AHRAM CANADIAN UNIVERSITY

Lecture (07)
Internet Protocol (I)

<Internetwork @ tcp/ip> <Network @ OSI>

Dr. Ahmed M. ElShafee

Agenda

- Introduction
- Network Layer Interaction with the Data Link Layer
- Network Layer (Layer 3) Addressing
- IP Routing and Routing Protocols

Introduction

Typical features of OSI layer 3

OSI layer 3 or network layer, or internet layer in case of TCP/IP protocol is a protocol that defines routing and addressing

Such as

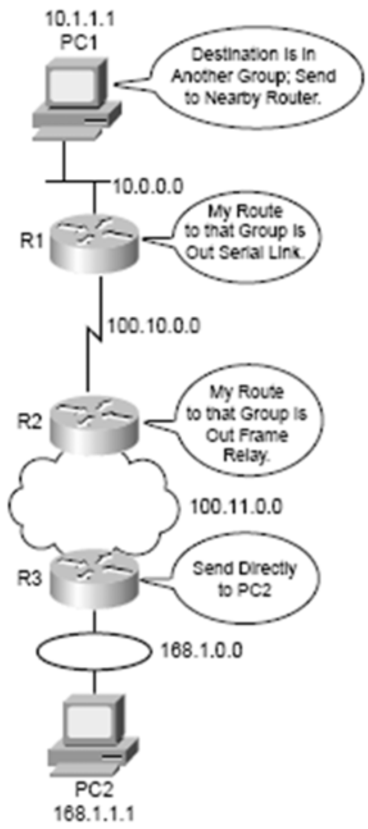
- Connectionless Network Services (CLNS),
- Internet Protocol (IP),
- Novell Internetwork Packet Exchange (IPX),
- or AppleTalk Dynamic Data Routing (DDR)

network layer protocols have many similarities.

Introduction (2)

Routing (Path Selection)

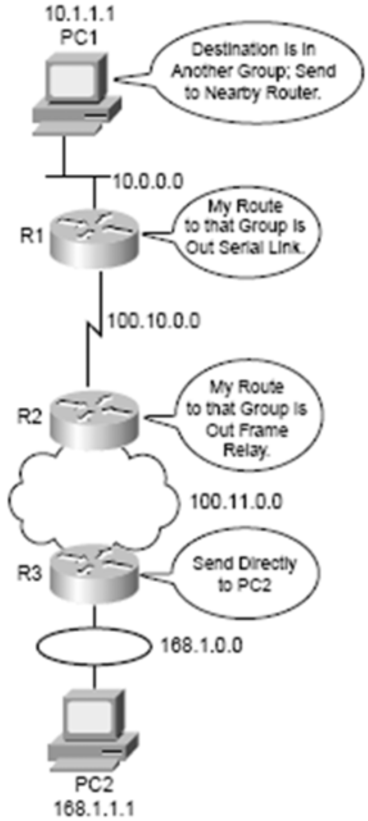
- Routing focuses on the end-to-end logic of forwarding data.
- Figure shows a simple example of how routing works. The logic seen in the figure is relatively simple.
- For PC1 to send data to PC2, it must send something to R1, when sends it to R2, then on to R3, and finally to PC2.



Introduction (3)

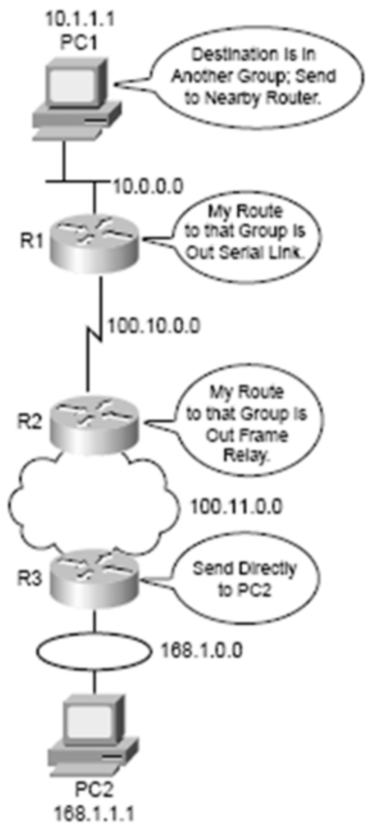
PC1’s Logic: Sending Data to a Nearby Router

- In this example, PC1 has some data to send data to PC2.
- Because PC2 is not on the same Ethernet as PC1, PC1 needs to send the packet to a router that is attached to the same Ethernet as PC1.
- The sender sends a data-link frame across the medium to the nearby router; this frame includes the packet in the data portion of the frame.



Introduction (4)

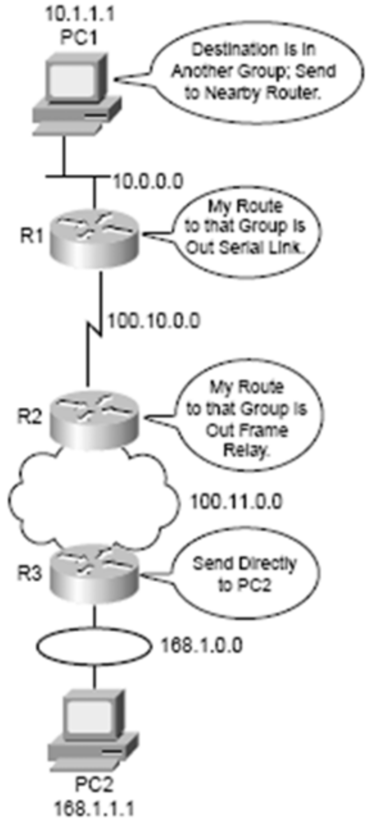
- That frame uses data link layer (Layer 2) addressing in the data-link header to ensure that the nearby router receives the frame.
- The main point here is that the originator of the data does not know much about the network—just how to get the data to some nearby router.
- PC1 needs to know only how to get the packet to R1.



Introduction (5)

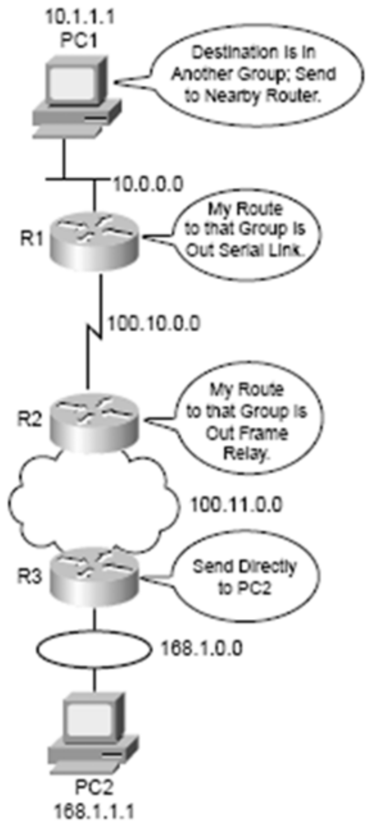
R1 and R2's Logic: Routing Data Across the Network

- R1 and R2 both use the same general process to route the packet
- The *routing table contains* one entry per group of addresses
- The router compares the destination network layer address in the packet to the entries in the routing table
- The matching entry in the routing table tells this router where to forward the packet next.



Introduction (6)

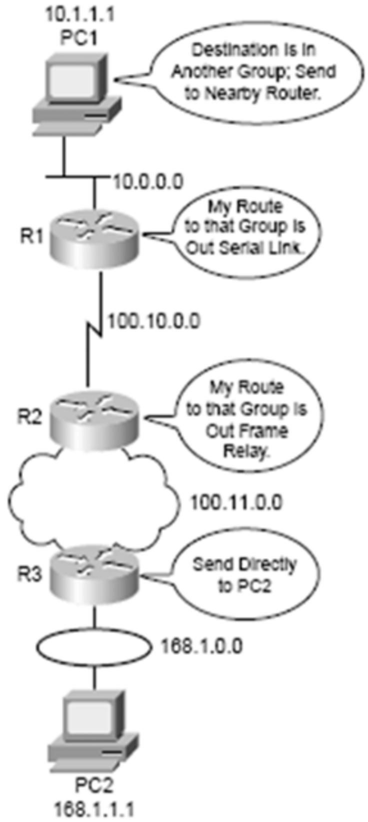
- Likewise, in Figure everyone in this the network whose IP address starts with 168.1 is on the Token Ring on which PC2 resides,
- So the routers can just have one routing table entry that means "all addresses that start with 168.1."
- Eventually, the packet is delivered to the router connected to the network or subnet of the destination host (R3),



Introduction (7)

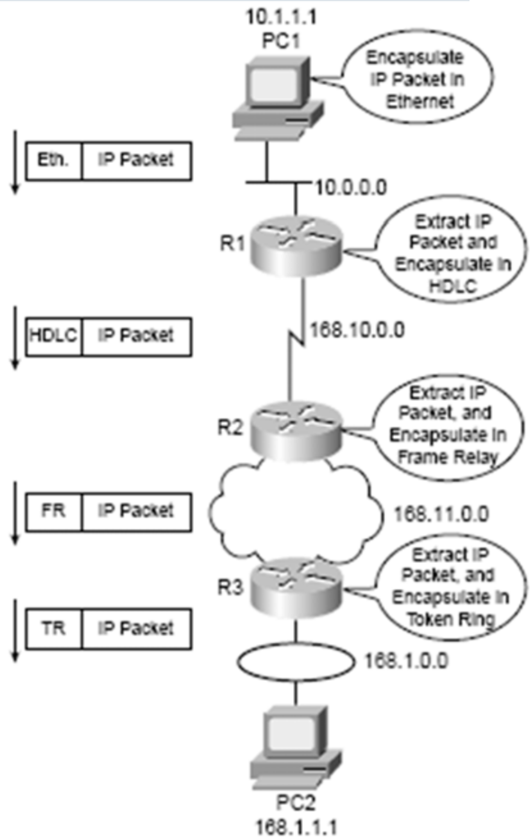
R3's Logic: Delivering Data to the End Destination

- R3 needs to forward the packet directly to PC2, not to some other router.



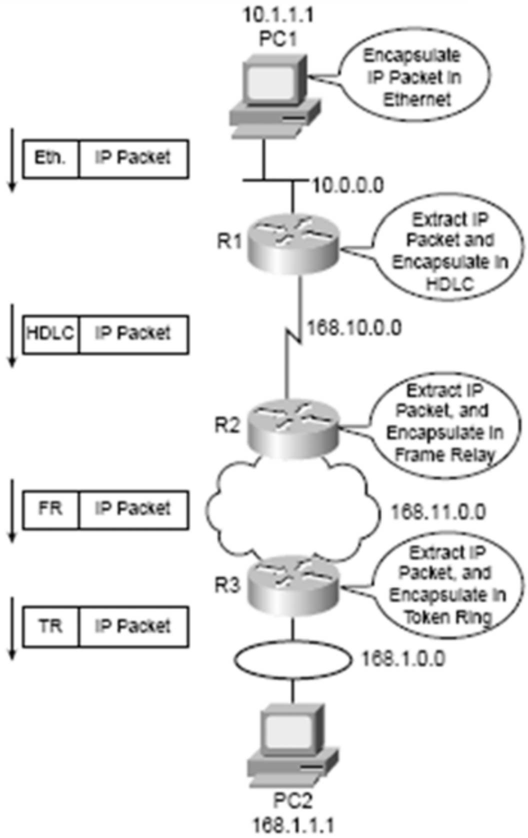
Network Layer Interaction with the Data Link Layer

- four different types of data links were used to deliver the data
- When the network layer protocol is processing the packet, it decides to send the packet out the appropriate data link layer.
- the data link layer adds the appropriate header and trailer to the packet, creating a frame, before sending the frames over each physical network.



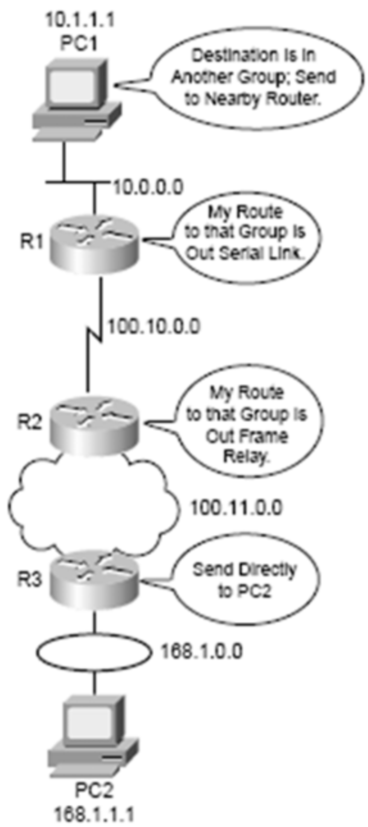
Network Layer Interaction with the Data Link Layer (2)

- The network layer processes deliver the packet end-to-end, using successive data-link headers and trailers just to get the packet to the next router or host in the path.
- the PCs and routers must have some way to decide what data-link addresses to use
- Address Resolution Protocol (ARP) is *used to dynamically learn the data-link address of an IP host connected to a LAN.*



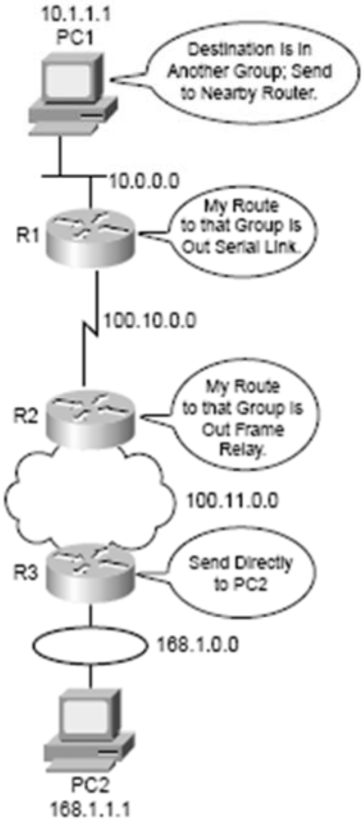
Network Layer (Layer 3) Addressing

- One key feature of network layer addresses is that they were designed to allow logical grouping of addresses (routing process)
- In TCP/IP, this group is called a *network or a subnet.*
- *In IPX, it is called a network.*
- *In* AppleTalk, the grouping is called a *cable range.*
- Just like postal street addresses, network layer addresses are grouped based on physical location in a network



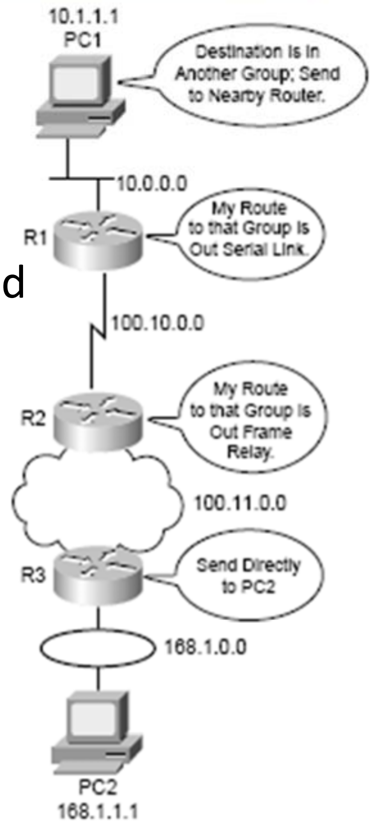
Network Layer (Layer 3) Addressing (2)

- In each of these network layer protocols, all devices on opposite sides of a router must be in a different Layer 3 group.
- The routing tables for each network layer protocol can have one entry for the group,
- Imagine an Ethernet with 100 TCP/IP hosts. A router needing to forward packets to any of those hosts needs only one entry in its IP routing table.
- This basic fact is one of the key reasons that routers can scale to allow tens and hundreds of thousands of devices



Network Layer (Layer 3) Addressing (3)

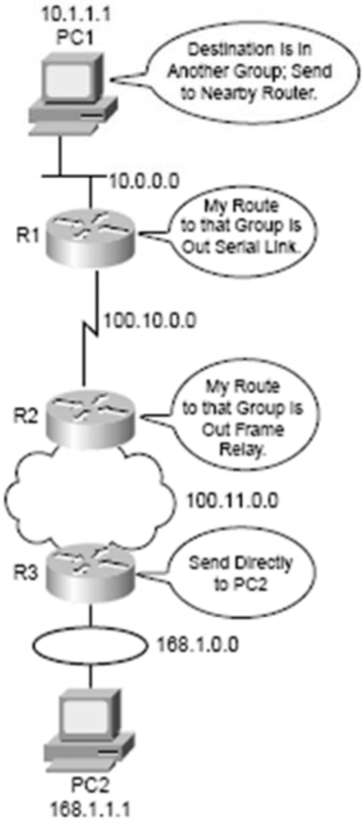
- The same logic of people in the same ZIP code live near to each other.
- If that local town wants to add streets, the rest of the post offices in the country already are prepared because they just forward letters based on the ZIP code, which they already know.
- The only postal employees who care about the new streets are the people in the local post office.
- Also, you can have duplicate local street addresses, as long as they are in different ZIP codes, and it all still works.



Network Layer (Layer 3) Addressing (4)

Example Layer 3 Address Structures

- Each Layer 3 address structure contains at least two parts. One (or more) part at the beginning of the address works like the ZIP code and essentially identifies the grouping.
- All addresses with the same value in the first part are in the same group—for example, the same IP subnet or IPX network or AppleTalk cable range.
- The last part of the address acts as a local address, uniquely identifying that device in that particular group



Network Layer (Layer 3) Addressing (5)

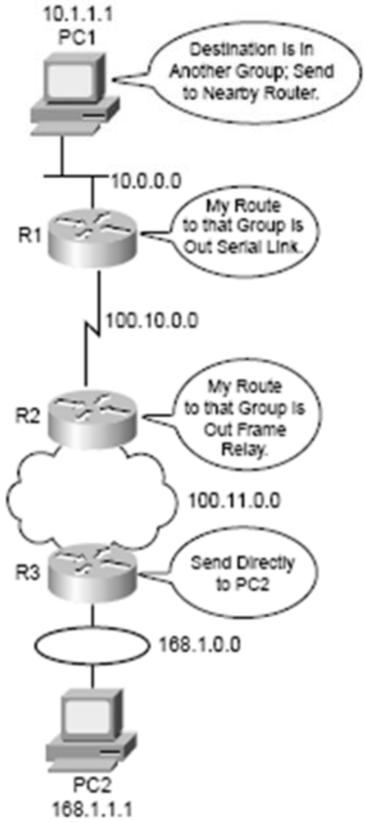
Layer 3 Address Structures

Protocol	Size of Address in Bits	Name and Size of Grouping Field in Bits	Name and Size of Local Address Field in Bits
IP	32	Network or subnet (variable, between 8 and 30 bits)	Host (variable, between 2 and 24 bits)
IPX	80	Network (32)	Node (48)
AppleTalk	24	Network* (16)	Node (8)
OSI	Variable	Many formats, many sizes	Domain-specific part (DSP—typically 56, including NSAP)

Network Layer (Layer 3) Addressing (6)

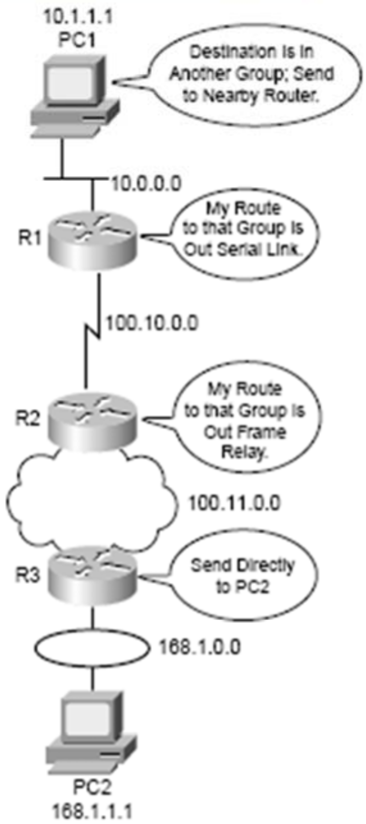
Routing Protocols

- In most cases, routing table entries are built dynamically by use of a routing protocol.
- Routing protocols learn about all the locations of the network layer “groups” in a network.
- Routing protocols define message formats and procedures to build the routing table.
- The end goal of each routing protocol is to fill the routing table with all known destination groups and with the best route to reach each group.



Network Layer (Layer 3) Addressing (7)

- routers uses the Routing Information Protocol (RIP) to learn the routes
- IP protocol called routed protocol, which is responsible of packet forwarded, or routed, through a network.



Network Layer (Layer 3) Addressing (8)

IP Addressing Definitions

- If a device wants to communicate using TCP/IP, it needs an IP address.
- Any device that can send and receive IP packets is called an *IP host.*
- IP addresses consist of a 32-bit number, usually written in *dotted-decimal notation*
- For instance, 168.1.1.1 is an IP address written in dotted-decimal form
- Each of the decimal numbers in an IP address is called an *octet* which is a *byte.*
- The range of decimal numbers in each octet is between 0 and 255, inclusive.

Network Layer (Layer 3) Addressing (9)

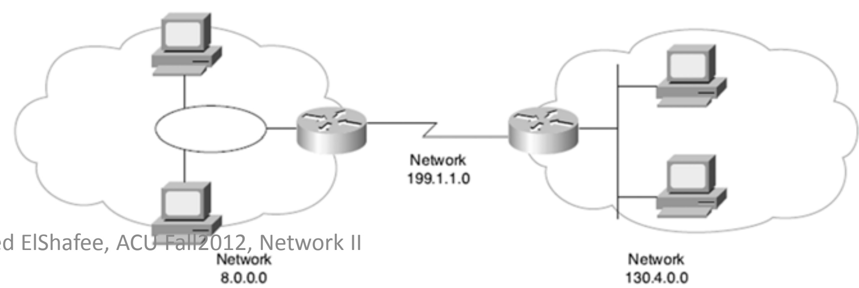
- computer's network card has an IP address. If you put two Ethernet cards in a PC to forward IP packets through both cards, they both would need unique IP addresses.
- Similarly, routers, which typically have many network interfaces that forward IP packets, have an IP address for each interface.

Network Layer (Layer 3) Addressing (10)

How IP Addresses Are Grouped Together

- For example, all IP addresses that begin with 8 are on the Token Ring on the left.
- Likewise, all IP addresses that begin with 130.4 are on the right.
- Along the same lines, 199.1.1 is the prefix on the serial link.
- By following this convention, the routers build a routing table with three entries, one for each prefix, or network number.

Sample Network Using Class A, B, and C Network Numbers

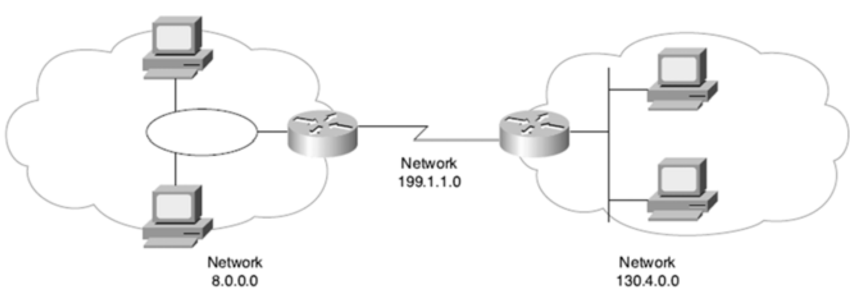


Network Layer (Layer 3) Addressing (11)

So, the general ideas about how IP address groupings can be summarized are as follows:

- All IP addresses in the same group must not be separated by a router.
- IP addresses separated by a router must be in different groups.

Sample Network Using Class A, B, and C Network Numbers

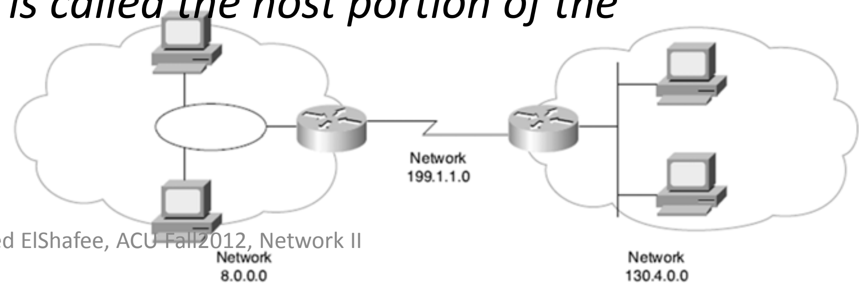


Network Layer (Layer 3) Addressing (12)

Classes of Networks

- IP defines three different network classes, called A, B, and C, from which individual hosts are assigned IP addresses.
- TCP/IP defines Class D (multicast) addresses and Class E (experimental) addresses as well.
- By definition, all addresses in the same Class A, B, or C network have the same numeric value *network portion of the addresses.*
- *The rest of the address is called the host portion of the* address.

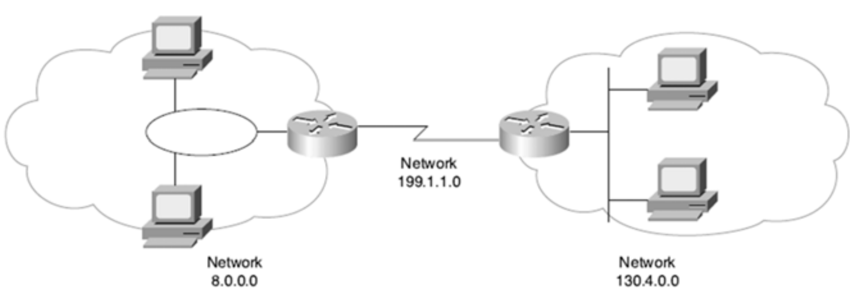
Sample Network Using Class A, B, and C Network Numbers



Network Layer (Layer 3) Addressing (13)

- Class A networks have a 1-byte-long network part. That leaves 3 bytes for the rest of the address, called the host part.
- Class B networks have a 2-byte-long network part, leaving 2 bytes for the host portion of the address.
- Class C networks have a 3-byte-long network part, leaving only 1 byte for the host part.

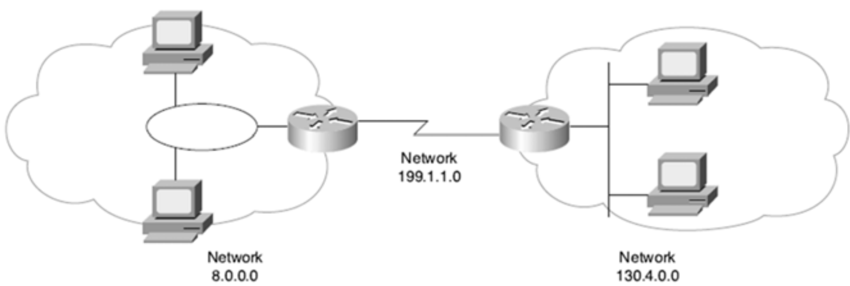
Sample Network Using Class A, B, and C Network Numbers



Network Layer (Layer 3) Addressing (14)

- network 8.0.0.0 next to the Token Ring. Network 8.0.0.0 is a Class A network, which means that only 1 byte is used for the network part of the address.
- Class B network 130.4.0.0 is listed next to the Ethernet; because it is Class B, 2 bytes define the network part, and all addresses begin with those same two bytes.
- So, Class A network “8” is written 8.0.0.0, Class B network 130.4 is written 130.4.0.0, and so on.

Sample Network Using Class A, B, and C Network Numbers



Network Layer (Layer 3) Addressing (15)

Sizes of Network and Host Parts of IP Addresses with No Subnetting

Any Network of This Class	Number of Network Bytes (Bits)	Number of Host Bytes (Bits)	Number of Addresses per Network*
A	1 (8)	3 (24)	$2^{24} - 2$
B	2 (16)	2 (16)	$2^{16} - 2$
C	3 (24)	1 (8)	$2^{8} - 2$

- Two numbers inside each Class A, B, or C network are reserved, one of the two reserved values is the network number itself

Example Network Numbers, Decimal and Binary

Network Number	Binary Representation, with Host Part Bold
8.0.0.0	00001000 00000000 00000000 00000000
130.4.0.0	10000010 00000100 00000000 00000000
199.1.1.0	11000111 00000001 00000001 00000000

Network Layer (Layer 3) Addressing (16)

- The other reserved value is the one with all binary 1s in the
- host part of the address—this number is called the *network broadcast or directed broadcast* address.
- network number is the lowest numerical value inside that network and the broadcast address is the largest, all the numbers between the network number and the broadcast address are the valid,

Network Layer (Layer 3) Addressing (17)

The Actual Class A, B, and C Network Numbers

*List of All Possible Valid Network Numbers**

Class	First Octet Range	Valid Network Numbers	Total Number of This Class of Network	Number of Hosts per Network
A	1 to 126	1.0.0.0 to 126.0.0.0	$2^7 - 2$	$2^{24} - 2$
B	128 to 191	128.1.0.0 to 191.254.0.0	$2^{14} - 2$	$2^{16} - 2$
C	192 to 223	192.0.1.0 to 223.255.254.0	$2^{21} - 2$	$2^8 - 2$

Network Layer (Layer 3) Addressing (18)

- The Valid Network Numbers column shows actual network numbers.
- There are several reserved cases. For example, networks 0.0.0.0 (originally defined for use as a broadcast address) and 127.0.0.0 (still available for use as the loopback address) are reserved.
- Networks 128.0.0.0, 191.255.0.0, 192.0.0.0, and 223.255.255.0 also are reserved.

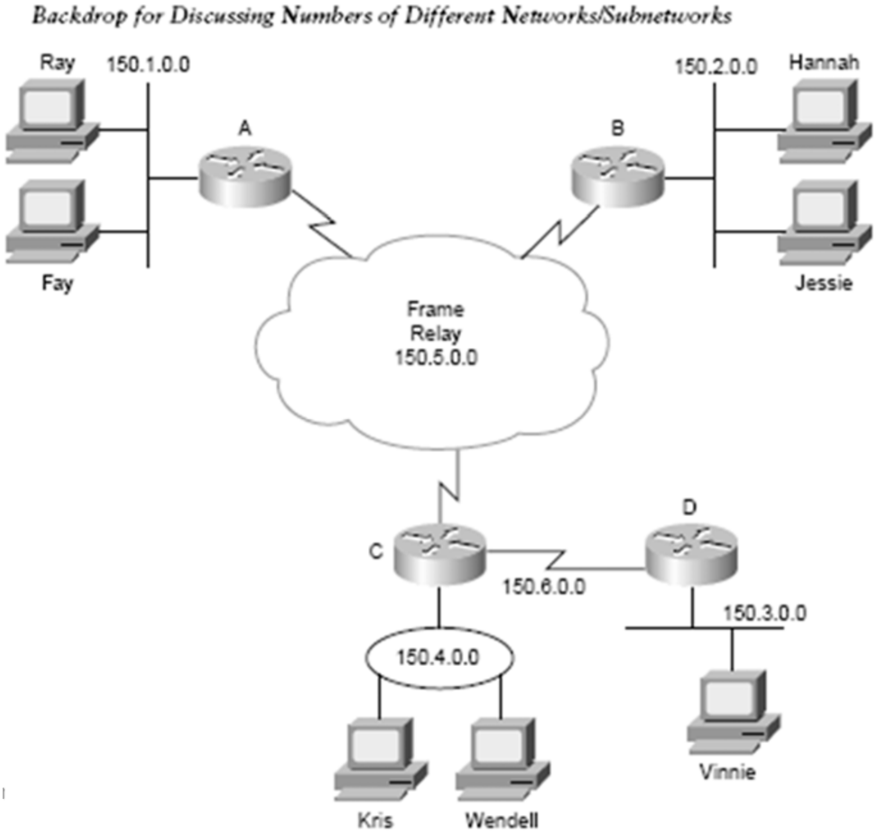
Network Layer (Layer 3) Addressing (19)

IP Subnetting

- IP subnetting creates vastly larger numbers of smaller groups of IP addresses, compared with simply using Class A, B, and C conventions.
- The Class A, B, and C rules still exist—but now, a single Class A, B, or C network can be subdivided into many smaller groups.
- By doing so, a single Class A, B, or C network can be subdivided into many non-overlapping subnets.

Network Layer (Layer 3) Addressing (20)

- The design in Figure requires six groups, each of which is a Class B network in this example.
- The four LANs each use a single Class B network.



Network Layer (Layer 3) Addressing (21)

- In other words, each of the LANs attached to routers A, B, C, and D is in a separate network.
- Additionally, the two serial interfaces composing the point-to-point serial link between routers C and D use the same network because these two interfaces are not separated by a router.
- Finally, the three router interfaces composing the Frame Relay network with routers A, B, and C are not separated by an IP router and would compose the sixth network.
- Each Class B network has $2^{16} – 2$ hosts addresses in it—far more than you will ever need for each LAN and WAN link.

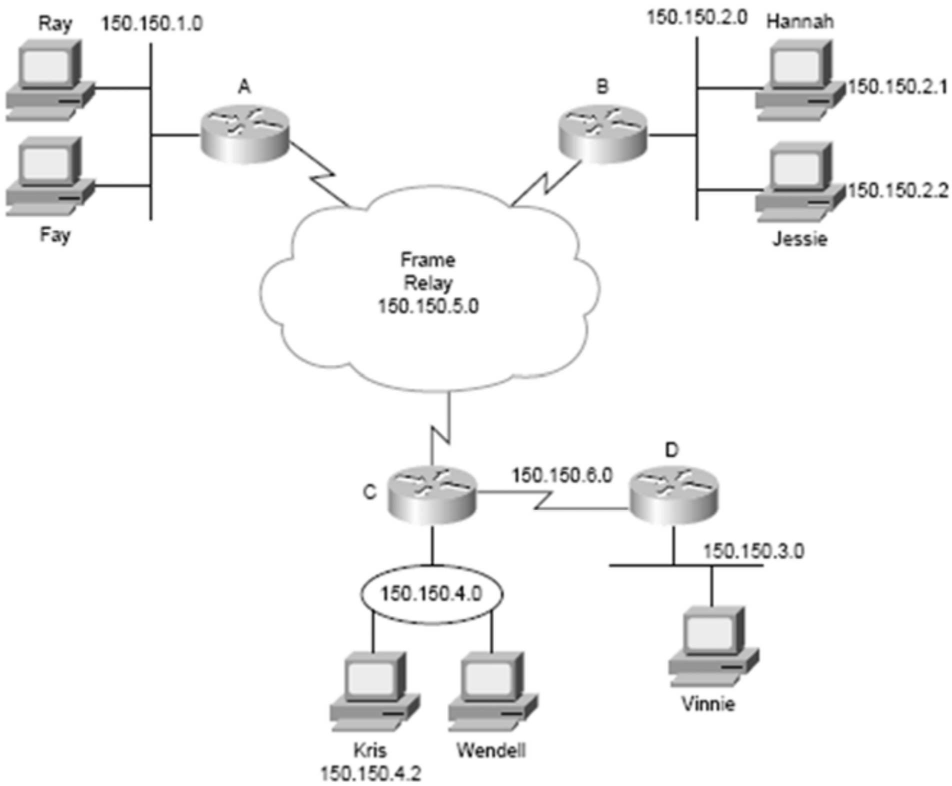
Network Layer (Layer 3) Addressing (22)

- If you connected to the internet, you probably would not even get one Class B network because most of the Class B addresses already are assigned.
- You more likely would get a couple of Class C networks, and the NIC would expect you to use subnetting.

Network Layer (Layer 3) Addressing (23)

- the design requires six groups
- uses six subnets, each of which is a subnet of a single Class B network

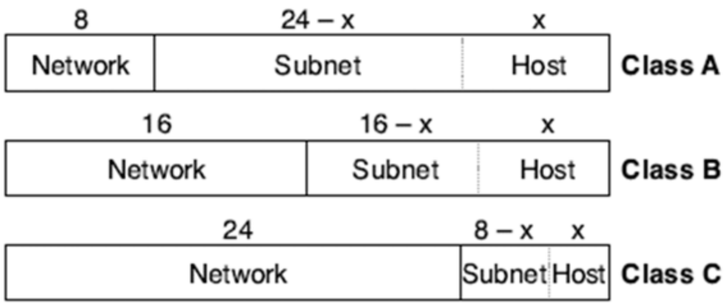
illustrates a more realistic example that uses basic subnettin



Network Layer (Layer 3) Addressing (24)

- This design subnets Class B network 150.150.0.0, which has been assigned by the NIC.
- To perform subnetting the third octet (in this example) is used to identify unique subnets of network 150.150.0.0.
- When subnetting, a third part of an IP address appears between the network and host parts of the address—namely, the subnet part of the address.

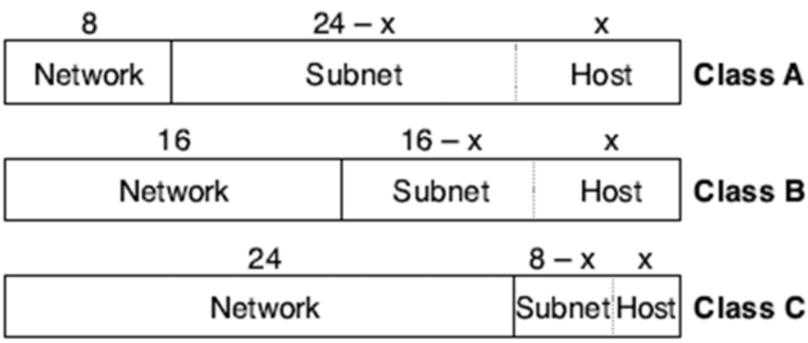
Address Formats When Subnetting Is Used



Network Layer (Layer 3) Addressing (25)

- This field is created by "stealing" or "borrowing" bits from the host part of the address.
- The size of the network part of the address never shrinks—in other words, Class A, B, and C rules still apply when defining the size of the network part of an address. The host part of the address shrinks to make room for the subnet part of the address.

Address Formats When Subnetting Is Used



Network Layer (Layer 3) Addressing (26)

- Now, instead of routing based on the network part of an address, routers can route based on the combined network and subnet parts. In fact, most people do not even bother
- distinguishing between the network part and the subnet part—they just call both fields together the subnet part of an address.
- Finally, IP addressing with subnetting uses a concept called a *subnet mask.*

Thanks,..

See you next week, isA,…