

CS 372 Lecture #27

Internet Protocol (IP)

- classless addressing
- subnetting
- Classless Inter-Domain Routing (CIDR)

Note: Many of the lecture slides are based on presentations that accompany *Computer Networking: A Top Down Approach*, 6th edition, by Jim Kurose & Keith Ross, Addison-Wesley, 2013.

IP address assignment

- ISP gets a “block” of addresses from ICANN

Example: **200.23.16.0/20**

ISP's block **11001000 00010111 00010000 00000000**

- **/20** means that the first 20 bits specify the *network address*
- Remaining 12 bits are *host numbers*
 - 2^{12} host numbers, range [0 ... 4095] [0000 00000000 ... 1111 11111111]
- A *host address* (*IP address*) is a *network address* combined with a *host number*
 - 2 addresses are reserved
 - 200.23.16.0 is the network address, can't be assigned to a host
 - 200.23.31.255 is reserved as a “broadcast” address
 - Host addresses range [200.23.16.1 ... 200.23.31.254]
 - from **11001000 00010111 00010000 00000001**
 - to **11001000 00010111 00011111 11111110**

Subnets

- ISP gets a “block” of addresses from ICANN

Example:

ISP's block 11001000 00010111 00010000 00000000 200.23.16.0/20

- ISP can create *subnets*

Organization 0 11001000 00010111 00010000 00000000 200.23.16.0/24
IP addresses from 200.23.16.1 to 200.23.16.254

Organization 1 11001000 00010111 00010010 00000000 200.23.18.0/24
IP addresses from 200.23.18.1 to 200.23.18.254

Organization 2 11001000 00010111 00010100 00000000 200.23.20.0/24
IP addresses from 200.23.20.1 to 200.23.20.254

...

....

....

....

Organization 7 11001000 00010111 00011110 00000000 200.23.30.0/24
IP addresses from 200.23.30.1 to 200.23.30.254

- In this example, each *subnet* gets 256 IP addresses (2 are reserved)

Subnets

- How many /24 subnets are possible in this example?

Example:

ISP's block 11001000 00010111 00010000 00000000 200.23.16.0/20

- ISP can create *subnets*

Organization 0 11001000 00010111 00010000 00000000 200.23.16.0/24
IP addresses from 200.23.16.1 to 200.23.16.254

Organization 1 11001000 00010111 00010010 00000000 200.23.18.0/24
IP addresses from 200.23.18.1 to 200.23.18.254

Organization 2 11001000 00010111 00010100 00000000 200.23.20.0/24
IP addresses from 200.23.20.1 to 200.23.20.254

...

....

....

....

Organization 7 11001000 00010111 00011110 00000000 200.23.30.0/24
IP addresses from 200.23.30.1 to 200.23.30.254

- 4 bits of freedom: [0000 ... 1111] (16 combinations)
- 16 possible subnets, each controls 254 host addresses

Extracting the network address

- Routers need network addresses
 - the first /x bits of any IP address is often called the *prefix*
 - a *netmask* is all 1's in the first x bits, and all zeros in the rest of the bits
- Example: **200.23.21.170/20**
 - address in binary: 11001000 00010111 00010101 10101010
 - netmask: 11111111 11111111 11110000 00000000
 - bit-wise AND: 11001000 00010111 00010000 00000000
 - network address: 200.23.16.0
 - netmask: 255.255.240.0
- Routers can use network address for longest prefix match

Extracting the host number

- Local admin needs host number for address with /x
 - the last (32 – x) bits of any IP address is often called the *suffix*
 - a *hostmask* is all zeros in the first x bits, and all 1's in the rest of the bits
- Example: **200.23.21.170/20**
 - address in binary: 11001000 00010111 00010101 10101010
 - hostmask: 00000000 00000000 00001111 11111111
 - bit-wise AND: 00000000 00000000 00000101 10101010
 - host number: 1450

Subnet

- Same IP address, but in a **/22** subnet
- Example: **200.23.21.170/22**
 - address in binary: 11001000 00010111 00010101 10101010
 - **netmask:** 11111111 11111111 111111**00** 00000000
 - bit-wise AND: 11001000 00010111 000101**00** 00000000
 - network address: 200.23.**20**.0
 - netmask: 255.255.**252**.0
- Example: **200.23.21.170/22**
 - address in binary: 11001000 00010111 00010101 10101010
 - **hostmask:** 00000000 00000000 000000**11** 11111111
 - bit-wise AND: 00000000 00000000 000000**01** 10101010
 - host number: **426**

CIDR

- CIDR (Classless Inter-Domain Routing) address includes specification for number of bits to use for the netmask

- Example: host address 128.193.47.25/22

10000000 11000001 00101111 00011001

- What is the netmask?

- 255.255.252.0

11111111 11111111 11111100 00000000

- What is the network address?

- 128.193.44.0

10000000 11000001 00101111 00011001
11111111 11111111 11111100 00000000
 10000000 11000001 00101100 00000000

- What is the hostmask?

- 0.0.3.255

00000000 00000000 00000011 11111111

- What is the host number?

- 0.0.3.25 = 319h

- 793 (decimal)

10000000 11000001 00101111 00011001
00000000 00000000 00000011 11111111
 00000000 00000000 00000011 00011001

- What is the netmask for /20 ?
 - 255.255.240.0
- What is the netmask for /24 ?
 - 255.255.255.0
- What is the netmask for /27 ?
 - 255.255.255.224
- How many hosts can be supported in /28 ?
 - $2^4 - 2 = 14$

Routing information

- Sending host puts destination internet address into datagram
 - *Destination address* in IP datagram is always ultimate destination
- *Address mask* defines how many bits of address are in *prefix*
 - /x defines how much of address used to identify network
- Router applies mask to destination address to obtain the *network address*
- Routing table relates network address to *next-hop address*
- Router forwards datagram to next-hop address

- Network address, host number, host IP address
- Netmask, hostmask, prefix, suffix
- CIDR
- Routing
- Computations:
 - Network address
 - Host number
 - Subnet mask, subnet address
 - Number of subnets, number of hosts
 - Convert dotted-decimal \Leftrightarrow binary