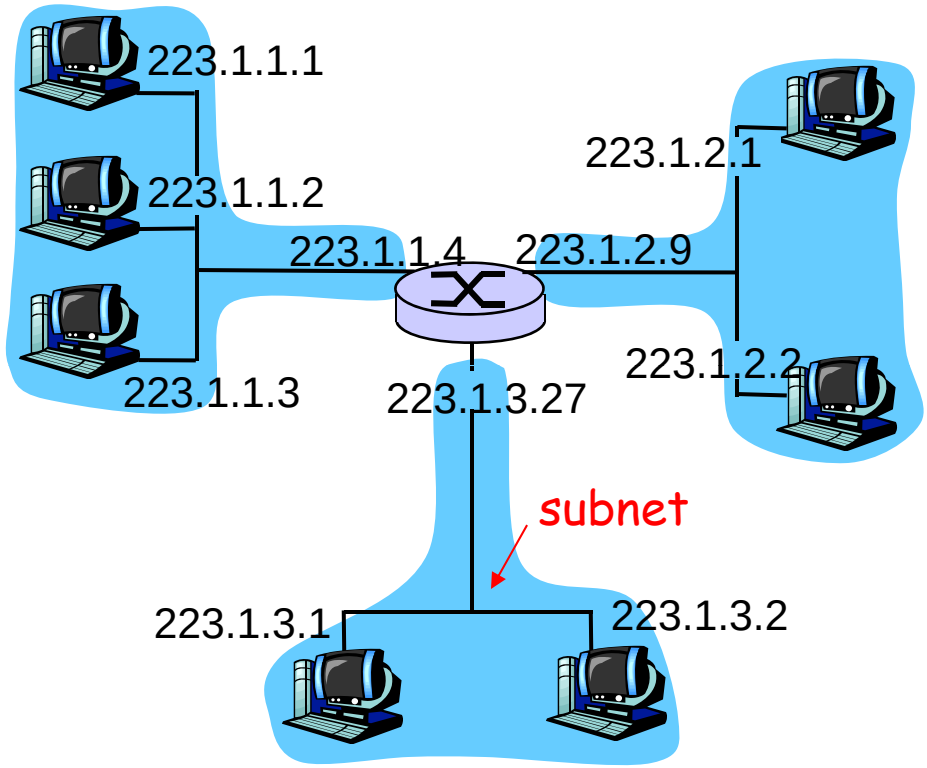


223.1.1.1 = 11011111 00000001 00000001 00000001

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

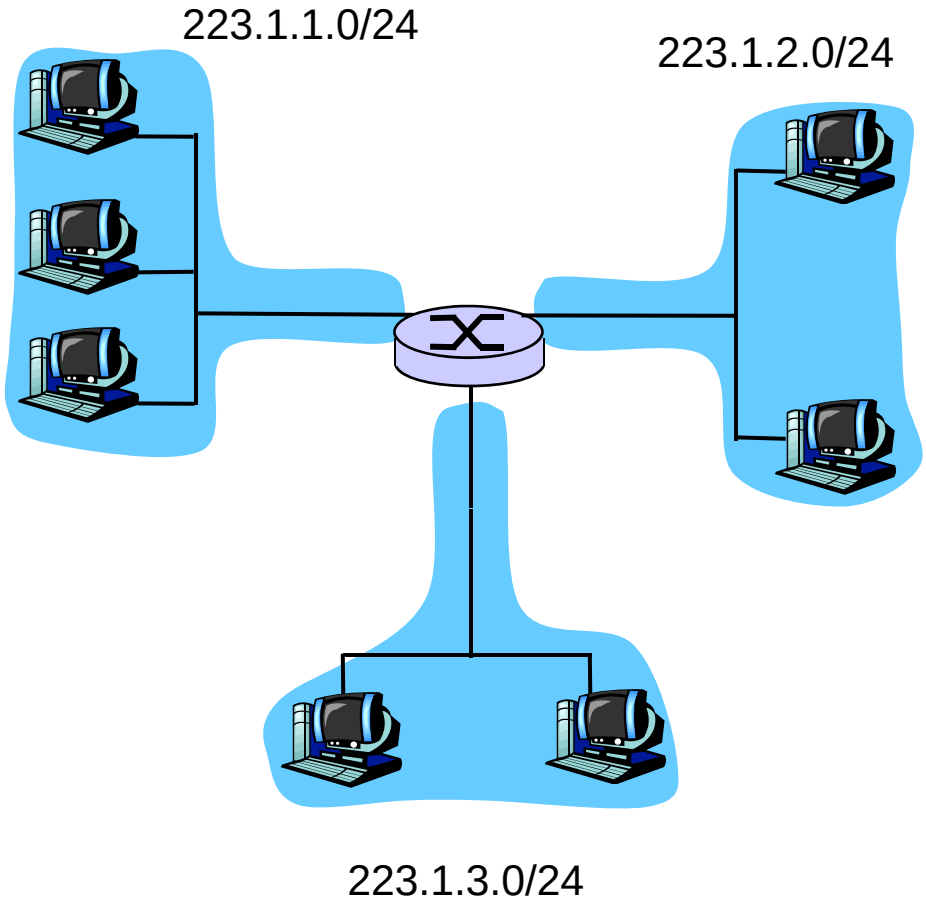


network consisting of 3 subnets

Subnets

Recipe

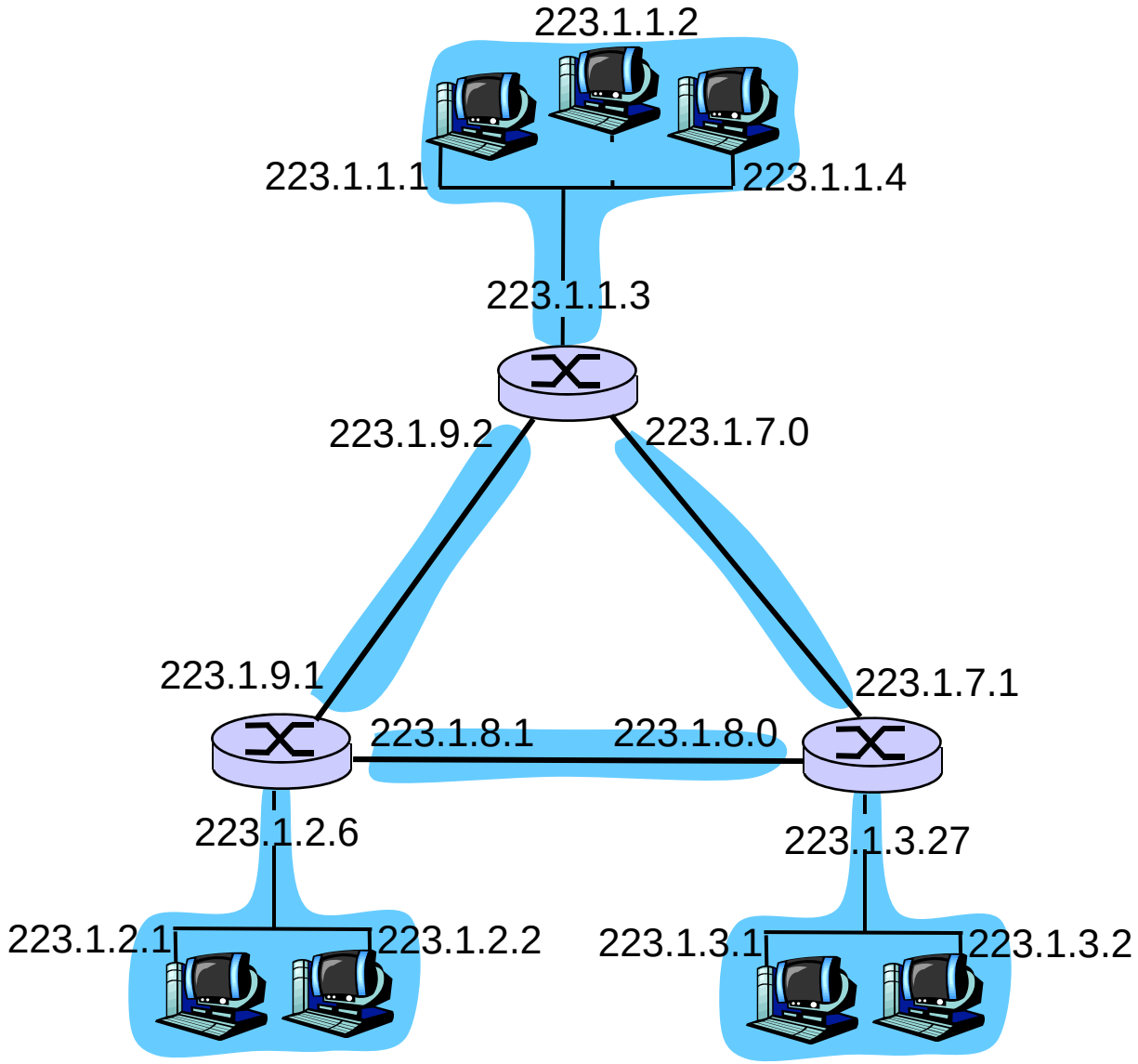
- To determine the subnets, detach each interface from its host or router, creating islands of isolated networks. Each isolated network is called a subnet.



Subnet mask: /24

Subnets

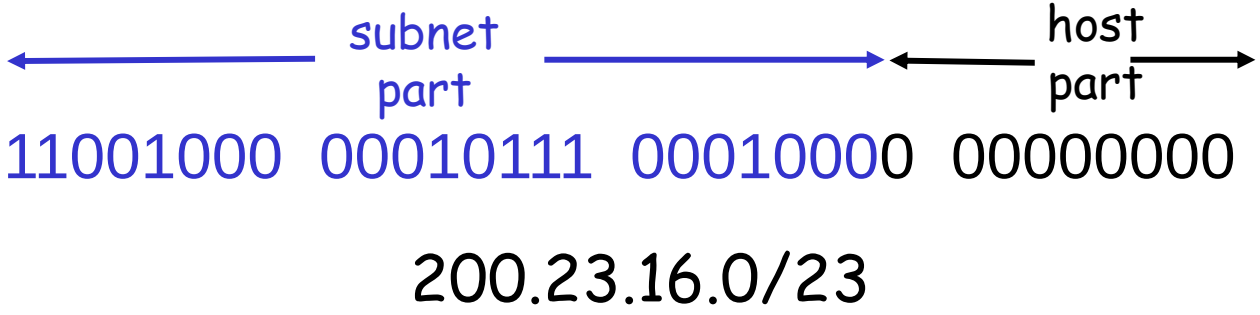
How many?



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

IP addresses: how to get one?

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

- hard-coded by system admin in a file
  - Windows: control-panel->network->configuration->tcp/ip->properties
  - UNIX: /etc/rc.config
- 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 an "on")
- Support for mobile users who want to join network (more shortly)

DHCP overview:

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

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

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

IPv6 - IP Version 6

- Initial motivation: 32-bit address space soon to be completely allocated.
- **IPv4** has a maximum of
  - $2^{32} \approx$ 4 billion addresses
- IPv6 datagram format:
  - fixed-length 40 byte header
- **IPv6** has a maximum of
  - **$2^{128} = (2^{32})^4 \approx$ 4 billion x 4 billion x 4 billion x 4 billion addresses**
- Additional motivation:
  - header format helps speed processing/forwarding
  - header changes to facilitate QoS

Summary

- The network layer implements the "glue" that achieves connectivity
  - Does addressing, forwarding, and routing
- Forwarding entails a routing table lookup
- IP address is a unique identifier to allow delivery of the datagram from its destination to its source
- IP Addressing involves CIDR and networks and sub-networks