LECTURE 3

IP Addressing

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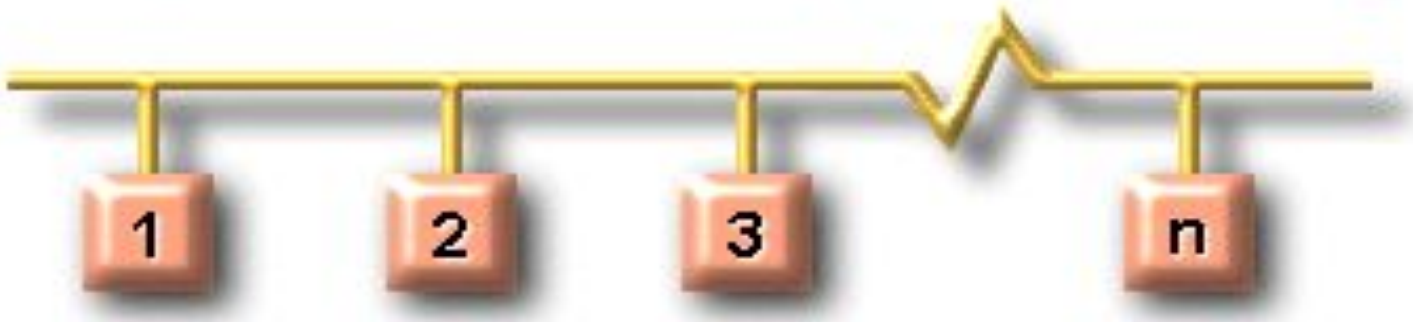
- What is Networking?
  - by ‘computer network’ we mean the *interconnection between different computers*.
- Why Networking?
  - to share *resources:*
    - *hardware* (storage, printers etc.) as well as
    - *software* (application programs, data etc.).

Nameless Computers on a Network

- **How to differentiate amongst the different, individually similar, computers attached to a network?**
  - The simple answer to this question is that we can use different *names* or *identifications* for each individual computer.

Mac Addresses: A Flat Addressing Scheme

Flat (Non-Hierarchical) Addressing



As n increases, communication becomes difficult

- For a large network, finding a standard rule for naming computers will be very difficult.

- One simple way of identifying individual computer is to assign an address to each computer, because naming convention may end up in having duplicate names in a large network.

What are the different methods of addressing?

i) MAC Addressing

ii) IP Addressing

MAC Addressing

- **Every computer has a unique way of identifying itself.**

- **Each computer, whether it is attached to a network or not, has a physical address. No two physical addresses are ever alike.**

- **Referred to as the Media Access Control Address or MAC Address, the physical address is located on the Network Interface Card or NIC Card**

- **MAC addresses are 48 bits in length.**
- **They are expressed as 12 hexadecimal digit**
- **MAC Addresses are split into two half, each consisting of 6 hexadecimal digits:**
  - 1st Half is the OUI identifier.
  - 2nd Half is Card identifier.

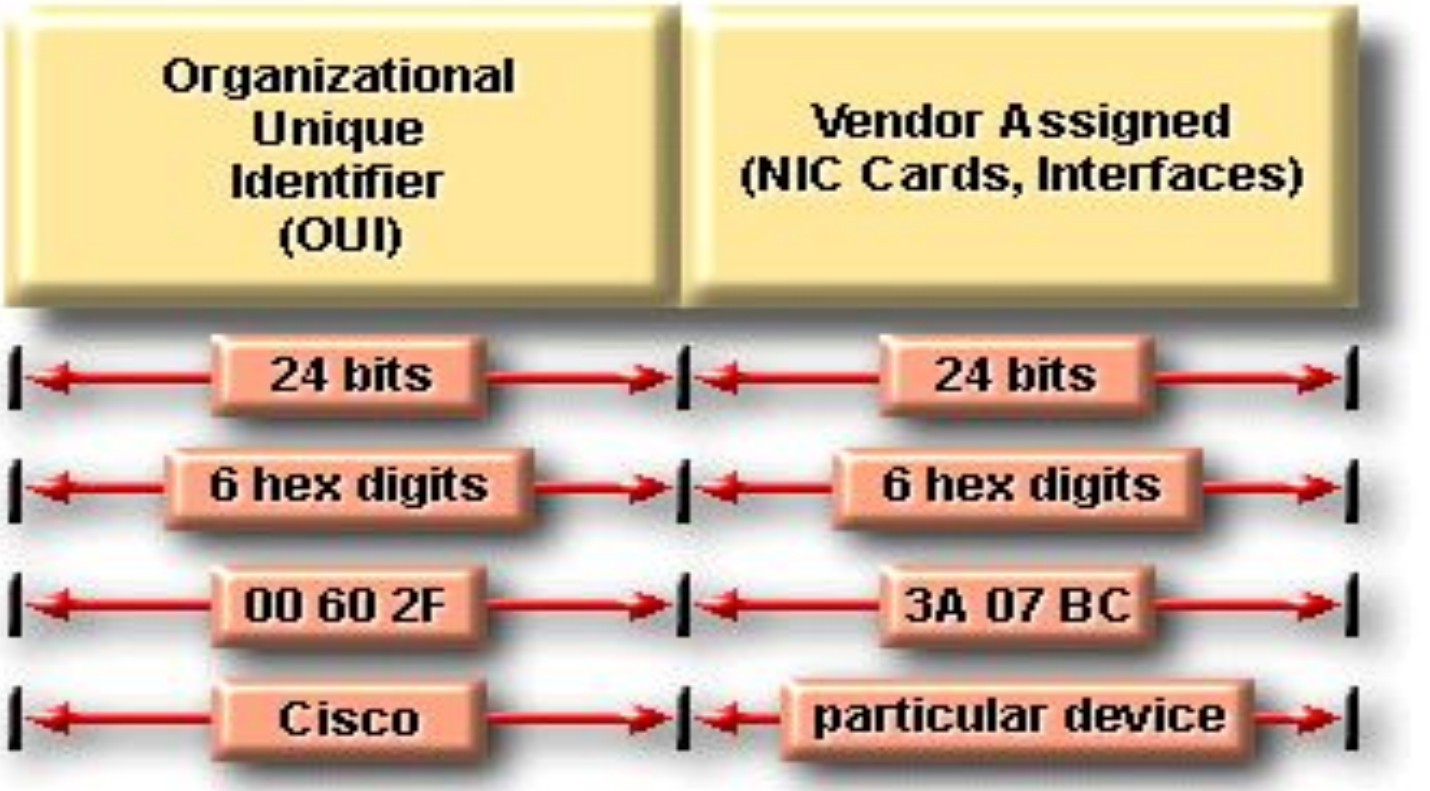
- **The first six hexadecimal digits identify th manufacturer or vendor**

- **These are also known as the Organizational Unique Identifier (OUI).**

- **These numbers are administered by the IEEE**

- **The last six hexadecimal digits comprise the interface serial number, or another value administered by the specific vendor.**

MAC Address Format



Two formats are used to express MAC address:

- octets 44-AB-5F-DF-C1-FB
- double octets 44AB.5FDF.C1FB

- The octet format is generally used.

Advantages of MAC Addressing

- **MAC addresses are vital to the functioning of a computer network.**
- **They provide a way for computers to identify themselves;**
- **they give hosts a permanent, unique name, and**
- **they are not going to run out anytime soon, since there are 16^12 (over 2 trillion!) possible MAC address names.**

Disadvantages of MAC

- **There is one major disadvantage to MAC addresses.**
- **MAC addresses are flat.**
- **What do we mean by flat?**
- **There is no structure.** The different number sections, divided by hyphens do not mean anything.

Disadvantages of MAC

- **Social Security number is a flat number (987-65-4321).**
- **The different number sections, divided by hyphens do not mean anything.**
- **On the other hand each section of a phone number, however means something:**

  880- 2- 980 0964
- **This approach is known as hierarchical addressing**

The primary limitation of MAC addressing: it is a flat, non-hierarchical naming system which does not scale well to large numbers of computers.

Since we are interested in internetworking large numbers of computers, another addressing scheme -- imposed at Layer three -- is necessary.

IP Addressing

- IP addresses **identify** *a device* on a network and the network to which it is attached.

- An IP address (in version 4) is represented by a 32 bit binary number.

11000000000001010000010100000001

- To make them easy to remember, IP addresses are usually written in *dotted-decimal* notation.

- We break up the 32 bits of the address into four *octets* (an octet is a group of 8 bits)

  11000000 00000101 00000101 00000001

- and each *octet* is expressed as a **decimal** number

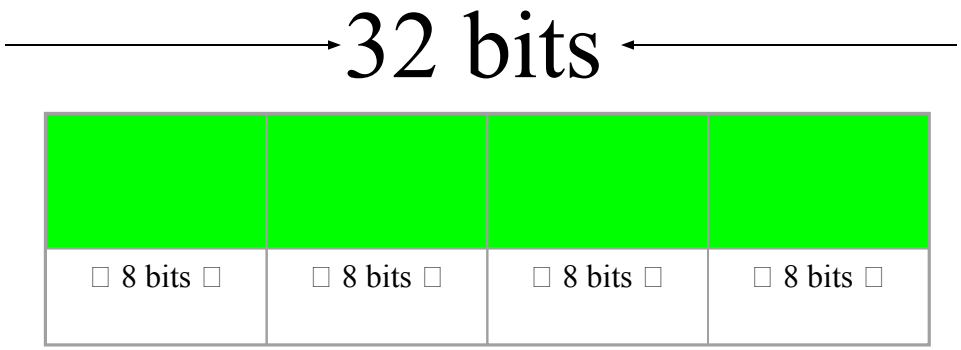
  192 5 5 1

- then we put a **dot** in between the decimal numbers.

  192. 5. 5. 1

- Therefore, IP addresses are 4 decimal numbers separated by dots.

IP Address Format



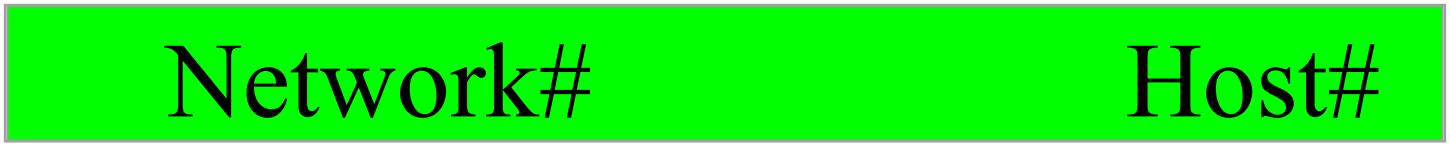
- The IP Address is divided in to two **component fields**
  - (i) *network number* and
  - (ii) *host number*

- The ***network number*** of an IP address identifies the network to which a device is attached and hence makes the hierarchical addressing, discussed earlier, possible.

- The ***host number*** of an IP address identifies the specific device on that network.

The network number and the host number make up the IP Address

32 bits



- Because IP addresses consist of four octets separated by dots, one, two, or three of these octets may be used to identify the network number.

- Similarly, up to three of these octets may be used to identify the host portion of an IP address.

- Depending on how many octets are there in *network# identification,* networks are classified into different classes

IP Address Classes

- There are ***five*** classes of IP addresses
- They are Class A, B, C, D and E.
- Only Class A, B, and C are for public use and is assigned by the American Registry for Internet Numbers (ARIN)
- Class D and E are reserved for special use and not allowed for public use

Class A

Class A	N	H	H	H
Class B	N	N	H	H
Class C	N	N	N	H

IP Address Classes

ARIN now reserves

- Class A addresses for governments throughout the world (although a few large companies, such as Hewlett Packard, have received one in the past)

- Class B addresses for medium-sized companies.

- Class C addresses for all other requestors

How to identify network classes from the IP Address?

Bits	7	6	5	4	3	2	1	0			
Class A	0										
	N								H	H	H
	0-127										
Class B	1	0									
	N								N	H	H
	128-191										
Class C	1	1	0								
	N								N	N	H
	192-223										

of hosts in different networks

- **Class A $2^{24} - 2 = 16777214$**
- **Class B $2^{16} - 2 = 65534$**
- **Class C $2^{8} - 2 = 254$**

Reserved Address Space

- Let us consider the following scenario:
  - we want to communicate with all of the devices on a *separate* network,
  - it would be quite unmanageable to write out the IP address for each device of that network.
  - We might try two hyphenated addresses, indicating that we are referring to all devices within a range of numbers, but that, too, would be quite unmanageable.
  - There is, however, a shorter method.

Reserved Address Space

- Let us consider another scenario:
  - we want to send data to all of the devices on the *same* network,
  - it would be quite unmanageable to write out the IP address for each device of the network.
  - We might try two hyphenated addresses, indicating that we are referring to all devices within a range of numbers, but that, too, would be quite unmanageable.
  - There is also another shorter method.

Reserved Address Space

- An IP address that ends with binary 0s in all host bits is **reserved** for the **network address**
- Therefore, as a Class A network example, 113.0.0.0 is the IP address of the network containing the host 113.1.2.3.
- As a Class B network example, the IP address 176.2.0.0 is a network address.
- They will never be used as an address for any device that is attached to these networks.

Reserved Address Space

- Similarly an IP address that ends with binary 1s in all host bits is **reserved** for the **broadcast address**.
- For the network in the example (176.2.0.0), where the last 16 bits make up the host field (or host part of the address), the broadcast that would be sent out to all devices on that network would include a destination address of 176.2.255.255 (since 255 is the decimal value of an octet containing 11111111).
- This will never be used as an address for any device that is attached to this network.

Subnetworks or Subnetting

- **What is a subnetwork or subnet?**
  - Network administrators sometimes need to divide networks, especially large ones, into smaller networks.
  - These smaller divisions are called *subnetworks*
  - Most of the time subnetworks are simply referred to as *subnets*.
- **Why Subnetting** ?
  - to provide addressing flexibility for Network Administrators
  - to reduce the size of a broadcast domain.

How are subnets formed?

- Subnet addresses are assigned locally, usually by the network administrator. Also, like other IP addresses, each subnet address is unique.

- Subnet addresses include the Class A, Class B, or Class C network portion, plus a subnet field and a host field.

- The subnet field and the host field are created from the original host portion for the entire network.

Class A

Class A	N		SN		H	H			H	
Class B	N			N			SN		H	
Class C	N			N			N		SN	H

How are subnets formed?

- The ability to decide how to divide the original host portion into the new subnet and host fields provides addressing flexibility for the network administrator.

- To create a subnet address, a network administrator *borrows* bits from the original host portion and designates them as the subnet field.

How many bits to borrow?

- If we borrow only 1 bit, to create a subnet, then we would have
  - –a network with number 0 and
  - –another with network number 1

- But we know that these are reserve numbers.

How many bits to borrow?

- So, the minimum number of bits that can be borrowed from any class is 2.

- The maximum number of bits that can be borrowed can be any number that leaves at least 2 bits remaining, for the host number.

Subnet mask

- What is a subnet mask?
  - The subnet mask is not an address,
  - it determines which part of an IP address is the network field and which part is the host field.
  - A subnet mask is 32 bits long just like an IP address.

Subnet mask

•How is it created?

- To determine the subnet mask for a particular subnetwork IP address follow these steps:
  - (1) Express the subnetwork IP address in binary form.
  - (2) Replace the network and subnet portion of the address with all 1s.
  - (3) Replace the host portion of the address with all 0s.
  - (4) As the last step convert the binary expression back to dotted-decimal notation.

Default subnet masks

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

Why do we need a subnet mask?

- Hosts and routers use the ANDing process to determine if a destination host is on the same network or not.

- The ANDing operation happens any time a host wants to send a packet to another host on an IP network.

Why do we need a subnet mask?

- The result of the 1st AND is to identify the network where the source host resides.

- It will then compare the destination IP address to its own subnet mask (2nd AND) to determine the network address of the destination host.

SUBNET MASKS

Host X (Source) on network 200.1.1.0 (Class C Network) has an IP address of 200.1.1.5 and wants to send a packet to Host Z (Destination) on network 200.1.2.0 and has an IP address of 200.1.2.8. All hosts on each network are connected to hubs or switches and then to a router (Remember that with a class C network, ARIN assigns the first 3 octets (24 bits) as the network address, so these are two different networks.

	Source (X)	Destination (Z)
Host IP	200.1.1.5	200.1.2.8
Network#	200.1.1.0	200.1.2.0
Subnet Mask	255.255.255.0	255.255.255.0

SUBNET MASKS

- Host **X** compares it's own IP address to its own subnet mask using the ANDing process

- Host **X** IP 200.1.1.5

  11001000.00000001.00000001.00000101
- **SN Mask 255.255.255.0**

  11111111.11111111.11111111.00000000
- ANDing result

  11001000.00000001.00000001.00000000
- Own network address **200 . 1 . 1 . 0**

SUBNET MASKS

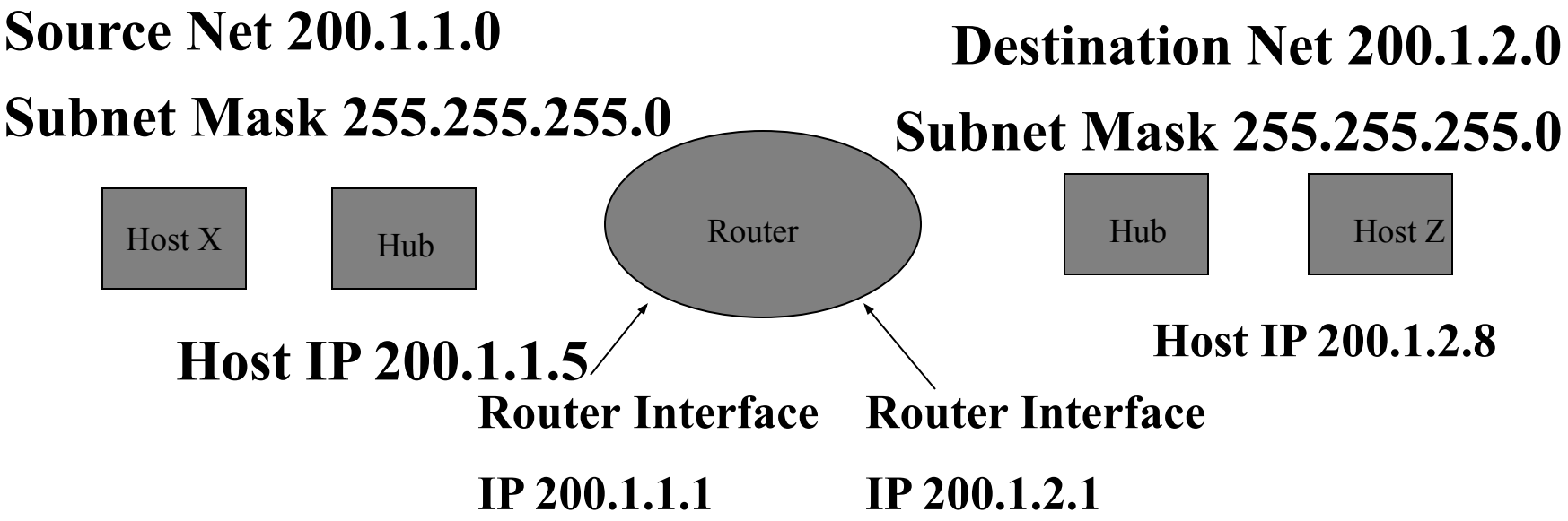
- Next Host **X** compares the IP address of the Host **Z** dest. to its own subnet mask using the ANDing process

- Host **Z** IP 200.1.2.8
  11001000.00000001.00000010.00001000
- Subnet Mask 255.255.255.0
  11111111.11111111.11111111.00000000
- ANDing result
  11001000.00000001.00000010.00000000
- network address **200 . 1 . 2 . 0**

SUBNET MASKS

Host **X** now knows that host Z is not in its Local Area Network (LAN) and it must send the packet to its "Default Gateway" which is the IP address of the router interface of 200.1.1.1 on network 200.1.1.0. The router will then repeat the ANDing process to determine which router interface to send the packet out.

SUBNET MASKS



THANK YOU ALL