Configuration and Management of Networks

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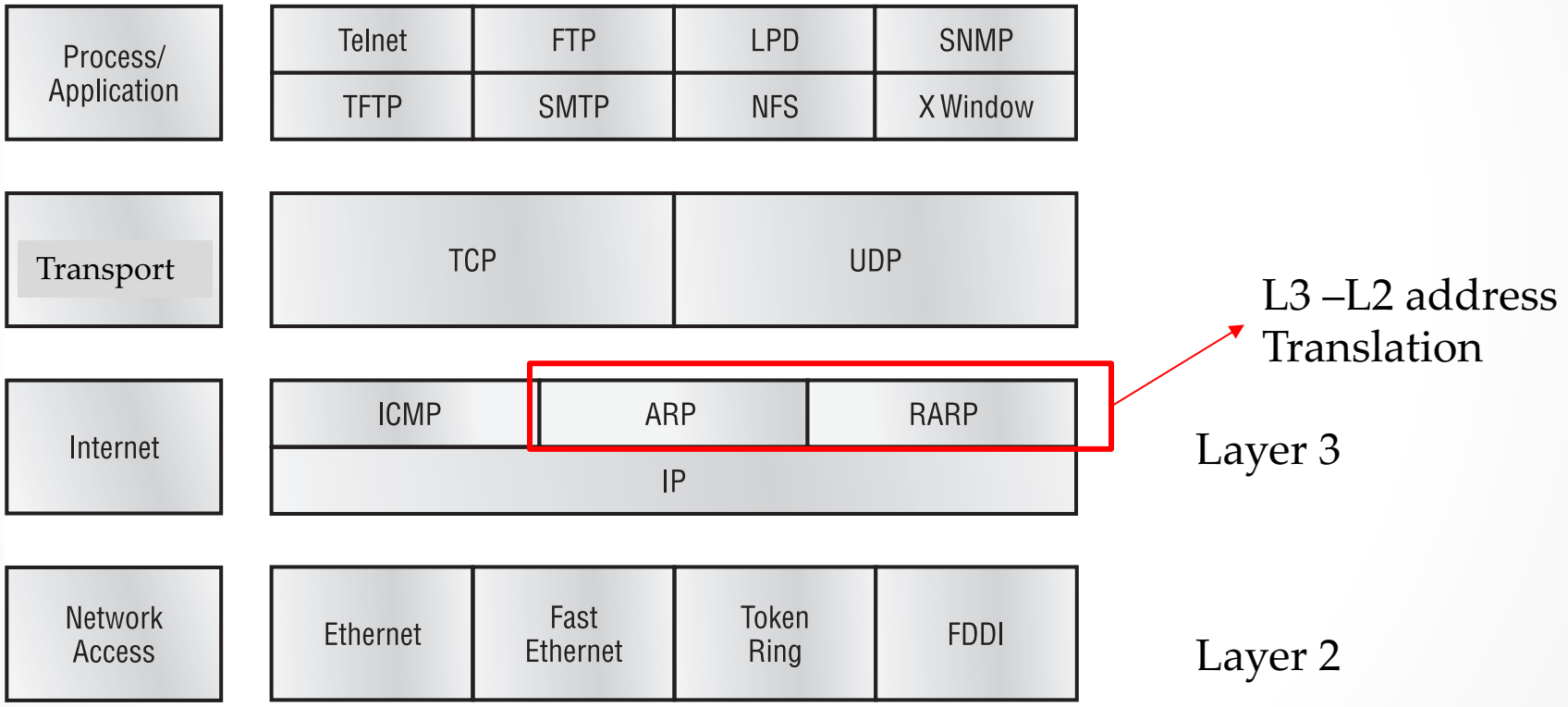
General concepts – internetworking models

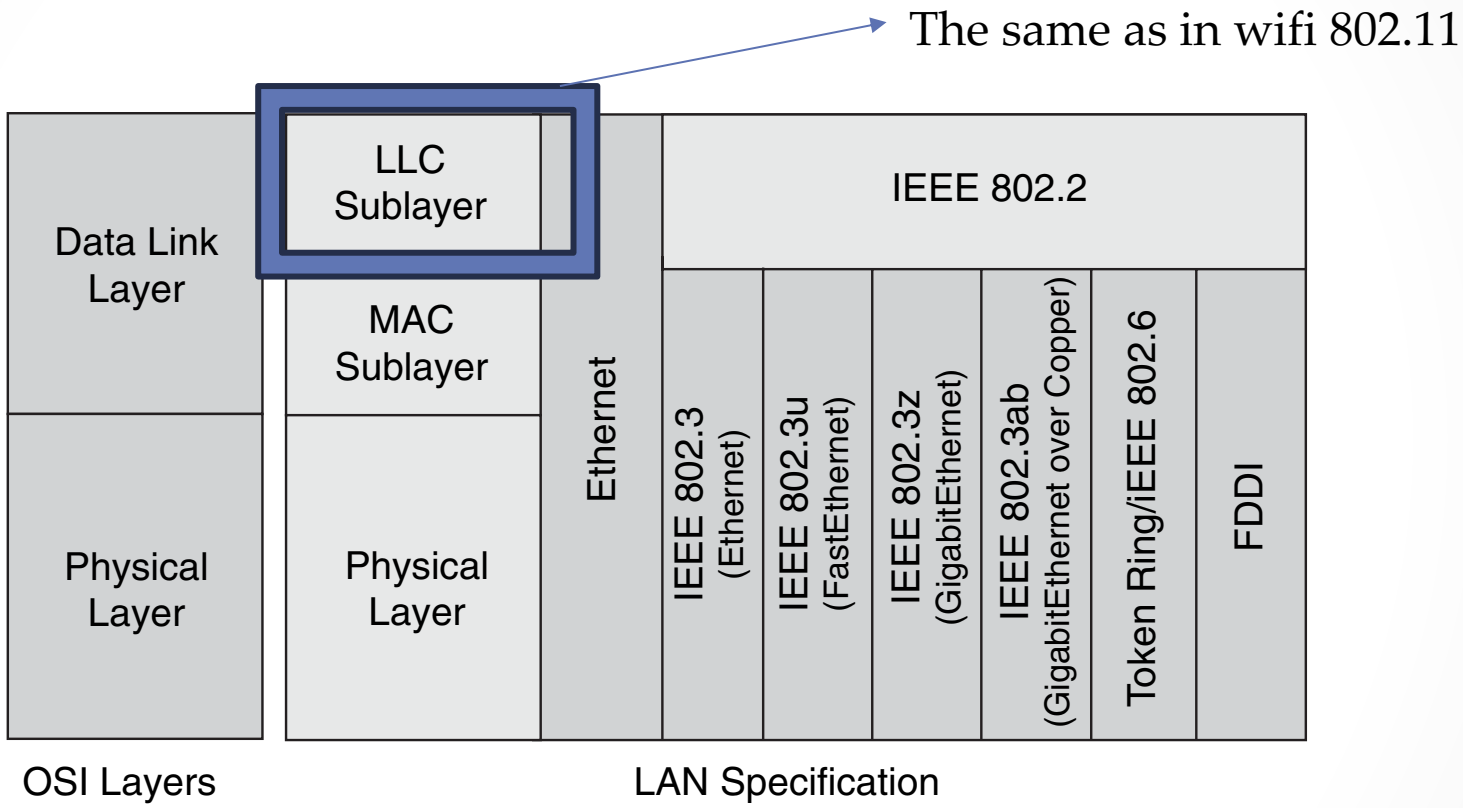
(TCP/IP) – Protocol suite



Ethernet foundation

- Contention media access method that allows all hosts on a network to share the same bandwidth of a link.
- Uses both Data Link and Physical layer specifications.
- Medium Access Protocol used is Carrier Sense Multiple Access with Collision Detection (CSMA/CD).
- Transmissions propagate trough the entire segment.
- Used Technology in Local Area Networks (enterprise and Data Center) and Metro Access Networks.

Ethernet foundation - Standards



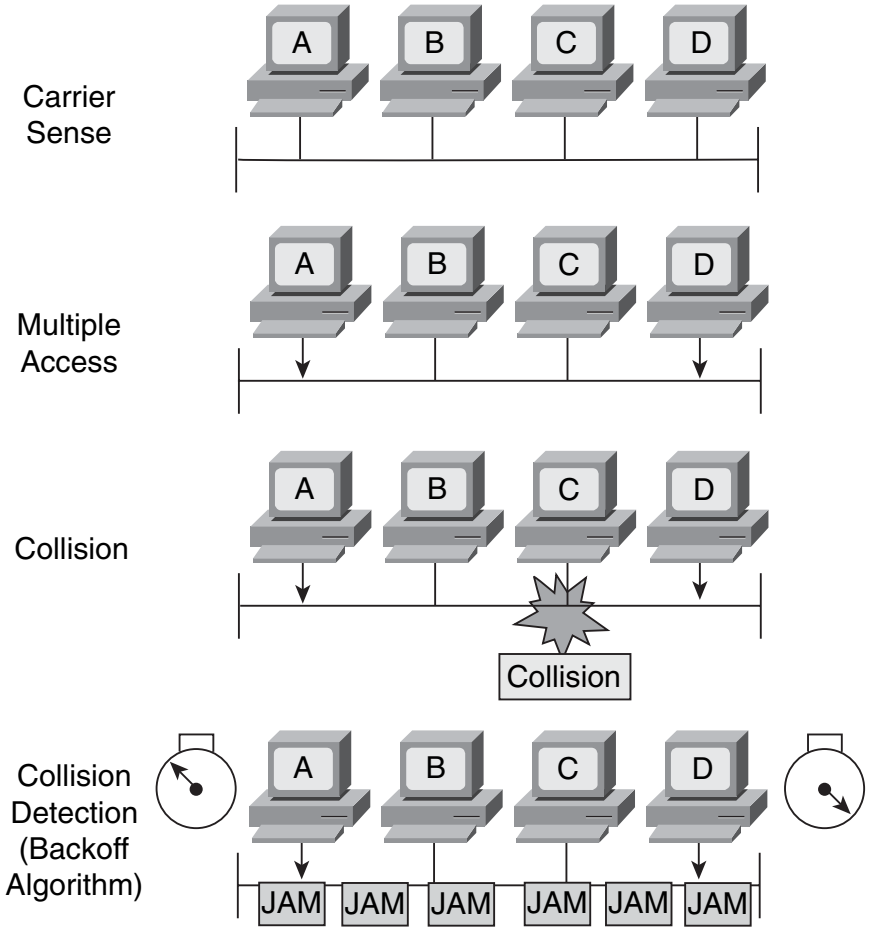
Ethernet foundation - Standards

The IEEE divides the OSI data link layer into two separate sublayers:

- **Logical link control (LLC):** Transitions up to the network layer.
  - Encapsulation process.
  - LLC header tells the network layer what to do with a packet when it receives a frame.

- **MAC:** Transitions down to the physical layer.
  - Physical media access.
  - MAC addresses.
  - Uses CSMA/CD.

Ethernet foundation – CSMA/CD



Ethernet foundation - CSMA/CD

Collision occurs when two stations listen for network traffic, hear none, and transmit simultaneously. At this point:

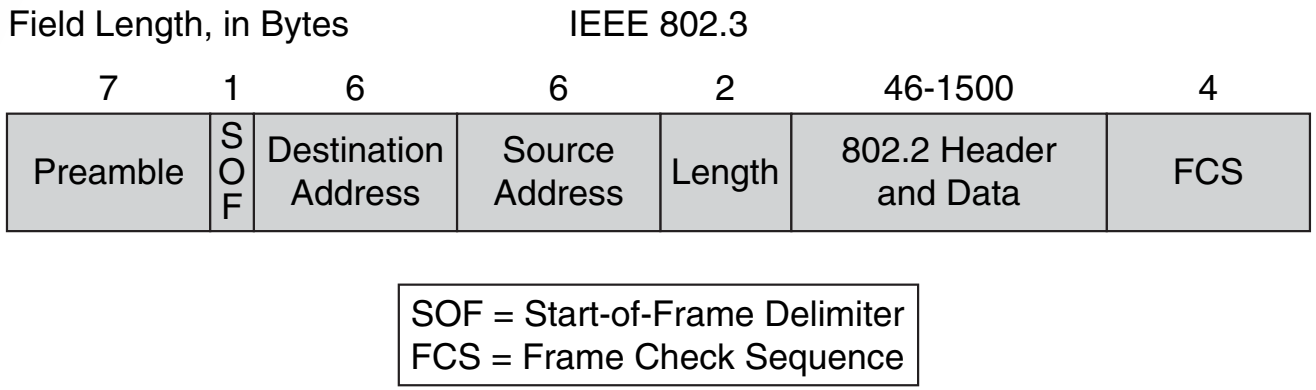
- A jam signal informs all devices that a collision occurred.
- The collision invokes a random back off algorithm.

- Each device on the Ethernet segment stops transmitting for a short time until the timers expire.

- All hosts have equal priority to transmit after the timers have expired.

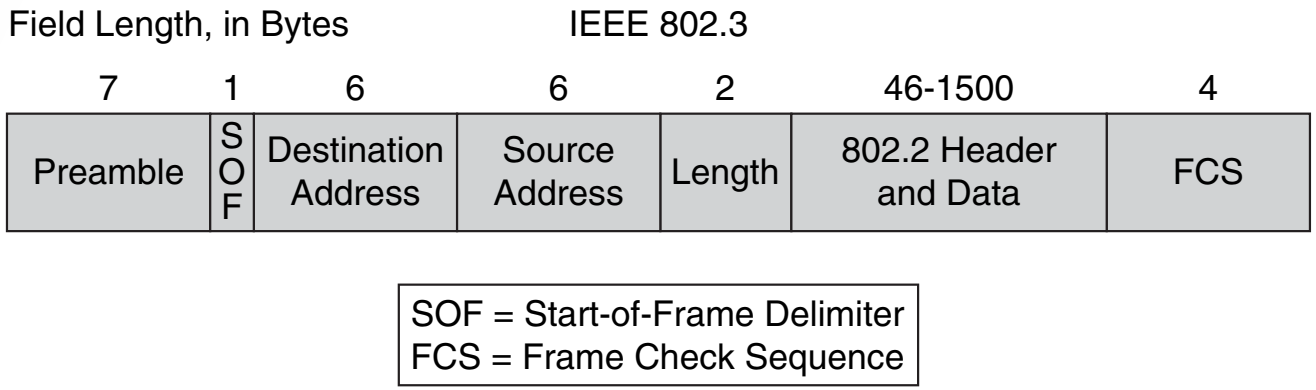
The extent of the network segment over which collisions occur is referred to as the collision domain.

Ethernet foundation – Ethernet Frame



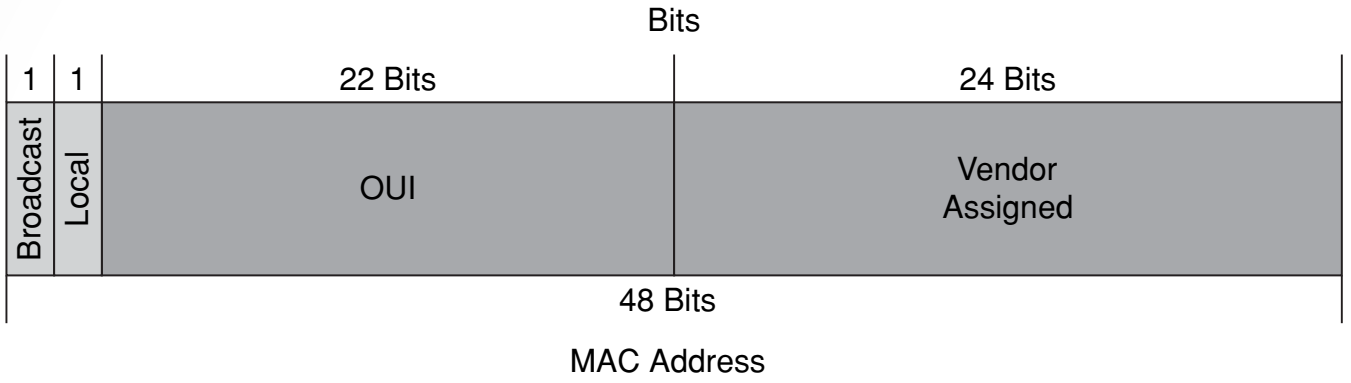
- **Preamble:** This field consists of 7 bits, which synchronize the signals of the communicating computers.
- **Start-of-frame (SOF) delimiter:** Signals the receiving computer that the transmission of the actual frame is about to start.
- **Destination address:** This field contains the address of destination.
- **Source address:** This field contains the address of destination.

Ethernet foundation – Ethernet Frame



- **Length:** This field specifies the length of the data field.
- **802.2 Header and Data** – This field has the LLC layer fields followed by the transmitted data. (e.g. an IPv4 or IPV6 Packet)
- **Frame check sequence (FCS):** This field includes a checking mechanism to ensure that the packet of data has been transmitted without corruption.

Ethernet foundation – Addressing



- MAC address is the physical address - A number in hexadecimal format that is actually burned into the NIC.

- Each device on a LAN must have a unique MAC address to participate in the network.
- Should not be changed.

- Ex: 50:65:f3:5c:99:1a

Ethernet foundation – Summary

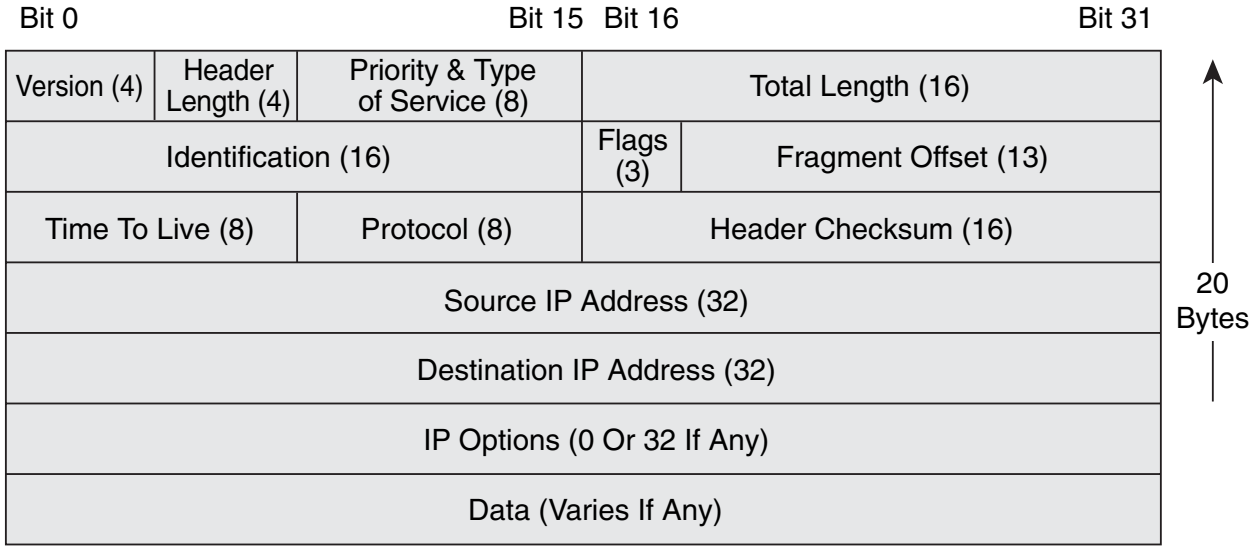
- A LAN is a network that is located in a limited area.
- Ethernet LAN standards specify cabling and signaling at both the physical and data link layers of the OSI model.
- CSMA/CD stations listen to the network to determine whether it is already in use.
- A collision occurs when two stations listen for the network traffic, hear none, and transmit simultaneously.
- The address used in an Ethernet LAN is a 48-bit number usually represented in hexadecimal format called MAC address.

IP addressing

- IP addressing includes various aspects: Constructing an IP address ; classes of IP addresses designated for specific uses; public versus private IP Addresses.
- Two different types of IP addresses exist: IP version 4 (IPv4) with 32 bit and IP version 6 (IPv6) with 128 bit.
- IP addresses are numeric identifiers assigned to each machine to identify it at the network layer.
- Both manual and automatic assignment are possible

IP addressing – IPv4

The header of the Internet layer of TCP/IP is known as the IP header.



Each IP datagram carries this header, which includes a source IP address and destination IP address

IP addressing – IPv4

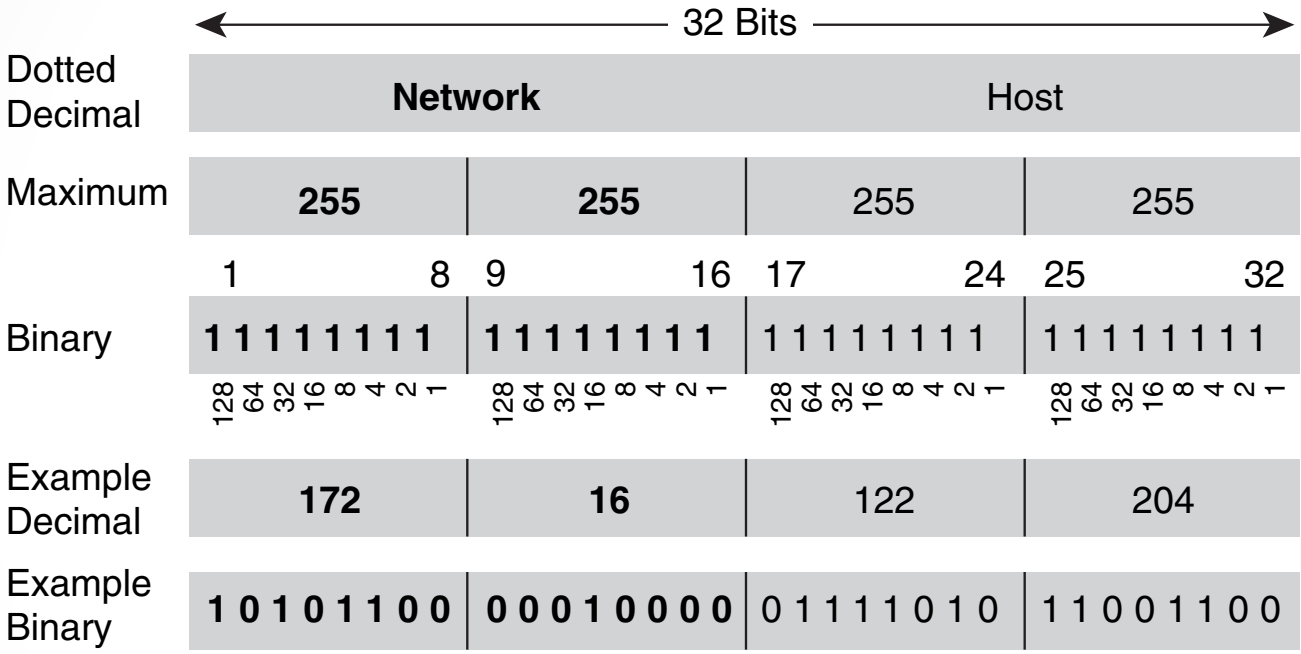
You can depict an IP address using one of three methods:

- Dotted-decimal, as in 172.16.30.56
- Binary, as in 10101100.00010000.00011110.00111000
- Hexadecimal, as in AC.10.1E.38

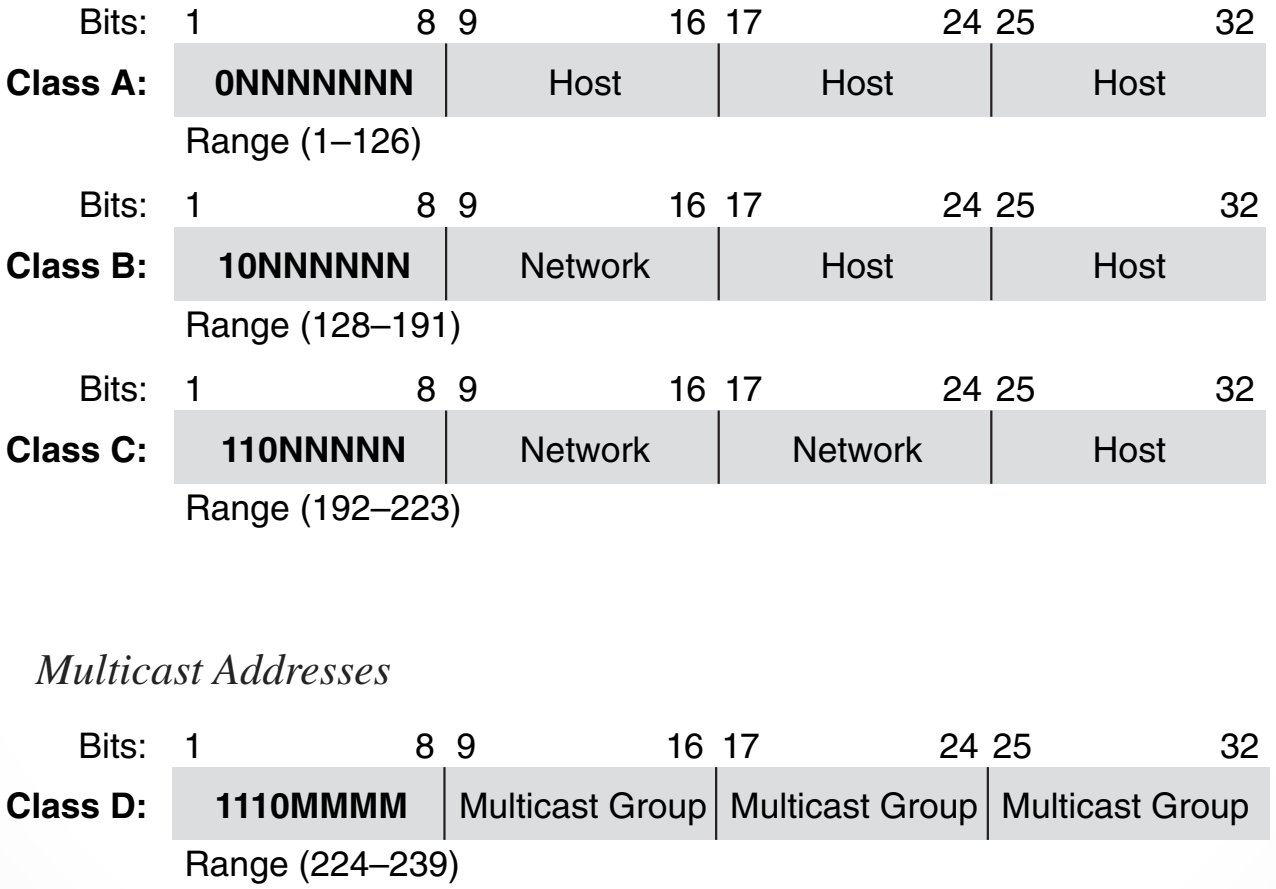
An IP address is a hierarchical address, and it consists of two parts:

- The high order, or leftmost, bits specify the network address component (network ID) of the address. (172.16)
- The low order, or rightmost, bits specify the host address component (host ID) of the address. (30.56)

IP addressing – IPv4



IP addressing – IPv4 Address classes

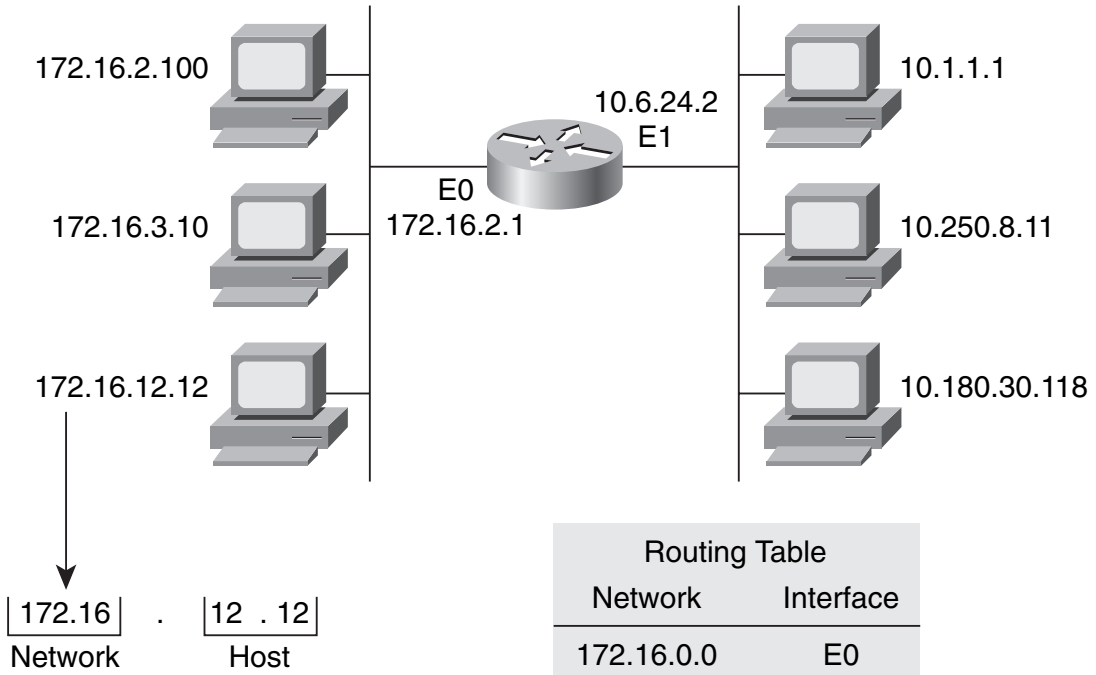


Multicast Addresses

IP addressing – IPv4 Address classes

Address	Function
Network address of all 0s	Interpreted to mean "this network or segment."
Network address of all 1s	Interpreted to mean "all networks."
Network 127.0.0.1	Reserved for loopback tests. Designates the local node and allows that node to send a test packet to itself without generating network traffic.
Node address of all 0s	Interpreted to mean "network address" or any host on specified network.
Node address of all 1s	Interpreted to mean "all nodes" on the specified network; for example, 128.2.255.255 means "all nodes" on network 128.2 (Class B address).
Entire IP address set to all 0s	Used by Cisco routers to designate the default route. Could also mean "any network."
Entire IP address set to all 1s (same as 255.255.255.255)	Broadcast to all nodes on the current network; sometimes called an "all 1s broadcast" or limited broadcast.

IP addressing – IPv4 Address classes



Routing Table

Network	Interface
172.16.0.0	E0
10.0.0.0	E1

IP addressing – IPv4 Public and Private Addresses

Internet stability depends directly on the uniqueness of publicly used network addresses.

ISPs allocate addresses from the range assigned by their upstream registry or their appropriate regional registry, which is managed by IANA.

Internet hosts require a globally unique IP address, private hosts that are not connected to the Internet can use any valid address, as long as it is unique within the private network.

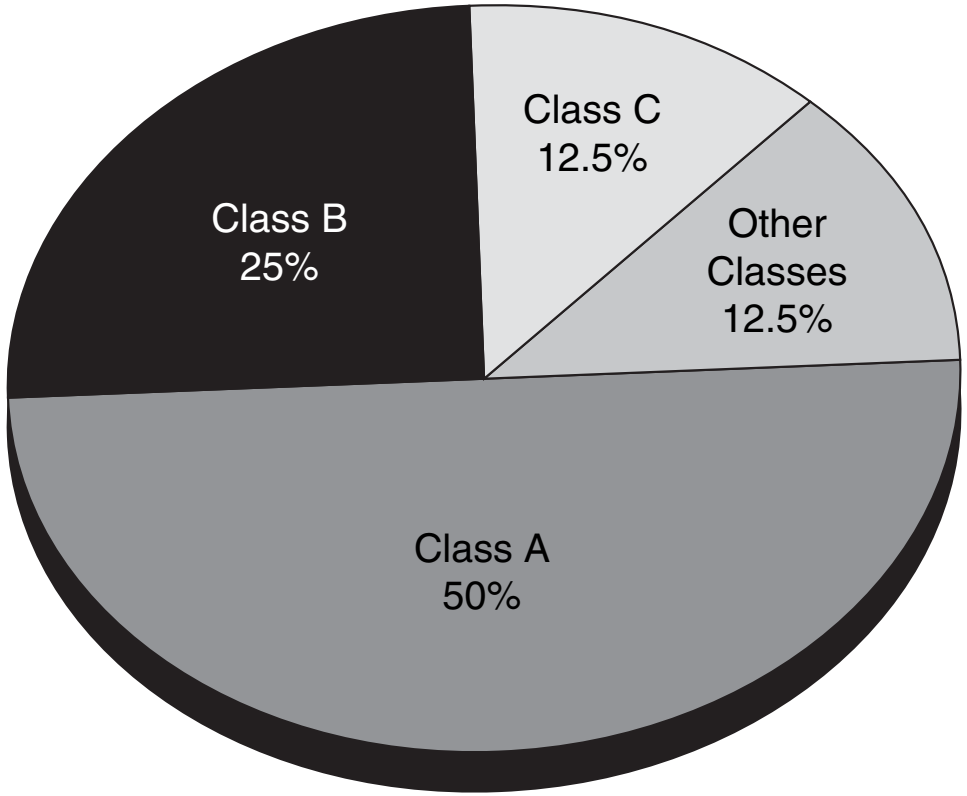
IP addressing – IPv4 Public and Private Addresses

IETF defined 3 blocks of IP addresses (1 Class A network, 16 Class B networks, and 256 Class C networks) in RFC 1918.

Class	RFC 1918 Internal Address Range
A	10.0.0.0 to 10.255.255.255
B	172.16.0.0 to 172.31.255.255
C	192.168.0.0 to 192.168.255.255

Network Address Translation (NAT) is performed by a router at the border between the private and public networks.

IP addressing –Address Exhaustion



IP addressing –CIDR

CIDR :

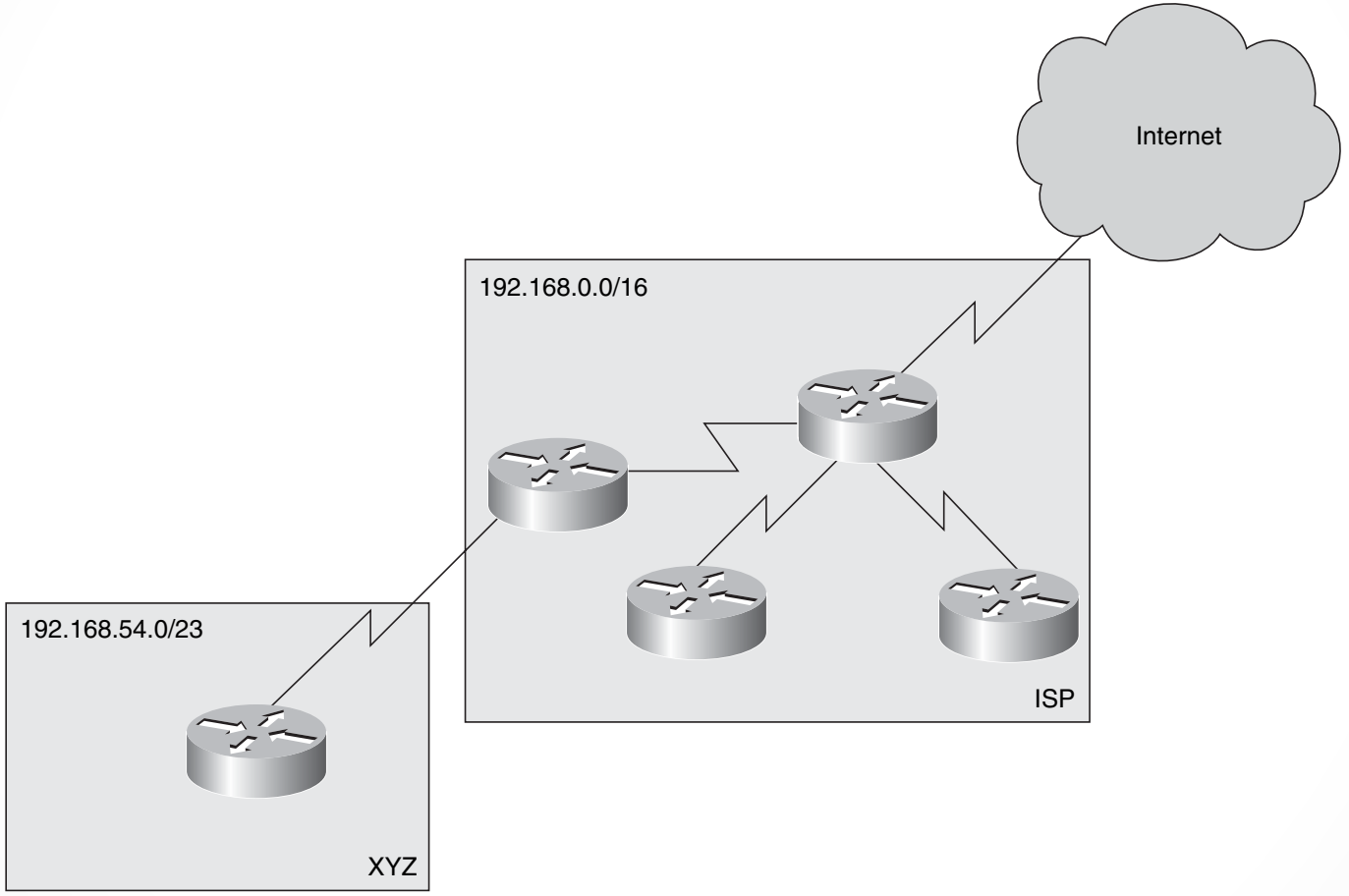
Replaces classful addressing with a more flexible and less wasteful scheme.

Provides enhanced route aggregation, also known as super-netting.

A CIDR network address looks like this:

192.168.54.0/23

IP addressing –CIDR

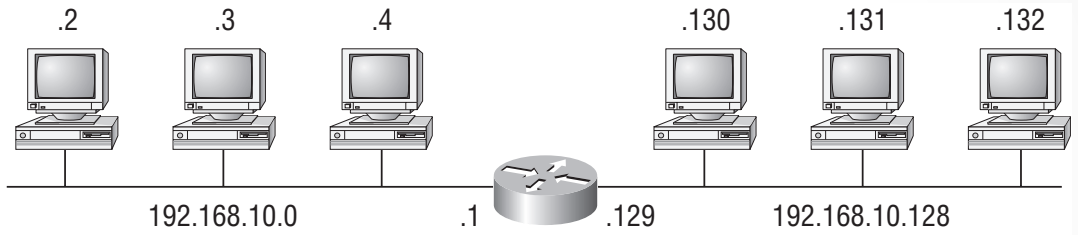


IP addressing –CIDR

Class	Format	Default Subnet Mask
A	*network.node.node.node*	255.0.0.0
B	*network.network.node.node*	255.255.0.0
C	*network.network.network.node*	255.255.255.0

Subnet Mask	CIDR Value
255.0.0.0	/8
255.128.0.0	/9
255.192.0.0	/10
255.224.0.0	/11
255.240.0.0	/12

IP addressing – Sub-netting Class C



Router#show ip route
[output cut]
C 192.168.10.0 is directly connected to Ethernet 0.
C 192.168.10.128 is directly connected to Ethernet 1.

Binary	Decimal	CIDR
00000000	0	/24
10000000	128	/25
11000000	192	/26
11100000	224	/27
11110000	240	/28
11111000	248	/29
11111100	252	/30

From 1 to 127 one network
From 129 to 254 another

IP addressing – rules

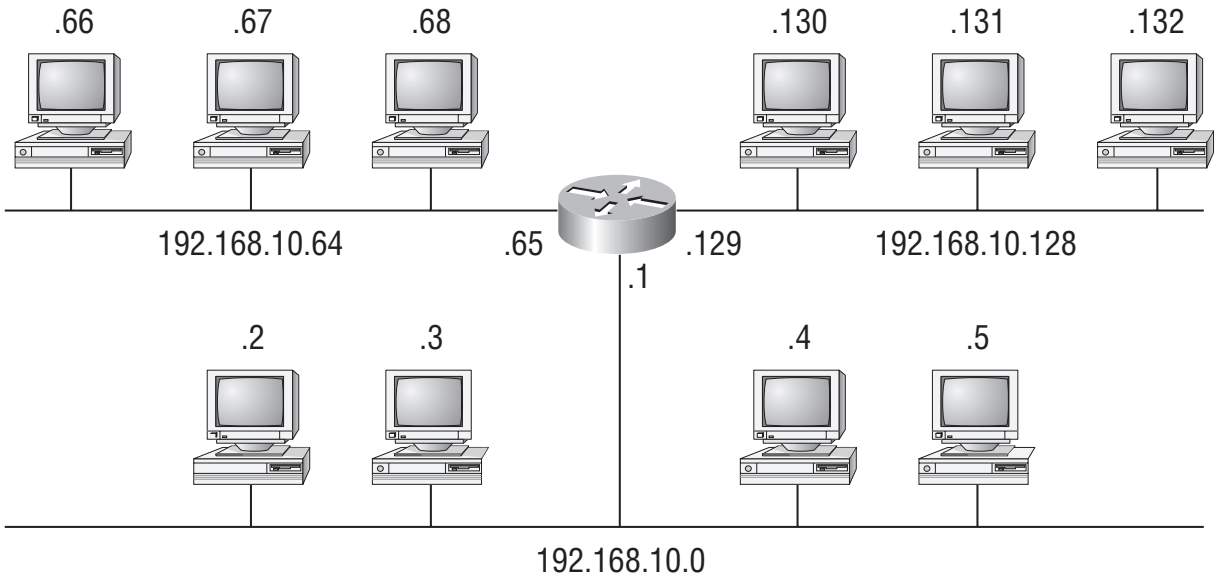
- How many subnets? 2^x = number of subnets. x is the number of masked bits, or the 1s.

- How many hosts per subnet? 2y – 2 = number of hosts per subnet. y is the number of
- unmasked bits, or the 0s.

- What are the valid subnets? 256 – subnet mask = block size or increment number. An example would be 256 – 192 = 64. The block size of a 192 mask is always 64.

- What are the valid hosts? Valid hosts are the numbers between the subnets, omitting the all 0s and all 1s.

IP addressing – Sub-netting Class C /26 mask



Router#show ip route
[output cut]
C 192.168.10.0 is directly connected to Ethernet 0
C 192.168.10.64 is directly connected to Ethernet 1
C 192.168.10.128 is directly connected to Ethernet 2

IP addressing – Subnetting Class B

255.255.0.0	(/16)		
255.255.128.0	(/17)	255.255.255.0	(/24)
255.255.192.0	(/18)	255.255.255.128	(/25)
255.255.224.0	(/19)	255.255.255.192	(/26)
255.255.240.0	(/20)	255.255.255.224	(/27)
255.255.248.0	(/21)	255.255.255.240	(/28)
255.255.252.0	(/22)	255.255.255.248	(/29)
255.255.254.0	(/23)	255.255.255.252	(/30)

Class B 255.255.240.0 mask:

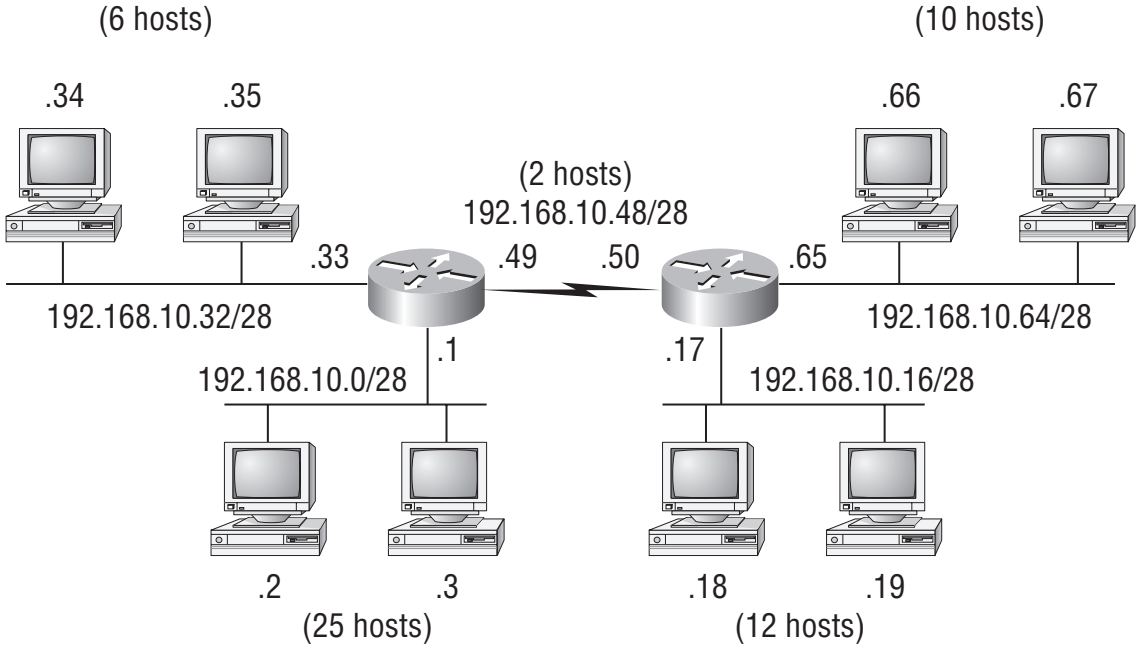
Subnet	0.0	16.0	32.0	48.0
First host	0.1	16.1	32.1	48.1
Last host	15.254	31.254	47.254	63.254
Broadcast	15.255	31.255	47.255	63.255

IP addressing – Subnetting Class A

255.0.0.0	(/8)		
255.128.0.0	(/9)	255.255.240.0	(/20)
255.192.0.0	(/10)	255.255.248.0	(/21)
255.224.0.0	(/11)	255.255.252.0	(/22)
255.240.0.0	(/12)	255.255.254.0	(/23)
255.248.0.0	(/13)	255.255.255.0	(/24)
255.252.0.0	(/14)	255.255.255.128	(/25)
255.254.0.0	(/15)	255.255.255.192	(/26)
255.255.0.0	(/16)	255.255.255.224	(/27)
255.255.128.0	(/17)	255.255.255.240	(/28)
255.255.192.0	(/18)	255.255.255.248	(/29)
255.255.224.0	(/19)	255.255.255.252	(/30)

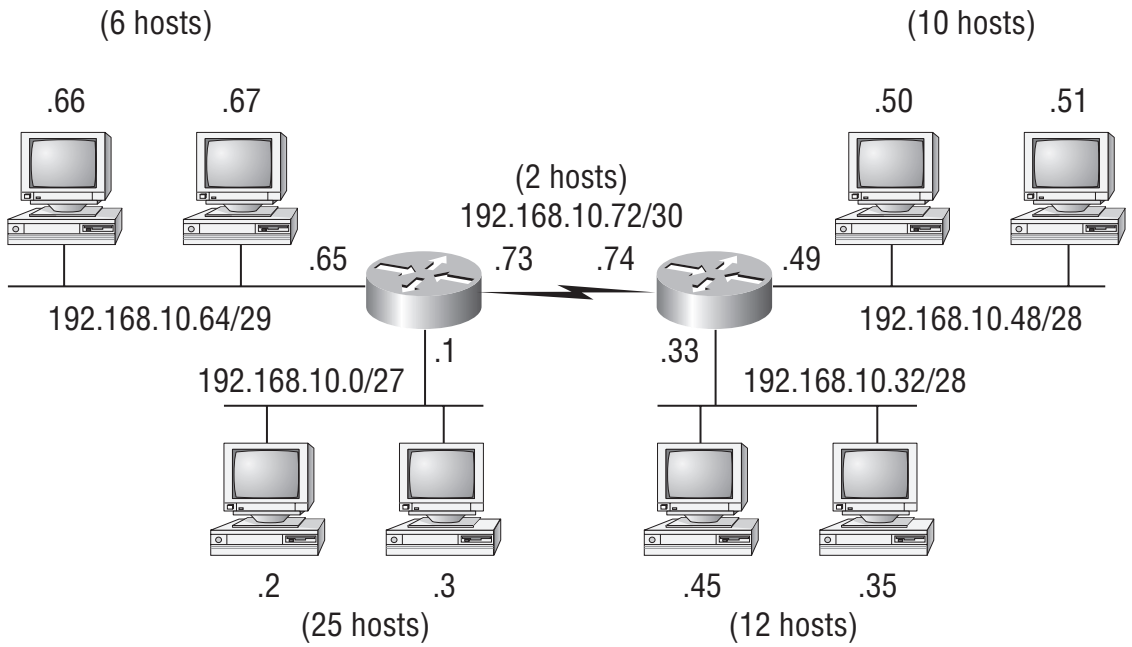
IP addressing – Variable Length Subnet Masks (VLSMs)

With VLSMs we can have different subnet masks for different router interfaces.

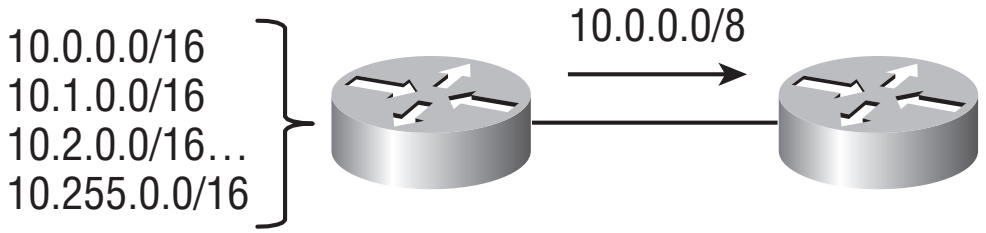


Each LAN has 14 valid hosts available!

IP addressing – Variable Length Subnet Masks (VLSMs)



IP addressing – Summarization



Here's another example:
Networks 172.16.32.0 through 172.16.50.0

Starting at network 32 using a block size of 16, then the network address is 172.16.32.0 with a mask of 255.255.240.0

This only summarizes from 32 to 47. 48 through 50 would be advertised as single networks.

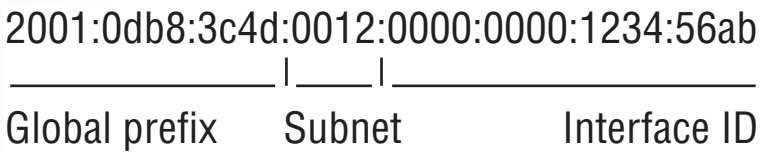
IP addressing – IPv6

An IPv6 address is a 128-bit binary value, which can be displayed as 32 hexadecimal digits.

Version	IPv4	IPv6
Number of octets	4 octets	16 octets
Binary representation of address	11000000.10101000.11001001.01110001	11010001.11011100.11001001.01110001.11010001.11011100.11001100.01110001.11010001.11011100.11001001.01110001.11010001.11011100.11001001.01110001

Version	IPv4	IPv6
Notation of address	192.168.201.113	A524:72D3:2C80:DD02:0029:EC7A:002B:EA73
Total number of addresses available	4,294,467,295 IP addresses	3.4×10^{38} IP addresses

IP addressing – IPv6



you can drop any leading zeros

```
2001:db8:3c4d:12:0:0:1234:56ab
```

you can replace only one contiguous block of zeros

```
2001:db8:3c4d:12::1234:56ab
```

```
2001:0000:0000:0012:0000:0000:1234:56ab
```

```
2001::12:0:0:1234:56ab
```

IP addressing – IPv6

Unicast - Packets addressed to a unicast address are delivered to a single interface.

Global unicast addresses - These are your typical publicly routable addresses, and they're the same as they are in IPv4.

Link-local addresses - These are like the private addresses in IPv4 in that they're not meant to be globally routed.

IP addressing – IPv6

Unique local addresses – These are also intended for non-routing purposes, they are nearly globally unique it's unlikely that one of them overlaps.

Multicast - Again, same as in IPv4, packets addressed to a multicast address are delivered to all interfaces identified by the multicast address.

Anycast – identifies multiple interfaces but the packet is only delivered to one with shortest routing distance.

IP addressing – IPv6 Special Addresses

0:0:0:0:0:0:0:0 Equals :: equivalent to IPv4's 0.0.0.0

0:0:0:0:0:0:0:1 Equals ::1. The equivalent of 127.0.0.1 in IPv4 (local loop).

2000::/3 The global unicast address range.

FC00::/7 The unique local unicast range.

FE80::/10 The link-local unicast range.

FF00::/8 The multicast range.

3FFF:FFFF::/32 Reserved for examples and documentation.

2001:0DB8::/32 Also reserved for examples and documentation.

IP addressing – Dynamic Host Configuration Protocol DHCP

DHCP is a protocol used to assign IP addresses automatically and to set TCP/IP stack configuration parameters, such as the subnet mask, default router, and Domain Name System (DNS) servers for a host.

Address is only "leased" to the host, so the host periodically contacts the DHCP server to extend the lease.