Introduction to Networks & Distributed Computing
CECS 327

IP (Internet Protocol) Addressing

Special IP Addresses

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

IP (Internet Protocol) Addressing

Special IP Addresses

Private IP address space	
From	**To**
10.0.0.0	10.255.255.255
172.16.0.0	172.31.255.255
192.168.0.0	192.168.255.255

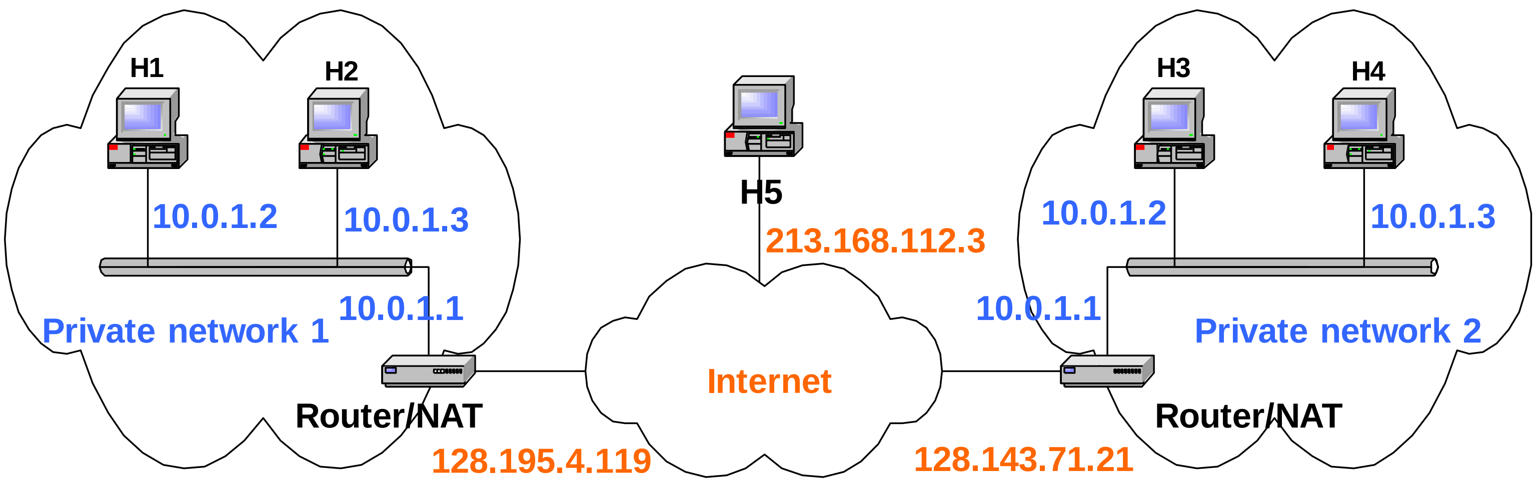
IP (Internet Protocol) Addressing

What is your IP address?

Is it private or public?

Network Address Translation

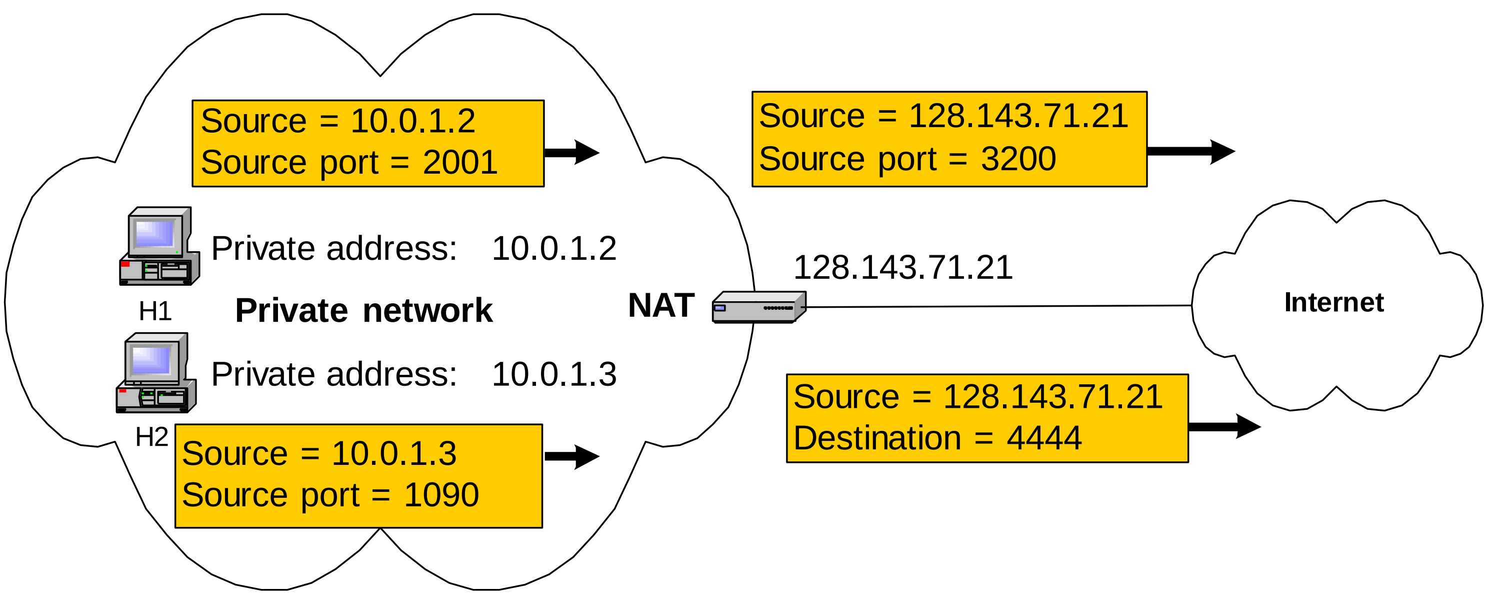
NAT (Network Address Translation) Maps Private IPs to Public IPS



IP (Internet Protocol) Addressing

- Static NAT : Maps unique Private IP to unique Public IP

- Dynamic NAT : Maps Multiple Private IP to a Pool of Public IPs (Port Address Translation : Maps a Public IP and Port Number to a service in Private IP)



IP (Internet Protocol) Addressing

ICANN

Internet Corporation for Assigned Names and Numbers (ICANN) authority was established to handle:

- address assignment and
- adjudicate disputes

ICANN does not assign individual prefixes.

Instead, ICANN authorizes a set of registrars to assign prefixes.

Registrars make blocks of addresses available to ISPs.

ISPs provide addresses to subscribers.

To obtain a prefix a corporation usually contacts an ISP.

IP (Internet Protocol) Addressing

Subnets and Classless Addressing:

Original goal: network part would uniquely identify a single physical network

But

- Being exhausted IP address
- Inefficient address space usage
- Class A & B networks too big
- Also, very few LANs have close to 64K hosts
- Easy for networks to outgrow class-C
- routing table size is too high

Two mechanisms were invented to overcome the limitation:

- Subnet addressing
- Classless addressing

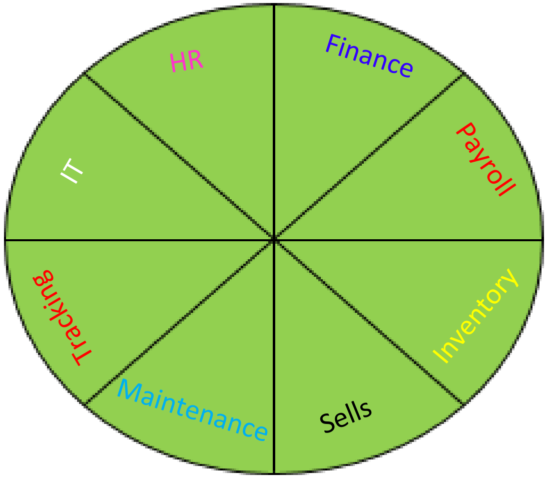
The two mechanisms are closely related and can be considered to be part of a single abstraction.

IP (Internet Protocol) Addressing

Subnetting :

Main concept: Instead of having three distinct address classes (Class A, B & C), allow the division between prefix/suffix to occur on an arbitrary bit boundary.

- Security
- Organization
- Performance



IP (Internet Protocol) Addressing

Subnets and Classless Addressing (cont'd):

<u>Example:</u>

Consider an ISP that hands out prefixes and a customer of the ISP that requests a prefix for a network that contains 55 hosts.

<u>Classful addressing</u>, would require a complete class C prefix.

8-bits of suffix = 256 possible values = 0..255

<u>Note:</u> *We do not use 0 (0000 0000) or 255 (1111 1111) for hosts (why?)*

So Class C gives us 254 possible addresses.

that means 199 of the 254 possible suffixes would never be assigned

most of the class C address space is wasted

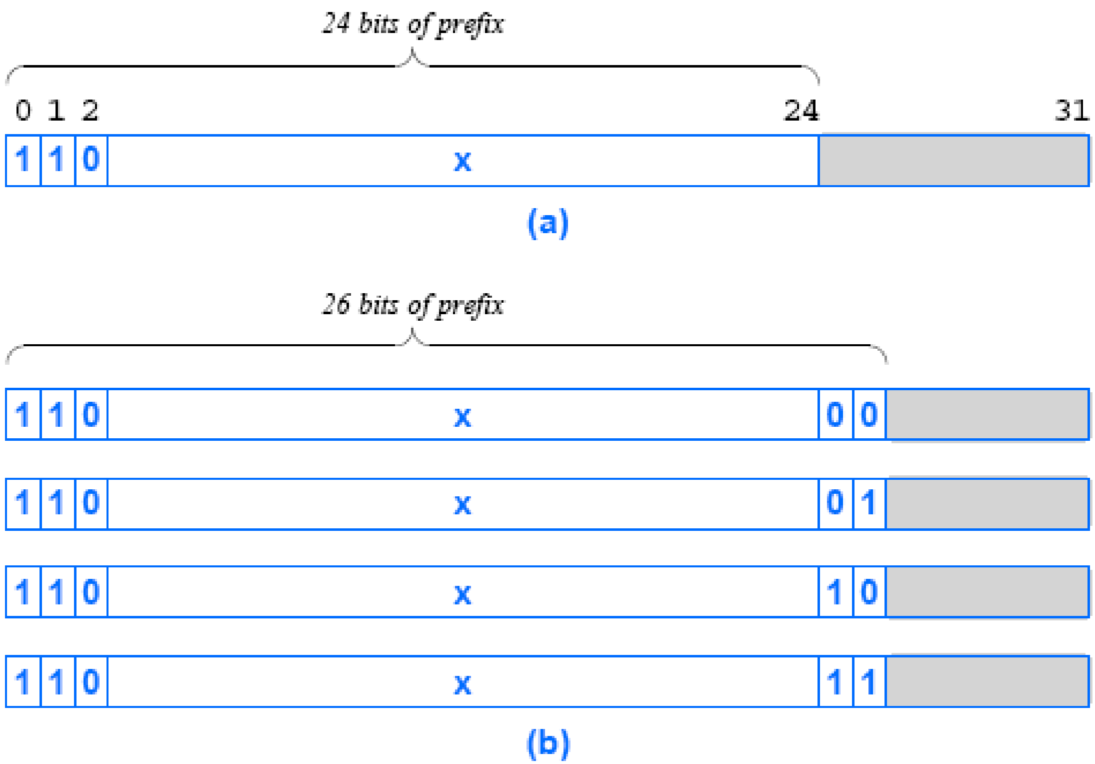
<u>With Classless addressing</u>, the ISP can assign:

a prefix that is 26 bits long

a suffix that is 6 bits long

6-bits of suffix = 2^6 possible values = 64 (minus 0 and 63) = 62 addresses

IP (Internet Protocol) Addressing



This figures illustrates the way classless addressing can be used by an ISP to divide a class C prefix into four (4) longer prefixes:

- each one can accommodate a network of up to 62 hosts.
- the host portion of each prefix is shown in gray.

IP (Internet Protocol) Addressing

Address (or Subnet) Masks

The **classless** and **subnet addressing** schemes require hosts and routers to store an additional piece of information: a value that specifies the exact boundary between the network prefix and the host suffix.

To mark the boundary, IPv4 uses a 32-bit value known as an ***address mask***, also called a ***subnet mask***.

Why store the boundary size as a bit mask?

- Hosts and routers need to compare the network prefix portion of the address to a value in their forwarding tables.
- The bit-mask representation makes the comparison efficient by making bitwise operations.

IP (Internet Protocol) Addressing

Address (or Subnet) Masks:

Each IP class has a default subnet:

- Class A: 255.0.0.0
- Class B: 255.255.0.0
- Class C: 255.255.255.0

IP (Internet Protocol) Addressing

Address (or Subnet) Masks

Subnetting Example 1:

Consider the following 32-bit network prefix:

10000000 00001010 00000000 00000000 = 128.10.0.0

Consider a 32-bit mask:

11111111 11111111 00000000 00000000 = 255.255.0.0

Consider a 32-bit destination address on the network which has address:

10000000 00001010 00000010 00000011 = 128.10.2.3

A logical AND (&) between the destination address and the address mask extracts the high-order 16-bits:

10000000 00001010 00000000 00000000 = 128.10.0.0

IP (Internet Protocol) Addressing

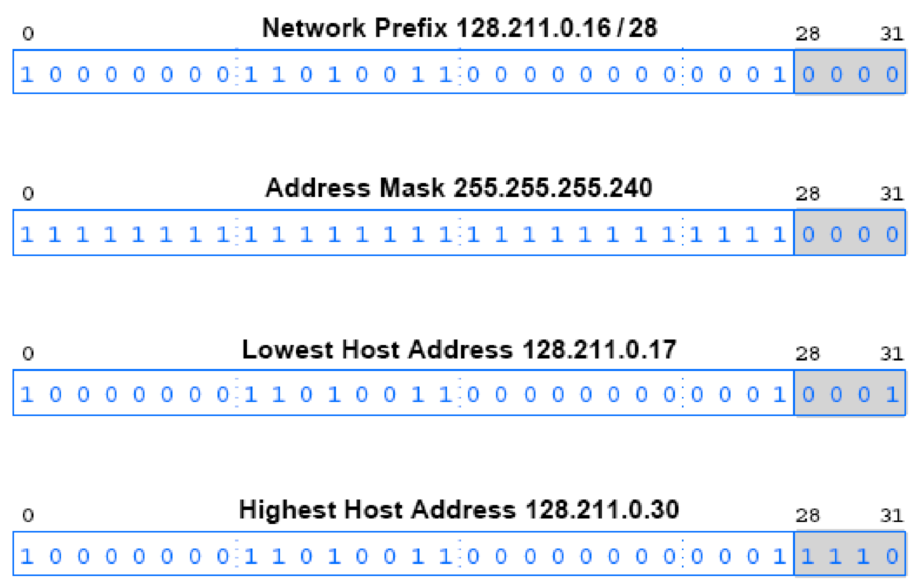
Classless Inter-Domain Routing (CIDR)

The general form of CIDR notation is: **ddd.ddd.ddd.ddd/m**

- **ddd** is the decimal value for an octet of the address
- **m** is the number of one bits in the mask

Consider the mask needed for a network with 28 bits of prefix:

- It has 28-bits of 1s followed by 4-bits of 0s
- In dotted decimal, the mask is: **255.255.255.240**



IP (Internet Protocol) Addressing

A list of address masks in CIDR notation and in dotted decimal

CIDR Notation	Dotted Decimal	CIDR Notation	Dotted Decimal
/1	128.0.0.0	/17	255.255.128.0
/2	192.0.0.0	/18	255.255.192.0
/3	224.0.0.0	/19	255.255.224.0
/4	240.0.0.0	/20	255.255.240.0
/5	248.0.0.0	/21	255.255.248.0
/6	252.0.0.0	/22	255.255.252.0
/7	254.0.0.0	/23	255.255.254.0
/8	255.0.0.0	/24	255.255.255.0
/9	255.128.0.0	/25	255.255.255.128
/10	255.192.0.0	/26	255.255.255.192
/11	255.224.0.0	/27	255.255.255.224
/12	255.240.0.0	/28	255.255.255.240
/13	255.248.0.0	/29	255.255.255.248
/14	255.252.0.0	/30	255.255.255.252
/15	255.254.0.0	/31	255.255.255.254
/16	255.255.0.0	/32	255.255.255.255

IP (Internet Protocol) Addressing

Classless Inter-Domain Routing (CIDR)

The Mask field in a routing table is used to extract the network part of an address during lookup.

A bit mask makes prefix extraction efficient, using Boolean AND.

Example 2:

A datagram is destined for 192.4.10.3

If 192.4.10.3 is a class C* network, the subnet mask will be 255.255.255.0.

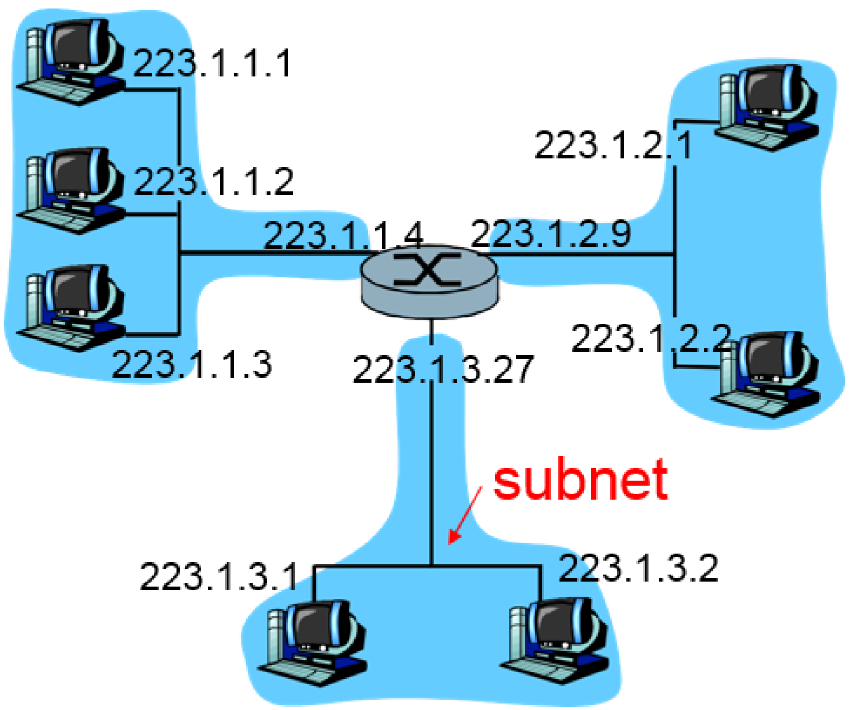
192.4.10.3 & 255.255.255.0 = 192.4.10.0

* Why is 192.4.10.3 considered a class C network?

(Hint: see previous slide.)

IP (Internet Protocol) Addressing

How many subnets? And What are they?



The network consisting of 3 subnets

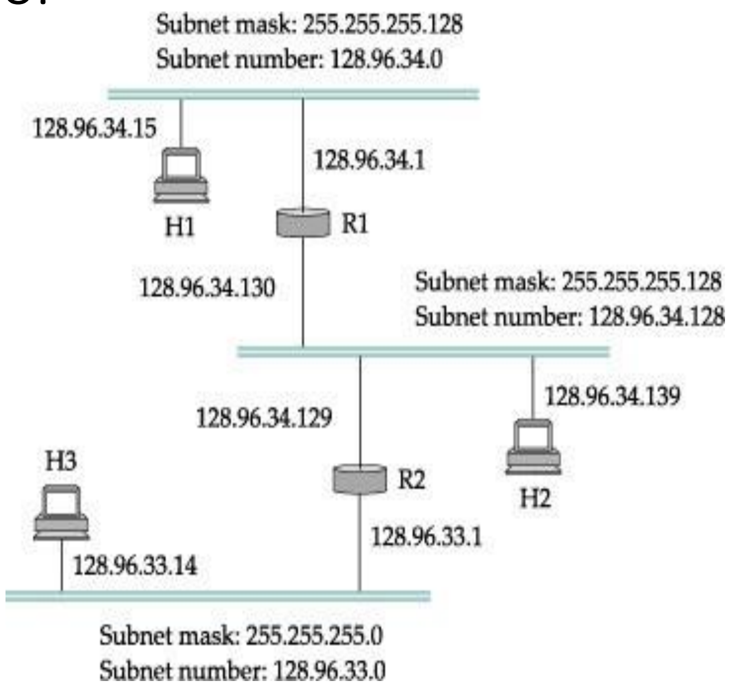
IP (Internet Protocol) Addressing

Q: How H1 sends packets to H2?

A:

- (128.96.34.139) AND (255.255.255.128)

  -> 128.96.34.128
- Does it match the subnet number for H1? NO!
- Sends the packet to default router R1



References

- Distributed Systems: Concepts and Design. George Coulouris, Jean Dol-limore, Tim Kindberg and Gordon Blair. Fifth Edition, Pearson, 2012.
- Computer Networks, Fifth Edition: A Systems Approach (The Morgan Kaufmann Series in Networking).
- Computer Networks and Internets (5th Edition)
- Some slides by Dr. Tracy Bradley Maples