Objectives

- Understand IPv4 addresses and classes
- Identify the class of an IP address
- Find the network address given an IP address
- Understand masks and how to use them
- Understand subnets

Introduction

The identifier used in the IP layer of the TCP/IP protocol suite to identify each device connected to the Internet is called the Internet address or **IP address**.
An IP address is a 32-bit address that uniquely and universally defines the connection of a host or a router to the Internet.
IP addresses are unique. They are unique in the sense that each address defines one, and only one, connection to the Internet.
Two devices on the Internet can never have the same address.

200.100.125.100

23456789

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Note

An IP address is a 32-bit address.

The IP addresses are unique.

The address space of IPv4 is 2^{32} or 4,294,967,296.

10

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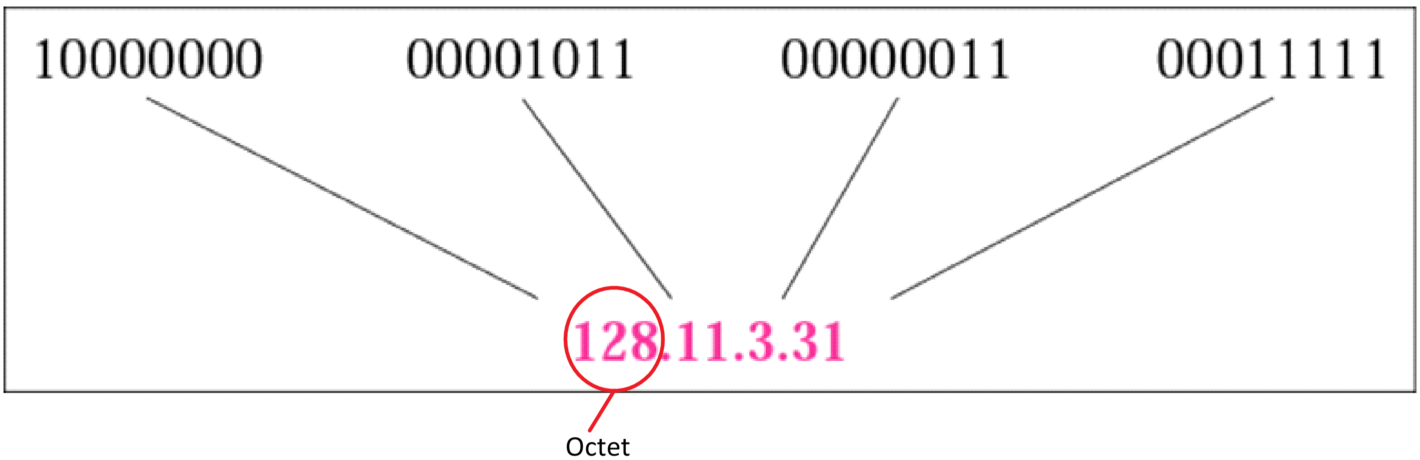
The Structure of IP Address



IP address format is dotted decimal. Dotted decimal makes it easy to work with IP addresses.

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Example

00000000 = 0
11111111 = 255

11100111 11011011 10001011 01101111

231.219.139.111

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IP Address Classes

RFC 791 defines the IP protocol.

	First byte	Second byte	Third byte	Fourth byte	
Class A*	**0 to 127**				
Class B	**128 to 191**				
Class C	**192 to 223**				
Class D	**224 to 239**				Multicast
Class E	**240 to 255**				Research

*The valid addresses in class A start from 1 to 126. Network 0.0.0.0 is defined for use as a broadcast address and 127.0.0.0 is reserved for use as loopback address.

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Example

Find the class of each address:

1. 227.12.14.87
2. 193.14.56.22
3. 14.23.120.8
4. 252.5.15.111
5. 134.11.78.56

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Solution

1. 227.12.14.87

The first byte is 227 (between 224 and 239); the class is D.

2.193.14.56.22

The first byte is 193 (between 192 and 223); the class is C.

3.14.23.120.8

The first byte is 14 (between 0 and 127); the class is A.

4. 252.5.15.111

The first byte is 252 (between 240 and 255); the class is E.

5.134.11.78.56

The first byte is 134 (between 128 and 191); the class is B.

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IP Address Classes

	First byte	Second byte	Third byte	Fourth byte	
Class A	**0**				
Class B	**10**				
Class C	**110**				
Class D	**1110**				Multicast
Class E	**1111**				Research

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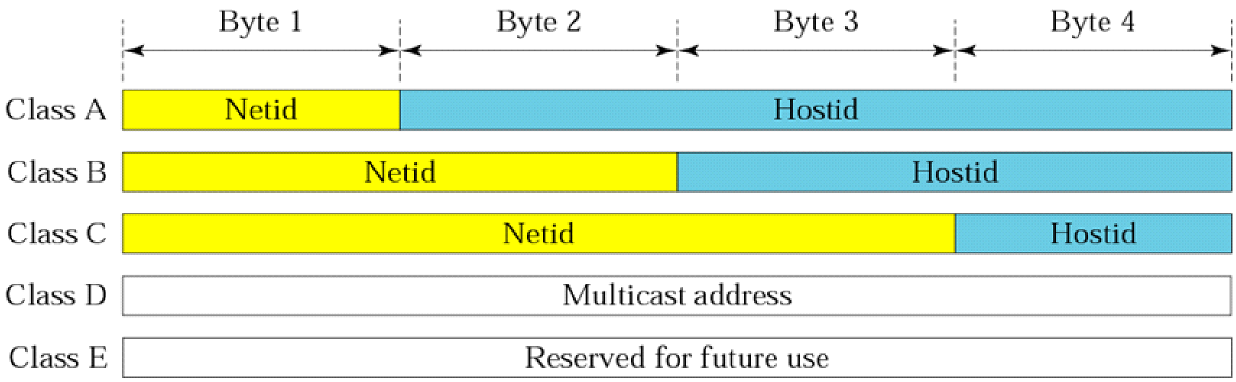
Netid and Hostid



In classful addressing, an IP address in class A, B and C is divided into two parts netid and hostid. These parts are varying length, depending on the class of the address.

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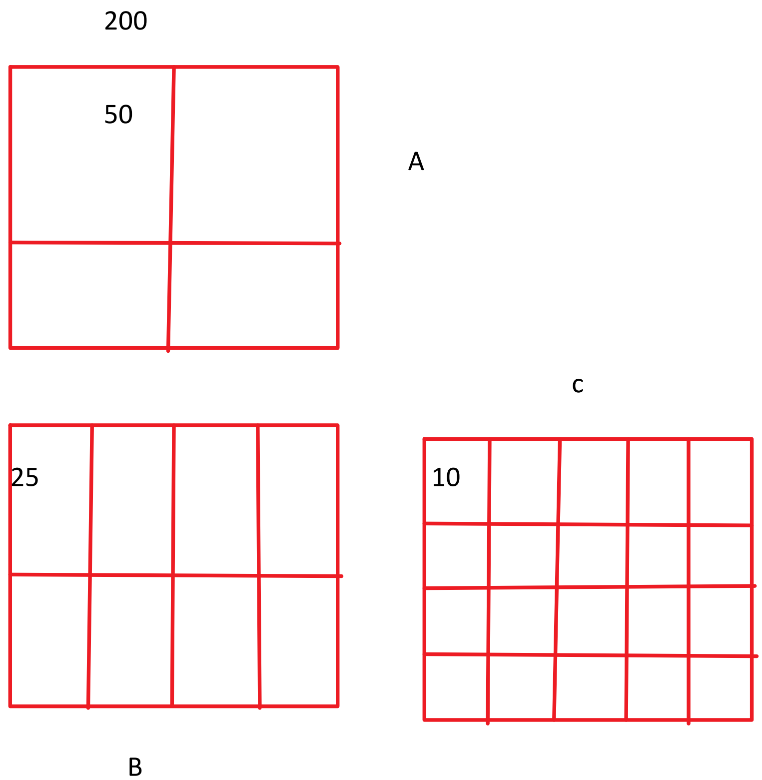

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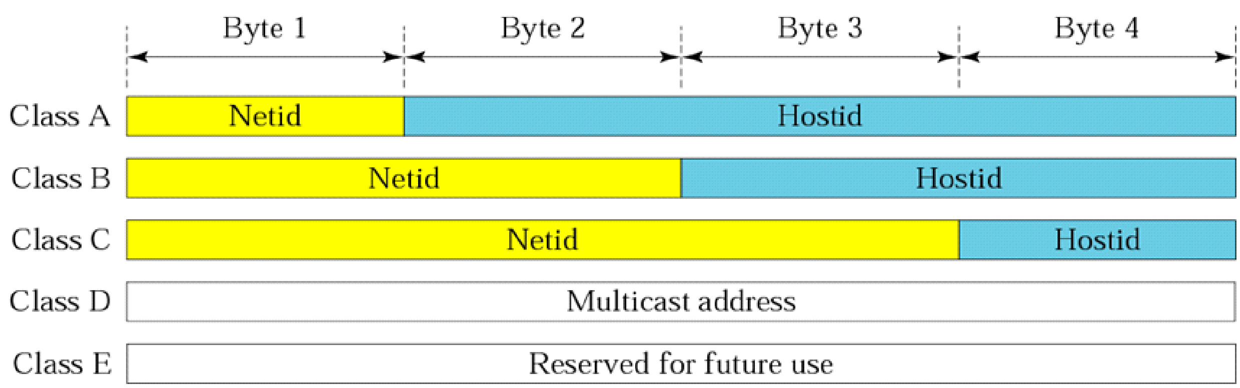
Number of Network Bits and Host Bits in each class

Class	Number of Network bits	Number of Host bits
A	8	24
B	16	16
C	24	8



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Number of Networks and Hosts Per each Network

Class	Number of Networks	Number of Hosts
A	2^8	2^{24}
B	2^{16}	2^{16}
C	2^{24}	2^8

NNNNNNNN.HHHHHHHH.HHHHHHHH.HHHHHHHH

$2^8 = 256$ $2^{24} = 16777216$

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Number of Networks and Hosts Per each Network

$2^{\text{Number of Network bits}}$ = Number of Networks

$2^{\text{Number of Host bits}}$ = Number Hosts

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Netid and Hostid

In classful addressing, the network address (the first address in the block) is the one that is assigned to the organization. Then the range of addresses can automatically be inferred from the network address.

80.0.0.0

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Subnet Mask

Class	Default Subnet Mask
A	255.0.0.0
B	255.255.0.0
C	255.255.255.0

11111111.00000000.00000000.00000000
11111111.11111111.00000000.00000000
11111111.11111111.11111111.00000000

Subnet Mask

Class	Default Subnet Mask
A	255.0.0.0
B	255.255.0.0
C	255.255.255.0

11111111.00000000.00000000.00000000
11111111.11111111.00000000.00000000
11111111.11111111.11111111.00000000

Class	Number of Network bits	Number of Host bits
A	8	24
B	16	16
C	24	8

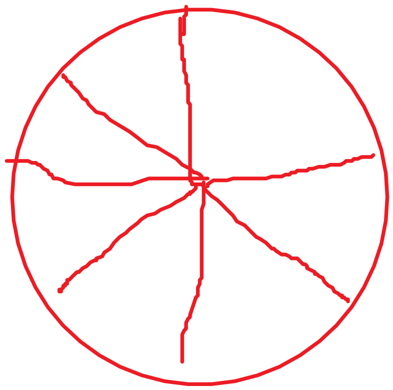
The subnet mask determine which part of the address belongs to the Network address and which part belongs to the Host address.

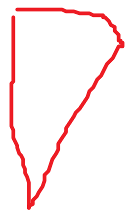
Subnet Mask

Number of Zeros in subnet mask represent the number of Host bits

$60

$12





80.0.0.0

255.0.0.0

255.255.254.0

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Subnet Mask

80.0.0.0
255.0.0.0 the number of subnet bits

11111111.11111111.11111110.00000000

255.255.254.0

300 $2^{\text{Number of subnet bits}}$ = Number of subnets

$2^{\text{Number of Host bits}} \geq 300 \Rightarrow 2^9 = 512 > 300$
Number of host bits = 9 => Number of zeros in subnet mask is 9

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Example

What is the appropriate subnet mask for a network with 400 hosts?

$2^{\text{Number of host bits}}$ = Number of hosts

$2^{\text{Number of host bits}} \geq$ 400 => 2^{9} = 512 > 400 =>

Number of host bits = 9

Number of zeros in subnet mask = 9

11111111.11111111.11111110.00000000

255.255.254.0

150.100.10.2

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Example

What is the appropriate subnet mask for a network with 400 hosts?

$$2^{\text{Number of Host bits}} \geq \text{Number Hosts}$$

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Solution

What is the appropriate subnet mask for a network with 400 hosts?

$2^{\text{Number of Host bits}} \geq \text{Number Hosts}$

$2^{\text{Number of Host bits}} \geq 400$

$2^9 = 512 > 400$ => Number of Host bits = 9 => Number of zeros in subnet mask = 9

11111111.11111111.11111110.00000000 = 255.255.254.0

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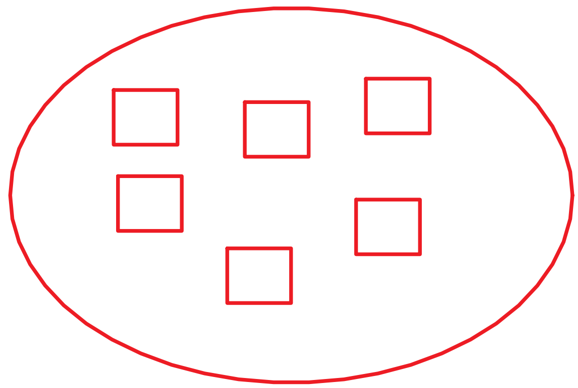
Network Address

Cisco Systems, Inc.
170 West Tasman Dr.
San Jose, CA 95134 USA

95134



150.100.10.2
255.255.0.0

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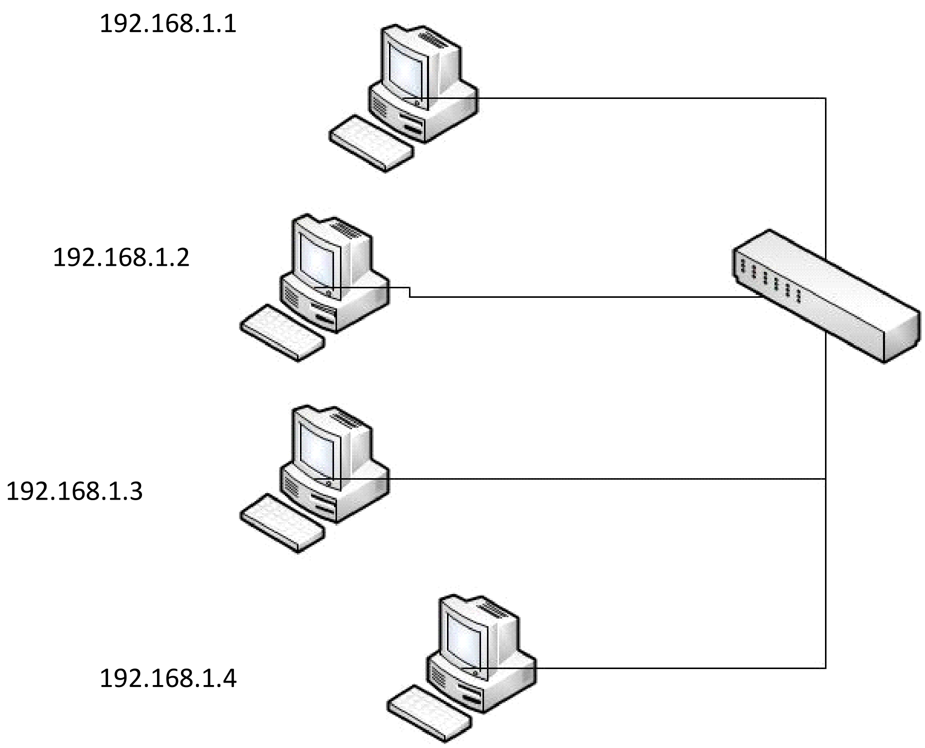
Network Address



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Network Address or Subnet Address

150.100.10.2
255.255.0.0

150	100	10	2

  10010110.01100100.00001010.00000010
& 11111111.11111111.00000000.00000000

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Network Address or Subnet Address

A	B	A & B
1	1	1
1	0	0
0	1	0
0	0	0

150.100.10.2
255.255.0.0

150 100 10 2

```
  10010110.01100100.00001010.00000010
& 11111111.11111111.00000000.00000000
  -----------------------------------
  10010110.01100100.00000000.00000000
  150.100.0.0
```

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Broadcast Address

150.100.10.2
255.255.0.0

No of host bits = 16

150 100 10 2

10010110.01100100.00001010.00000010
& 11111111.11111111.00000000.00000000

10010110.01100100.00000000.00000000

10010110.01100100.11111111.11111111
150.100.255.255

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First and Last valid addresses

150.100.10.2
255.255.0.0

150 100 10 2

10010110.01100100.00001010.00000010
11111111.11111111.00000000.00000000

10010110.01100100.00000000.00000000 Network id 150.100.0.0
10010110.01100100.00000000.00000001 First valid IP add. 150.100.0.1

10010110.01100100.11111111.11111110 Last valid IP add.
150.100.255.254

10010110.01100100.11111111.11111111 Broadcast add. 150.100.255.255

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Number of Hosts

$$2^{\text{Number of Host bits}} = \text{Number Hosts}$$

$$2^{\text{Number of Host bits}} \geq \text{Number Hosts}$$

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Number of Hosts

$$2^{\text{Number of Host bits}} - 2 = \text{Number Hosts}$$

$$2^{\text{Number of Host bits}} - 2 \geq \text{Number Hosts}$$

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Example

What is the appropriate subnet mask for a network with 400 hosts?

$$2^{\text{Number of Host bits}} - 2 \geq \text{Number Hosts}$$

$$2^{\text{Number of Host bits}} - 2 \geq 400$$

2^{9} - 2 = 512 - 2 = 510 > 400 => Number of Host bits = 9
=> Number of zeros in subnet mask = 9

11111111.11111111.11111110.00000000 = 255.255.254.0

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Example

What is the appropriate subnet mask for a network with 512 hosts?

$$2^{\text{Number of Host bits}} - 2 \geq \text{Number Hosts}$$

$$2^{\text{Number of Host bits}} - 2 \geq 512$$

2^{10} - 2 = 1024 - 2 = 1022 > 512 => Number of Host bits = 10
=> Number of zeros in subnet mask = 10

11111111.11111111.11111100.00000000 = 255.255.252.0

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Exercise

Given each IP address and mask, supply the following information for it:

1. The class of IP address
2. Number of network bits
3. Number of host bits
4. Number of subnet bits
5. Number of networks
6. Number of hosts in this network
7. Number of subnets in this network
8. Subnet address
9. Broadcast address
10. First valid address
11. Last valid address

172.31.200.10 mask 255.255.248.0

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Exercise

Given each IP address and mask, supply the following information for it:

1. The class of IP address
2. Number of network bits
3. Number of host bits
4. Number of subnet bits
5. Number of networks
6. Number of hosts in this network
7. Number of subnets in this network
8. Subnet address
9. Broadcast address
10. First valid address
11. Last valid address

172.31.200.10, mask 255.255.248.0

1. 172 is between 128 and 191 therefore it is a class **B** address

Exercise

Given each IP address and mask, supply the following information for it:

1. The class of IP address
2. Number of network bits
3. Number of host bits
4. Number of subnet bits
5. Number of networks
6. Number of hosts in this network
7. Number of subnets in this network
8. Subnet address
9. Broadcast address
10. First valid address
11. Last valid address

172.31.200.10, mask 255.255.248.0

2. Number of Network bits is 16 since the address is a class B address

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Exercise

Given each IP address and mask, supply the following information for it:

1. The class of IP address
2. Number of network bits
3. Number of host bits
4. Number of subnet bits
5. Number of networks
6. Number of hosts in this network
7. Number of subnets in this network
8. Subnet address
9. Broadcast address
10. First valid address
11. Last valid address

172.31.200.10, mask 255.255.248.0

3. 11111111.11111111.11111000.00000000

No. of host bits is 11

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Exercise

Given each IP address and mask, supply the following information for it:

1. The class of IP address
2. Number of network bits
3. Number of host bits
4. Number of subnet bits
5. Number of networks
6. Number of hosts in this network
7. Number of subnets in this network
8. Subnet address
9. Broadcast address
10. First valid address
11. Last valid address

    172.31.200.10, mask 255.255.248.0

4. To find out the number of subnet bit … look at the subnet mask in binary

    11111111.11111111.11111000.00000000

    Number of subnet bits = 5

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Exercise

Given each IP address and mask, supply the following information for it:

1. The class of IP address
2. Number of network bits
3. Number of host bits
4. Number of subnet bits
5. Number of networks
6. Number of hosts in this network
7. Number of subnets in this network
8. Subnet address
9. Broadcast address
10. First valid address
11. Last valid address

172.31.200.10, mask 255.255.248.0

5. $2^{\text{Number of Network bits}} = \text{Number of Networks}$

$2^{16} = 65536$

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Exercise

Given each IP address and mask, supply the following information for it:

1. The class of IP address
2. Number of network bits
3. Number of host bits
4. Number of subnet bits
5. Number of networks
6. Number of hosts in this network
7. Number of subnets in this network
8. Subnet address
9. Broadcast address
10. First valid address
11. Last valid address

172.31.200.10, mask 255.255.248.0

6. $2^{\text{Number of Host bits}} - 2 = \text{Number of Hosts}$

$2^{11} - 2 = 2048 - 2 = 2046$ Hosts in this network

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Exercise

Given each IP address and mask, supply the following information for it:

1. The class of IP address
2. Number of network bits
3. Number of host bits
4. Number of subnet bits
5. Number of networks
6. Number of hosts in this network
7. Number of subnets in this network
8. Subnet address
9. Broadcast address
10. First valid address
11. Last valid address

172.31.200.10, mask 255.255.248.0

7. $2^{\text{Number of subnet bits}} = \text{Number of Subnets}$

$2^5 = 32$ subnets

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Exercise

Given each IP address and mask, supply the following information for it:

1. The class of IP address
2. Number of network bits
3. Number of host bits
4. Number of subnet bits
5. Number of networks
6. Number of hosts in this network
7. Number of subnets in this network
8. Subnet address (Network address)
9. Broadcast address
10. First valid address
11. Last valid address

172.31.200.10, mask 255.255.248.0

```
8.  10101100.00011111.11001000.00001010
&   11111111.11111111.11111000.00000000
    -----------------------------------------------
    10101100.00011111.11001000.00000000
    172.31.200.0
```

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Exercise

Given each IP address and mask, supply the following information for it:

1. The class of IP address
2. Number of network bits
3. Number of host bits
4. Number of subnet bits
5. Number of networks
6. Number of hosts in this network
7. Number of subnets in this network
8. Subnet address (Network address)
9. Broadcast address
10. First valid address
11. Last valid address

Number of host bits = 11

172.31.200.10, mask 255.255.248.0

9.
```
  10101100.00011111.11001000.00001010
& 11111111.11111111.11111000.00000000
  -----------------------------------------------
  10101100.00011111.11001000.00000000

  10101100.00011111.11001111.11111111
  172.31.207.255
```

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Exercise

Given each IP address and mask, supply the following information for it:

1. The class of IP address
2. Number of network bits
3. Number of host bits
4. Number of subnet bits
5. Number of networks
6. Number of hosts in this network
7. Number of subnets in this network
8. Subnet address (Network address)
9. Broadcast address
10. First valid address
11. Last valid address

172.31.200.10, mask 255.255.248.0

10101100.00011111.11001000.00001010
11111111.11111111.11111000.00000000

&
10101100.00011111.11001000.00000000 network add. 172.31.200.0

10101100.00011111.11001000.00000001 first valid add. 172.31.200.1

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Exercise

Given each IP address and mask, supply the following information for it:

1. The class of IP address
2. Number of network bits
3. Number of host bits
4. Number of subnet bits
5. Number of networks
6. Number of hosts in this network
7. Number of subnets in this network
8. Subnet address (Network address)
9. Broadcast address
10. First valid address
11. Last valid address

172.31.200.10, mask 255.255.248.0

10101100.00011111.11001000.00001010
11111111.11111111.11111000.00000000

&
10101100.00011111.11001000.00000000 network add. 172.31.200.0

10101100.00011111.11001111.11111110 last valid add. 172.31.207.254

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Summary

- **An IP address is a 32-bit unique address.**
- **Find the network address given an IP address and subnet mask.**
- **What is a subnet.**

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References

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