

Introduction to Information Technology IT111

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Lecture 7 - Computer Networks



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Learning Objectives

1. Define a computer network and its purpose.
2. Describe several uses for networks.
3. Understand the various characteristics of a network, such as topology, architecture, and size.
4. Understand characteristics about data and how it travels over a network.
5. Name specific types of wired and wireless networking media and explain how they transmit data.
6. Identify the most common communications protocols and networking standards used with networks today.
7. List several types of networking hardware and explain the purpose of each.

Overview

- **This chapter covers:**
 - Common networking and communications applications
 - Networking concepts and terminology
 - Technical issues related to networks, including general characteristics of data transmission, and types of transmission media in use today
 - Explanation of the various communications protocols and networking standards

What Is a Network?

- **Network**
 - A connected system of objects or people
- **Computer network**
 - A collection of computers and other hardware devices connected together so users can share hardware, software, data, and communication.
- **Computer networks are converging with telephone and other communications networks**
- Networks range from small private networks to the Internet (largest network in the world)
- In most businesses, computer networks are essential

Networking Applications

- **The Internet**
 - Largest computer network in the world
- **Telephone Service**
 - POTS Network (plain old telephone system)
 - One of the first networks
 - Still used today to provide telephone service to landline phones
 - **Mobile Phones (wireless phones)**
 - Use a wireless network for communications

Mobile Phones

- **Cellular (cell) Phones**
 - Must be within range of cell tower to function
- **Satellite Phones**
 - Used where cell service is not available
 - Most often used by individuals such as soldiers, journalists and researchers



Networking Applications

- **Television and Radio Broadcasting**

- Still used to deliver TV and radio content to the public
- Other networks involved with television content delivery are cable TV networks, satellite TV networks.

- **Global Positioning System (GPS) Applications**

- Uses satellites and a receiver to determine the exact geographic location of the receiver
- Commonly used by individuals to determine their exact location



Networking Applications

- **Monitoring Systems**

- Use networking technology to determine the current location or status of an object
 - Radio Frequency Identification RFID-based Systems
 - Monitor the status of objects
 - GPS-based Monitoring Systems
 - Monitor the physical location of object.
 - Electronic Medical Monitors
 - Home health care

Monitoring Systems

- Sensor Networks
 - Devices that respond to heat, light, pressure and generate a measurable electrical signal



Networking Applications



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- **Multimedia Networking**

- Distributing digital multimedia content, typically via a home network

- **Placeshifting Content**

- Allows individuals to view multimedia content at a more convenient location, i.e.,

1. Slingbox device is connected to the user's home DVR, cable set-top box, or satellite receiver.



2. SlingPlayer software allows the user to watch and control his or her home TV system from anywhere with an Internet connection.

Networking Applications

- **Videoconferencing**, Collaborative Computing, and Telecommuting
 - Use of computers, video cameras, microphones, and networking technologies to conduct face-to-face meetings between people located in different places



Networking Applications

– Collaborative Computing (workgroup computing)

- Enables individuals to work together on documents and projects
- Individuals work from a remote location (usually home) and communicate with their places of business and clients using networking technologies
- Allows for employee flexibility

Networking Applications

- **Telemedicine**

- Use of networking technology to provide medical information and services
 - Remote monitoring and consultations
 - Remote diagnosis
 - Telesurgery
 - Doctor's physical location is different from the patient's physical location
 - Robot assisted
 - Will be needed for long-term space exploration

TELESURGERY

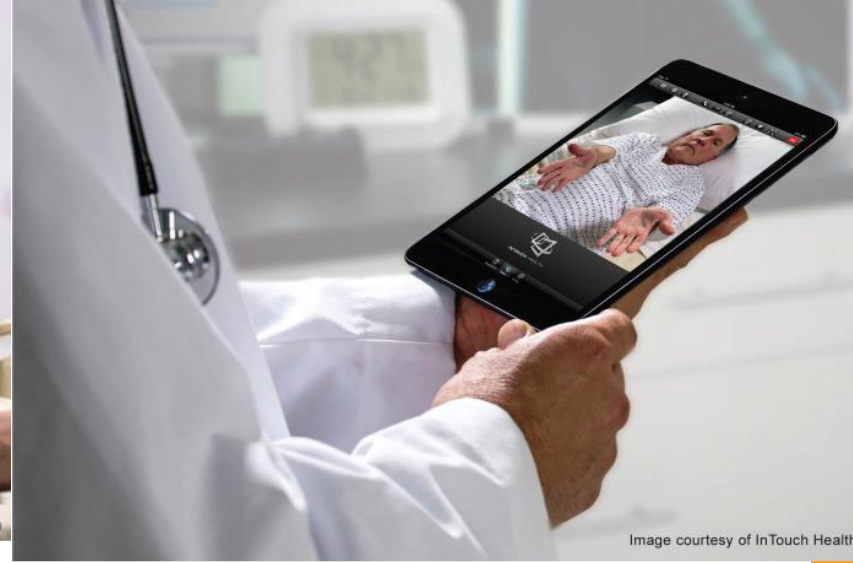


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REMOTE CONSULTATIONS

Using remote-controlled teleconferencing robots, physicians can “virtually” consult with patients or other physicians in a different physical location; the robot (left photo) transmits video images and audio to and from the doctor (via his or her computer or mobile device, right photo) in real time.



TELESURGERY

Using voice or computer commands, surgeons can perform operations (such as inserting a catheter during the heart surgery shown here) remotely via the Internet or a private network; a robotic system uses the surgeon's commands to physically operate on the patient.



Network Characteristics

Wired vs. Wireless Networks

– Wired

- A network in which computers and other devices are physically connected to the network with cables
- Found in homes, schools, businesses, and government facilities

– Wireless

- A network in which computers and other devices are connected to the network without physical cables
- Data is typically sent via radio waves

Network Characteristics

Network Topologies

- How the devices in the network are arranged
 - Star Networks
 - All networked devices connect to a central device such as a server
 - If the central device fails, the network cannot work



STAR NETWORKS

Use a central device to connect each device directly to the network.

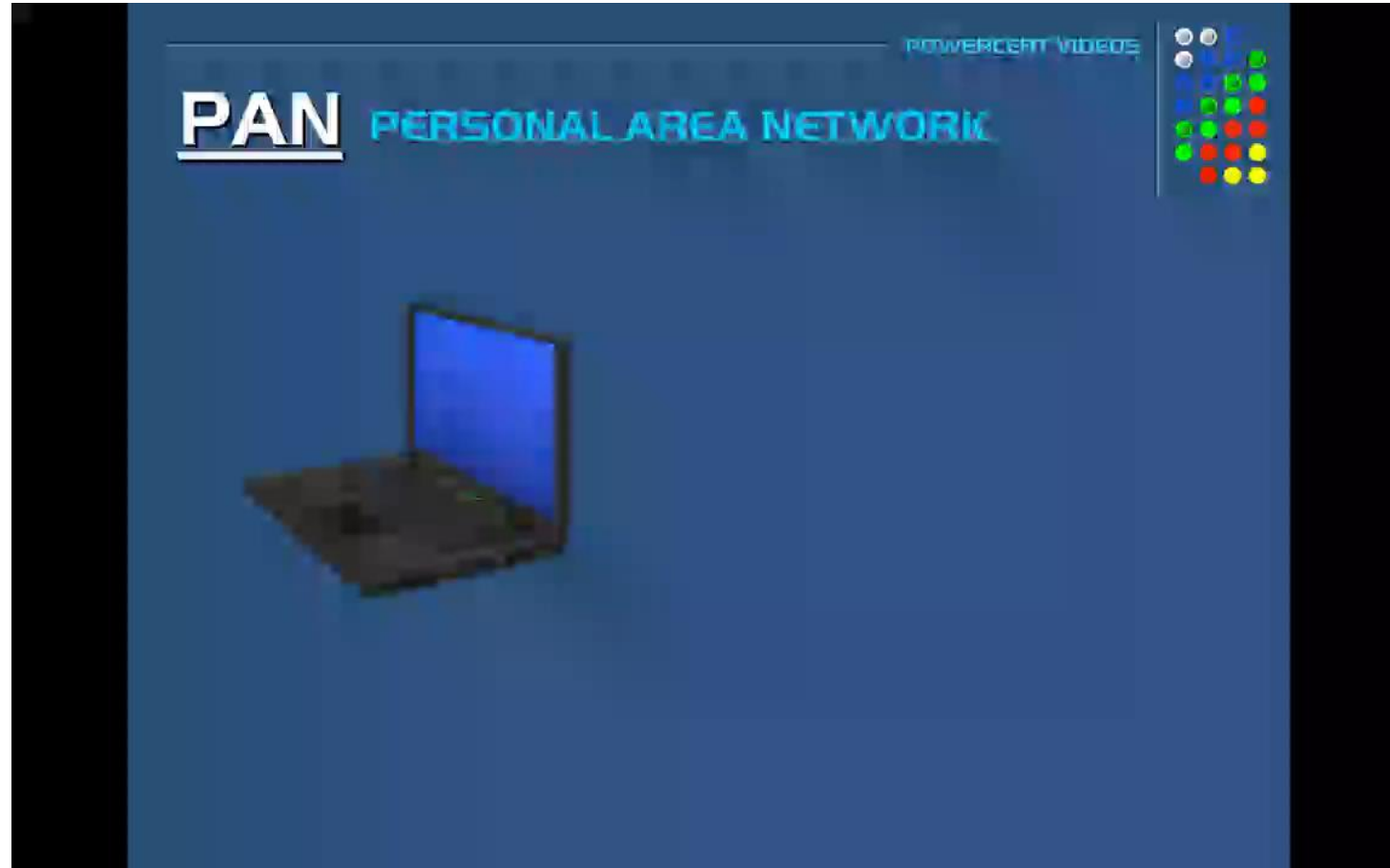
Network Characteristics

- **Bus Network**
 - All network devices are connected to a central cable
 - If bus line fails, the network cannot function
- **Ring Network**
 - Special case of bus network.
- **Mesh Networks**
 - A network in which there are multiple connections between the devices on the network so that data can take any of several paths
- Some networks use a combination of topologies

Network Size and Coverage Area



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Network Characteristics

Network Size and Coverage Area

- **Personal Area Networks (PANs)**
 - Connect an individual's personal devices
 - Personal computer, mobile phone, digital camera
 - Devices must be physically located close together
- **Local Area Networks (LANs)**
 - Connect devices located in a small geographic area
- **Metropolitan Area Networks (MANs)**
 - Cover a metropolitan area such as a city or county
- **Wide Area Networks (WANs)**
 - Cover a large geographic area
 - Two or more LANs connected together

Network Characteristics

Intranets and Extranets

Intranet

- Private network designed to be used by an organizations' employees
- Set up like the Internet

Extranet

- Network that is accessible by authorized outsiders

– Virtual Private Networks (VPNs)

- Secure path over the Internet that provides authorized users a secure means of accessing a private network via the Internet
- Uses tunneling and special encryption technology

SO WHAT

Data Transmission Characteristics

- **Bandwidth**

- The amount of data that can be transferred in a given period of time
- Measured in bits per second (bps), Kbps (thousands), Mbps (millions), or Gbps (billions)

- **Analog vs. Digital Signals**

- Most data is sent using digital signals
 - Data represented by two discrete states: 0s and 1s
- Conventional telephone systems use analog signals
 - Represent data with continuous waves



ANALOG SIGNALS



DIGITAL SIGNALS

Data Transmission Characteristics

Transmission Type and Timing

– Serial vs. Parallel Transmission

- **Serial**

- Data sent one bit at a time, one after another, along a single path

- **Parallel**

- Data sent at least one byte at time with each bit in the byte taking a different path

01000001 →

SERIAL TRANSMISSIONS

All the bits in one byte follow one another over a single path.



PARALLEL TRANSMISSIONS

The eight bits in each byte are transmitted over separate paths at the same time.

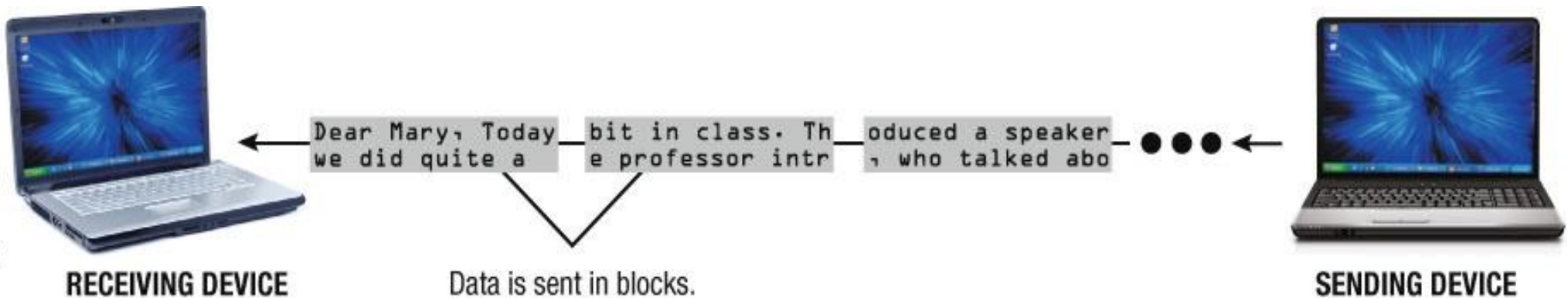
Data Transmission Characteristics

– Synchronous Transmissions

- Blocks of data are transferred at regular, specified intervals
- Most data transmissions within a computer and over a network are synchronous

SYNCHRONOUS TRANSMISSIONS

Data is sent in blocks and the blocks are timed so that the receiving device knows when they will arrive.



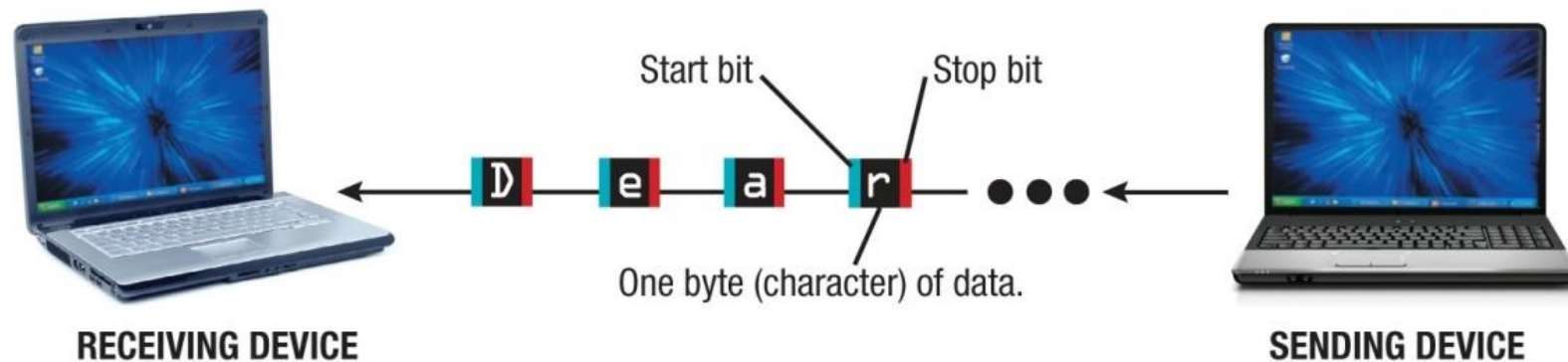
Data Transmission Characteristics

– Asynchronous Transmission

- Data is sent when ready without being synchronized
- Start bits and stop bits used to identify the bits that belong in each byte

ASYNCHRONOUS TRANSMISSIONS

Data is sent one byte at a time, along with a start bit and a stop bit.



Data Transmission Characteristics

Another distinction between types of transmissions is the direction in which transmitted data can move.

– Simplex Transmission

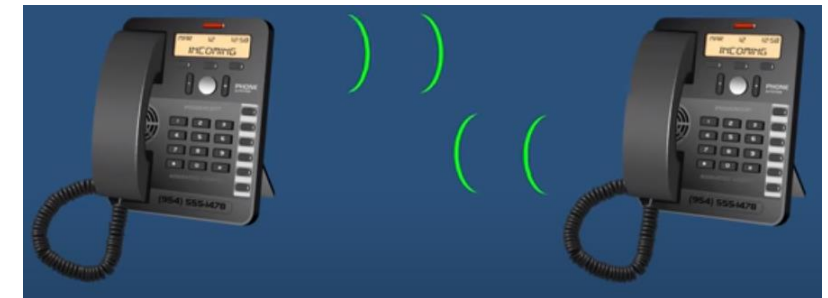
- Data travels in a single direction only

– Half-Duplex Transmission

- Data travels in either direction but only one way at a time

– Full-Duplex Transmission

- Data travels in both directions, both ways at the same time



Data Transmission Characteristics

Delivery Method

– Circuit-Switching

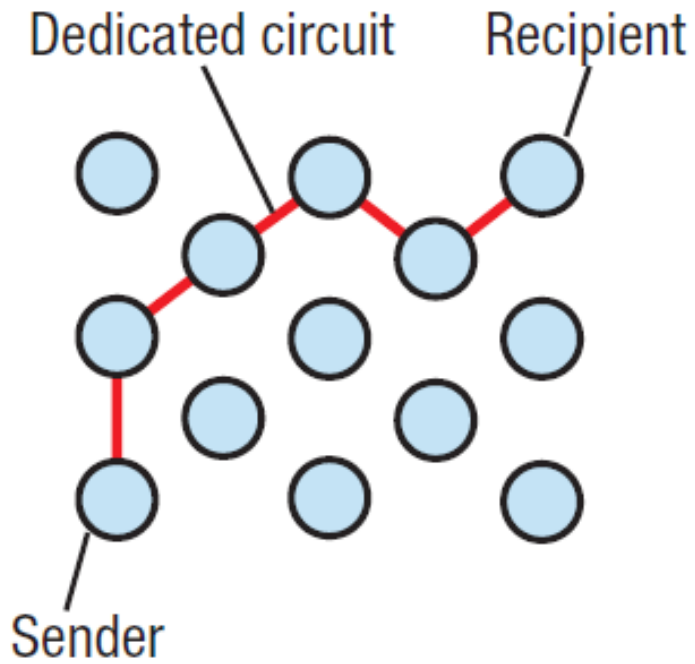
- Dedicated path over a network is established between sender and receiver and all data follows that path

– Packet-Switching

- Messages are separated into small units called packets and travel along the network separately
- Used to send data over the Internet

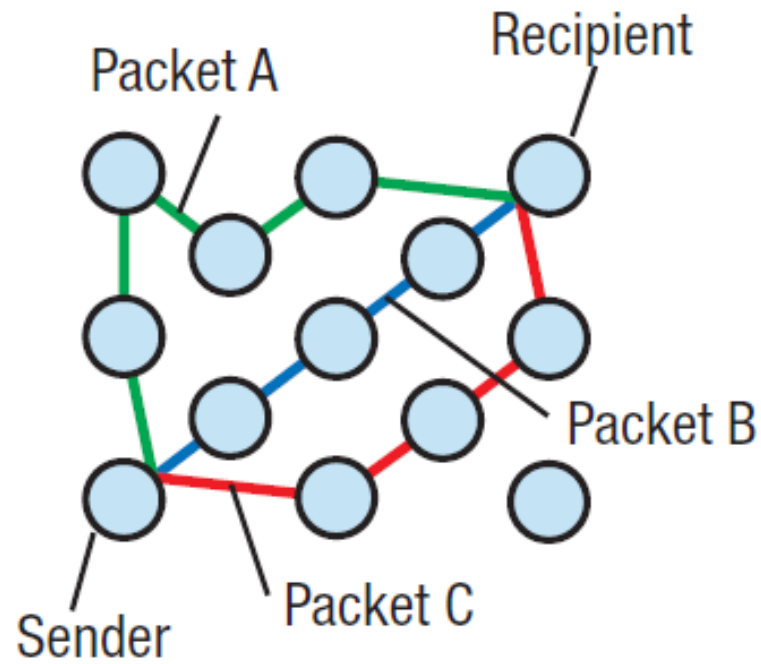
– Broadcasting

- Data is sent out to all other nodes on the network and retrieved only by the intended recipient
- Primarily used with LANs



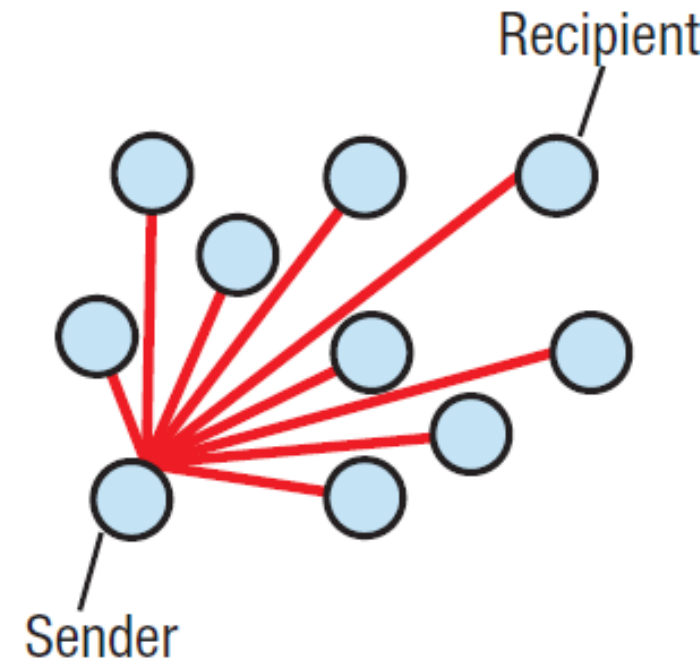
CIRCUIT-SWITCHED NETWORKS

Data uses a dedicated path from the sender to the recipient.



PACKET-SWITCHED NETWORKS

Data is sent as individual packets, which are assembled at the recipient's destination.



BROADCAST NETWORKS

Data is broadcast to all nodes within range; the designated recipient retrieves the data.

Networking Media

Wired Networking Media

– Twisted-Pair Cable

- Pairs of insulated wires twisted together
- Used for telephone and network connections (LANs)

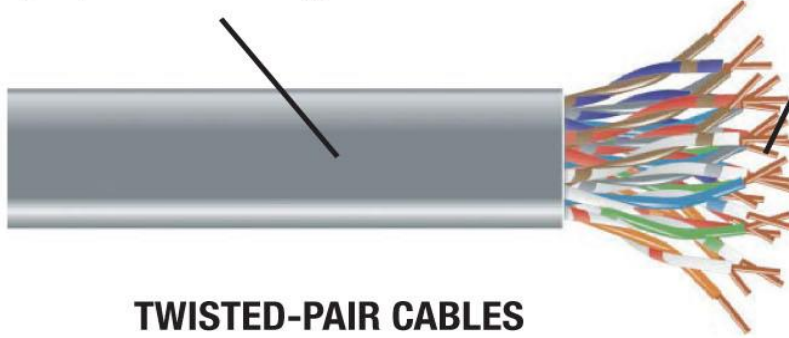
– Coaxial Cable

- Thick center wire surrounded by insulation
- Used for computer networks and cable television delivery

– Fiber-Optic Cable

- Utilizes hundreds of thin transparent clear glass or plastic fibers over which lasers transmit data as light
- Used for high-speed communications

The entire cable is covered by a plastic covering.



Pairs of copper wires are insulated with a plastic coating and twisted together; most cables contain at least two pairs.

TWISTED-PAIR CABLES



The entire cable is covered by a plastic covering.



Outer conductor is made out of woven or braided metal.

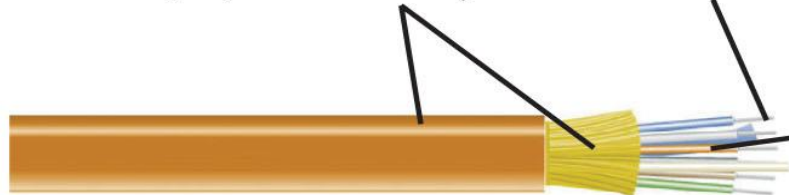
White insulating material surrounds the copper wire.

The innermost part of the cable is a single copper wire.

COAXIAL CABLES



The entire cable is surrounded by strengthening material and covered by a plastic covering.



The core of each fiber is a single glass or plastic tube, which is surrounded by a reflective cladding.

A protective plastic coating protects each fiber; a cable contains multiple fibers.

FIBER-OPTIC CABLES



Communications Protocols and Networking Standards

- **Protocol**

- A set of rules for a particular situation
- Communications Protocol
 - A set of rules that determine how devices on a network communicate

- **Standard**

- A set of criteria or requirements approved by a recognized standards organization
- Networking Standards
 - Address how networked computers connect and communicate
- Needed to ensure products can work with other products

Communications Protocols and Networking Standards

TCP/IP and Other Communications Protocols

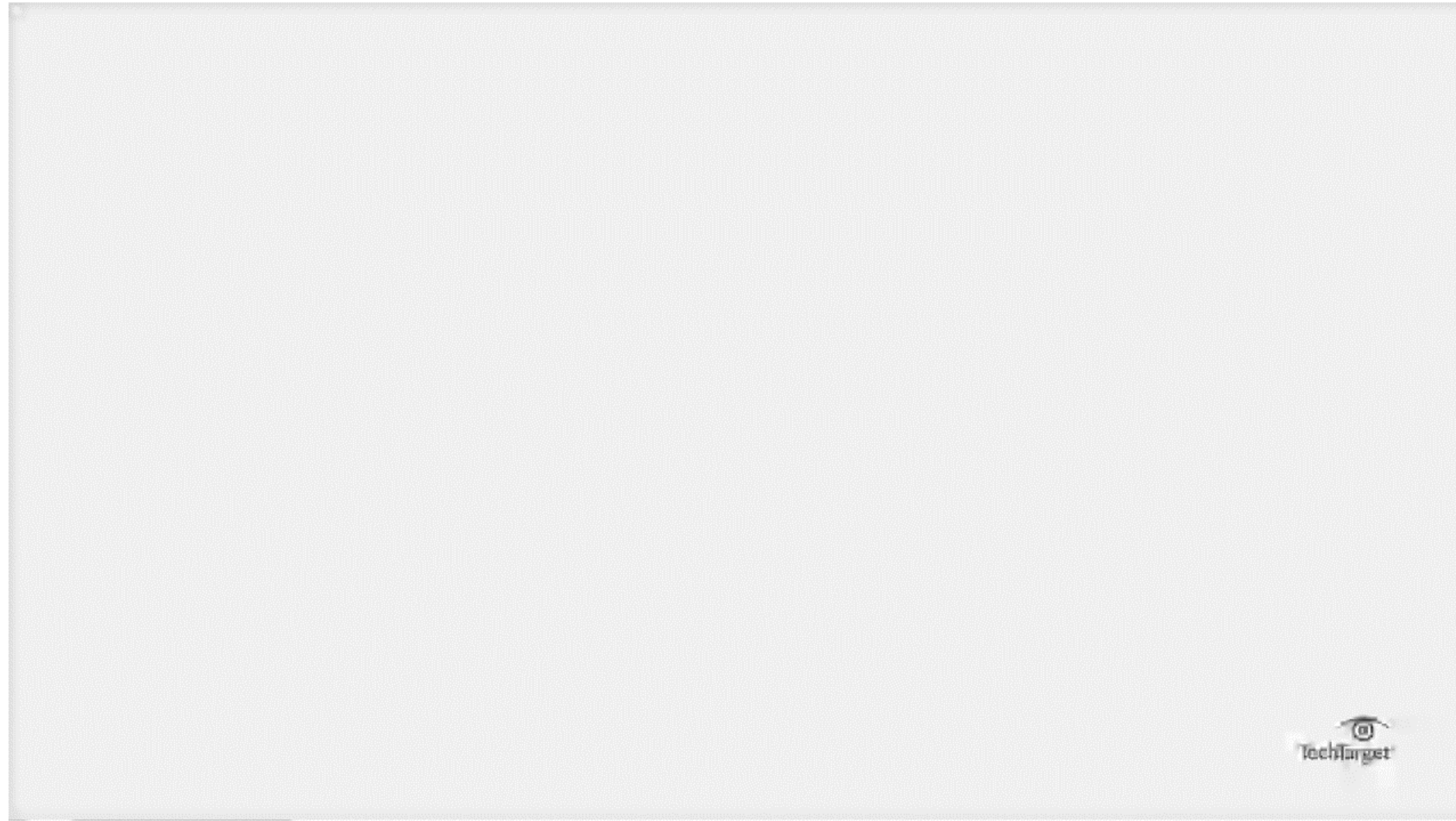
- Most widely used communications protocol
- Consists of two protocols
 - Transmission Control Protocols (TCP)
 - Responsible for delivery of data
 - Internet Protocols (IP)
 - Provides addresses and routing information
- Uses packet switching to transmit data
- TCP/IP support is built into almost all operating systems and IP addresses are used to identify computers and devices on networks

TCP/IP



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Communications Protocols and Networking Standards

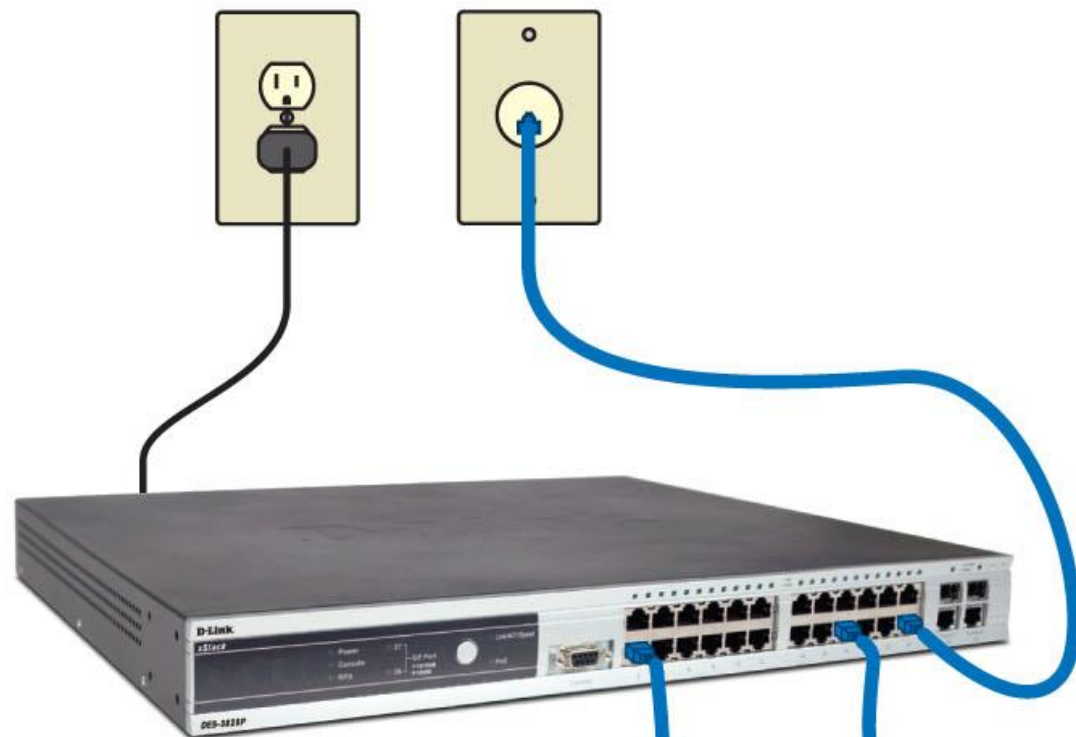
Ethernet (802.3)

- Most widely used standard for wired networks
- Typically used with LANs
- Works with twisted-pair, coaxial, and fiber-optic cabling
- Continually evolving
- Most common today are Fast Ethernet, Gigabit Ethernet, 10 Gigabit Ethernet, 40 Gigabit Ethernet, 100 Gigabit Ethernet, 400 Gigabit Ethernet.

Communications Protocols and Networking Standards

Power over Ethernet (PoE)

- Allows electrical power to be sent along the cables on an Ethernet network along with data
- Can be used to supply power to network devices
- Most often used in business networks with remote wired devices
- Requires special hardware and devices designed for PoE
- Eliminates the need for power outlets in that portion of the network



PoE SWITCH



PoE CAMERA



PoE ADAPTER



**NON-PoE
OUTDOOR
WIRELESS
ACCESS POINT**



Communications Protocols and Networking Standards

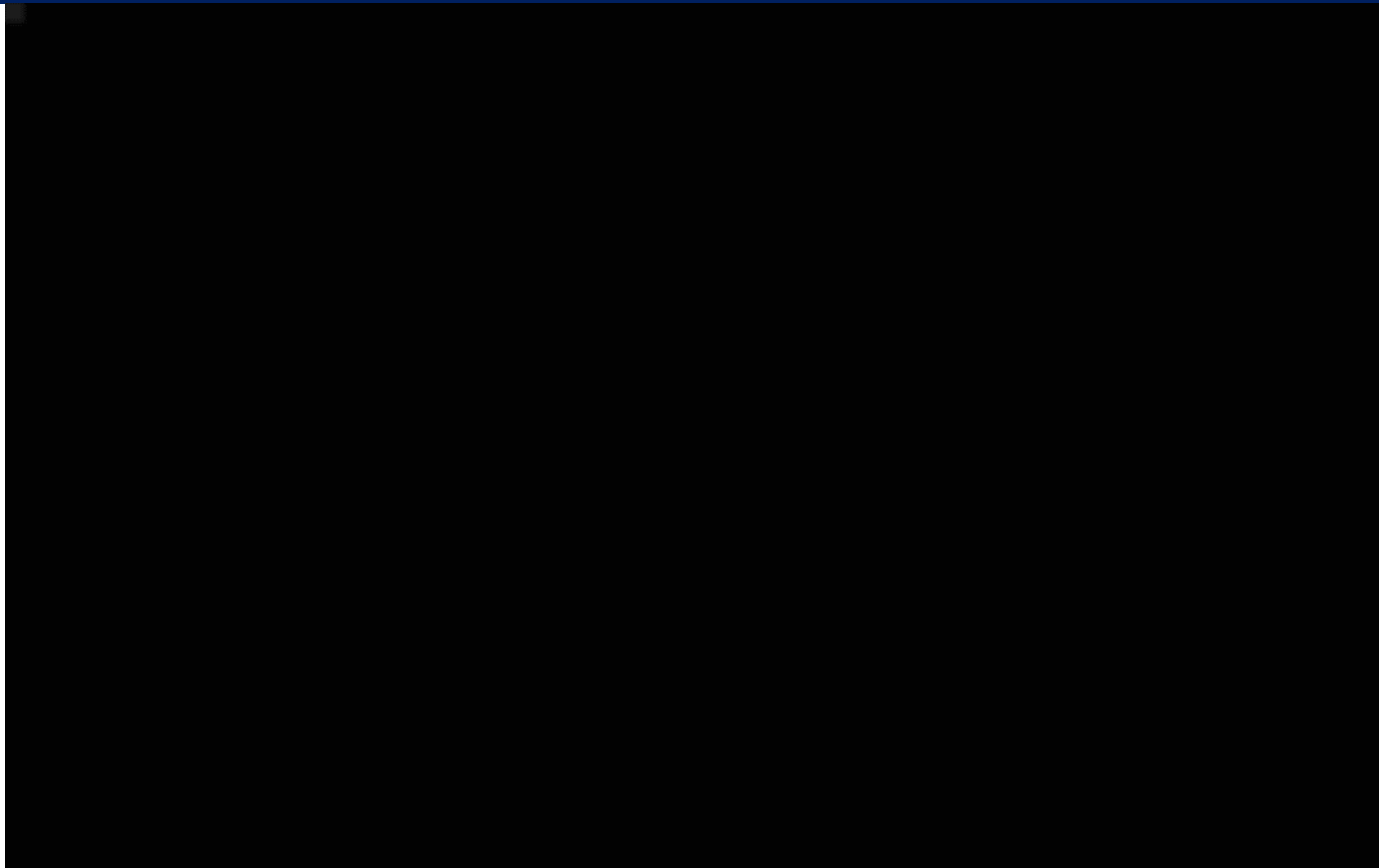
Phoneline, Powerline.

- Phoneline
 - Allows networking via ordinary telephone wiring
- Powerline
 - Allows networking via ordinary electrical outlets
 - For wired home networks, Phoneline and Powerline are alternatives to Ethernet

Powerline



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Communications Protocols and Networking Standards

Wi-Fi (802.11)

- A family of wireless networking standards using the IEEE standard 802.11
- Current standard for wireless networks in homes and offices
- Designed for medium-range transmission
- Wi-Fi hardware built into most portable computers and many consumer devices
- Integrated into printers, digital cameras, e-book readers, televisions, etc.



Courtesy of Motorola

MOBILE TABLETS



Courtesy of Logitech

MUSIC PLAYERS



Courtesy of Sony Electronics Inc.

BLU-RAY DISC PLAYERS

Communications Protocols and Networking Standards

- Most widely used standards today are 802.11g and 802.11n
 - 802.11n standard is the fastest
- Wi-Fi Alliance
 - Certifies that hardware from various vendors will work together
- Wi-Fi has a limited range
- Many businesses may be physically
 - Too large for Wi-Fi to cover the entire organization



Communications Protocols and Networking Standards

WI-FI STANDARD	DESCRIPTION
802.11b	An early Wi-Fi standard; supports data transfer rates of 11 Mbps.
802.11a	Supports data transfer rates of 54 Mbps, but uses a different radio frequency (5 GHz) than 802.11b/g (2.4 GHz), making the standards incompatible.
802.11g	A current Wi-Fi standard; supports data transfer rates of 54 Mbps and uses the same 2.4 GHz frequency as 802.11b, so their products are compatible.
802.11n	A current Wi-Fi standard; supports speeds up to about 300 Mbps and has twice the range of 802.11g. It can use either the 2.4 GHz or 5 GHz frequency.
802.11ac	The newest Wi-Fi standard expected to be ratified in 2014; supports speed up to about three times faster than 802.11n and uses the 5 GHz frequency (though virtually all 802.11ac routers also support 2.4 GHz devices for backward compatibility).

Communications Protocols and Networking Standards

Cellular Standards

- First Generation
 - Analog and voice only
- 2G (Second Generation)
 - Digital, both voice and data, faster
- 3G (Third Generation)
 - Current standard with speeds between 1 and 4 Mbps
- 4G (Fourth Generation)
 - Current standard with speeds between 3 and 15 Mbps
 - Service is four to ten times faster than 3G
- 5G (Fifth Generation)
 - Download speed up to 10 gigabits per second (Gbit/s).
 - 5G has higher bandwidth and can thus connect more different devices

Communications Protocols and Networking Standards

Bluetooth and Wi-Fi Direct

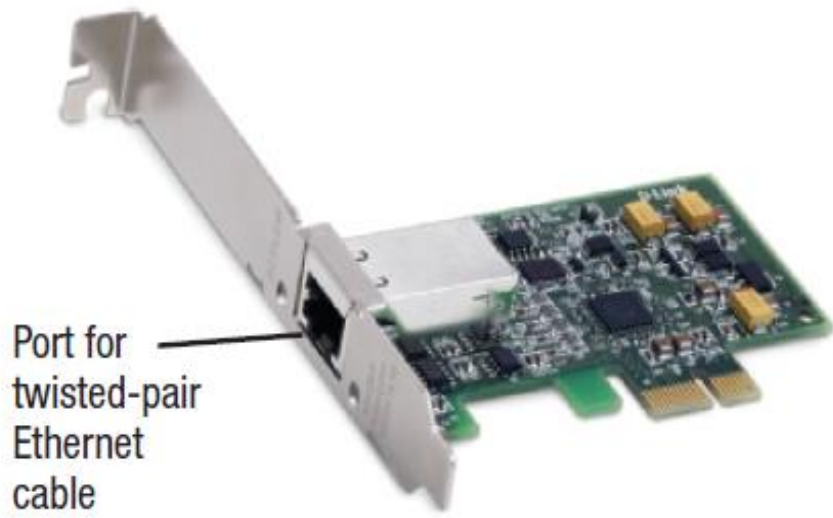
- *Bluetooth 4.0* has a range up to 200 feet
- Used for communication between computers or mobile devices and peripheral devices
- Works using radio signals in the frequency band of 2.4 GHz, the same as Wi-Fi
- Wi-Fi Direct
 - New standard that allows Wi-Fi devices to connect directly to each other—no router or access point required
 - Competitor to Bluetooth

Networking Hardware

- Network Adapters and Modems
 - Network Adapters used to connect a computer to a network and Internet
 - Also called network interface card (NIC)
 - Are often built into portable computers
 - Adapter must match the type of networking media being used (twisted-pair cabling, coaxial cabling, or wireless signal)

Networking Hardware

- Modems are used to connect a computer to a network via telephone lines
- Converts digital signals (used by computer) to modulated analog signals (used by telephone lines) and vice versa
- Type of modem needed depends on the type of device, network, and Internet access being used
 - Ethernet, Wi-Fi, Cellular



**PCI EXPRESS GIGABIT
ETHERNET ADAPTERS**

Courtesy NETGEAR



**MICRO USB WI-FI
ADAPTERS (802.11N)**

Connects to
USB port



**TRADITIONAL USB WI-FI
ADAPTERS (802.11AC)**

Connects to a
power outlet

Connects to an
Ethernet cable



Connects
to USB port

Courtesy Verizon Wireless



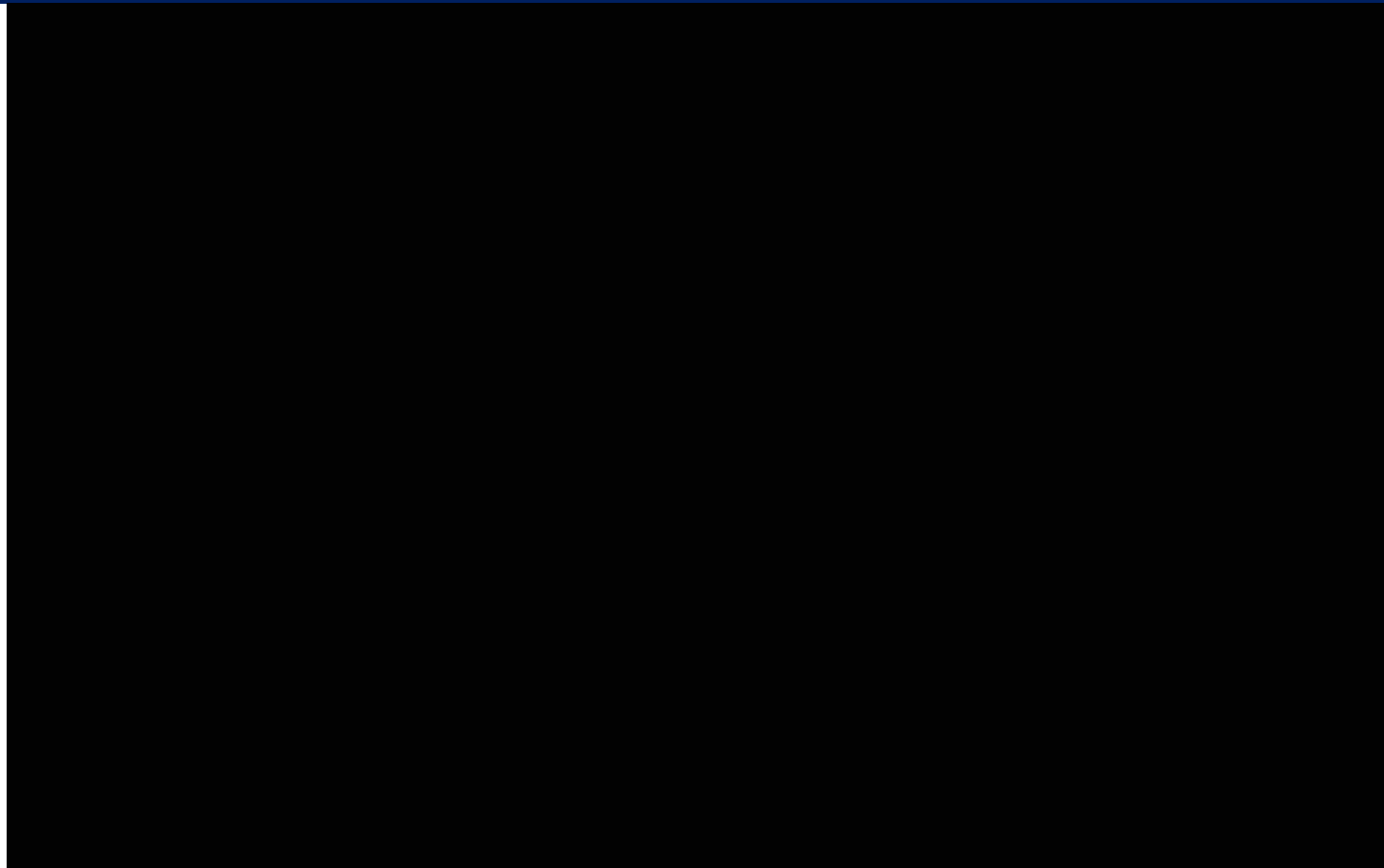
Incoming coaxial cable
from cable provider and
an Ethernet cable coming
from the computer or
router connect to the back
of the modem.



Modem vs Router



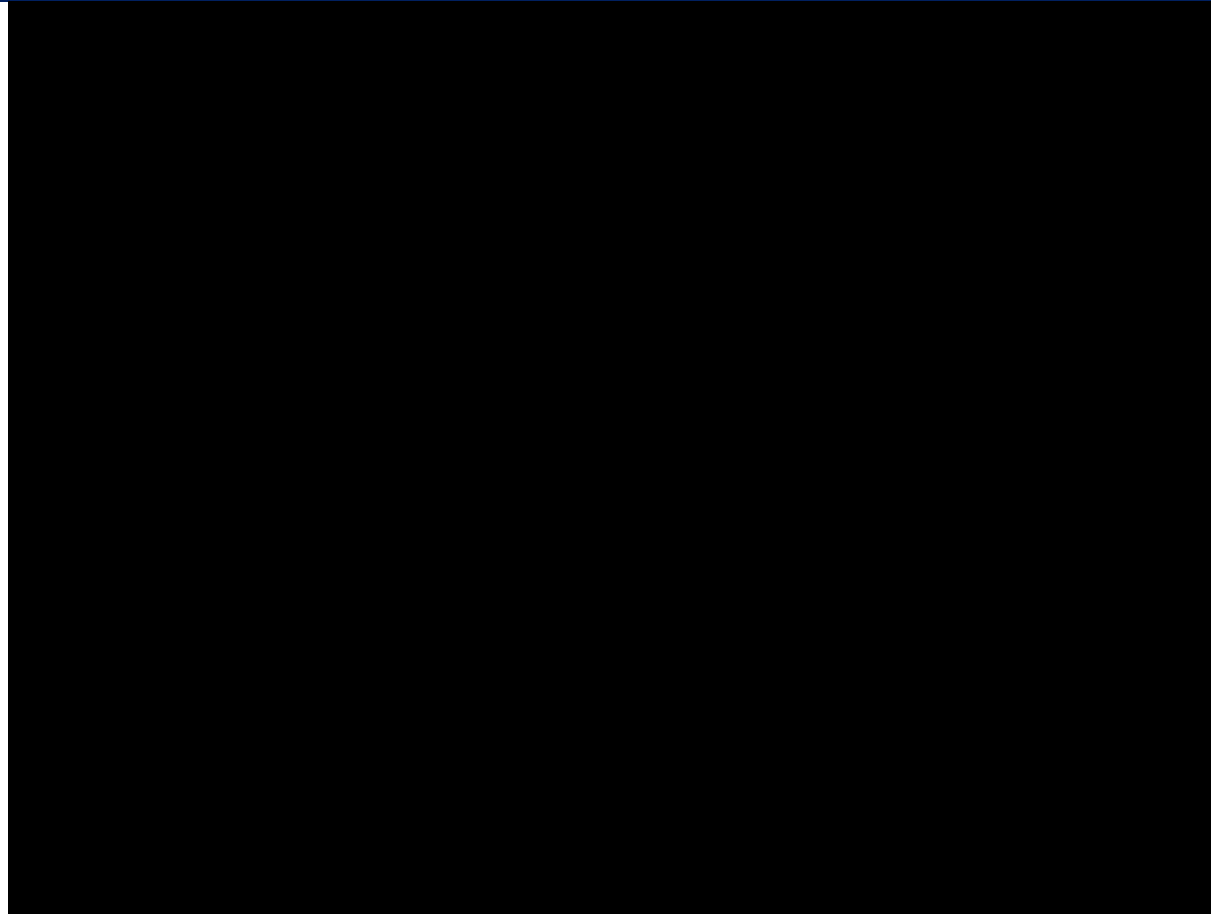
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Hub, Switch, & Router



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Networking Hardware

- Switches, Routers, and Other Hardware for Connecting Devices and Networks
 - Switch
 - Central device that connects devices in a wired network but only sends data to the intended recipient
 - Router
 - Connects multiple networks: two LANs, two WANS, LAN and the Internet
 - Passes data to intended recipient only
 - Routes traffic over the Internet
 - Wireless Access Point
 - Device used to grant network access to wireless client devices

Networking Hardware

–Wireless Router

- Typically connects both wired and wireless devices to a network and connect the network to the Internet
- Integrates a switch, router, a wireless access point



Wired devices can connect here.

Modem providing Internet access connects here.

USB devices (such as a printer or external hard drive) can connect here.

CONVENTIONAL WIRELESS ROUTERS

This 802.11ac router also includes a switch and wireless access point.

Networking Hardware

–Bridge

- Used to connect just two LANs together
- In a home network, wirelessly connects a wired device to the network

–Other Devices

- 3G Mobile Broadband Router used to share a 3G mobile wireless Internet connection with multiple devices

Networking Hardware

Repeaters

- Devices that amplify signals along a network. They are necessary whenever signals have to travel farther than would be otherwise possible over the networking medium being used.
- Repeaters are available for both wired and wireless networks
- Repeaters for a wireless network are often called range extenders.
- Range extenders usually connect wirelessly to the network and repeat the wireless signal to extend coverage of that network outside or to an additional floor of a building, or to eliminate dead spots—areas within the normal network range that don't have coverage.

Networking Hardware

– Antennas

- Devices used for receiving or sending radio signals
- Higher–gain antennas increase the range and speed of a Wi-Fi network and can be used with routers
- Some network adapters can use an external antenna

Summary

- Networking Applications
- Network Characteristics
- Data Transmission Characteristics
- Networking Media
- Communications Protocols and Networking Standards
- Networking Hardware