

# Switching (Chapter-8)

## 1. Describe the need for switching and define a switch.

In data communication, switching is essential for efficient data communication within local area networks (LANs). Here's an overview of the need for switching and a definition of a switch:

Need for switching:

- Improved network performance
- Bandwidth optimization
- Network segmentation
- Scalability
- Reduced latency

A switch is a component that **connects devices in a network to each other**, enabling them to talk by exchanging data packets.

## 2. List the three traditional switching methods. What are the most common today?

Certainly The three traditional switching methods are:

1. Circuit switching
2. Message switching
3. Packet switching

Among these, packet switching is by far the most common method used in modern computer Packet switching is the most common method today because:

1. Efficiency: It allows for better utilization of network resources by sharing bandwidth among multiple communications.
2. Flexibility: Packets can take different routes to reach their destination, improving network resilience.
3. Scalability: It's well-suited to handling varying amounts of traffic and network growth.
4. Cost-effectiveness: Network resources are used only when data is actually being transmitted.

## 4. What are the two approaches to packet-switching?

There are two main approaches to packet-switching:

1. Datagram packet switching
2. Virtual circuit packet switching

**1. Datagram packet switching:**

- Also known as connectionless packet switching
- Each packet is treated independently and may take different routes
- Packets can arrive out of order, requiring reordering at the destination
- More flexible and robust, but less reliable

**2. Virtual circuit packet switching:**

- Also called connection-oriented packet switching
- Establishes a pre-determined route for all packets in a session
- Packets arrive in order
- More reliable, but less flexible

**3. Compare and contrast a circuit-switched network and a packet-switched network.**

**Circuit-switched:**

- Dedicated path for entire communication
- Fixed bandwidth allocation
- Consistent latency
- Less efficient for bursty data
- Example: Traditional telephone systems

**Packet-switched:**

- No fixed path; packets routed independently
- Dynamic resource allocation
- Variable latency
- More efficient for data networks
- Example: Internet

**5. Compare space-division and time-division switches.**

Comparison of space-division and time-division switches:

**Space-division switches:**

1. Operation: Use separate physical paths for each connection
2. Capacity: Limited by number of physical connections

3. Topology: Often use crossbar or multistage designs
4. Bandwidth: Each connection gets dedicated bandwidth
5. Complexity: Simpler in concept, but can be complex to scale
6. Example: Traditional telephone exchange switchboards

### **Time-division switches:**

1. Operation: Share a single path by dividing it into time slots
2. Capacity: Limited by number of time slots and transmission speed
3. Topology: Typically use a bus or ring structure
4. Bandwidth: Shared among multiple connections
5. Complexity: More complex control, but easier to scale
6. Example: Digital PBX systems, some computer network switches

## **Transmission Media(chapter-7)**

### **1. What is the position of the transmission media in the OSI or the Internet model?**

In both the OSI (Open Systems Interconnection) model and the Internet (TCP/IP) model, the transmission media (e.g., cables, wireless signals) are considered to be **below** the first layer.

#### **OSI Model:**

- **Physical Layer (Layer 1):** The transmission media is typically associated with the Physical Layer. This layer is responsible for the physical connection between devices, including the hardware (like cables, switches, and network interface cards) that transmits the raw bit stream over the network.

#### **Internet (TCP/IP) Model:**

- **Network Interface Layer (Link Layer):** In the TCP/IP model, the transmission media is linked to the Network Interface Layer, also known as the Link Layer. This layer corresponds to both the Physical Layer and the Data Link Layer of the OSI model and handles hardware addressing and the transmission of data over a particular physical medium.

### **2. Name the two major categories of transmission media.**

The two major categories of transmission media are:

1. **Guided (Wired) Media:**

- This type of transmission media involves physical cables or wires through which data is transmitted. The signal is guided along the path of the physical medium.
- Examples include:
  - Twisted Pair Cables (e.g., Cat5, Cat6 Ethernet cables)
  - Coaxial Cables
  - Fiber Optic Cables

2. **Unguided (Wireless) Media:**

- This type of transmission media does not involve physical cables. Instead, data is transmitted through the air or space using electromagnetic waves.
- Examples include:
  - Radio Waves (e.g., Wi-Fi, AM/FM radio)
  - Microwaves (e.g., satellite communications)
  - Infrared (e.g., remote controls, some short-range communication systems)

**3. How do guided media differ from unguided media?**

Guided media uses physical cables (like twisted pair, coaxial, or fiber optic) to transmit signals, offering higher reliability and speed with less interference. Unguided media transmits signals wirelessly through the air (using radio waves, microwaves, etc.), providing flexibility and wider coverage but with more susceptibility to interference and varying performance.

**4. What are the three major classes of guided media?**

The three major classes of guided media are:

1. **Twisted Pair Cable:**

- Consists of pairs of insulated copper wires twisted together.
- Commonly used in telephony and Ethernet networks (e.g., Cat5, Cat6 cables).

2. **Coaxial Cable:**

- Composed of a central conductor, an insulating layer, a metallic shield, and an outer insulating layer.
- Used for cable television, internet connections, and some local area networks (LANs).

3. **Fiber Optic Cable:**

- Uses light to transmit data through strands of glass or plastic fibers.
- Offers high bandwidth and long-distance transmission with minimal signal loss, used in telecommunications and high-speed network connections.

**5. What is the significance of the twisting in twisted-pair cable?**

The twisting in twisted-pair cables is essential for minimizing electromagnetic interference (EMI) and crosstalk between the wires. By twisting the pairs of wires together, the electromagnetic fields generated by each wire are more likely to cancel each other out, reducing external interference. This also helps in minimizing crosstalk, where signals from one pair of wires can interfere with those in another pair. The twisting ensures more consistent exposure to external noise, preserving signal integrity over longer distances and leading to clearer and more reliable communication in network systems.

## 6. What is refraction? What is reflection?

### Refraction:

Refraction is the bending of light or any other wave as it passes from one medium to another with a different density. This change in speed causes the wave to change direction. For example, when light passes from air into water, it slows down and bends towards the normal line (an imaginary line perpendicular to the surface at the point of contact). Refraction is why a straw looks bent when placed in a glass of water.

### Reflection:

Reflection is the phenomenon where light or any other wave bounces back after hitting a surface. When a wave encounters a reflective surface, such as a mirror, it does not pass through the surface but instead returns into the medium it came from. The angle at which the wave strikes the surface (the angle of incidence) is equal to the angle at which it reflects (the angle of reflection). This principle explains why we see images in mirrors.

## 7. What is the purpose of cladding in an optical fiber?

The purpose of cladding in an optical fiber is to ensure that light signals are kept within the core of the fiber, enabling efficient transmission over long distances. The cladding, which surrounds the core, has a lower refractive index than the core, causing the light to reflect back into the core whenever it tries to escape. This process, known as **total internal reflection**, keeps the light signals confined within the core, allowing them to travel with minimal loss and maintaining the integrity of the transmitted data. Additionally, cladding provides mechanical protection for the core and helps prevent signal loss due to external interference.

## 8. Name the advantages of optical fiber over twisted-pair and coaxial cable.

## Optical fiber offers several advantages over twisted-pair and coaxial cables:

- **Higher Bandwidth:** Optical fiber supports much faster data rates than twisted-pair and coaxial cables.
- **Longer Distance:** Fiber optics transmit data over longer distances with less signal loss.
- **Reduced Signal Loss:** Optical fibers have lower attenuation, maintaining signal quality over longer spans.
- **Immunity to EMI:** Fiber is not affected by electromagnetic interference, unlike twisted-pair and coaxial cables.
- **Greater Security:** Fiber optics are harder to tap into without detection, enhancing data security.
- **Smaller Size and Weight:** Optical fibers are thinner and lighter, making them easier to install and manage.
- **Higher Reliability:** Fiber optics are more resilient to environmental factors and interference, ensuring more reliable performance.

## Advantages and Disadvantages of Optical Fiber:

### Advantages:

1. **High Bandwidth:** Fast data transmission rates.
2. **Long Distance:** Transmits data over long distances with minimal loss.
3. **Low Signal Loss:** Maintains signal quality over long spans.
4. **Immunity to EMI:** Not affected by electrical interference.
5. **Enhanced Security:** Difficult to tap into undetected.
6. **Small Size and Lightweight:** Easier to install and manage.
7. **Durability:** Resistant to environmental damage.

### Disadvantages:

1. **Cost:** Higher initial installation and equipment costs.
2. **Fragility:** More prone to damage if mishandled.
3. **Complex Installation:** Requires specialized skills and equipment.
4. **Limited Equipment Availability:** May have fewer compatible components in some areas.
5. **Maintenance Challenges:** More complex and costly to repair.

## Optical vs twisted vs coaxial:

Twisted pair cable	Co-axial cable	Optical fiber
1. Transmission of signals takes place in the electrical form over the metallic conducting wires.	1. Transmission of signals takes place in the electrical form over the inner conductor of the cable.	1. Signal transmission takes place in an optical form over a glass fiber.
2. In this medium the noise immunity is low.	2. Coaxial having higher noise immunity than twisted pair cable.	2. Optical fiber has highest noise immunity as the light rays are unaffected by the electrical noise.
3. Twisted pair cable can be affected due to external magnetic field.	3. Coaxial cable is less affected due to external magnetic field.	3. Not affected by the external magnetic field.
4. Cheapest medium.	4. Moderate Expensive.	4. Expensive
5. Low Bandwidth.	5. Moderately high bandwidth.	5. Very high bandwidth
6. Attenuation is very high.	6. Attenuation is low.	6. Attenuation is very low.
7. Installation is easy.	7. Installation is fairly easy.	7. Installation is difficult.

## Difference between Radio wave, Microwave, and Infrared waves :

Sr. No.	Basis	Radiowave	Microwave	Infrared wave
1.	Direction	These are omnidirectional in nature.	These are unidirectional in nature.	These are unidirectional in nature.
2.	Penetration	At low frequency, they can penetrate through solid objects and walls but high frequency they bounce off the	At low frequency, they can penetrate through solid objects and walls. at high frequency, they cannot	They cannot penetrate through any solid object and walls.

Sr. No.	Basis	Radiowave	Microwave	Infrared wave
		obstacle.	penetrate.	
3.	Frequency range	Frequency range: 3 KHz to 1GHz.	Frequency range: 1 GHz to 300 GHz.	Frequency range: 300 GHz to 400 THz.
4.	Security	These offers poor security.	These offers medium security.	These offers high security.
5.	Attenuation	Attenuation is high.	Attenuation is variable.	Attenuation is low.
6.	Government License	Some frequencies in the radio-waves require government license to use these.	Some frequencies in the microwaves require government license to use these.	There is no need of government license to use these waves.
7.	Usage Cost	Setup and usage Cost is moderate.	Setup and usage Cost is high.	Usage Cost is very less.
8.	Communication	These are used in long distance communication.	These are used in long distance communication.	These are not used in long distance communication.

### UTP (Unshielded Twisted Pair) vs. STP (Shielded Twisted Pair) Cables:

#### Unshielded Twisted Pair (UTP):

- **Shielding:** No additional shielding beyond the insulation of individual wire pairs.
- **Cost:** Generally lower cost.
- **Flexibility:** More flexible and easier to install.
- **Performance:** More susceptible to electromagnetic interference (EMI) and crosstalk, which can affect signal quality, particularly in noisy environments.
- **Typical Use:** Common in home networks and office environments where EMI is minimal.

## Shielded Twisted Pair (STP):

- **Shielding:** Includes a shield (foil or braided mesh) around the insulated wire pairs to protect against EMI and crosstalk.
- **Cost:** Typically higher cost due to additional shielding.
- **Flexibility:** Less flexible and more rigid, which can make installation more challenging.
- **Performance:** Better protection against EMI and crosstalk, making it suitable for environments with high electrical noise.
- **Typical Use:** Used in environments with potential interference, such as industrial settings or data centers.

## Unguided signals can travel in several ways:

- Ground propagation:

radio waves travelling through the lowest portion of the atmosphere. These low frequency signals emanate in all directions and follow the curvature of the planet.

- Sky propagation:

Higher frequency radio waves radiate upward into the ionosphere where they are reflected back

- Line of sight propagation:

very high frequency are transmitted in straight lines directly between antennas.

## Unidirectional Antennas (for microwaves):

- ✚ Parabolic dish antenna:

- Every line parallel to the line of symmetry reflects off the curve at angles such that all lines intersect at a common point called focus.
- It catches wide range of waves and direct them to the focus.

- ✚ Horn Antenna:

- Outgoing transmission are broadcast up a stem and deflects outward in a series of narrow parallel beams by the curve head.

# Multiplexing(chapter-6)

## 1. Describe the goals of multiplexing in data communication.

Multiplexing in data communication is a technique used to combine multiple signals or data streams into one, allowing them to be transmitted over a single communication channel or medium. The main goals of multiplexing include:

- **efficient Resource Utilization:** Maximizes bandwidth usage by combining multiple signals on a single channel.
- **Cost Reduction:** Decreases infrastructure costs by reducing the number of channels required.
- **Increased Capacity:** Enables more data to be transmitted simultaneously.
- **Improved Communication:** Supports simultaneous transmission of different types of data (e.g., voice, video, and data).
- **Minimized Interference:** Isolates different data streams to avoid cross-interference.channel or medium.

## 2. List three main multiplexing techniques mentioned in this chapter.

The three main multiplexing techniques typically mentioned in data communication are:

1. **Time Division Multiplexing (TDM)**
2. **Frequency Division Multiplexing (FDM)**
3. **Wavelength Division Multiplexing (WDM)**

These methods allow multiple signals to share the same transmission medium efficiently.

## 3. Distinguish Between Link and Channel in Multiplexing

In the context of multiplexing, "link" and "channel" refer to different aspects of data transmission:

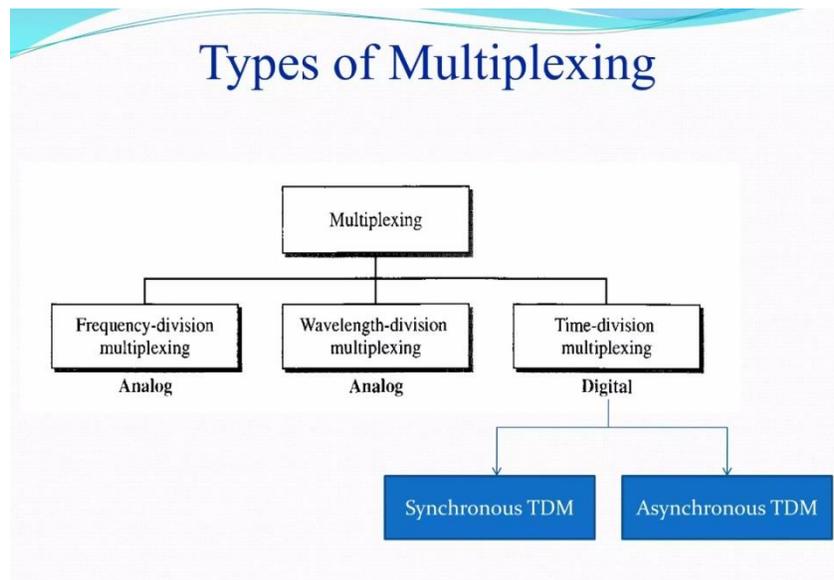
1. **Link:**
  - A link refers to the physical or logical connection between two or more devices in a communication network.
  - It can be a physical medium like a fiber optic cable, a copper wire, or a wireless connection.

- The link is the actual pathway that data travels through, connecting the transmitter and receiver.

## 2. Channel:

- A channel is a subdivision of the link that carries a specific data stream.
- In multiplexing, multiple channels are created within a single link, each carrying its own data signal.
- Channels can be separated by time (TDM), frequency (FDM), or wavelength (WDM) to ensure that multiple signals can coexist on the same link without interference.

## 4. Which of the three multiplexing techniques is (are) used to combine analog signals? Which of the three multiplexing techniques is (are) used to combine digital signals?



### **✚ Multiplexing techniques used to combine analog signals:**

- **Frequency Division Multiplexing (FDM):**

Primarily used for combining analog signals. It separates the signals by allocating different frequency bands within the same link.

- **Wavelength Division Multiplexing (WDM):**

While generally associated with optical signals (which can be either digital or analog), WDM is mostly used to combine digital signals, particularly in fiber optic communication.

#### Multiplexing techniques used to combine digital signals:

- **Time Division Multiplexing (TDM):**

Typically used for combining digital signals by allocating different time slots for each signal within the same link.

### 5. Which of the three multiplexing techniques is common for fiber optic links? Explain the reason

**Wavelength Division Multiplexing (WDM)** is the most common multiplexing technique for fiber optic links because it allows multiple data streams to be transmitted simultaneously over a single fiber by using different wavelengths of light. This maximizes the bandwidth of the fiber, greatly increases data capacity, and reduces the need for additional physical infrastructure, making it both efficient and cost-effective. Additionally, WDM is scalable and compatible with existing fiber networks, allowing for easy upgrades and future expansion.

### 6. Distinguish between multilevel TDM, multiple slot TDM, and pulse-stuffed TDM.

A distinction between **Multilevel TDM**, **Multiple Slot TDM**, and **Pulse-Stuffed TDM**:

- **Multilevel TDM:** This technique combines several lower-rate data streams into a single higher-rate stream by assigning each stream a specific time slot within the TDM frame. Each input stream gets one slot, regardless of its rate, and the combined data is transmitted sequentially.

- **Multiple Slot TDM:** In this method, data streams that require more bandwidth or have higher data rates are allocated multiple time slots within the same TDM frame. This allows those streams to transmit more data per frame compared to others that use only one slot.

- **Pulse-Stuffed TDM:** Used to synchronize data streams with slightly different rates, this technique adds extra bits (or pulses) to some streams. These additional bits ensure that all streams are synchronized correctly within the TDM frame, preventing timing mismatches during transmission.

## 6. Distinguish between synchronous and statistical TDM.

### Comparison of data multiplexer techniques

Sr.No.	Parameter	FDM	Synchronous TDM	Statistical TDM
1	Line utilization efficiency	Poor	Good	Very good
2	Flexibility	Poor	Good	Very good
3	Channel capacity	Poor	Good	Excellent
4	Error control	Not possible	Not possible	Possible
5	Multidrop capacity	Very good	Difficult to achieve	Possible
6	Transmission delay	Does not exist	Low	Random
7	Cost	High	Low	Moderate

## 7. Define FHSS and explain how it achieves bandwidth spreading.

**Frequency Hopping Spread Spectrum (FHSS)** is a method of transmitting radio signals by rapidly switching the carrier frequency among many distinct frequencies within a larger bandwidth. These frequency hops follow a specific sequence known to both the transmitter and receiver, allowing them to stay synchronized.

### How FHSS Achieves Bandwidth Spreading:

- i. **Frequency Hopping:** FHSS rapidly switches the carrier signal across multiple frequencies in a pseudo-random pattern.
- ii. **Bandwidth Spreading:** The signal is spread over a wide frequency range, reducing power concentration on any single frequency.
- iii. **Interference Avoidance:** The hopping reduces the likelihood of interference since the signal doesn't stay on any one frequency for long.
- iv. **Security:** The random hopping sequence adds a layer of security, making it difficult for unauthorized receivers to intercept the signal.

## 8. Define DSSS and explain how it achieves bandwidth spreading.

**Direct Sequence Spread Spectrum (DSSS)** is a technique used in wireless communication where the original data signal is multiplied by a much faster pseudo-random noise (PN) sequence, spreading the signal over a wider frequency band.

## How DSSS Achieves Bandwidth Spreading

1. **Data Signal Multiplication:** The original data signal is combined (multiplied) with a high-rate PN sequence, which consists of a stream of chips (binary bits). This sequence is much faster than the original data rate.
2. **Spreading:** The multiplication process spreads the signal's power across a much broader frequency band than the original signal's bandwidth. Each bit of the original data is spread over several chips.
3. **Bandwidth Utilization:** The spread signal occupies a wider bandwidth, making it less susceptible to narrowband interference and more difficult for unauthorized receivers to detect or intercept.
4. **Signal Recovery:** At the receiver's end, the same PN sequence is used to despread the signal, recovering the original data by correlating the received signal with the PN sequence.

TABLE I. COMPARISONS BETWEEN FHSS & DSSS

Systems Behaviors	FHSS	DSSS
System collocations	It is easier to use FHSS for installations of big coverage and multiple collocated cells.	DSSS can be used but collocated cells must be non-overlapping cells at the radio level which is required using directional antennas.
Noise and Interference Immunity	FHSS systems operate with SNR of about 18 dB	DSSS systems operate with SNR 12 dB because Phase-shift keying is used.
Near or Far problem	If the receiver uses FHSS, the worst case will be foreign transmitter, which will block some hops.	In DSSS systems, the problem is more critical and signals generated by the foreign transmitter could not be heard at the receiver.
Throughput	FHSS systems never collide. They provide more or less the same throughput as DSSS systems.	DSSS systems provide greater throughput than with non-synchronized FHSS.
Multipath Immunity	An FHSS system shows more resistance to multipath immunity.	For long distance systems, the use of directional antennas may help reducing the multipath sensitivity in DSSS systems.
Security	In FHSS, frequencies may be selected by the user and there is no need for application level encryption.	DSSS systems use spreading sequence of 11 chips, which modulate 14 channels and it needs message encryption at the application layer.
Bluetooth Interference	Bluetooth radio is a FHSS operating in the 2.4 GHz band.	DSSS is more sensitive to Bluetooth interference rather than in the FHSS systems

**distinguish between asynchronous and synchronous tdm**

## ASYNCHRONOUS vs. SYNCHRONOUS

- |                                                |                                                                                            |
|------------------------------------------------|--------------------------------------------------------------------------------------------|
| • Dynamically assign slots in the TDM path.    | • Synchronized time slot in the TDM path                                                   |
| • Better use of capacity.                      | • Wastes of capacity.                                                                      |
| • Greater number of channels.                  | • Limited number of channels.                                                              |
| • Better utilization of composite TDM circuit. | • Utilization can be improved by using a STDM and increasing the number of input channels. |



## Comparison of FDM and TDM Systems

Sr. No.	FDM	TDM
1	The signals which are to be multiplexed are added in the time domain. But they occupy different slots in the frequency domain.	The signals which are to be multiplexed can occupy the entire bandwidth but they are isolated in the time domain.
2	FDM is usually preferred for the analog signals.	TDM is preferred for the digital signals.
3	Synchronization is not required.	Synchronization is required.
4	The FDM requires a complex circuitry at the transmitter and receiver.	TDM circuitry is not very complex.
5	FDM suffers from the problem of crosstalk due to imperfect band pass filters.	In TDM the problem of crosstalk is not severe.
6	Due to wideband fading in the transmission medium, all the FDM channels are affected.	Due to fading only a few TDM channels will be affected.
7	Due to slow narrowband fading taking place in the transmission channel only a single channel may be affected in FDM.	Due to slow narrowband fading all the TDM channels may get wiped out.

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