CSCE 463/612
Networks and Distributed Processing
Spring 2024

Network Layer III

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Chapter 4: Roadmap

4.1 Introduction

4.2 Virtual circuit and datagram networks

4.3 What's inside a router

4.4 IP: Internet Protocol

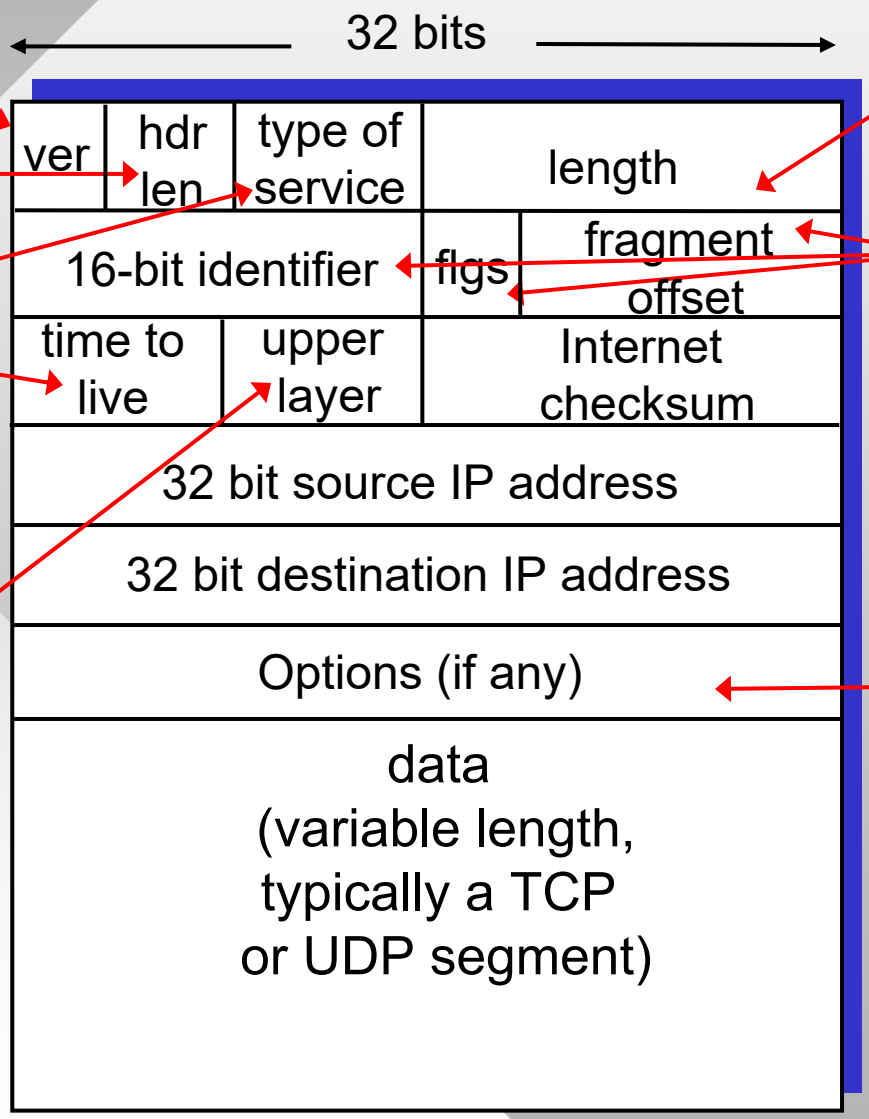
- Datagram format
- IPv4 addressing
- ICMP
- IPv6

4.5 Routing algorithms

4.6 Routing in the Internet

4.7 Broadcast and multicast routing

IPv4 Datagram Format



IP protocol version number

Header length (in 4-byte words)

QoS requested

Max number remaining hops (decremented at each router)

Upper layer protocol to deliver payload to

Total datagram length (bytes)

For fragmentation/ reassembly

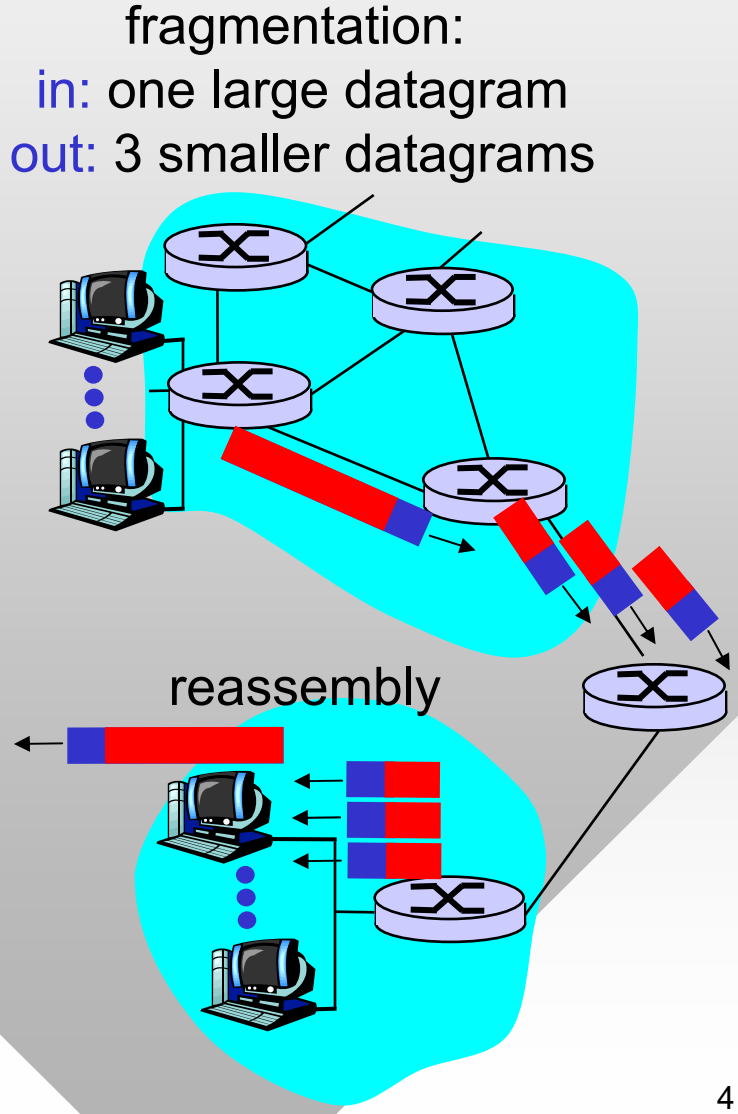
E.g. timestamp, record route taken, specify list of routers to visit

How much overhead with TCP?

- 20 bytes of TCP
- 20 bytes of IP
- = 40 bytes

IP Fragmentation & Reassembly

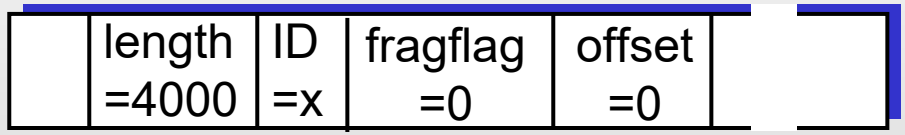
- Network links have varying MTUs (maximum transmission units) – largest possible link-level frames
  - Different link types, different MTUs (most common 1500)
- Large IP datagram divided ("fragmented") within network
  - One datagram becomes several datagrams
  - "Reassembled" only at final destination
  - IP header bits used to identify, order related fragments



IP Fragmentation and Reassembly

Example

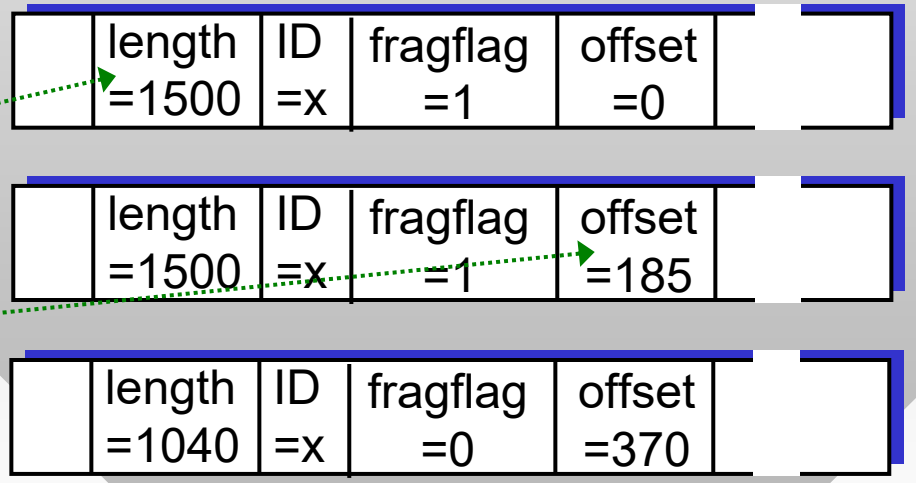
- 4000 byte datagram (including IP header)
- MTU = 1500 bytes



One large datagram becomes several smaller datagrams

1480 bytes in payload

offset is in 8-byte words: 185 = 1480/8



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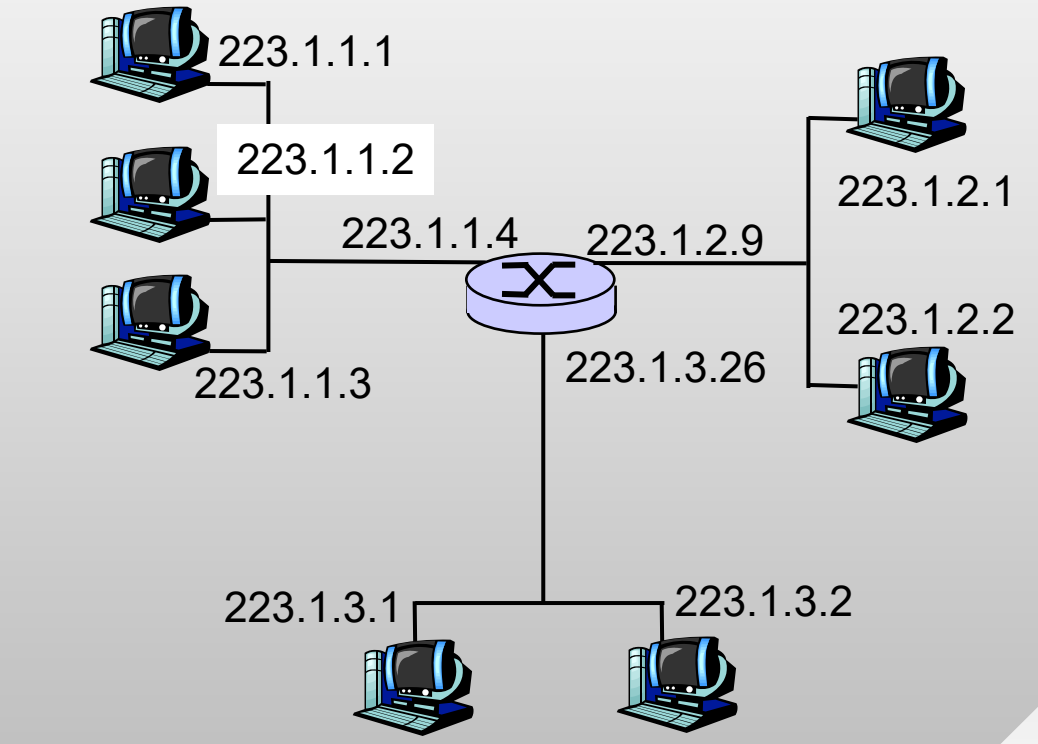
IP Addressing: Introduction

- IP address: 32-bit identifier for host or router *interface*
- *Interface:* connection between host/router and physical link
  - Also called a port
  - Routers have many interfaces
- Can hosts have multiple interfaces?
  - Yes, it's called multi-homing

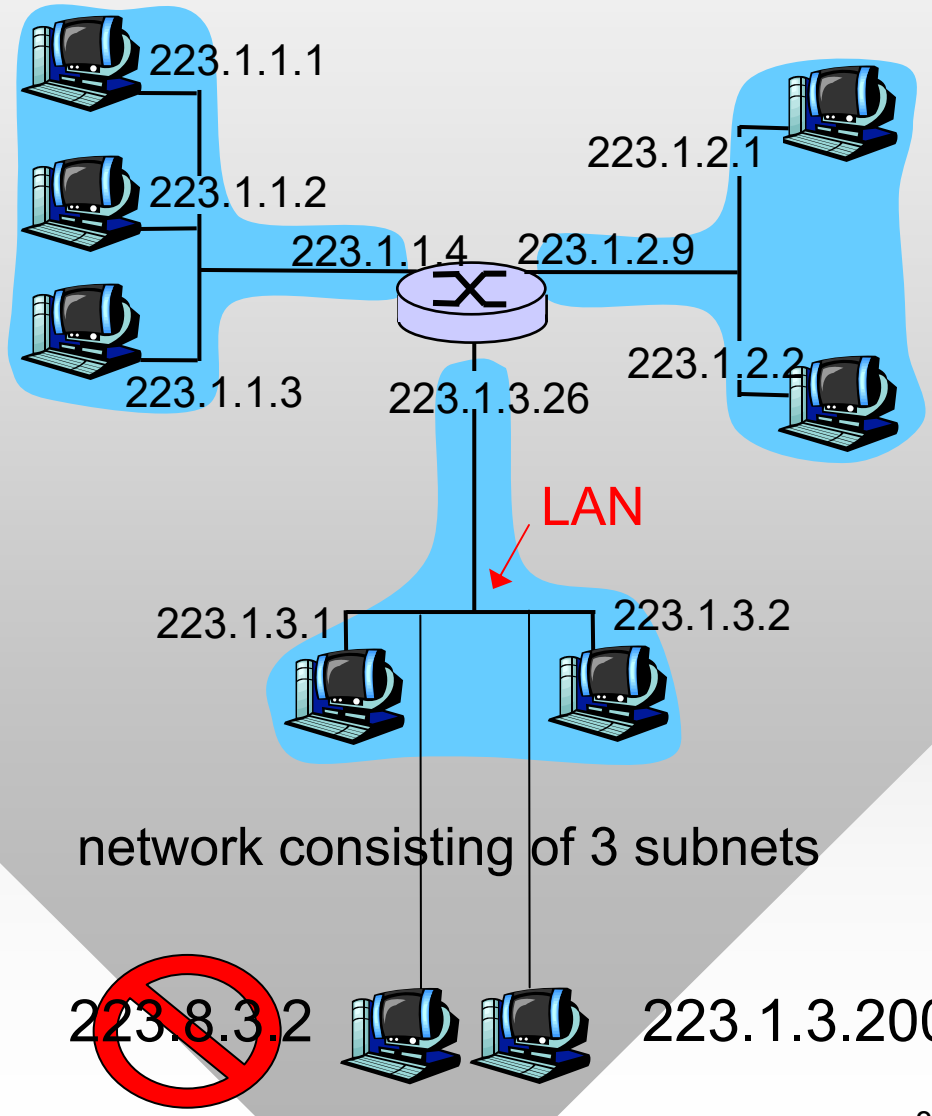


223.1.1.1 = 11011111 00000001 00000001 00000001

223 1 1 1

Subnets

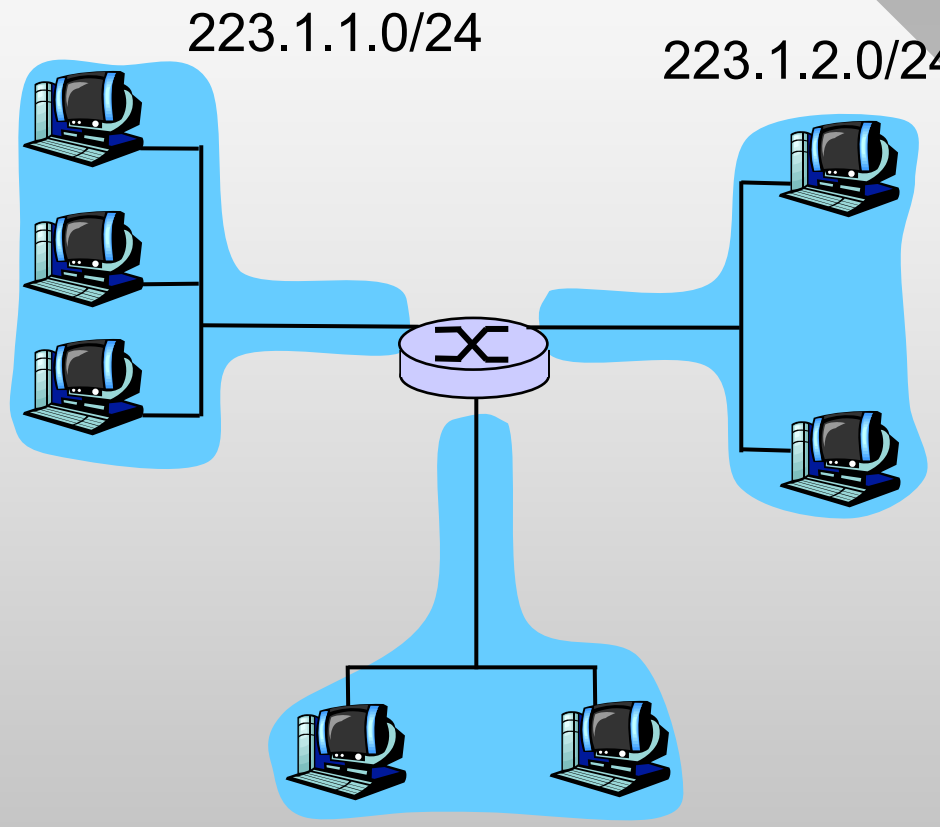
- IP address:
  - Subnet prefix: *k* bits
  - Host suffix: 32-*k* remaining bits
- *What's a subnet (LAN)?*
  - Network composed of devices with the same subnet prefix of IP address
  - Can physically reach each other without intervening router



Subnets

Recipe

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

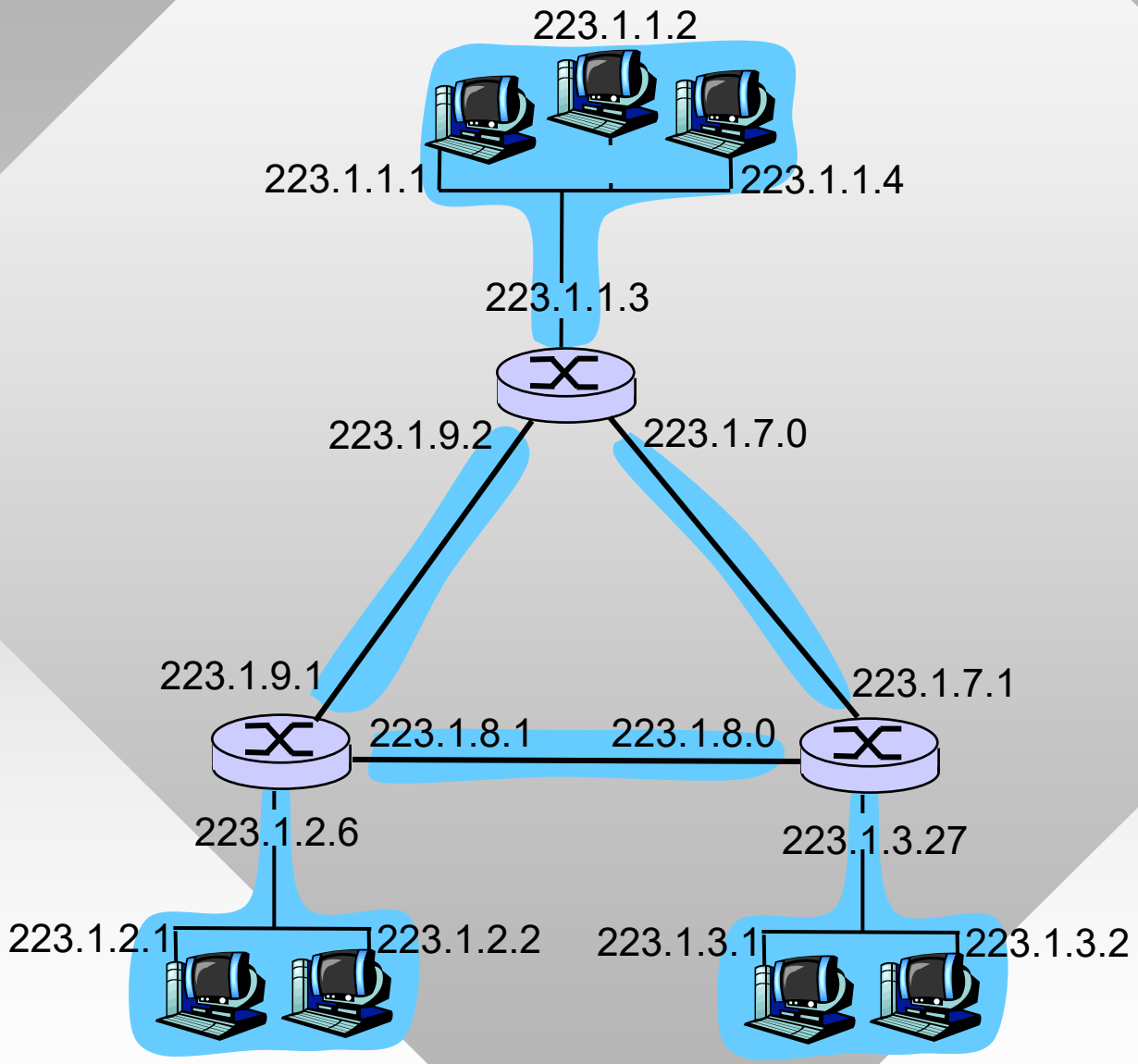


Subnet mask:

- 255.255.255.0
- or /24

Subnets

How many?

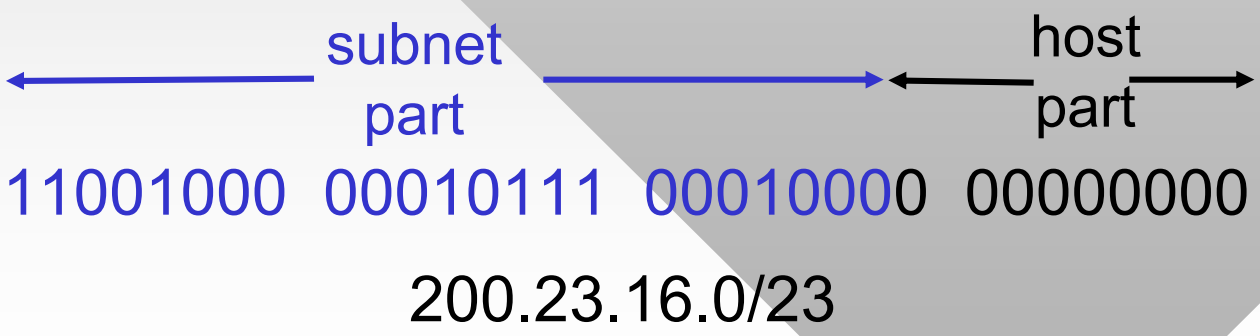


IP Addressing: CIDR

- In the early Internet, only subnets with 8, 16, or 24 bit prefixes were allowed ("class A, B, C" networks)
- This was inflexible and wasteful as well

CIDR: Classless InterDomain Routing

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



IP Addresses: How to Get One?

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

- Either hard-coded by system admin in a file
  - Windows: Control-panel → network → configuration → tcp/ip → properties
  - Linux: /etc/rc.config
- Or dynamically assigned by DHCP (Dynamic Host Configuration Protocol)
  - "Plug-and-play" (more in Chapter 5)

IP Addresses: How to Get One?

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

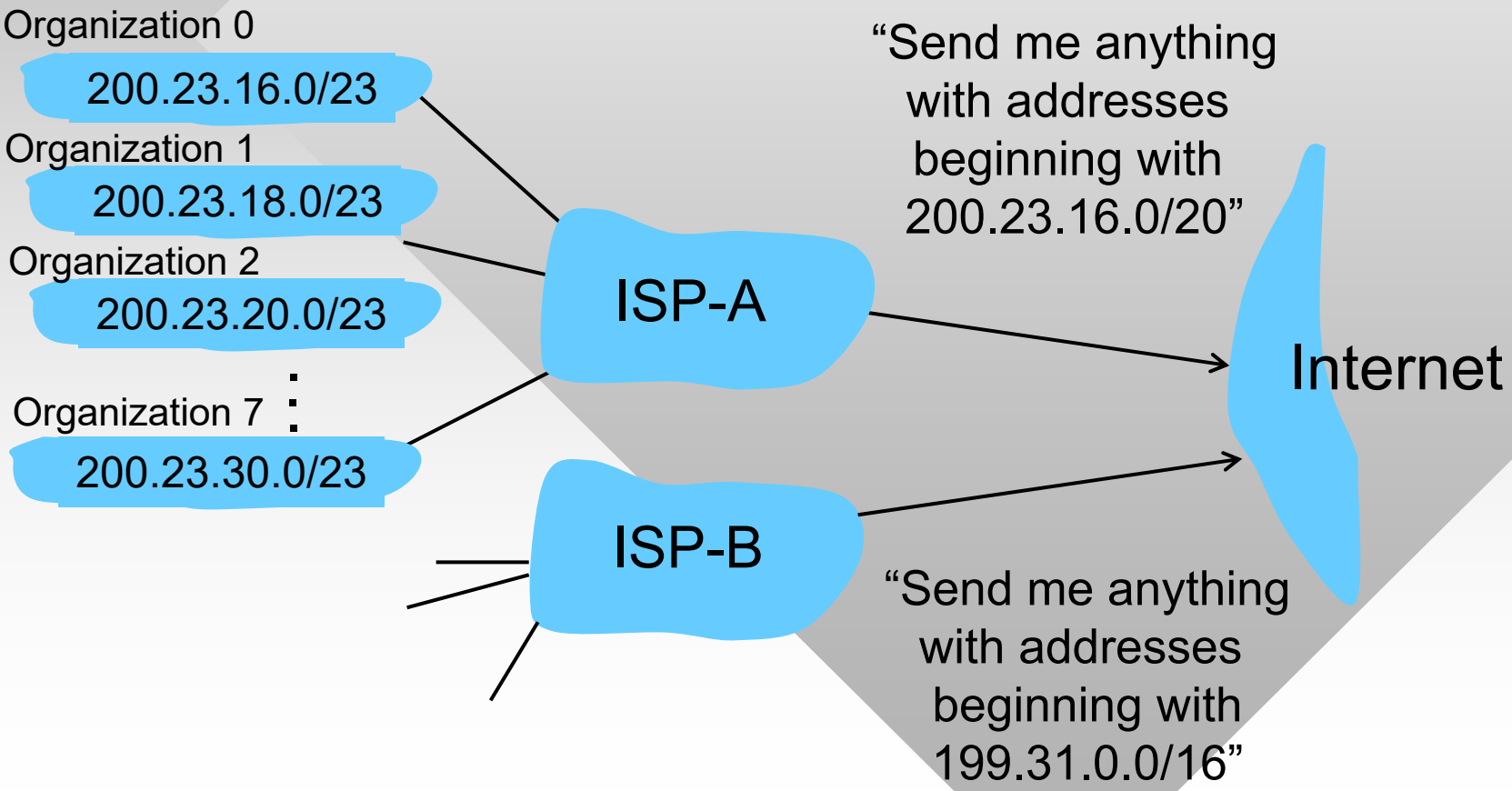
A: Gets allocated portion of its provider ISP's address space

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

- Task: split this ISP into one /21, three /23, and eight /26

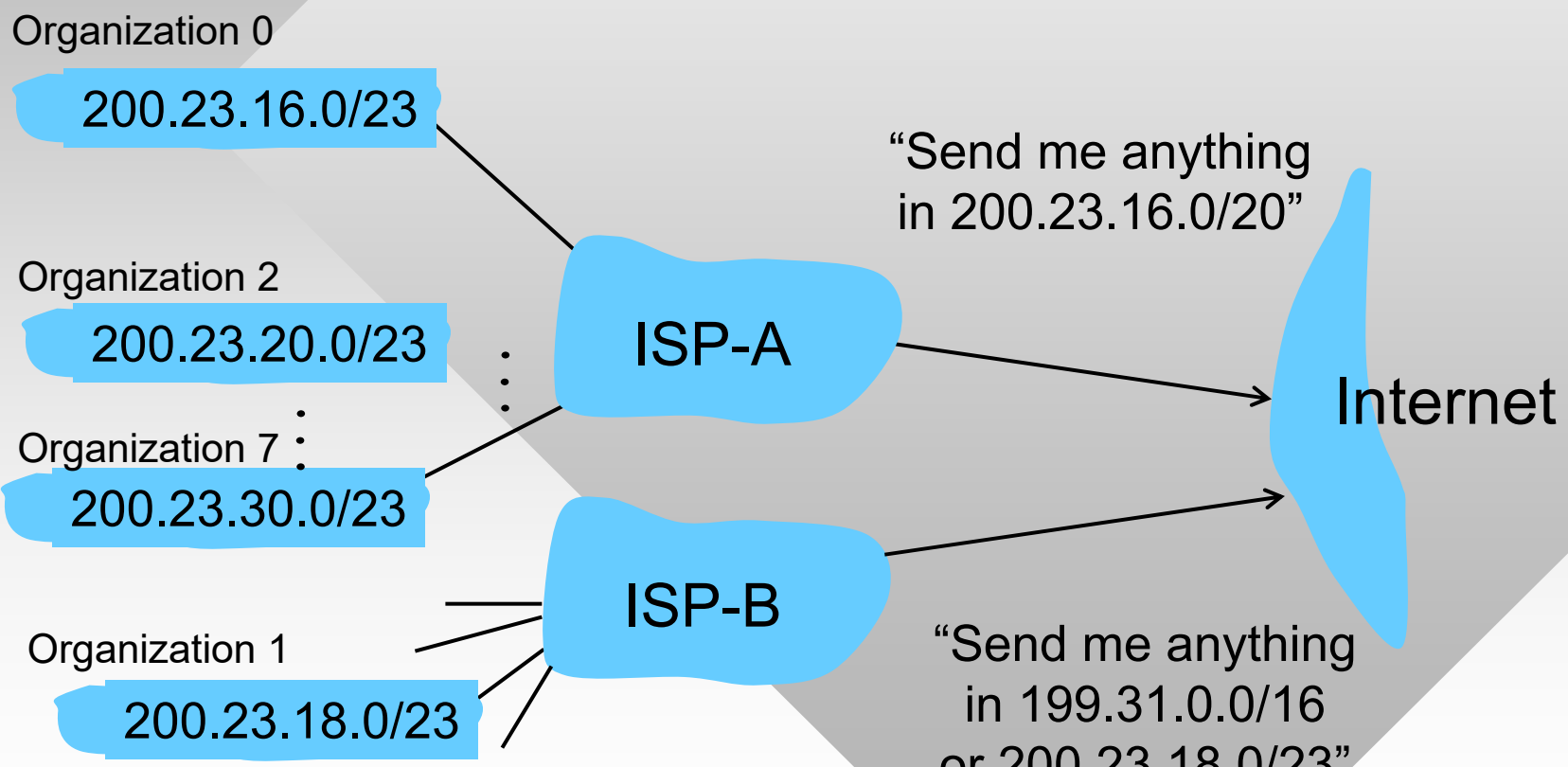
Hierarchical Addressing: Route Aggregation

Hierarchical addressing allows efficient advertisement of routing information:



Hierarchical Addressing: More Specific Routes

ISP-B has a more specific route to Organization 1



IP Addressing: Last Word...

Q: How does an ISP get a block of addresses?

A: ICANN: Internet Corporation for Assigned Names and Numbers assigns IPs to regional registries

- These are ARIN (North/South America), RIPE (Europe), APNIC (Asia-Pacific), and AfriNIC (Africa)

- These registries process ISP and user requests for subnet space
  - Also manage DNS and resolve disputes