IP Addressing
Week 6

Module : Computer Networks

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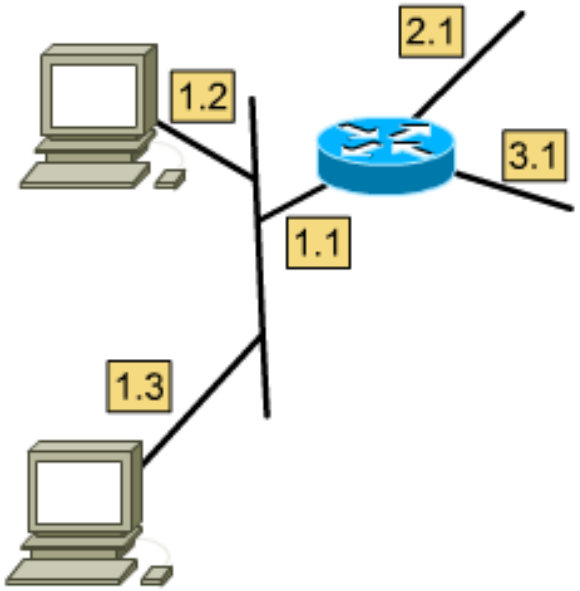
Addressing: Network & Host

Network	Host
1	1
	2
	3
2	1
3	1



- **Network address** help to identify route through the network cloud
- Network address divided into two parts:
  - **Network**
  - **host**
- Different network protocols have their own methods of dividing the network address into network and host portions. (We will only discuss IP.)

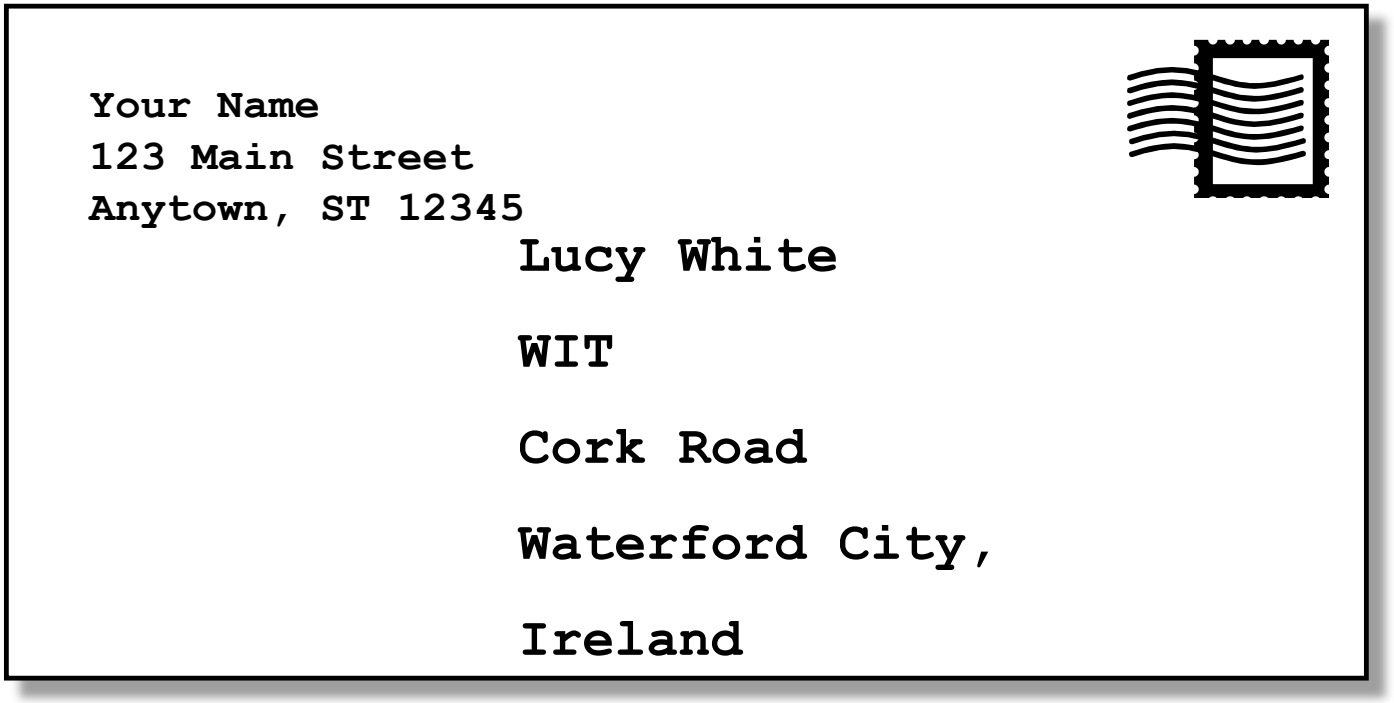
Network Addressing: Network & Host

- Phone numbers are similar to network addresse
  - Area Code / Phone Number
  - 831 – 479-5783

  - 831 → Network Portion
  - 479-5783 → Host Portion

  - 831 → Santa Cruz / Monterey Counties
  - 479-5783 → Rick Graziani, Cabrillo College

Network Addressing: Network & Host

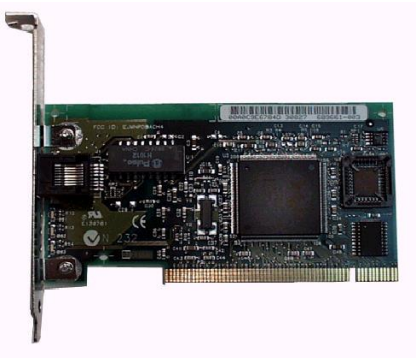


ZIP codes direct your mail to your local post office and your neighborhood. The street address then directs the carrier to your home.

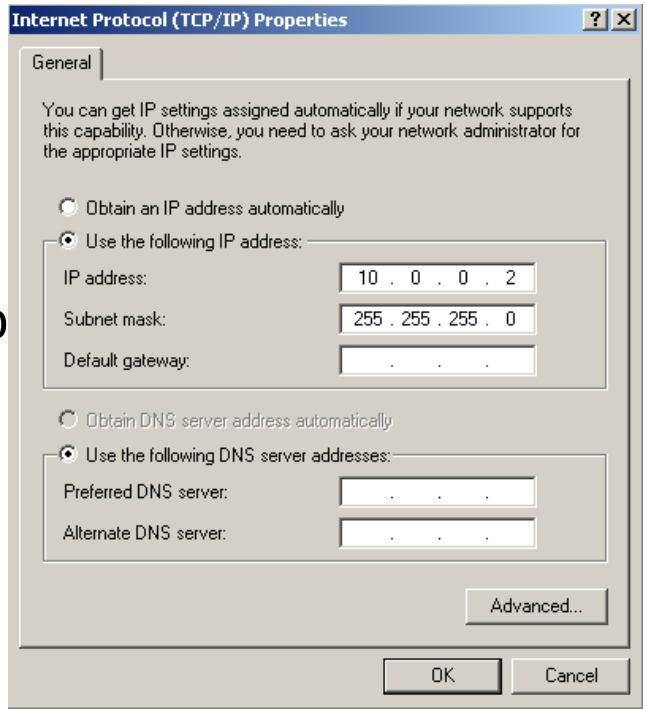
Computer Mobility

Layer 2 (Ethernet) and Layer 3 (IP) Addresses are needed:

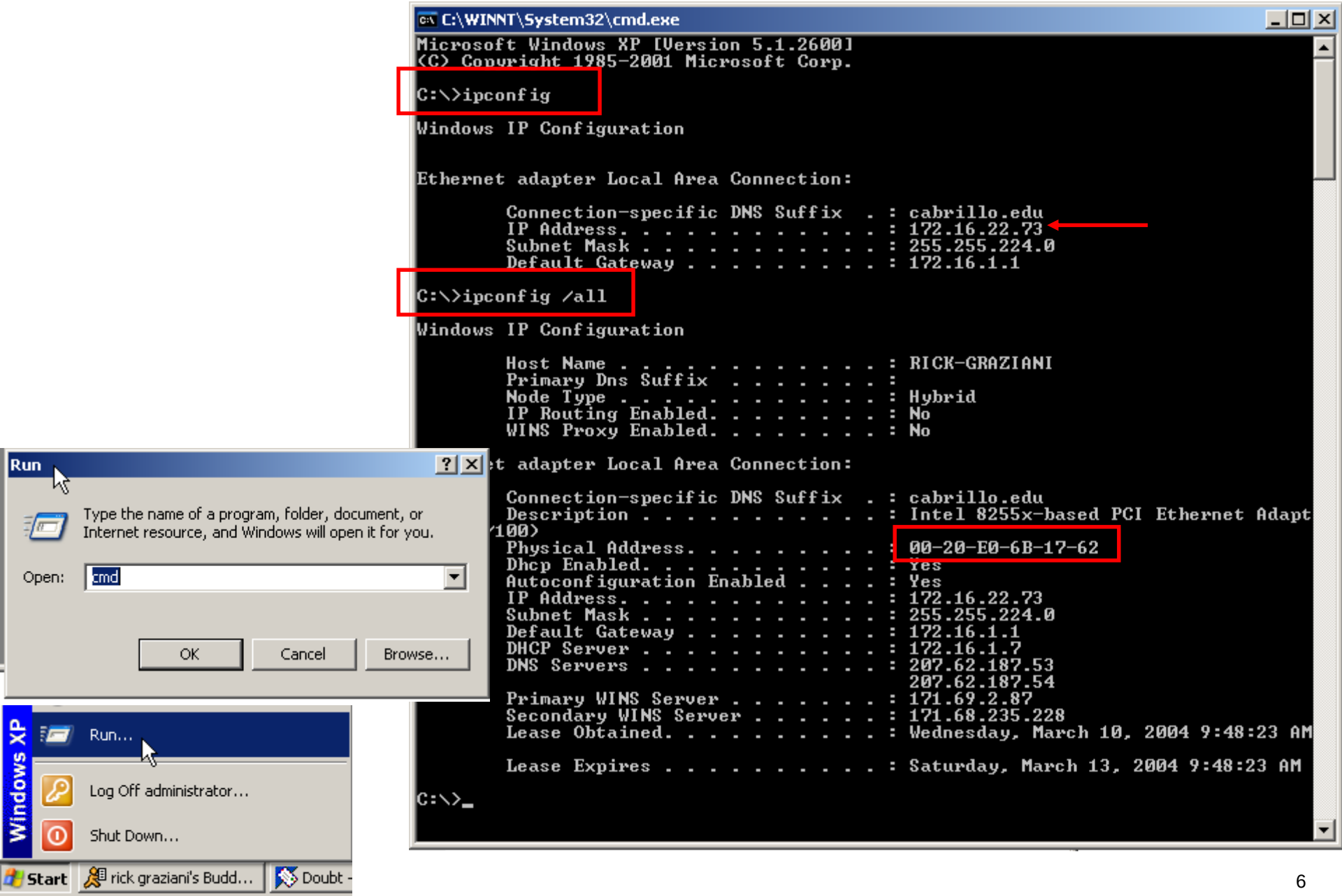
- Layer 2 / MAC address
  - Flat Addressing Scheme
  - Physically burned into the NIC
  - Doesn't change
  - The device's real identity (PPS No.)



- Layer 3 / Internet Protocol (IP) address
  - Hierarchical Addressing Scheme
  - Set with software
  - The device's "mailing" address (Phone No
  - Needs to change when device is moved



What is the MAC and IP Address on my computer?



Layer 2 Addresses = Flat Addressing

If the Internet was a flat network with only layer 2 addresses, switches would need to know the millions of layer 2 host addresses or broadcast the frame as an unknown unicast.

Layer 3 Addresses = Organized by Network

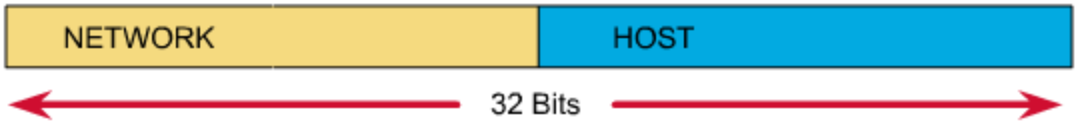
WIT

UCD

Your ISP

- **Layer 3 Addresses** are organized by network.
- To know the layer 3 address, means you know what network this packet belongs to.
- **Routers** maintain lists of layer 3 network addresses to route the packet to the right network.
- Layer 2 addresses are still used!
- Hosts will have both Layer 2 and Layer 3 addresses.
- We will see how these work together a little later.

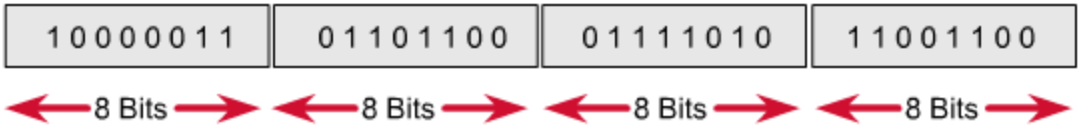
IP Addressing Scheme



IPv4 Addresses are **32 bits**.

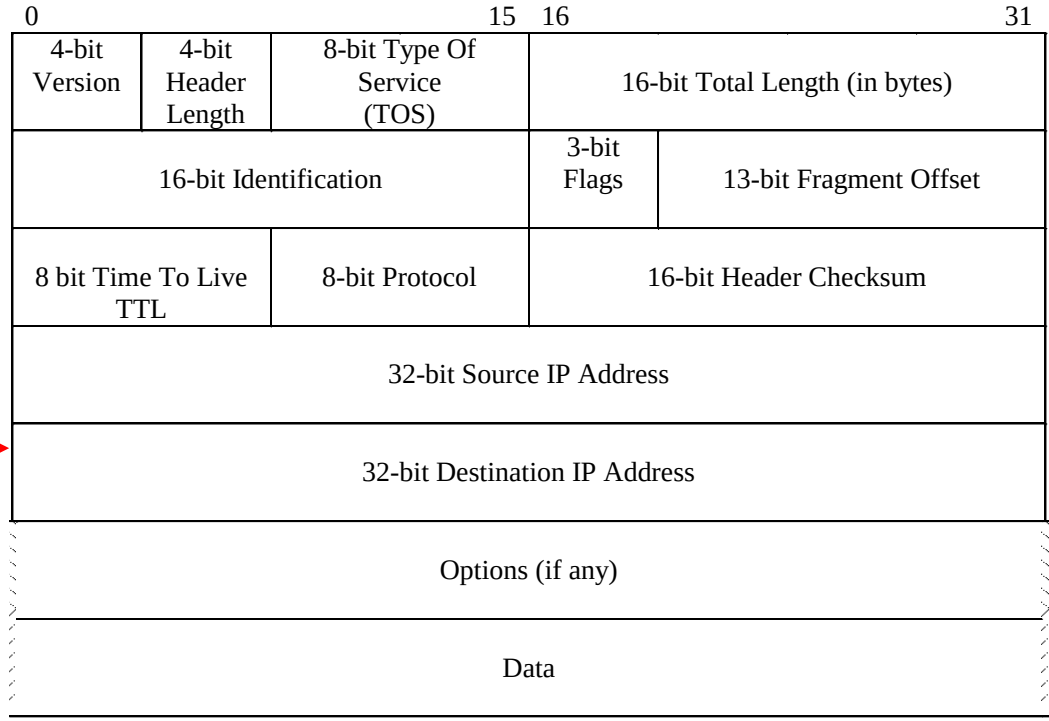
Where the network part ends ant the host part begins depends on the subnet mask (coming).

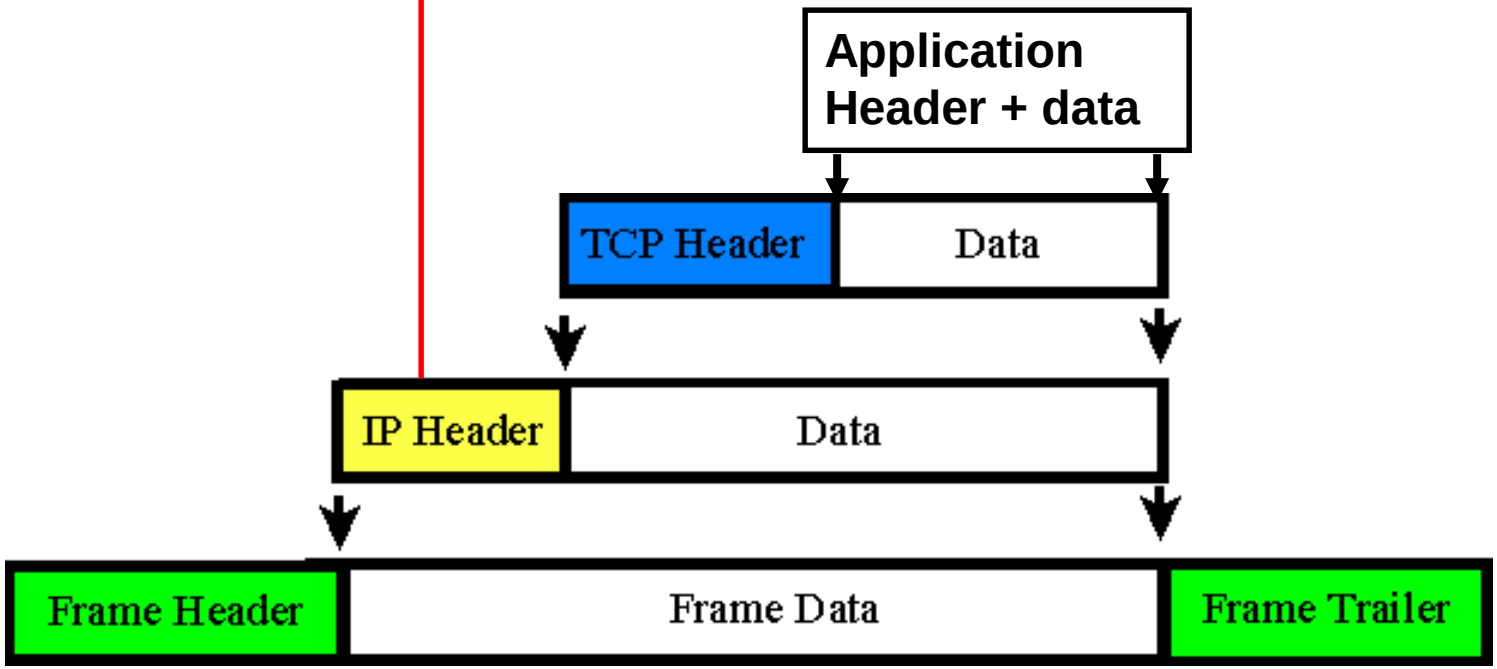
Divide into four 8 bit sections (octets).



Convert from binary to decimal.

IP – Layer 3


0
15
16
31
4-bit Version
4-bit Header Length
8-bit Type Of Service (TOS)
16-bit Total Length (in bytes)
16-bit Identification
3-bit Flags
13-bit Fragment Offset
8 bit Time To Live TTL
8-bit Protocol
16-bit Header Checksum
32-bit Source IP Address
32-bit Destination IP Address
Options (if any)
Data


Application Header + data
TCP Header
Data
IP Header
Data
Frame Header
Frame Data
Frame Trailer

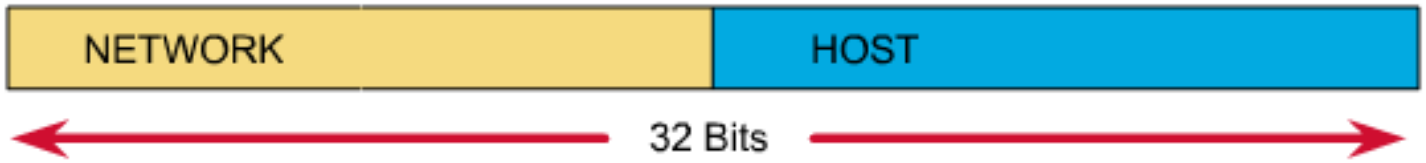
IP Addresses

An IP address has two parts:

- **network number**
- **host number**

Which bits refer to the network number?

Which bits refer to the host number?



IP Addresses

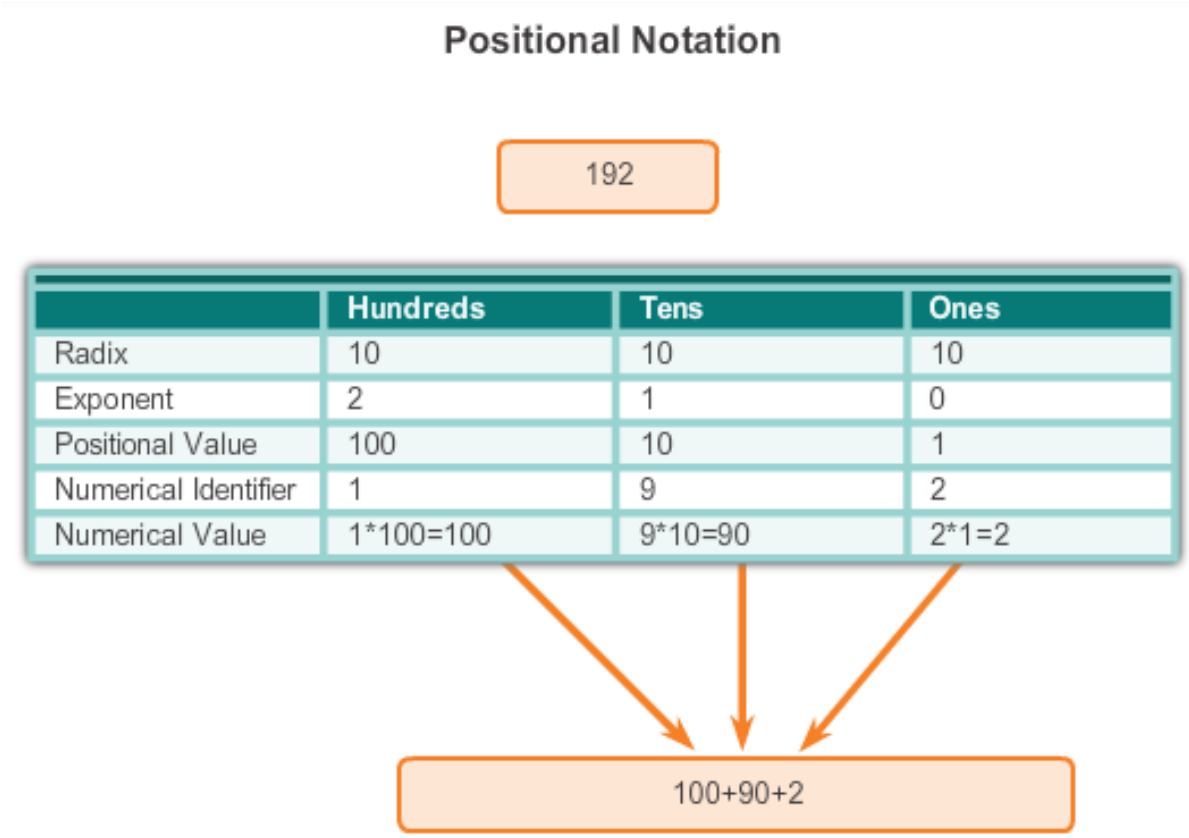
Answer:

- Older technology - **Classful IP Addressing**
  - **Value of first octet** determines the network portion and the host portion.
  - Used with classful routing protocols like RIPv1.

- Current technology - **Classless IP Addressing**
  - The **subnet mask** determines the network portion and the host portion.
  - Value of first octet does NOT matter (older classful IP addressing)
  - Hosts and Classless Inter-Domain Routing (CIDR).
  - Classless IP Addressing is what is used within the Internet and in most internal networks.

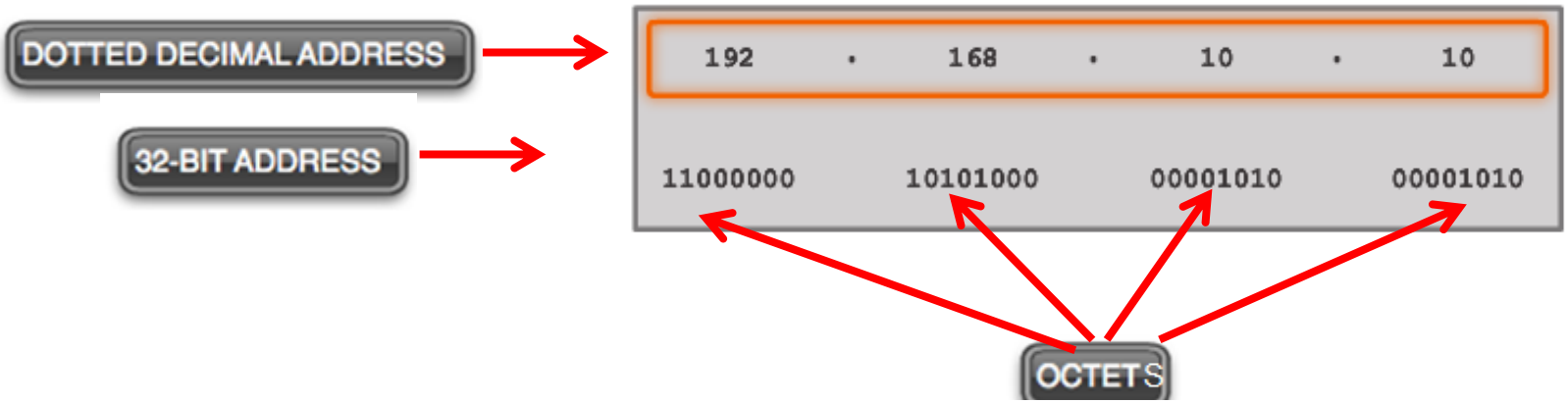
Binary Notation

- Binary notation refers to the fact that computers communicate in 1s and 0s
- Converting binary to decimal requires an understanding of the mathematical basis of a numbering system – positional notation



IPv4 Address Structure

Binary Number System



Radix	2	2	2	2	2	2	2	2
Exponent	7	6	5	4	3	2	1	0
Octet Bit Values	128	64	32	16	8	4	2	1
Binary Address	1	1	0	0	0	0	0	0
Binary Bit Values	128	64	0	0	0	0	0	0

Add the binary bit values.

128 + 64 = 192

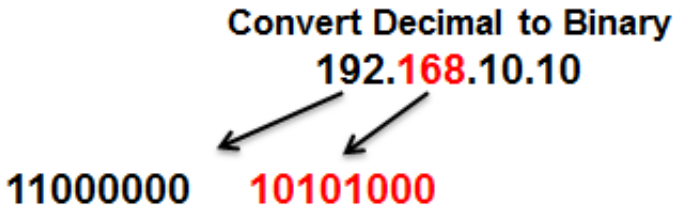
Converting a Binary Address to Decimal

Practice

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

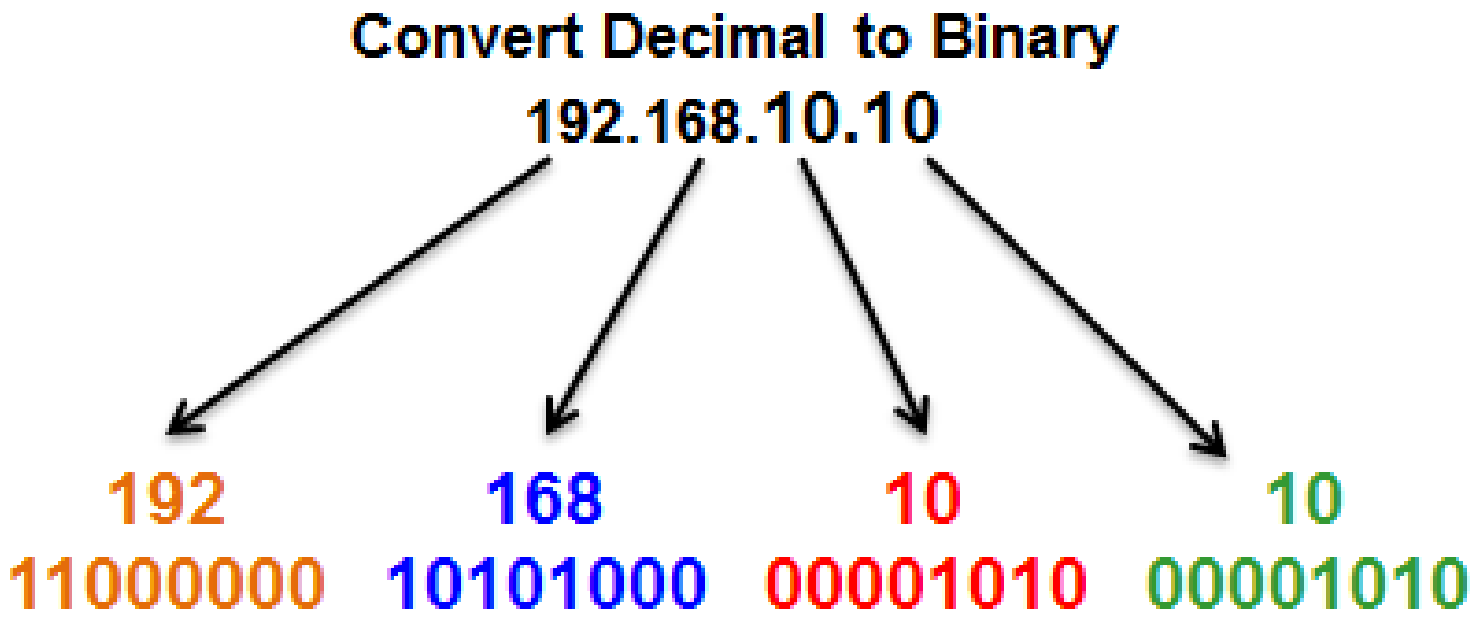
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
1	1	1	1	1	1	1	1

Converting from Decimal to Binary



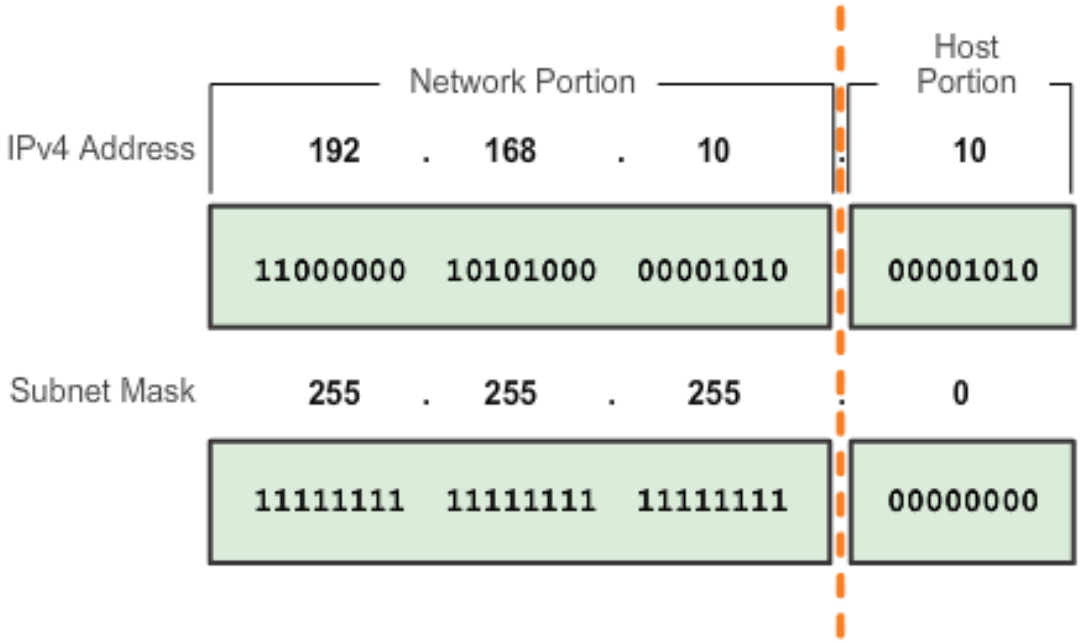
		128	64	32	16	8	4	2	1
168 -128	> 128, place a 1 in the 128 position subtract 128	1							
40	< 64, place a 0 in the 64 position do not subtract	1	0						
40 -32	> 32, place a 1 in the 32 position subtract 32	1	0	1					
8	< 16, place a 0 in the 16 position do not subtract	1	0	1	0				
8	= 8, place a 1 in the 8 position subtract 8	1	0	1	0	1			
0	place a 0 in all remaining positions All done. Result	**1**	**0**	**1**	**0**	**1**	**0**	**0**	**0**

Converting from Decimal to Binary Conversions



IPv4 Subnet Mask

Network Portion and Host Portion of an IPv4 Address



- To define the network and host portions of an address, a devices use a separate 32-bit pattern called a subnet mask
- The subnet mask does not actually contain the network or host portion of an IPv4 address, it just says where to look for these portions in a given IPv4 address

IPv4 Subnet Mask

Network Portion and Host Portion of an IPv4 Address

Valid Subnet Masks

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

IPv4 Subnet Mask

Examining the Prefix Length

	Dotted Decimal	Significant bits shown in binary
Network Address	10.1.1.0/24	10.1.1.00000000
First Host Address	10.1.1.1	10.1.1.00000001
Last Host Address	10.1.1.254	10.1.1.11111110
Broadcast Address	10.1.1.255	10.1.1.11111111
Number of hosts: 2^8 - 2 = 254 hosts		
Network Address	10.1.1.0/25	10.1.1.00000000
First Host Address	10.1.1.1	10.1.1.00000001
Last Host Address	10.1.1.126	10.1.1.01111110
Broadcast Address	10.1.1.127	10.1.1.01111111
Number of hosts: 2^7 - 2 = 126 hosts		
Network Address	10.1.1.0/26	10.1.1.00000000
First Host Address	10.1.1.1	10.1.1.00000001
Last Host Address	10.1.1.62	10.1.1.00111110
Broadcast Address	10.1.1.63	10.1.1.00111111
Number of hosts: 2^6 - 2 = 62 hosts		

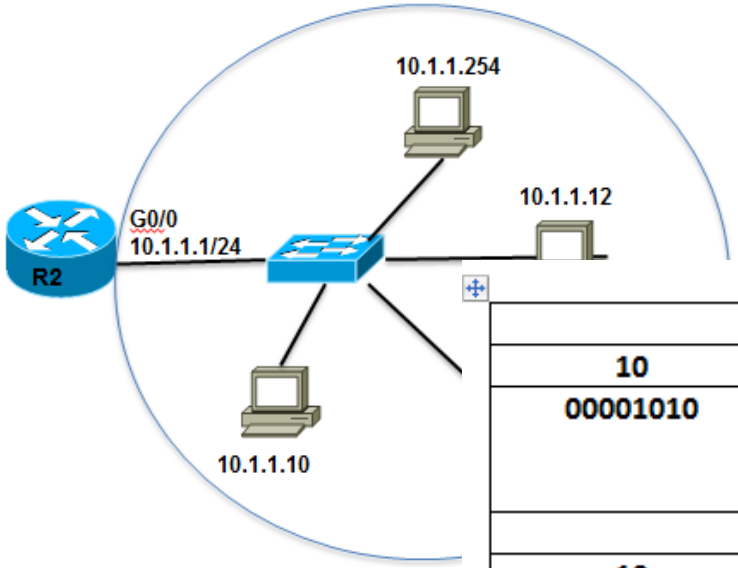
IPv4 Subnet Mask

Examining the Prefix Length

```
Network Address 10.1.0.0/23    00001010.00000001.00000000.00000000
255.255.254.0                  11111111.11111111.11111110.00000000

10.1.0.1        00001010.00000001.00000000.00000001 (first)
10.1.1.254      00001010.00000001.00000001.11111110 (last)
10.1.1.255      00001010.00000001.00000001.11111111 (broadcast)

Number of hosts: 2^9 – 2 = 512 – 2 = 510 hosts

Network Address 10.1.0.0/22    00001010.00000001.00000000.00000000
255.255.252.0                  11111111.11111111.11111100.00000000

10.1.0.1        00001010.00000001.00000000.00000001 (first)
10.1.3.254      00001010.00000001.00000011.11111110 (last)
10.1.3.255      00001010.00000001.00000011.11111111 (broadcast)

Number of hosts: 2^10 – 2 = 1024 – 2 = 1022 hosts
```

IPv4 Network, Host, and Broadcast Address

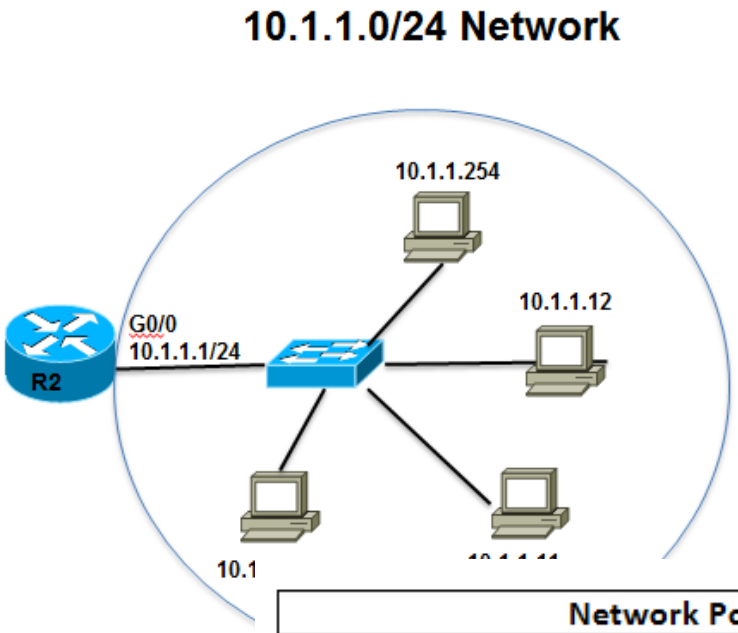
10.1.1.0/24 Network



Network Portion			Host Portion	
10	1	1	0	
00001010	00000001	00000001	00000000	All 0s – NETWORK ADDRESS
10	1	1	10	
00001010	00000001	00000001	00001010	0s and 1s in host portion
10	1	1	255	
00001010	00000001	00000001	11111111	All 1s – BROADCAST ADDRESS

IPv4 Subnet Mask

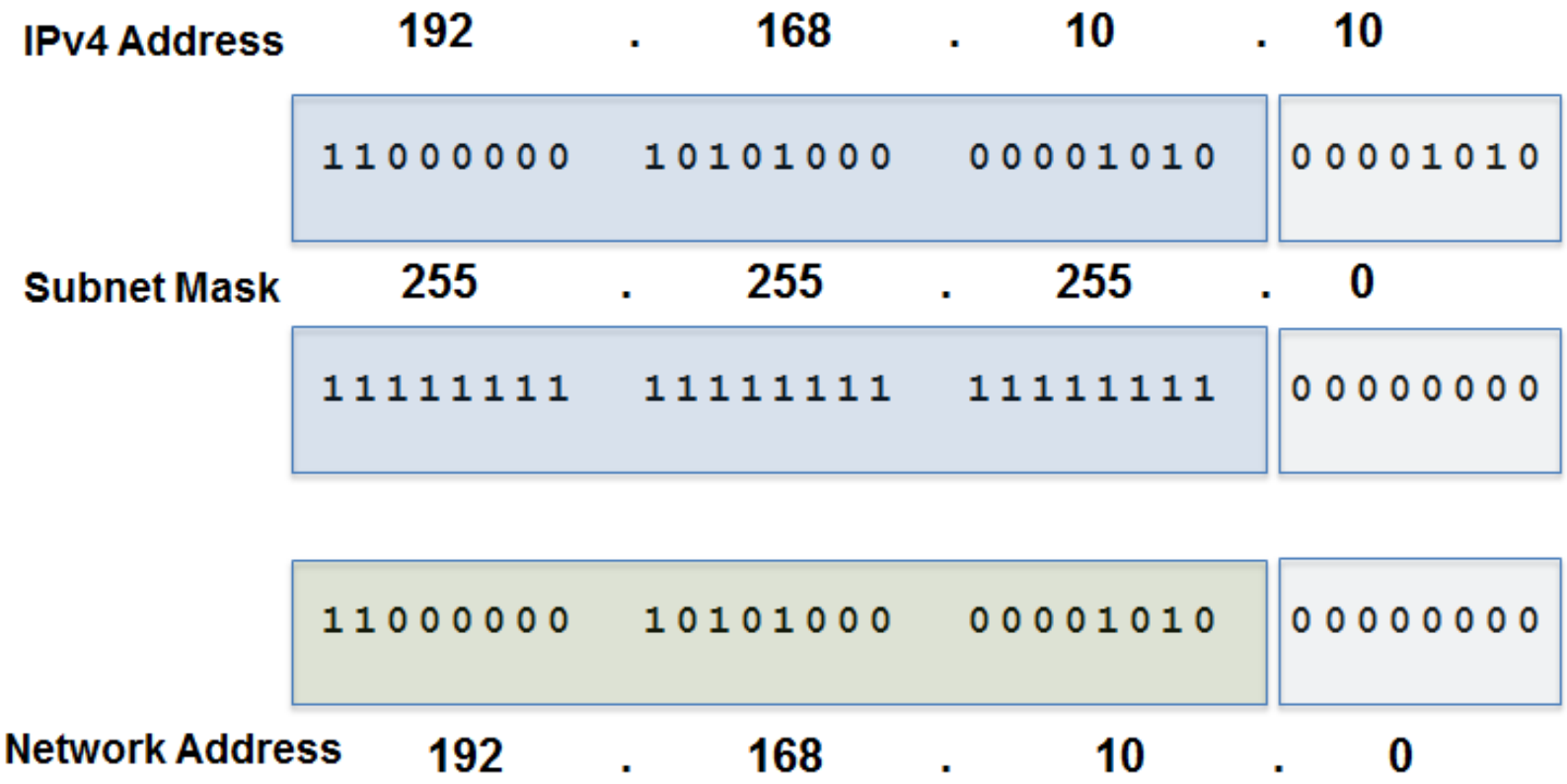
First Host and Last Host Addresses



Network Portion			Host Portion	
10	1	1	1	FIRST HOST
00001010	00000001	00000001	00000001	All 0s and a 1 in the host portion
10	1	1	254	LAST HOST
00001010	00000001	00000001	11111110	All 1s and a 0 in the host portion

IPv4 Subnet Mask

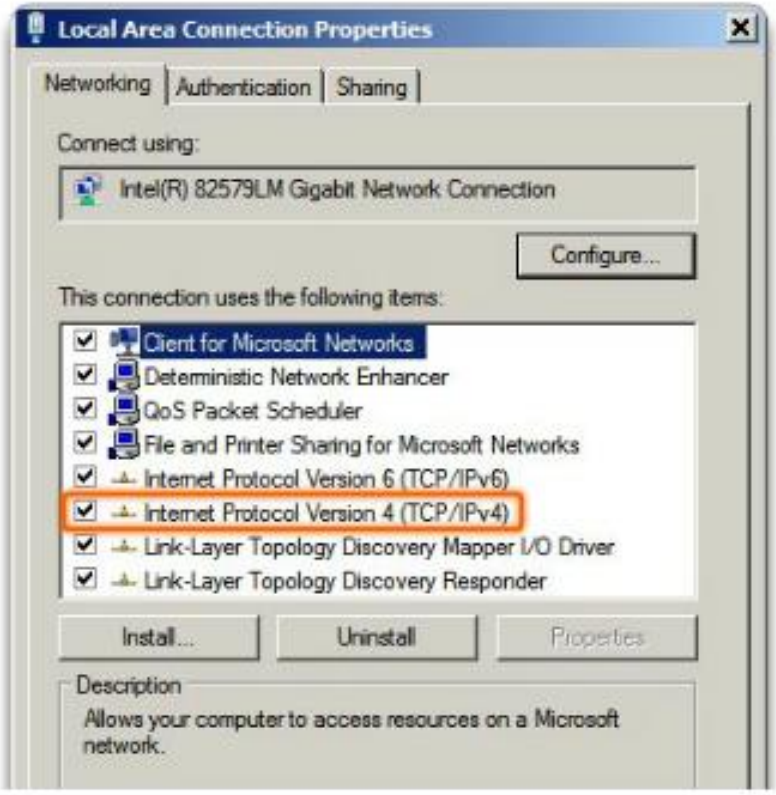
Bitwise AND Operation



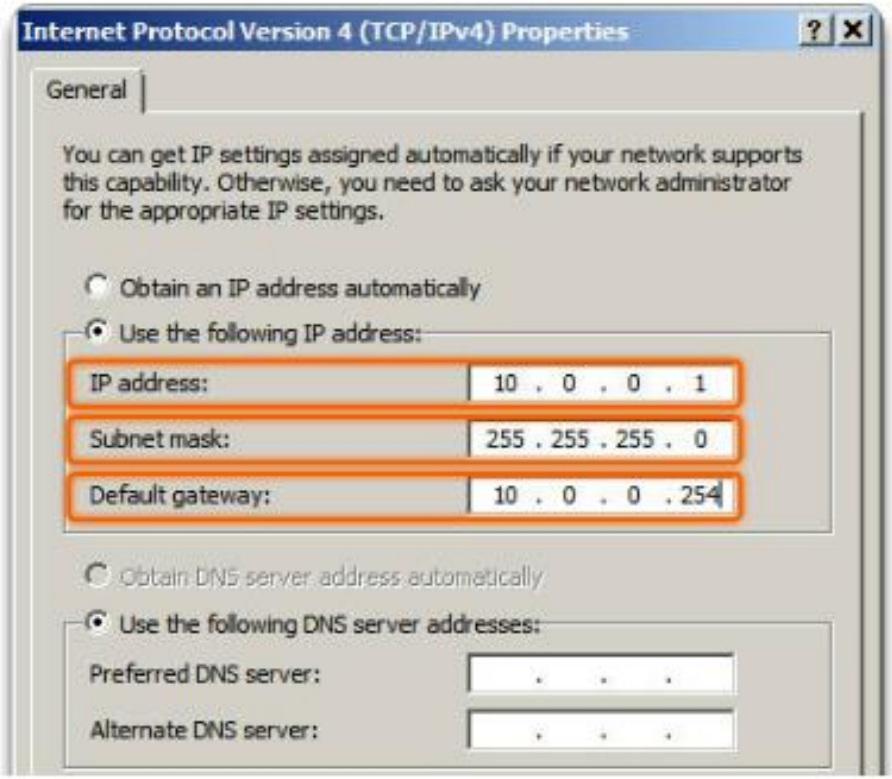
1 AND 1 = 1 1 AND 0 = 0 0 AND 1 = 0 0 AND 0 = 0

Assigning a Static IPv4 Address to a Host

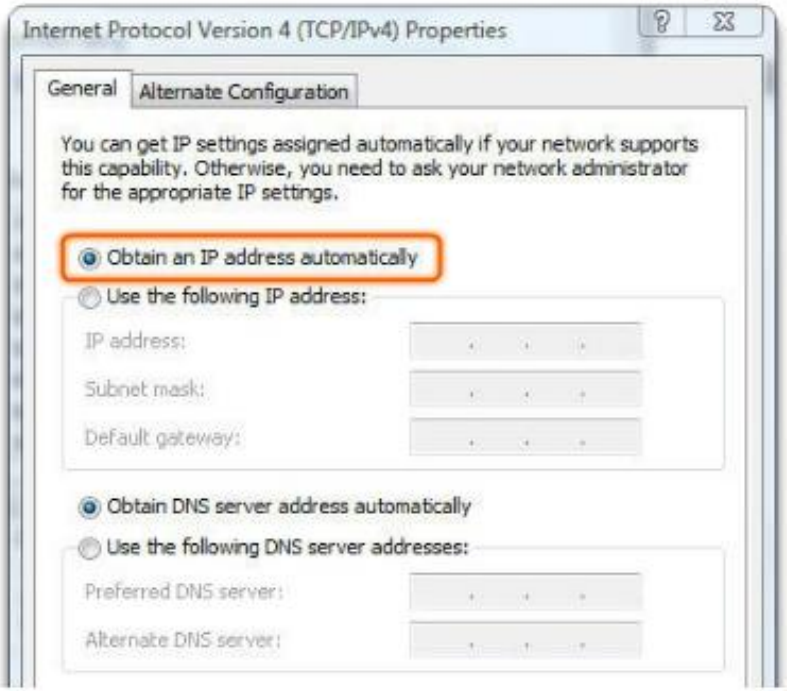
LAN Interface Properties

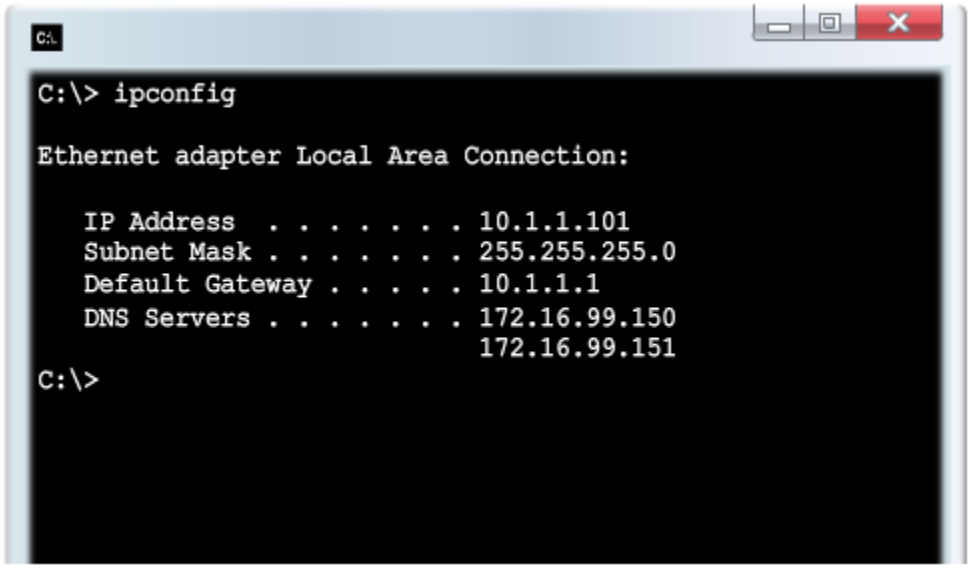


Configuring a Static IPv4 Address



Assigning a Dynamic IPv4 Address to a Host





Verification

DHCP - preferred method of “leasing” IPv4 addresses to hosts on large networks, reduces the burden on network support staff and virtually eliminates entry errors

Classful IP Addressing

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

- 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.

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

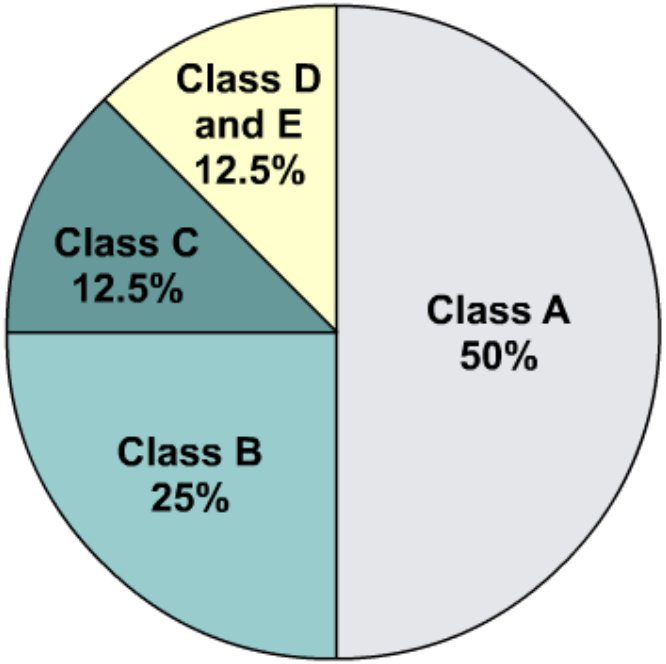
- No medium size host networks
- In the early days of the Internet, IP addresses were allocated to organizations based on request rather than actual need.

Network based on first octet

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.

IP addressing crisis



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

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.

Long Term Solution: IPv6

- 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

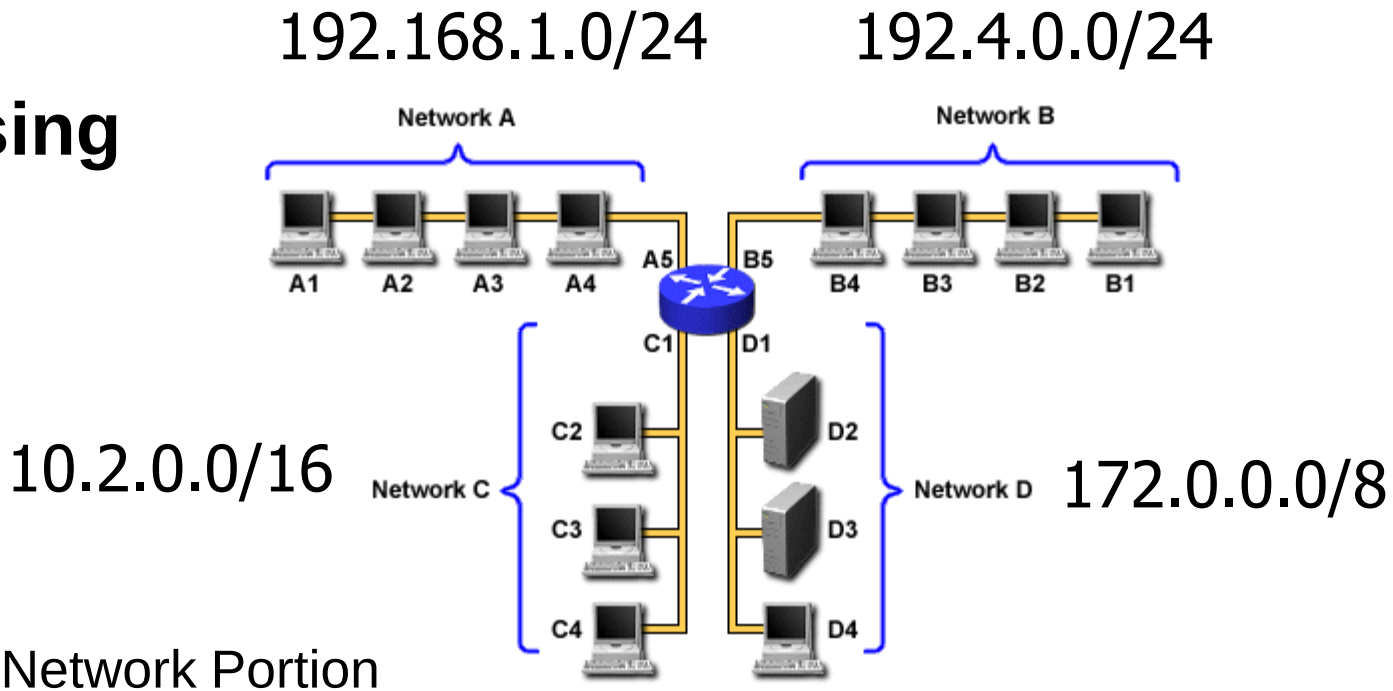
  possible addresses.
- IPv6 has been slow to arrive
- IPv6 requires new software; IT staffs must be retrained
- IPv6 will most likely coexist with IPv4 for years to come.
- Some experts believe IPv4 will remain for more than 10 years.

Short Term Solutions: IPv4 Enhancements

- 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)

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

Classless IP Addressing



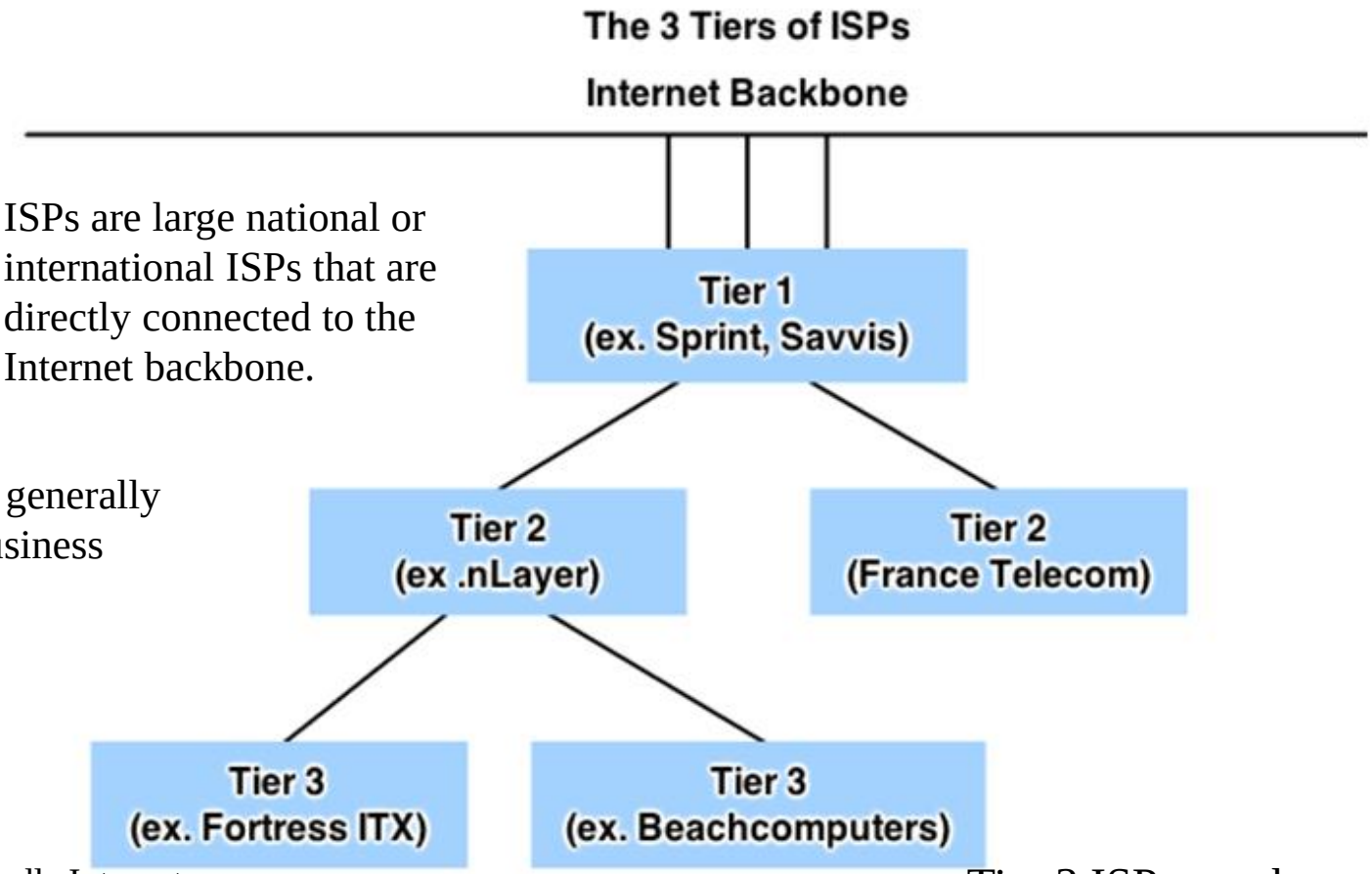
- Network ID or Network Portion
  - Host on a network can only communicate directly with devices if they have the same network ID, i.e. same network or same subnet.
  - The **subnet mask** determines the network portion and the host portion.
  - Network address cannot be used as an address for any device that is attached to the network, such as hosts, router interfaces, etc.

Assignment of IP Addresses

Regional Internet Registries (RIRs)
The major registries are:

Types of IPv4 Address

Assignment of IP Addresses



ISPs are large national or international ISPs that are directly connected to the Internet backbone.

Tier 2 ISPs generally focus on business customers.

Tier 3 ISPs often bundle Internet connectivity as a part of network and computer service contracts for their customers.

Tier 3 ISPs purchase their Internet service from Tier 2 ISPs.

Public and Private IPv4 Addresses

Private address blocks are:

- Hosts that do not require access to the Internet can use private addresses
- 10.0.0.0 to 10.255.255.255 (10.0.0.0/8)
- 172.16.0.0 to 172.31.255.255 (172.16.0.0/12)
- 192.168.0.0 to 192.168.255.255 (192.168.0.0/16)

Shared address space addresses:

- Not globally routable
- Intended only for use in service provider networks
- Address block is 100.64.0.0/10

Special Use IPv4 Addresses

- **Network and Broadcast addresses** - within each network the first and last addresses cannot be assigned to hosts
- **Loopback address -** 127.0.0.1 a special address that hosts use to direct traffic to themselves (addresses 127.0.0.0 to 127.255.255.255 are reserved)
- **Link-Local address -** 169.254.0.0 to 169.254.255.255 (169.254.0.0/16) addresses can be automatically assigned to the local host
- **TEST-NET addresses** - 192.0.2.0 to 192.0.2.255 (192.0.2.0/24) set aside for teaching and learning purposes, used in documentation and network examples
- **Experimental addresses -** 240.0.0.0 to 255.255.255.254 are listed as reserved