CSIS 4222

Ch 21: IP: Internet Protocol Addresses

Addresses for the Virtual Internet

Addressing is a critical component of the Internet

- All host computers must use a uniform addressing scheme
- Each address must be unique

  MAC addresses are unique but the Internet includes multiple network technologies with different MAC addressing

Addresses for the Virtual Internet

IP addressing is uniform:

- A pair of application programs can communicate without knowing the type of network hardware or MAC addresses being used
- IP addresses are supplied by protocol software

The IP Addressing Scheme

Each host is assigned a unique 32-bit number (its IP address or Internet address)

When sending a packet across the Internet, sender must specify

- its own 32-bit IP address (source address)
- the address of the intended recipient (destination address)

IP Addresses have two parts

A *network number* (prefix)

A *host number* (suffix)

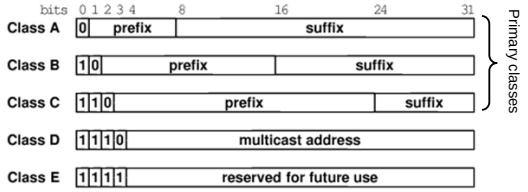
- Every ***network*** in a TCP/IP internet is assigned a unique *network number*
- Each ***host*** on a specific network is assigned a *host address* that is unique ***within that network***
- Organizations get a network number and can assign all valid IPs within a specified range to their hosts

Properties of IP Addresses

- Network addresses are unique
- Host addresses may be reused on different networks
- The combination of network number prefix and host address suffix will be unique

IP Address Classes (the old way)

- First four bits determine class
- Class determines boundary between prefix and suffix



IP Addresses use Dotted Decimal Notation

Convert each octet of an address into a decimal number and separate by periods

– ***Not*** the same as names like:
www.stockton.edu

Dotted Decimal Notation

Four decimal values per 32-bit address
Each decimal number represents 8 bits
(0 to 255)

32-bit Binary Number	Equivalent Dotted Decimal
10000001 00110100 00000110 00000000	129.52.6.0
11000000 00000101 00110000 00000011	192.5.48.3
00001010 00000010 00000000 00100101	10.2.0.37
10000000 00001010 00000010 00000011	128.10.2.3
10000000 10000000 11111111 00000000	128.128.255.0

134.210.1.200 is the IP for **www.stockton.edu**

Classes and Network Sizes

The Internet needs to allow for both large and small networks

Maximum network size is determined by its class

– Class A : Large (small prefix, large suffix)
– Class B : Medium
– Class C : Small (large prefix, small suffix)

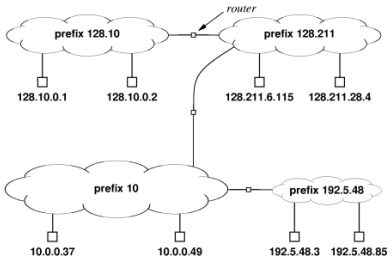
The classing scheme yields a different number of networks in each class

Address Class	Bits In Prefix	Maximum Number of Networks	Bits In Suffix	Maximum Number Of Hosts Per Network
A	7	128	24	16777216
B	14	16384	16	65536
C	21	2097152	8	256

Internet Corporation for Assigned Names and Numbers (ICANN)

– The authority that handles address assignment and adjudicate disputes
– ICANN authorizes a set of registrars to assign address prefixes
– Registrars make blocks of addresses available to ISPs
– ISPs provide addresses to subscribers

Address Example



Classful vs. Classless Addressing

- Class C network can have 254 hosts max
- Class B network can have 65,634 hosts max
- What if you have 2,000 hosts?
  - Get a class B address and waste 63,000 addresses
  - Use Classless Interdomain Routing (CIDR) where the network number can be any number of bits
  - Use subnetting to create its own internal networks

Subnet and Classless Addressing

Assume an ISP owns a class C prefix

- Classful addressing assigns the entire prefix to one organization
- With classless addressing the ISP can divide the prefix into several longer prefixes and assign each to a subscriber
- ISP can assign each of the classless prefixes to a subscriber

Subnet and Classless Addressing

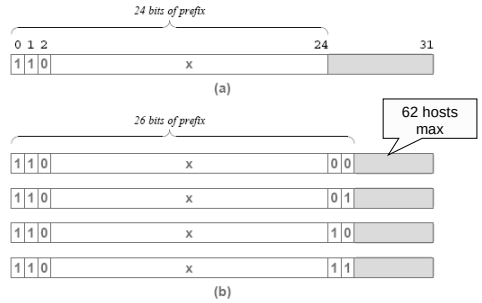


Figure 21.4 (a) A class C prefix, and (b) the same prefix divided into four classless prefixes.

Address Masks

- Classless and subnet addressing schemes require hosts and routers to store additional information:
- An address mask (subnet mask)
  - Specifies the exact boundary between the network prefix and the host suffix

Address Mask Example

- Mask:

  11111111 11111111 00000000 00000000 = 255.255.0.0
- Destination address

  10000000 00001010 00000010 00000011 = 128.10.2.3
- Logical ***and*** these to extract the network prefix (high-order 16 bits)

  10000000 00001010 00000000 00000000 = 128.10.0.0

CIDRized Network Addresses

- Classless Inter-Domain Routing has been standardized so its no longer necessary to use classful addressing
- CIDRized addresses have the form
  - *a.b.c.d/x* where *x* is the number of leading bits that form the network part of the address
- The number of addresses is a power of 2

CIDR vs. Classes

CIDR mask	/8	/16	/24
Class	A	B	C

CIDR Example

Assume an ISP has the following address block 128.211.0.0/16

The ISP has 2 customers

- One customer needs 12 IP addresses and the other needs 9
- Give customer1 CIDR: 128.211.0.16/28
- Give customer2 CIDR: 128.211.0.32/28
- Binary value assigned to customer1:
  10000000 11010011 00000000 0001 0000
- Binary value assigned to customer2:
  10000000 11010011 00000000 0010 0000

CIDR Host Addresses

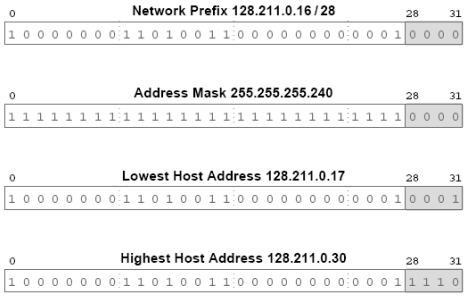
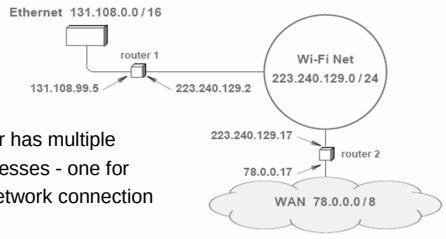


Figure 21.6 Illustration of CIDR addressing for an example / 28 prefix.

Routers and IP Addresses

- Routers connect to two or more networks
- IP address specifies an *interface*, or network attachment point, *not* a computer



A router has multiple IP addresses - one for each network connection

Special IP Addresses

- Network address not used in packets
- Loopback never leaves local computer

Prefix	Suffix	Type Of Address	Purpose
all-0s	all-0s	this computer	used during bootstrap
network	all-0s	network	identifies a network
network	all-1s	directed broadcast	broadcast on specified net
all-1s	all-1s	limited broadcast	broadcast on local net
127	any	loopback	testing

Loopback Address

Used to test network applications

- A programmer can test program logic quickly without needing two computers and without sending packets across a network
- During loopback testing no packets leave a computer
  - the IP software forwards packets from one application to another

Private IP Addresses

Class	Private IP's
A	10.0.0.0 – 10.255.255.255
B	172.16.0.0 – 172.31.255.255
C	192.168.0.0 – 192.168.255.255

Private addresses are **non-routable** (to the Internet)

Addressing Summary

MAC Address
- Hardware (NIC)
- Only known within a LAN

IP Address
- Virtual
- Associated with a host

Need to translate between MAC and IP addresses

ARP

- Used to translate between IP and MAC
- Each host and router on a LAN runs ARP software
- ARP query is broadcast on LAN
- Response is in a non-broadcast frame
- ARP cache is in RAM

DHCP

Dynamic Host Configuration Protocol

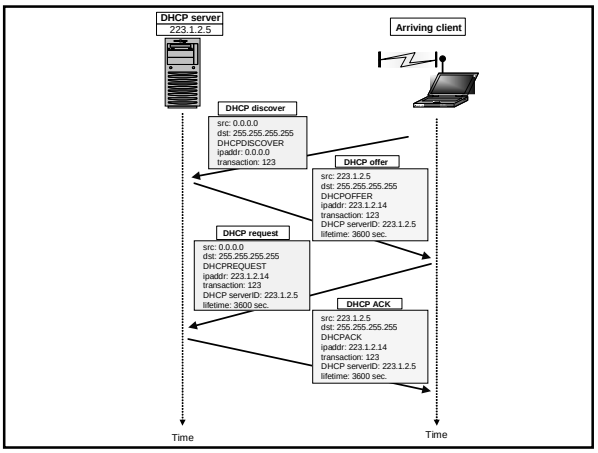
Assigning a Host Address

- *Manual configuration:* System admin manually configures the IP address into the host
- *Dynamic Host Configuration Protocol (DHCP):* Host obtains an IP address automatically from a server

DHCP Process

For a newly arriving host:

1. *DHCP server discovery* – Host finds a DHCP server by sending a **DHCP discover message** (broadcast)
2. *DHCP server offer(s)* – A DHCP server responds to client with a **DHCP offer message**. Multiple offers if more than one DHCP server is present
3. *DHCP request* – Client selects an offer and responds with **DHCP request message**
4. *DHCP ACK* – Server responds with **DHCP ACK** message confirming requested parameters



IP Address Lease

- Once the client receives the DHCP ACK, it can use the IP address for the lease duration
- DHCP provides a mechanism for renewing the lease on an IP address
  - Only requires exchange of request/acknowledge packets
- Suppose the laptop in the example moves from library to classroom to dorm
  - Joins a new network and gets a new IP from DHCP server at each location

DHCP

- Server manages a set of IP addresses and client negotiates use of an address
- Lease for an IP address is for some limited time
- Restarting a host will request the same IP it had before