

Guide to Networking Essentials, 6th Edition

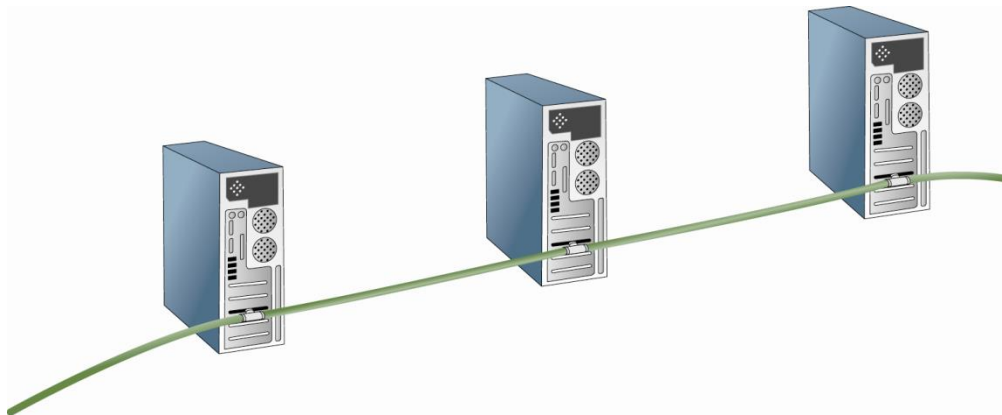
Chapter 2: Network Hardware Essentials

Objectives

- Describe the basic operation of network repeaters and hubs
- Explain the purpose of network switches
- Summarize the operation of wireless access points
- Describe the basic operation of network interface cards
- Explain the function of routers

Network Repeaters and Hubs

- Early networks didn't use interconnecting devices

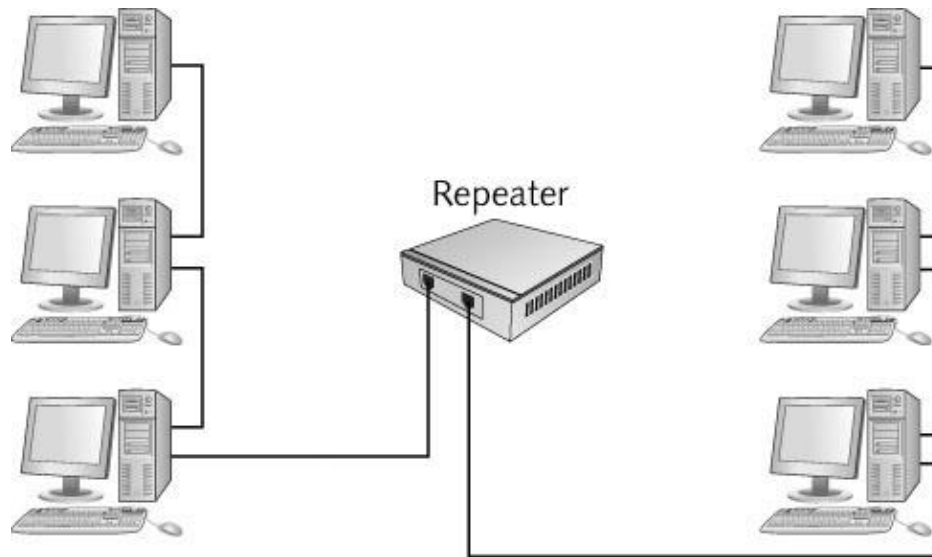


- Severely limited the total cable length and number of computers

Network Repeaters and Hubs

- Some problems were resolved with a device called a repeater
 - A repeater receives bit signals generated by NICs and other devices, strengthens them, and then “repeats” them to other parts of the network
- A repeater enables you to connect computers whose distance from one another would make communication impossible
- A traditional repeater has two ports or connections that you can use to extend your network

Network Repeaters and Hubs

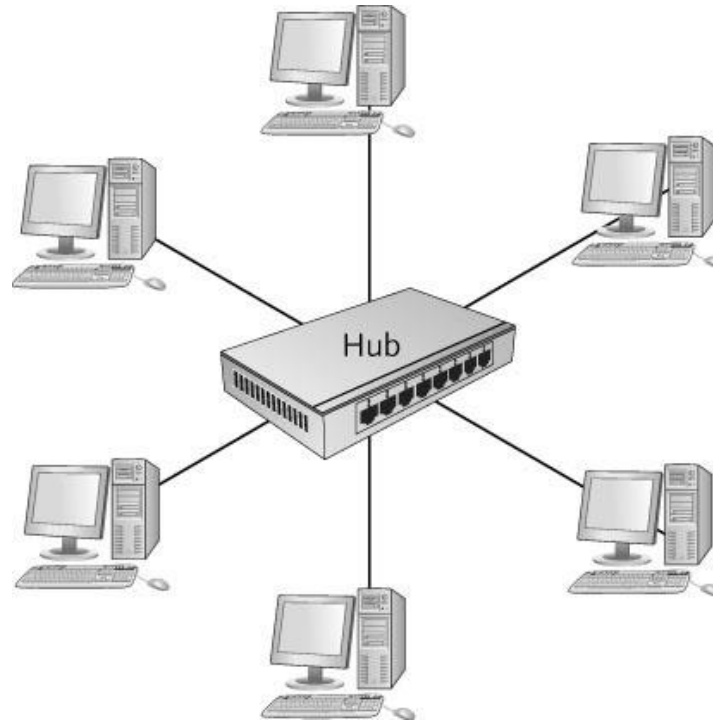


A repeater extends the length of a network

Multiport Repeaters and Hubs

- A multiport repeater is just a repeater with several ports to which you can connect cabling
- Also referred to as a **hub**
- Receives bit signals generated from a connected computer on one of its ports
- Cleans the signal by filtering out electrical noise
- Regenerates the signal to full strength
- Transmits the regenerated signal to all other ports a computer (or other network device) is connected to

Multiport Repeaters and Hubs



A multiport repeater or hub

Hubs and Network Bandwidth

- Amount of data that can be transferred in an interval is network bandwidth
 - Network bandwidth is usually measured in bits per second (bps) and networks operate at speeds from 10 million bps up to 10 gigabit per second (Gbps)
- Hubs share bandwidth with all other connected computers
 - Only one computer can successfully transmit data at a time
 - Creates a problem on today's networks due to an increased dependency on file sharing and the Internet
- **Bandwidth sharing** – when all computers connected to the hub must share the amount of bandwidth the hub provides

Hub Indicator Lights

- Power, link status, network activity, collisions
- Uplink port – port used to connect two hubs together or hub to a switch

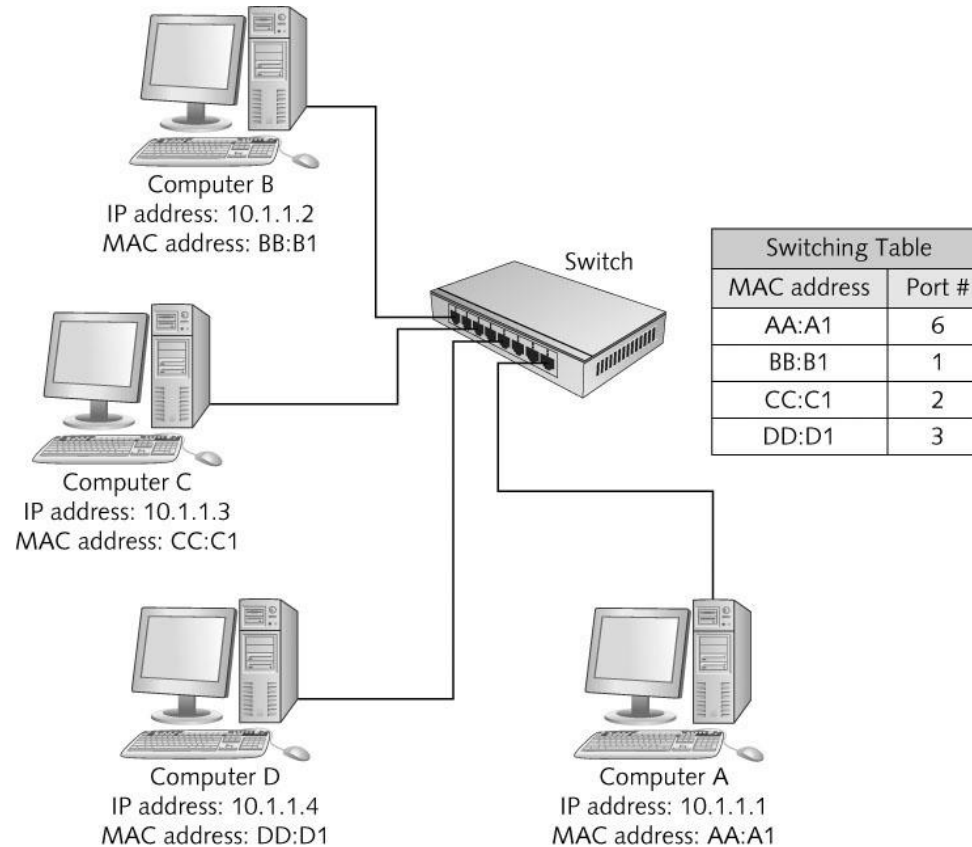


- *Simulation 3: Basic operation of a hub*

Network Switches

- Looks just like a hub
- Instead of simply regenerating incoming bit signals a switch, actually reads data in the message, determines which port the destination device is connected to, and forwards the message to only that port
- Basic Switch Operation
 - Data is sent onto the medium one frame at a time
 - The beginning of each frame has the destination MAC address
 - Switch reads the addresses:
 - Keeps a record of which computer is on which port (**switching table**)
 - Forwards the frame to the port where the destination MAC can be found

Network Switches



Switches maintain a switching table

Network Switches

Steps of switch operation:

1. The switch receives a frame.
 2. The switch reads the source and destination MAC addresses.
 3. The switch looks up the destination MAC address in its switching table.
 4. The switch forwards the frame to the port where the computer owning the MAC address is found.
 5. The switching table is updated with the source MAC address and port information.
- *Simulation 4: Basic operation of a switch*

Switches and Network Bandwidth

- Each port gets **dedicated bandwidth**
 - Instead of having to share bandwidth with all ports
- Many conversations can occur simultaneously
- Can operate in **full-duplex mode**
 - Can send and receive data simultaneously
- Hubs can only operate in **half-duplex mode**
 - Can send or receive (but not both) at one time
- Switches are the preferred device because of these advantages

Switch Indicator Lights

- Like hubs, switches have indicator lights
- Switches have link status indicators and activity indicators
- May also have indicators for whether the switch is operating in full-duplex or half-duplex mode
- Switches can be connected to one another so that your LAN can grow beyond the limitations of ports on a single switch
 - Some switches have a dedicated port for uplinking to another switch

Wireless Access Points

- The heart of a wireless network is the wireless access point (AP)
- APs operate similarly to a hub without wires
- All communication passes through the AP
- Most small business and home networks use a device typically called a wireless router that combines the functions of an AP, a switch, and a router
- Wireless LANs usually attached to wired networks

Wireless Access Points



A wireless router

Basic AP Operation

- Similar to a wired hub
- All stations hear all data being transmitted
- Extra step is required: receiving device sends an acknowledgment back to the sending device to indicate successful reception
- Some configurations require additional handshaking:
 - sending station must send a request to send (RTS) message and receive a clear to send (CTS) message before transmitting
 - The RTS/CTS “handshake” lets all other stations know that another station is about to transmit

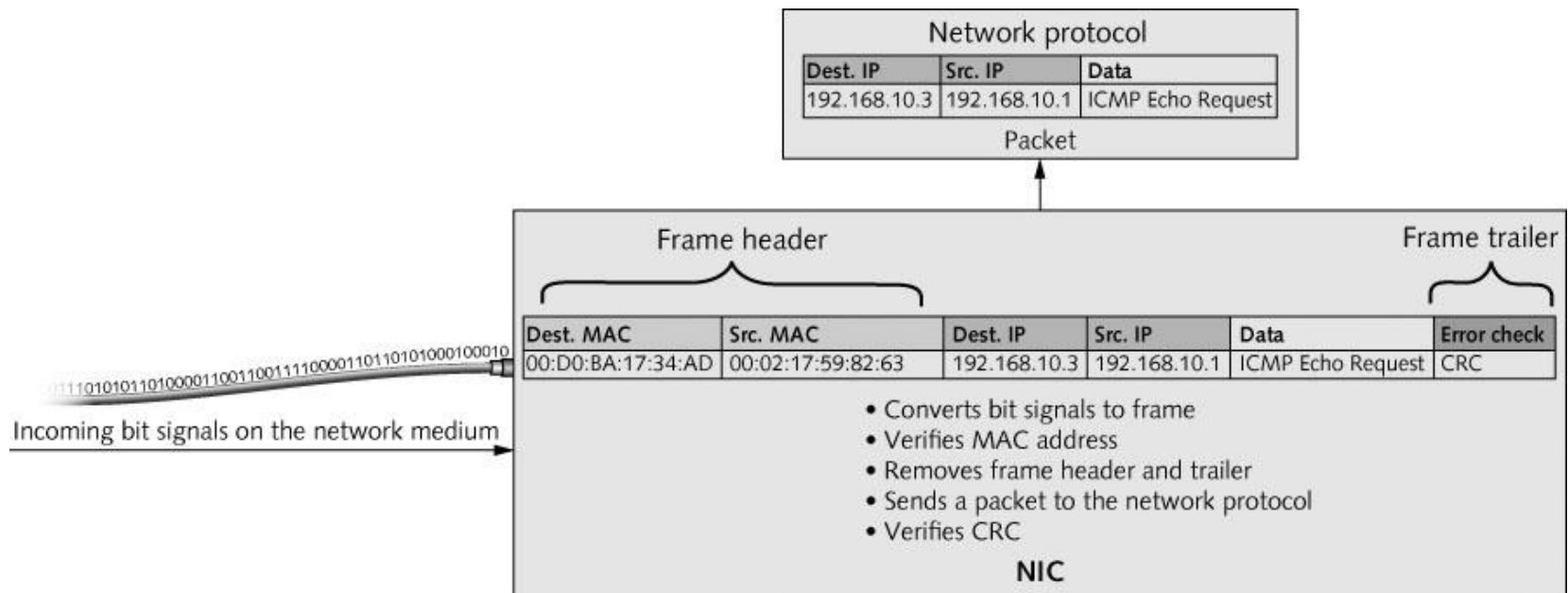
Wireless APs and Network Bandwidth

- All the extra chatter required to send data in a wireless network slows communication
- The effective bandwidth is about half of effective bandwidth found on physical networks
- Most APs operate from 11Mbps to several hundred Mbps

Network Interface Cards

- Provide a connection from computer to medium
- Incoming messages: Receives bit signals and assembles them into frames
 - Verifies the destination address
 - Removes frame header and sends the resulting packet to the network protocol
- Outgoing messages: receive packets from network protocol
 - Creates frames by adding MAC addresses and error check
 - Converts frame into bit signals suitable for the medium and transmits them

Network Interface Cards

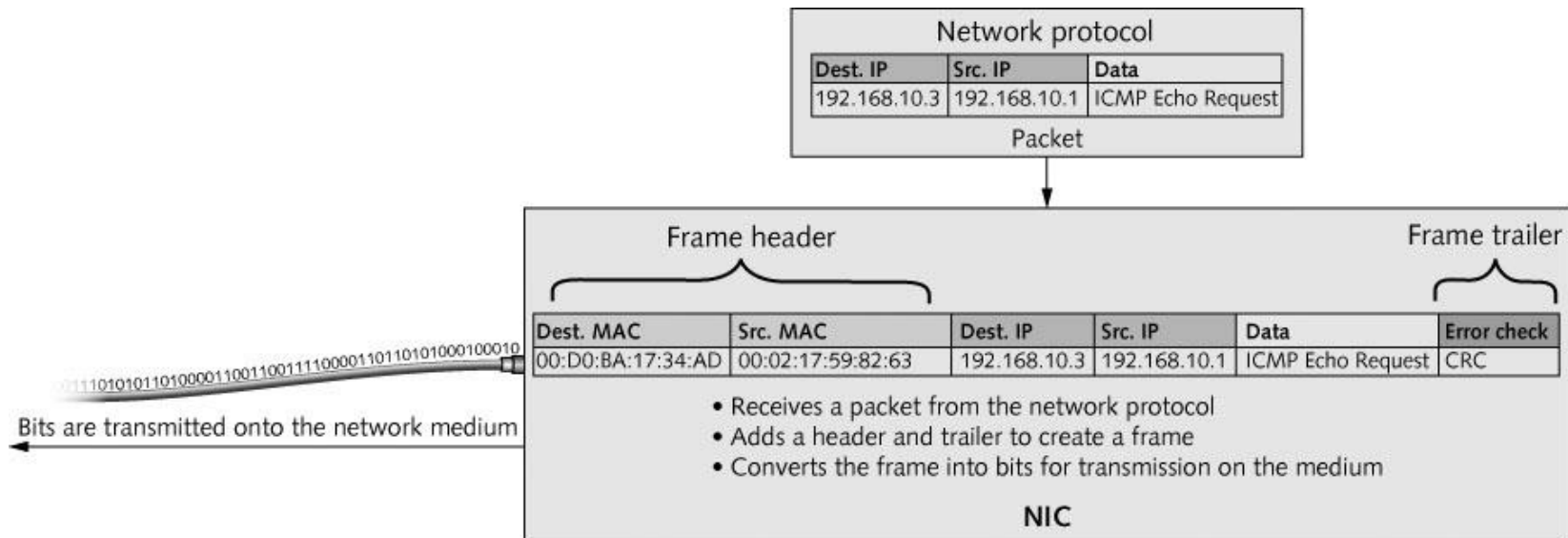


A NIC handles incoming data from the network medium

Network Interface Cards

- Attaching a computer to a network requires a network interface card (NIC) to create and mediate the connection between a computer and the networking medium
 - Networking medium might be copper wire, fiber-optic cable, or airwaves
- Most NICs are built into a computer's motherboard
 - Occasionally fail or additional NICs are needed for an application
 - It is important to know how to install a new NIC

Network Interface Cards



A NIC handles outgoing data to be sent to the network medium

NICs and MAC addresses

- NIC manufacturers ensure that every NIC they produce has a unique address because networks won't function correctly if duplicate MAC addresses exist
- MAC address is stored in read-only memory (ROM) on the NIC
- Also called the burned-in address (BIA)
- Two 24-bit hexadecimal numbers
 - 24-bit manufacturer ID called OUI
 - 24-bit serial number assigned by the manufacturer
- 48-bit address expressed in 12 hexadecimal digits:
04-40-31-5B-1A-C4

The NIC as a Gatekeeper

- When a frame arrives at a NIC, the NIC checks the frame's destination MAC address to see whether it matches its built-in MAC address
- NIC only permits inbound communications if the destination MAC:
 - Matches the NIC's burned-in address
 - Is a **broadcast address** (ff-ff-ff-ff-ff-ff)
 - NIC is in a special mode called promiscuous
- When the destination MAC address matches the BIA of a NIC, it's a **unicast frame**

The NIC as a Gatekeeper

- When the destination is the broadcast address, it's a **broadcast frame**
 - Broadcast frames are intended to be processed by all computers on the network
- **Promiscuous mode** – turns off the gatekeeper functions and enables the NIC to process all frames it sees
- *Simulation 5: How a NIC works*

NIC Indicator Lights

- NICs have indicator lights to show status information
 - Usually a link status indicator and an activity indicator
- The link light is usually green when the NIC has a valid connection to the network medium
- Some NICs support multiple speeds
 - There is usually a separate light for each speed so that you can determine at what speed the NIC is connected to the hub or switch
 - In other cases the light is a different color for each speed, such as amber for 100 Mbps and green for 1000 Mbps

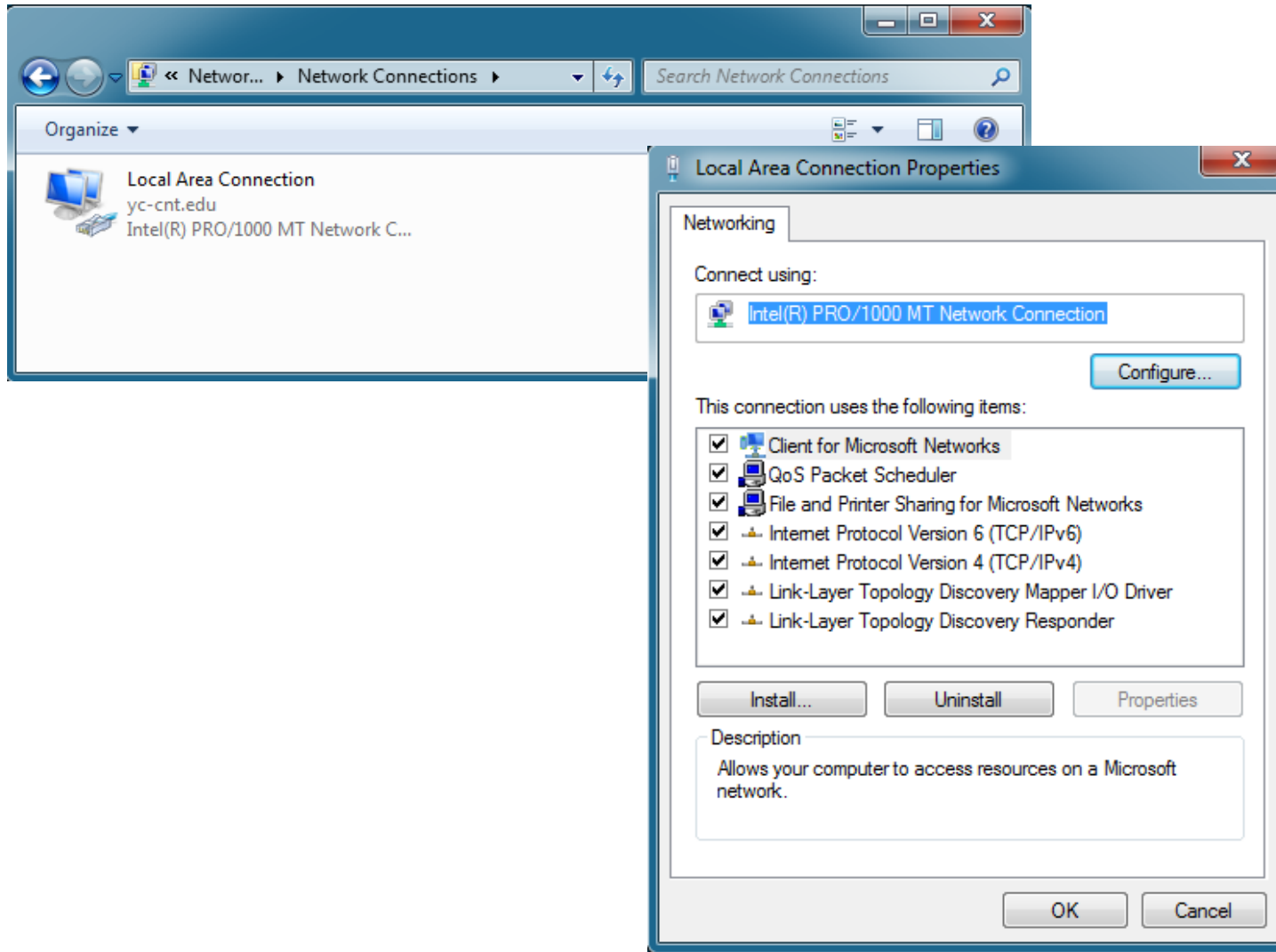
Selecting a NIC

- Average user may never have to install a NIC because they are often built into motherboard
- However, an additional NIC or a faster NIC may need to be installed
- When selecting a NIC you need to select correct bus interface
 - The connection the NIC makes to the motherboard is the bus connection
 - Peripheral Component Interconnect (PCI) are most common
- The NIC driver (software) must be available for your OS
- Desktop NICs versus server NICs
 - For desktops, a standard NIC is good enough
 - For servers, consider a NIC with onboard memory and multiple ports and performs faster

NIC Drivers

- Most OSs ship with drivers for wide range of NICs
- Most NICs include drivers for the most common OSs
 - In most cases you only need to install the NIC and restart your computer
 - If the OS has a suitable driver available, it is installed automatically
- After installation, Windows 7 shows your installed NIC as a Network Connection
- In Windows, each connection is assigned a name as in “Local Area Connection”, “Local Area Connection 2”
 - You can rename these

NIC Drivers

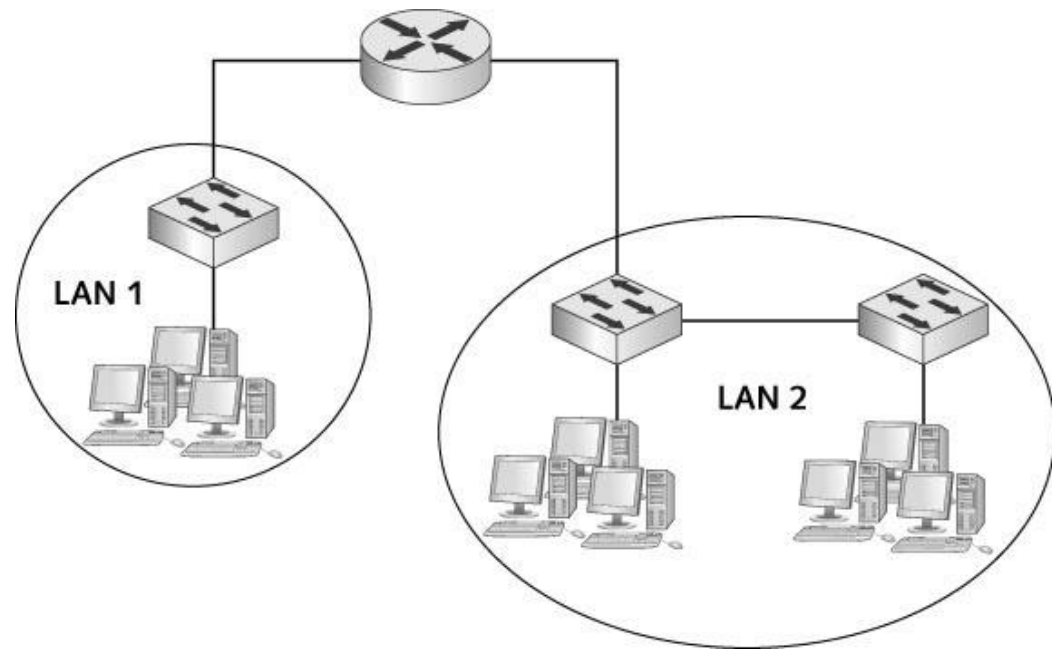


Wireless NICs

- Wireless NICs must be chosen according to type of wireless AP being used
- Typical ones are Wireless-g, Wireless-n or 802.11 b/g
 - The letter g, n, and b refer to the wireless networking standard the device supports
- Wireless NICs connect to network using service set identifier (SSID)
 - SSID is the name assigned to the wireless network
- You may also need to enter a security key or a username and password, depending on the network's security configuration

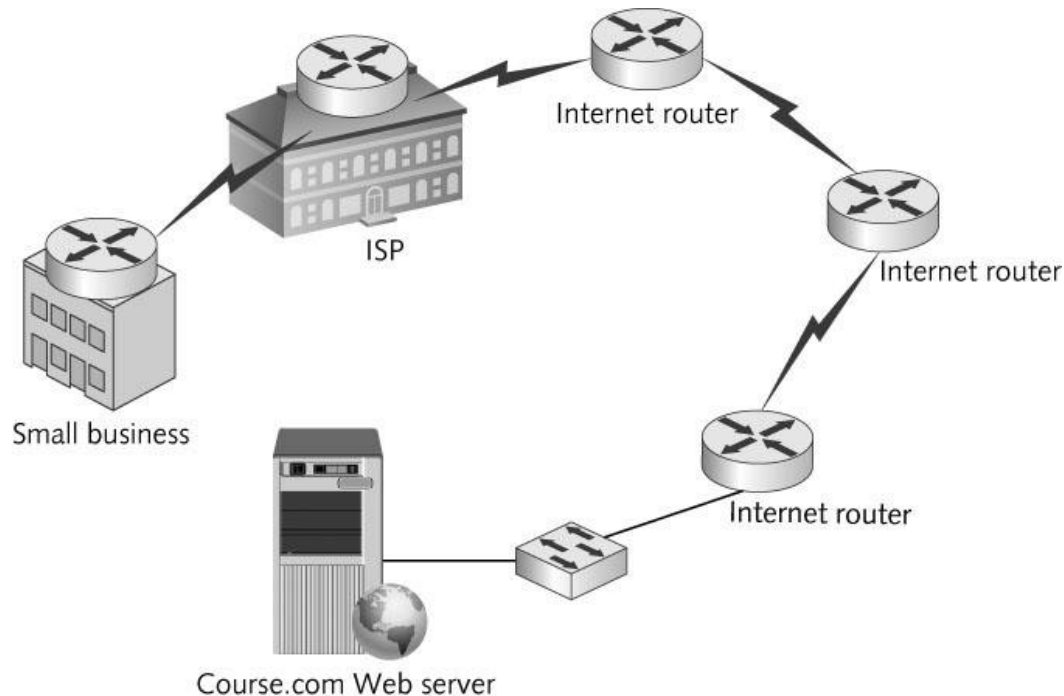
Routers

- Most complex device
- Connect LANs together to create an internetwork



Routers

- **Routers** are devices that enable multiple LANs to communicate with one another by forwarding packets from one LAN to another



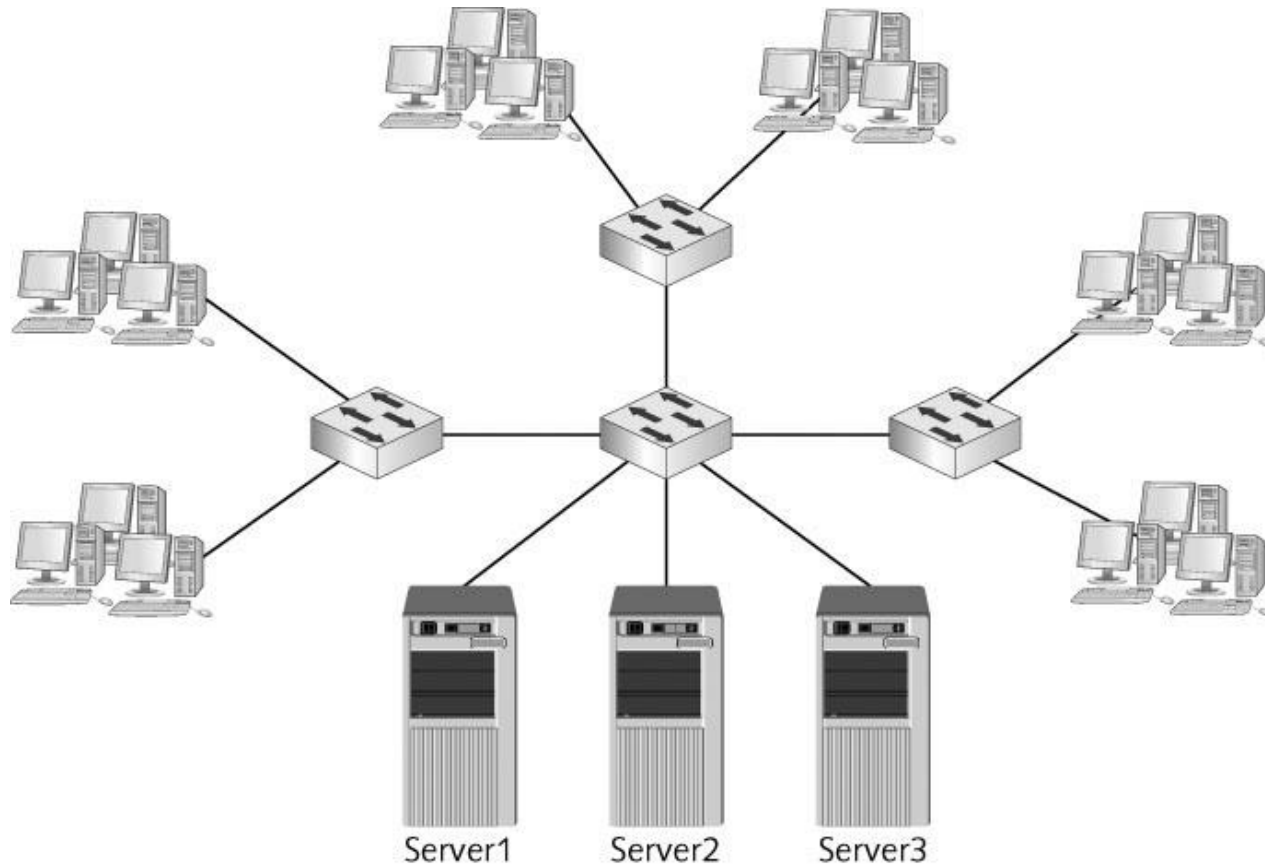
Routers

- The following are the differences between routers and switches
 - Routers connect LANs; switches connect computers
 - Routers work with logical (IP) addresses' switches work with physical (MAC) addresses
 - Routers work with packets; switches with frames
 - Routers don't forward broadcasts; switches do
 - Routers use routing tables; switches use switching tables

Routers Connect LANs

- As computers are added to a LAN, effective communication can suffer
 - Broadcast traffic is forwarded to all members of a LAN and can cause a network to become congested
- The picture on the next slide shows 3 different groups of users and 3 different servers all connected by switches
 - Since they are connected by switches, they are all part of the same LAN and all broadcast traffic will be heard by all devices

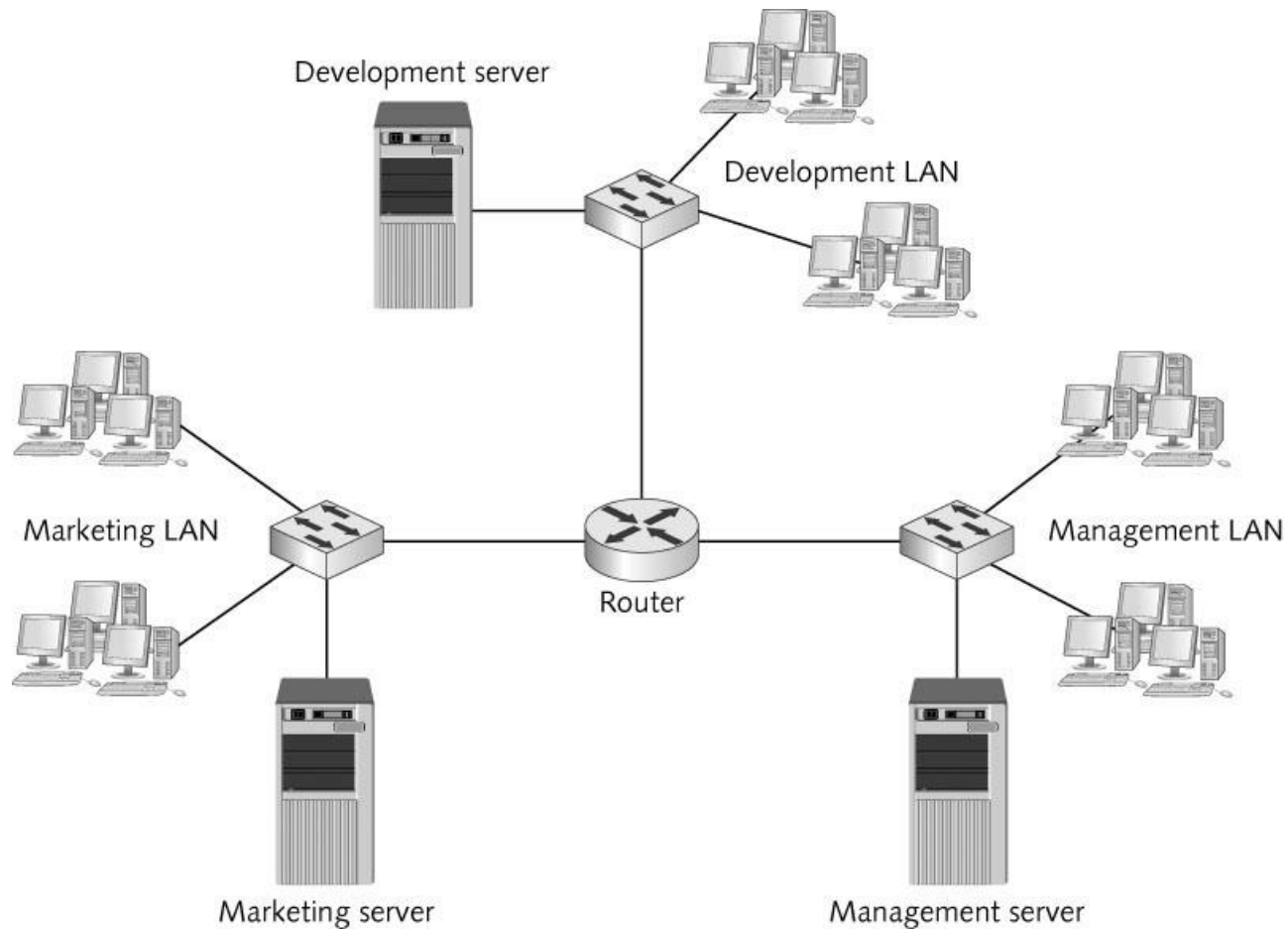
Routers Connect LANs



Routers Connect LANs

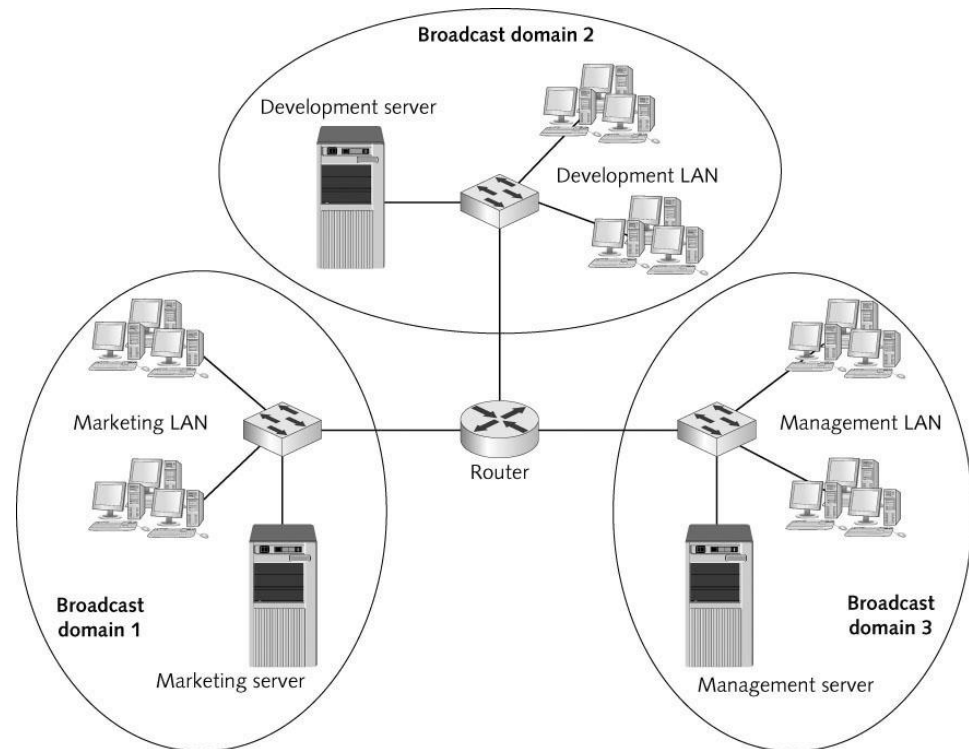
- The picture on the next slide shows a better solution for the previous network
- The administrator groups users and servers together based on their department or function
 - The router is used to create 3 separate LANs in order to contain broadcast traffic and facilitate more effective communication in each department LAN

Routers Connect LANs



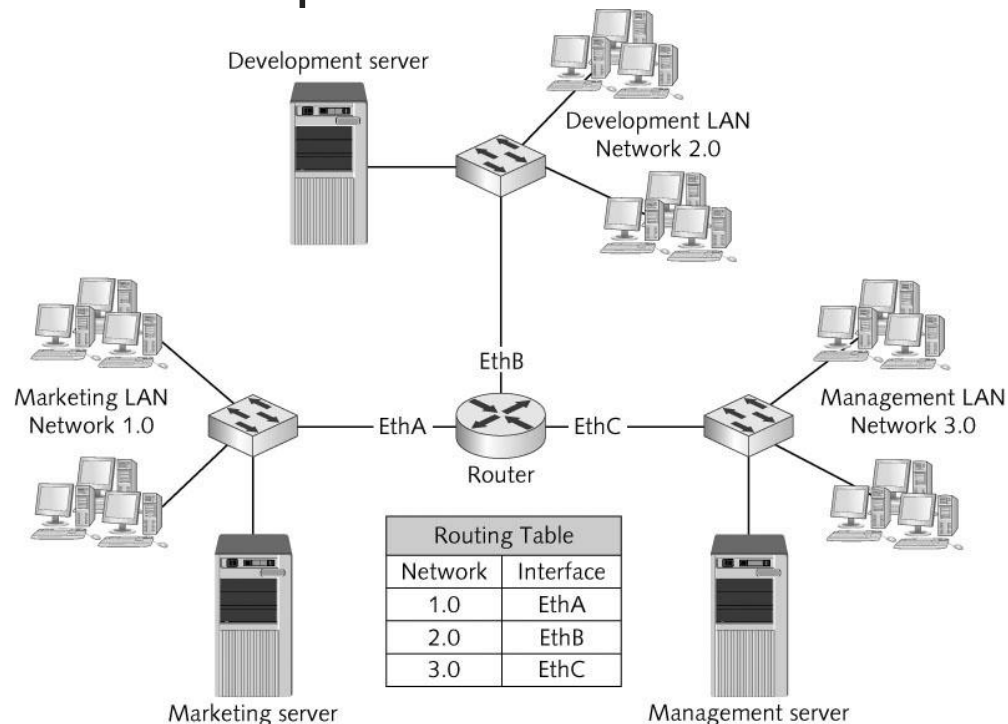
Routers Create Broadcast Domains

- The scope of devices to which broadcast frames are forwarded is called a **broadcast domain**
 - Each router interface in a network creates another broadcast domain



Routers Work with IP Addresses and Routing Tables

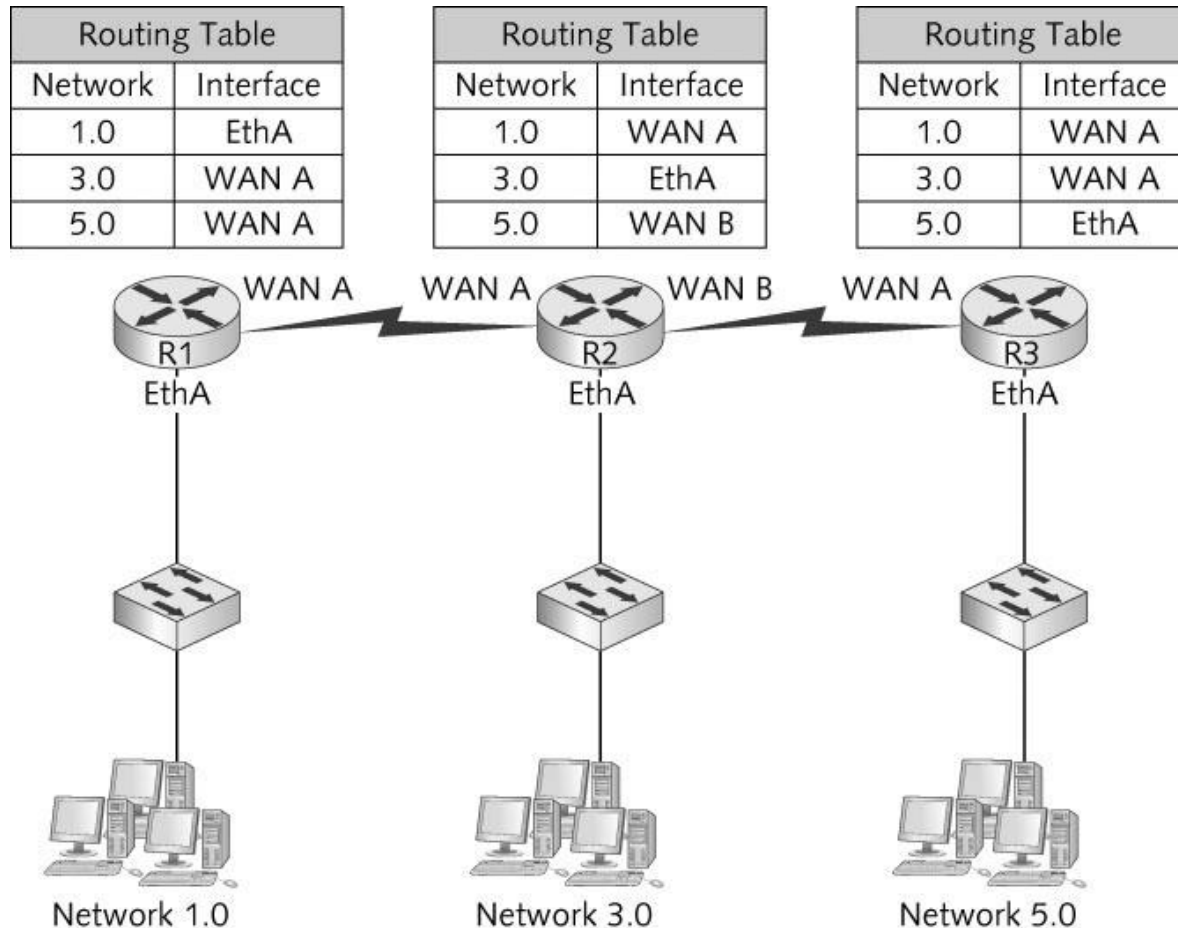
- Routers maintain routing tables composed of IP network addresses and interface pairs to determine where to forward packets on an internetwork



Routers Work with IP Addresses and Routing Tables

- What happens when a router isn't connected to the network the packet is addressed to?
- The picture on the following slide shows what the routing table would look like on each router between the source and destination networks

Routers Work with IP Addresses and Routing Tables



Routers Work with IP Addresses and Routing Tables

- Default route — where to send a packet when the router doesn't have an entry in its routing table
- Network unreachable — Message sent when the network can't be found and there is no default route
- Default gateway — In a computer's IP address configuration – the IP address of the computer's router

- *Simulation 6: Router operation in a simple internetwork*

Chapter Summary

- Network repeaters and hubs take incoming bit signals and repeat those signals at their original strength out all connected ports
- Network switches interconnect multiple computers just as hubs do
- Switches use switching tables to determine which MAC address can be found on which port
- Access points are a central device in a wireless network and perform a similar function to hubs
- Network interface cards create and mediate the connection between the computer and network medium

Chapter Summary

- Wireless NICs perform the same function as wired NICs
- Routers connect LANs to one another and forward packets from one LAN to another according to the destination network specified by the destination IP address in the packet
- Unlike hubs and switches, routers do not forward broadcast frames