# *IP Addresses: Classful Addressing*

# CONTENTS

## 4.1

# INTRODUCTION

**Note**

***An IP address is a 32-bit address.***

**Note**

***The IP addresses are unique.***

**One IP address points to one computer.**
**But a computer may have many IP addresses.**

# Address Space

# *RULE:*

**If a protocol uses $N$ bits to define an address, the address space is $2^N$ because each bit can have two different values (0 and 1) and $N$ bits can have $2^N$ values.**

Note

***The address space of IPv4 is***

$2^{32}$

***or***

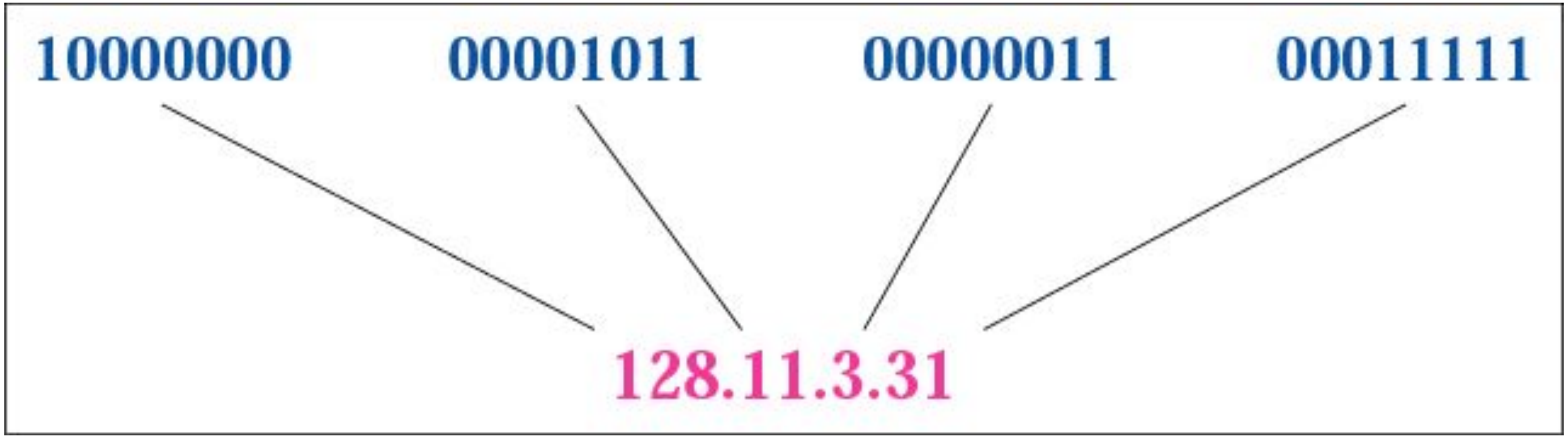
***4,294,967,296.***

# *Binary Notation*

01110101   10010101   00011101   11101010

Figure 4-1

# Dotted-decimal notation



# *Hexadecimal Notation*

**0111 0101 1001 0101 0001 1101 1110 1010**

| 75 | 95 | 1D | EA |
|---|---|---|---|

**0x75951DEA**

**Note**

***The binary, decimal, and hexadecimal number systems are reviewed in Appendix B.***

## *Example 1*

Change the following IP address from binary notation to dotted-decimal notation.

10000001 00001011 00001011 11101111

## *Solution*

*129.11.11.239*

## Example 2

Change the following IP address from dotted-decimal notation to binary notation.

111.56.45.78

## Solution

***01101111 00111000 00101101 01001110***

## Example 3

Find the error, if any, in the following IP address:

111.56.045.78

## Solution

There are no leading zeroes in dotted-decimal notation (045).

## Example 3 (continued)

Find the error, if any, in the following IP address:

75.45.301.14

## Solution

In dotted-decimal notation, each number is less than or equal to 255; 301 is outside this range.

## *Example 4*

Change the following IP addresses from binary notation to hexadecimal notation.

10000001 00001011 00001011 11101111

## *Solution*

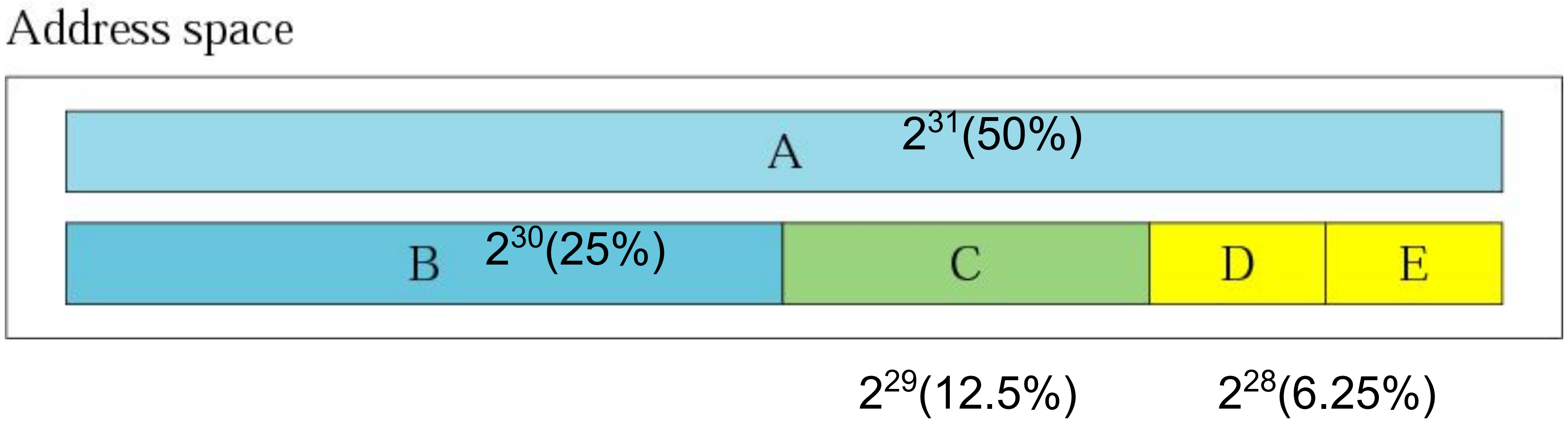
0X810B0BEF or $810B0BEF_{16}$

## 4.2

# CLASSFUL ADDRESSING

Figure 4-2

# Occupation of the address space



Note

***In classful addressing, the address space is divided into five classes: A, B, C, D, and E.***

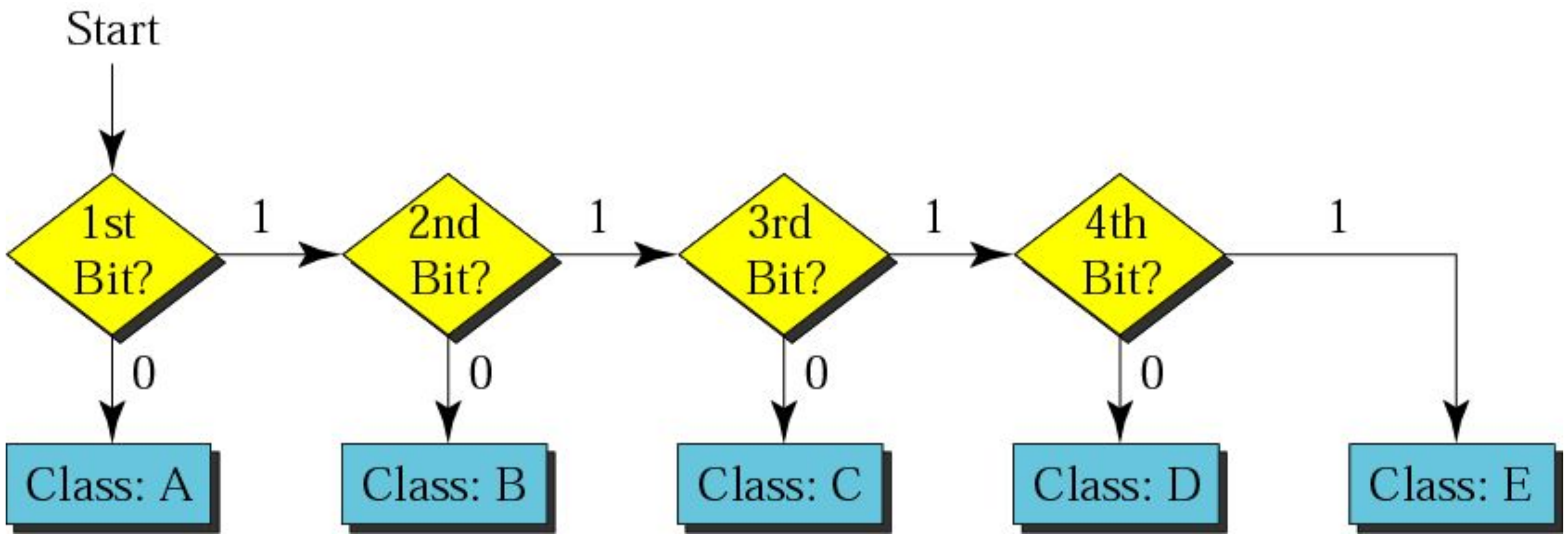
Figure 4-3

# Finding the class in binary notation

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

Figure 4-4

# Finding the address class



## Example 5

How can we prove that we have 2,147,483,648 addresses in class A?

## Solution

In class A, only 1 bit defines the class.
The remaining 31 bits are available
for the address. With 31 bits,
we can have $2^{31}$ or 2,147,483,648 addresses.

## *Example 6*

Find the class of the address:

**0**0000001 00001011 00001011 11101111

## *Solution*

The first bit is 0. This is a class A address.

## ***Example 6 (Continued)***

Find the class of the address:

**110**00001 10000011 00011011 11111111

## ***Solution***

The first 2 bits are 1; the third bit is 0.
This is a class C address.

Figure 4-5

# Finding the class in decimal notation

| | 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** | | | |
| Class E | **240 to 255** | | | |

## *Example 7*

Find the class of the address:

**227**.12.14.87

## *Solution*

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

## *Example 7 (Continued)*

Find the class of the address:

**193**.14.56.22

## *Solution*

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

# Find the Class of IP Address:

| IP Address | Class |
|---|---|
| 192.168.1.10 | |
| 10.10.200.6 | |
| 172.15.165.1 | |
| 230.10.65.30 | |

# Spot the Error, if any:

| Question | Answer |
|---|---|
| 111.56.045.78 | |
| 221.34.7.8.20 | |
| 75.45.301.14 | |
| 11100010.23.14.67 | |

# Classes of IPv4 Address

| Address Class | 1st Octet range in decimal | 1st Octet bits (Blue Dots do not change) | Network (N) and Host (H) Portion | Default mask (Decimal) | Number of possible networks and hosts per network |
|---|---|---|---|---|---|
| A | 0-127 | 00000000 - 01111111 | N.H.H.H | 255.0.0.0 | 128 Nets ($2^7$)<br>16,777,214 hosts ($2^{24}-2$) |
| B | 128-191 | 10000000 - 10111111 | N.N.H.H | 255.255.0.0 | 16,384 Nets ($2^{14}$)<br>65,534 hosts ($2^{16}-2$) |
| C | 192-223 | 11000000 - 11011111 | N.N.N.H | 255.255.255.0 | 2,09,150 Nets ($2^{21}$)<br>254 hosts ($2^8-2$) |
| D | 224-239 | 11100000 - 11101111 | NA (Multicast) | - | - |
| E | 240-255 | 11110000 - 11111111 | NA (Experimental) | - | - |

# Subnet Mask

| | | |
|---|---|---|
| 10.10.10.1<br>10.10.20.16 | 255.0.0.0 | Same N/W |
| 10.10.10.1<br>10.10.20.16 | 255.255.255.0 | Different N/W |
| 172.16.200.1<br>172.16.165.2 | 255.255.0.0 | Same N/W |
| 10.10.36.1<br>10.10.12.1 | 255.255.0.0 | Same N/W |
| 10.10.36.1<br>10.10.12.1 | 255.255.255.0 | Different N/W |
| 172.16.200.1<br>172.16.165.2 | 255.255.255.0 | Different N/W |

# Question

Subnet the IP address 216.21.5.0 into 30 hosts in each subnet.

# Subnetting - 5 Steps

1. Identify the class of the IP address and note the Default Subnet Mask.
2. Convert the Default Subnet Mask into Binary.
3. Note the number of hosts required per subnet and find the Subnet Generator (SG) and octet position.
4. Generate the new subnet mask.
5. Use the SG and generate the network ranges (subnets) in the appropriate octet position.

# Solution

1. Class C – Default Subnet Mask: 255.255.255.0

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   1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 0 0 0 0 0 0 0 0

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# Solution

1. Class C – Default Subnet Mask: 255.255.255.0

   1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 0 0 0 0 0 0 0 0

2. No. of hosts/subnet: $\boxed{\text{30 (11110) – 5 bits}}$ SG: $\boxed{32}$ Octet Position: $\boxed{4}$

   1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 0 0 0 0 0

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1. New subnet mask: 255.255.255.224 or /27

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   1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 0 0 0 0 0 0 0 0

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   1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 0 0 0 0 0

1. New subnet mask: 255.255.255.224 or /27

2. Network Ranges (Subnets)
   216.21.5.0 – 216.21.5.31
   216.21.5.32 – 216.21.5.63
   216.21.5.64 – 216.21.5.95
   216.21.5.96 – 216.21.5.127
   216.21.5.128 – 216.21.5.159
   and so on....

# Question

Subnet the IP address 196.10.20.0 into 52 hosts in each subnet.

# Solution

1. Class C – Default Subnet Mask: 255.255.255.0

   1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 0 0 0 0 0 0 0 0

2. No. of hosts/subnet: 52 (110100) – 6 bits SG: 64 Octet Position: 4

   1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 0 0 0 0 0 0

1. New subnet mask: 255.255.255.192 or /26

2. Network Ranges (Subnets)

   196.10.20.0 – 196.10.20.63
   196.10.20.64 – 196.10.20.127
   196.10.20.128 – 196.10.20.191
   196.10.20.192 – 196.10.20.255

$2^2$ = 4 Networks

$2^6$ = 64 Hosts per Network (Subnet)

# Question

Subnet the IP address 150.15.0.0 into 500 hosts in each subnet.

# Solution

1. Class B – Default Subnet Mask: 255.255.0.0

   1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

2. No. of hosts/subnet: $\boxed{\text{500(111110100)–9 bits}}$ SG: $\boxed{2}$ Octet Position: $\boxed{3}$

   1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 0 . 0 0 0 0 0 0 0 0

1. New subnet mask: 255.255.254.0 or /23

2. Network Ranges (Subnets)
   150.15.0.0 – 150.15.1.255
   150.15.2.0 – 150.15.3.255
   150.15.4.0 – 150.15.5.255
   150.15.6.0 – 150.15.7.255
   150.15.8.0 – 150.15.9.255
   and so on....

$2^9$ = 512 Hosts per Network (Subnet)
$2^7$ = 128 Subnets (Networks)

# Question

Subnet the IP address 10.0.0.0 into 100 hosts in each subnet.

# Solution

1. Class A – Default Subnet Mask: 255.0.0.0

   1 1 1 1 1 1 1 1 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

2. No. of hosts/subnet: $\boxed{\text{100(1100100)–7 bits}}$ SG: $\boxed{128}$ Octet Position: $\boxed{4}$

   1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 0 0 0 0 0 0 0

1. New subnet mask: 255.255.255.128 or /25

2. Network Ranges (Subnets)
   10.0.0.0 – 10.0.0.127
   10.0.0.128 – 10.0.0.255
   10.0.1.0 – 10.0.1.127
   10.0.1.128 – 10.0.1.127
   10.0.2.0 – 10.0.2.127
   and so on....

# Solution

1. Class A – Default Subnet Mask: 255.0.0.0

   1 1 1 1 1 1 1 1 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

2. No. of hosts/subnet: 100(1100100)–7 bits SG: 128 Octet Position: 4

   1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 0 0 0 0 0 0 0

1. New subnet mask: 255.255.255.128 or /25

2. Network Ranges (Subnets)
   10.0.0.0 – 10.0.0.127
   10.0.0.128 – 10.0.0.255
   10.0.1.0 – 10.0.1.127
   10.0.1.128 – 10.0.1.255
   10.0.2.0 – 10.0.2.127
   and so on....

$2^7$ = 128 Hosts per Network (Subnet)
$2^{17}$ = 131072 Networks (Subnets)

# Try on your own!

1. Break 201.1.1.0 into networks of 40 hosts each.
2. Break 170.15.0.0 into networks of 1000 hosts each.
3. Break 15.0.0.0 into networks of 100 hosts each.

An organization follows class A for their internal network. One of the hosts in the network has an IP address 10.200.240.4. Find the number of addresses, the network address, and the broadcast address of the organization's network.

**Solution:**

Class A Network

N.H.H.H (255.0.0.0 or /8)

10.200.240.4

This network: 10.0.0.0 – 10.255.255.255

Number of addresses: $2^{24}$ = 16,777,216

Number of usable addresses: 16,777,216 – 2 = 16,777,214

First Address: 10.0.0.0 (Network Address)

Last Address: 10.255.255.255 (Broadcast Address)

A PC with IP: 192.168.1.127 and

subnet mask: 255.255.255.224

Troubleshoot the issue with assigned IP.

**Solution:**

Subnet Mask: 255.255.255.224

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 1 1 1 0 0 0 0 0

Subnet Generator (SG): 32

Network ranges:

192.168.1.0 – 192.168.1.31
192.168.1.32 – 192.168.1.63
192.168.1.64 – 192.168.1.95
192.168.1.96 – 192.168.1.127
192.168.1.128 – 192.168.1.159

**If the IP address of one host is 25.34.12.56/16. What is the first address (Network Address) in this block?**

## Solution:

Class B subnet mask 255.255.0.0

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

SG = 1 and Octet Position = 2

Network Ranges (Subnets)

25.34.0.0 – 25.34.255.255

25.35.0.0 – 25.35.255.255

25.36.0.0 – 25.36.255.255

25.37.0.0 – 25.37.255.255

and so on

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 25 | . | 34 | . | 12 | . | 56 |
| | 00011001 | . | 00100010 | . | 00001100 | . | 00111000 |
| | 11111111 | . | 11111111 | . | 00000000 | . | 00000000 |
| AND | 00011001 | . | 00100010 | . | 00000000 | . | 00000000 |
| | 25 | . | 34 | . | 0 | . | 0 |

**If the IP address of one host is 25.34.12.56/16. What is the first address (Network Address) in this block?**

# Solution:

Class B subnet mask 255.255.0.0

1 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

SG = 1 and Octet Position = 2

<u>Network Ranges (Subnets)</u>

25.34.0.0 – 25.34.255.255

25.35.0.0 – 25.35.255.255

25.36.0.0 – 25.36.255.255

25.37.0.0 – 25.37.255.255

and so on

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 25 | . | 34 | . | 12 | . | 56 |
| | 00011001 | . | 00100010 | . | 00001100 | . | 00111000 |
| | 11111111 | . | 11111111 | . | 00000000 | . | 00000000 |
| AND | 00011001 | . | 00100010 | . | 00000000 | . | 00000000 |
| | 25 | . | 34 | . | 0 | . | 0 |