NETWORKING CONCEPTS

Networking

involves **connecting computers and other electronic devices**, sharing information and resources communication

Fundamentals

Elementary Network

Two computers connected by some kind of transmission medium

Peripheral Device Sharing

Enables users to take advantage of peripherals and other devices attached directly to a network or to a generally available computer attached to a network

Kinds of Network

1. **Personal Area Network (PAN)**
   - **Smallest and most basic type**
   - Made up of wireless modem, a computer or two, other devices and revolves around one person in one building.
   - Typically found in small offices/residences
   - **Two Types:**
     - Wired PAN
     - Wireless PAN

2. **Local Area Network (LAN)**
   - Most frequently discussed, **one of the most common, most original and simplest types.**
   - Connects groups of computers and low-voltage devices together across short distances

3. **Wireless Local Area Network (WLAN)**
   - **Make use of wireless network technology (WI-FI)**
   - Don't require that devices rely on physical cables to connect to network

4. **Campus Area Network (CAN)**
   - Typically seen in **universities, large K-12 school districts or small businesses**
   - Can be spread across several buildings that are fairly close to each other

5. **Metropolitan Area Network (MAN)**
   - Span an **entire geographic area**
   - Ownership and maintenance is handled by either a single person or company

6. **Wide Area Network (WAN)**
    - Connects computers together across **longer physical distances**
    - Allows computers to be remotely connected to each other even when they're miles apart
    - The **Internet** is the most basic example of WAN

7. **Storage-Area Network (SAN)**
    - Move storage resources away from the network and place them into their **own high-performance network.**
    - Can be accessed in the same fashion as a drive attached to a server

8. **System-Area Network (SysAN)**
    - Designed to provide high-speed connection in **server-to-server applications, storage area networks,** and **processor-to-processor applications.**

9. **Passive Optical Local Area Network (POLAN)**
    - Can be integrated into structured cabling to overcome concerns about **supporting traditional ethernet protocols and network applications.**

10. **Enterprise Private Network (EPN)**
    - **Built and owned by businesses** that want to securely connect its various connections to share computer resources

11. **Virtual private Network (VPN)**
    - Lets its users send and receive data **as if their devices were connected to the private network** - even if they're not.

Network Medium

Computers must share access to a network medium to **communicate properly**

Network Protocol

Common **set of rules that allows two computers on a network to communicate** with one another successfully

Network Operating System (NOS)

Determines what **services that computer can offer** or request

Network Services

- **Server Component**
  Provides access to the resource
- **Client Component**
  Requests access to the resource
- **Both components**
  Service

Network Types

2 Major Types:

- Peer-to-Peer
- Client/Server

Peer-to-Peer Networking

- Every user must also act as a **network administrator**

  def. Controls access to the resources on their machines

Server-Based Networks

Makes the most sense for networks with **10 or more users** or any networks where resources are heavily used

Role of Network Servers

- The server is at the **heart of any network** that's too large for a peer-to-peer configuration
- Most large networks with more than a few dozen workstations rely on several network servers

Kinds of Servers

Web Servers

- Is software and hardware that uses HTTP and other protocols to respond to client requests made over the World Wide Web.
- Its main job is to **display website content through storing, processing and delivering web pages to users.**

Application Servers

- **Supply the server side of client/server applications**, and often the data that goes along with them, to network clients
- Designed to **run together with a Web Server.**

Communication Servers

- Provide a mechanism for **users outside a network to access that network's resources**
- Sometimes permit users on a network to access resources outside network's local scope

Domain Controllers/Directory Servers

- Make it possible to **locate, store, and secure information about a network** and its resources

Fax Servers

- **Manage fax traffic** for a network

- Receive incoming faxes via telephone, distribute them to recipients over the network, and collect outgoing faxes across the network before sending them via telephone

File and Print Servers

- Provide basic **network file storage, retrieval services, and access to networked printers**

Mail Servers

- **Handle email messages for users**
- Also commonly provide "store-and-forward" services

NETWORK DESIGN ESSENTIALS

Topology

the **physical layout** of its computers, cables, and other resources, and also to how those components communicate with each other.

Physical Topology

Arrangement of cabling

Logical Topology

The **path** that data travels between computers on a network

Understanding Standard Topologies

Networks are based on **3 Physical Topologies:**

1. **Bus**
   Consists of a series of computers connected along a **single cable segment**
2. **Star**
   Computers connected via a **central concentration point (hub)**
3. **Ring**
   Computers connected to form a **loop**

Fault Tolerance

The property that enables a system to **continue operating properly in the event of the failure** of some of its components.

Graceful Degradation

The ability of **maintaining functionality when portions of a system break down**

Fault-Tolerant Design

Enables a system to **continue its intended operation, possibly at a reduced level,** rather than failing completely, when some part of the system fails.

Signal Propagation

Computers communicate by **sending information across the media as a series of signals**

Signal Bounce

Occurs when a signal is transmitted down a line, reaches a destination, and **gets reflected back to its source.**

Cable Termination

The **connection of the wire or fiber to a device**, such as equipment, panels or a wall outlet, which allows for connecting the cable to other cables or devices.

Cable Failure

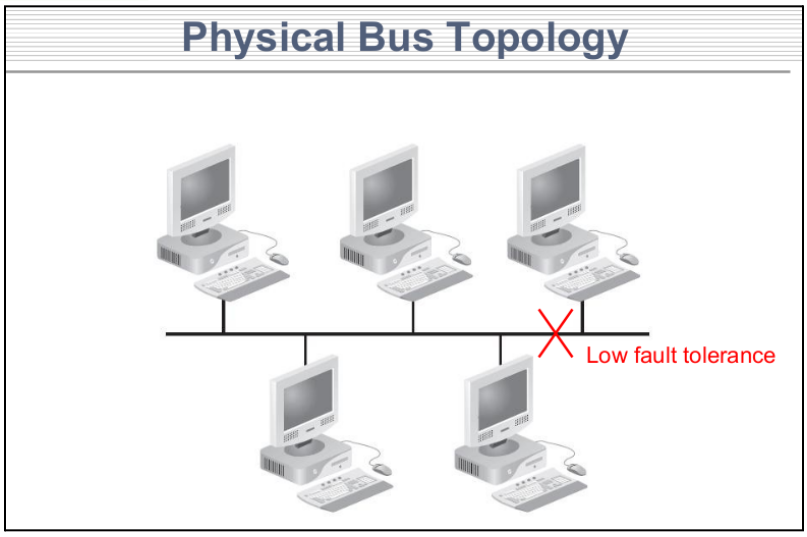
Connectivity issues are **usually caused by a fault in a cable** or its connections at either end.

Bus Topology

A **passive** topology

In an **active topology** network, computers and other devices regenerate signals and are responsible for moving data through the network

Physical Bus Topology



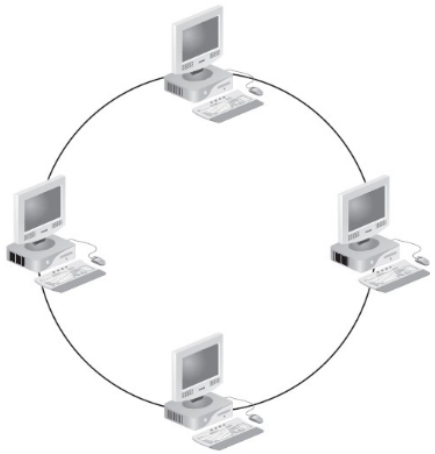
Logical Bus Topology

A physical bus topology is almost always implemented as a logical bus as well

Technology has moved past the physical bus, but a logical bus topology is still in use on some physical topologies, in particular, a star

Physical Ring Topology

A **Ring Network** is a network topology in which each node connects to exactly two other nodes, forming a single continuous pathway for signals through each node - a ring.



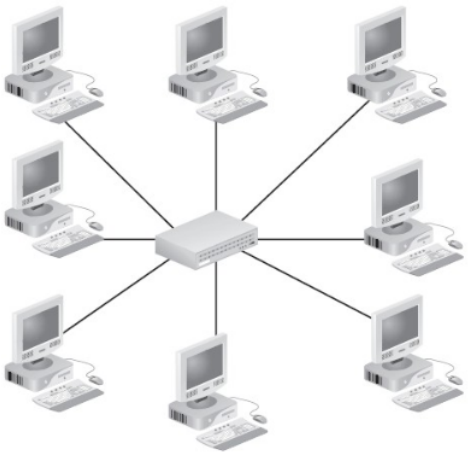
Logical Ring Topology

Data in a logical ring topology travels from one device, or node, on the network to the next device until the data reaches its destination

Token passing is one method for sending data around a ring

Physical Star Topology

The simplest form of the physical star topology consists of multiple cables—one for each network device—attached to a single, central connection device.



Logical Star Topology

Defines how nodes in a network communicate across its physical topology. The logical topology can be considered isomorphic to the physical topology, as vice versa.

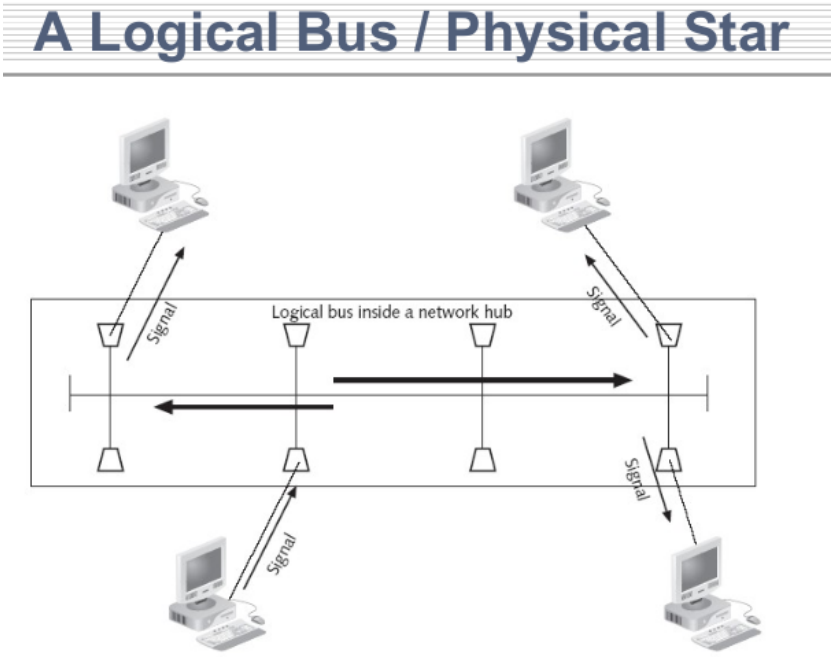


Figure 2-7 A logical bus implemented as a physical star

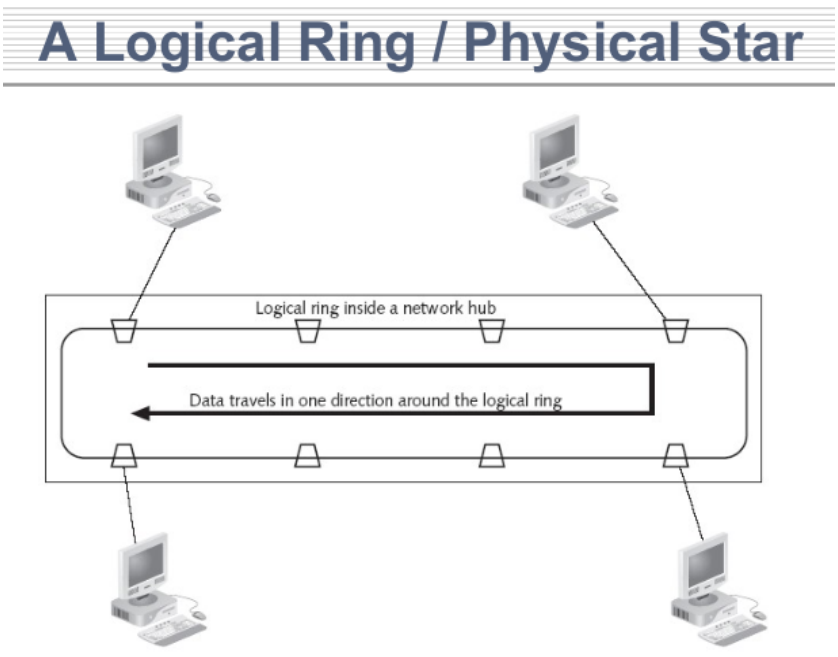


Figure 2-8 A logical ring implemented as a physical star

Wireless Topologies

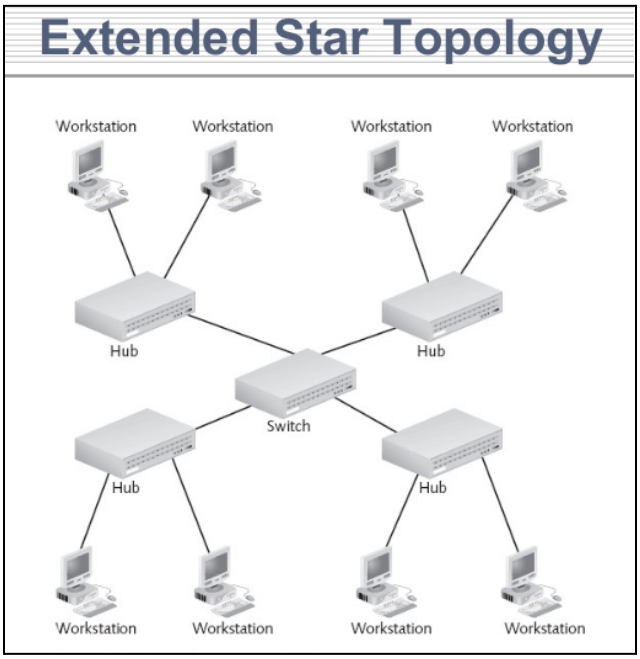
- **Ad hoc topology**
  Two computers can communicate directly with one another; sometimes called a peer-to-peer topology

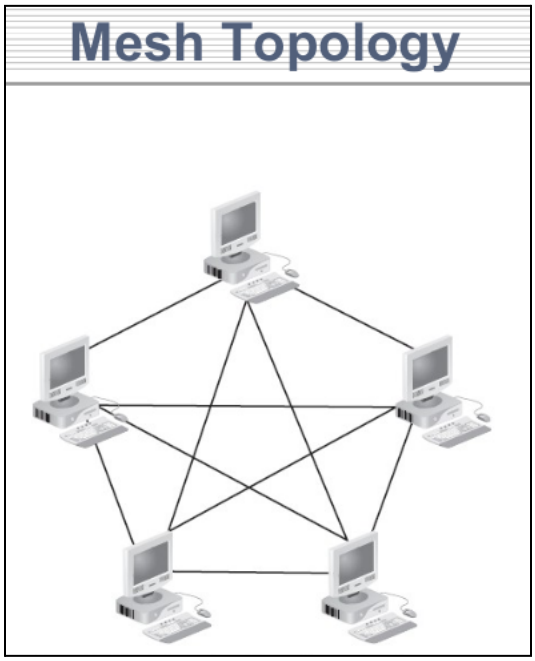
- **Infrastructure mode**
  Use a central device, called an access point (AP), to control communications

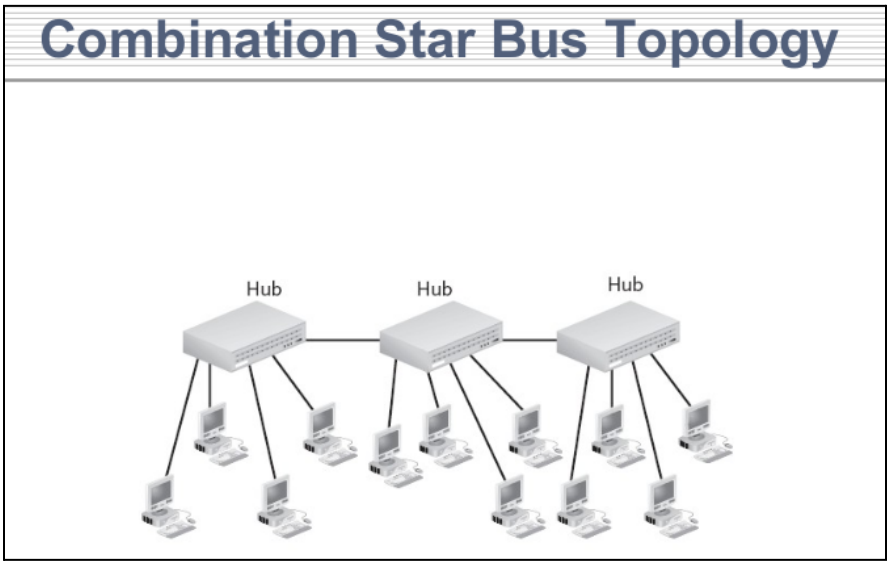
Variations of Physical Topologies

The major physical topologies have **3 typical variations/combinations:**

- Extended star
- Mesh
- Combination star and bus





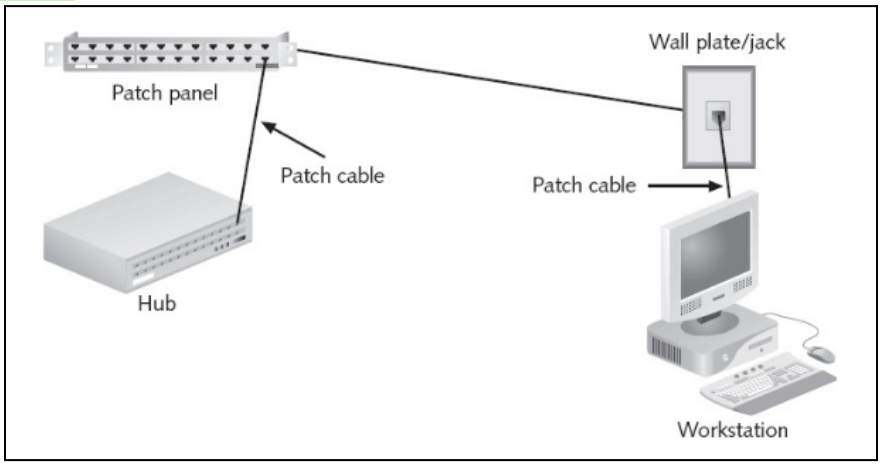


Hubs and Switches

Hubs

In network usage, there are a number of variations on this central theme

- **Active hub**
  - Most common type of hub today
  - Regenerate, or repeat, the signals (requires electrical power to run)
  - Also called multiport repeaters or repeating hubs
- **Passive hub**



- **Repeating hub** (just a type of active hub)
- **Switching hub**

Switches

- Central connecting point in a star topology network
- Does more than simply regenerate signals
- Looks just like a hub, with several ports for connecting workstations in a star topology
- Determines to which port the destination device is connected and forwards the message to that port

NETWORKING MEDIA

Network Cabling

interface between a computer and the medium to which it attaches defines the translation from a computer's native digital information into the form needed to send outgoing messages.

Baseband and Broadband Transmission

Baseband Transmission

Uses a digital encoding scheme at a single fixed frequency, where signals take the form of discrete pulses of electricity or light.

Broadband Transmission

Systems use analog techniques to encode binary 1s and 0s across a continuous range of values.

2 primary approaches:

- Mid-split
- Dual-cable

Primary Cable Examples

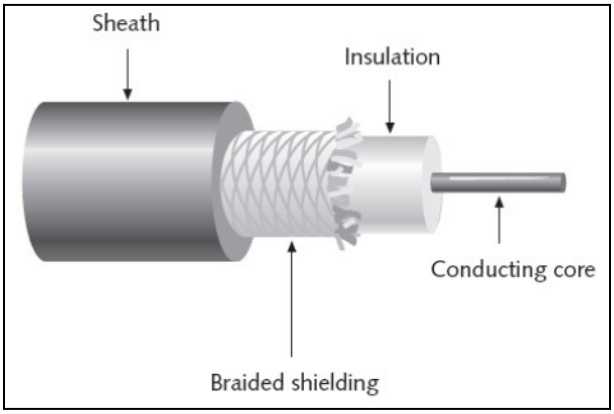
All forms of cabling are similar, in that they provide a medium across which network information can travel in the form of a physical signal, whether electrical or light pulses

Primary cable types:

- Coaxial cable
- Twisted-pair
- Fiber-optic cable

Coaxial Cable

- Was the predominant form of network cabling
- **Shielding:** protective layer(s) wrapped around cable to protect it from external interference
- Less susceptible to interference and attenuation than twisted-pair, but more susceptible than fiber-optic

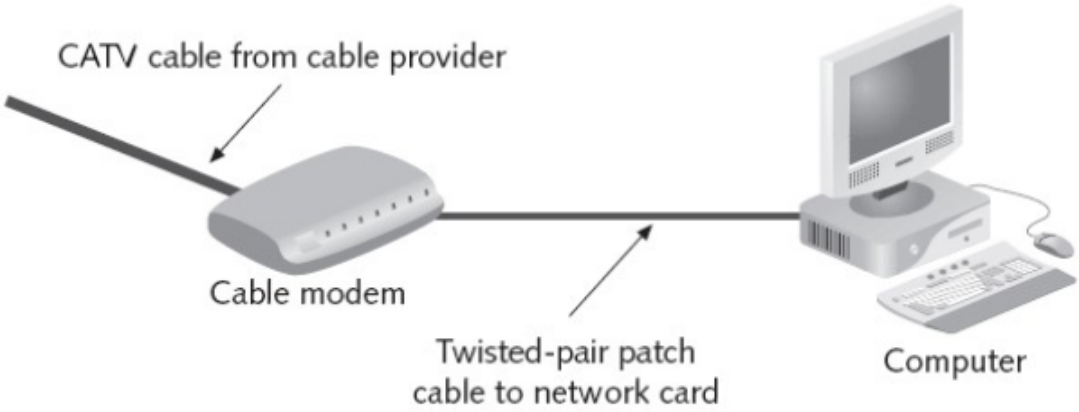


The Use of Coaxial Cable for Ethernet

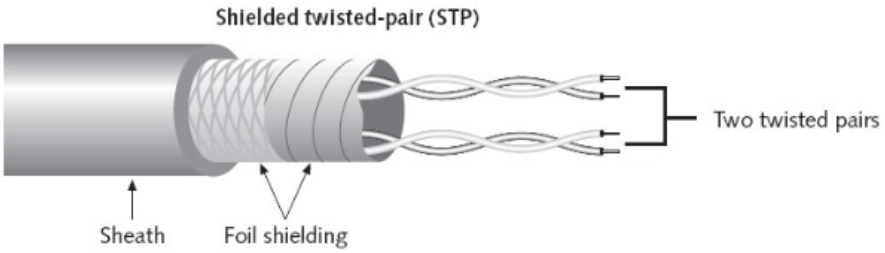
- Ethernet's beginnings are in coaxial cable
  - First, it was run on a very thick, rigid cable, usually yellow, referred to as thicknet (10Base5)
  - Later, a more manageable coaxial cable called thinnet (10Base2) was used
- 10Base5 is an IEEE designation
  - 10 Mbps
  - Baseband
  - Maximum segment length is 500 meters

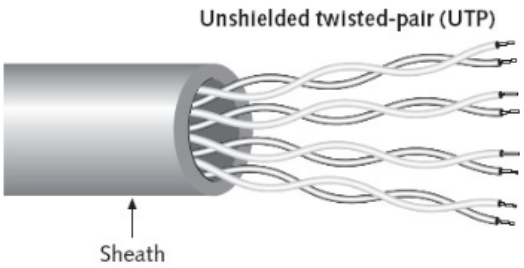
Coaxial Cable in Cable Modem Applications

The standard cable (75 ohm, RG-6; RG stands for —radio gradeǁ) that delivers cable television (CATV) to millions of homes nationwide is also being used for Internet access



Twisted-Pair Cable





Unshielded Twisted Pair (UTP)

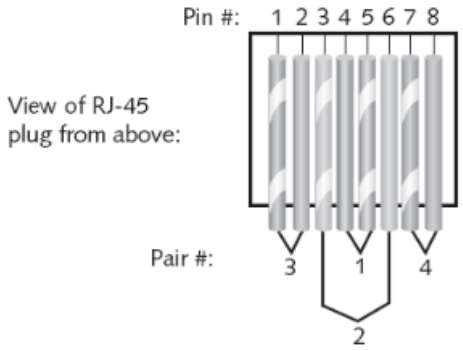
- 10BaseT
  - Maximum length is 100 meters
- Used for networking usually includes one or more pairs of insulated wires

Shielded Twisted Pair (STP)

- Shielding reduces crosstalk and limits external interference

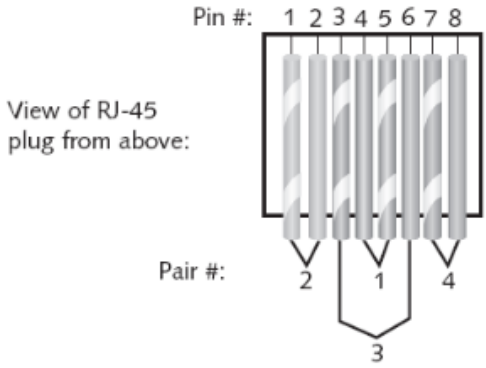
Making Twisted-Pair Connections

First End



Pin #	Color	Pair #	Function
1	White with green stripe	3	Transmit +
2	Green	3	Transmit -
3	White with orange stripe	2	Receive +
4	Blue	1	Unused
5	White with blue stripe	1	Unused
6	Orange	2	Receive -
7	White with brown stripe	4	Unused
8	Brown	4	Unused

Last End



Pin #	Color	Pair #	Function
1	White with orange stripe	2	Transmit +
2	Orange	2	Transmit -
3	White with green stripe	3	Receive +
4	Blue	1	Unused
5	White with blue stripe	1	Unused
6	Green	3	Receive -
7	White with brown stripe	4	Unused
8	Brown	4	Unused

Fiber Optic Cable

Installation of fiber-optic networks is more difficult and time-consuming than copper media installation

Two Types

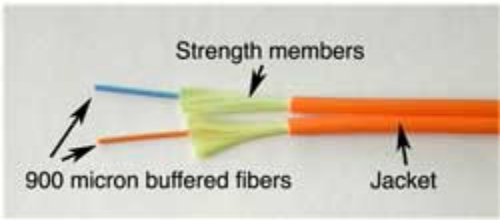
- **Single-mode**
  costs more and generally works with laser-based emitters, but spans the longest distances
- **Multimode**
  costs less and works with light emitting diodes (LEDs), but spans shorter distances

Fiber-Optic Connectors

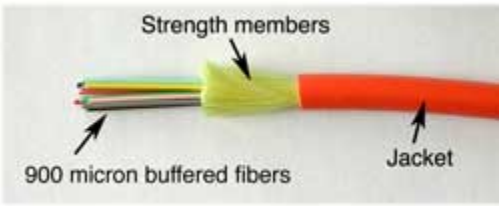
- SC connector
- ST connector
- MT-RJ connector
- LC connector

Fiber-Optic Cable Types

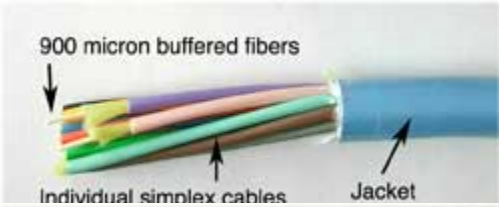
- **Simplex and zip cord**
  - used mostly for patch cord and backplane applications, but zipcord can also be used for desktop connections.



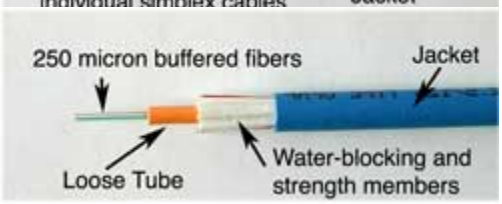
- **Distribution cables**
  - the most popular indoor cable, as it is small in size and light in weight.
  - used for short, dry conduit runs, riser and plenum applications.



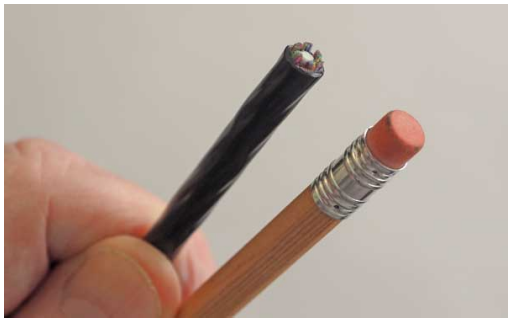
- **Breakout cables**
  - strong, rugged design, but is larger and more expensive than the distribution cables.
  - perfect for industrial applications where ruggedness is needed.



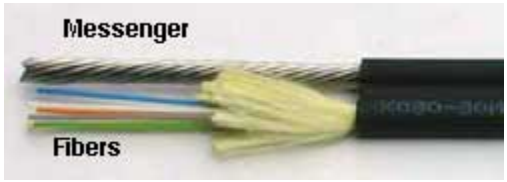
- **Loose tube cables**
  - most widely used cables for outside plant trunks because it offers the best protection for the fibers under high pulling tensions and can be easily protected from moisture with water-blocking gel or tapes.



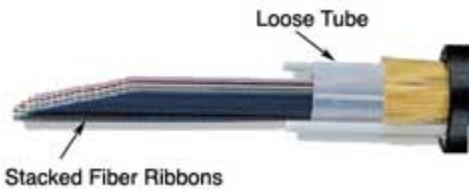
- **Micro cables**
  - a new class of cables that are very high density cables.
  - bend insensitive fiber allows fibers to be packed into cables with much higher density since the fibers are not as sensitive to the stress caused by the crowded fibers.



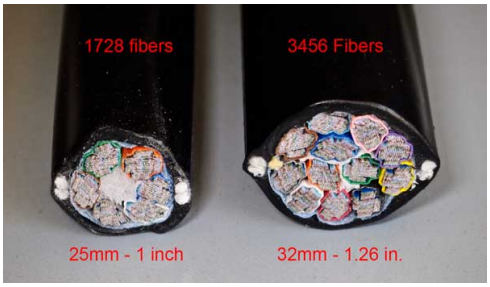
- **Aerial cable**
  - for outside installation on poles.
  - can be lashed to a messenger or another cable or have metal or aramid strength members to make them self supporting.



- **Ribbon cable**
  - more flexible and allow ribbon cables of new construction types, including rolled up ribbons in loose tubes instead of hard ribbons that have to be stacked up and can bend in only one direction.



- **High Fiber Count cables**
  - very high density and often use regular or flexible ribbons
  - primarily used for short runs in data centers or metropolitan areas.



Fiber Color Codes

Fiber Number	Color
1	Blue
2	Orange
3	Green
4	Brown
5	Slate
6	White
7	Red
8	Black
9	Yellow
10	Violet
11	Rose
12	Aqua

Wireless Networking: Intangible Media

Wireless technologies continue to play an increasing role in all kinds of networks
Since **1990**, the number of wireless options has increased, and the cost continues to decrease.

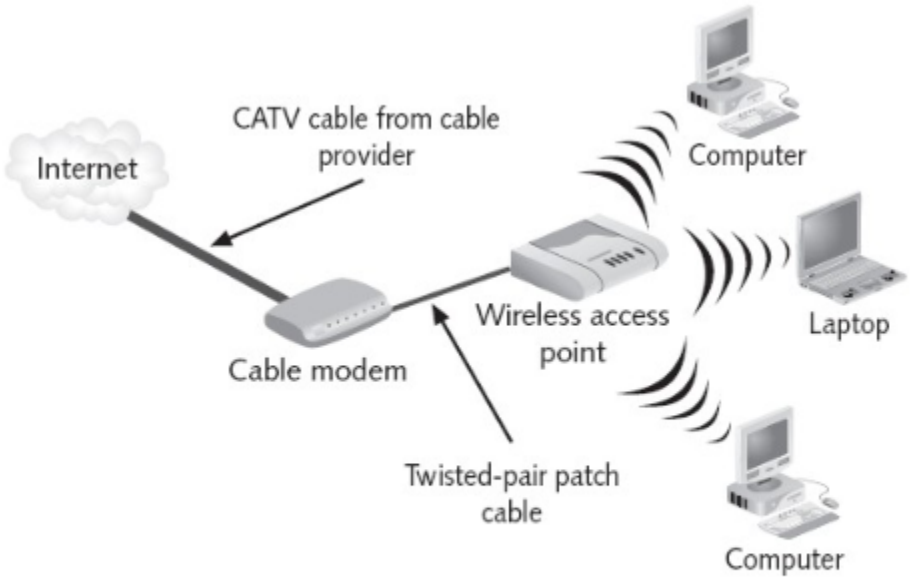


Figure 3-12 A typical home wireless network

Types of Wireless Networks

3 Main Categories

- Local Area Networks
- Extended LANs
- Mobile computing

Wireless LAN Components

- NIC attaches to an **antenna** and an **emitter**
- A **transceiver (**transmitter/receiver) or an access point, must be installed to translate between the wired and wireless networks
- An **access point device** includes an antenna and a transmitter to send and receive wireless traffic, but also connects to the wired side of the network

Wireless LAN Transmission

Wireless LANs make use of **4 primary technologies** for transmitting and receiving data

- Infrared
- Laser

- Narrowband (single-frequency radio)
- Spread-spectrum radio

Infrared LAN Technologies

Infrared light beams send signals between pairs of devices

4 Main Kinds of Infrared LANs

- Line of sight networks
- Reflective wireless networks
- Scatter infrared networks
- Broadband optical telepoint networks

Laser-Based LAN Technologies

- Laser-based transmissions also require a clear line of sight between sender and receiver
- Any solid object or person blocking a beam blocks data transmissions
- To protect people from injury and avoid excess radiation, laser-based LAN devices are subject to many of the same limitations as infrared

Narrowband Radio LAN Technologies

Table 3-4 Narrowband wireless LAN characteristics

Characteristic	Value
Frequency ranges	Unregulated: 902–928 MHz, 2.4 GHz, 5.72–5.85 GHz
Maximum distance	50–70 m (164–230 ft.)
Bandwidth	1–10 Mbps
Installation and maintenance	Easy to install and maintain
Interference	Highly susceptible
Cost	Moderate
Security	Highly susceptible to eavesdropping within range

Table 3-5 High-powered single-frequency LAN characteristics

Characteristic	Value
Frequency ranges	Unregulated: 902–928 MHz, 2.4 GHz, 5.72–5.85 GHz
Maximum distance	Line of sight, unless extension technologies are used
Bandwidth	1–10 Mbps
Installation and maintenance	Difficult, highly technical, requires licensing
Interference	Highly susceptible
Cost	Expensive to very expensive
Security	Highly susceptible to eavesdropping

Spread-Spectrum LAN Technologies

Table 3-6 Spread-spectrum LAN characteristics

Characteristic	Value
Frequency ranges	Unregulated: 902–928 MHz or 2.4 GHz
Maximum distance	Limited to cell boundaries but often extends over several miles
Bandwidth	1–2 Mbps for frequency hopping, 2–6 Mbps for direct-sequence modulation
Installation and maintenance	Depends on equipment; ranges from easy to difficult
Interference	Moderately resistant
Cost	Inexpensive to moderate
Security	Not very susceptible to eavesdropping

802.11 Wireless Networking

- also referred to as **Wireless Fidelity (Wi-Fi)**
- promises to make wireless networking commonplace in homes and corporate environments

Wireless Extended LAN Technologies

Table 3-7 Wireless extended LAN characteristics

Characteristic	Value
Frequency ranges	Spread-spectrum, infrared, laser
Maximum distance	1–3 miles for short-range, up to 25 miles for long-range
Bandwidth	1–6 Mbps for spread-spectrum, 2–100 Mbps for infrared and laser
Installation and maintenance	Depends on equipment; ranges from easy to difficult
Interference	Highly resistant
Cost	Inexpensive to moderate
Security	Not very susceptible to eavesdropping

Wireless MAN: The 802.16 Standard

One of the latest wireless standards, 802.16 **Worldwide Interoperability for Microwave Access (WiMax)**, comes in two flavors:

- **802.16-2004** (previously named 802.16a), or fixed WiMax
  - used to deliver wireless Internet access to entire metropolitan areas rather than the limited-area hotspots available with 802.11
  - can blanket an area up to a mile in radius
- **802.16e**, or mobile WiMax
  - promises to bring broadband Internet roaming to the public

- allow users to roam from area to area without losing the connection, which offers mobility much like cell phone users enjoy

Microwave Networking Technologies

Table 3-8 Terrestrial microwave LAN/WAN characteristics

Characteristic	Value
Frequency ranges	4–6 GHz or 21–23 GHz
Maximum distance	Typically 1–50 miles
Bandwidth	1–10 Mbps
Installation and maintenance	Difficult
Interference	Varies depending on power and distance; longer distances are more prone to weather disturbances
Cost	Expensive
Security	Highly susceptible, but signals are usually encrypted

Table 3-9 Satellite microwave WAN characteristics

Characteristic	Value
Frequency ranges	11–14 GHz
Maximum distance	Global reach
Bandwidth	1–10 Mbps
Installation and maintenance	Prohibitively difficult
Interference	Prone to EM interference, jamming, atmospheric disturbances
Cost	Prohibitive
Security	Not very susceptible to eavesdropping