Chapter 2
Network Devices

Objectives

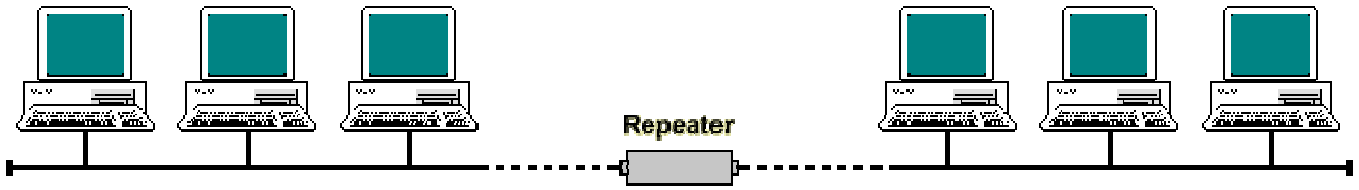
- Explain the uses, advantages, and disadvantages of repeaters, hubs, wireless access points, bridges, switches, and routers
- Define the standards associated with wireless media
- Explain basic wireless connection parameters, security, and troubleshooting
- Define network segmentation

Objectives (continued)

- Explain network segmentation using bridges, switches, routers, brouters, and gateways
- Explain Ethernet operations
- Define Fast Ethernet and Gigabit Ethernet

Repeaters

- The number of **nodes** on a network and the length of cable used
  - Influence the quality of communication on the network
- **Attenuation**
  - The degradation of signal clarity
- **Repeaters**
  - Work against attenuation by repeating signals that they receive on a network
    - Typically cleaning and regenerating the digital transmission in the process



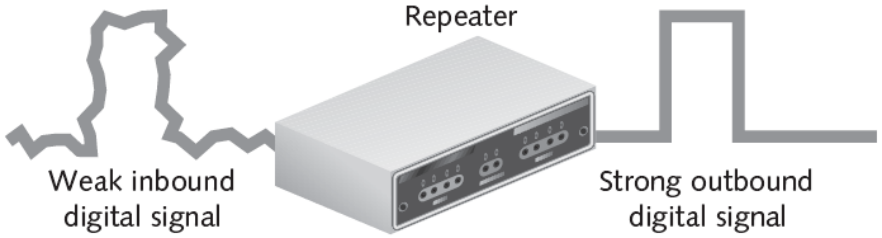
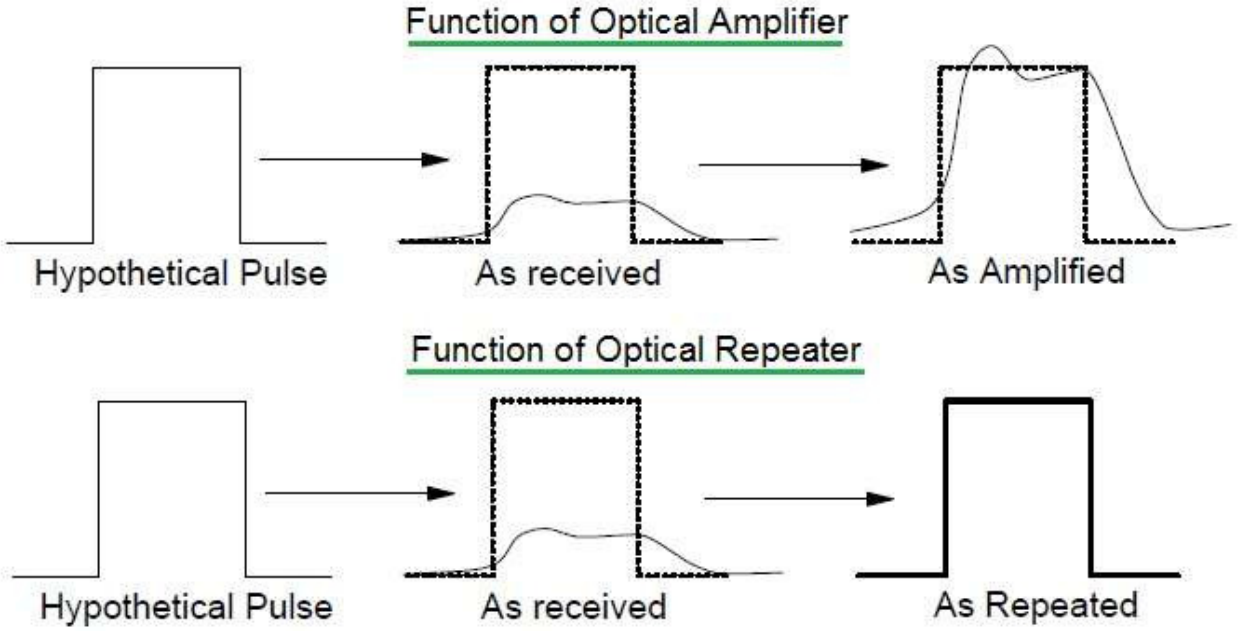


Figure 2-1 Repeater

Repeaters (continued)

- Note that on **analog** networks, devices that boost the signal are called **amplifiers**
- These devices do not have the same signal regeneration capabilities as repeaters
  - Because they must maintain the shape of the received signal
- Repeaters work in the Physical layer (layer 1)
- On optical networks, signal amplification is handled by **optical repeaters**
- Some repeaters can be used to connect two physically different types of cabling



Repeaters (continued)

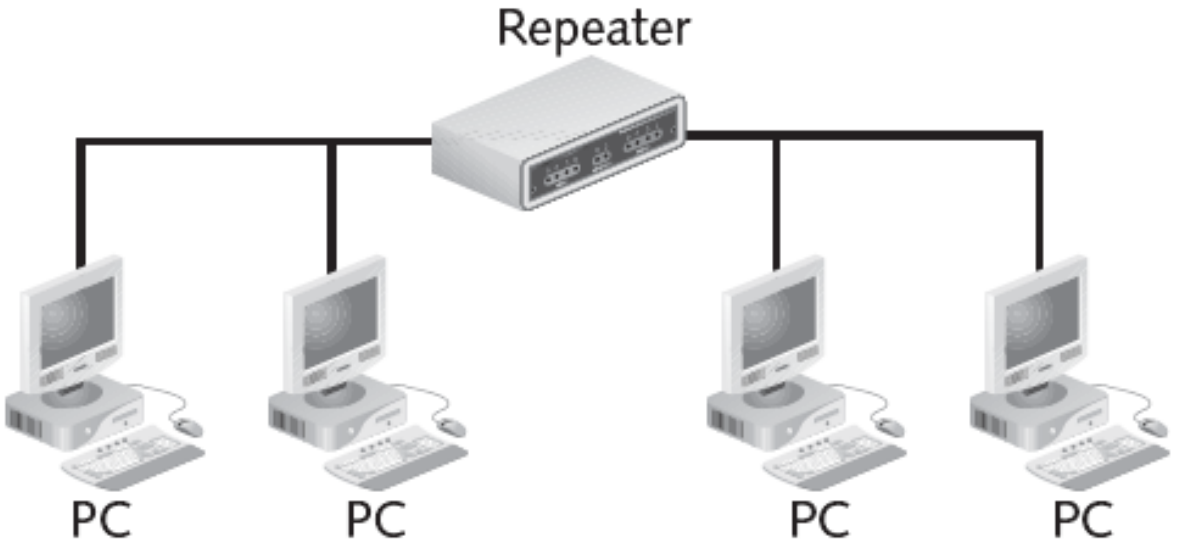
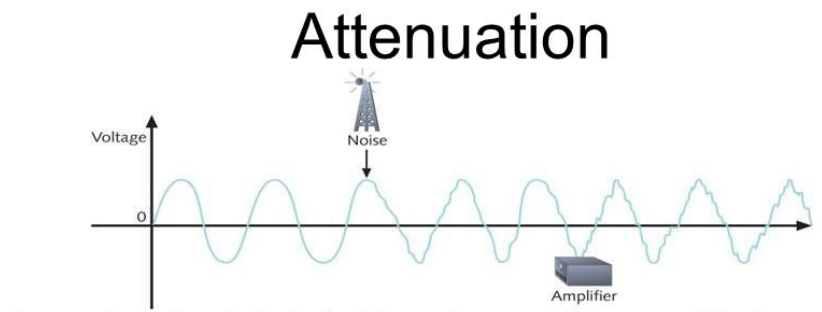


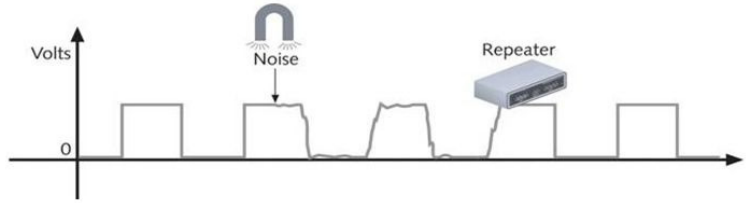
Figure 2-2 Repeater in the network

Hubs

- **Hub**
  - Generic connection device used to tie several networking cables together to create a link between different stations on a network
- **Active hubs**
  - Amplify or repeat signals that pass through them
- **Passive hub**
  - Merely connects cables on a network and provides no signal regeneration
- **Topology** refers to the physical layout of network cable and devices



An analog signal distorted by noise and then amplified



A digital signal distorted by noise and then repeated

Hubs (continued)

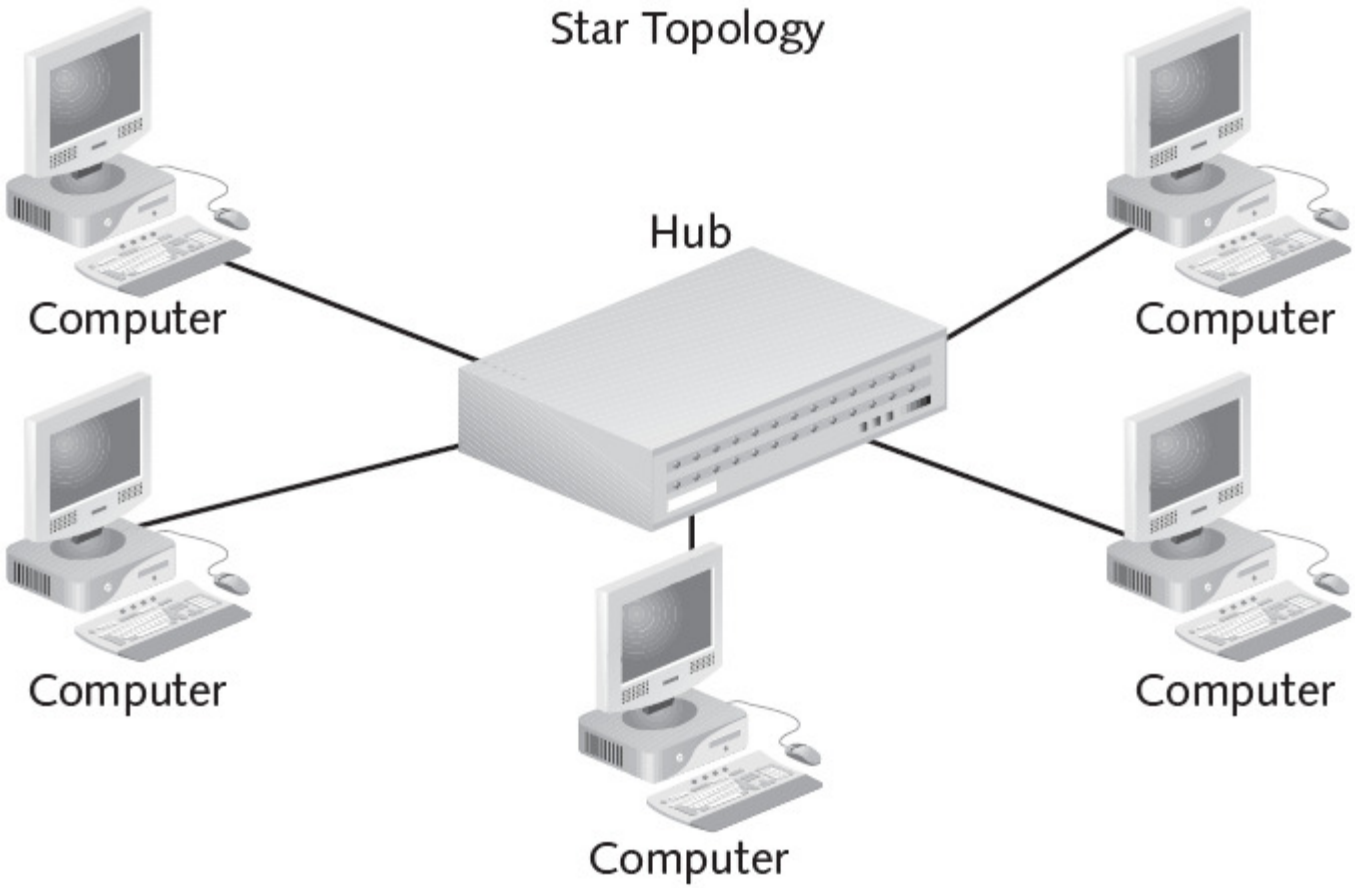


Figure 2-3 Star topology

Advantages and Disadvantages of Repeaters and Hubs

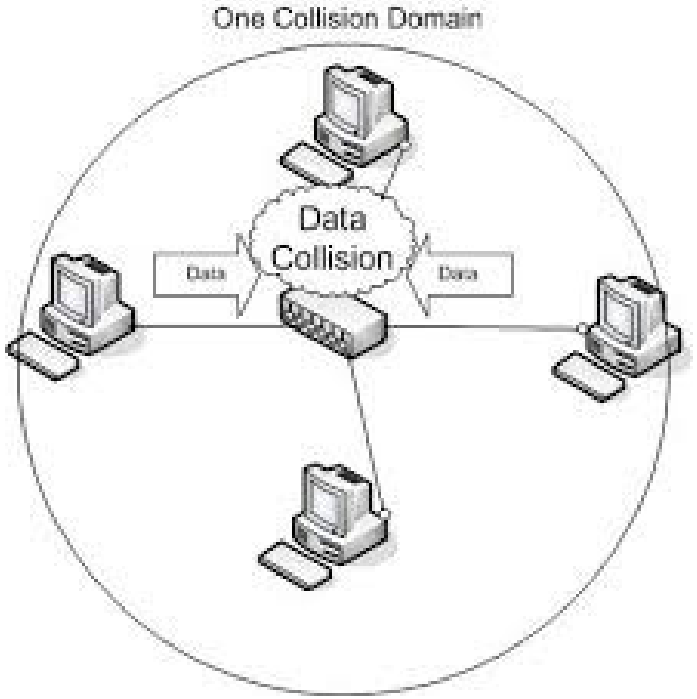
- Advantages
  - Can extend a network's total distance
  - Do not seriously affect network performance
  - Certain repeaters can connect networks using different physical media

Advantages and Disadvantages of Repeaters and Hubs (continued)

- Disadvantages
  - Cannot connect different network architectures, such as Token Ring and Ethernet
  - Do not reduce network traffic
    - They repeat everything they receive
  - Do not segment the network
  - Do not reformat data structures
    - Cannot connect networks that require different types of frames

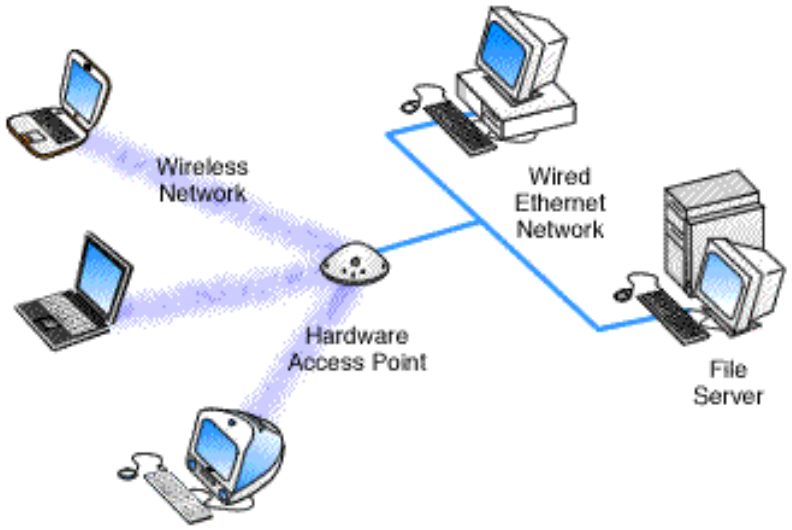
Advantages and Disadvantages of Repeaters and Hubs (continued)

- Repeaters do not segment a network
  - Frames that are broadcast on a given segment may collide
- Devices that “see” the traffic of other devices are said to be on the same **collision domain**



Wireless Access Points

- **Wireless access points**
  - Provide cell-based areas where wireless clients such as laptops and PDAs can connect to the network
    - By associating with the access point
- Operate at the Physical and Data Link layers of the OSI model
  - In most respects, a wireless access point functions exactly like a hub



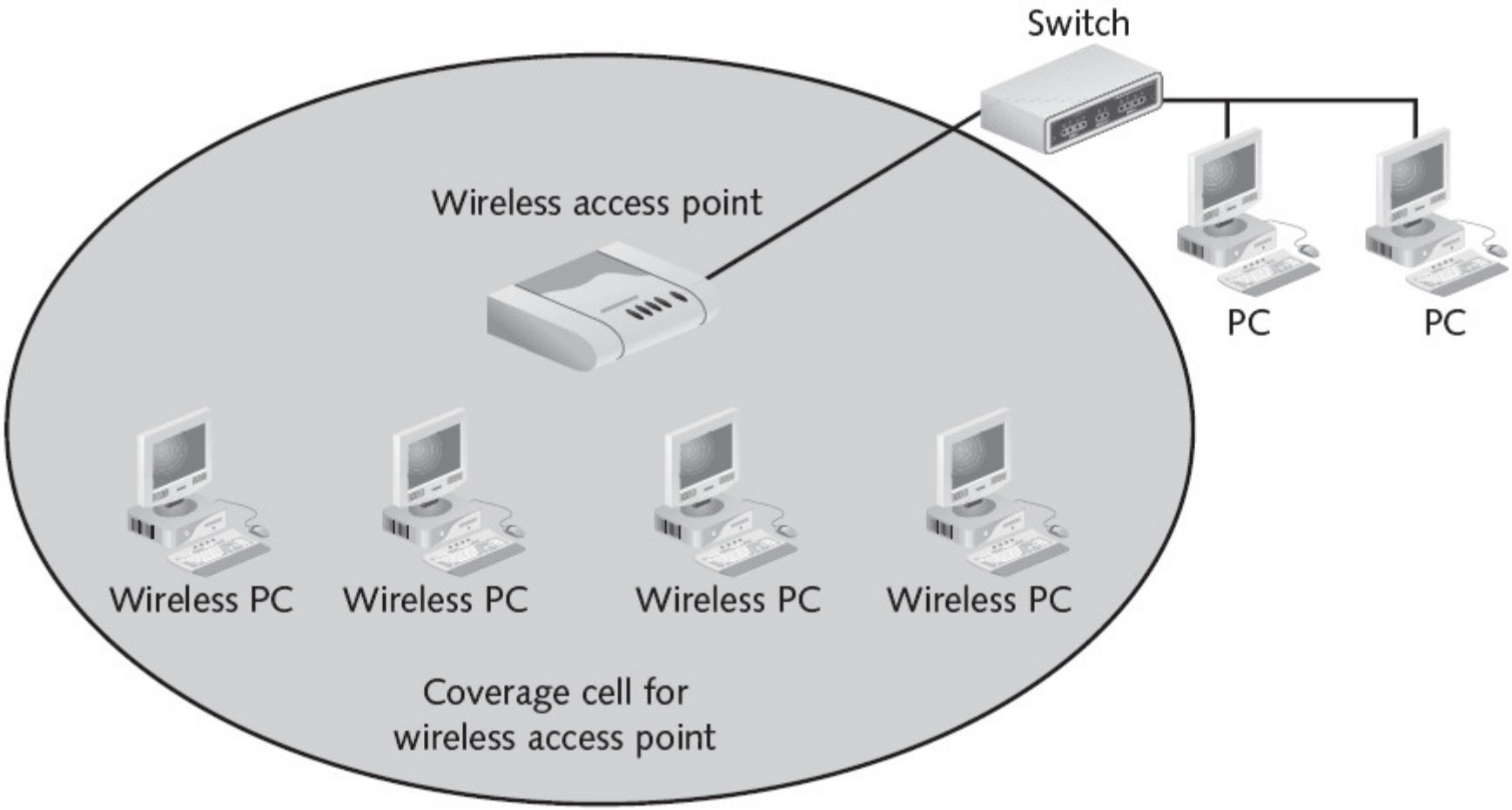


Figure 2-4 Wireless access point in the network

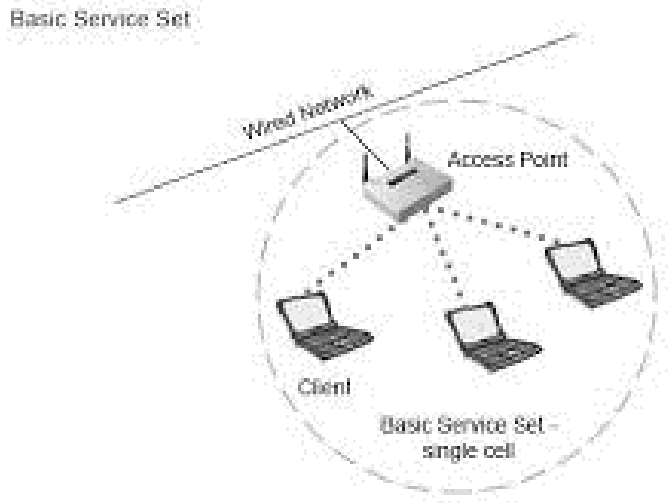
Wireless Standards and Organizations

Standard	Frequency Band (GHz)	Transmission Method	Data Rates (Mbps)
Original 801.11	2.4	infrared, frequency hopping spread spectrum, direct sequence spread spectrum	1, 2
802.11b	2.4	direct sequence spread spectrum	1, 2, 5.5, 11
802.11a	5	orthogonal frequency division multiplexing	6, 9, 12, 18, 24, 36, 48, 54
802.11g	2.4	direct sequence spread spectrum and orthogonal frequency division multiplexing	1, 2, 5.5, 11 and 6, 9, 12, 18, 24, 36, 48, 54

Table 2-1 802.11 Standards

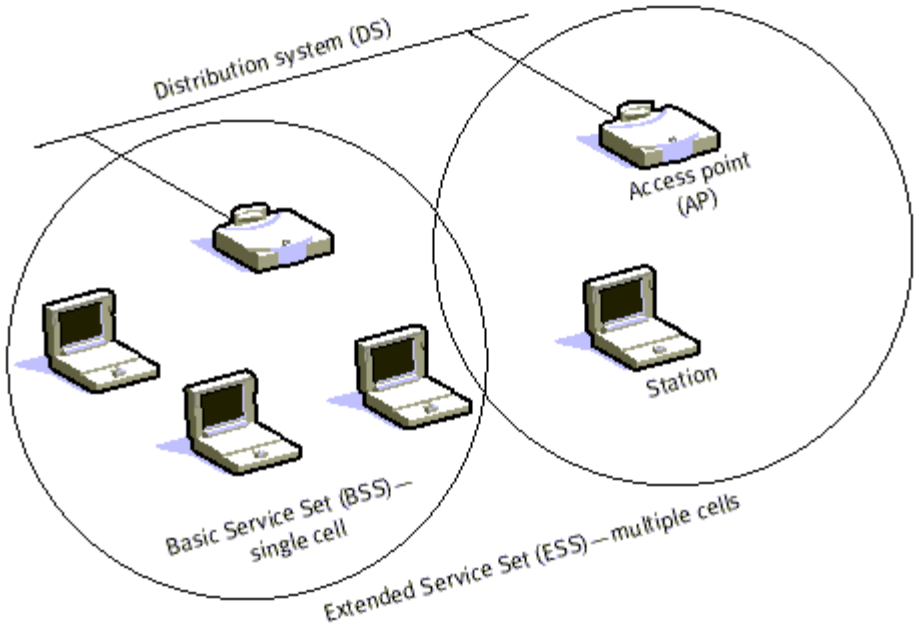
Wireless Network Components

- In **ad hoc mode**
  - Wireless clients can connect and communicate directly with each other
  - There is no access point
- In **infrastructure mode**
  - Wireless clients attach wirelessly to an access point
  - Involves the access point wired back into a switch
- **Basic Service Set** (BSS)
  - When a single access point is available in infrastructure mode



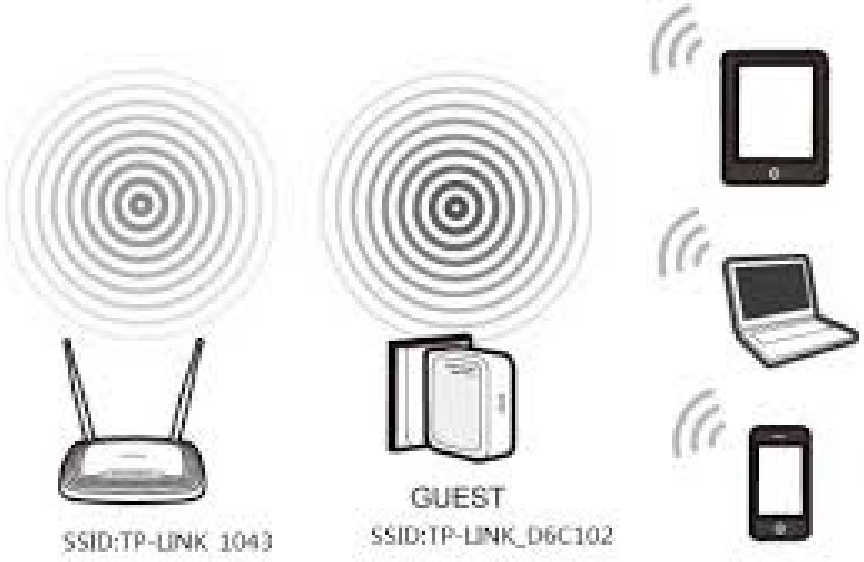
Wireless Network Components (continued)

- **Extended Service Set** (ESS)
  - Involve multiple access points connected to various switches in the network
  - Allows users to roam around the building and remain connected to the WLAN as well as the LAN and WAN



Wireless Connectivity

- Access points typically broadcast their network name
- The **Service Set Identifier** (SSID)
  - The network name
- When wireless clients are powered on, they begin scanning the airspace for available access points
- They detect the broadcasted SSID of the various access points in the area
  - Attempt to associate with the one that has the highest signal level and the lowest error rate

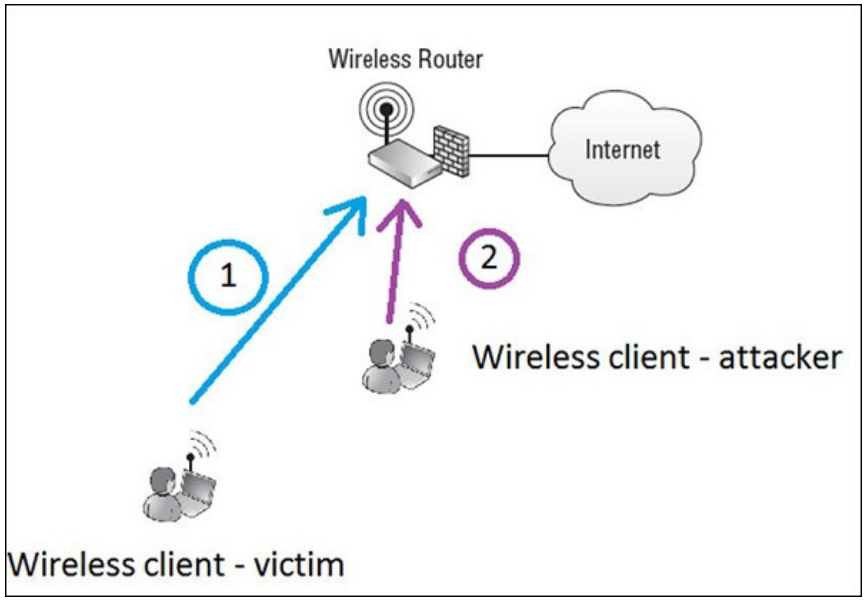


Wireless Connectivity (continued)

- If the system is open, the client is accepted by the access point and begins communications
- When SSID is not broadcasted
  - Wireless clients must already be configured with the correct SSID
- The client will send out a probe request with:
  - Configured SSID
  - Access point with that SSID configured will allow the client to associate

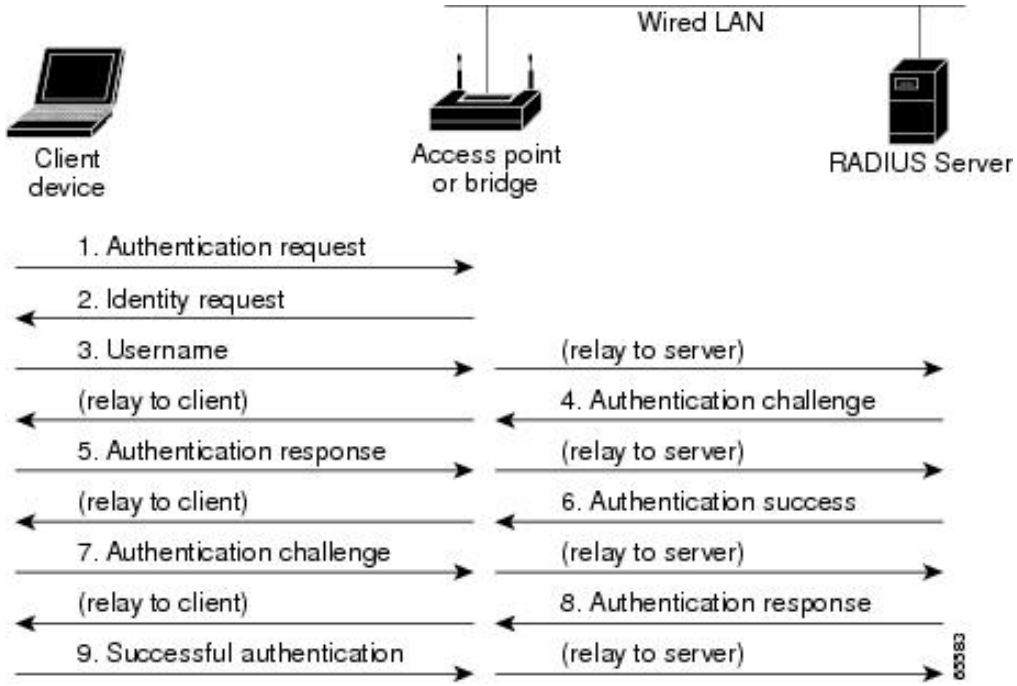
Wireless Security Measures

- While security is always necessary in WLANs due to the broadcast nature of the medium
  - These devices are not designed to handle the most complex and highest levels of security
- The most important reason to implement security on your WLAN at home
  - Others in your neighborhood do not use your bandwidth for free



Wireless Security Measures (continued)

- Workspace situations call for security that not only requires the client device to authenticate
  - But that also prompts the device user to enter a username and password
- **802.1x** is used at the physical layer to block ports
- The **Extensible Authentication Protocol (EAP)** is used at layer 2 to transfer the authentication frames



Wireless Security Protocols (continued)

802.11 Security Option	Type of Encryption	Uses
WEP (Wired Equivalent Privacy)	Lower-level encryption: RC4 algorithm, static key	Home
WPA (Wi-Fi Protected Access)	Higher level encryption: TKIP algorithm, dynamic keys, user authentication also supported (802.1x)	Home and small office
WPA2 (Wi-Fi Protected Access version 2)	Highest level of encryption: AES algorithm, dynamic keys, user authentication also supported (802.1x)	Home and small office
802.11i (The IEEE standard based on WPA2)	Highest level of encryption: AES algorithm, dynamic keys, user authentication with 802.1x/EAP	Businesses

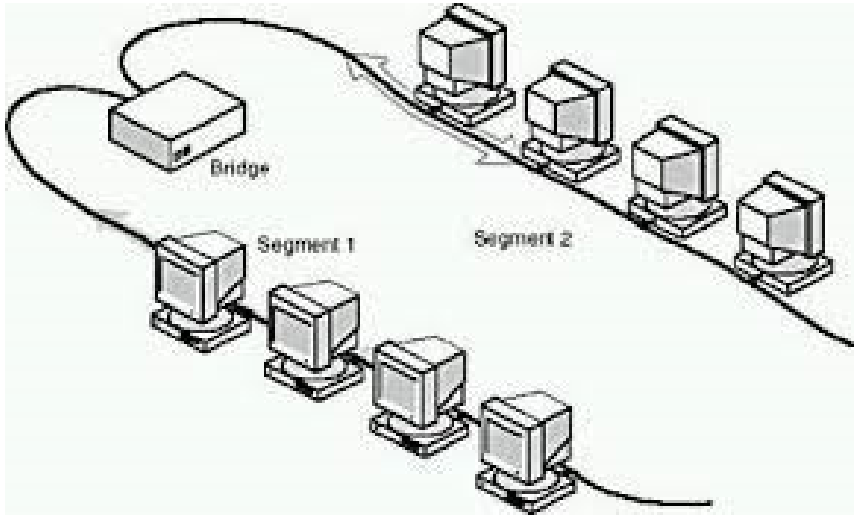
Table 2-2 802.11 Security

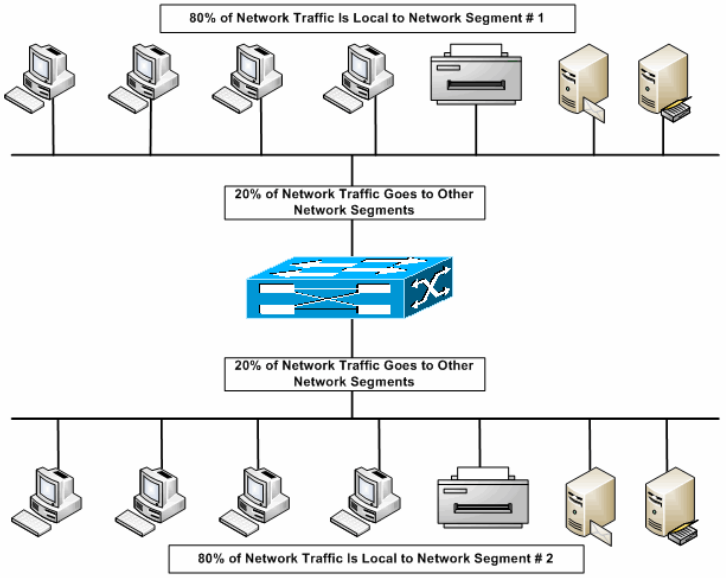
Advantages and Disadvantages of Wireless Access Points

- Advantages
  - Provide the ability to work anywhere within range of your access points
  - Extends the range of your network without running additional wires
- Disadvantages
  - Introduces serious security concerns
  - 802.11 provides much less bandwidth than wired devices
  - Many situations exist where 802.11 will not function well due to serious interference from various sources

Network Segmentation

- **Segmentation**
  - The breaking down of a single heavily populated network segment into smaller segments, or collision domains, populated by fewer nodes
- **Segment**
  - Part of a network that is divided logically or physically from the rest of the network
- When network administrators place too many nodes on the same network segment
  - Causes the number of collisions to increase





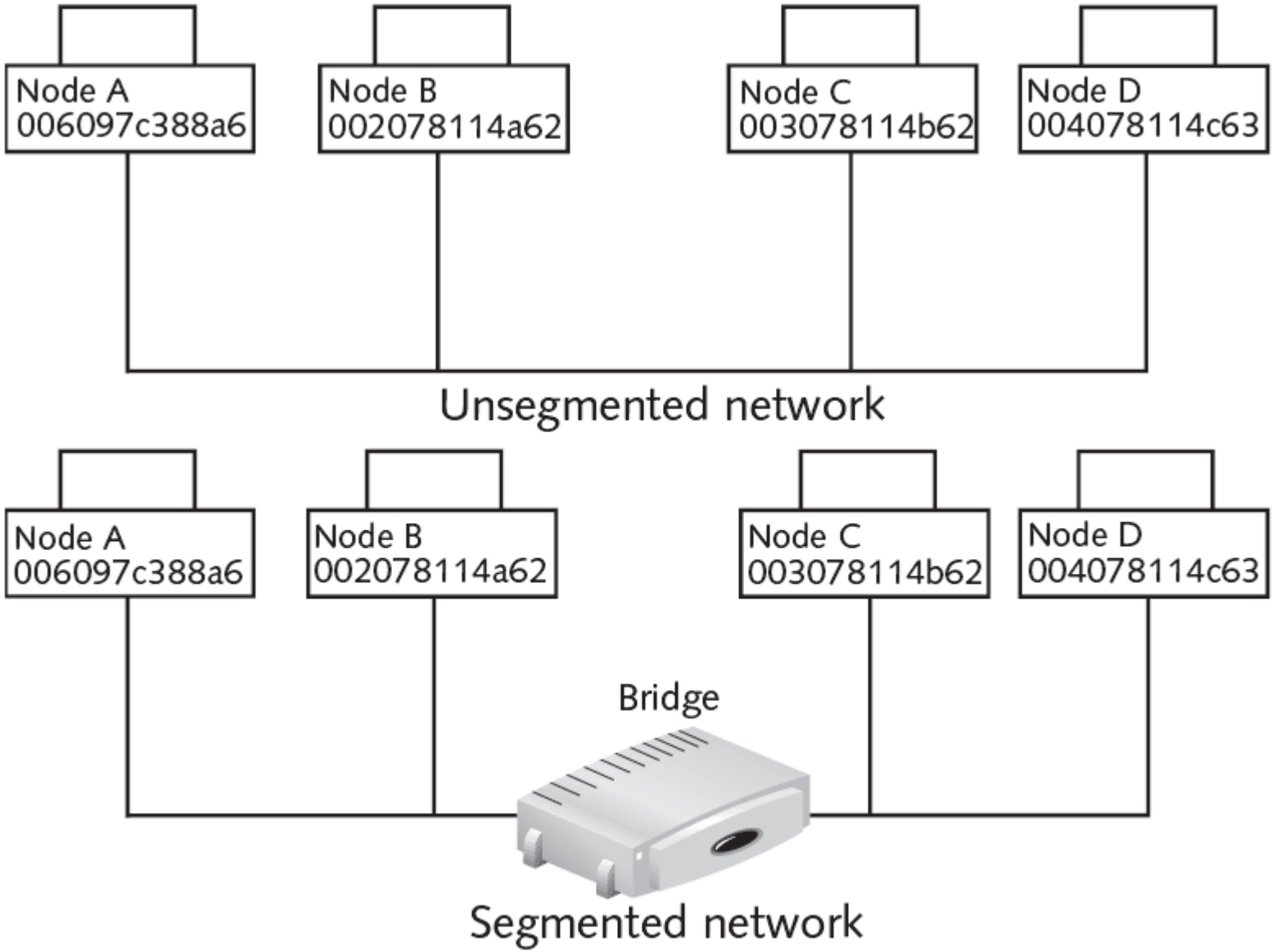
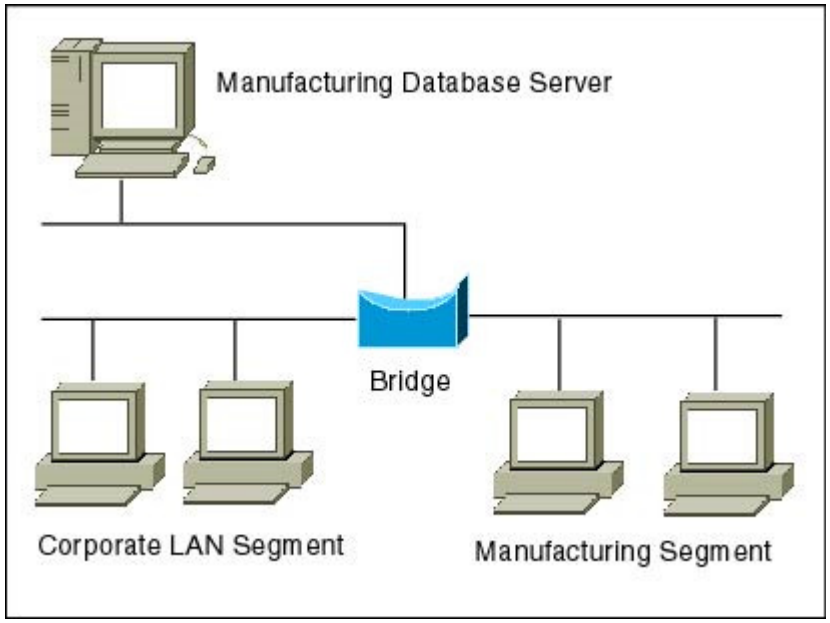


Figure 2-5 Network segmentation

Bridges

- **Bridges**
  - Operate at the Data Link layer of the OSI model
  - Filter traffic between network segments by examining the destination MAC address
    - Based on the destination MAC address, the bridge either forwards or discards the frame
  - Reduce network traffic by keeping local traffic on the local segment
- **Broadcast** frame
  - Frame destined for all computers on the network



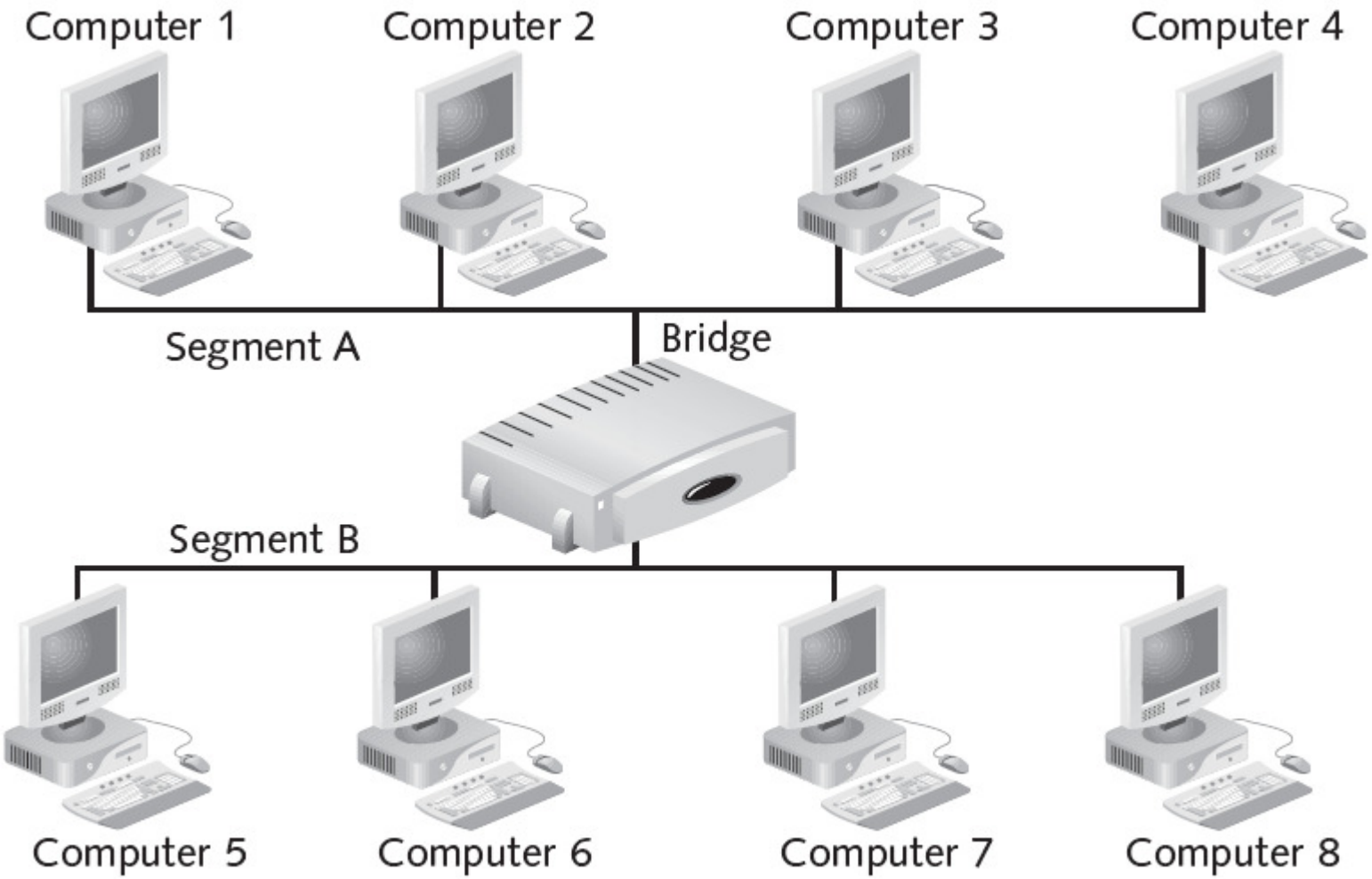
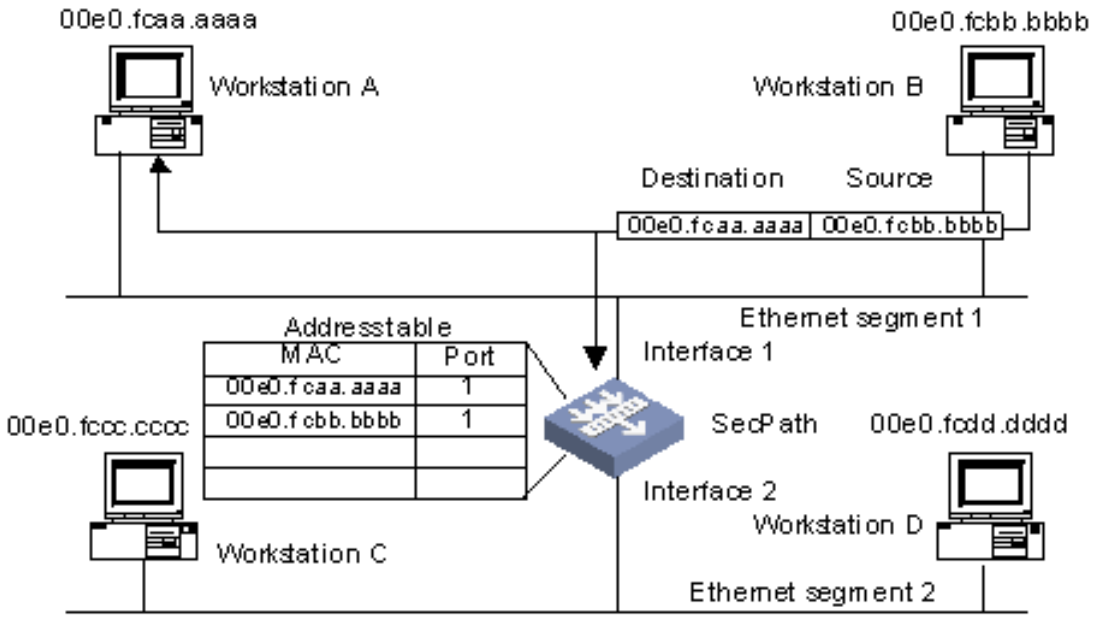


Figure 2-6 Bridge

Transparent Bridges

- Also called learning bridges
  - Because they build a table of MAC addresses as they receive frames
- They “learn” which addresses are on which segments
- The bridge uses the source MAC addresses to determine which addresses are on which segments
  - By determining a frame’s origin, the bridge knows where to send frames in the future
- Ethernet networks mainly use transparent bridges

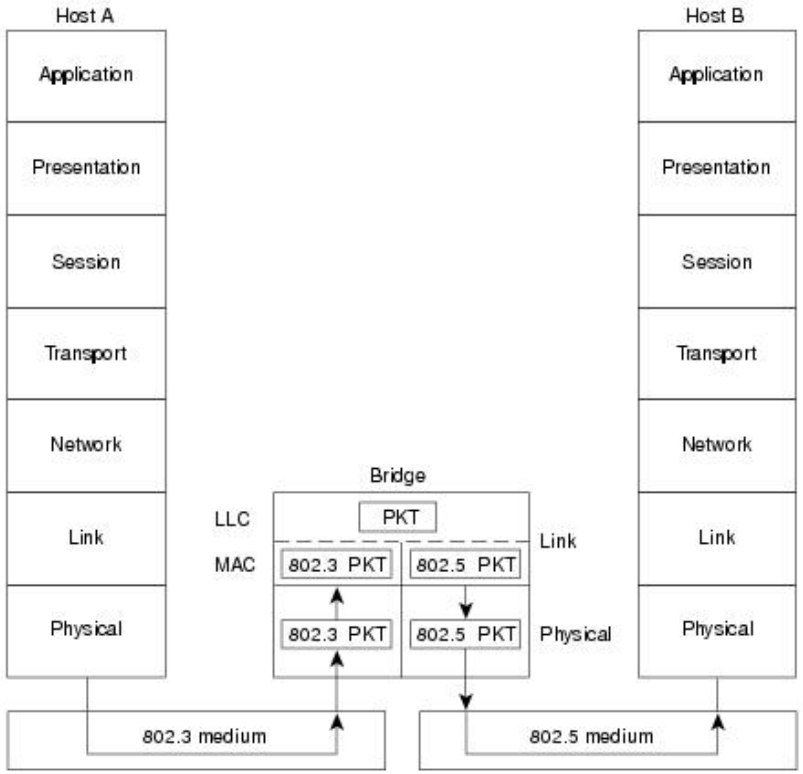


Source-Routing Bridges

- Rely on the source of the frame transmission to provide the routing information
  - The source computer determines the best path by sending out explorer frames
- The source includes the routing information returned by its explorer frames in the frame sent across the network
  - The bridge uses this information to build its table

Translation Bridges

- Can connect networks with different architectures, such as Ethernet and Token Ring
- These bridges appear as:
  - Transparent bridges to an Ethernet host
  - Source-routing bridges to a Token Ring host



Advantages and Disadvantages of Bridges

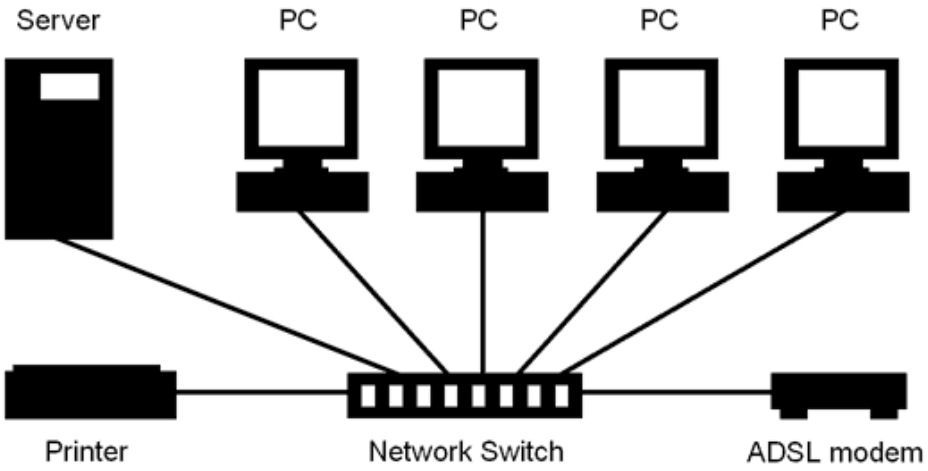
- Advantages
  - Can extend a network by acting as a repeater
  - Can reduce network traffic on a segment by subdividing network communications
  - Increase the available bandwidth to individual nodes because fewer nodes share a collision domain
  - Reduce collisions
  - Some bridges connect networks using different media types and architectures

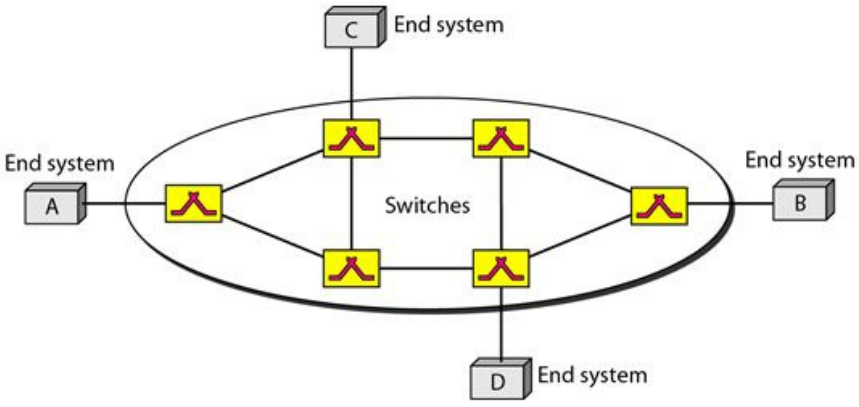
Advantages and Disadvantages of Bridges (continued)

- Disadvantages
  - Slower than repeaters and hubs
    - Extra processing by viewing MAC addresses
  - Forward broadcast frames indiscriminately, so they do not filter broadcast traffic
  - More expensive than repeaters and hubs
- **Broadcast storm**
  - When two or more stations engage in the transmission of excessive broadcast traffic

Switches

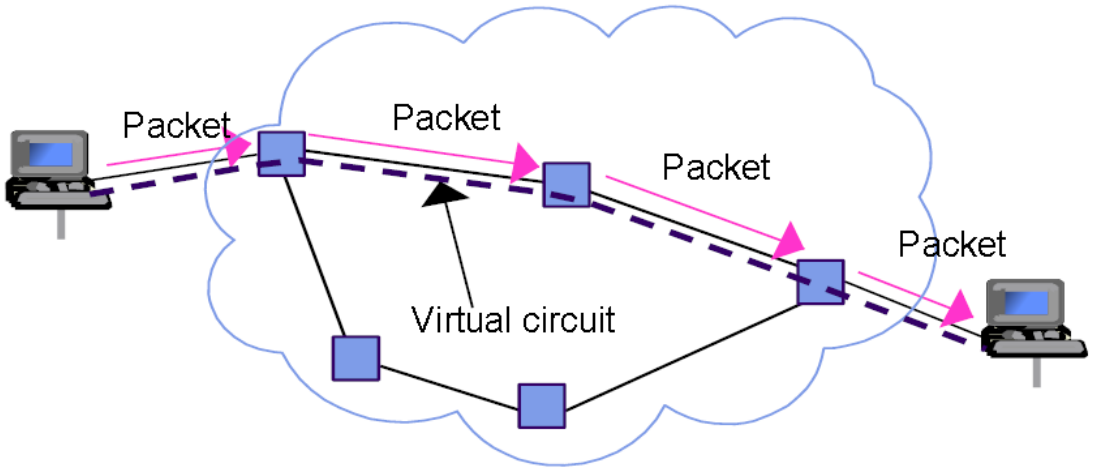
- **Switches**
  - Operate at the Data Link layer of the OSI model
  - Increase network performance by reducing the number of frames transmitted to the rest of the network
- Switch opens a **virtual circuit** between the source and the destination
  - Prevents communications between just two computers from being broadcast to every computer on the network or segment
  - Called **microsegmentation**





Switches (continued)

- When two machines have a virtual circuit
  - They do not have to share the bandwidth with any other computers
- Multiple virtual circuits can be in use at the same time, each with its own full **bandwidth**
  - Called “switched bandwidth”
- When machines must share a wire and compete for available bandwidth with other machines, they experience **contention**



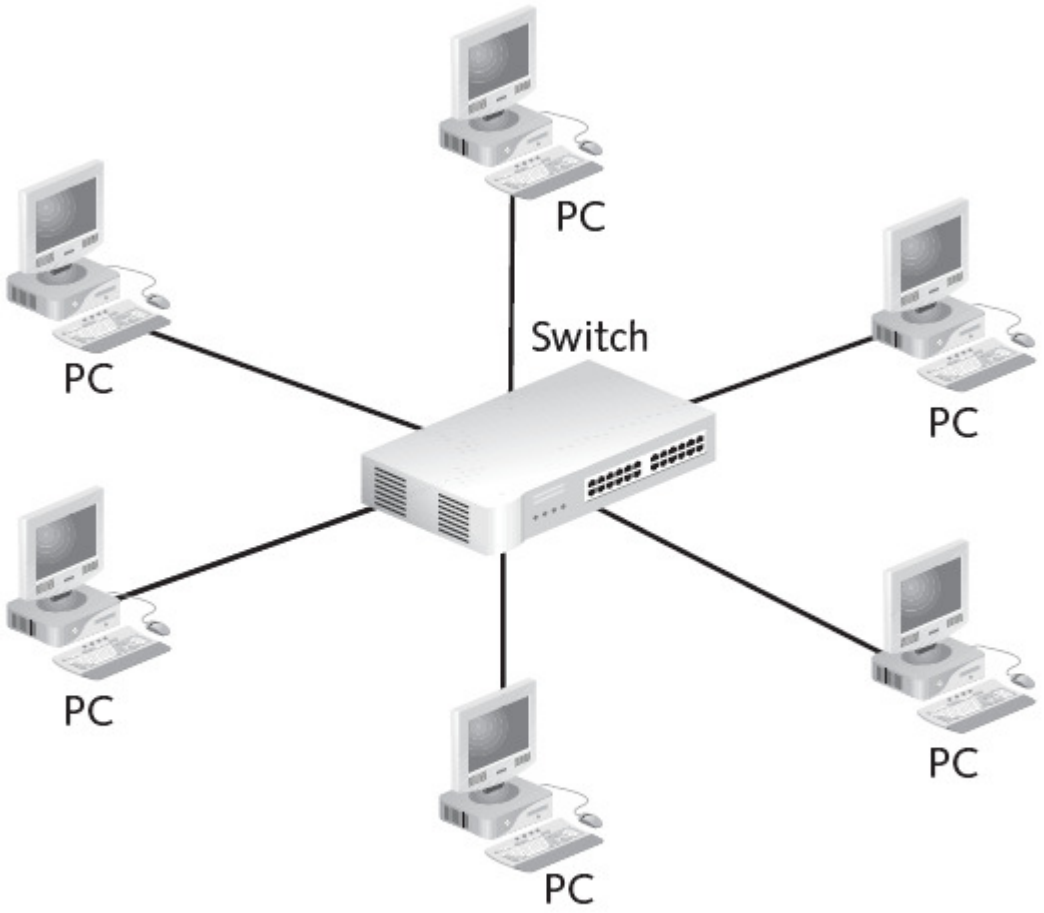


Figure 2-7 Star topology using a switch

Advantages and Disadvantages of Switches

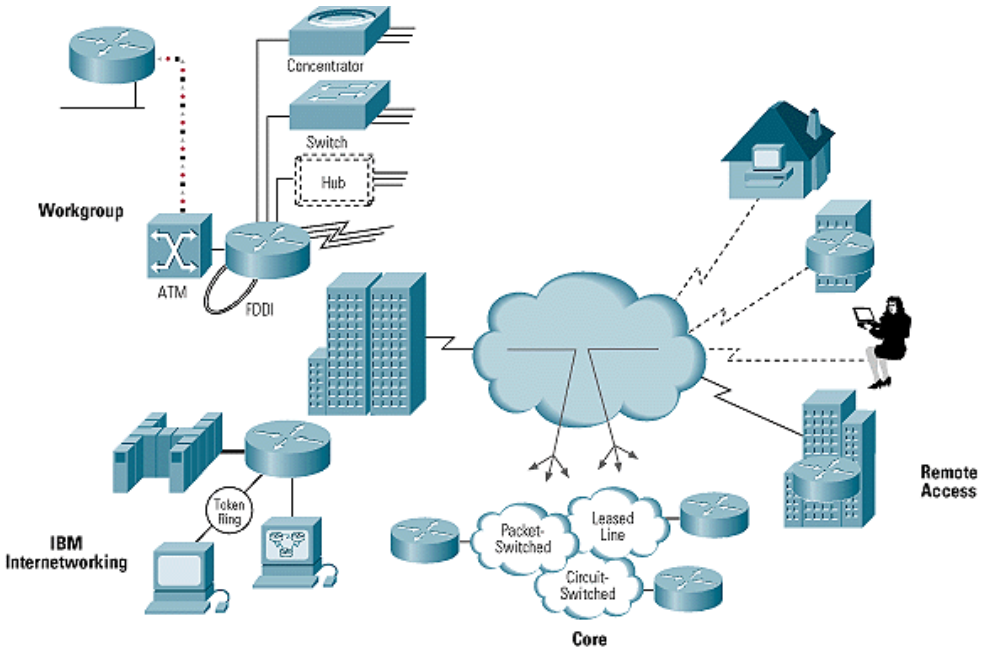
- Advantages
  - Switches increase available network bandwidth
  - Switches reduce the workload on individual computers
  - Switches increase network performance
  - Networks that include switches experience fewer frame collisions because switches create collision domains for each connection (a process called microsegmentation)
  - Switches connect directly to workstations

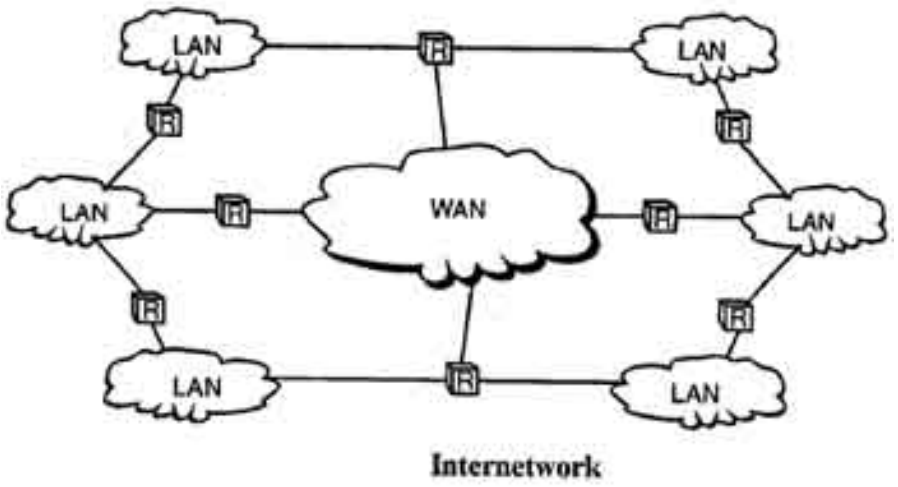
Advantages and Disadvantages of Switches (continued)

- Disadvantages
  - Switches are significantly more expensive than bridges
  - Network connectivity problems can be difficult to trace through a switch
  - Broadcast traffic may be troublesome

Routers

- **Routers**
  - Operate at the Network layer of the OSI model
  - Provide filtering and network traffic control on LANs and WANs
  - Can connect multiple segments and multiple networks
- **Internetworks**
  - Networks connected by multiple routers
- Similar to switches and bridges in that they segment a network and filter traffic
  - Routers use the logical address





Physical vs. Logical Addresses

- MAC address
  - Found at the Data Link layer of the OSI model
  - Used by bridges and switches to make forwarding decisions within a network or **subnetwork**
- **IP address**
  - Logical address when TCP/IP is used on an internetwork
- Routers use the IP address to route packets to the correct network segment

Physical vs. Logical Addresses (continued)

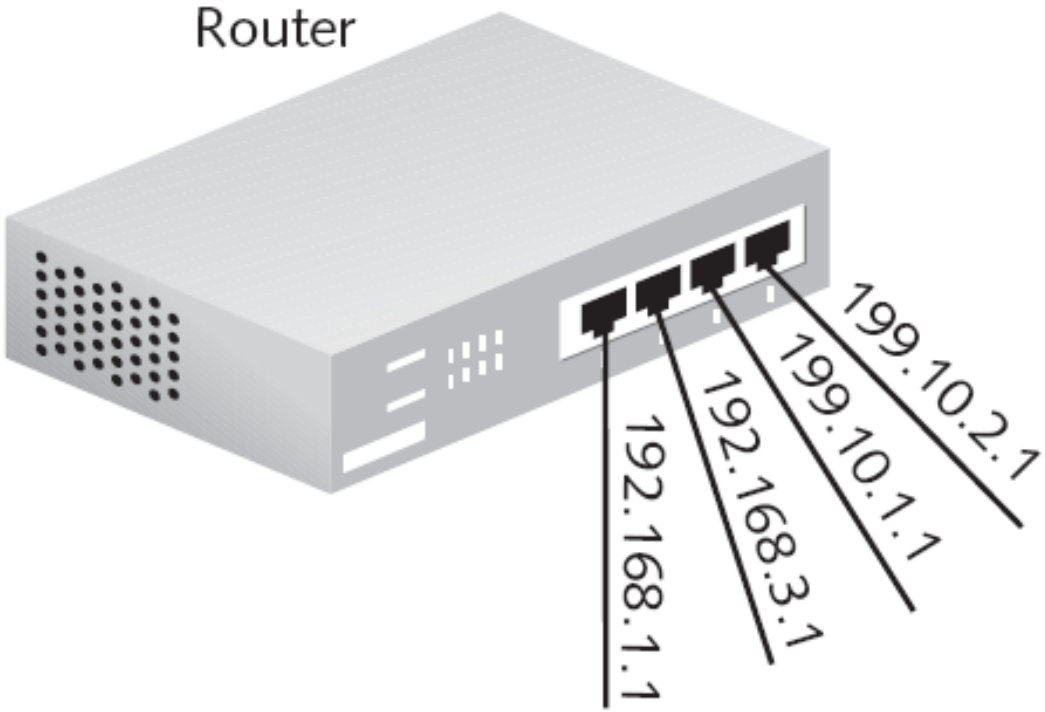


Figure 2-8 Router

Advantages and Disadvantages of Routers

- Advantages
  - Can connect different network architectures, such as Ethernet and Token Ring
  - Can choose the best path across an internetwork using dynamic routing techniques
  - Reduce network traffic by creating collision domains
  - Reduce network traffic by creating broadcast domains

Advantages and Disadvantages of Routers (continued)

- Disadvantages
  - Routers work only with routable network protocols; most but not all protocols are routable
  - Routers are more expensive than other devices
  - Dynamic router communications (inter-router communication) cause additional network overhead, which results in less bandwidth for user data
  - Routers are slower than other devices because they must analyze a data transmission from the Physical through the Network layer

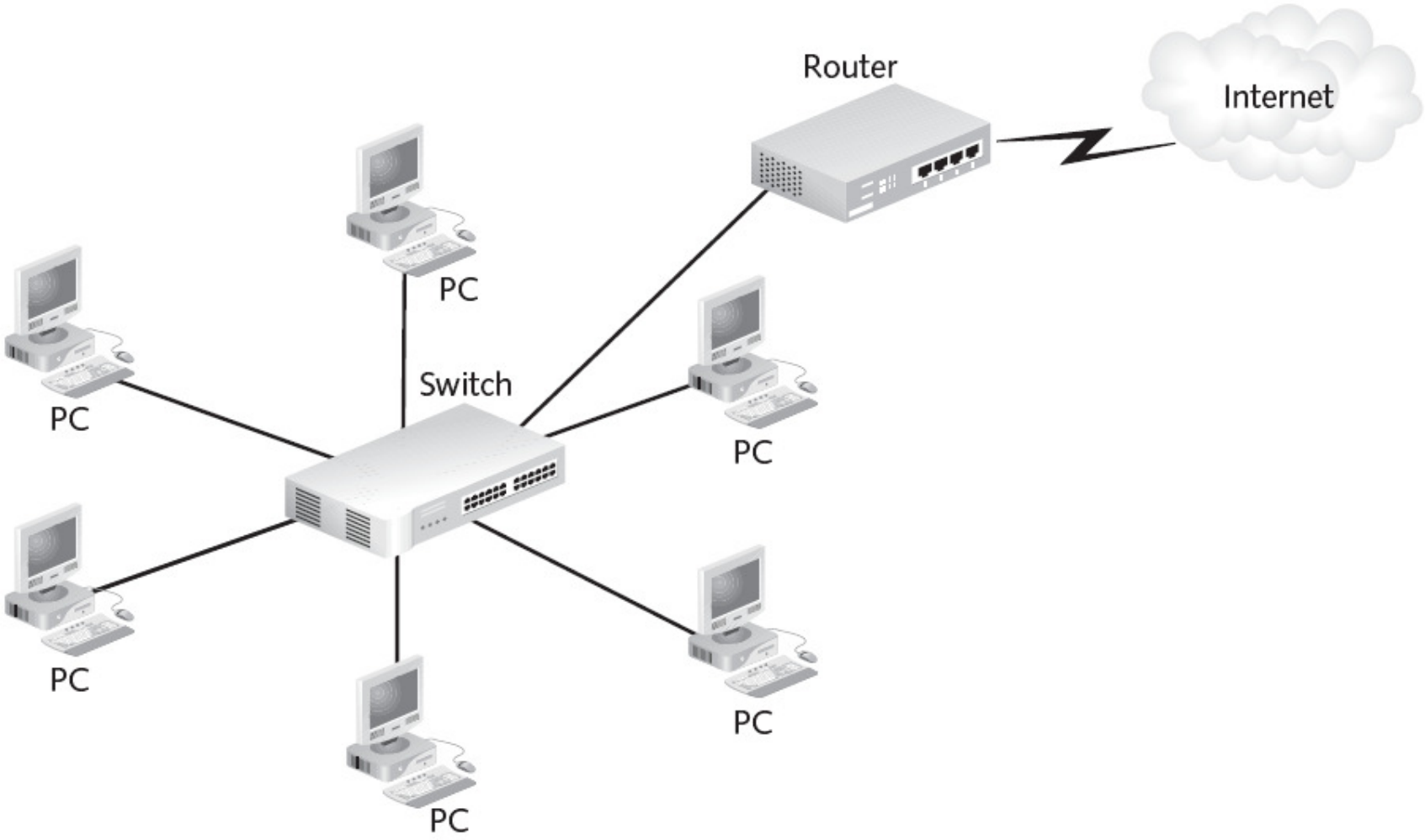
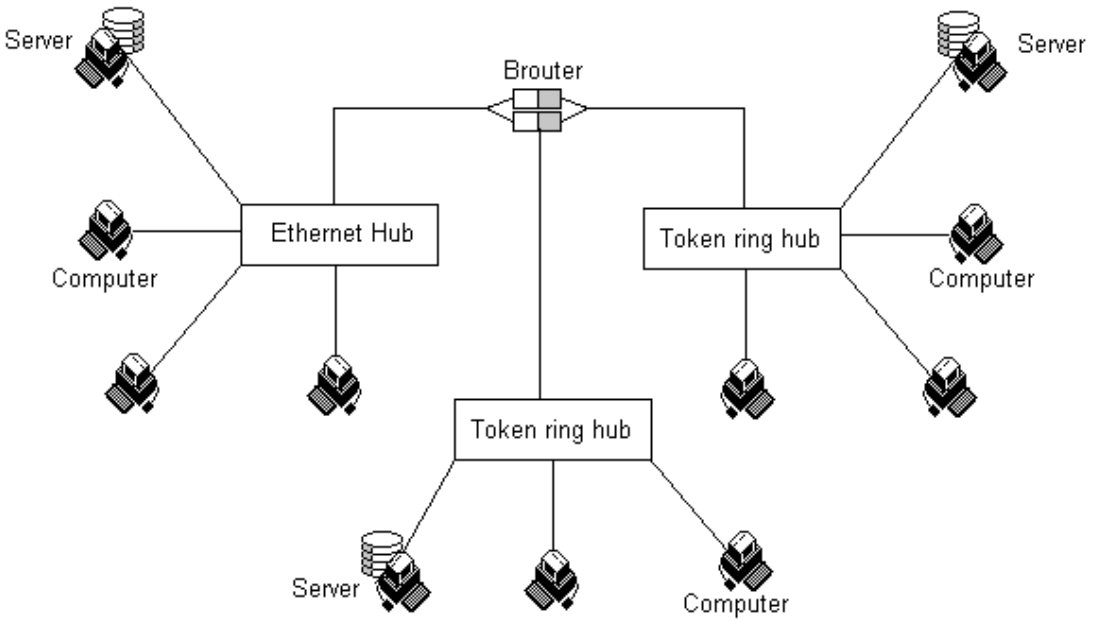


Figure 2-9 Router connecting network to the Internet

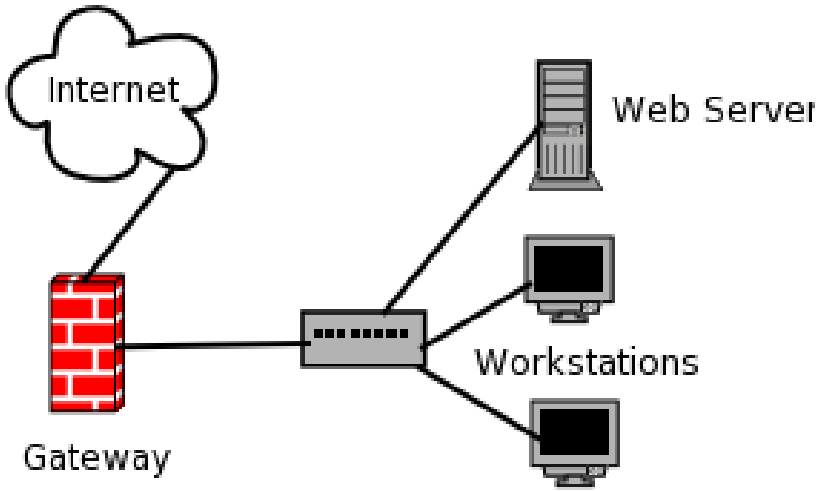
Brouters

- **Brouter**
  - Hybrid device
  - Functions as both a bridge for nonroutable protocols and a router for routable protocols
  - Provides the best attributes of both a bridge and a router
  - Operates at both the Data Link and Network layers and can replace separate bridges and routers



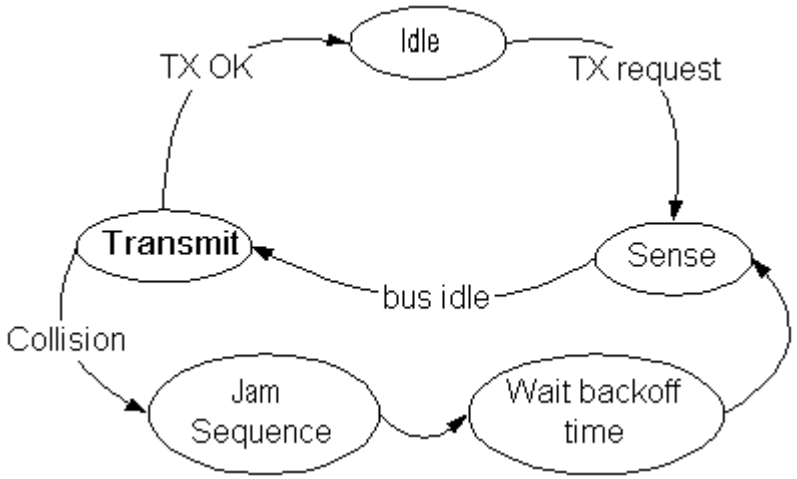
Gateways

- **Gateway**
  - Usually a combination of hardware and software
  - Translates between different protocol suites
  - Has the most negative effect on network performance
    - Packets must be rebuilt not just at the lower levels but at the very upper levels
      - So that actual data content can be converted into a format the destination can process
  - Creates the most **latency**



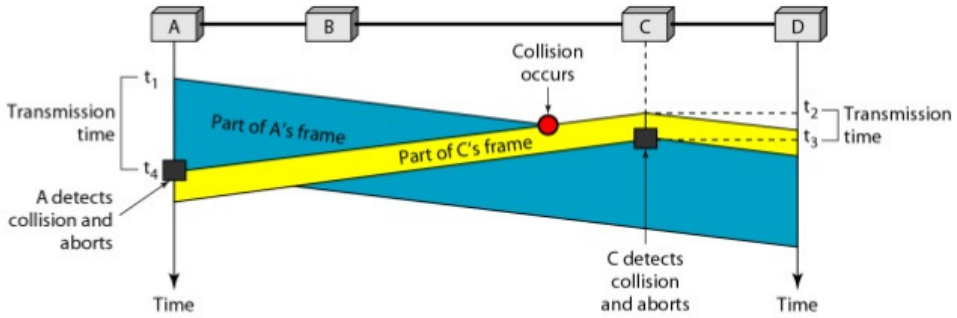
Ethernet Operations

- **Ethernet**
  - A **network access method** (or **media access method**) originated by the University of Hawaii
  - Later adopted by Xerox Corporation, and standardized as IEEE 802.3 in the early 1980s
- Today, Ethernet is the most commonly implemented media access method in new LANs



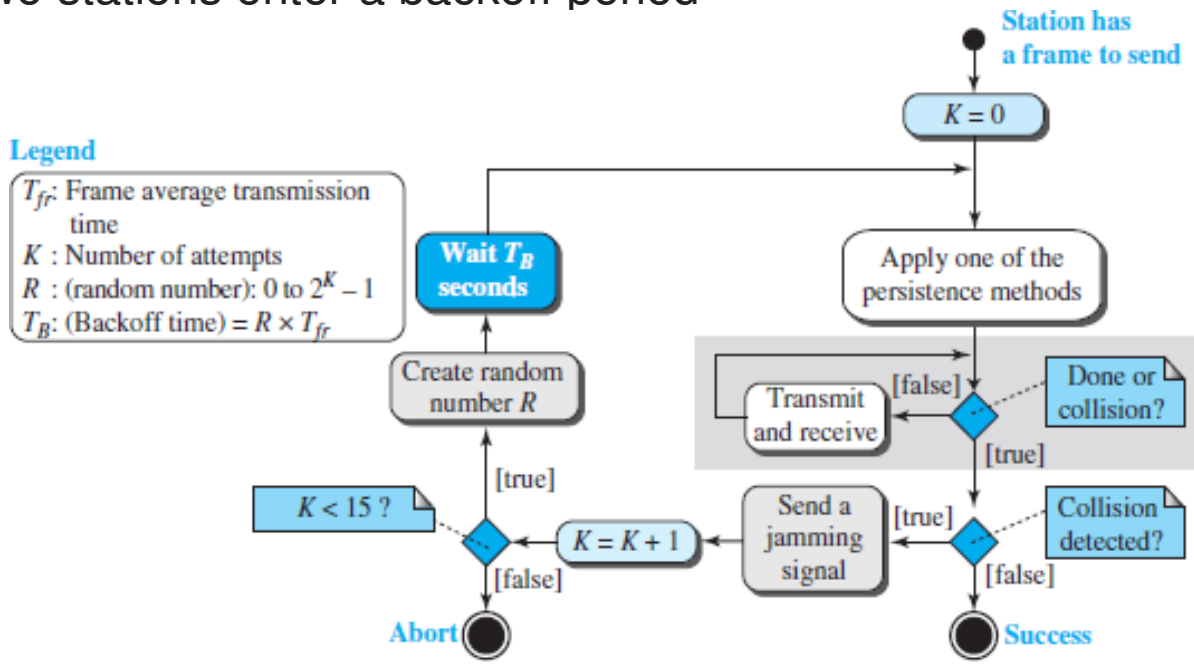
CSMA/CD

- **Carrier Sense Multiple Access with Collision Detection (CSMA/CD)**
  - Used by Ethernet to prevent data packets from colliding on the network
  - Allows any station connected to a network to transmit anytime there is not already a transmission on the wire
- After each transmitted signal, each station must wait a minimum of 9.6 microseconds before transmitting another frame
  - Called the **interframe gap (IFG)**, or **interpacket gap (IPG)**



CSMA/CD (continued)

- Collisions
  - Two stations could listen to the wire simultaneously and not sense a carrier signal
    - In such a case, both stations might begin to transmit their data simultaneously
      - A collision would occur on the network wire
  - The first station to detect the collision transmits a 32-bit **jam signal**
    - Tells all other stations not to transmit for a brief period
  - The two stations enter a backoff period



CSMA/CD (continued)

- Collision domain
  - The physical area in which a frame collision might occur
  - Routers, switches, bridges, and gateways do segment networks
    - And thus create separate collision domains

Fast Ethernet

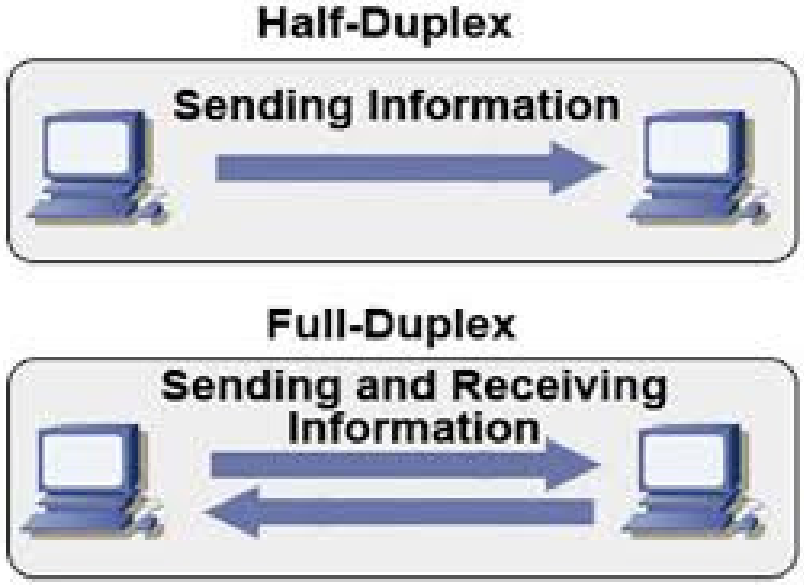
- **Fast Ethernet** (100BaseT)
  - Uses the same network access method (CSMA/CD) as common 10BaseT Ethernet
  - Provides ten times the data transmission rate
- When you upgrade from 10BaseT to Fast Ethernet
  - All the network cards, hubs, and other connectivity devices that are now expected to operate at 100 Mbps must be upgraded
- Fast Ethernet is defined under the **IEEE 802.3u** standard

Gigabit Ethernet

- **Gigabit Ethernet** (1000BaseX)
  - The next iteration of Ethernet, increasing the speed to 1000 Mbps
  - Defined in the **IEEE 802.3z** standard
- Gigabit Ethernet can work in half-duplex mode through hubs
  - Not typical
  - Almost all applications of the standard are full-duplexed through switches
- 10 Gigabit Ethernet (10GBaseX, 10GbE or 10GigE) is the fastest of the Ethernet standards

Half- and Full-Duplex Communications

- **Half-duplex** communications
  - Devices can send and receive signals, but not at the same time
- **Full-duplex** communications
  - Devices can send and receive signals simultaneously
- Most Ethernet networks can use equipment that supports half- and full-duplex communications
- Full-duplex communications use one set of wires to send and a separate set to receive



Half- and Full-Duplex Communications (continued)

- Benefits of using full-duplex:
  - Time is not wasted retransmitting frames, because there are no collisions
  - The full bandwidth is available in both directions because the send and receive functions are separate
  - Stations do not have to wait until other stations complete their transmissions