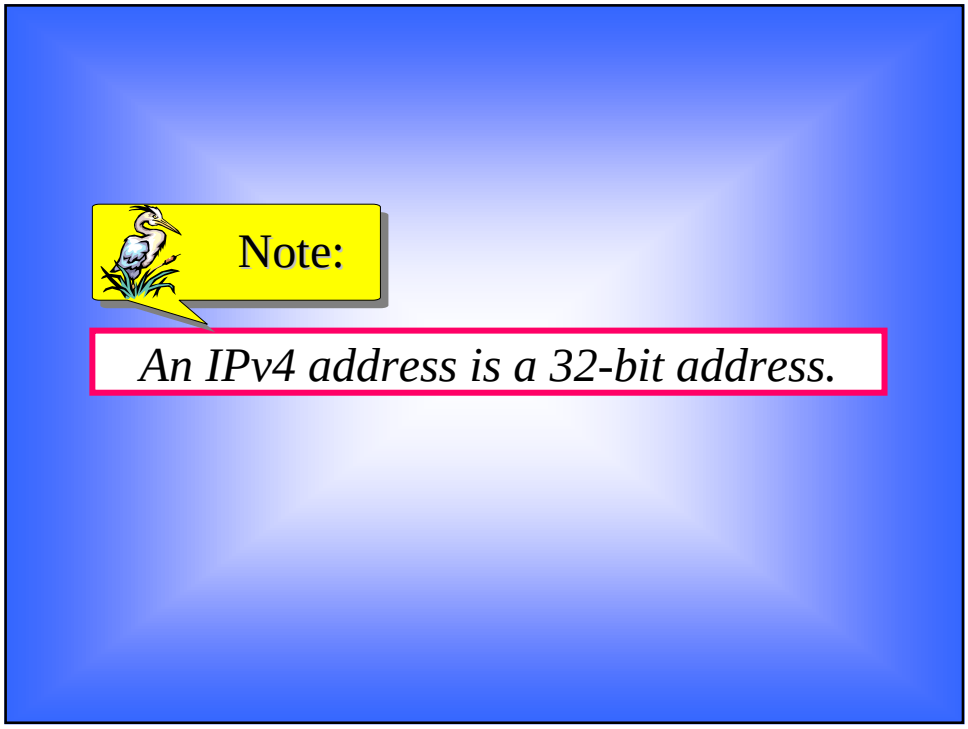
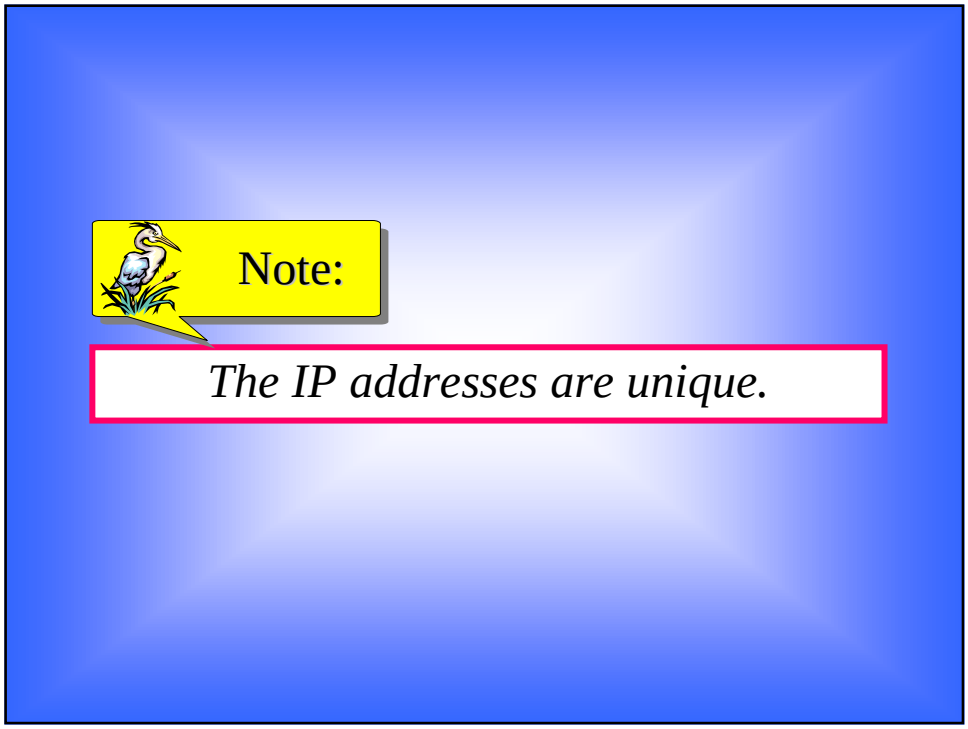
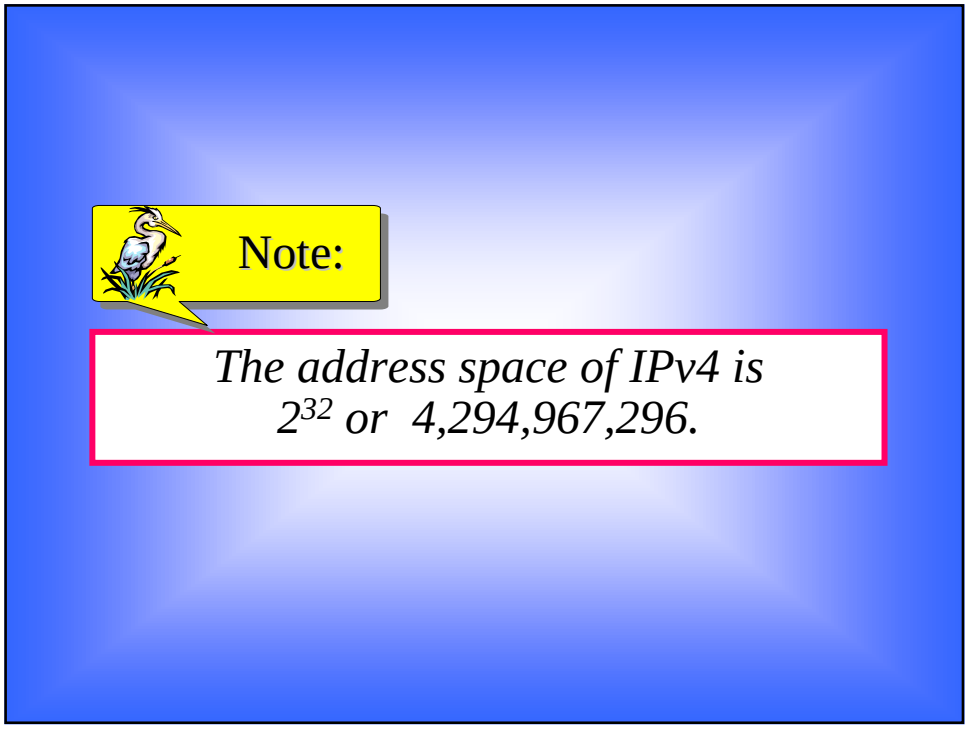
IP Addressing and Sub-netting

What is a IP Address ?

- An IP address is a unique number that devices use to identify and communicate with each other on a computer network.

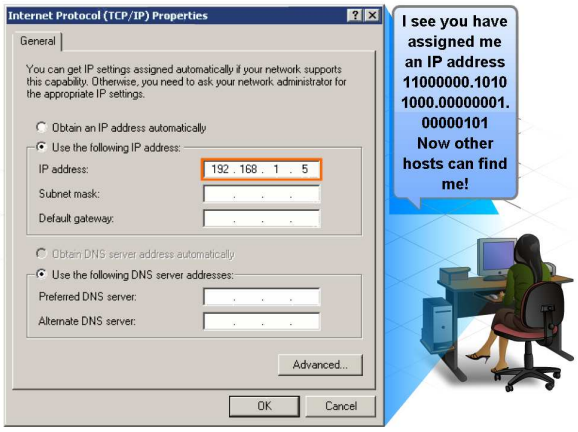






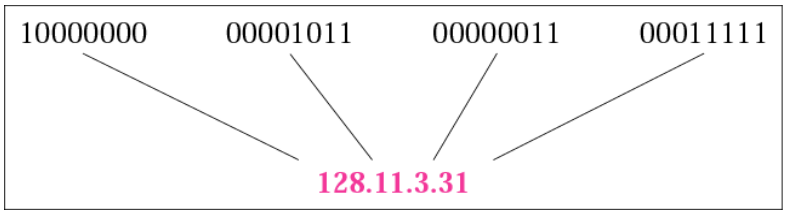
IP Addressing Structure

- Describe the dotted decimal structure of a binary IP address and label its parts



IP version 4 (IPv4) is the current form of addressing used on the Internet.

Dotted-decimal notation of IPv4 Address



Binary to Decimal Conversion

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
0	0	1	1	1	1	1	1

Decimal Value = 128 + 64 + 16 + 1

Decimal Value = 128 + 64 + 32 + 16 + 8 + 4 + 2 + 1

= 127

Easy way 128 – 1 = 127

Decimal to Binary Conversion

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1

Binary Value of 192 =

Is 192 ≥ 128 ? Yes, put highest bit = 1

192 – 128 = 64

64 ≥ 64 ? Yes, put next highest bit = 1

64 – 64 = 0

0 ≥ 32 ? No, put next highest bit = 0

0 ≥ 16 ? No, put next highest bit = 0

0 ≥ 8 ? No, put next highest bit = 0

0 ≥ 4 ? No, put next highest bit = 0

0 ≥ 2 ? No, put next highest bit = 0

0 ≥ 1 ? No, put next highest bit = 0

So Binary Value = 1 1 0 0 0 0 0 0

Binary Value of 63

63 ≥ 128 ? No, put highest bit = 0

63 ≥ 64 ? No, put next highest bit = 0

63 ≥ 32 ? Yes, put next highest bit = 1

63 - 32 = 31

31 ≥ 16 ? yes, put next highest bit = 1

31 - 16 = 15

15 ≥ 8 ? yes, put next highest bit = 1

15 - 8 = 7

7 ≥ 4 ? yes, put next highest bit = 1

7- 4 = 3

3 ≥ 2 ? yes, put next highest bit = 1

3 - 2=1

1 ≥ 1 ? yes, put next highest bit = 1

So Binary Value = 0 0 1 1 1 1 1 1

IP Addressing Structure

- Practice converting decimal to 8-bit binary

Decimal to Binary Conversion Activity

Given a decimal value, enter the correct binary values for each positon.

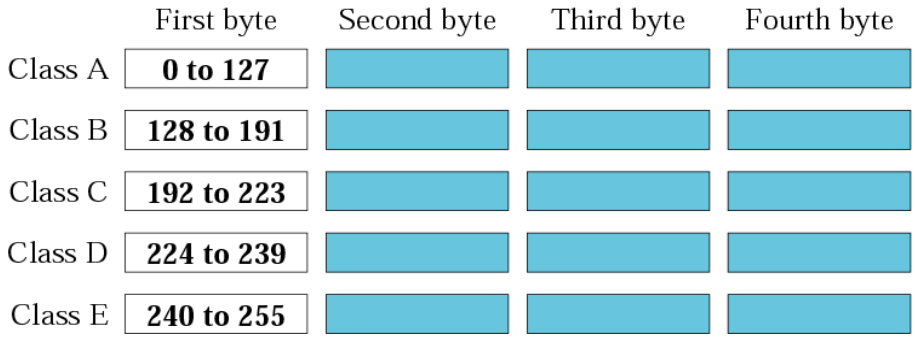
Decimal Value	209							
Exponent	2^7th	2^6th	2^5th	2^4th	2^3rd	2^2nd	2^1st	2^0
Position	128	64	32	16	8	4	2	1
Bit								

Enter numbers for these 8 positions.

IPv4 Classes

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

Range of IPv4 Classes

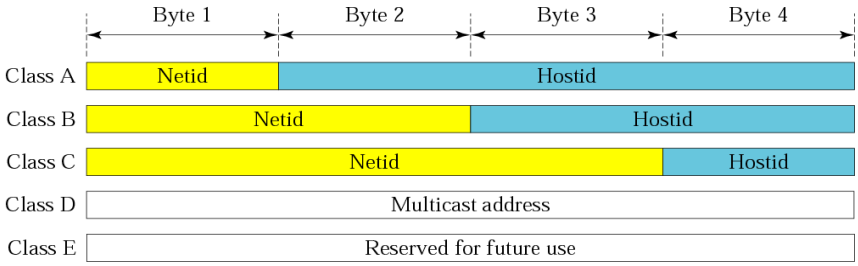


Class A, B, C are commonly used for addressing networks and devices

Class D and E are reserved for special purposes

Type of Address	Usage	Reserved IPv4 Address Range	RFC
Host Address	used for IPv4 hosts	0.0.0.0 to 223.255.255.255	790
Multicast Addresses	used for multicast groups on a local network	224.0.0.0 to 239.255.255.255	1700
Experimental Addresses	• used for research or experimentation • cannot currently be used for hosts in IPv4 networks	240.0.0.0 to 255.255.255.254	1700 3330

Network Portion (*Netid*)and Host portion (*hostid*) of IPv4 Classes



Network and Host Portions

- The no. of bits in the network portion determines how many different networks.
- The number of bits used in this host portion determines the number of hosts that we can have within the network.

HOW WILL YOU FIND

How many bits are NETWORK portion ?

How many bits are HOST portion ?

Solution : Using Network Prefix or Subnet Mask . . .

Network Prefixes

- A Network Prefix is a method to identify the network portion and host portion of an IP address.
- The prefix length is nothing but the number of network bits in the IP address.
- For example, in 192.168.1.0 /24, the number 24 is no. of network bits.

Subnet mask

- Subnet Mask is another common method used to identify the network portion and host portion of an IP address.
- In a subnet mask, All network bits = 1
  All host bits = 0

For example, 172.16.4.0 /16,
the subnet mask = 255.255.0.0

Default Subnet masks of IPv4 Classes

Class	*Mask in binary*	*Mask in dotted-decimal*
A	**11111111** 00000000 00000000 00000000	**255.**0.0.0
B	**11111111 11111111** 00000000 00000000	**255.255.**0.0
C	**11111111 111111111 11111111** 00000000	**255.255.255.**0

IP Address Classes

Address Class	1st octet range (decimal)	1st octet bits (green bits do not change)	Network(N) and Host(H) parts of address	Default subnet mask (decimal and binary)	Number of possible networks and hosts per network
A	1-127**	00000000-01111111	N.H.H.H	255.0.0.0	128 nets (2^7) 16,777,214 hosts per net (2^24-2)
B	128-191	10000000-10111111	N.N.H.H	255.255.0.0	16,384 nets (2^14) 65,534 hosts per net (2^16-2)
C	192-223	11000000-11011111	N.N.N.H	255.255.255.0	2,097,150 nets (2^21) 254 hosts per net (2^8-2)
D	224-239	11100000-11101111	NA (multicast)		
E	240-255	11110000-11111111	NA (experimental)		

** All zeros (0) and all ones (1) are invalid hosts addresses.

Network Address

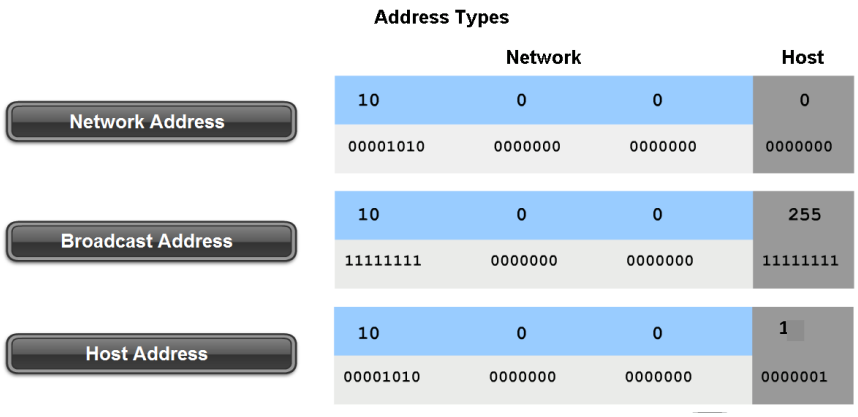
- The address by which we refer to the network.
- Its lowest (first) address in a network.
- All the host bits in a network address equals 0
- The address cannot be assigned to any end devices in the network
- Eg. 192.168.2.0/24 , 172.16.0.0/16 , 10.0.0.0/8

Broadcast Address

- A special address used to send data to all hosts in the network.
- Its highest (final) address of a network
- All the host bits in a network address equals 1
- The address also cannot be assigned to any end devices in the network
- Eg. 192.168.2.255/24 , 172.16.255.255/16 , 10.255.255.255/8

Host Address

- The addresses can assigned to the end devices in the network.
- For eg. PC, IP Phone, Router Interfaces etc.
- These are the addresses between network and broadcast address.

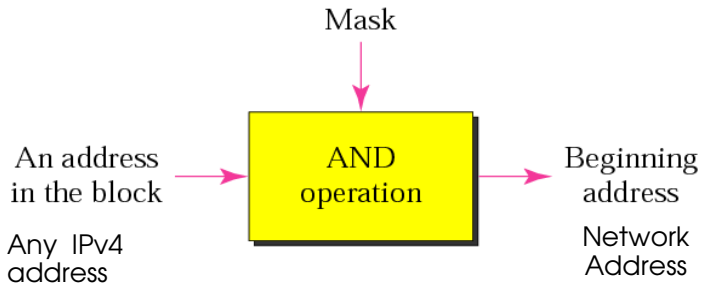


Calculating number of networks and hosts in Different Classes

No. of networks = $2^{\text{network bits}}$

No. of hosts in each network = $2^{\text{host bits}} - 2$

How to find the Network address when a Host IP and Subnet mask is given …



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AND ing the Host IP and Subnet mask to get Network Address

Applying the Subnet Mask

A device with address 192.0.0.1 belongs to network 192.0.0.0

	High order bits Prefix /16		Low order bits	
	192 . 0 . 0 . 1			
Host	11000000	00000000	00000000	00000001
Subnet	255	255	0	0
	11111111	11111111	00000000	00000000
Network	11000000	00000000	00000000	00000000
Network	192 . 0 . 0 . 0			

Use the subnet mask to determine the network address for the host 173.16.132.70/20.

Convert binary network address to decimal

Host Address	172 .	16 .	132 .	70
Binary Host Address	10101100	00010000	10000100	01000110
Binary Subnet Mask	11111111	11111111	11110000	00000000
Binary Network Address	10101100	00010000	10000000	00000000
Network Address	172 .	16 .	128 .	0

Given address/prefix of **183.26.103.215 /30**

For each row, enter the values ...

Type of Address	Enter LAST octet in binary	Enter LAST octet in decimal	Enter full address in decimal
Network			
Broadcast			
First Usable Host Address			
Last Usable Host Address			

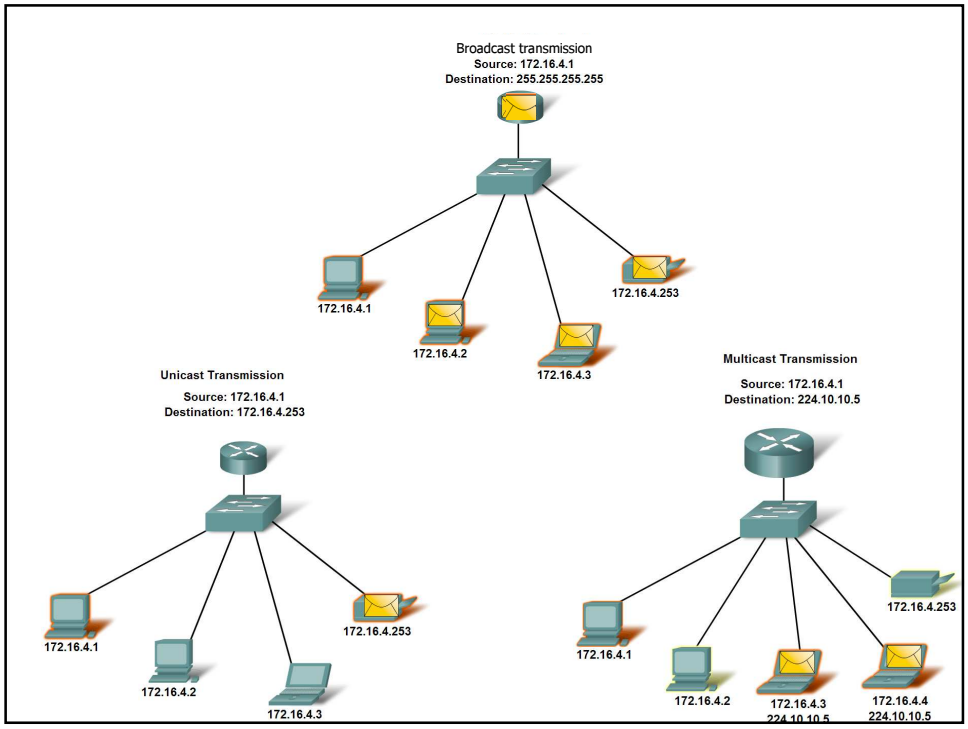
Calculating Addresses

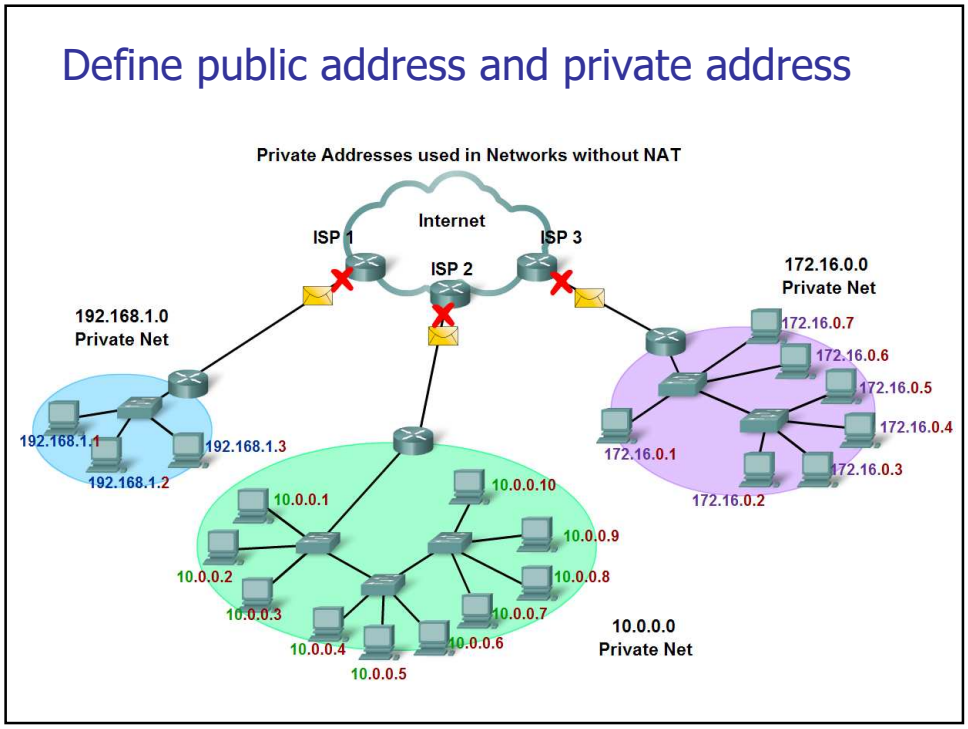
Given the network address and the subnet mask, define the range of hosts, the broadcast address, and the next network address.

Network Address in decimal	10	187	0	0
Subnet Mask in decimal	255	255	224	0
Network address in binary	00001010	10111011	00000000	00000000
Subnet Mask in binary	11111111	11111111	11100000	00000000
First Usable Host IP Address in decimal	1st octet	2nd octet	3rd octet	4th octet
Last Usable Host IP Address in decimal	1st octet	2nd octet	3rd octet	4th octet
Broadcast Address in decimal	1st octet	2nd octet	3rd octet	4th octet
Next Network Address in decimal	1st octet	2nd octet	3rd octet	4th octet

Communication in a IPv4 network

- Unicast - the process of sending a packet from one host to an individual host. It is used for the normal host-to-host communication in both a client/server and a peer-to-peer network.
- Broadcast - the process of sending a packet from one host to all hosts in the network
- Multicast - the process of sending a packet from one host to a selected group of hosts





Special IP Addresses

Default Route

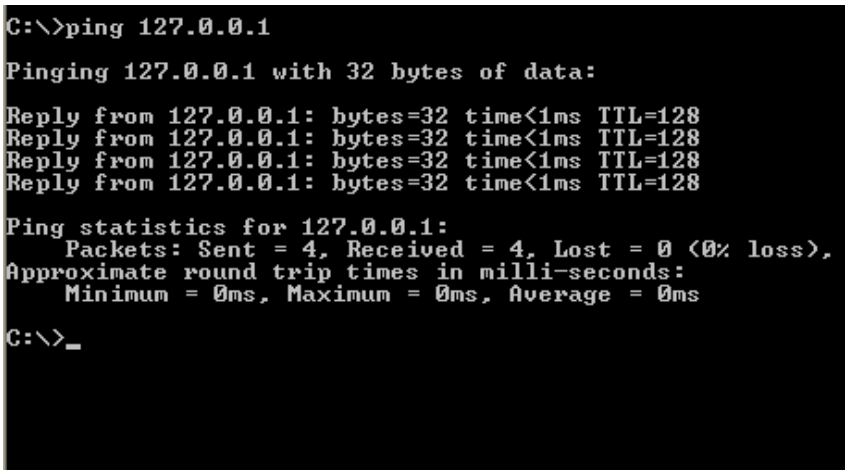
- Represent the IPv4 default route as 0.0.0.0
- Used as a "catch all" route when a more specific route is not available.
- Use of this address also reserves all addresses in the range 0.0.0.0 - 0.255.255.255 (0.0.0.0/8) address block.

Special IP Addresses……continued

Loopback Address

- Addresses 127.0.0.0 to 127.255.255.255 are reserved for loopback purposes.
- The loopback is a special address that hosts use to direct traffic to themselves.
- Used to check that TCP/IP stack is working properly

Pinging loopback address to check TCP/IP stack



Special IP Addresses……continued

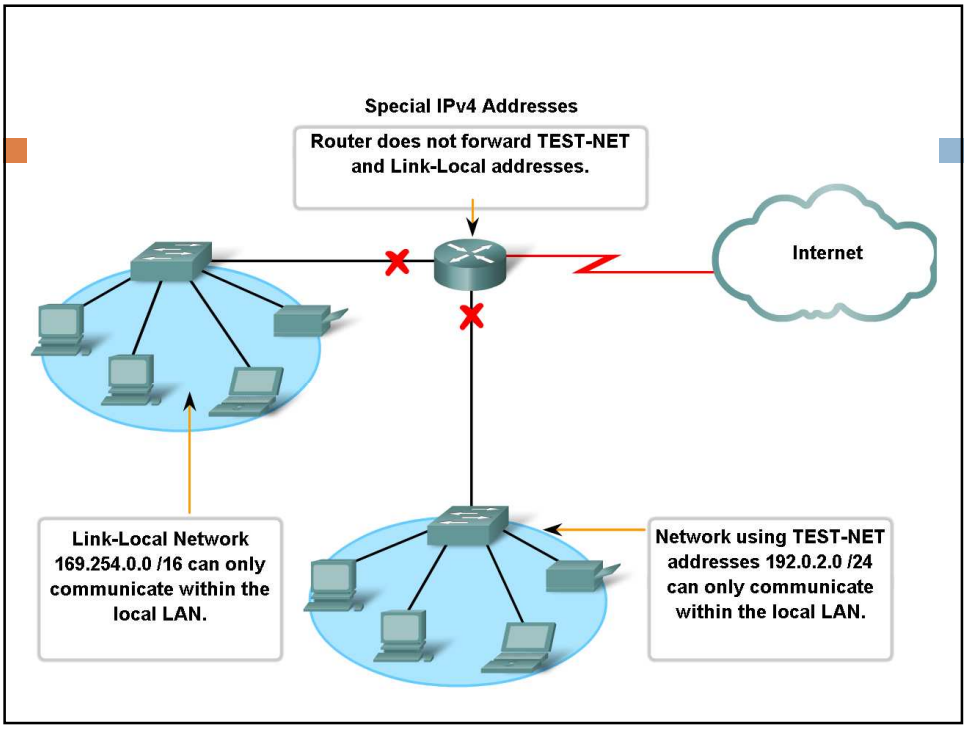
Link-Local Addresses

- Addresses 169.254.0.0 to 169.254.255.255 (169.254.0.0/16) are designated as link-local addresses.
- These addresses can be automatically assigned to the local host by the operating system in environments where no IP configuration is available.
- Link-local addresses do not provide services outside of the local network.

Special IP Addresses……continued

TEST-NET Addresses

- The address block 192.0.2.0 to 192.0.2.255 (192.0.2.0/24) is set aside for teaching and learning purposes.
- These addresses can be used in documentation and network examples.
- Addresses within this block should not appear on the Internet.

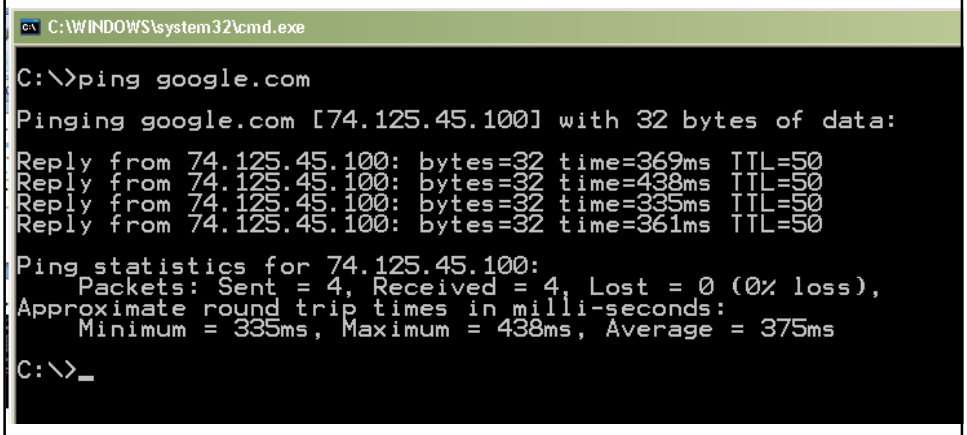


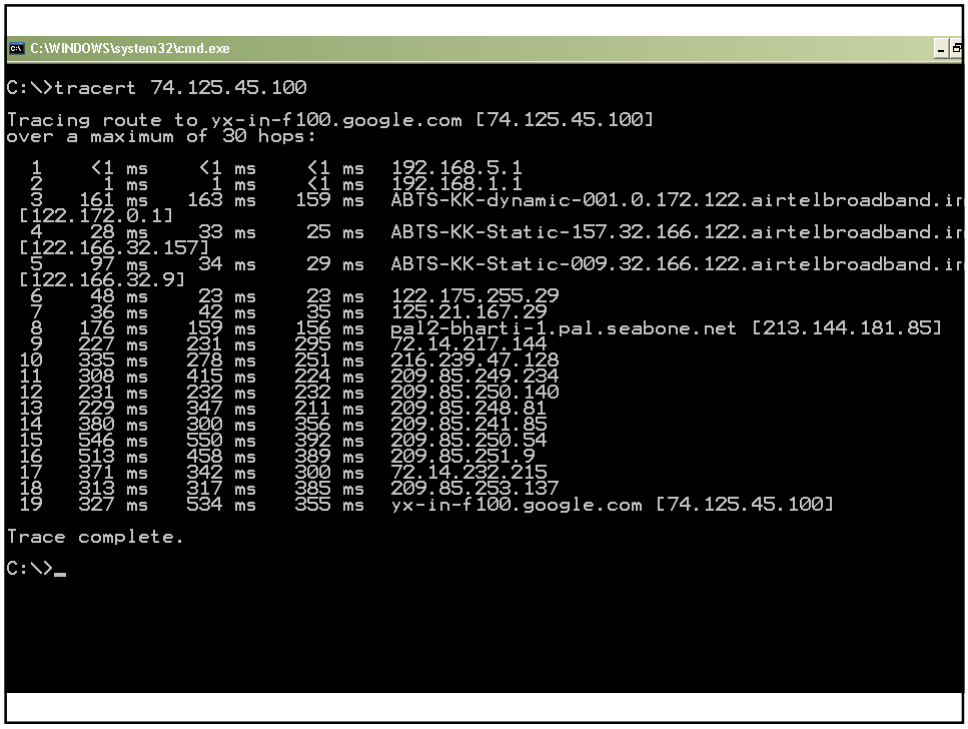
Tracert (traceroute)

- is a utility that allows us to observe the path between these hosts.

- The trace generates a list of hops that were successfully reached along the path

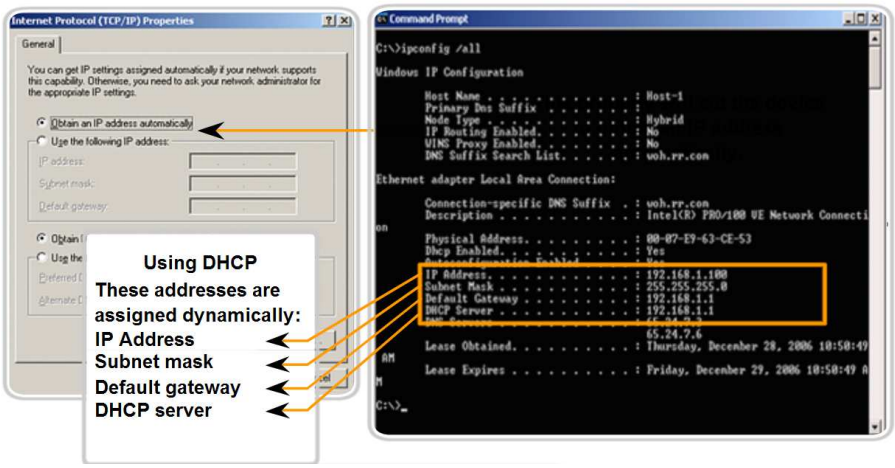
Checking connectivity to http://www.google.com using ping tool





Assigning DHCP Addresses

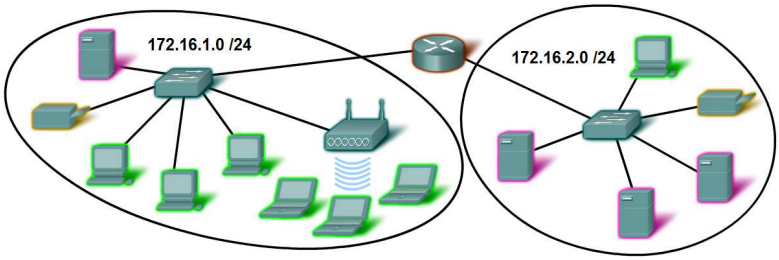
Assigning Dynamic Addresses



Assigning Addresses

Devices IP Address Ranges

Use	First Address	Last Address	Summary Address
Network Address	172.16.x.0	.....	172.16.x.0 /25
User hosts (DHCP pool)	172.16.x.1	172.16.x.127	
Servers	172.16.x.128	172.16.x.191	172.16.x.128 /26
Peripherals	172.16.x.192	172.16.x.223	172.16.x.192 /27
Networking devices	172.16.x.224	172.16.x.253	172.16.x.224 /27
Router (gateway)	172.16.x.254	.....	
Broadcast	172.16.x.255	.....	



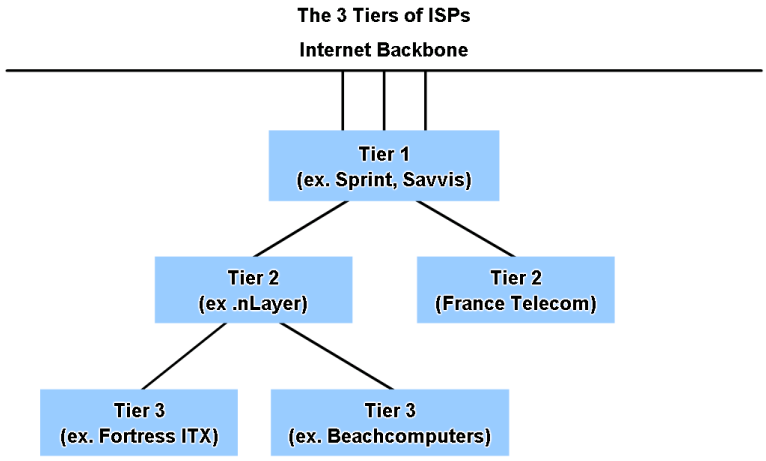
IP Global and Regional Agencies

Entities that Oversee IP Address Allocation

IANA - Internet Assigned Numbers Authority
- Responsible for IP address allocation to ISPs

Global	IANA				
Regional Internet Registries	**AfriNIC** Africa Region	**APNIC** Asia/ Pacific Region	**LACNIC** Latin America And Caribbean Region	**ARIN** North America Region	**RIPE NCC** Europe, Middle East, Central Asia Region

ISP Classification



Why IPv6 ?

IPv6 Header

Version 6	Traffic Class 8 bits	Flow Label 20 bits	
Payload Length 16 bits	Next Hdr 8 bits	HopLimit 8 bits	
3ffe:6a88:85a3:08d3:1319:8a2e:0370:7344			Source Address
2001:0db8:0000:0000:0000:0000:1428:57ab			Destination Address

Subnetting

Sub-netting is the process of dividing a major network into smaller networks called subnets.

By Sub-netting a network, we can save IPv4 addresses.

We can assign IP address to a network according to the requirement

Sub-netting means borrowing bits from the host portions and adding them to network portions.

By borrowing bits from host potion we can divide a network into subnets

Calculating number of subnets and number of host per subnet

No. of subnets = $2^{\text{borrowed bits}}$

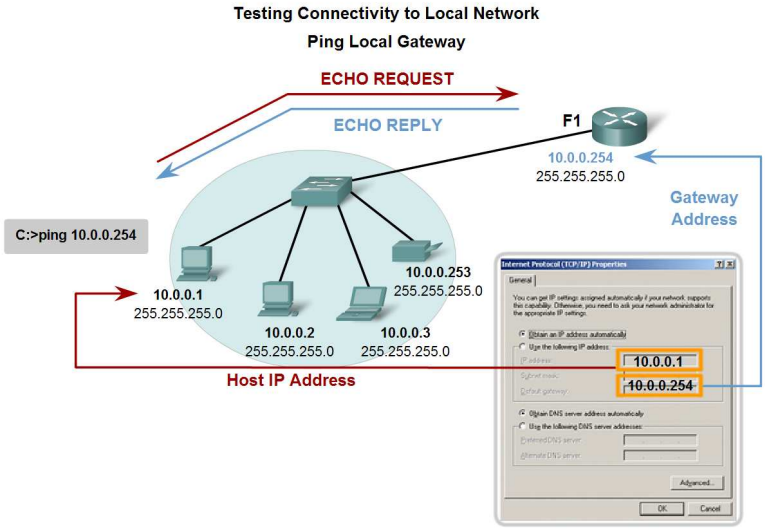
No. of hosts in each subnet = $2^{\text{host bits}} - 2$

Testing the Network Layer

- Use ping to verify connectivity
- Ping to loopback address to check TCP/IP stack
- Use tracert tool to trace the path.

Note : PING - ***P**acket **In**ternet **G**roper*

Ping tool and ICMP protocol



Summary

In this chapter, you learned to:

- Explain the structure IP addressing and demonstrate the ability to convert between 8-bit binary and decimal numbers.
- Given an IPv4 address, classify by type and describe how it is used in the network.
- Explain how addresses are assigned to networks by ISPs and within networks by administrators.
- Determine the network portion of the host address and explain the role of the subnet mask in dividing networks.
- Given IPv4 addressing information and design criteria, calculate the appropriate addressing components.
- Use common testing utilities to verify and test network connectivity and operational status of the IP protocol stack on a host.