ACIT 2620

Principles of Enterprise Networking

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Internet Protocol Version 4

TCP/IP Suite

- Internet Protocol (IP)

- Routing Protocols (Used in routing table generation)

- Dynamic Host Configuration Protocol (DHCP)

- Transport Control Protocol (TCP)

- User Datagram Protocol (UDP)

- Internet Control Message Protocol (ICMP)

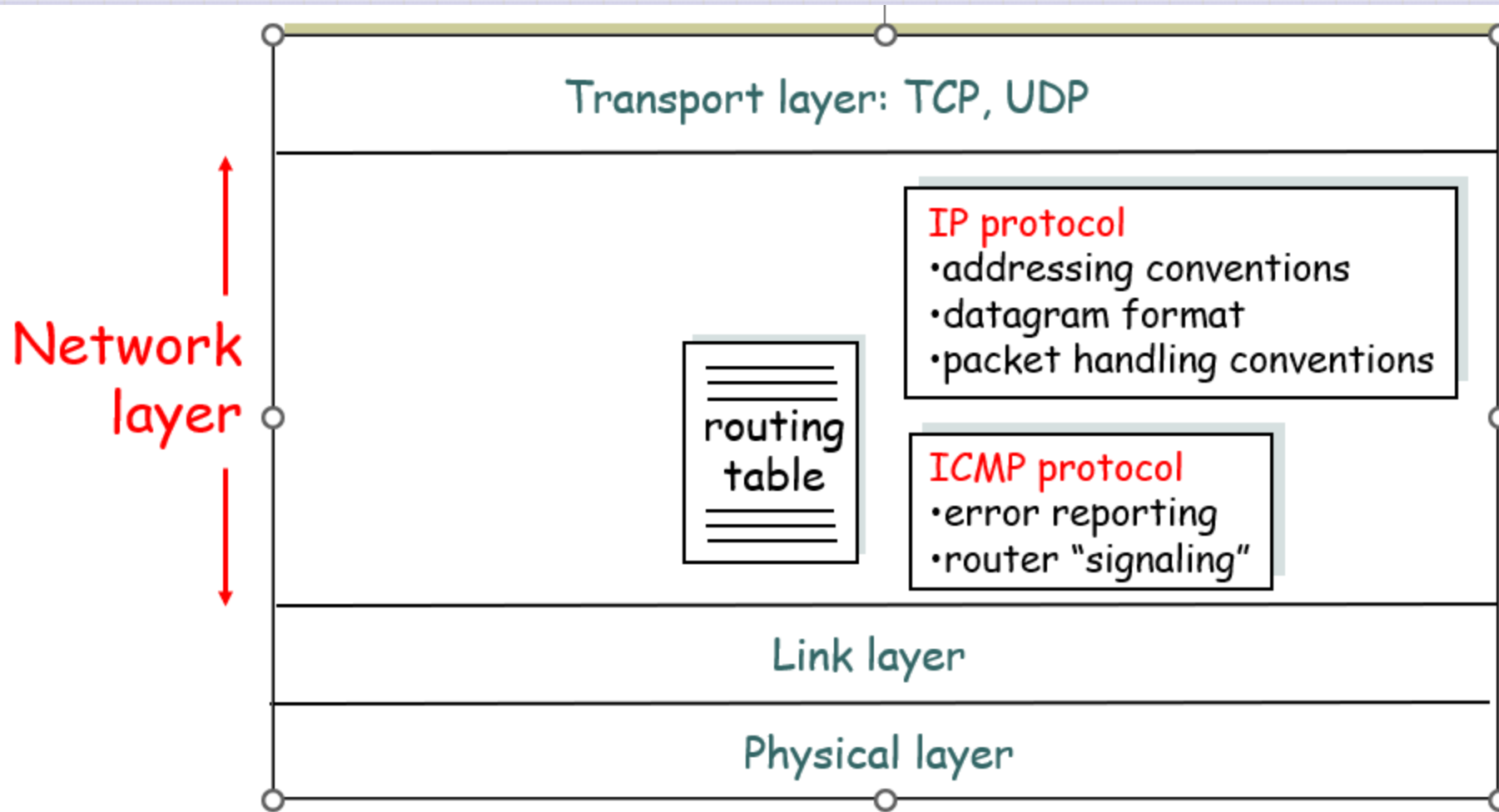- Address Resolution Protocol (ARP)

Recap: Data-link layer

- Generally Ethernet

- Handles the movement of data between nodes on the same link

- Present on every network device

- Data Link Specific Devices: bridge, hub, switch

Network Layer

- **Goal**: move packets for source to destination
  - **Path Determination**:

    the calculation of the route taken by packets -> routing

  - **Forwarding**:

    The movement of a packet from one network to the next appropriate network

Network Layer functions

Transport layer: TCP, UDP

Network layer

IP protocol
- addressing conventions
- datagram format
- packet handling conventions

routing table

ICMP protocol
- error reporting
- router "signaling"

Link layer

Physical layer

Internet Protocol (IP)

- Provides information about how and where data should be delivered

- Responsible for **internetworking** (from where the term internet is derived)

- To internetwork is to traverse more than one LAN segment and more than one type of network through a router

- In an internetwork, the individual networks that are joined together are called subnetworks

- IP is an unreliable, connectionless protocol, which means it does not guarantee delivery of data

- i.e IP will service a request without requesting verified session and without guaranteeing delivery of data, making it simpler and faster

IP Addressing

- **IP address**: 32-bit identifier for host, router interface

- **interface**: connection between host, router and physical link
  - routers typically have multiple interfaces
  - host may have multiple interfaces
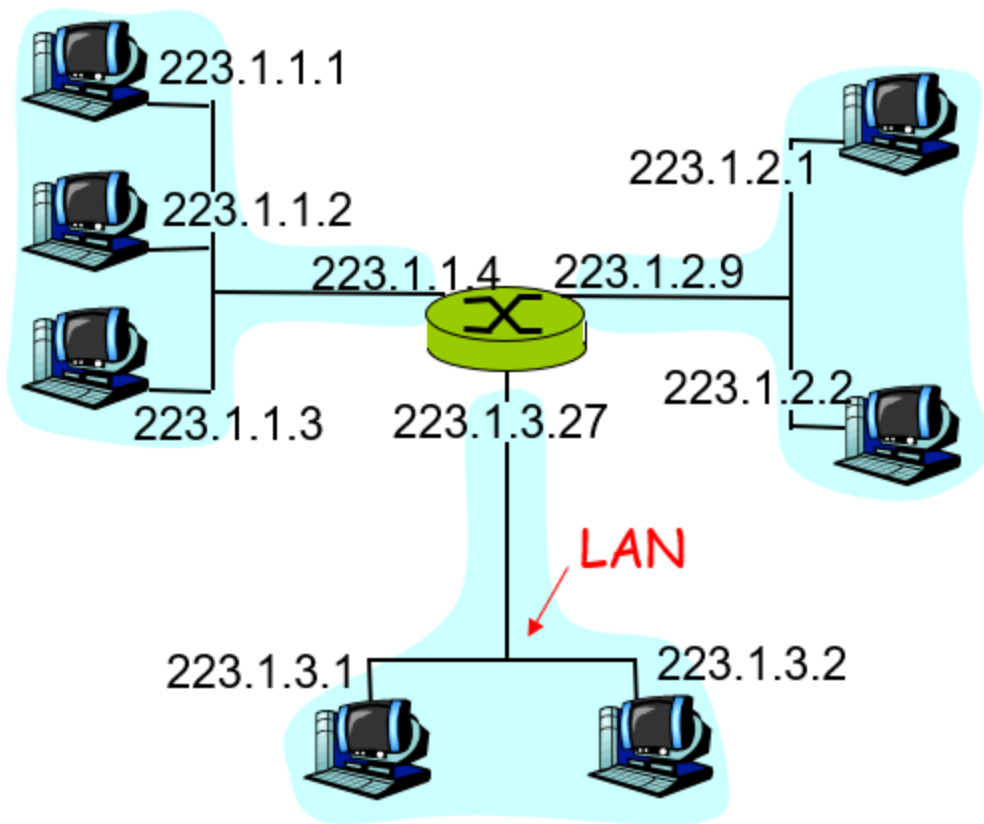 - IP addresses associated with interface, not host, router
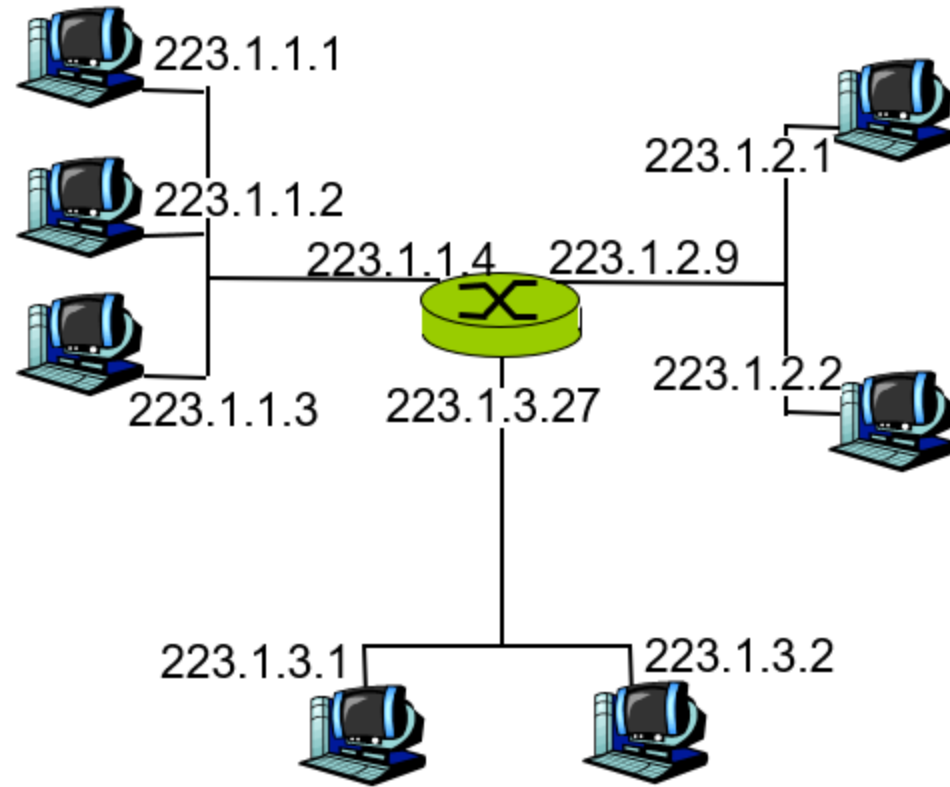
223.1.1.1 = 11011111 00000001 00000001 00000001

223   1   1   1

Components of an IP address

- network part (high order bits)
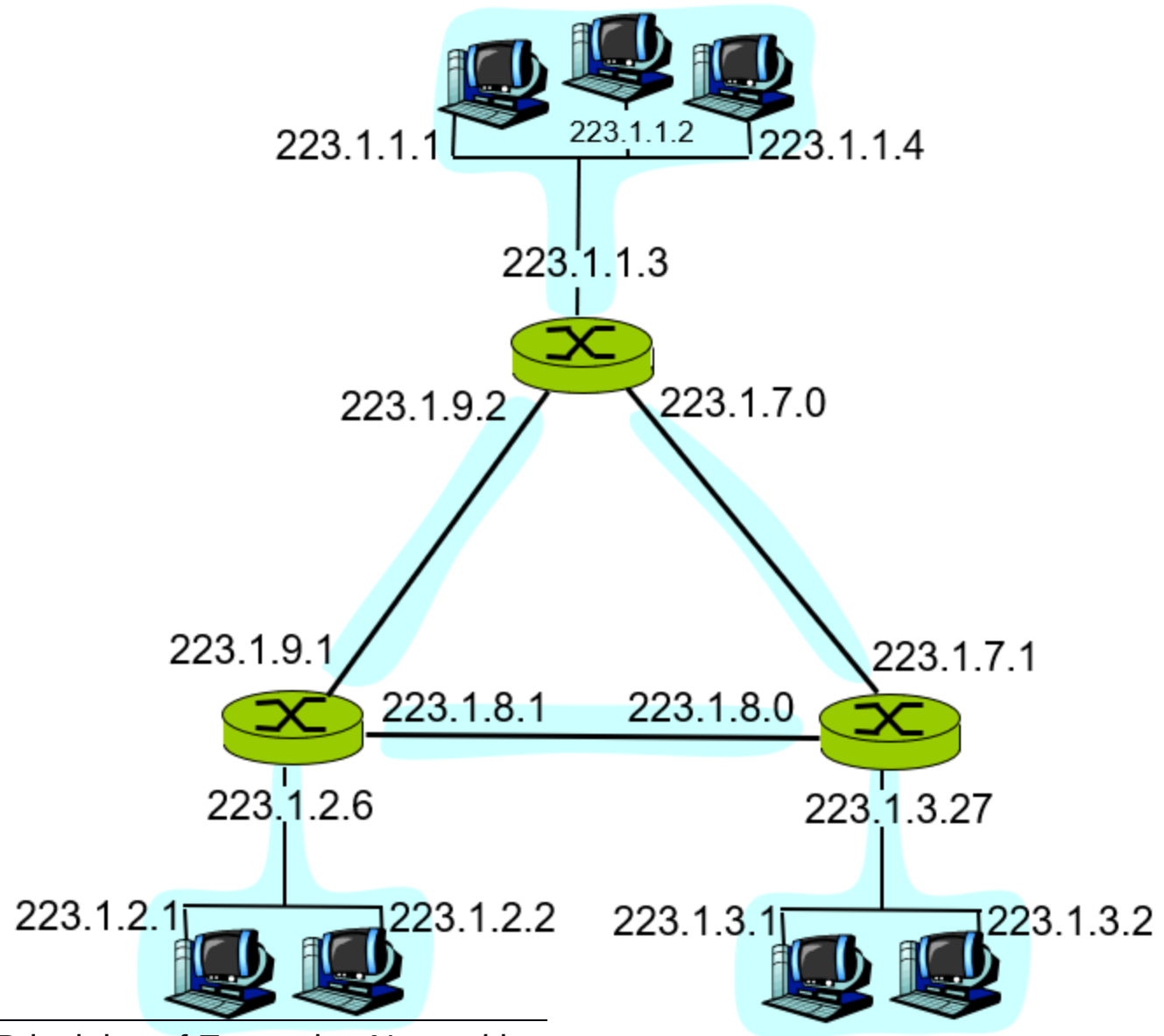
- host part (low order bits)

IP Network

- device interfaces with same network part of IP address

- can physically reach each other without intervening router

network consisting of 3 IP networks
(for IP addresses starting with 223,
first 24 bits are network address)

How many networks do you see?

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IP Address Space

"class-full" addressing:

class

|			
A	0 network	host	1.0.0.0 to 127.255.255.255
B	10 network	host	128.0.0.0 to 191.255.255.255
C	110 network	host	192.0.0.0 to 223.255.255.255
D	1110 multicast address		224.0.0.0 to 239.255.255.255

← 32 bits →

IP range notations

- **CIDR**: Classless Inter Domain Routing
    - network portion of address of arbitrary length
    - address format: `a.b.c.d/x` , where `x` is # of bits in network portion of address
    - Also written as address + subnet mask
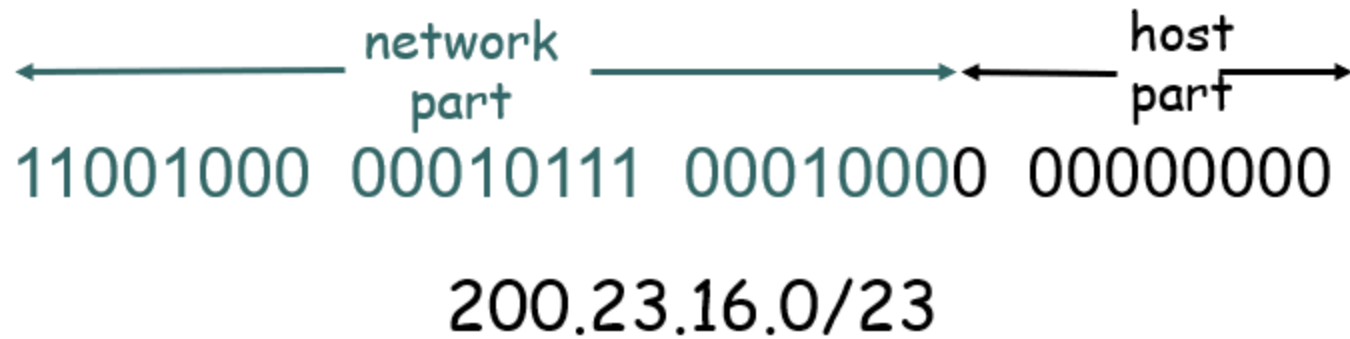
- CIDR using Subnet Mask
  - Usually written in dotted decimal notation reminiscent of an IP address

Using mask 255.255.255.0
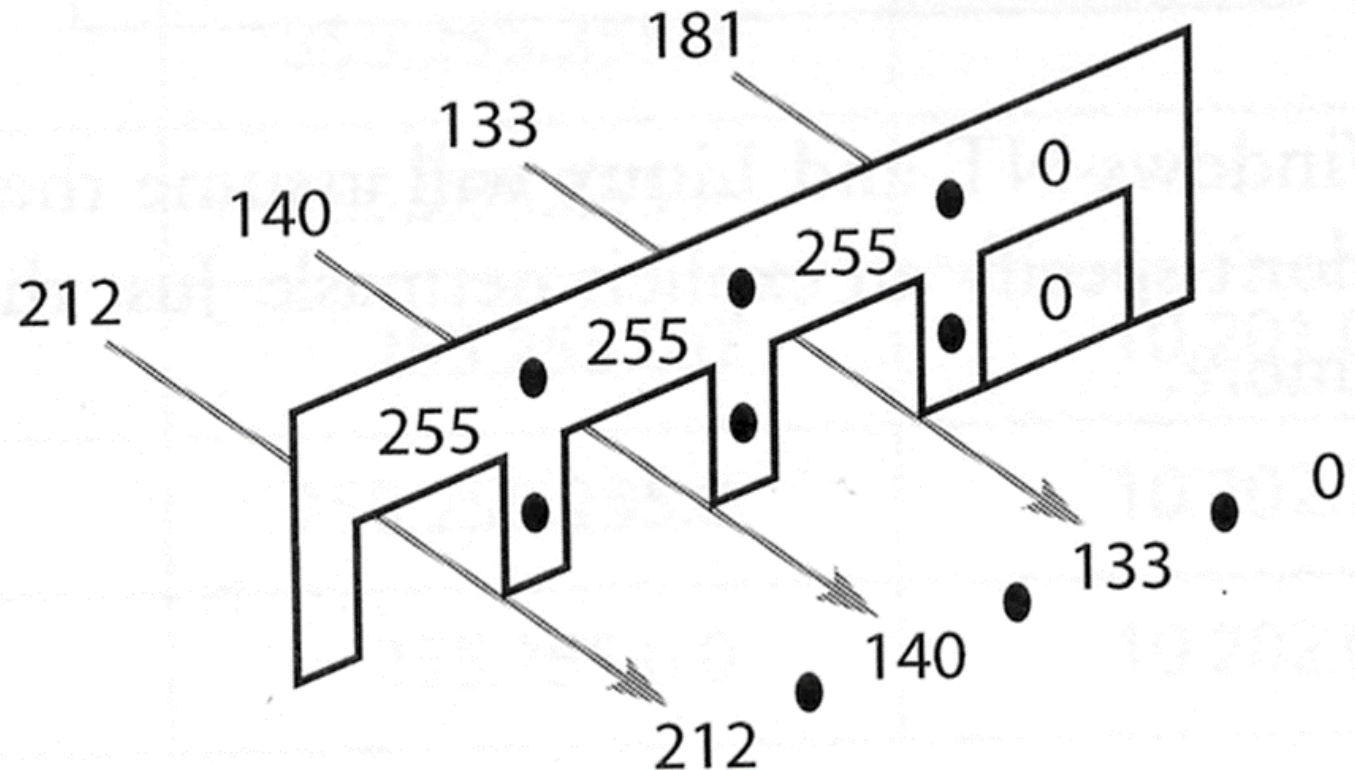
Special Addresses

- Private IP Addresses
  - 10.0.0.0 -> 10.255.255.255
  - 172.16.0.0 -> 172.31.255.255
  - 192.168.0.0 -> 192.168.255.255

- Documentation IP Addresses
  - 192.0.2.0 -> 192.0.2.255
- Self-Configured IP Addresses (often DHCP Failure)
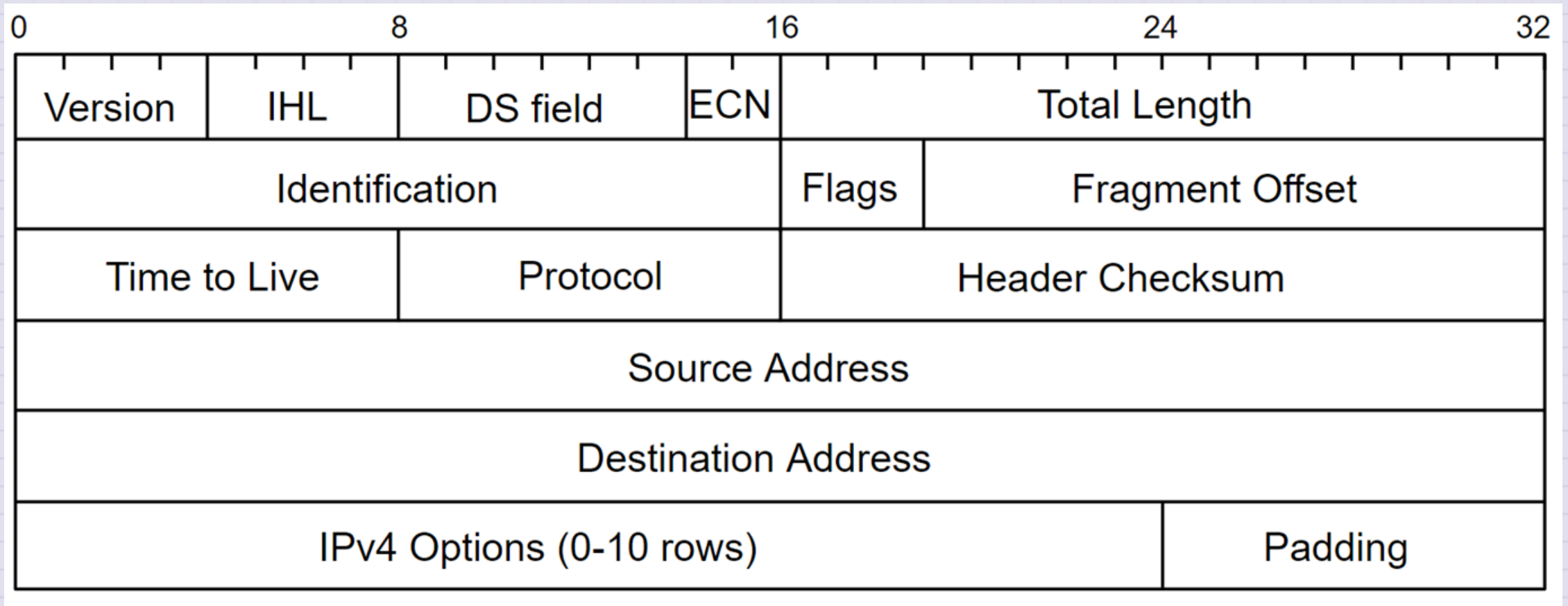 - 169.254.0.0 -> 169.254.255.255

- Unknown Address
  - 0.0.0.0

- Loopback Address
  - 127.0.0.1 (actually, 127.0.0.0/8)

- Network Address (All host bits set to 1)
  - E.g: 192.168.1.0, Subnet Mask = 255.255.255.0

Broadcasting and Multicasting

- Limited Broadcast
  - 255.255.255.255
  - Transmitted only on local segment -> not routed
- Network Broadcast Address
  - Network Address + All host bits set to one
    - Network Address = 192.168.1.x
    - Network Broadcast Address = 192.168.1.255

- Multicast Address
  - Lie within the 224.0.0.0 /4 network
  - http://www.iana.org/assignments/multicast-addresses

IPv4 Header

Version	IHL	DS field	ECN	Total Length			
Identification				Flags	Fragment Offset		
Time to Live		Protocol		Header Checksum			
Source Address							
Destination Address							
IPv4 Options (0-10 rows)						Padding	

IPv4 routing: the basics

routing table in A

Dest. Net.	next router	Nhops
223.1.1		1
223.1.2	223.1.1.4	2
223.1.3	223.1.1.4	2

IP datagram:

misc fields	source IP addr	dest IP addr	data

- datagram remains unchanged, as it travels source to destination
- addr fields of interest here
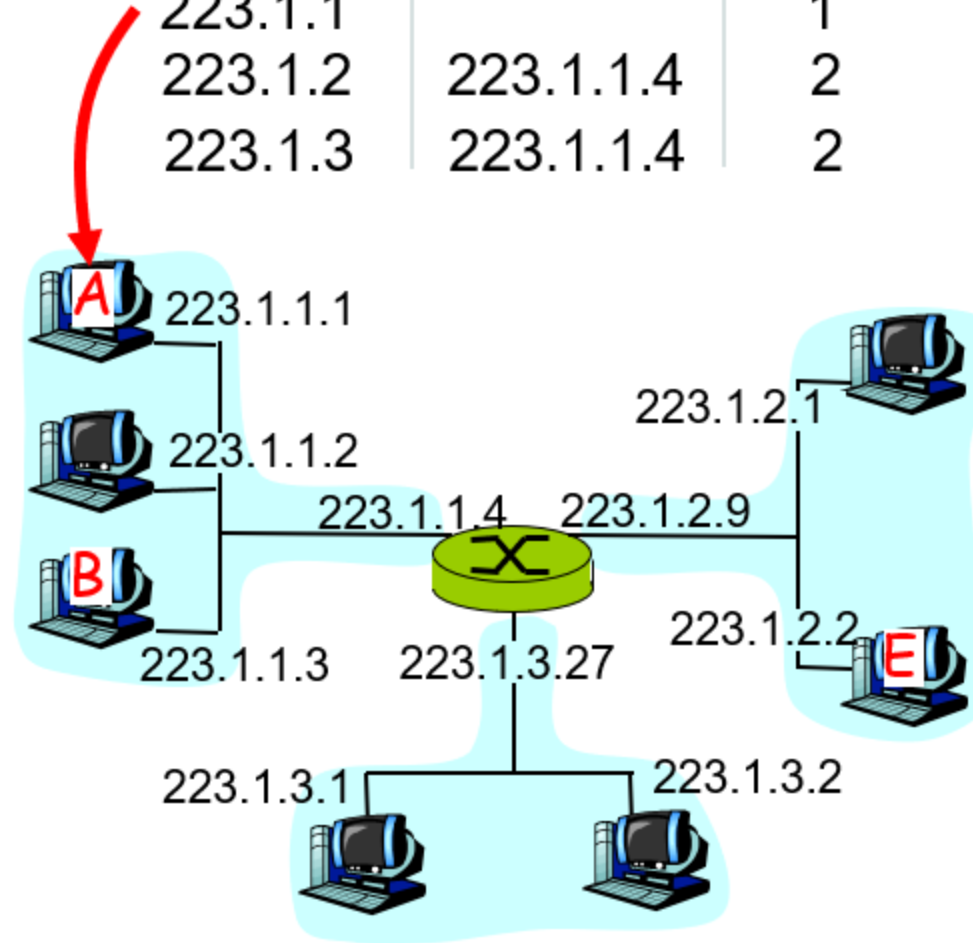
misc fields	223.1.1.1	223.1.1.3	data

Dest. Net.	next router	Nhops
223.1.1		1
223.1.2	223.1.1.4	2
223.1.3	223.1.1.4	2

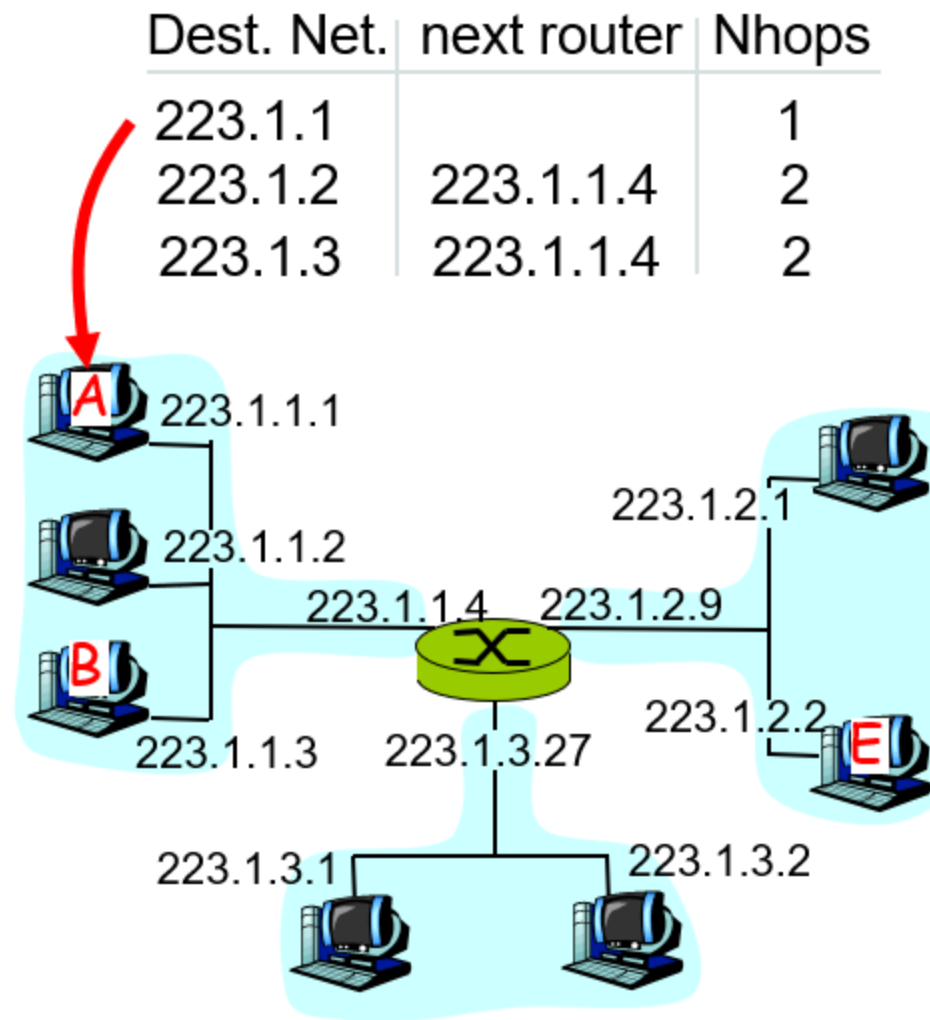Starting at A, given IP datagram addressed to B:

- look up net. address of B
- find B is on same net. as A
- link layer will send datagram directly to B inside link-layer frame
  - B and A are directly connected

A 223.1.1.1

223.1.1.2

223.1.1.4   223.1.2.9

B 223.1.1.3   223.1.3.27

223.1.2.1

223.1.2.2 E

223.1.3.1   223.1.3.2

misc fields	223.1.1.1	223.1.2.2	data

Dest. Net.	next router	Nhops
223.1.1		1
223.1.2	223.1.1.4	2
223.1.3	223.1.1.4	2
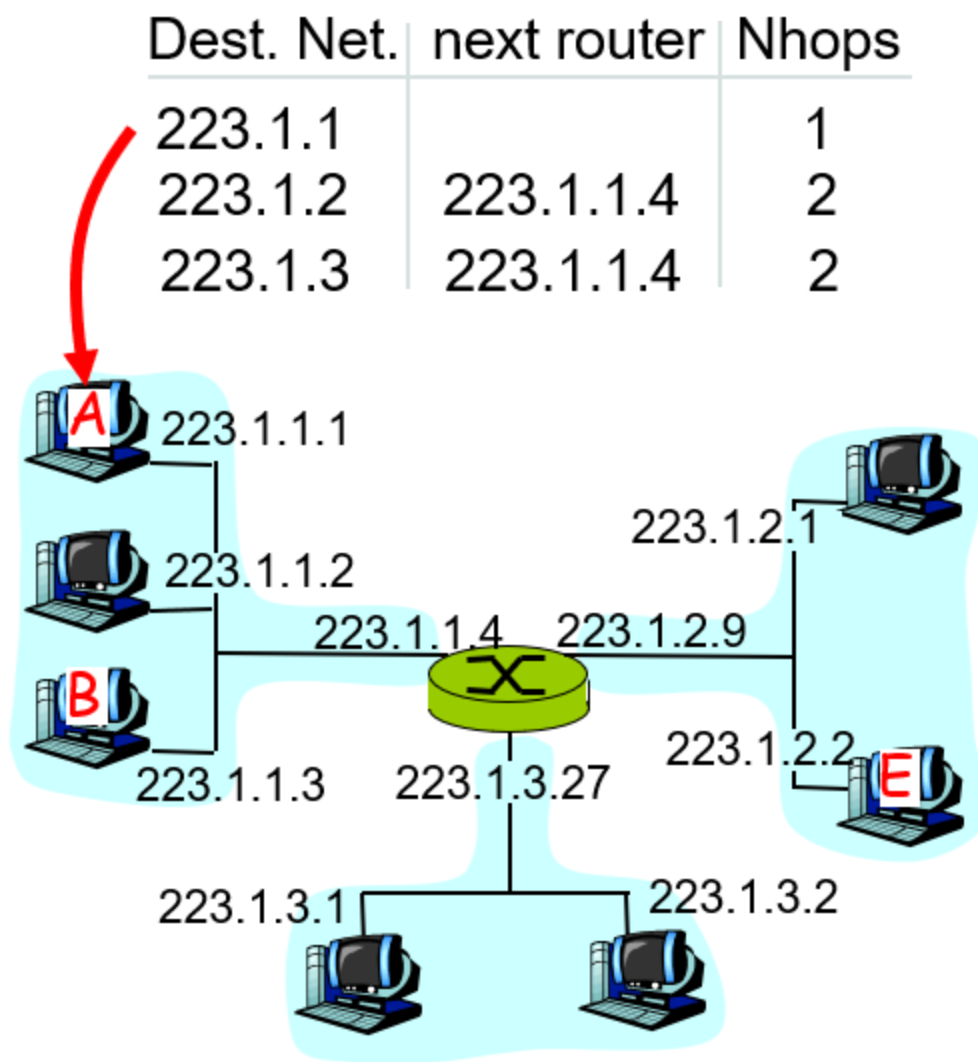
Starting at A, dest. E:

- look up network address of E
- E on *different* network
  - A, E not directly attached
- routing table: next hop router to E is 223.1.1.4
- link layer sends datagram to router 223.1.1.4 inside link-layer frame
- datagram arrives at 223.1.1.4
- continued…..

A   223.1.1.1
223.1.1.2
B
223.1.1.3   223.1.3.27
223.1.1.4   223.1.2.9
223.1.2.1
223.1.2.2   E
223.1.3.1   223.1.3.2

misc fields	223.1.1.1	223.1.2.2	data

Dest. network	next router	Nhops	interface
223.1.1	-	1	223.1.1.4
223.1.2	-	1	223.1.2.9
223.1.3	-	1	223.1.3.27

Arriving at 223.1.4, destined for 223.1.2.2

- look up network address of E
- E on *same* network as router's interface 223.1.2.9
  - router, E directly attached
- link layer sends datagram to 223.1.2.2 inside link-layer frame via interface 223.1.2.9
- datagram arrives at 223.1.2.2!!! (hooray!)

223.1.1.1 A
223.1.1.2
223.1.1.4 223.1.2.9
223.1.1.3 B
223.1.3.27
223.1.2.1
223.1.2.2 E
223.1.3.1 223.1.3.2
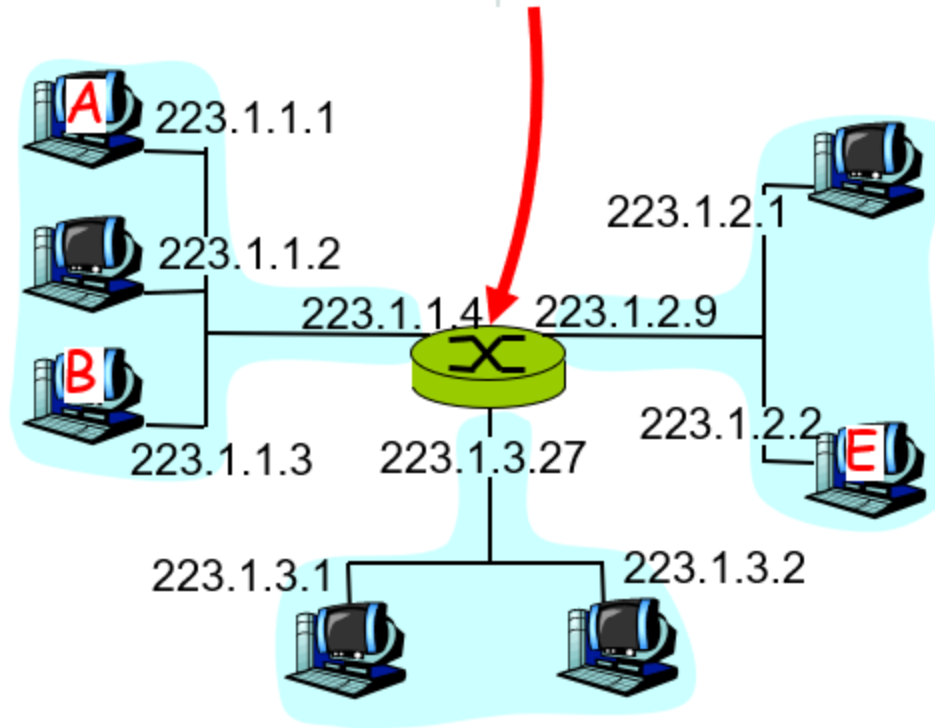
Next: IPv4 subnetting

Reading List

- IPv4 Subnets