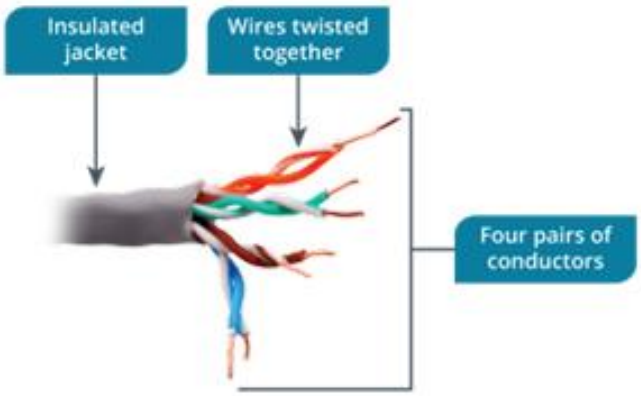
Topic 4C: Explain Network Cable Types

Recognizing suitable cabling options for a given scenario will help you determine the best choice for a particular network location.

Unshielded Twisted Pair:

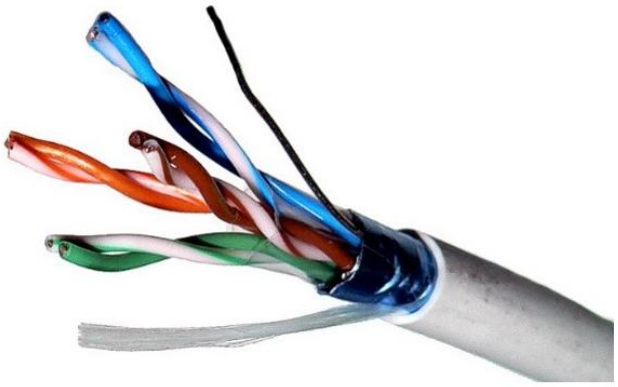


UTP cable. (Image © 123RF.com.)

Unshielded Twisted Pair (UTP) cable is the most used network cable in modern networks. It is made of **four pairs of copper wires**, with each pair twisted together at different rates. This twisting helps reduce **electromagnetic interference (EMI)** from external sources, making the signal clearer.

Each pair of wires is twisted to **cancel out** interference. Each wire in a pair carries an **equal but opposite signal**. This balance makes it easier to filter out interference and maintain signal quality. UTP cables are effective for distances up to **100 meters (328 feet)**. Beyond this, the signal weakens due to **attenuation** (loss of signal strength. Imagine setting up an office network where computers, printers, and phones are connected to a central switch. **CAT5e or CAT6 UTP cables** are used to connect these devices because they are cost-effective, flexible, and reliable for the required distances.

Shielded Twisted Pair:



F/UTP cable with a foil screen surrounding unshielded pairs. (Image by Baran Ivo and released to public domain.)

Shielded Twisted Pair (STP) cables offer additional protection against **electromagnetic interference (EMI)** compared to **Unshielded Twisted Pair (UTP)** cables. This makes them suitable for high-speed networks like **10G Ethernet** and environments with high interference levels, such as those near power lines, motors, or fluorescent lights. STP cables have one or more layers of shielding around the wire pairs to reduce external interference and improve reliability. Frequently used in **datacenters** for 10G Ethernet and higher. Essential in environments with **high EMI**. **Types of Shielding**

1. **Screened Twisted Pair (ScTP)**:
   - Includes a **thin foil shield** around all the wire pairs.
   - Designations: **F/UTP** (Foiled/Unshielded Twisted Pair) or **FTP**.
2. **Fully Shielded Twisted Pair (S/FTP)**:
   - Combines a **braided outer screen** and **foil-shielded individual pairs** for maximum interference protection.
   - Variants include **F/FTP**, with a foil outer shield.

Installation Considerations

- **Shielding Bonding**:
  - The shielding must be **bonded** to connectors and patch panels to avoid acting as an antenna, which could cause interference.
  - Modern F/UTP and S/FTP designs include built-in bonding mechanisms for seamless installation.

Real-Life Example
In a datacenter, where high-speed connections (e.g., 10G Ethernet) are required, **S/FTP cables** ensure reliable data transmission by minimizing interference from nearby power equipment and lighting.

Understanding CAT Standards for Twisted Pair Cables

The **Category (CAT) standards** define twisted-pair cable construction methods, rated for specific Ethernet standards and data transfer rates. Higher CAT numbers support faster speeds and improved performance. These standards are specified in the **TIA/EIA-568-C Commercial Building Telecommunications Cabling Standards**.

CAT Specifications Overview

Category	Max. Transfer Rate	Max. Distance	Supported Ethernet Standards
Cat 5	100 Mbps	100 m (328 ft)	100BASE-TX (Fast Ethernet)
Cat 5e	1 Gbps	100 m (328 ft)	1000BASE-T (Gigabit Ethernet)
Cat 6	1 Gbps (100 m), 10 Gbps (55 m)	100 m (Gigabit), 55 m (10G Ethernet)	1000BASE-T, 10GBASE-T (limited)
Cat 6A	10 Gbps	100 m (328 ft)	10GBASE-T (10G Ethernet)

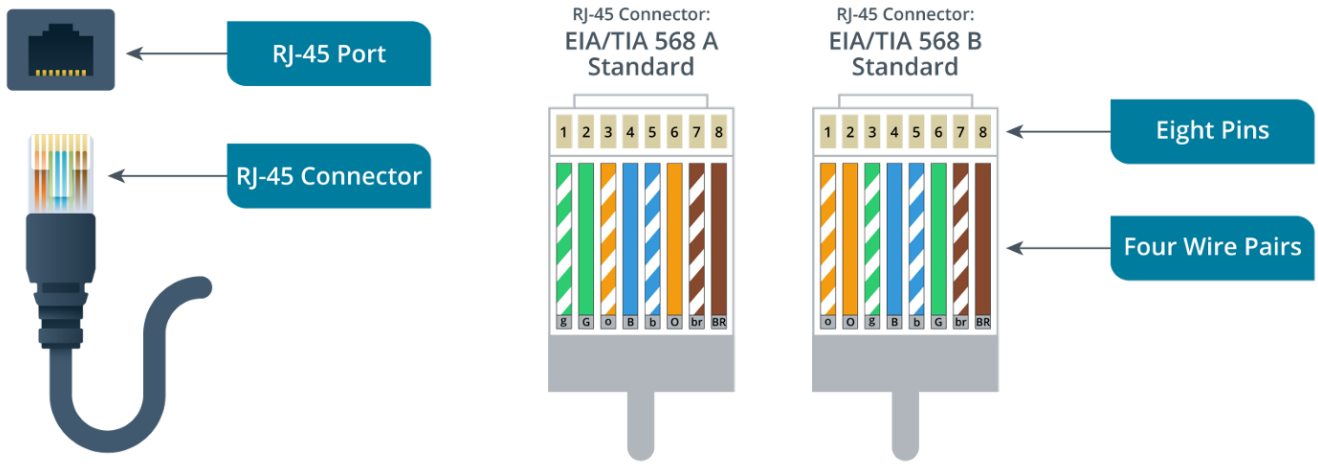
Key Details

1. **Cat 5**:
   - Older standard supporting **100 Mbps (Fast Ethernet)**.
   - No longer commercially available.
   - Networks using Cat 5 need rewiring for Gigabit Ethernet.
2. **Cat 5e**:
   - Enhanced version of Cat 5, supporting **1 Gbps (Gigabit Ethernet)**.
   - Suitable for most basic networks but increasingly being replaced by Cat 6.
3. **Cat 6**:
   - Improved construction for reliability.
   - Supports **1 Gbps up to 100 m** and **10 Gbps up to 55 m**.
   - Commonly installed for modern networks.
4. **Cat 6A**:
   - Supports **10 Gbps** over the full distance of **100 m**.
   - Bulkier and more challenging to install, with stricter requirements.
   - Recommended for healthcare facilities and PoE (802.3bt) installations.

Real-Life Example

- A small office may use **Cat 5e** to provide affordable **Gigabit Ethernet** to client computers.
- A hospital might install **Cat 6A** to future-proof its network, supporting high-speed **10 Gbps Ethernet** and **PoE devices** like access points.

Copper Cabling Connectors: RJ45 and RJ11:



Twisted pair RJ45 connectors. (Image © 123RF.com.)

Twisted pair cabling, commonly used for Ethernet, is terminated using modular connectors like **RJ45** and **RJ11**. These connectors ensure proper communication between devices by following specific wiring standards.

RJ45 Connectors (8P8C)

- **RJ45** connectors, also called **8P8C** (eight-position/eight-contact), are the standard for Ethernet cabling.
- Each **four-pair Ethernet cable** has color-coded conductors:
  - Pairs are identified by colors: **orange, green, blue, and brown**.
  - Each pair consists of one wire with a white base and colored stripes, and one wire with a solid color.

Wiring Standards

The **TIA/EIA-568** standard defines two wiring methods for RJ45:

1. **T568A**:
   - Pin 1: Green/White
   - Pin 2: Green
   - Pin 3: Orange/White
   - Pin 6: Orange
2. **T568B**:
   - Swaps the green and orange pairs:
   - Pin 1: Orange/White
   - Pin 2: Orange
   - Pin 3: Green/White
   - Pin 6: Green

Straight-Through and Crossover Cables

- **Straight-Through Cable**:
  - Both ends use the same wiring standard (T568A or T568B).
  - Commonly used to connect devices like computers to switches.
- **Crossover Cable**:
  - One end uses **T568A** and the other **T568B**.
  - Historically used for direct connections between devices, but **Gigabit Ethernet** can now perform the crossover automatically.

RJ11 Connectors

- **RJ11** connectors are smaller and have **6P4C** (six-position/four-contact).
- Used with **two-pair cables** for telephone systems and **DSL modems**.
- Unlike RJ45, RJ11 is not suitable for Ethernet but is still used for voice and broadband connections.

Real-Life Examples

1. **RJ45**: In an office, Ethernet cables with RJ45 connectors are used to link computers and printers to the network switch.
2. **RJ11**: At home, the phone line connecting your landline or DSL modem uses an RJ11 connector.

Copper Cabling Installation Tools:

In a building or office, the data cables are installed as a structured cabling system. The computer network port is connected to the wall port using the **patch cord.** And the wall port is connected to the patch panel with **permanent cable.** And finally, the patch panel is connected to the **Ethernet Switch.**

Cable Termination Types

There are two types of cable termination:

- **Patch Cords:** These are terminated with **RJ45 plugs** using a **crimper tool**. They use **stranded cable**, which is flexible but more prone to signal loss (attenuation).
- **Permanent Cable:** These are terminated at wall ports or patch panels using **punchdown tools** on **Insulation Displacement Connectors (IDC)**. They use **solid cable**, which has thicker wires and better performance for long distances.

Distance Limitations

The total cable length for the **channel link** cannot exceed **100 meters**. Patch cords, which connect devices to wall ports or patch panels, are limited to a maximum length of **5 meters**.

Installation Tools

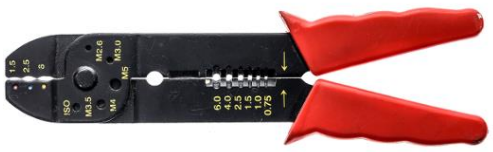
To install structured cabling, the following tools are essential:

- **Cable Strippers:** Remove the outer cable jacket without damaging internal wires.
- **Punchdown Tools:** Secure wires into IDCs or punchdown blocks.
- **Crimpers:** Attach RJ45 connectors to patch cords.

Key Differences Between Cable Types

- **Solid Cable:** Used for permanent links, features thicker wires, and is less flexible but better for long-distance performance.
- **Stranded Cable:** Used for patch cords, offers flexibility but is less effective over longer distances due to higher attenuation.

Cable Stripper and Snips:



A cable stripper. (Image by gasparij © 123RF.com)

In any Ethernet cable, there is some plastic cover at the end of the cable on both side right. But to place that plastic cover, we need to take the outer cover of the cable to insert those 8 wires into that small plastic cover. So, in this case, **cable stripper** is used to remove that outer cover of the wire so that we can have those twister wires to insert into that plastic cover. For this, set the stripper to the correct

diameter, and then place the cable in the stripper and rotate tool once or twice.

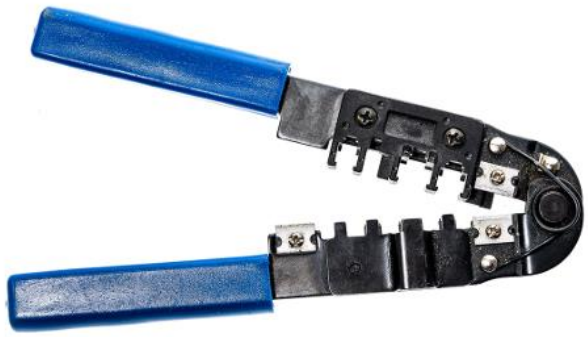
Punchdown Tool:

Connecting UTP cable to IDCs using a punchdown tool. (Image by dero2084 © 123RF.com.)

A punchdown tool is used to terminate wires into an Insulation Displacement Connector (IDC). Start by untwisting the wire pairs and laying them into the color-coded terminals on the IDC, following the appropriate termination standard (T568A or T568B). To minimize interference, make sure you untwist no more than ½ inch (13 mm) of wire.

Once the wires are placed in their terminals, use the punchdown tool to press each wire into its slot. The blades in the terminal will cut through the wire insulation, creating an electrical connection. This ensures secure and reliable termination.

Crimper:



A wire crimper. (Image by gasparij © 123RF.com)

A crimper is used to attach an RJ45 plug to a patch cord. Begin by orienting the RJ45 plug so the tab latch is underneath, with Pin 1 on the far left. Arrange the wire pairs in the correct order according to the termination standard (T568A or T568B).

Push the wires firmly into the RJ45 plug, ensuring they reach the end of the connector and are properly aligned. Then, place the plug into the crimper tool and squeeze it tightly. This action pierces the wire insulation at the pins and secures the plug to the cable, ensuring both electrical contact and a strong connection to the outer jacket.

Copper Cable Test Tools:

Once you have terminated the cable, you must test it to ensure that each wire makes a good electrical contact and is in the correct pin position.

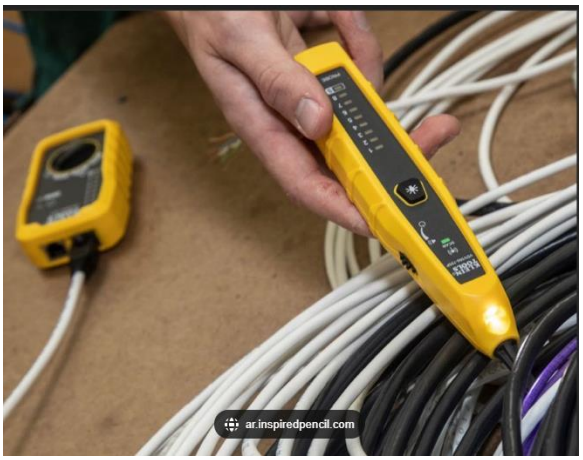
Cable Tester:

A cable tester is a pair of devices used to check the integrity of a cable. To use it, connect one device to each end of the cable. It can test a patch cord or a permanent link by connecting through the wall port and patch panel using patch cords.

The tester works by energizing each wire in sequence. LEDs on the device will light up to confirm successful termination. If an LED doesn't activate, the wire isn't conducting a signal. This could be due to damaged insulation or improper insertion into the RJ45 plug or IDC.

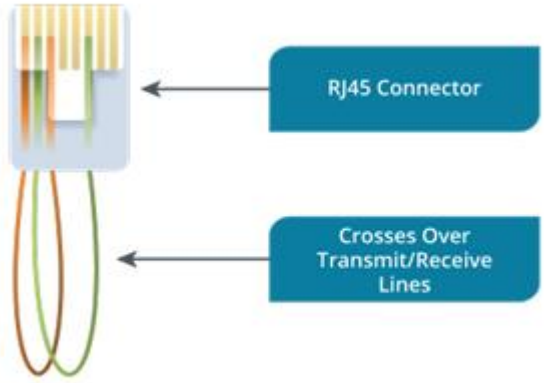
If the LEDs light up in a different sequence at each end, it indicates that the wires are terminated to different pins. This is usually caused by using different termination standards (T568A and T568B) on either end. Always ensure both ends are terminated using the same standard.

Toner Probe:



A toner probe is a tool used to trace and identify cables. It consists of two parts: the toner and the probe. The **toner** sends a signal through a cable by attaching its clips to the cable or plugging it into a port. The **probe** detects the signal and emits an audible tone when it is placed near the cable carrying the signal. This tool is particularly useful for finding cables in a bundle or tracing cables through walls. It helps identify the correct cable without needing to physically disconnect or terminate it. Disconnect the other end of the cable from any network equipment before activating the tone generator because if the cable is still connected to a powered network device, it may carry electrical signals or data traffic. These signals can interfere with the tone generator, making it harder to trace the cable accurately. And activating the tone generator while the cable is connected to a powered device could potentially damage the network equipment or the tone generator.

Loopback Plug:



A **loopback plug** is a diagnostic tool used to test the functionality of network ports. It works by redirecting (or "looping back") the signal from the transmit pins to the receive pins within the same port. This helps verify that the port is working correctly. A loopback plug made from a cable stub is unlikely to work with Gigabit Ethernet ports. You can obtain manufactured Gigabit port loopback testers.

Uses of a Loopback Plug:

1. **Testing Network Ports:**
   Insert the plug into a network adapter or switch port to check if the port is sending and receiving signals properly.
2. **Diagnosing Issues:**
   It helps determine if problems are due to the port, cable, or other network components.

Common Types of Loopback Plugs:

- **Ethernet Loopback Plug:** Used for RJ45 ports.
- **Serial Loopback Plug:** Used for serial ports (e.g., RS-232).

Network Taps Explained:

Think of a **network tap** as a device that acts like a "listening station" for your network traffic. It intercepts and copies the signals traveling through a cable and sends them to a tool (like a protocol analyzer) for monitoring or troubleshooting.

Example: Listening to Conversations

Imagine you have a phone line between two people. A **network tap** works like a tool that secretly listens to the conversation without disturbing it. There are two types of taps:

1. **Passive TAP (Unpowered):**
   A passive TAP is like putting a simple splitter on the phone line. It splits the signal and sends a copy to a "listener" without making any decisions or altering the signal. It captures everything, even broken or incomplete messages.
   - Example: You connect a splitter to a wire, and one output goes to the listener (like an analyzer).
2. **Active TAP (Powered):**
   An active TAP is more advanced and powered. It not only splits the signal but also **boosts or regenerates** it to keep the signal strong. This is useful when monitoring complex or high-speed data (like Gigabit Ethernet), where a simple splitter might not work. However, if the TAP loses power, the network connection it's monitoring may fail.
   - Example: Like a powered device that copies and amplifies the phone conversation but stops working during a power outage.

SPAN (Switched Port Analyzer)

Instead of using a physical TAP, you can configure a network switch to copy data from specific ports to another port (called a **mirror port**). This is like telling the switch to send a copy of all conversations from certain phones to a separate listener.

Real Life Use Case of Network Taps (Just for Understanding):

A financial company, **SecureBank**, wants to protect its customer data and detect potential cyberattacks. They install a **network tap** between their corporate network and the firewall that connects to the internet.

1. **Setup:**
   - The **network tap** is placed inline on the link between the internal network and the firewall.
   - The tap sends a copy of all traffic to a dedicated **Intrusion Detection System (IDS)**.
2. **How It Works:**
   - **Normal Traffic:** Legitimate traffic (e.g., employees accessing cloud services or customers using online banking) passes through the tap without interruption. A copy of this traffic is sent to the IDS.
   - **Suspicious Activity:** A hacker attempts to exploit a vulnerability by sending malicious packets to the company's network. The tap copies this malicious traffic and forwards it to the IDS.
3. **Outcome:**
   - The IDS detects the malicious packets, such as a SQL injection attempt or port scanning activity.
   - The security team is alerted immediately to investigate and block the hacker's IP address before any damage is done.

By using the tap, **SecureBank** can monitor all traffic without impacting network performance or risking packet loss that might occur with other methods like SPAN ports.

Copper Cabling Installation Considerations:

Installation of cable must be compliant with local building regulations and fire codes. This means that specific cable types must be used in some installation scenarios.

- ### Plenum Cable:

  A plenum cable is used in areas of a building designed for air circulation, such as false ceilings or raised floors, known as plenum spaces. These spaces are often part of HVAC systems, making them prone to fire hazards due to high air flow and lack of fire barriers. Plenum cables are made with fire-resistant materials that produce minimal smoke, are self-extinguishing, and can withstand higher temperatures, ensuring compliance with strict fire safety regulations.

  Plenum-rated cables are made using treated PVC or fluorinated ethylene polymer (FEP), which makes them less flexible but does not affect data transmission speeds or bandwidth. These cables are marked CMP/MMP under the US National Electrical Code (NEC).

  In contrast, regular cables, marked CMG/MMG or CM/MP, use standard PVC jackets and emit toxic smoke when burned. These general-purpose cables are not safe for plenum spaces. Plenum cables are essential in these areas to reduce fire risks and meet building code requirements.

- ### Direct Burial and Outside Plant (OSP) Cabling:

  Outside Plant (OSP) cabling is used for running cables outside buildings or between buildings. These cables face tough weather conditions like extreme temperatures, moisture, and sunlight, so they need special protection.

  Types of OSP Cable Installations:

1. **Aerial Cable:**
   - Strung between poles or anchors.
   - Exposed to UV rays, changing temperatures, and moisture, which can degrade standard PVC.
2. **Buried Cable in Conduit:**
   - Cables are run through protective conduits underground.
   - Conduits protect against physical damage but don't fully eliminate exposure to damp and temperature extremes.
3. **Direct Burial Cable:**
   - Placed directly into the ground and covered with earth or concrete.
   - These cables must have durable coatings, often gel-filled to resist moisture and temperature changes.
   - They may also need **armoring** to protect against rodent damage.

  Special Features of OSP Cables:

  - **UV and Abrasion Resistance:** Prevents degradation from sunlight and rough conditions.
  - **Gel-Filled Core:** Keeps water out and protects cables from moisture.
  - **Armoring:** Shields cables from rodents or other physical damage.

  Using the right type of OSP cable ensures durability and reliable performance in outdoor environments.

Optical Cabling:

Patch cord with duplex SC format connectors (left) and LC connectors (right). (Image by YANAWUT SUNTORNKIJ © 123RF.com.)

Optical cabling uses light pulses instead of electrical signals to transmit data. This makes it immune to interference and reduces signal loss (attenuation), allowing for **faster speeds** (gigabits to terabits per second) and **longer distances** (measured in miles).

Structure of a Fiber Optic Cable

1. **Core:** Ultra-fine glass or plastic that carries the light pulses.
2. **Cladding:** Surrounds the core and reflects light back into it, keeping the signal on track.
3. **Buffer Coating:** Protects the cladding from damage.
4. **Jacket:** The outer protective layer of the cable.

Types of Fiber Optic Cable

1. Single-Mode Fiber (SMF):

- **Core Size:** Small (8–10 microns).
- **Light Source:** Infrared lasers (1,310 or 1,550 nm).
- **Performance:** High data rates (up to 10 Gbps or better) and long distances (many kilometers).
- **Use Case:** Ideal for long-distance links like WANs or between data centers.

2. Multi-Mode Fiber (MMF):

- **Core Size:** Larger (50 or 62.5 microns).
- **Light Source:** LEDs or VCSELs (850 or 1,300 nm).
- **Performance:** Lower speeds and shorter distances compared to SMF.
- **Use Case:** Suitable for shorter links like LANs within a building or campus.

Fiber Optic Connectors

1. **Straight Tip (ST):**
    - Bayonet-style, twist-and-lock design.
    - Commonly used in older multi-mode networks.
2. **Subscriber Connector (SC):**
    - Push/pull connector for easy insertion/removal.
    - Available in **simplex** (single connector) or **duplex** (two connectors clipped together).
    - Used in both single-mode and multi-mode fiber.
3. **Lucent Connector (LC):**
    - Smaller push/pull connector, like SC but with higher port density.
    - Popular for modern networks.

Patch Cords and Care

- Patch cords can have the same connector on both ends (e.g., SC-SC) or mixed (e.g., ST-SC).
- **Fragility:** Fiber connectors are delicate and prone to damage if frequently plugged and unplugged. Always use dust caps to protect unused connectors or ports from contamination.

Coaxial Cabling:

Detailed layers of a coaxial cable. (Image by destinacigdem © 123RF.com)

F-type coaxial connector. (Image © 123RF.com.)

Coaxial cable, or **coax**, is a type of copper cabling that carries electrical signals. Unlike twisted pair cables, coax uses a design where two conductors share the same axis to minimize interference.

Structure of a Coaxial Cable:

1. **Core Conductor:** Carries the signal (usually copper).
2. **Plastic Insulation (Dielectric):** Surrounds the core and separates it from the shielding.
3. **Wire Mesh Shielding:** Acts as both EMI protection and a grounding conductor.
4. **Outer Jacket:** Protects the cable from physical damage.

Common Uses of Coaxial Cable:

1. **CCTV Installations:** Used to connect cameras to recording devices or monitors.
2. **Cable Access TV (CATV):** Delivers TV signals to homes and businesses.
3. **Broadband Internet:** Used as patch cables for cable modems in some installations.

Connectors for Coaxial Cable:

- **F-Type Connector:** A screw-down connector commonly used in CATV and broadband internet setups.

Coaxial cables are durable, resistant to EMI, and ideal for specific applications, though they've largely been replaced by twisted pair and fiber optic cables for modern networking.

Some Questions and Answers:

1. You are performing a wiring job, but the company wants to purchase the media and components from another preferred supplier. The plan is to install a network using copper cabling that will support Gigabit Ethernet. The customer is about to purchase Cat 5e cable spools. What factors should they consider before committing to this decision?

- **Answer:**
  - **Cat 5e:** Meets the requirement and is the least expensive option.
  - **Cat 6:** Offers better performance with slightly higher cost.
  - **Cat 6A:** Best choice for future-proofing but likely exceeds the customer's budget.

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2. A network consultant is recommending the use of S/FTP to extend a cable segment through a factory. Is this likely to be an appropriate cable choice?

- **Answer:**
  Yes. **Shielded/Foiled Twisted Pair (S/FTP)** provides excellent protection against interference from factory machinery, making it a suitable choice for this environment.

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3. You are reviewing network inventory and come across an undocumented cable reel with "CMP/MMP" marked on the jacket. What installation type is this cable most suitable for?

- **Answer:**
  This is **plenum cable**, which is rated for use in **plenum spaces** (building voids used for HVAC systems).

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4. You need to connect permanent cable to the back of a patch panel. Which networking tool might help you?

- **Answer:**
  A **cable stripper** to remove the jacket insulation and a **punchdown tool** to terminate the wire pairs into **insulation displacement connector (IDC)** blocks.

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5. Which fiber optic connector uses a small form factor design?

- **Answer:**
  The **Lucent Connector (LC)**.