Computer Techniques Engineering Department
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Networks Simulation

Network Layer & IP addressing

Topic 4

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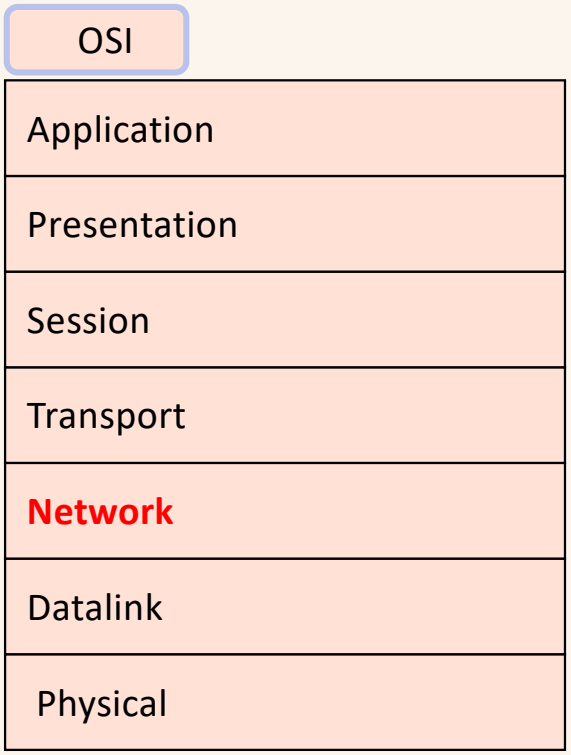
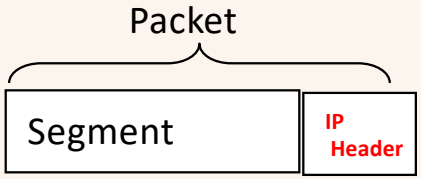
Network Layer

The Network layer, **or OSI Layer 3**, provides services to exchange individual pieces of data over the network between identified end devices.



This produces a **data unit** or **PDU called a *packet.***



This header provides details of the layer-3 source and destination addresses and instructions for routers.

IP addressing

IP specifies that each host is assigned **a unique number** known as **the host's Internet Protocol address, IP address, or Internet address**.

The important point is that the IP address scheme guarantees that:

- **Each computer (Host) is assigned a unique address.**

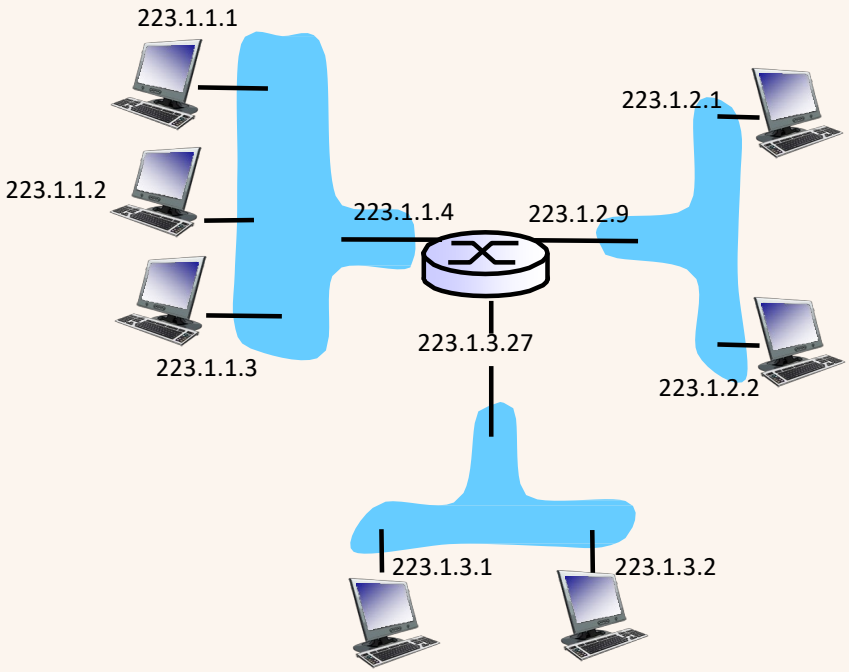
Dotted decimal treats each ***octet*** (each **8-bit** value) as an unsigned binary integer.

The **smallest** possible value, ***0***, occurs when all bits of an octet are zero, and the **largest** possible value, ***255*,** occurs when all bits of an octet are one.

192.52.6.0

IP addressing

- *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*

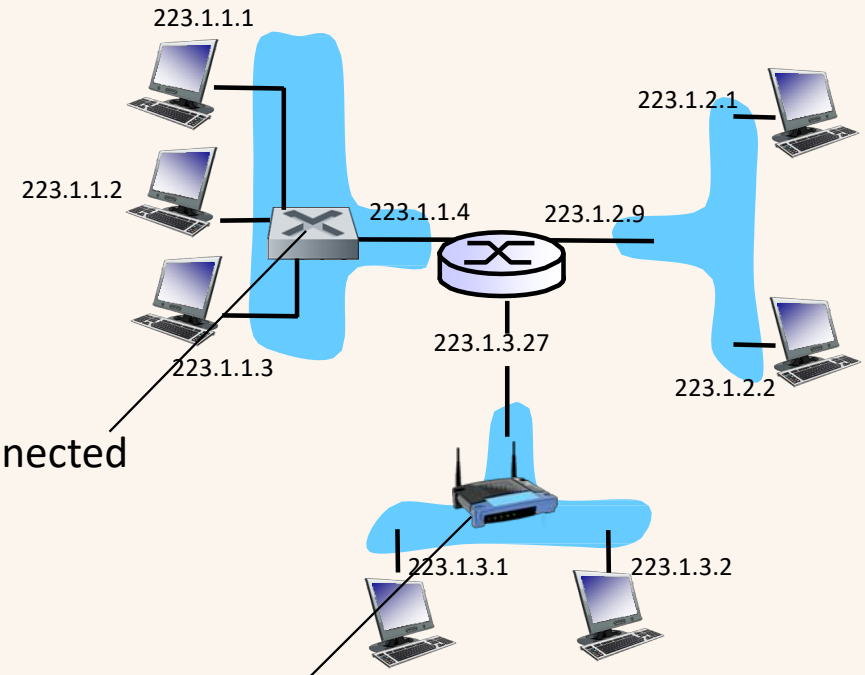


223.1.1.1 = 11011111 00000001 00000001 00000001

223 1 1 1

IP addressing

Q: how are interfaces actually connected?



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)

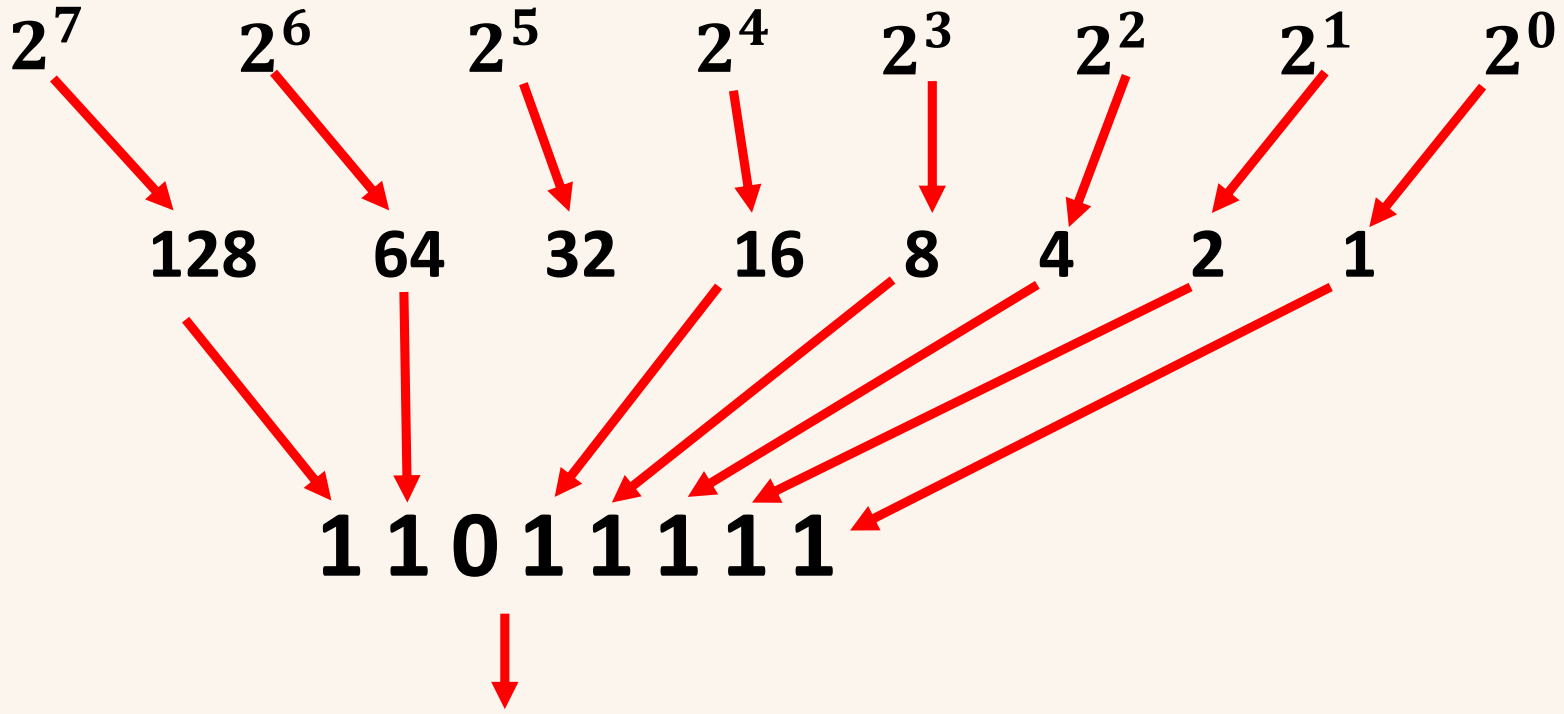
A: wireless WiFi interfaces connected by WiFi base station

Decimal Equivalents of 8-Bit Patterns

$2^{(7)}$	$2^{(6)}$	$2^{(5)}$	$2^{(4)}$	$2^{(3)}$	$2^{(2)}$	$2^{(1)}$	$2^{(0)}$
128	64	32	16	8	4	2	1
192.57.30.224							
11000000.00111001.00011110.11100000							

128	64	32	16	8	4	2	1	
1	0	0	0	0	0	0	0	= 128
1	1	0	0	0	0	0	0	= 192
1	1	1	0	0	0	0	0	= 224
1	1	1	1	0	0	0	0	= 240
1	1	1	1	1	0	0	0	= 248
1	1	1	1	1	1	0	0	= 252
1	1	1	1	1	1	1	0	= 254
1	1	1	1	1	1	1	1	= 255

IP addressing



128 + 64 + 16 + 8 + 4 + 2 +1 = 223

223.1.1.1 = 11011111. 00000001. 00000001. 00000001

223 .1 .1 .1

IP addressing: introduction

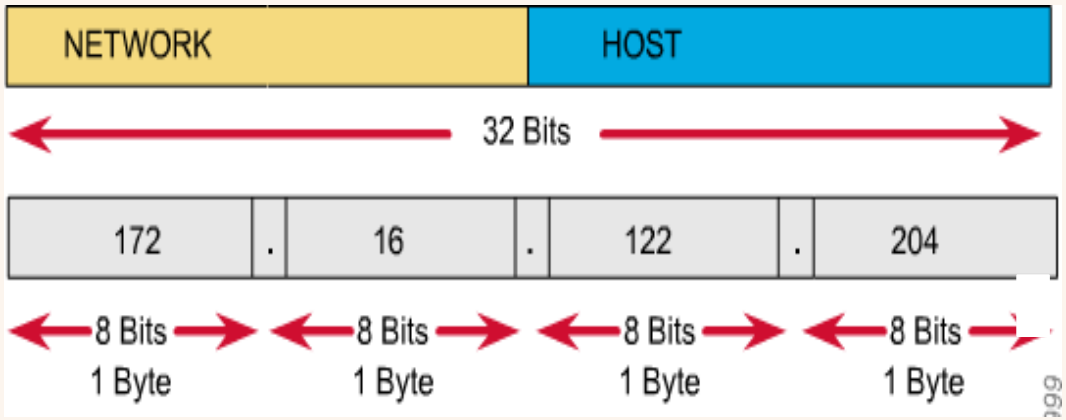
32-bit Binary Number	Equivalent Dotted Decimal
11000000.00110100.00000110.00000000	192.52.6.0
11000000.00000101.00110000.00000011	192.5.48.3
00001010.00000010.00000000.00100101	10.2.0.37
10000000.00001010.00000010.00000011	128.10.2.3
10000000.10000000.11111111.00000000	128.128.255.0

Internet IP Addresses

IP Address as a 32-Bit Binary Number

192. **.5** **.34** **.11**

192.5.34.11



IPv4 Address Classes (Classful Addressing)

Address Class	First Octet Range	Number of Possible Networks	Number of Hosts per Network
Class A	0 to 127	128 (2 are reserved)	16,777,214
Class B	128 to 191	16,348	65,534
Class C	192 to 223	2,097,152	254

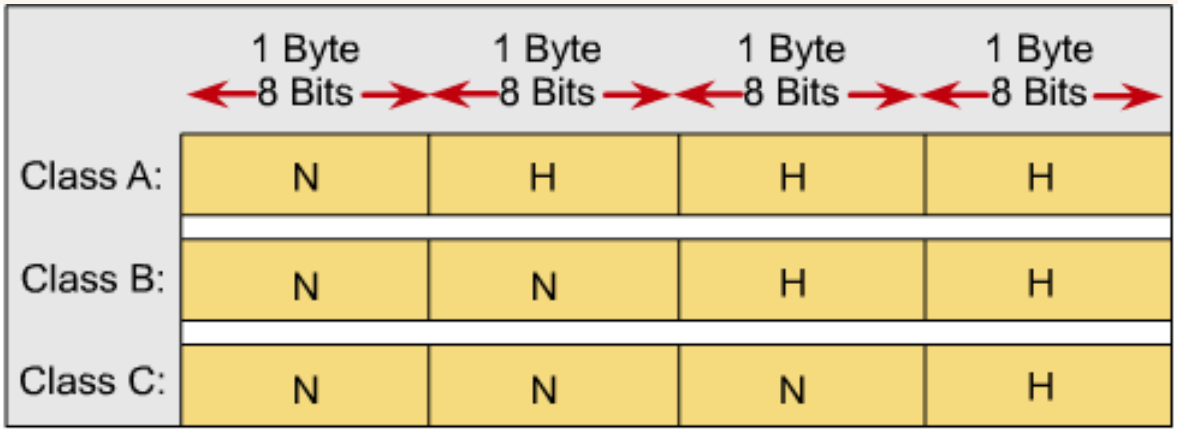
Class D Addresses

- A Class D address begins with **binary 1110 in the first octet**.
- First octet range from 224 to 239.
- Class D address can be used to represent a group of hosts called **a host group, or multicast group.**

Class E Addresses

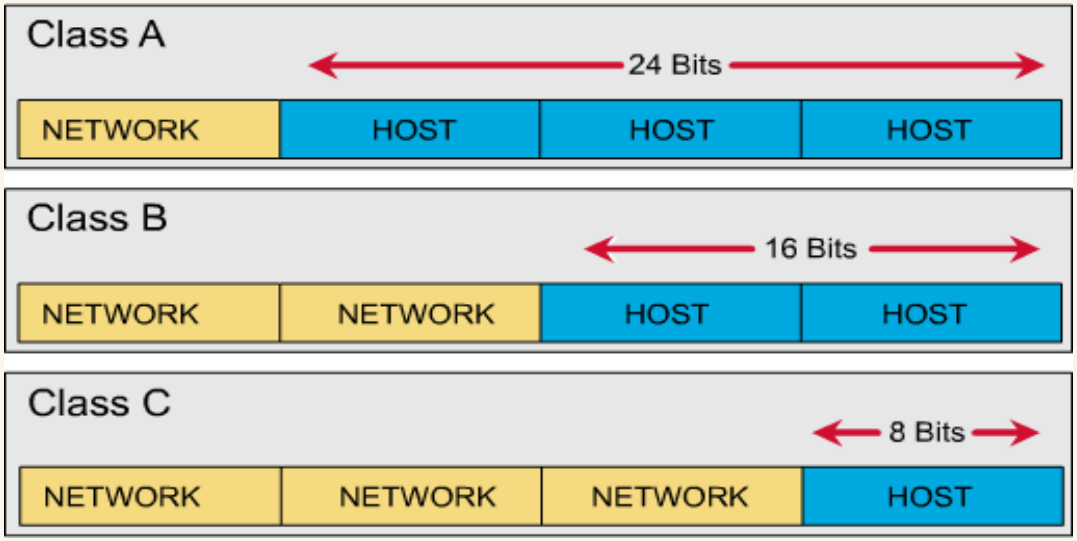
- The first octet of an IP address begins with 1111
- First octet range from 240 to 255.
- Class E addresses are reserved for experimental purposes and should not be **used for addressing hosts or multicast groups**.

IP Address Classes



- N = Network number assigned by ARIN
- H = Host number assigned by administrator

Hosts for Classes of IP Addresses



Class A (24 bits for hosts) $2^{24} - 2^{*} = 16{,}777{,}214$ maximum hosts

Class B (16 bits for hosts) $2^{16} - 2^{*} = 65{,}534$ maximum hosts

Class C (8 bits for hosts) $2^{8} - 2^{*} = 254$ maximum hosts

* ***Subtracting the network and broadcast reserved address***

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"

IP addresses: how to get one?

Q: How does the *network* get the subnet part of the IP address?

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 0001000**0**	00000000	200.23.16.0/23
Organization 1	11001000 00010111 0001001**0**	00000000	200.23.18.0/23
Organization 2	11001000 00010111 0001010**0**	00000000	200.23.20.0/23
...	.....	....	....
Organization 7	11001000 00010111 0001111**0**	00000000	200.23.30.0/23

Hierarchical addressing

A 32-bit IPv4 address is also hierarchical but divided only into **two parts:**

- **The first part** of the address, called the **prefix**, **defines the Network**.
- **The second part** of the address, called the **suffix**, defines **the Host**

A prefix can be **fixed length (**classful addressing**)** or **variable length** (classless addressing).

Hierarchical addressing

192.52.6.0 /24

32 bits

Prefix	Suffix
n bits	(32 – n) bits

Defines Network

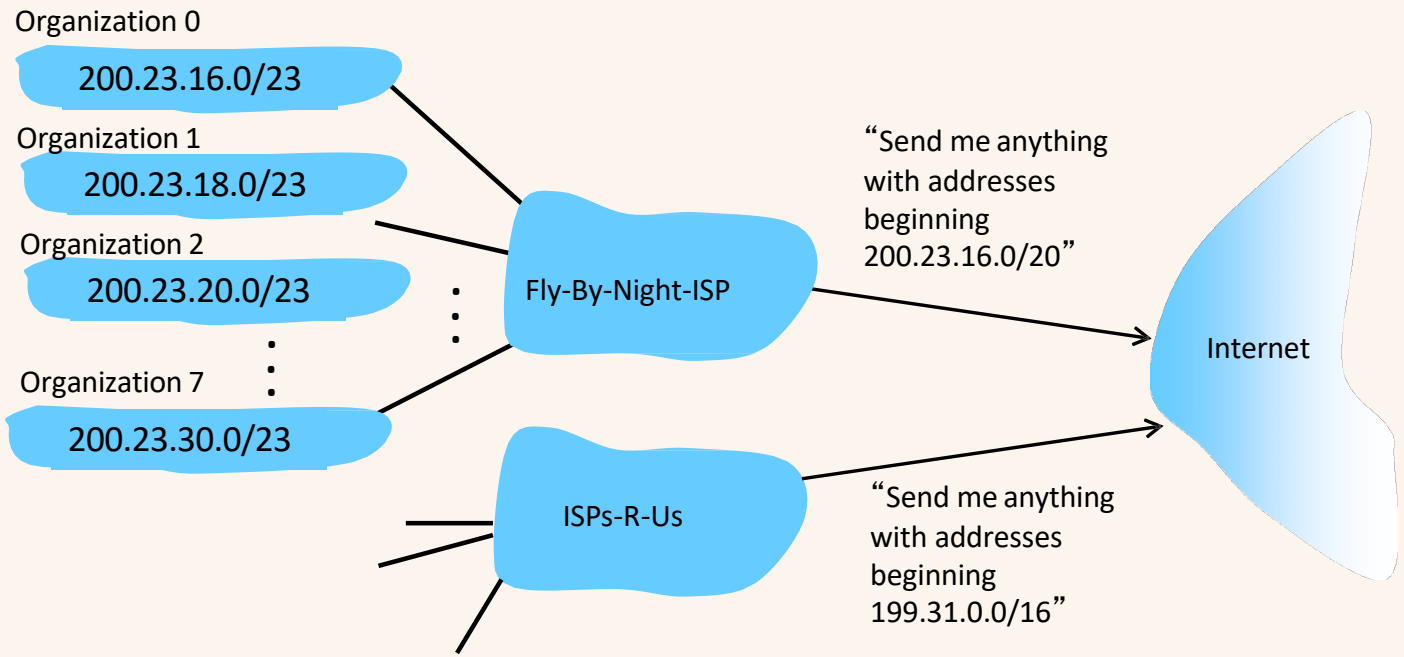
192.52.6

Defines Host

.0

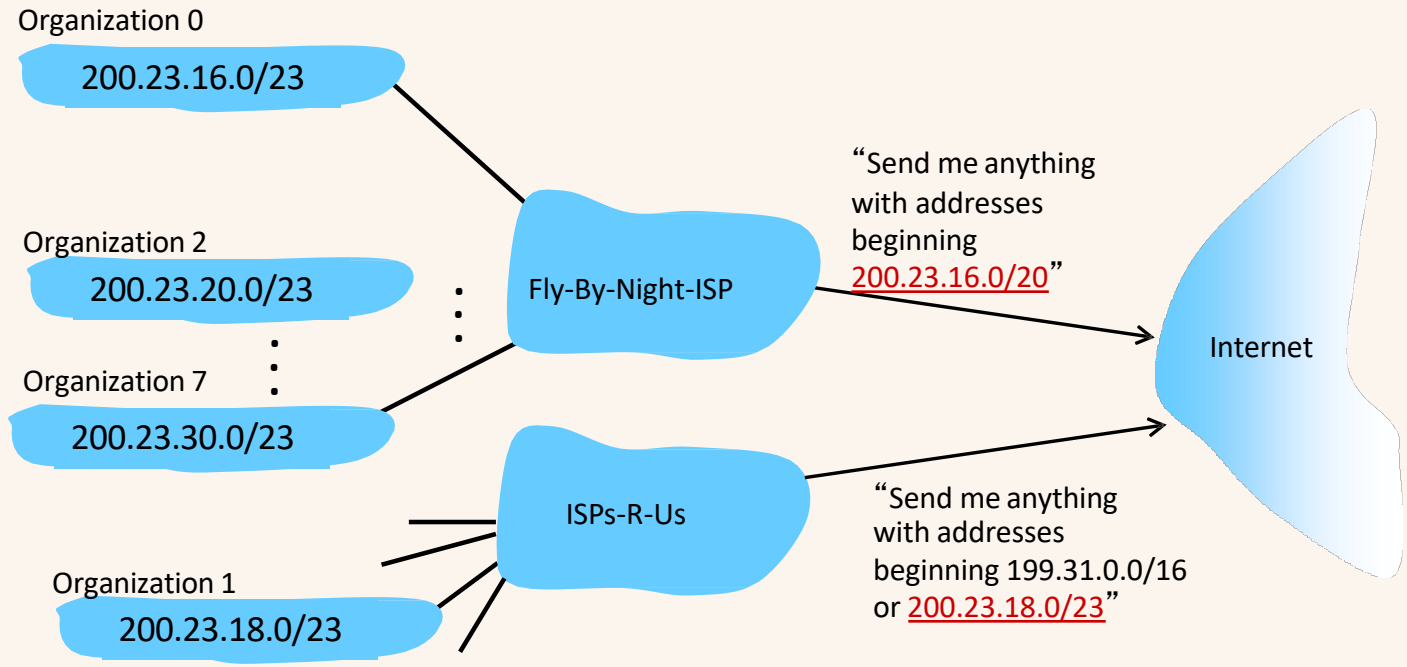
Hierarchical addressing

hierarchical addressing allows efficient advertisement of routing information:



Hierarchical addressing: more specific routes

ISPs-R-Us has a more specific route to Organization 1



IP addressing: the last word...

Q: How does an ISP get a 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

Address Masks & subnet mask

How can an IP address be divided at an arbitrary boundary?

The classless and subnet addressing schemes require hosts and routers that process addresses to store an additional piece of information known as an ***address mask,*** which was originally called a ***subnet mask***.

Classless Inter-Domain Routing (CIDR) notation, an address and a mask can be specified by giving a dotted decimal address followed by a slash.

Length (CIDR)	Address Mask	Notes
/1	128.0.0.0	Class A
/10	255.192.0.0	Class B
/16	255.255.0.0	Class B
/19	255.255.224.0	Class C
/23	255.255.254.0	Class C
/26	255.255.255.192	Class C

Address Masks

Length (CIDR)	Address Mask	Notes
/1	128.0.0.0	Class A

$$2^7 \quad 2^6 \quad 2^5 \quad 2^4 \quad 2^3 \quad 2^2 \quad 2^1 \quad 2^0$$

128 64 32 16 8 4 2 1

1 0 0 0 0 0 0 0

128.0.0.0

Octet

Address Masks

Length (CIDR)	Address Mask	Notes
/10	255.192.0.0	Class B

$$2^7 \quad 2^6 \quad 2^5 \quad 2^4 \quad 2^3 \quad 2^2 \quad 2^1 \quad 2^0$$

128 64 32 16 8 4 2 1

11111111. 11000000.00000000.00000000

255 — Octet — 8 bits

192 — Octet — 2 bits

0 — Octet

0 — Octet

/10

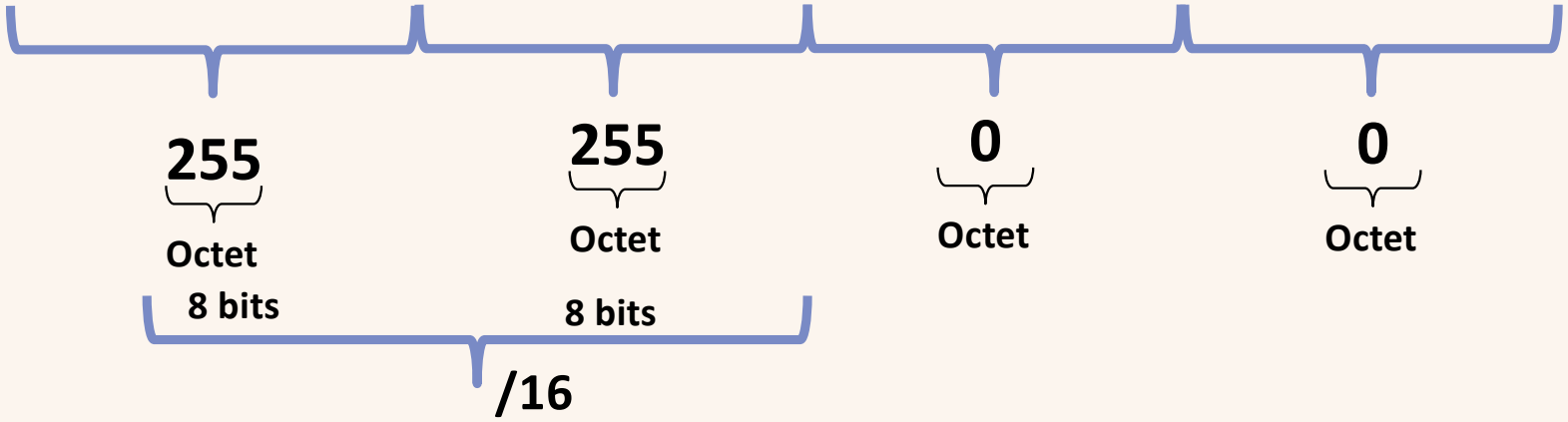
Address Masks

Length (CIDR)	Address Mask	Notes
/16	255.255.0.0	Class B

$$2^7 \quad 2^6 \quad 2^5 \quad 2^4 \quad 2^3 \quad 2^2 \quad 2^1 \quad 2^0$$

128 64 32 16 8 4 2 1

11111111. 11111111.00000000.00000000



Address Masks

Length (CIDR)	Address Mask	Notes
/19	255.255.224.0	Class C

$$2^7 \quad 2^6 \quad 2^5 \quad 2^4 \quad 2^3 \quad 2^2 \quad 2^1 \quad 2^0$$

128 64 32 16 8 4 2 1

11111111. 11111111.11100000.00000000

255 — Octet — 8 bits

255 — Octet — 8 bits

224 — Octet — 3 bits

0 — Octet

\+ \+

/19

Address Masks

Length (CIDR)	Address Mask	Notes
/23	255.255.254.0	Class C

$$2^7 \quad 2^6 \quad 2^5 \quad 2^4 \quad 2^3 \quad 2^2 \quad 2^1 \quad 2^0$$

128 64 32 16 8 4 2 1

11111111.11111111.11111110.00000000

255	255	254	0
Octet	Octet	Octet	Octet

8 bits + 8 bits + 7 bits

/23

Address Masks

Length (CIDR)	Address Mask	Notes
/26	255.255.255.192	Class C

$$2^7 \quad 2^6 \quad 2^5 \quad 2^4 \quad 2^3 \quad 2^2 \quad 2^1 \quad 2^0$$

128 64 32 16 8 4 2 1

11111111. 11111111.11111111.11000000

255	255	255	192
Octet	Octet	Octet	Octet
8 bits +	8 bits +	8 bits +	2 bits

/26

Homework As a Group: Find the Range of IP address

IP Address	Length (CIDR)
192.168.1.35	/27

$$2^7 \quad 2^6 \quad 2^5 \quad 2^4 \quad 2^3 \quad 2^2 \quad 2^1 \quad 2^0$$

$$128 \quad 64 \quad 32 \quad 16 \quad 8 \quad 4 \quad 2 \quad 1$$

The range of IP addresses: -

First IP : ….. to Last IP ….

Thank you!

Do you have any questions?

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