

# **IP Addressing - Part 2**

## **Classful Subnetting**

# Classful IP 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 A	Network		Host	
Octet	1	2	3	4

Class B	Network		Host	
Octet	1	2	3	4

Class C	Network			Host
Octet	1	2	3	4

Class D	Host			
Octet	1	2	3	4

- In the early days of the Internet, IP addresses were allocated to organizations based on request rather than actual need.
- When an organization received an IP network address, that address was associated with a “**Class**”, **A, B, or C**.
- This is known as **Classful IP Addressing**
- The **first octet** of the address determined what class the network belonged to and which bits were the network bits and which bits were the host bits.
- There were **no** subnet masks.
- It was not until 1992 when the IETF introduced CIDR (Classless Interdomain Routing), making the address class meaning less.
- This is known as **Classless IP Addressing**.
- For now, all you need to know is that today’s networks are classless, except for some things like the **structure of Cisco’s IP routing table** and for those networks that still use Classful routing protocols.

# IPv4 Address Classes

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<b>Class A</b>	<b>Network</b>	<b>Host</b>		
Octet	1	2	3	4

<b>Class B</b>	<b>Network</b>		<b>Host</b>	
Octet	1	2	3	4

<b>Class C</b>	<b>Network</b>			<b>Host</b>
Octet	1	2	3	4

<b>Class D</b>	<b>Host</b>			
Octet	1	2	3	4

# Address Classes

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	1st octet	2nd octet	3rd octet	4th octet
<b>Class A</b>	<b>Network</b>	<b>Host</b>	<b>Host</b>	<b>Host</b>
<b>Class B</b>	<b>Network</b>	<b>Network</b>	<b>Host</b>	<b>Host</b>
<b>Class C</b>	<b>Network</b>	<b>Network</b>	<b>Network</b>	<b>Host</b>

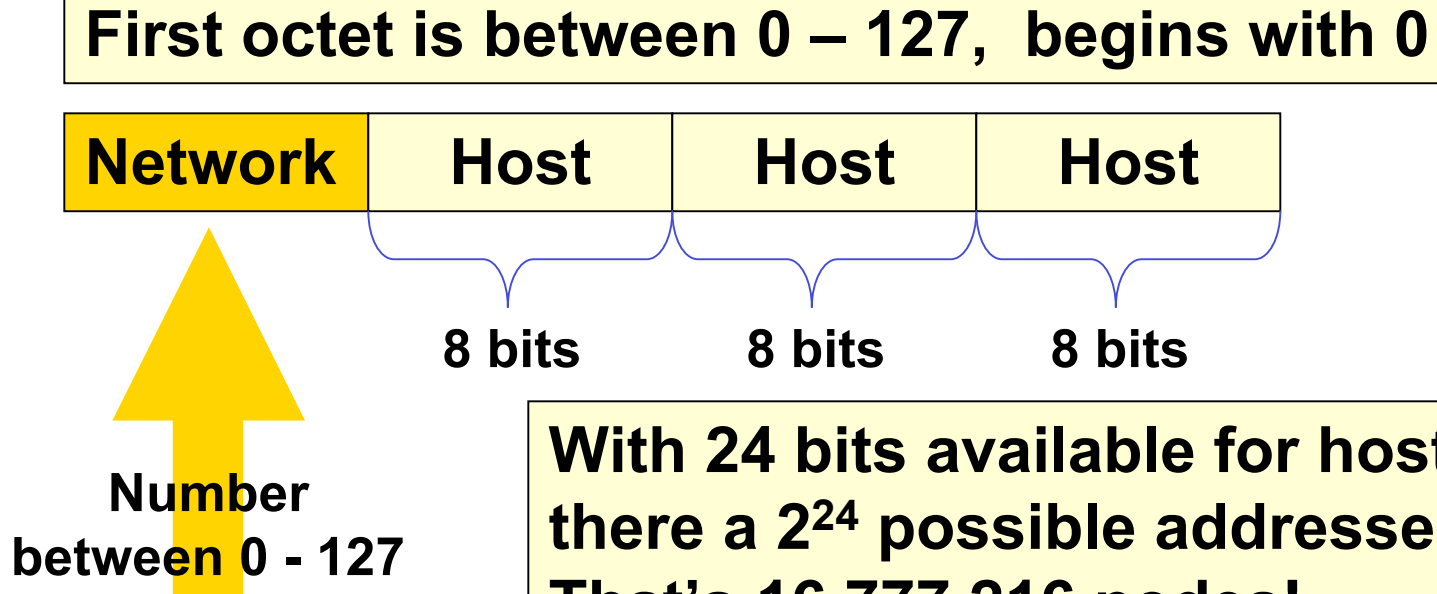
**N = Network number assigned by ARIN**

**(American Registry for Internet Numbers)**

**H = Host number assigned by administrator**

# Class A addresses

Default Mask: 255.0.0.0 (/8)

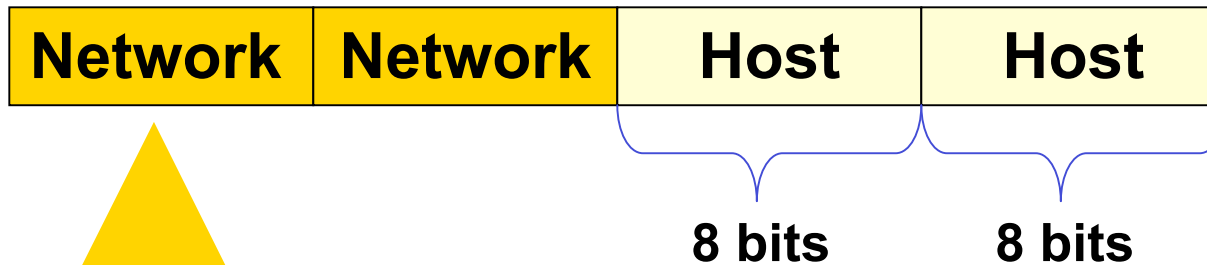


- There are 126 class A addresses.
  - 0 and 127 have special meaning and are not used.
- 16,777,214 host addresses, one for network address and one for broadcast address.
- Only large organizations such as the military, government agencies, universities, and large corporations have class A addresses.
- For example ISPs have 24.0.0.0 and 63.0.0.0
- Class A addresses account for 2,147,483,648 of the possible IPv4 addresses.
- That's 50 % of the total unicast address space, *if* classful was still used in the Internet!

# Class B addresses

**Default Mask: 255.255.0.0 (/16)**

**First octet is between 128 – 191, begins with 10**



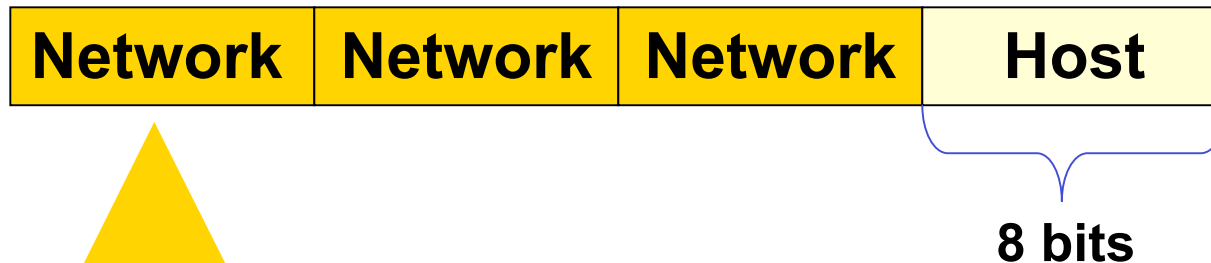
**Number  
between  
128 - 191**

**With 16 bits available for hosts,  
there a  $2^{16}$  possible addresses.  
That's 65,536 nodes!**

- There are 16,384 ( $2^{14}$ ) class B networks.
- 65,534 host addresses, one for network address and one for broadcast address.
- Class B addresses represent 25% of the total IPv4 unicast address space.
- Class B addresses are assigned to large organizations including corporations (such as Cisco, government agencies, and school districts).

# Class C addresses **Default Mask: 255.255.255.0 (/24)**

**First octet is between 192 – 223, begins with 110**



**Number  
between  
192 - 223**

**With 8 bits available for hosts,  
there a  $2^8$  possible addresses.  
That's 256 nodes!**

- There are 2,097,152 possible class C networks.
- 254 host addresses, one for network address and one for broadcast address.
- Class C addresses represent 12.5% of the total IPv4 unicast address space.

# IPv4 Address Classes

Class A	Network	Host		
Octet	1	2	3	4

Class B	Network		Host	
Octet	1	2	3	4

Class C	Network			Host
Octet	1	2	3	4

Class D	Host			
Octet	1	2	3	4

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

- No medium size host networks
- In the early days of the Internet, IP addresses were allocated to organizations based on request rather than actual need.

# Network based on first octet

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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

- The network portion of the IP address was dependent upon the first octet.
- There was no “Base Network Mask” provided by the ISP.
- The network mask was inherent in the address itself.

# IPv4 Address Classes

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
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## Class D Addresses

- A Class D address begins with binary 1110 in the first octet.
- First octet range 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

First octet of an IP address begins with 1111

- Class E addresses are reserved for experimental purposes and should not be used for addressing hosts or multicast groups.

# Fill in the information...

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1. 192.168.1.3                      Class \_\_\_\_\_                      Default Mask: \_\_\_\_\_  
Network: \_\_\_\_\_                      Broadcast: \_\_\_\_\_  
Hosts: \_\_\_\_\_ through \_\_\_\_\_

2. 1.12.100.31                      Class \_\_\_\_\_                      Default Mask: \_\_\_\_\_  
Network: \_\_\_\_\_                      Broadcast: \_\_\_\_\_  
Hosts: \_\_\_\_\_ through \_\_\_\_\_

3. 172.30.77.5                      Class \_\_\_\_\_                      Default Mask: \_\_\_\_\_  
Network: \_\_\_\_\_                      Broadcast: \_\_\_\_\_  
Hosts: \_\_\_\_\_ through \_\_\_\_\_

# Fill in the information...

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1. 192.168.1.3                      Class C                      Default Mask: 255.255.255.0  
Network: 192.168.1.0                      Broadcast: 192.168.1.255  
Hosts: 192.168.1.1 through 192.168.1.254
2. 1.12.100.31                      Class A                      Default Mask: 255.0.0.0  
Network: 1.0.0.0                      Broadcast: 1.255.255.255  
Hosts: 1.0.0.1 through 1.255.255.254
3. 172.30.77.5                      Class B                      Default Mask: 255.255.0.0  
Network: 172.30.0.0                      Broadcast: 172.30.255.255  
Hosts: 172.30.0.1. through 172.30.255.254

# Class separates network from host bits

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- The Class determines the Base Network Mask!

1. 192.168.1.3

Class C → Default Mask: 255.255.255.0  
Network: 192.168.1.0

2. 1.12.100.31

Class A → Default Mask: 255.0.0.0  
Network: 1.0.0.0

3. 172.30.77.5

Class B → Default Mask: 255.255.0.0  
Network: 172.30.0.0

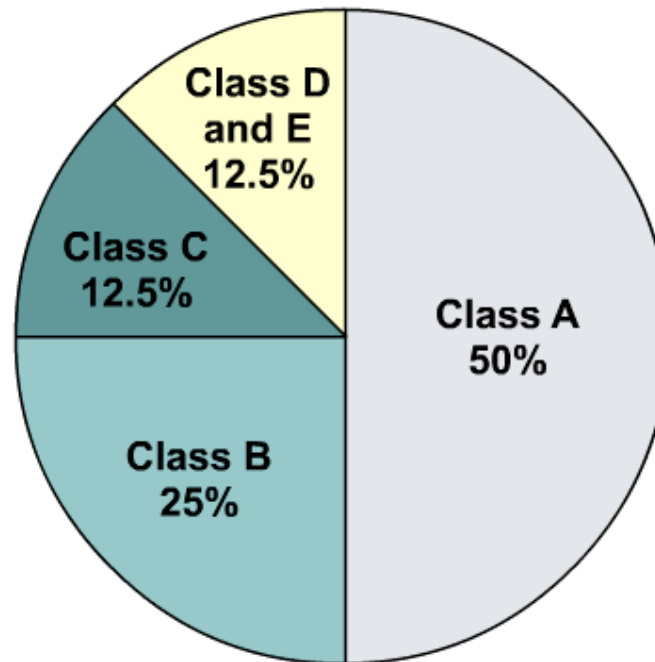
# Know the classes! (Write this out)

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<u>Class</u>	<u>First Bits</u>	<u>First Octet</u>	<u>Network Bits</u>	<u>Host Bits</u>
A	0	0 - 127	8	24
B	10	128 - 191	16	16
C	110	192 - 223	24	8
D	1110	224 - 239		
E	1111	240 -		

# IP addressing crisis

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With Class A and B addresses virtually exhausted, Class C addresses (12.5 percent of the total space) are left to assign to new networks.

- Address Depletion
- Internet Routing Table Explosion

# IPv4 Addressing

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## Subnet Mask

- One solution to the IP address shortage was thought to be the subnet mask.
- Formalized in 1985 (RFC 950), the subnet mask breaks a single class A, B or C network in to smaller pieces.
- This does allow a network administrator to divide their network into subnets.
- Routers still associated an network address with the first octet of the IP address.

# All Zeros and All Ones Subnets

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## Using the All Ones Subnet

- **There is no command to enable or disable the use of the all-ones subnet, it is enabled by default.**

```
Router(config)#ip subnet-zero
```

- **The use of the all-ones subnet has always been explicitly allowed and the use of subnet zero is explicitly allowed since Cisco IOS version 12.0.**

**RFC 1878 states, "This practice (of excluding all-zeros and all-ones subnets) is obsolete! Modern software will be able to utilize all definable networks." Today, the use of subnet zero and the all-ones subnet is generally accepted and most vendors support their use, though, on certain networks, particularly the ones using legacy software, the use of subnet zero and the all-ones subnet can lead to problems.**

CCO: Subnet Zero and the All-Ones Subnet

[http://www.cisco.com/en/US/tech/tk648/tk361/technologies\\_tech\\_note09186a0080093f18.shtml](http://www.cisco.com/en/US/tech/tk648/tk361/technologies_tech_note09186a0080093f18.shtml)

# Long Term Solution: IPv6 (coming)

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- IPv6, or IPng (IP – the Next Generation) uses a 128-bit address space, yielding  
340,282,366,920,938,463,463,374,607,431,768,211,456  
possible addresses.
- IPv6 has been slow to arrive
- IPv6 requires new software; IT staffs must be retrained
- IPv6 will most likely coexist with IPv4 for years to come.
- Some experts believe IPv4 will remain for more than 10 years.

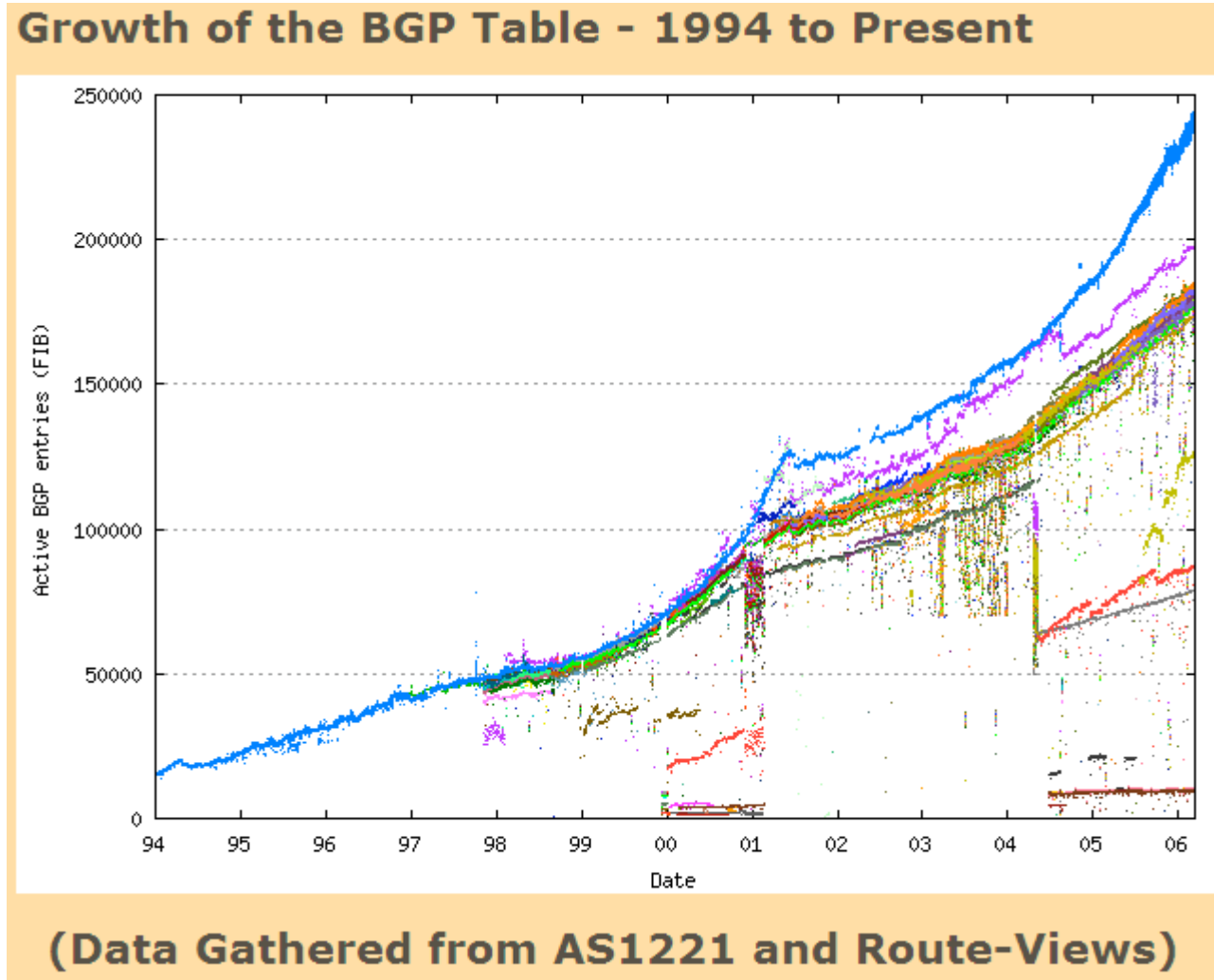
# Short Term Solutions: IPv4 Enhancements

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- CIDR (Classless Inter-Domain Routing) – RFCs 1517, 1518, 1519, 1520
- VLSM (Variable Length Subnet Mask) – RFC 1009
- Private Addressing - RFC 1918
- NAT/PAT (Network Address Translation / Port Address Translation) – RFC
  - More later when we discuss TCP

Class	RFC 1918 Internal Address Range	CIDR Prefix
A	10.0.0.0 to 10.255.255.255	10.0.0.0/8
B	172.16.0.0 to 172.31.255.255	172.16.0.0/12
C	192.168.0.0 to 192.168.255.255	192.168.0.0/16

# Active BGP entries – March, 2006



<http://bgp.potaroo.net/>

# ISP/NAP Hierarchy - “The Internet: Still hierarchical after all these years.” Jeff Doyle *(Tries to be anyways!)*

