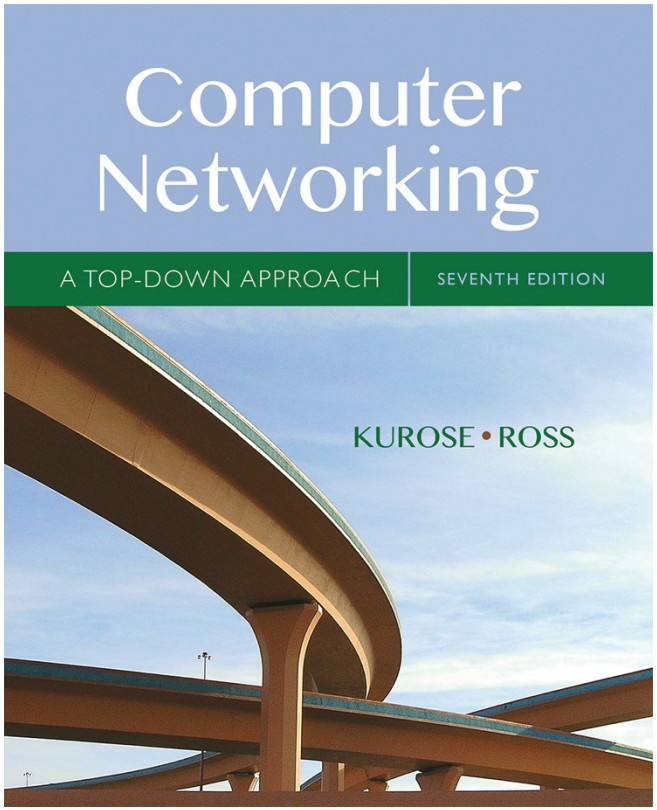
Chapter 4
Network Layer: The Data Plane



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Thanks and enjoy! JFK/KWR

Computer Networking: A Top Down Approach

7th edition
Jim Kurose, Keith Ross
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Minor modifications made to original slides by Nathan Bowman

Chapter 4: outline

4.1 Overview of Network layer
- data plane
- control plane

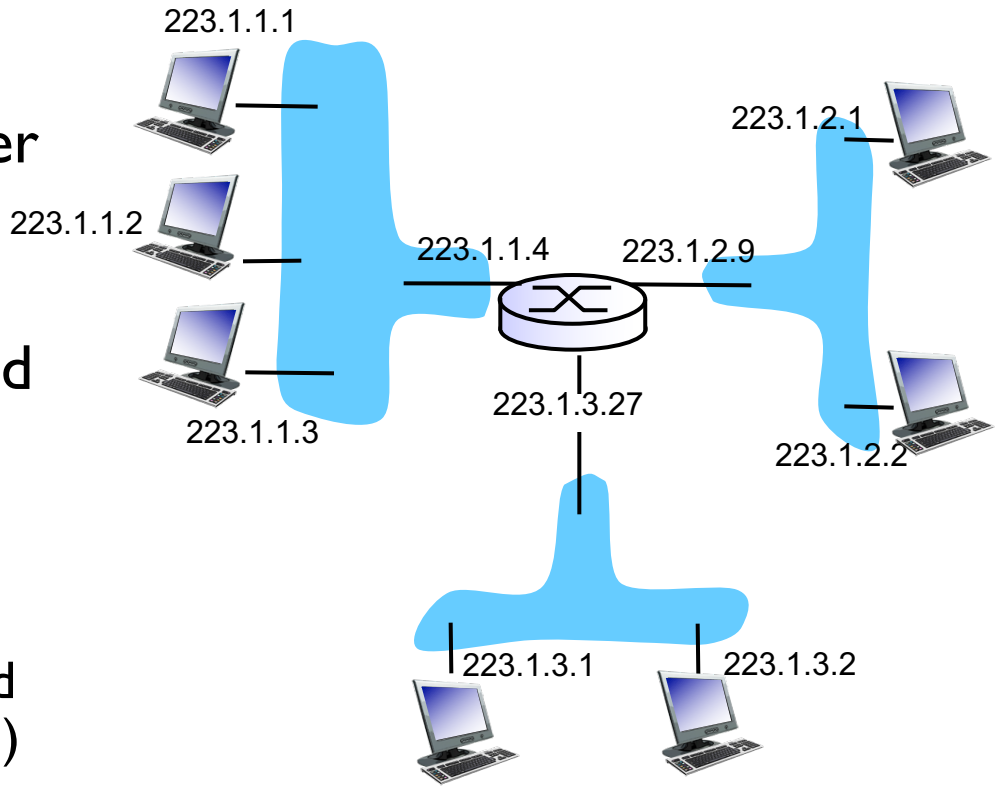
4.2 What's inside a router

4.3 IP: Internet Protocol
- datagram format
- fragmentation
- IPv4 addressing
- network address translation
- IPv6

4.4 Generalized Forward and SDN
- match
- action
- OpenFlow examples of match-plus-action in action

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*

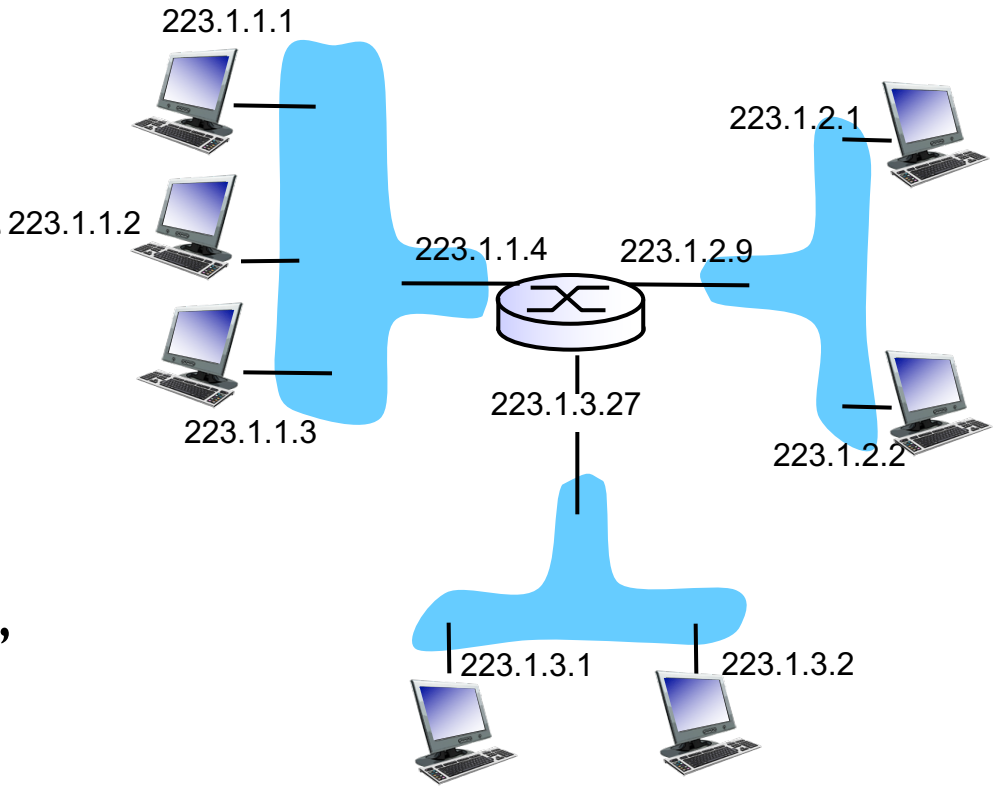


223.1.1.1 = 11011111 00000001 00000001 00000001

223 1 1 1

IP addressing: introduction

- 32 bits is 4 bytes
- Each byte representable as number 0 - 255
- IP address usually represented for human convenience as four numbers separated by '.'



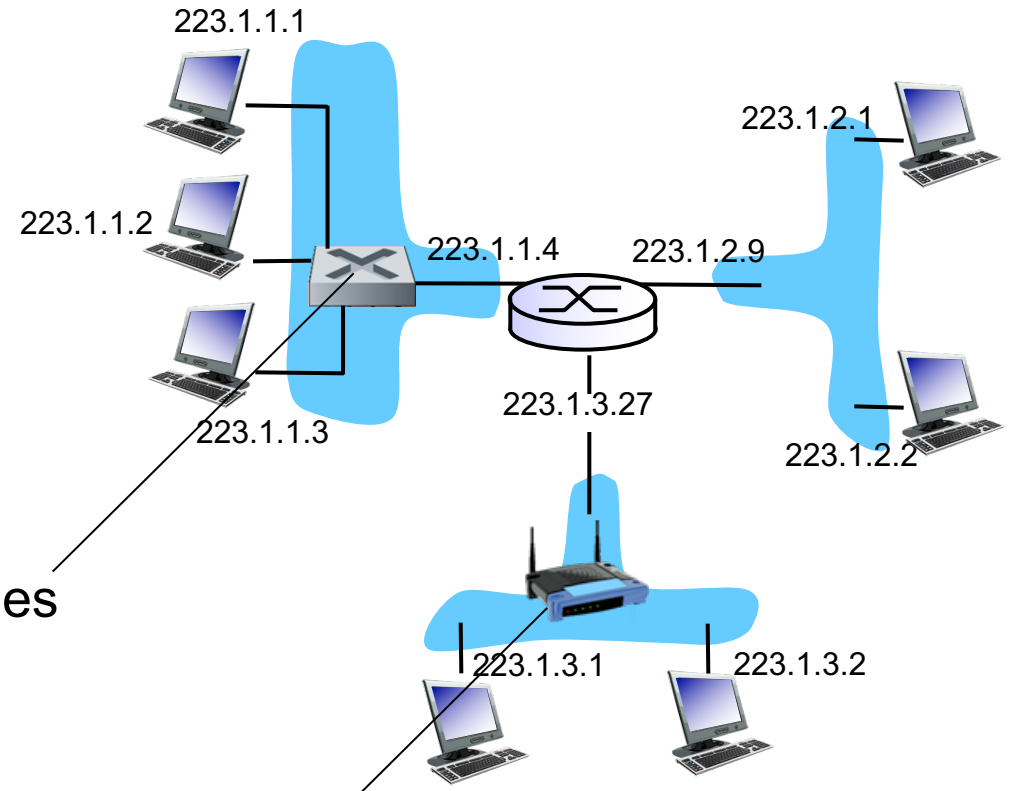
223.1.1.1 = 11011111 00000001 00000001 00000001

223 1 1 1

IP addressing: introduction

Q: how are interfaces actually connected?

A: we'll learn about that in chapter 5, 6.



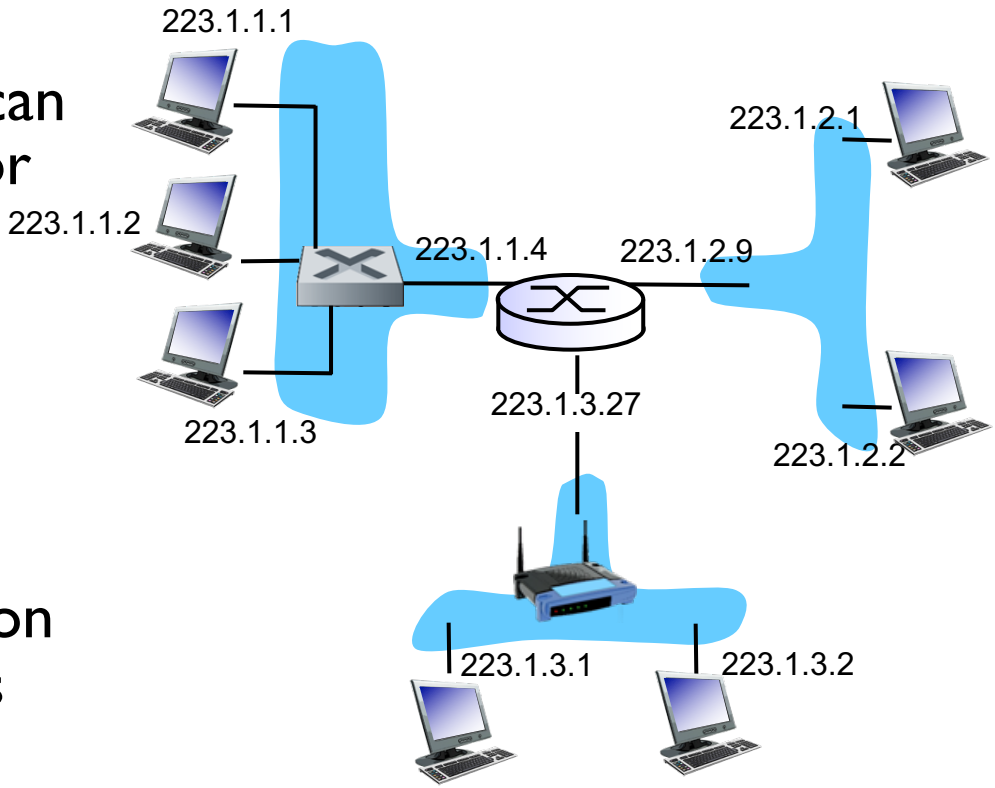
A: wired Ethernet interfaces connected by Ethernet switches

For now: don't need to worry about how one interface is connected to another (with no intervening router)

A: wireless WiFi interfaces connected by WiFi base station

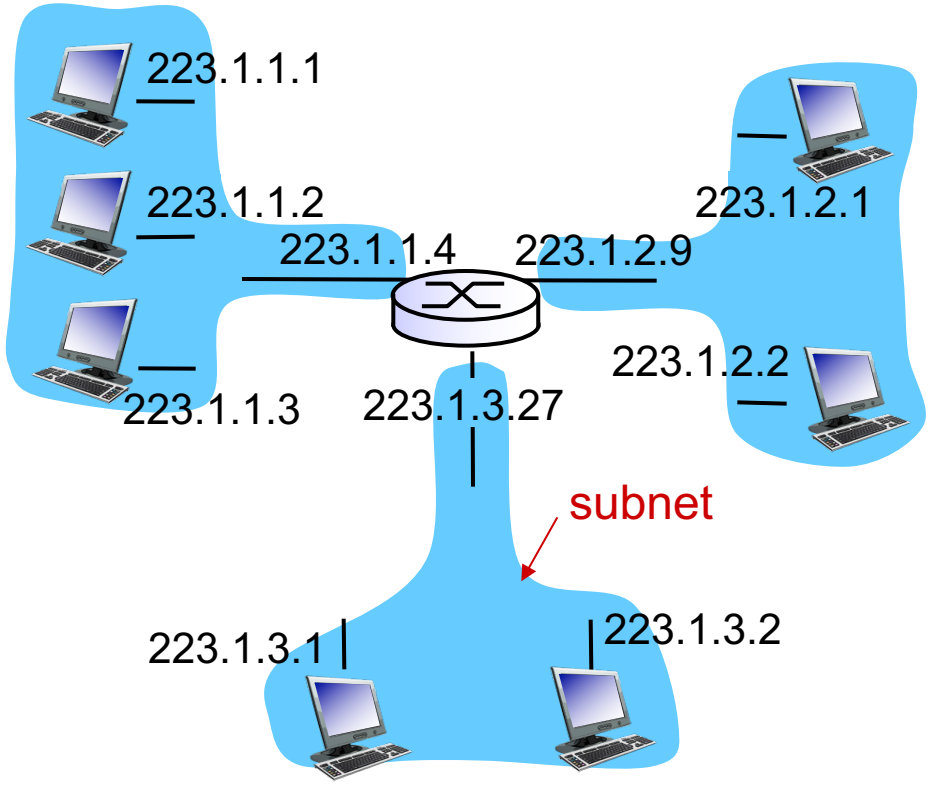
IP addressing: introduction

- Term "packet switch" can refer to either router or link-layer switch
- Learn more about link-layer switches later
- For now, main distinction is that router interfaces have IP addresses



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*

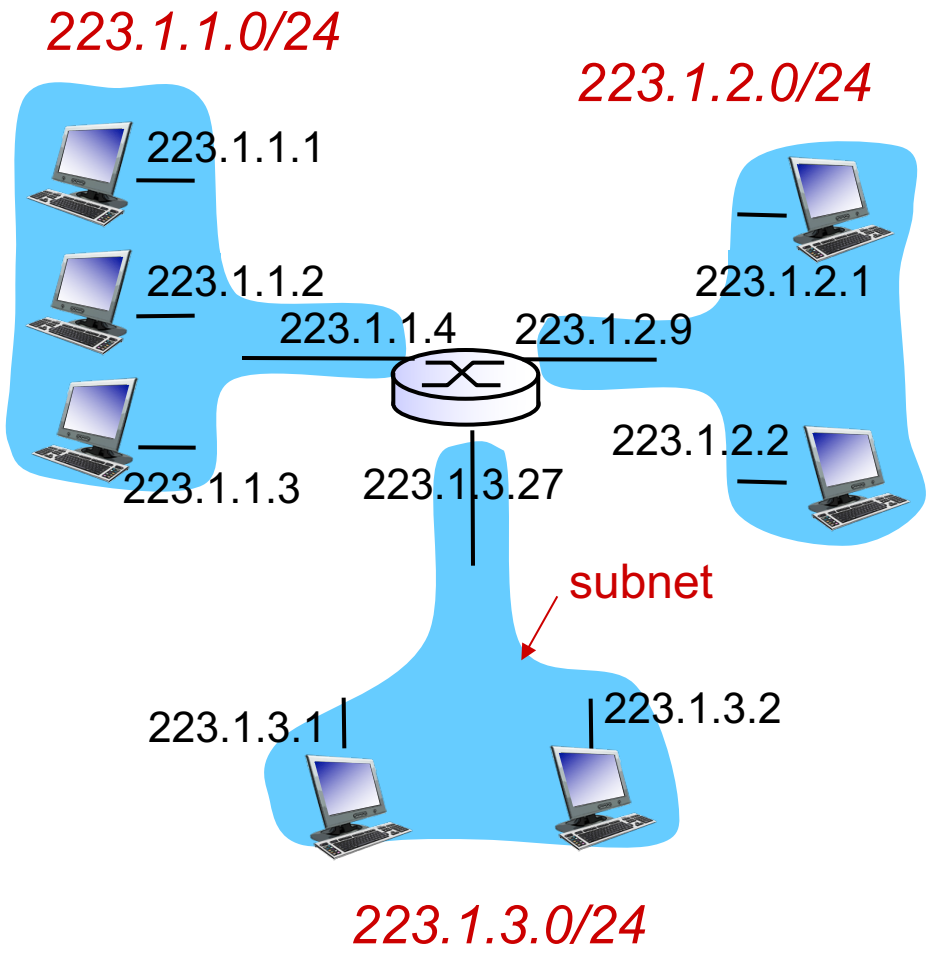


network consisting of 3 subnets

Subnets

recipe

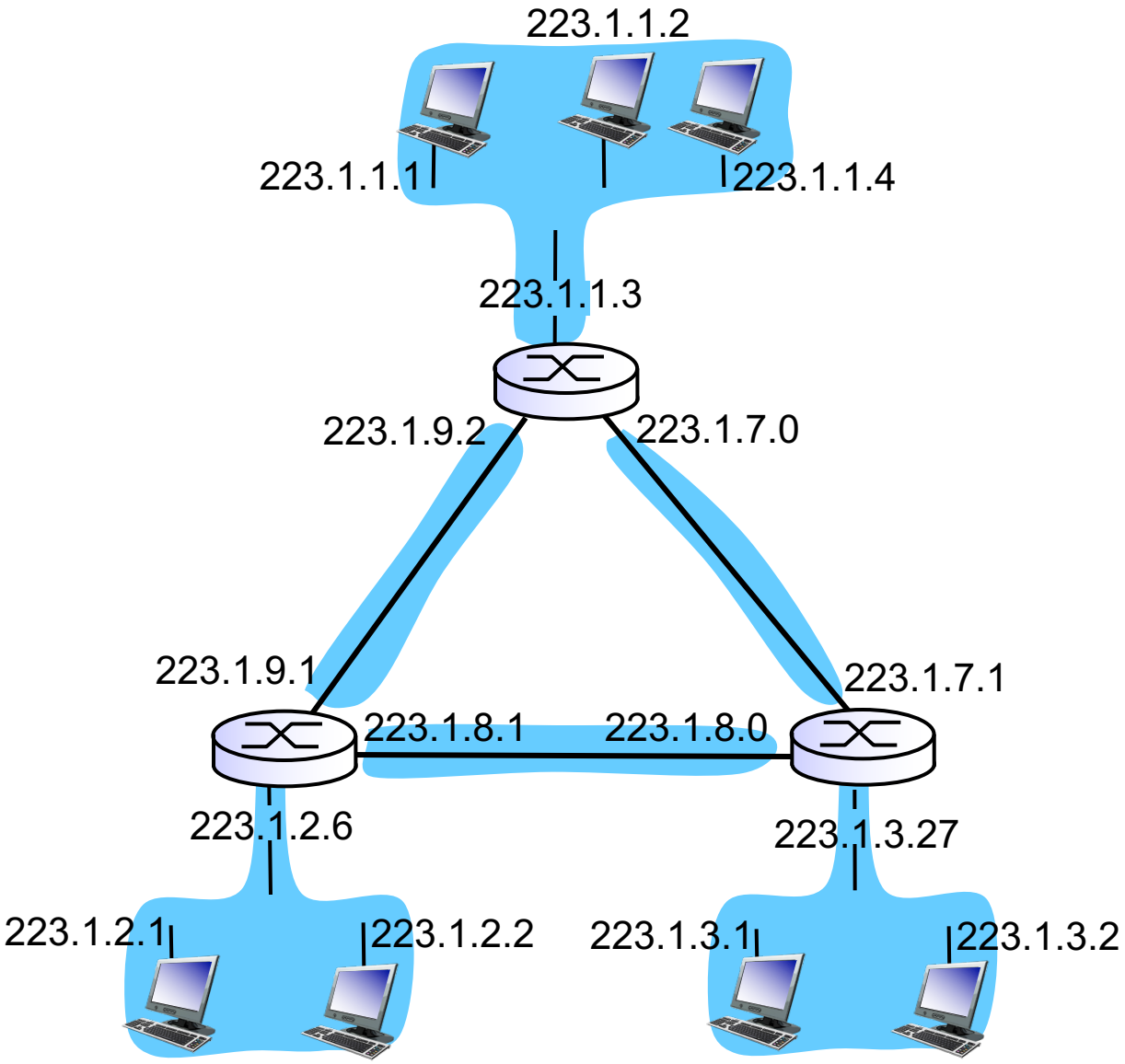
- to determine the subnets, detach each interface from its host or router, creating islands of isolated networks
- each isolated network is called a *subnet*



subnet mask: /24

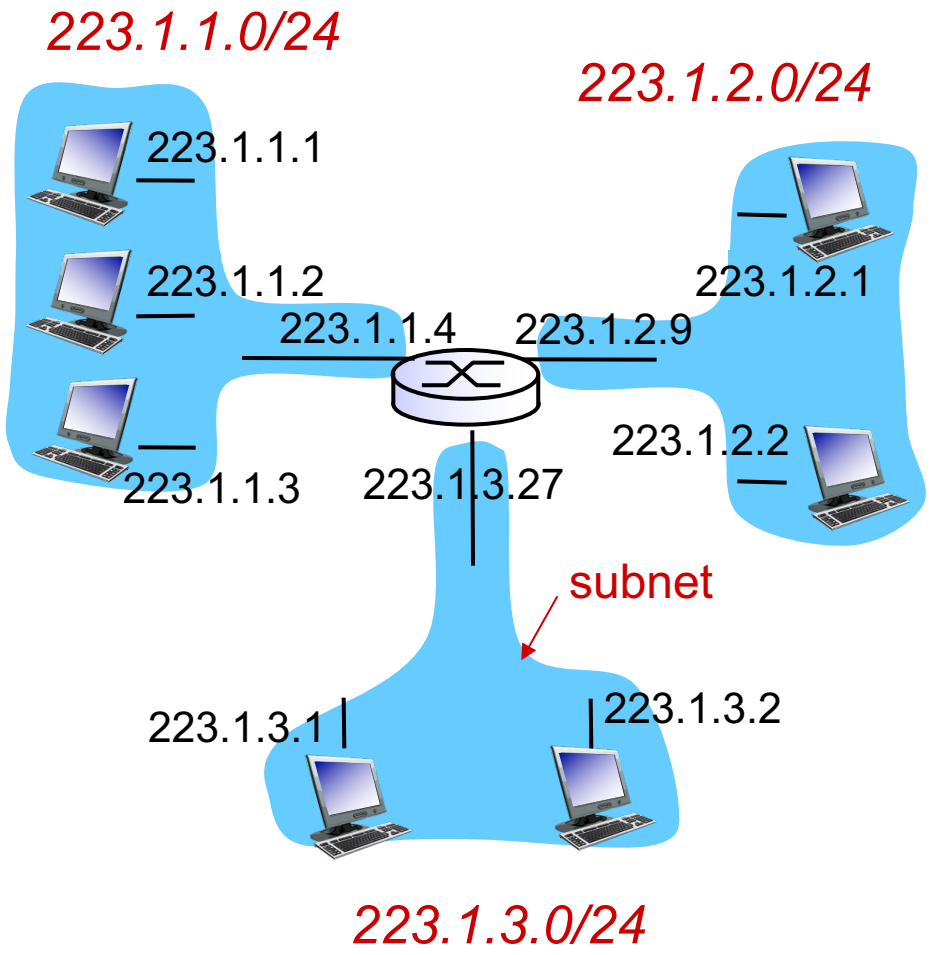
Subnets

how many?



Subnets

- Devices know which addresses are in their subnet via **subnet mask**
- Consider one subnet from image: 223.1.1.0/24
- Subnet mask /24 indicates that anything with same leading 24-bits in address resides on same subnet
- In this case, leaves 8 bits to specify particular host within subnet

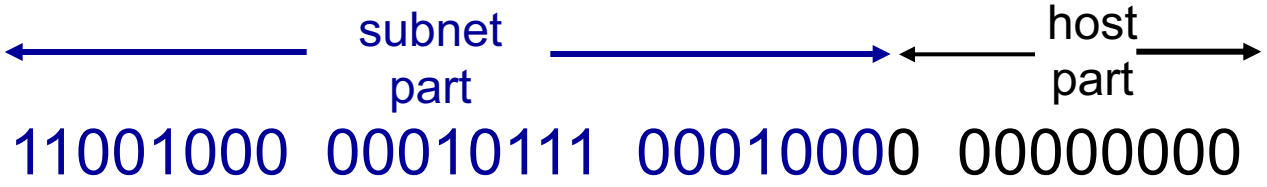


subnet mask: /24

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 addressing: CIDR

Instead of /23, may also see subnet mask written out as:

`11111111 11111111 11111110 00000000`

indicating that bits with 1 are fixed as part of subnet address and bits with 0 are free to change to specify host

Same idea more concisely: 255.255.254.0

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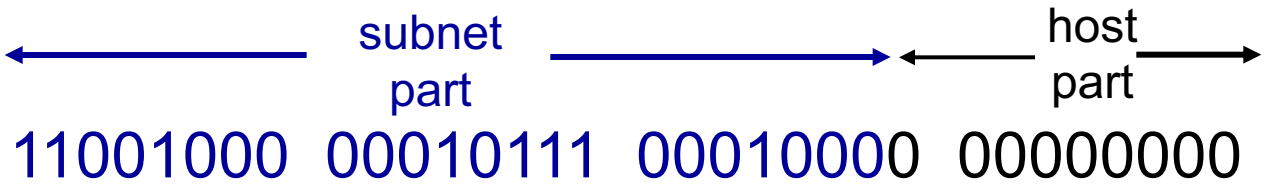
IP addressing: CIDR

Before CIDR, addresses were allocated in blocks of 2^8, 2^{16}, or 2^{24}

With CIDR, restriction is removed



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IP addressing: CIDR

Subnet mask need not be multiple of 8 in size

Easy enough to see in binary, but be aware that subnet won't always split up cleanly into bytes like 192.168.XXX.XXX

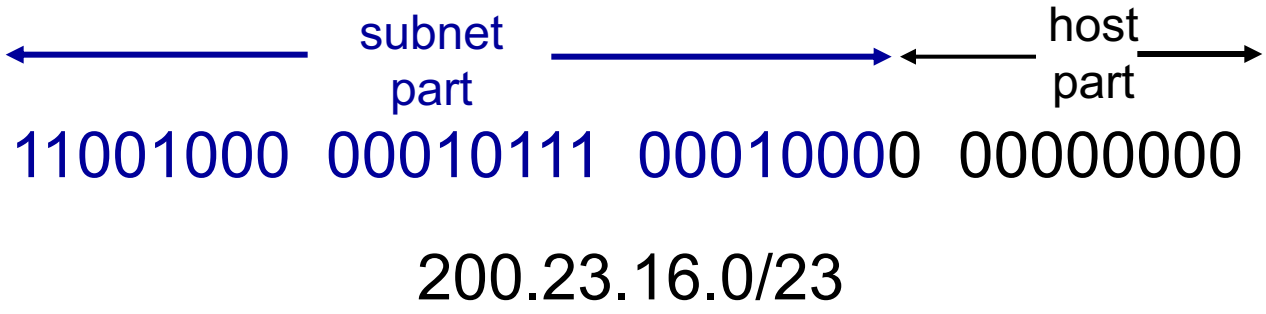
In case below, possible address range is

200.23.16.0 – 200.23.17.255

200.23.16.0/23

IP addressing: CIDR

In case below, how many hosts can their be on particular subnet?



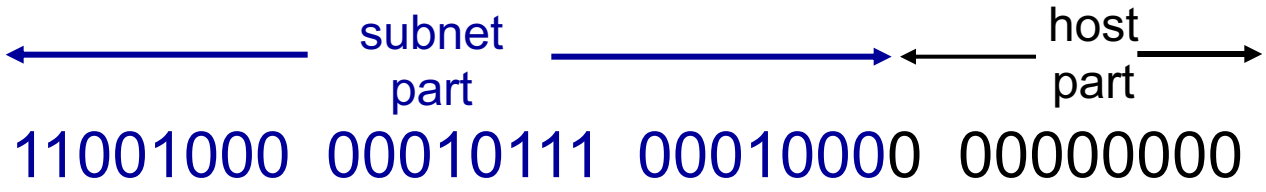
IP addressing: CIDR

32 bits for IP address split into subnet and host

23 bits to specify subnet in this case

Leaves 9 bits to specify host on subnet

2^9 = 512 hosts



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