Lecture 4

LAN cabling

Objectives

- Identify general cabling characteristics applied to physical media
- Describe the primary cable types used in networking
- Identify the components in a structured cabling installation

Network Cabling: Tangible Physical Media

- The 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
  - Because all media must support the basic tasks of sending and receiving signals, you can view all networking media as doing the same thing; only the methods vary
  - You need to know the physical characteristics and limitations of each kind of network media so that you can make the best use of each type
    - Each has a unique design and usage, with associated cost, performance, and installation criteria

General Cable Characteristics

- The following characteristics apply network cabling:
  - Bandwidth rating
  - Maximum segment length
  - Maximum number of segments per internetwork
  - Maximum number of devices per segment
  - Interference susceptibility
  - Connection hardware
  - Cable grade
  - Bend radius
  - Material costs
  - Installation costs

Baseband and Broadband Transmission

- **Baseband transmission**
  - uses a digital encoding and a fixed signal
  - The entire bandwidth of the cable is used to transmit a single data signal.
  - Using baseband, only one computer can send data at a time.
    - **Repeaters** can be used to deal with “attenuation”

Baseband and Broadband Transmission (cont'd)

- **Broadband transmission**
  - systems use **analog** techniques to encode binary 1s and 0s across a continuous range of values
  - Multiple analog transmission channels can operate on a single broadband cable
    - **Amplifiers** can be used to deal with attenuation
  - Two primary approaches: mid-split and dual-cable
    - **Mid-split** communication uses a single cable and divides the bandwidth for two-way communication
    - **Dual-cable** uses two cables, one to transmit and one to receive.

The Importance of Bandwidth

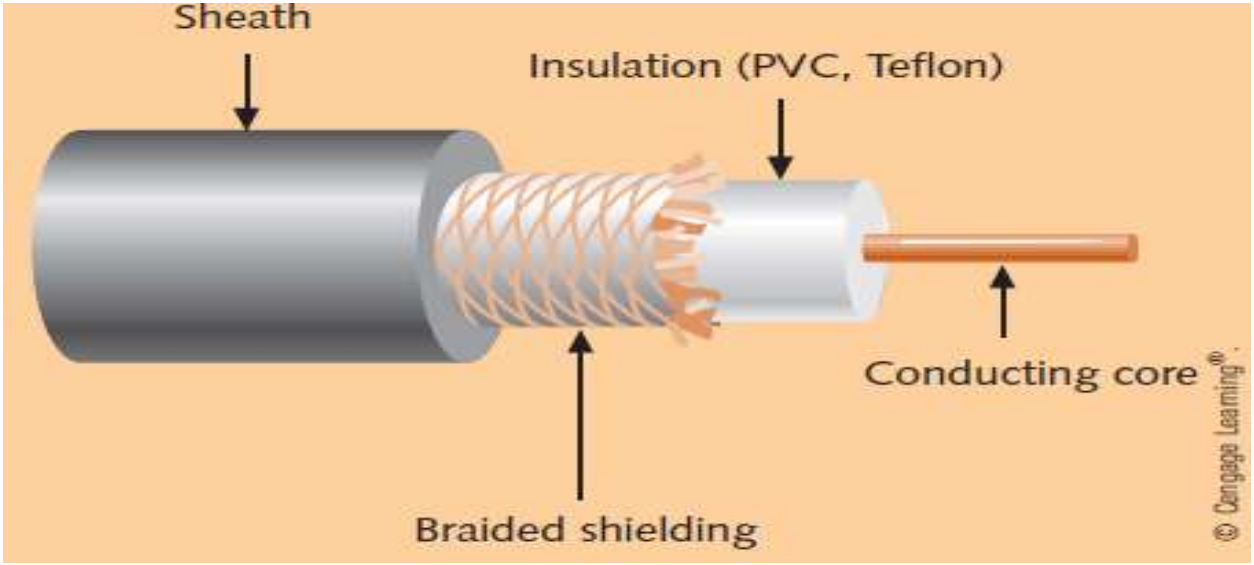
- The trend in networking is to offer more complex, comprehensive, and powerful services
  - These require much higher bandwidth
- Users demand access to these applications and have increased their use of existing networked applications, consuming still more bandwidth
- Technologists find ways to stretch bandwidth limits of existing technologies so that older, difficult-to-replace networking components can remain, yet support higher bandwidth than originally rated

Primary Cable Types

- 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
- The primary cable types are:
  - 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



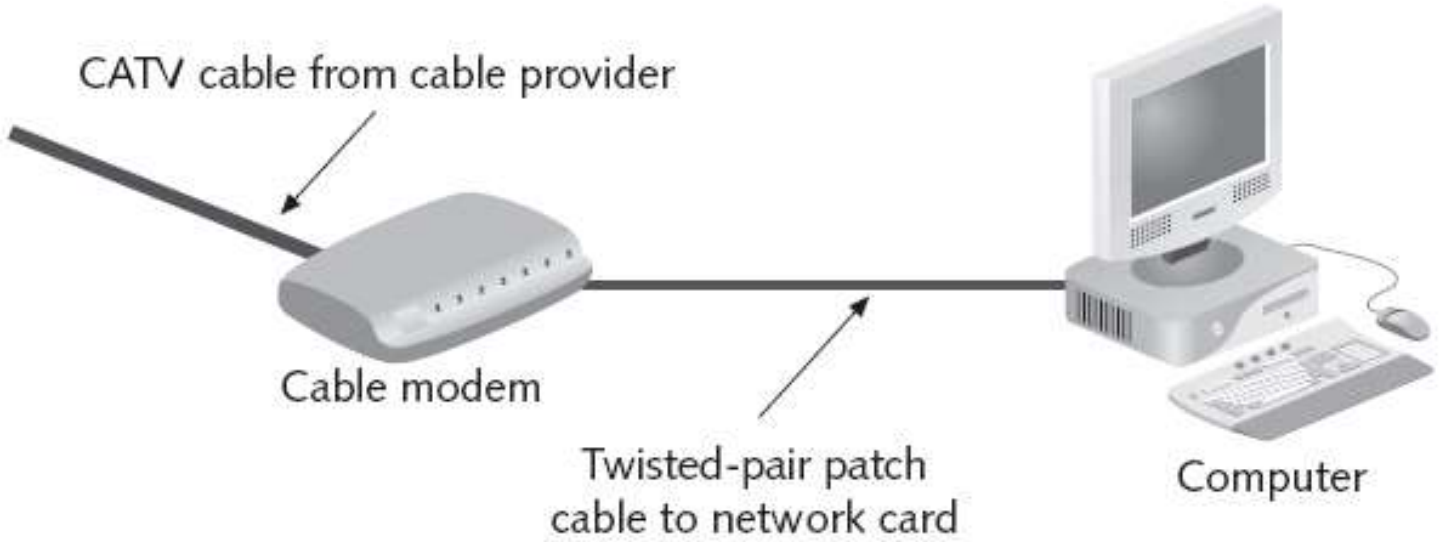
The Use of Coaxial Cable for Ethernet

- 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

- Coaxial cable in LANs has become obsolete
- The standard cable (75 ohm, RG-6; RG stands for “radio grade”) that delivers cable television (CATV) to millions of homes nationwide is also being used for Internet access

Coaxial Cable in Cable Modem Applications (cont'd)



A typical cable modem connection

Twisted-Pair (TP) Cable

- Color-coded pairs of insulated copper wires twisted around each other and encased in plastic coating
- Twists in wire help reduce effects of **crosstalk**
  - Number of twists per meter or foot known as **twist ratio**
- **Crosstalk**
  - When signals from adjacent cables interfere with another cable's transmission

Twisted-Pair Cable

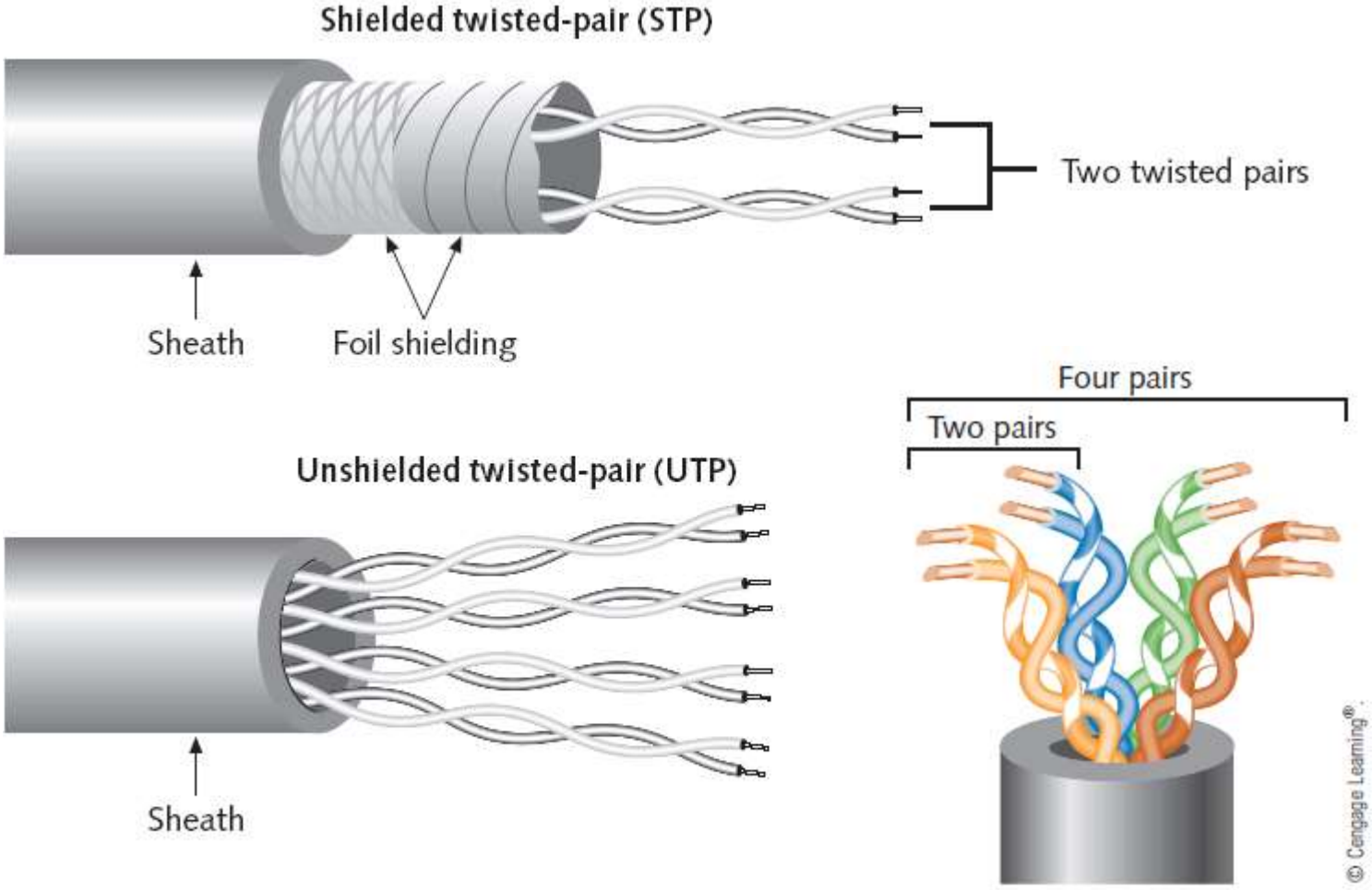


Figure 3-3 STP and UTP cable

Unshielded Twisted Pair (UTP)

- 10BaseT
  - Maximum length is 100 meters
- UTP is now the most popular form of LAN cabling
- The UTP cable used for networking usually includes one or more pairs of insulated wires
- UTP specifications govern the number of twists per foot (or per meter), depending on the cable's intended use
- UTP is used for telephony, but requirements for networking uses differ from the telephony ones

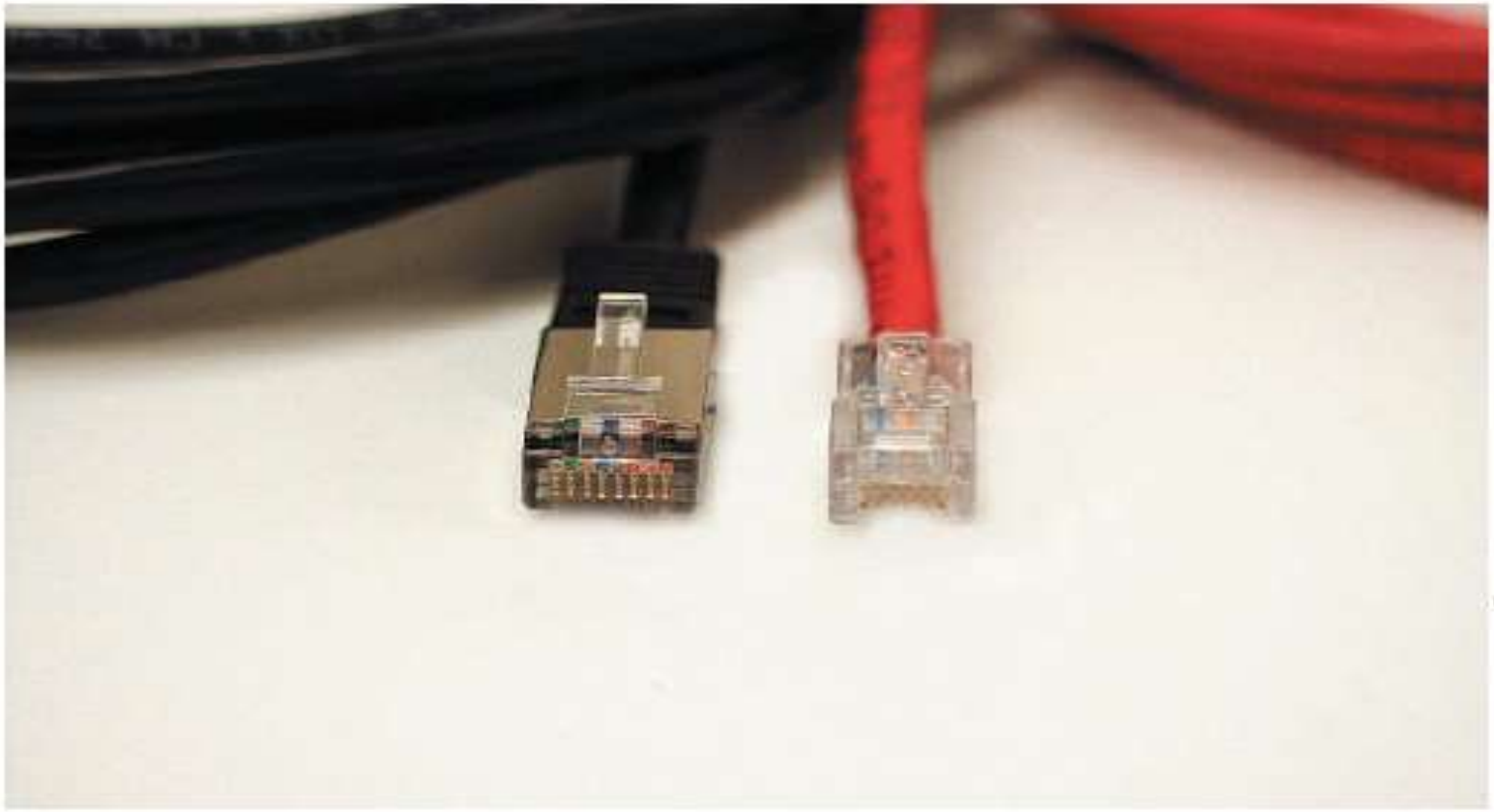
UTP Cabling Categories

- UTP cabling is rated according to a number of categories devised by the **TIA** and **EIA**; since 1991, **ANSI** has also endorsed these standards
  - ANSI/TIA/EIA 568 Commercial Building Wiring Standard for commercial environments includes:
    - Category 1 (**voicegrade**)
    - Category 2: up to 4 Mbps
    - Category 3: up to 10 Mbps (16 MHz)
    - Category 4 (**datagrade**)**:** up to 16 Mbps (20 MHz)
    - Category 5: up to 100 Mbps (100 MHz)
    - Category 5e: up to 1000 Mbps (100 MHz)
    - Category 6: up to 1000 Mbps (200 MHz)

Shielded Twisted Pair (STP)

- Shielding reduces crosstalk and limits external interference
  - Usually, wiring includes a wire braid inside cladding or sheath, and a foil wrap around each wire pair
    - Enables support of higher bandwidth over longer distances than UTP
  - No set of standards for STP corresponds to the ANSI/TIA/EIA 568 Standard, yet it's not unusual to find STP cables rated according to those standards
  - Uses two pairs of 150 ohm wire (defined by the IBM cabling system), and was not designed to be used in Ethernet applications, but it can be adapted to

Twisted-Pair Cable (continued)



RJ-45 and RJ-11 connectors

Twisted-Pair Cable (continued)

- Typically, twisted-pair systems include the following elements, often in a **wiring center**:
  - Distribution racks and modular shelving
  - Modular **patch panels**
  - **Wall plates**
  - **Jack couplers**

Twisted-Pair Cable (continued)

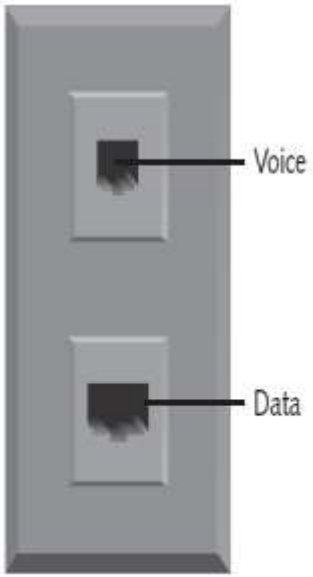


Figure 3-5 A wall plate providing both voice and data connections

Figure 3-6 Patch panel

Patch panel is a wall-mounted panel of data receptors

Twisted-Pair Cable (continued)

Table 3-1 Category 5, 5e, and 6 UTP cabling characteristics

Characteristic	Value
Maximum cable length	100 m (328 ft.)
Bandwidth	Up to 1000 Mbps
Bend radius	Minimum four times the cable diameter or 1 inch
Installation and maintenance	Easy to install, no need to reroute; the most flexible
Cost	Least expensive of all cabling options
Connector type	RJ-45 for device and wall-plate connections
Security	Moderately susceptible to eavesdropping
Signaling rates	100 MHz for Cat 5 and 5e; 200 MHz for Cat 6
Interference rating	Low; most susceptible of all electrical cable types

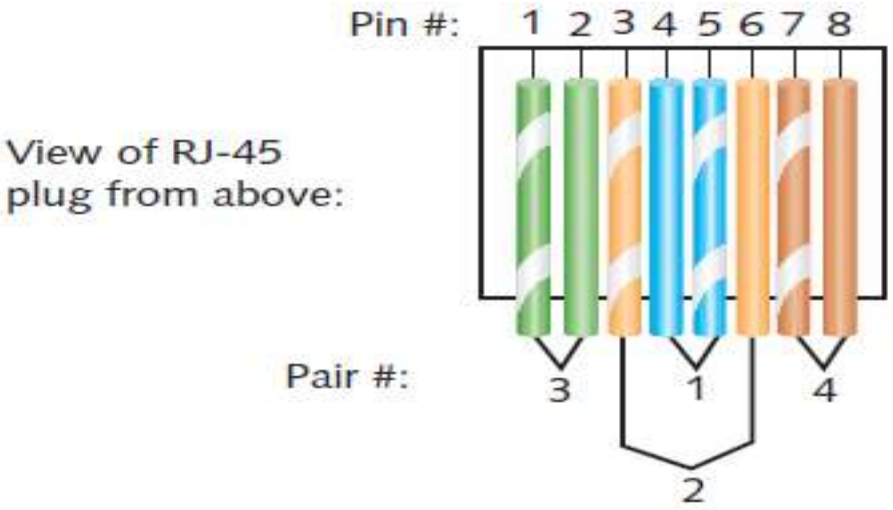
Making Twisted-Pair Cable Connections

- One of the skills required of a network technician is making a twisted-pair **patch cable**
  - **Patch cable** is a relatively short section of twisted-pair cabling with connectors on both ends that connect network devices to data outlets
- To do this, you need:
  - Wire cutters or electrician's scissors
  - Wire stripper
  - Crimp tool
  - RJ-45 plugs
  - UTP cable
- There are two standards for the arrangement of wires: TIA/EIA 568A and TIA/EIA 568B
  - You must stick to one throughout your network

Straight-Through or Crossover

- Straight-through cables connect unlike devices:
  - Switch to router
  - Switch to PC or server
  - Hub to PC or server
- Crossover cables connects like devices:
  - Switch to switch
  - Switch to hub
  - Hub to hub
  - Router to router
  - PC to PC
  - Router to PC

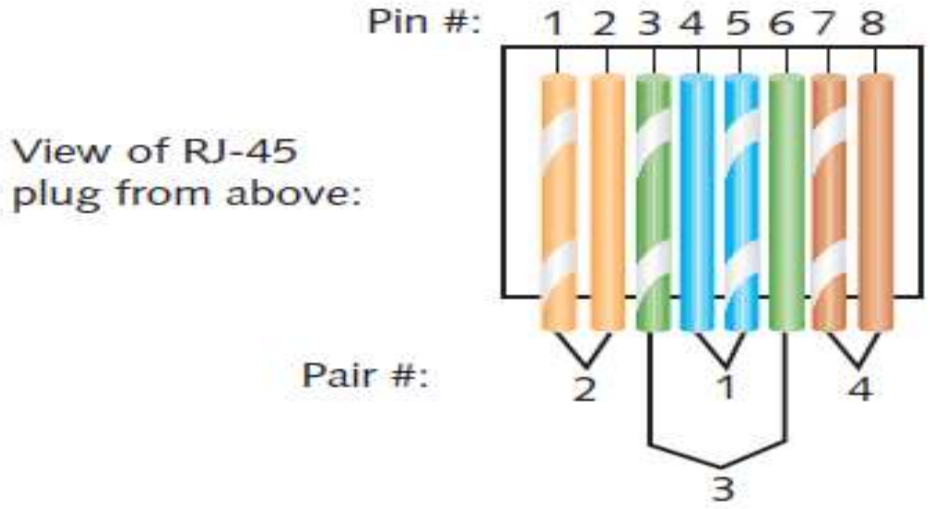
Making Twisted-Pair Cable Connections (continued)



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

TIA/EIA 568A standard terminations

Making Twisted-Pair Cable Connections (continued)



Pin #	Color	Pair #	Function
1	White with orange stripe	2	Transmit +
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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

TIA/EIA 568B standard terminations

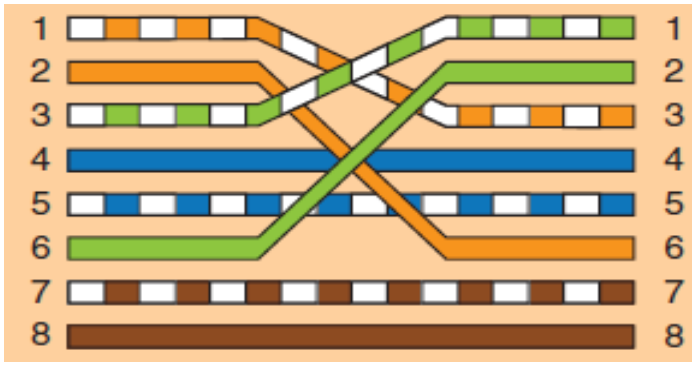
Making Twisted-Pair Cable Connections (continued)

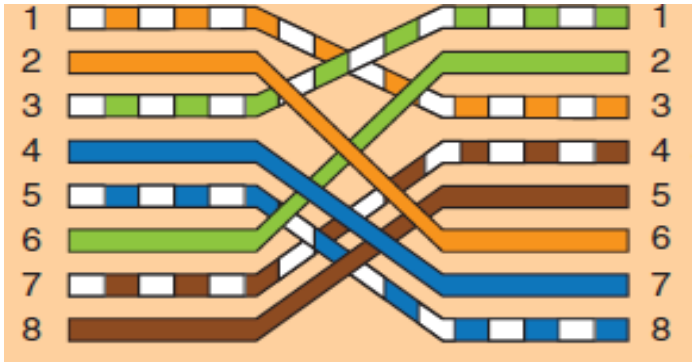
- To create a straight through cable, terminate the RJ-45 plugs at both ends of a patch cable identically, following one of the TIA/EIA 568 standards, that is, TIA/EIA 568 A or B.
- It is so named because it allows signals to pass “straight through” from one end to the other.
- Also known as a patch cable

Making Twisted-Pair Cable Connections (continued)

- To create a cross over cable, reverse the transmit and receive wires
  - In (a), pairs 2 and 3 reversed (orange and green) and will work. with 10- or 100-Mbps Ethernet because these types of Ethernet transmit on two pairs.
  - In (b), pairs 1, 2, 3, and 4 (blue, orange, green, and brown) reversed and will work with Gigabit Ethernet because Gigabit Ethernet transmits on four pairs.

(a)





(b)

Fiber-Optic Cable

- Contains one or several glass fibers at its **core**
  - Surrounding the fibers is a layer of glass called **cladding**
- 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

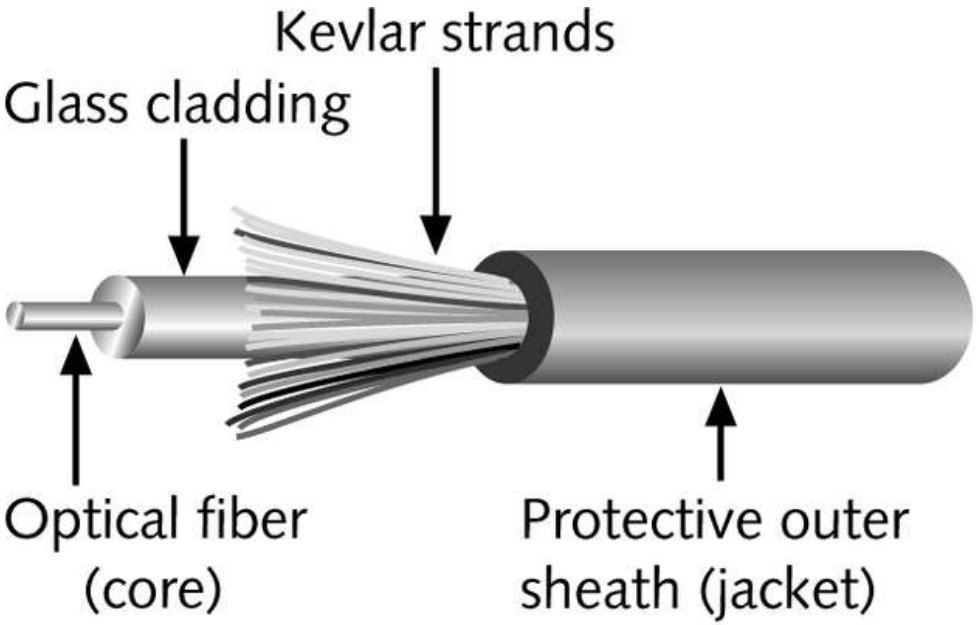


Figure: A fiber-optic cable

Fiber-Optic Cable (cont'd)

- Installation of fiber-optic networks is more difficult and time-consuming than copper media installation
- Connectors and test equipment are considerably more expensive than their copper counterparts

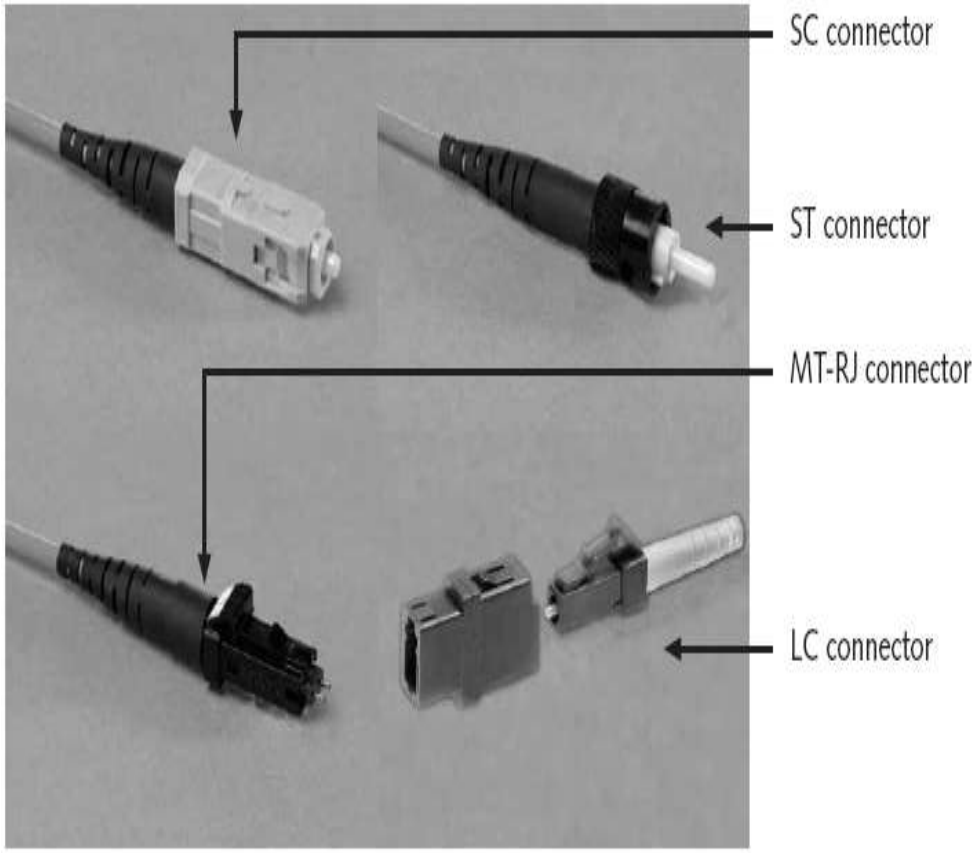


Figure 3-10 Fiber-optic connectors

Fiber-Optic Cable (cont'd)

Table 3-2 Fiber-optic cable characteristics

Characteristic	Value
Maximum cable length	2 km (6562 ft.) to 100 km (62.14 miles)
Bandwidth	10 Gbps and up
Bend radius	30 degrees per foot
Installation and maintenance	Difficult to install and reroute, sensitive to strain and bending
Cost	Most expensive of all cabling options
Connector type	Several types (see bulleted list later in this section)
Security	Not susceptible to eavesdropping
Interference rating	None; least susceptible of all cable types

Cable Selection Criteria

- Criteria to be considered for a network installation
  - Bandwidth
  - Budget
  - Capacity
  - Environmental considerations
  - Placement
  - Scope
  - Span

Cable Selection Criteria (continued)

Table 3-3 Comparison of general cable characteristics

Type	Maximum Cable Length	Bandwidth	Installation	Interference	Cost
UTP	100 m	10–1000 Mbps	Easy	High	Cheapest
STP	100 m	16–1000 Mbps	Moderate	Moderate	Moderate
10Base2	185 m	10 Mbps	Easy	Moderate	Cheap
10Base5	500 m	10 Mbps	Hard	Low	Expensive
Fiber-optic	2–100 km	100 Mbps–10 Gbps	Moderate	None	Most expensive

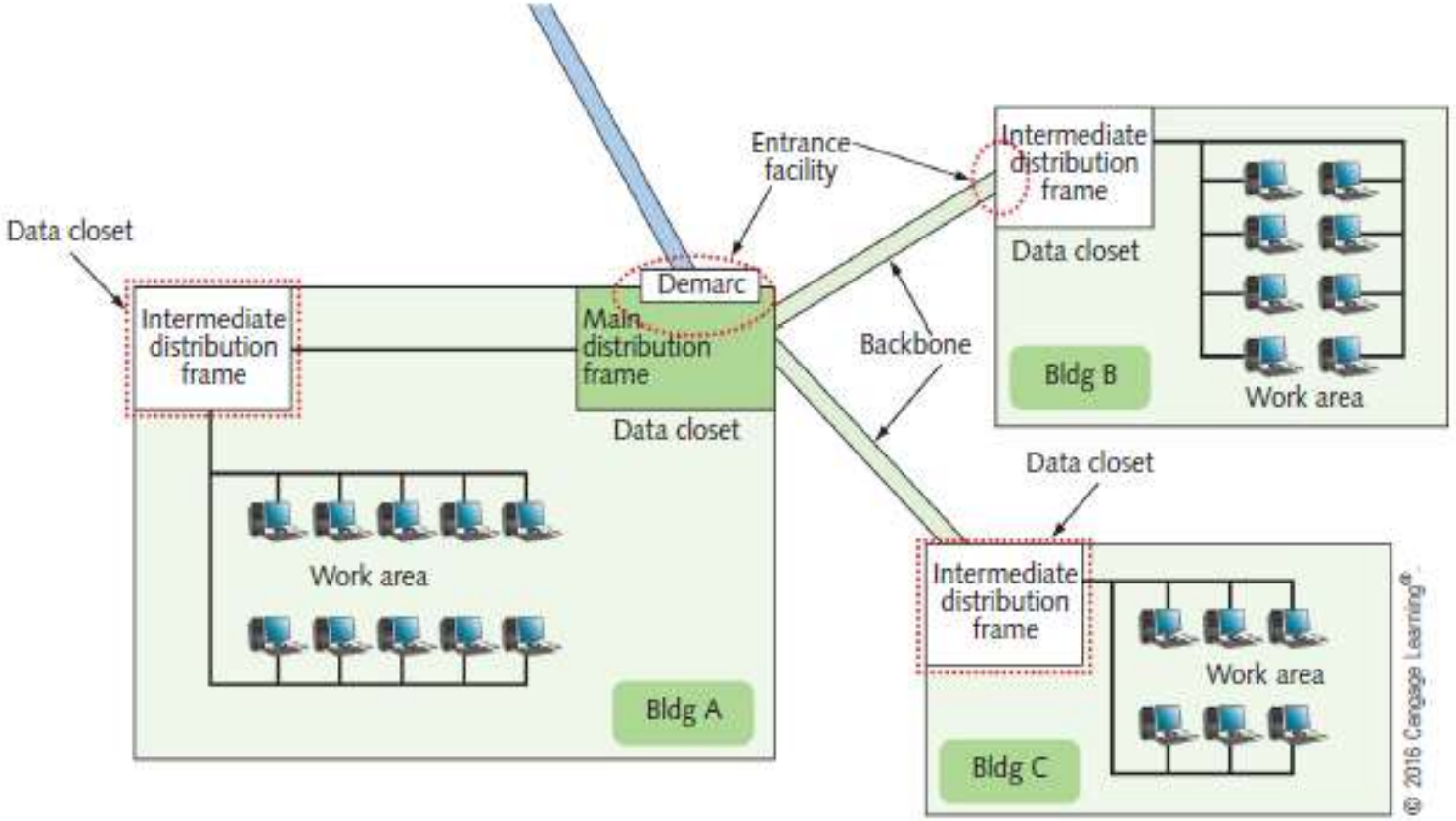
Structured Cabling

- Specifies how cabling should be organized
- Suggests how telecommunications media can best be installed to maximize performance and minimize upkeep.
- It is based on a hierarchical design and assumes a network is based on the star or extended star physical topology.
- Can be applied to any size of network

Structured Cabling: Advantages

- Consistency
  - A structured cabling system uses the same cabling for data, voice, and video.
- Support for multivendor equipment
  - A standards-based system supports numerous applications and hardware for all vendors.
- Simplified additions, moves, and changes
  - The system is designed to support any changes within it.
- Simplified troubleshooting
  - The wiring scheme makes it difficult for a single problem to bring down the network. Problems are easier to isolate and repair.
- Support for new applications
  - Structured cabling systems support new applications such as multimedia and video conferencing with little or no upgrade difficulty.

Structured Cabling: Components



TIA/EIA structured cabling in a campus network with three buildings

Structured Cabling: Components

- Details of a cable plant have six components
  - Work area
  - Horizontal wiring
  - Telecommunications closets
  - Equipment rooms
  - Backbone or vertical wiring
  - Entrance facilities

Work Area

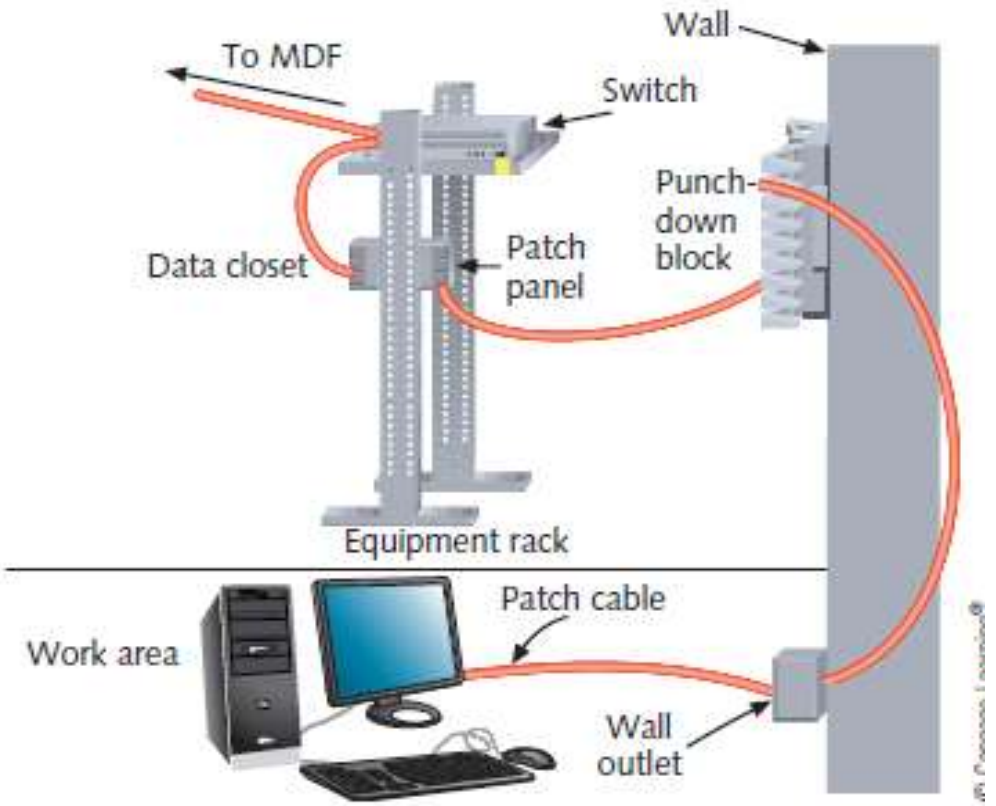
- The **work area** is where computer workstations and other user devices are located
  - Faceplates and wall jacks are installed in the work area, and patch cables connect computers and printers to wall jacks, which are in turn connected to a nearby telecommunications closet
  - Patch cables should be less than 6 meters long
  - TIA/EIA 568 standard calls for at least one voice and one data outlet on each faceplate in each work area
  - Connection between wall jack and telecommunications closet is made with horizontal wiring

Horizontal Wiring

- **Horizontal wiring** runs from the work area's wall jack to the telecommunications closet and is usually terminated at a patch panel
  - Acceptable horizontal wiring types include four-pair UTP (Category 5e or 6) or two fiber-optic cables
  - Horizontal wiring from the wall jack to the patch panel should be no longer than 90 meters
    - Patch cables in the work area and in the telecommunications closet can total up to 10 meters

Telecommunications Closet

An enclosed area, such as a room or a cabinet, for housing telecommunications equipment, distribution frames, cable terminations and cross connects.



Work area, horizontal wiring and telecommunication closet

Equipment Rooms

- The **equipment room** houses servers, routers, switches, and other major network equipment, and serves as a connection point for backbone cabling running between TCs
  - Can be the main cross-connect of backbone cabling for the network, or it might serve as the connecting point for backbone cabling between buildings
  - In multibuilding installations, each building often has its own equipment room

Backbone Cabling

- **Backbone cabling** (or vertical cabling) interconnects TCs and equipment rooms
  - Runs between floors or wings of a building and between buildings
  - Frequently fiber-optic cable but can also be UTP
  - When it connects buildings, it is usually fiber-optic
    - Multimode fiber can extend up to 2000 meters
    - Single-mode fiber can reach distances up to 3000
  - Between equipment rooms and TCs, the distance is limited to 500 meters for both fiber-optic cable types
  - From the main cross-connect to equipment rooms, fiber-optic cable can run up to 1500 meters

Entrance Facilities

- An **entrance facility** is the location of the cabling and equipment that connects a corporate network to a third-party telecommunications provider
  - Can serve as an equipment room and the main cross-connect for all backbone cabling
  - It is also where a connection to a WAN is made and the point where corporate LAN equipment ends and a third-party provider's equipment and cabling begins—also known as the "demarcation point"

End