# Transmission Media & Network Cabling

This lecture focuses on the fundamental aspects of data transmission, emphasizing the characteristics and selection criteria for various transmission media, including copper cabling and optical fiber. By the end of this lecture, students will gain a comprehensive understanding of how data is transmitted, the types of cables used, and the performance factors that influence network design.

## Objectives

- Describe how data is transmitted between devices.
- Understand the characteristics of transmission media: STP, UTP, and optical fiber.
- Understand the factors affecting the performance of network cables.
- Identify and select appropriate network cables.

## Data Transmission

Data is transmitted in **bits**, which can be sent individually or in groups depending on the physical layer specification. The signals representing these bits may take various forms:

- **Electric current or voltage**
- **Electromagnetic waves**
- **Radio waves**
- **Light**

Signals travel from the transmitter in the sending device to the receiver in the receiving device through a transmission medium. Common transmission media include:

- **Copper (Twisted Pair)**
- **Optical Fiber**

Additionally, radio waves and infrared waves are considered **unguided transmission media** (transmission without wires).

## Transmission Media

Two of the most widely used types of transmission media are:

- **Optical Fiber**
- **Twisted Pair**

Among twisted pair options, there are two types:

- **Shielded Twisted Pair (STP)**
  - Features additional shielding to improve noise resistance.
- **Unshielded Twisted Pair (UTP)**
  - The most widely used due to its low cost and flexibility.
  - UTP cables are commonly used in environments where electromagnetic interference (EMI) is less of a concern.

## Electromagnetic and Radio Frequency Interference

**EMI** refers to any frequency of electrical noise that can disrupt signal transmission. **RFI** is a specific subset of EMI, which includes noise that occurs at radio frequencies. Radiated RFI is emitted through the air.

# Transmission Medi··m vs Network Cable

The terms **transmission medium** and **network cable** convey different concepts:

- **Transmission Medium**
  - Refers to the physical means through which data signals are transmitted, such as copper or fiber optic.
- **Network Cable**
  - Incorporates a transmission medium and conforms to standards, such as the RJ45 cable using twisted pair wiring.
  - Network cables are essential for the physical connections between devices within a network.

## Connection using UTP Cables

When connecting devices using UTP cables:

- Utilize a switch with RJ45 sockets.
- Ensure network interface cards (NICs) are equipped with RJ45 sockets.
- Commonly, desktop computers connect to networks using UTP cables.

## Characteristics of UTP

UTP consists of:

- **Four pairs of twisted wires** (total of 8 wires) connected to RJ45 connectors at both ends.
- Also available in less commonly used configurations like **RJ11**, which comprises only two pairs of wires and is often used for telephone connections.

## Categories of UTP

UTP comes in several categories which define maximum speed and distance capabilities:

- **Cat 1:** Voice only (telephone); uses RJ11.
- **Cat 2:** Supports up to 4 Mbps.
- **Cat 3:** Supports up to 10 Mbps (now obsolete).
- **Cat 4:** Supports up to 20 Mbps.
- **Cat 5:** Supports up to 100 Mbps (nearly obsolete).
- **Cat 5e (enhanced):** Supports up to 1 Gbps.
- **Category 6:** Supports up to 10 Gbps (limited to 55m).
- **Cat 6A (augmented):** Supports up to 10 Gbps (up to 100m).
- **Cat 7:** A shielded option for Cat 6.

For example, a Category 6 RJ45 cable can support a data rate of 10 Gbps over a distance of 55m or 1 Gbps for up to 100m.

## Optical Fibre Overview

Optical fiber cables offer advantages in networking, particularly in LANs subject to EMI. Key benefits include:

- **High Data Rate:** Optical fiber networks can transmit data at significantly higher rates than copper cables.

- **Extended Distance:** Fiber optics allow for signal transmissions over longer distances without the need for signal repeaters.
- **Resistance to EMI:** Optical fiber is immune to electromagnetic interference.
- **Maintenance:** While installation may be costlier, maintenance costs are lower due to the lack of short circuits.

## Types of Optical Fibre

Two main types classify optical fiber cabling:

- **Single-Mode:** Uses a laser light source for transmission.
- **Multi-Mode:** Utilizes an LED light source.

### Common Optical Fiber Connectors

Optical fiber cables often feature various connectors:

- **ST Connector:** Typically used for multimode fiber.
- **SC Connector:** Commonly found in single-mode fiber installations.
- **LC Connector:** Highly popular for single-mode applications.

# Research Activity

Students are encouraged to explore their home networks for:

- The devices connected via optical fiber.
- Whether the fiber is single-mode or multimode.
- The types of connectors used.
- The method used for simultaneous upload and download streams over a single fiber.

# Factors Influencing Network Cable Performance

Key considerations in selecting a transmission medium include:

- **Data Rate:** Measured in Kbps, Mbps, and Gbps; affected by attenuation and interference.
- **Maximum Distance:** The length over which a signal can be transmitted effectively witl ut degradation.
- **Electromagnetic Interference:** The susceptibility of the cable type to disruption from external signals.
- **Security Factors:** Assessing the risk of data being intercepted or tampered with.
- **Fire Safety:** Evaluating the flammability of materials used in cabling.
- **Ease of Installation and Maintenance:** How manageable installation and upkeep are in various environments.
- **Relative Cost:** Analyzing the overall expenses associated with cabling.

## Data Rate Comparison

Various transmission media offer distinct data rates:

- Optical fiber supports the highest data rates (> 10 Gbps).
- UTP follows, able to reach speeds up to 10 Gbps.
- Wireless connections generally exhibit the lowest data rates due to interference and signal weakening.

## Recap of Ethernet Standards

Understanding the right cables for Ethernet standards is crucial:

| Ethernet PHY Standard | Speed/Data Rate | Cable Type | Maximum Distance |
|---|---|---|---|
| 100 Base-TX | 100 Mbps | UTP – Cat 5 | 100 m |
| 100 Base-FX | Optical Fibre (multi-mode) | 400m (half duplex), 2 km (full duplex) | |
| 1000 Base-T | 1 Gbps | UTP – 5e or 6 | 100 m |
| 1000 Base-SX | Optical Fibre – multi-mode | 550 m | |
| 1000 Base-LX | Optical Fibre | 550 m (multi-mode), 5 km (single-mode) | |
| 10G Base-T | 10 Gbps | UTP - Cat 6 & 6a | 55 m (Cat 6), 100 m (Cat 6a) |
| 10G Base-SR | Optical Fibre – multi-mode | 300 m | |
| 10G Base-LR | Optical Fibre – single-mode | 10 km | |

## Interference Considerations

Different types of cabling exhibit variegated susceptibility to interference:

- **Optical Fiber:** Highly resistant due to its materials.
- **Unshielded Twisted Pairs (UTP):** Prone to interference, though twisting wires help mitigate effects.
- **Shielded Twisted Pairs (STP):** Enhanced protection through metallic shielding.
- **Wireless (Radio Waves):** Most vulnerable, as signals are affected by physical barriers.

### Mechanical Factors

Consider the following when handling optical fiber:

- Fragility: Optical fibers require protective casings and cannot be excessively bent without risk of breaking.
- Longevity: Optical fibers generally have lower maintenance needs compared to copper cables.
- Safety: Optical fibers present no electrical hazards, unlike copper cables, which may spark or produce shocks.
- Flexibility: STP cables can be less flexible than UTP due to their thicker construction.
- Obstruction: Physical objects can hinder wireless signal propagation.

## Comparative Analysis: Optical Fiber vs Twisted Pair Copper Cable

- **Optical Fiber:**
  - Immunity to EMI and RFI.
  - Low signal attenuation and high data rates over long distances (up to 100 km for single-mode).

    - Greater security due to harder tap access.
    - Higher installation costs due to material and labor considerations.
- **Twisted Pair:[**
    - More straightforward to install, making it favorable for many applications.
    - Relative cost-effectiveness compared to fiber optics.

### Usage Considerations for Optical Fiber

Employ optical fiber when:

- EMI resistance is critical.
- High data rates over extended distances are required.
- Security is a top priority.
- Fire safety considerations are paramount.

Avoid optical fiber when:

- Installation ease is a priority.
- Cost constraints exist.

## Activities: Network Cabling

Students should refer to Tutorial 15 for practice questions.

## Summary

In summary, Ethernet LANs primarily utilize two types of cables: Twisted Pair and Optical Fiber. Within twisted pair cables, the main types are Shielded Twisted Pair (STP) and Unshielded Twisted Pair

(UTP), with UTP being the most common due to its cost-effectiveness. The common UTP categories include Cat 6, Cat 6A, and Cat 7. For optical fiber, one can choose between single-mode and multimode cables. The selection of suitable cables for Ethernet LANs depends on multiple factors such as data rate, distance, interference considerations among others. Optical fiber is superior in scenarios involving electrical interference, but it requires a larger investment and is often more complex to install. Wireless technologies are advantageous for mobility but lag behind in terms of data rate, range, and security compared to wired options.