Ethernet Technology and Virtualization

Types of Connections

Theere are two main types of wired connections : **Copper** and **Fiber Optic**.

1. Copper Cables

Copper cables are the most common and inexpensive network media found in organizations. They transmit data as electrical signals.

A. Unshielded Twisted Pair (UTP)

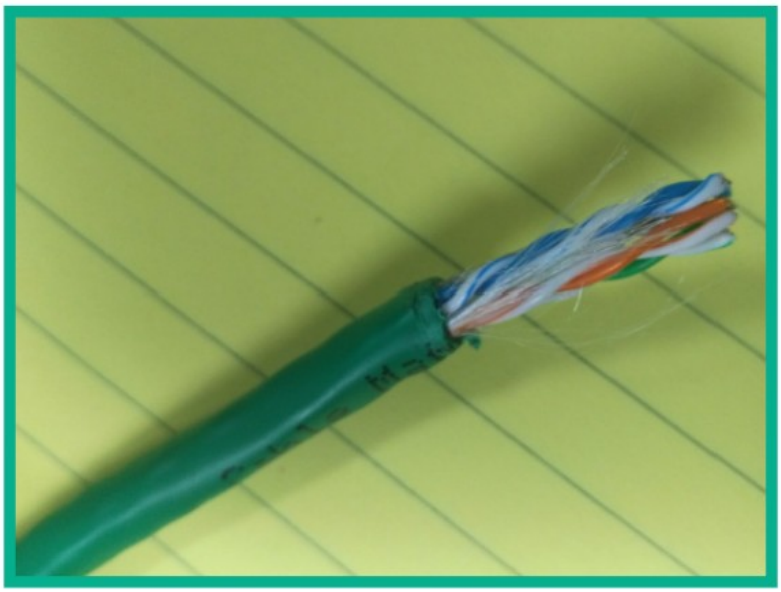

Figure 1: UTP cable

- **Construction:** Contains 8 individual wires (4 pairs) twisted together inside an outer jacket. The twisting is the primary method to reduce electromagnetic interference (EMI) from external sources.
- **Susceptibility:** Despite the twisting, UTP cables are still susceptible to EMI because they lack additional shielding. They are not recommended for environments with heavy machinery or many electrical wires.
- **Outer Jacket:** Typically made of **Polyvinyl Chloride (PVC)**, which releases toxic fumes when burned. These are **non-plenum-rated** cables.

B. Shielded Twisted Pair (STP)

- **Construction:** Similar to UTP, but with an additional foil shielding around the twisted pairs of wires inside the outer jacket.
- **Purpose:** This protective shielding is specifically designed to prevent EMI from reaching the copper conductors.
- **Cost:** More expensive than UTP due to the added layer of protection.
- **Use Case:** Implemented in environments with significant EMI.

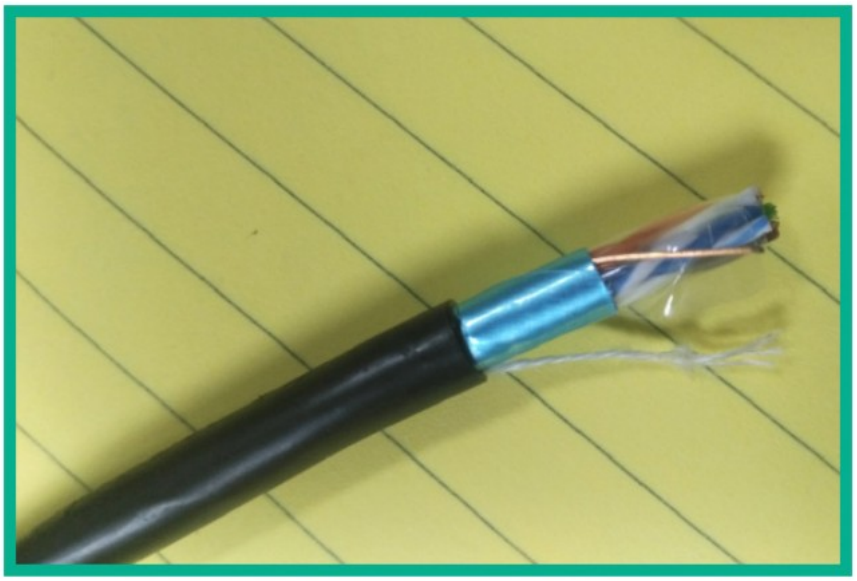

Figure 2: STP cable

C. Plenum-Rated Cables

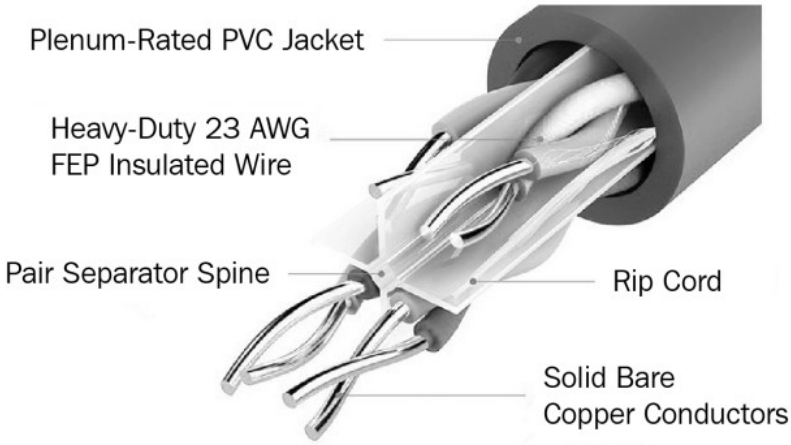

Figure 3: Plenum-rated cable

- **Purpose:** Standard PVC-jacketed cables (non-plenum) are a safety hazard if installed in **plenum spaces**—the areas in a building used for air circulation for heating and ventilation. In a fire, burning PVC releases toxic fumes that would be circulated throughout the building.
- **Solution:** Plenum-rated cables have a special fire-retardant jacket that is less toxic when burned. Their use in plenum spaces is often required by building codes for safety.
- **Cost:** Plenum-rated cables are more expensive than non-plenum cables.

D. Cable Categories and Standards

The **Telecommunication Industry Association (TIA)** defines cable categories, which specify the supported speed (bandwidth) and maximum distance (100 meters for most copper).

Category	Supported Speed	Maximum Distance	Common Use
Cat 3	10 Mbps	100 m	Legacy telephone systems
Cat 5	100 Mbps	100 m	Older networks (Fast Ethernet)

Category	Supported Speed	Maximum Distance	Common Use
Cat 5e	1 Gbps	100 m	Common in many existing installations
Cat 6	1 Gbps (10 Gbps up to 55m)	100 m	Modern standard for new installations
Cat 6a	10 Gbps	100 m	For higher-speed requirements
Cat 7	10 Gbps	100 m	Shielded, for high-noise environments
Cat 8	40 Gbps	30 m	Data center environments

E. Connectors and Wiring Standards

- **RJ-11:** A 4-pin connector used to terminate Cat 3 cables for telephone systems.

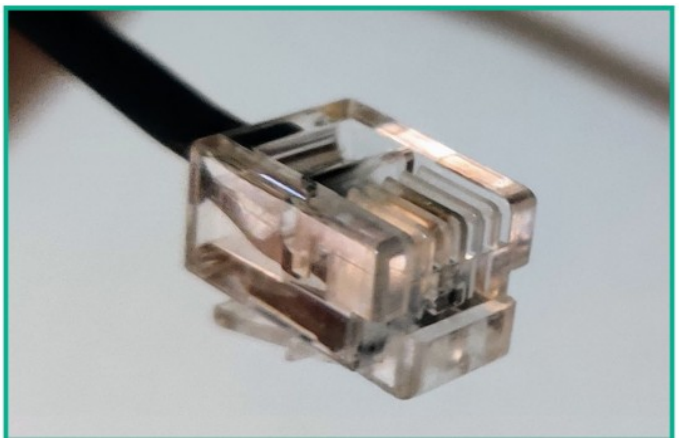

Figure 4: Cat 3 with an RJ 11 connector

- **RJ-45:** An 8-pin connector used for modern Ethernet cables (Cat 5 and above).

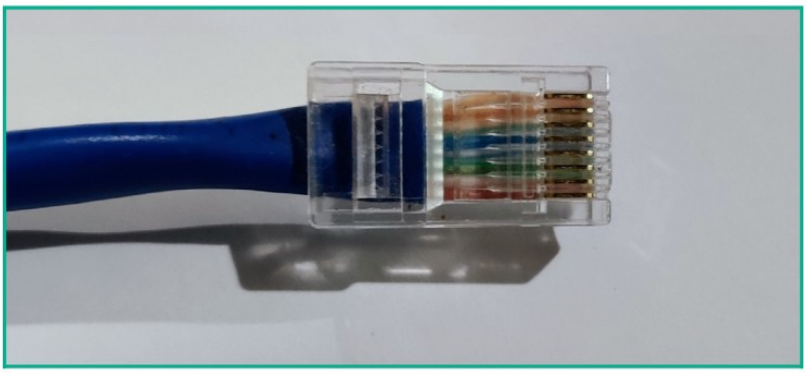

Figure 5: Ethernet cable with an RJ 45 connector

- **TIA-568 Standards:** Define the pinout (wire order) for the RJ-45 connector.
    - **TIA-568A** and **TIA-568B** are the two main standards. The key difference is that the green and orange wire pairs are swapped.
    - A **straight-through cable** uses the same standard (e.g., 568B) on both ends and is used to connect dissimilar devices (e.g., computer to switch).
    - A **crossover cable** uses 568A on one end and 568B on the other. This swaps the transmit and receive pairs and is used to connect similar devices (e.g., switch to

switch). Modern devices often have **Auto MDI-X**, which automatically detects the cable type and makes the necessary adjustment, allowing a straight-through cable to be used in all scenarios.

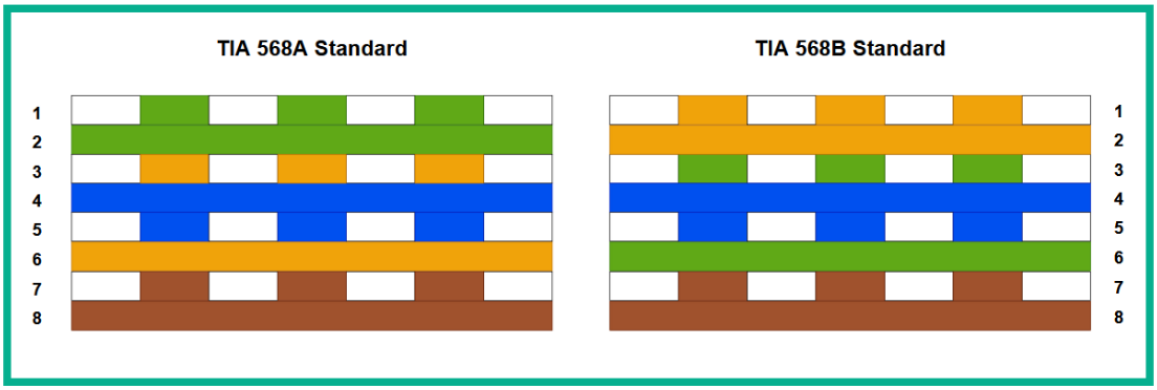

Figure 6: Comparing the TIA-568 standards

F. Coaxial Cables

- **Construction:** Has a central copper conductor surrounded by multiple layers of insulation and shielding.
    - **Copper conductor:** Transmits the electrical signals.
    - **Dielectric insulator:** Keeps the conductor centered.
    - **Foil shielding:** Prevents Radio Frequency Interference (RFI).
    - **Braided shielding:** Prevents Electromagnetic Interference (EMI).
    - **Protective coating (PVC):** Outer jacket.

Figure 7: Coaxial cable

- **Standards:** Uses the **Radio Guide (RG)** standard.
    - **RG-59:** Legacy standard for older TVs and cable modems.
    - **RG-6:** Newer standard for modern cable TV and broadband internet.

- **Connectors:**
    - **F-pin connector:** Most common, used for cable modems and TVs.
    - **BNC (Bayonet Neill-Concelman):** Used for RF signals in equipment like televisions and radios.
    - **T-connector:** Used to interconnect three coaxial cables.

2. Fiber Optic Cables

Fiber optic cables transmit data using pulses of light through a glass or plastic core, making them immune to EMI.

A. Advantages and Disadvantages

- **Advantages:**
    - **Faster throughput:** Light signals (photons) travel faster than electrical signals (electrons).
    - **Longer distances:** Lower signal attenuation (loss) allows runs of many kilometers without a repeater, unlike copper's 100-meter limit.
    - **Immunity to EMI:** Since they use light, they are unaffected by electromagnetic interference.
- **Disadvantages:**
    - **More expensive** than copper cables.
    - **Fragile:** The glass or plastic core is more delicate and can break if bent too sharply.

B. Structure of a Fiber Cable

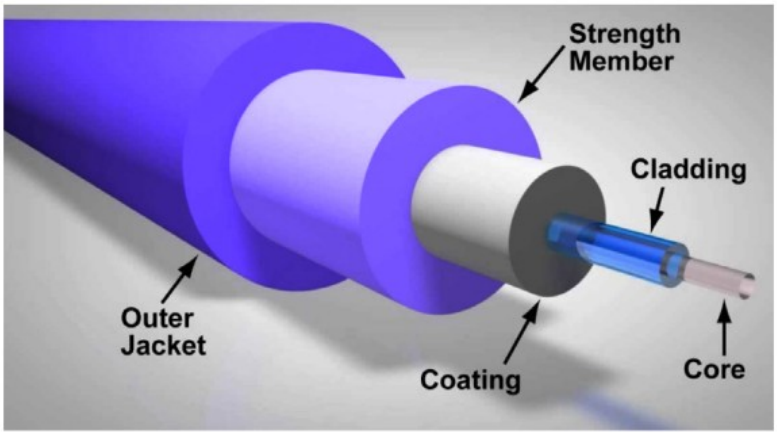

Figure 8: Fiber optic cable structure

From center to outer layer:

1. **Core:** The glass or plastic center where the light travels.
2. **Cladding:** Surrounds the core and reflects light back into it, enabling transmission.
3. **Coating:** A protective layer for the core and cladding.

4. **Strength member:** Adds tensile strength to prevent breaking.
5. **Outer jacket:** The final protective layer.

C. Single-Mode vs. Multimode Fiber

Feature	Single-Mode Fiber (SMF)	Multimode Fiber (MMF)
Core Diameter	Very small (e.g., 9 micrometers)	Larger (e.g., 62.5 micrometers)
Light Source	Laser	LED (Light Emitting Diode)
Light Path	Single path (mode)	Multiple paths (modes)
Distance	Long-range (kilometers)	Short-range (hundreds of meters)
Cost	More expensive (lasers, precise alignment)	Less expensive
Use Case	Connecting buildings, service provider networks	Within a building or campus

D. Fiber Connectors

- **LC (Lucent Connector):** Small form-factor connector with a 1.25 mm ferrule, popular in high-density environments like data centers.
- **ST (Straight Tip or Bayonet):** Older connector with a 2.5 mm ferrule and a bayonet-style twist lock.
- **SC (Subscriber Connector or Standard Connector):** Square, push-pull connector with a 2.5 mm ferrule.
- **MT-RJ (Mechanical Transfer Registered Jack):** A small, duplex connector that terminates two fibers on a single ferrule.

E. Fiber Transceivers

These are hot-swappable modules that plug into switches and routers to provide physical connectivity for fiber cables.

- **GBIC (Gigabit Interface Converter):** An older, larger transceiver standard.
- **SFP (Small Form-factor Pluggable):** A compact version that replaced the GBIC. Supports speeds of 1-2.5 Gbps.
- **SFP+ (Enhanced SFP):** Supports higher data rates, commonly 10 Gbps.
- **QSFP/QSFP+ (Quad SFP):** Combines four SFP/SFP+ channels to support speeds of 4 Gbps and 40 Gbps, respectively, allowing for high-density deployments.