

TCP/IP Networking Basics

UNIX System Administration
CIS 68C1

TCP/IP Networking

- What is TCP/IP?
 - ✗ A suite of protocols
 - ✗ Protocol: formal rules of behavior
 - ✗ TCP over IP
 - ✗ TCP: Transmission Control Protocol
 - ✗ IP: Internet Protocol
 - ✗ It is the networking protocol of the Internet
 - ✗ IP is a **packet switching** protocol
 - ✗ Packets are switched from one network to another
 - ✗ IP can only send packets to hosts on a directly attached network

TCP/IP Networking

- Three key components of IP
 - × Addressing
 - × How the destination host is uniquely and globally identified
 - × Routing
 - × How data is switched across networks
 - × Routers switch data from network to network
 - × Multiplexing
 - × How data is delivered to a specific service running on a host

Addressing

□ The IP Address

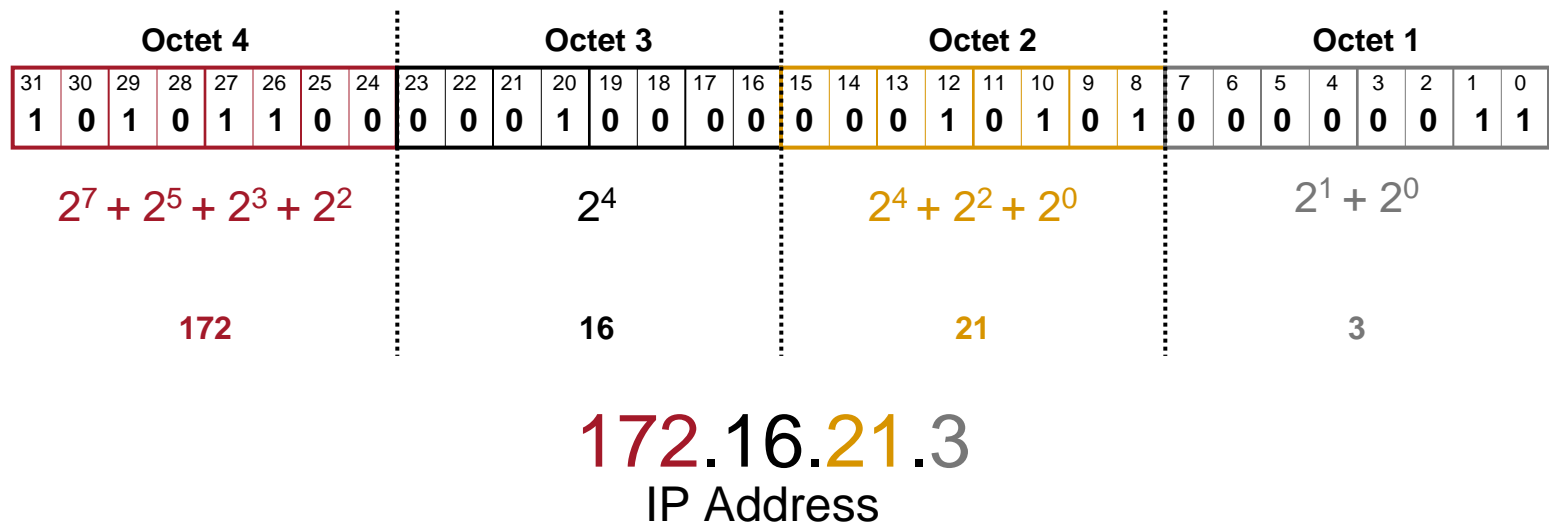
- ✗ An IP address is 32 bits
 - ✗ Not byte-oriented
- ✗ Is comprised of two parts
 - ✗ the **Network Address** part
 - ✗ Specifies the destination network in which to deliver the data
 - ✗ The **Host Address** part
 - ✗ Specifies the host on a given network in which to deliver the data

Network Address Part																Host Address Part															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
Octet 4				Octet 3				Octet 2				Octet 1																			

Addressing

□ The IP Address

- ✗ An IP address is a series of 32 bits of 0's and 1's
- ✗ But a more human readable form is used
- ✗ Comprised of 4 integers, separated by dots
 - ✗ Each integer is the decimal value of the corresponding octet



Addressing

□ Three Forms of Addressing

× Unicast

- × Packets are targeted to a single interface
 - × **Destination Address** of the IP datagram is interface's IP address

× Broadcast

- × Packets are targeted to all interfaces attached to the network
- × Broadcast packets are not transmitted across routers

× Multicast

- × Data is received only by subscribers
 - × A network card must be programmed to receive multicast data
- × If a router supports multicast, it may forward data (if requested)

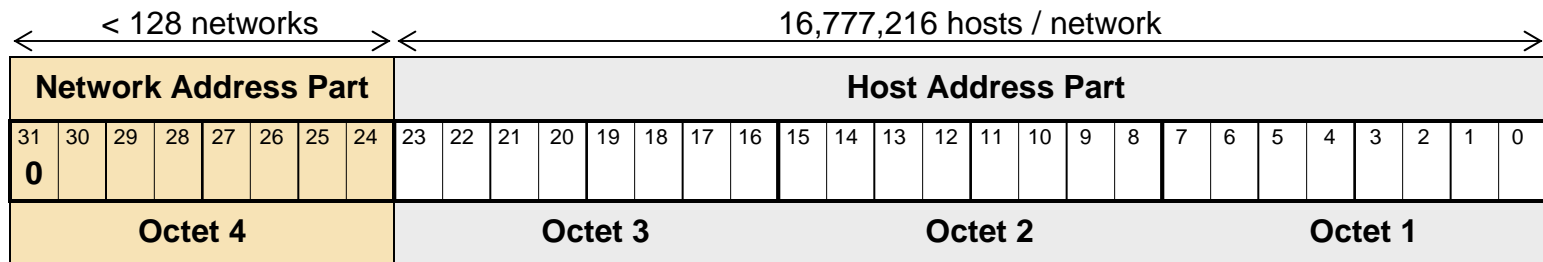
Addressing - Classes

- Traditional IP Address Classes
 - ✗ IP addresses were traditionally divided into classes
 - ✗ Class A
 - ✗ Class B
 - ✗ Class C
 - ✗ Class D (Multicast)
 - ✗ The class defines:
 - a) The range of valid IP addresses, and
 - b) The maximum number of hosts possible on a network

Addressing - Classes

□ Class A Addresses

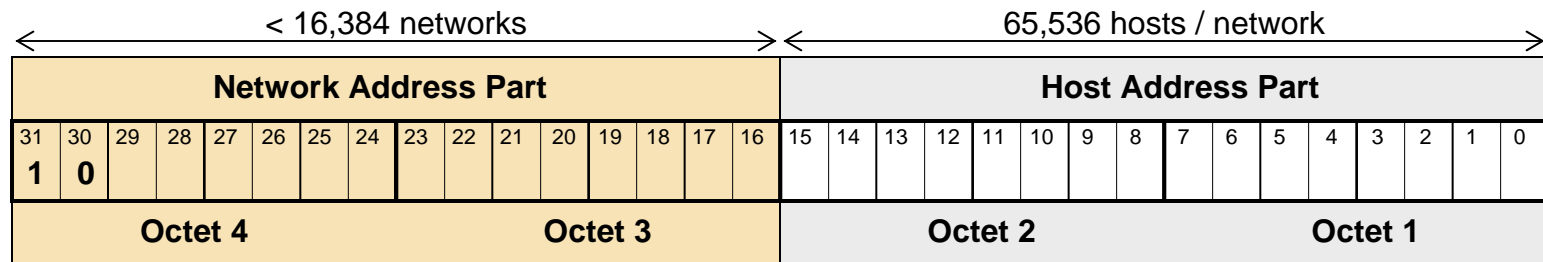
- ✗ Network address part is the first 8 bits
 - ✗ Bit 31 of IP address is 0
- ✗ Host address part is the last 24 bits
- ✗ IP addresses from 1.x.x.x to 127.x.x.x
- ✗ Number of networks: < 128 (2^7)
- ✗ Maximum hosts/network: 16,777,216 (2^{24})



Addressing - Classes

□ Class B Addresses

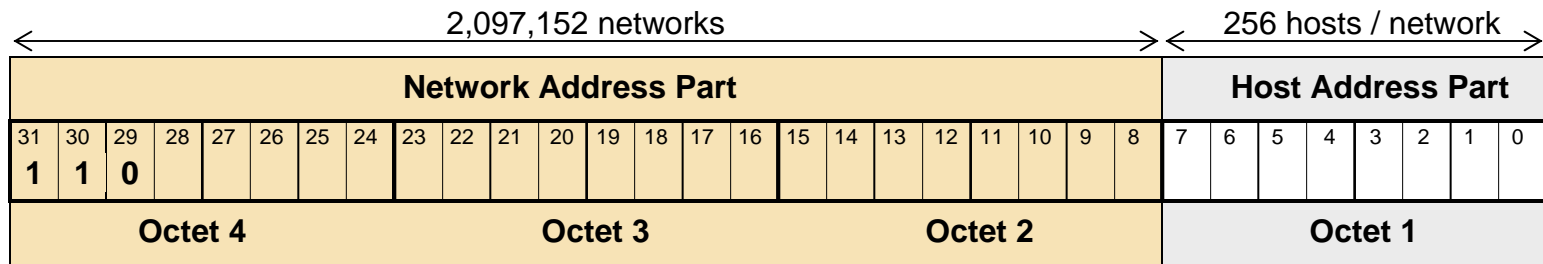
- ✗ Network address part is the first 16 bits
 - ✗ Bits 31-30 of IP address is 1 0
- ✗ Host address part is the last 16 bits
- ✗ IP addresses from 128.x.x.x to 191.x.x.x
- ✗ Number of networks: $< 16,384$ (2^{14})
- ✗ Maximum hosts/network: $65,536$ (2^{16})



Addressing - Classes

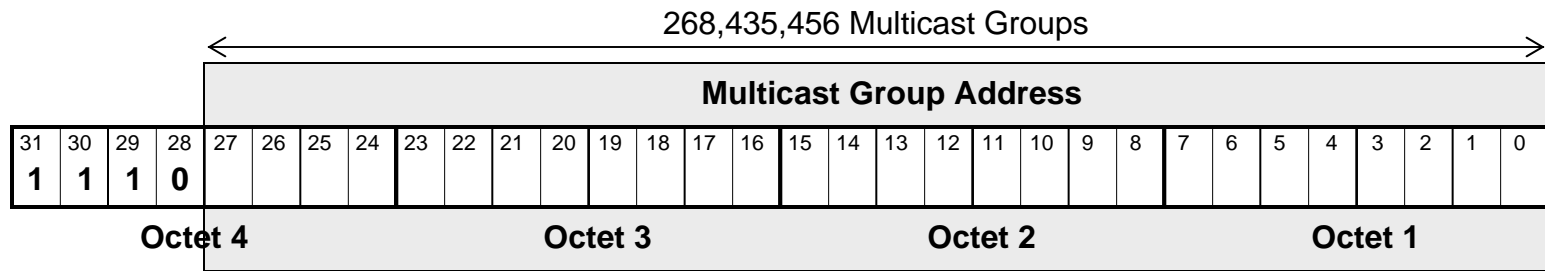
□ Class C Addresses

- ✗ Network address part is the first 24 bits
 - ✗ Bits 31-29 of IP address is 1 1 0
- ✗ Host address part is the last 8 bits
- ✗ IP addresses from 192.x.x.x to 223.x.x.x
- ✗ Number of networks: $< 2,097,152$ (2^{21})
- ✗ Maximum hosts/network: 256 (2^8)



Addressing - Classes

- Multicast Addresses (*aka* Class D)
 - ✗ No network part
 - ✗ Bits 31-28 of IP address is 1 1 1 0
 - ✗ Entire address specifies multicast group
 - ✗ Multicast group address is last 28 bits
 - ✗ IP addresses from 224.x.x.x to 239.x.x.x
 - ✗ Number of multicast groups: $< 268,435,456$ (2^{28})



Addressing - Classes

- Problems with Address Classes
 - × Class A
 - × Too many hosts per network; too few networks
 - × Class B
 - × Enough hosts per network; too few networks
 - × Class C
 - × Provides plenty of networks; too few hosts per network
 - × IP addresses were not distributed efficiently

Addressing - CIDR

- Classless Internet Domain Routing - CIDR
 - ✗ Removes the restrictions of IP address classes
 - ✗ Allows flexible division between network part and host part of an IP address
 - ✗ Requires a network mask
 - ✗ Known as a **subnet mask** or **netmask**
 - ✗ Another IP address that tells systems how to differentiate the network part of the IP address from the host part
 - ✗ The mask is an IP address that contains all 1's in the network part and all 0's in the host part

Addressing – Reserved IPs

□ Reserved Host Numbers

- ✗ All 0's host part of IP address
 - ✗ Refers to the **network** itself
 - ✗ Used by routers and routing software

Network Address Part																Host Address Part															
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
																			0	0	0	0	0	0	0	0	0	0	0	0	0

- ✗ All 1's host part of IP address
 - ✗ Is the **broadcast** address for the network

Network Address Part																Host Address Part																
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
																							1	1	1	1	1	1	1	1	1	1

Addressing – Reserved IPs

□ Reserved Network Numbers

✘ 0.0.0.0 (Class A)

- ✘ The network itself
- ✘ Simplifies routing table entries

✘ 127.0.0.0 (Class A)

- ✘ The **loopback** network address
- ✘ Simplifies programming network applications
- ✘ The standard hostname for the loopback interface is **localhost**

✘ 223.x.x.x to 239.x.x.x (Multicast)

✘ 240.x.x.x to 255.x.x.x are reserved for future use

Addressing – Private IPs

- Addresses for Private Internets
 - ✗ Class A: 10.0.0.0
 - ✗ Class B: 172.16.0.0 to 172.31.255.255
 - ✗ Class C: 192.168.0.0 to 192.168.255.255
 - ✗ For use in private internets only
 - ✗ Requires no coordination with in Internet registry
 - ✗ Must not be connected outside the *enterprise*
 - ✗ These systems cannot connect directly to the Internet
 - ✗ Reduces demands on limited IP address pool

Routing

- Routers and the Routing Table
 - ✗ Routers switch packets from network to network
 - ✗ Local network packets are addressed directly to the local host
 - ✗ Packets destined for other networks are addressed to a gateway host (aka router) for delivery
 - ✗ Routers are attached to more than one network
 - ✗ Routing decision based on network part of IP address
 - ✗ Network part determined by applying the network mask
 - ✗ Routers use a routing or forwarding table to lookup routes to other networks

Multiplexing

□ Port Numbers

- ✘ Once packets are delivered to the destination host, they need to be sent to the appropriate service or application
- ✘ A port number specifies the destination service
- ✘ Port numbers are just integers from 1 to 65535
- ✘ They are setup by the originating application

Configuring an IP Interface

- Requirements for configuring an IP Interface
 - ✗ IP address
 - ✗ Manually assigned or dynamically allocated (DHCP)
 - ✗ Network mask
 - ✗ Defined by the network administrator
 - ✗ Known by routers
 - ✗ Broadcast address
 - ✗ Calculated from IP address and network mask
 - ✗ Gateway (router) address
 - ✗ For sending packets to other networks
 - ✗ Defined by network administrator or ISP
 - ✗ DNS server
 - ✗ Resolve host names into IP addresses