CHAPTER 3

Network Cabling and Hardware Devices

TESTOUT NETWORK PRO

3.1 NETWORK CABLING AND HARDWARE DEVICES

Copper Cables and Connectors

Section Skill Overview

- Connect to an Ethernet network.
- Connect a cable modem.

Key Terms

- Crosstalk
- Unshielded twisted pair (UTP)
- Shielded twisted pair (STP)
- Plenum space
- Riser space

Key Definitions

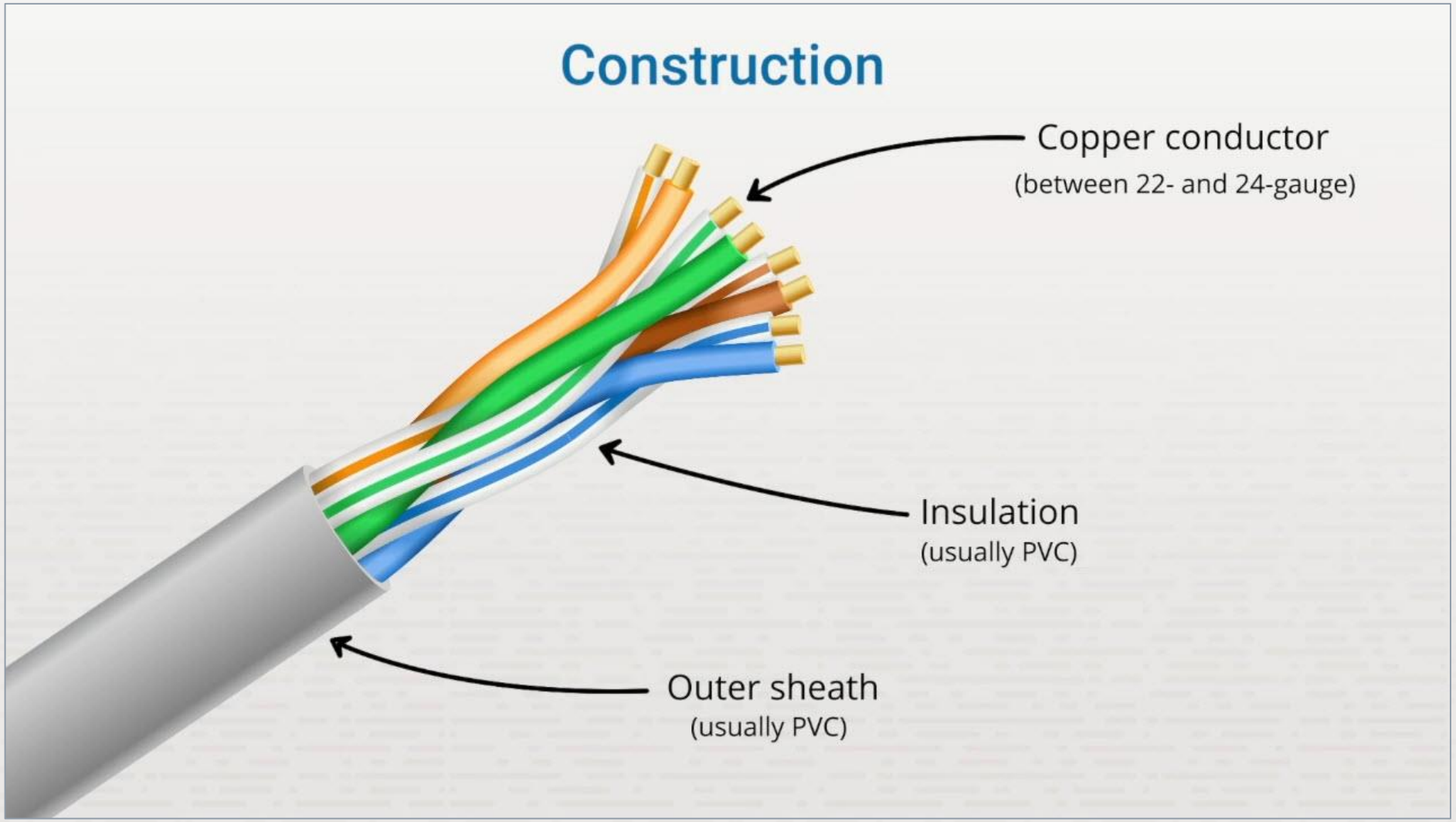
- **Crosstalk:** An unwanted transfer of signals between communication channels.
- **Unshielded twisted pair (UTP):** Two twisted wires that carry the data signals (one conductor carries a positive signal; one carries a negative signal). Twisting the cables reduces the effects of electromagnetic interference (EMI) and crosstalk.
- **Shielded twisted pair (STP):** Shielded twisted pair (STP) has a grounded outer copper shield around the bundle of twisted pairs or around each pair. This provides added protection against EMI.

Key Definitions

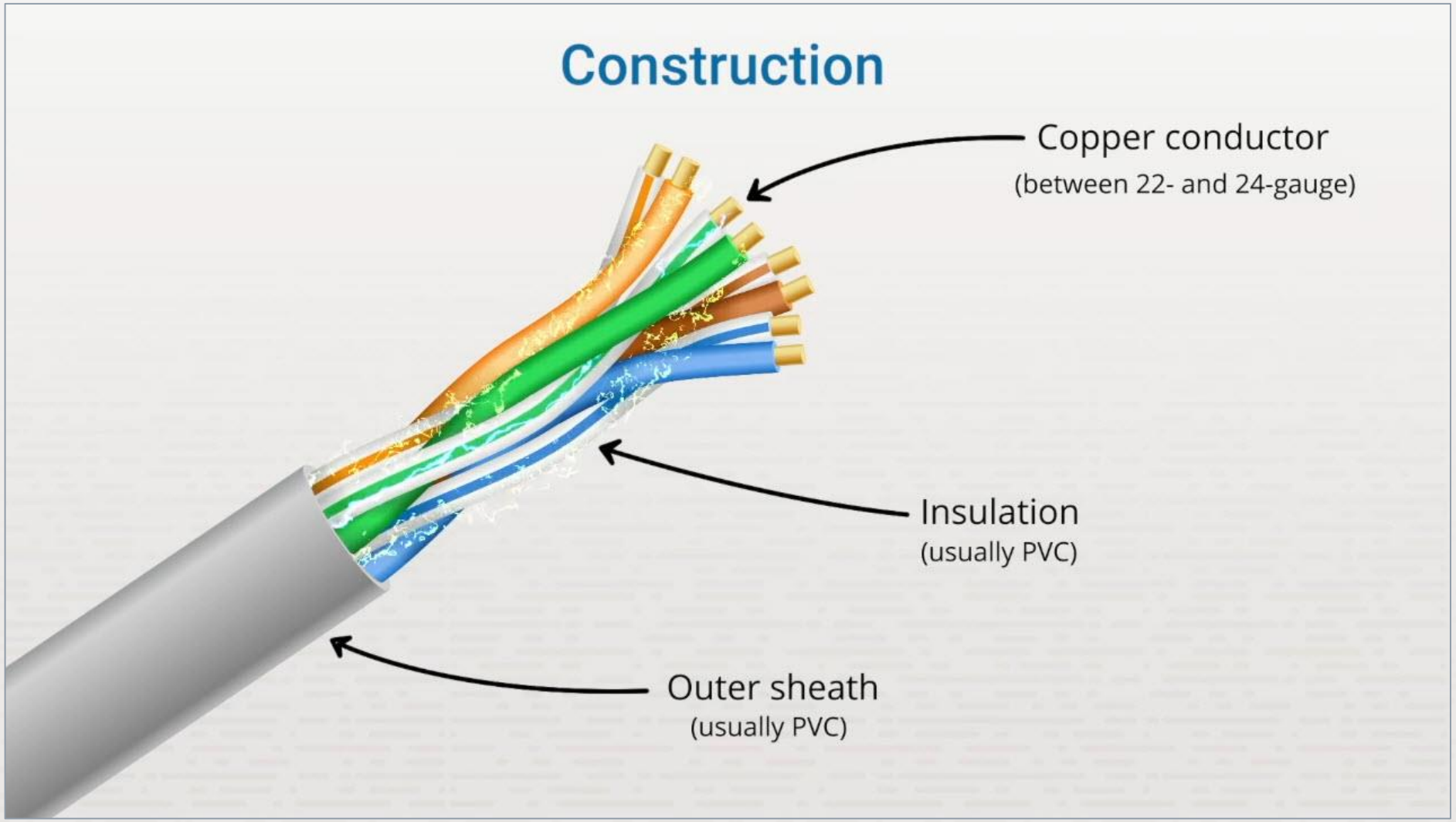
- **Plenum space:** A plenum space is a part of a building that provides a pathway for the airflow needed by heating and air conditioning systems, such as above a dropped ceiling or below a raised floor.
- **Riser space:** An area that connects multiple floors where cables can be run. This area cannot be a plenum space.

Twisted Pair

Twisted Pair



Twisted Pair



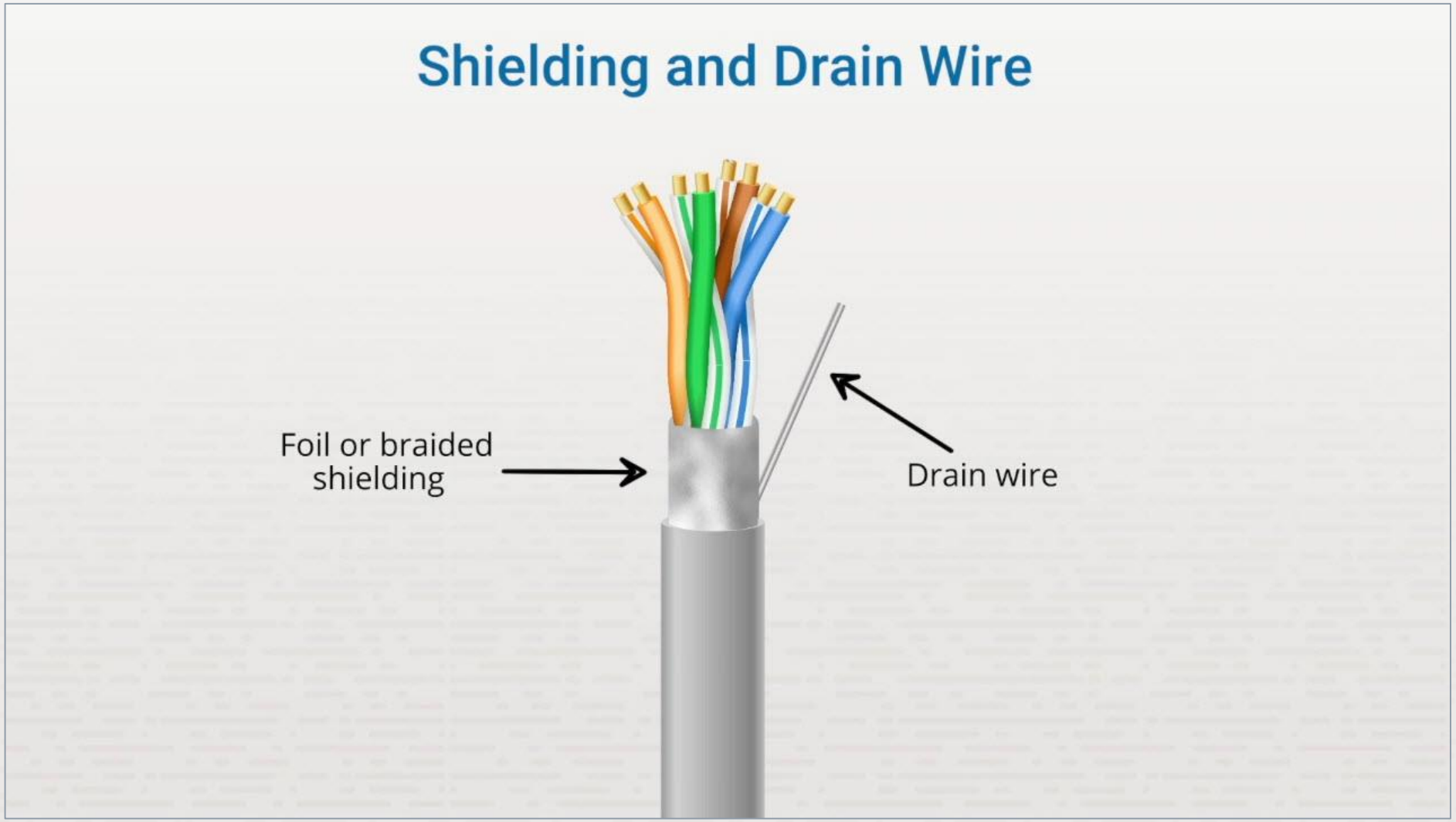
Advantages

- Flexible
- Less expensive
- Easy to work with

Disadvantages

- EMI
- Eavesdropping

Twisted Pair



Plenum and Riser

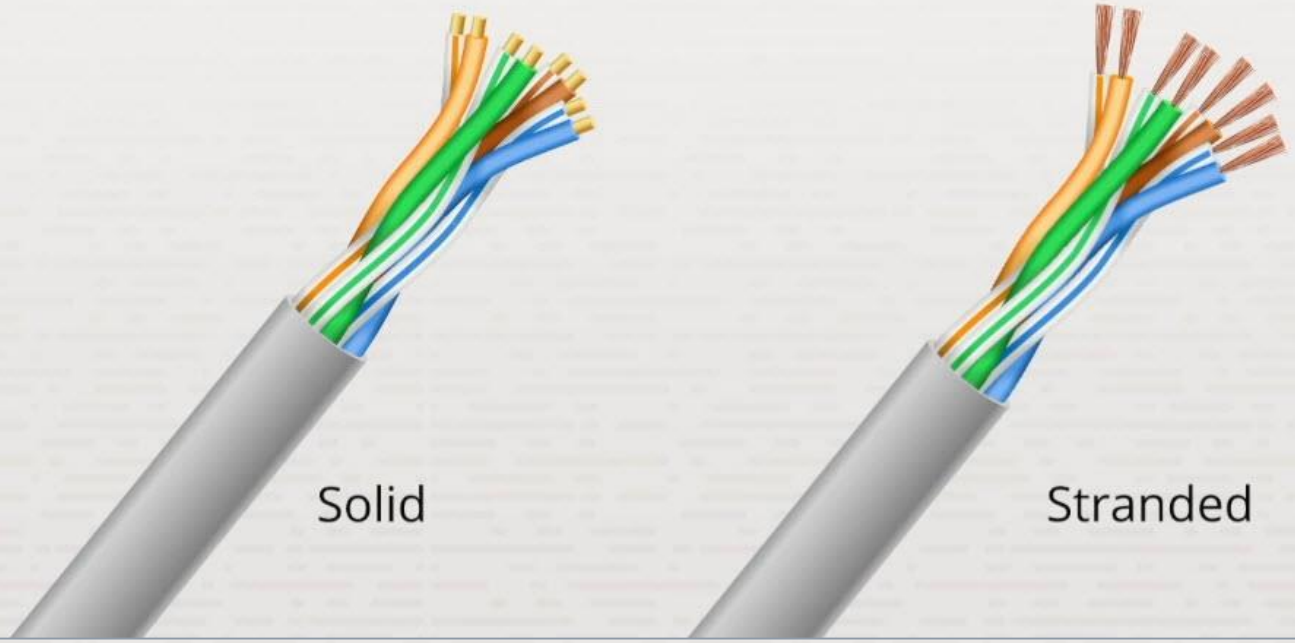
- Plenum space
- Plenum-rated cable
- Riser-rated cable
- Plenum vs. riser

Twisted Pair

Solid vs. Stranded

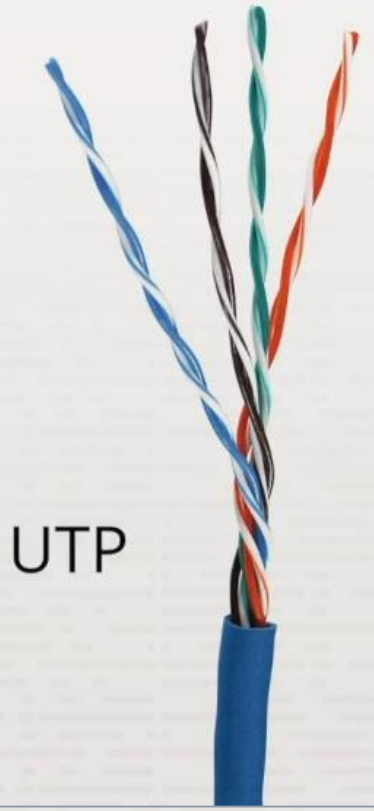
- Conduct signals better
- Prone to break

- More flexible
- Does not conduct signals as well
- Used for patch cables



Twisted Pair

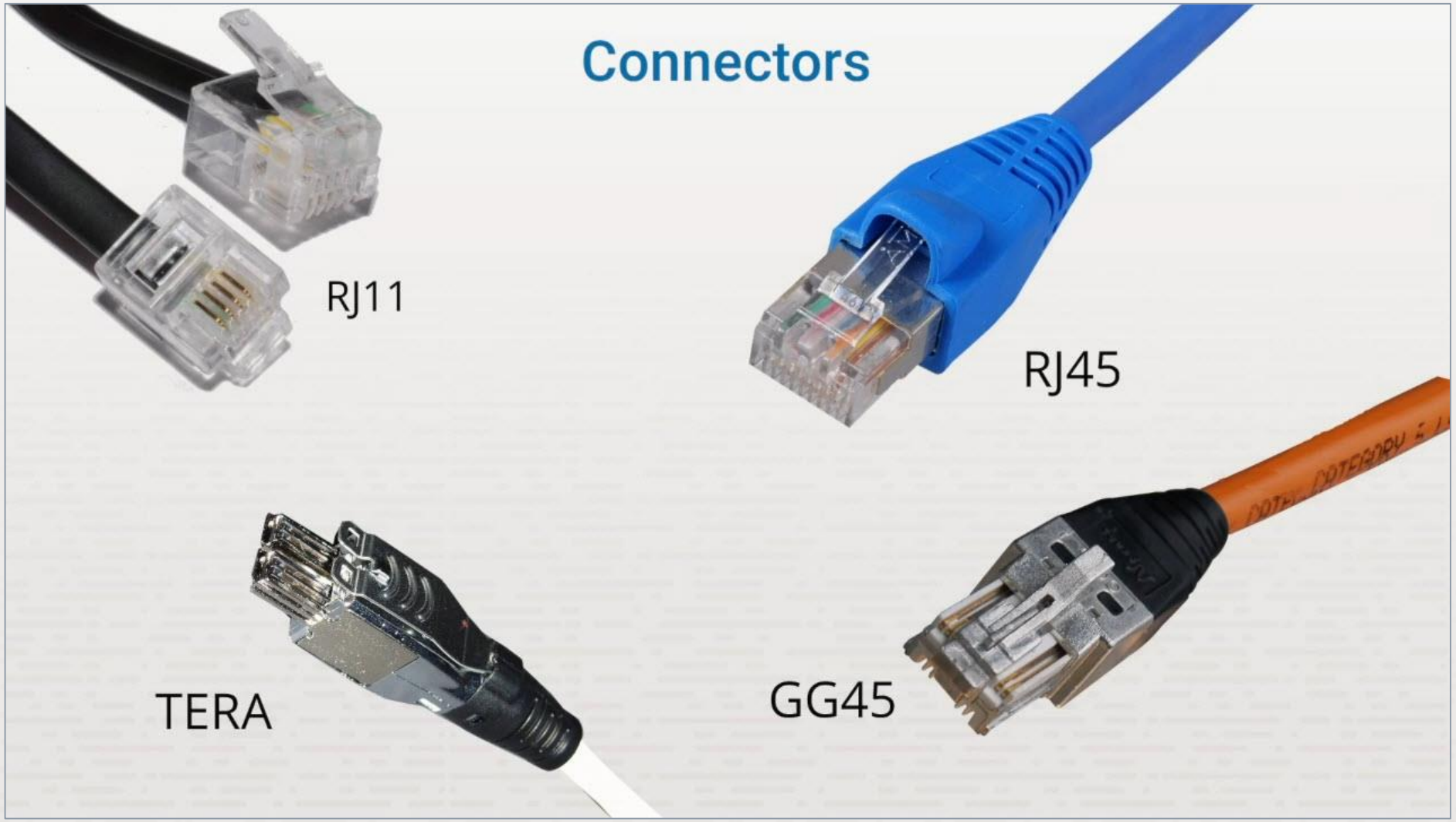
Cable Categories



UTP

- Cat 5
- Cat 5e
- Cat 6
- Cat 6a
- Cat 7
- Cat 8

Twisted Pair

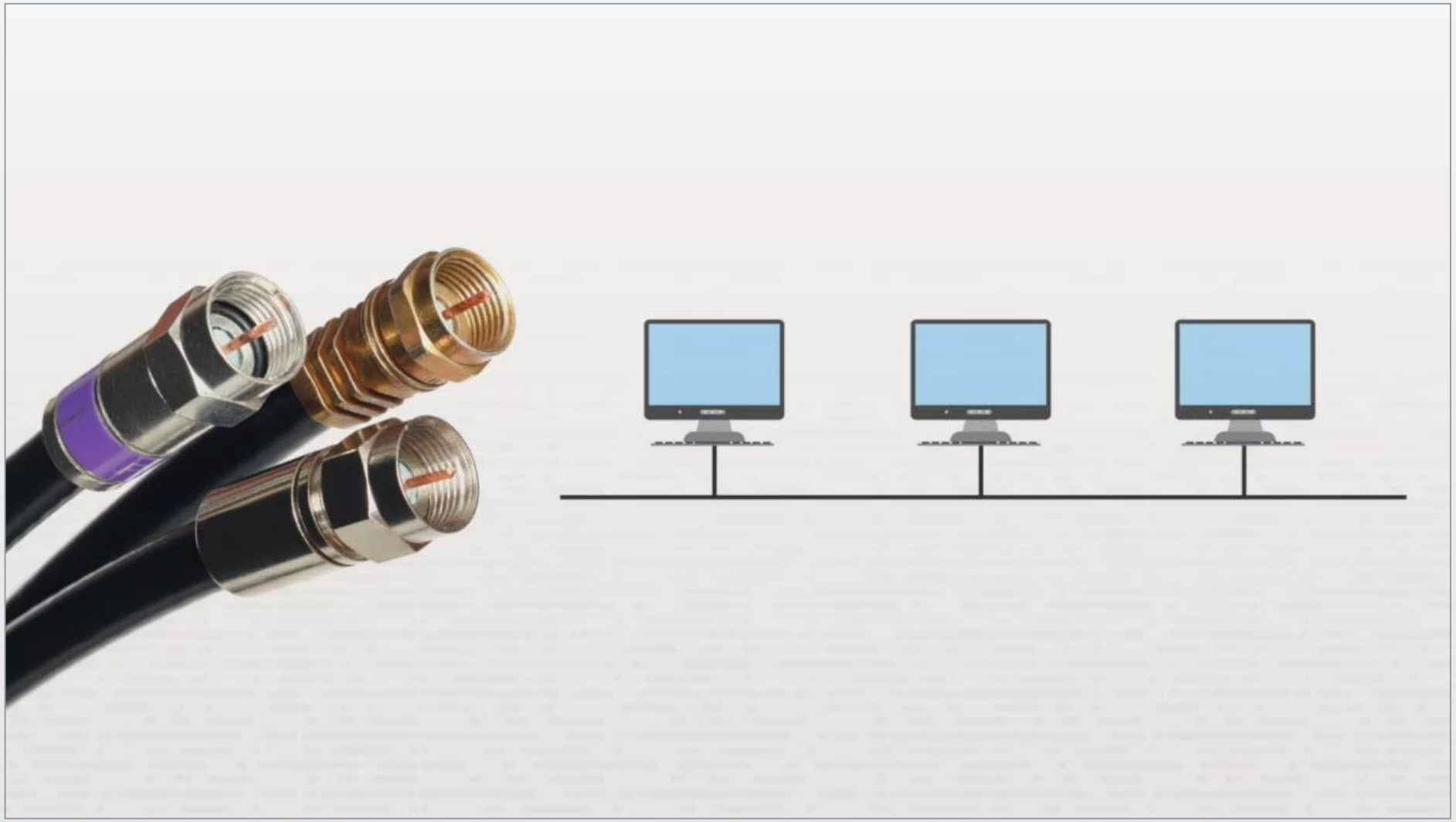


Summary

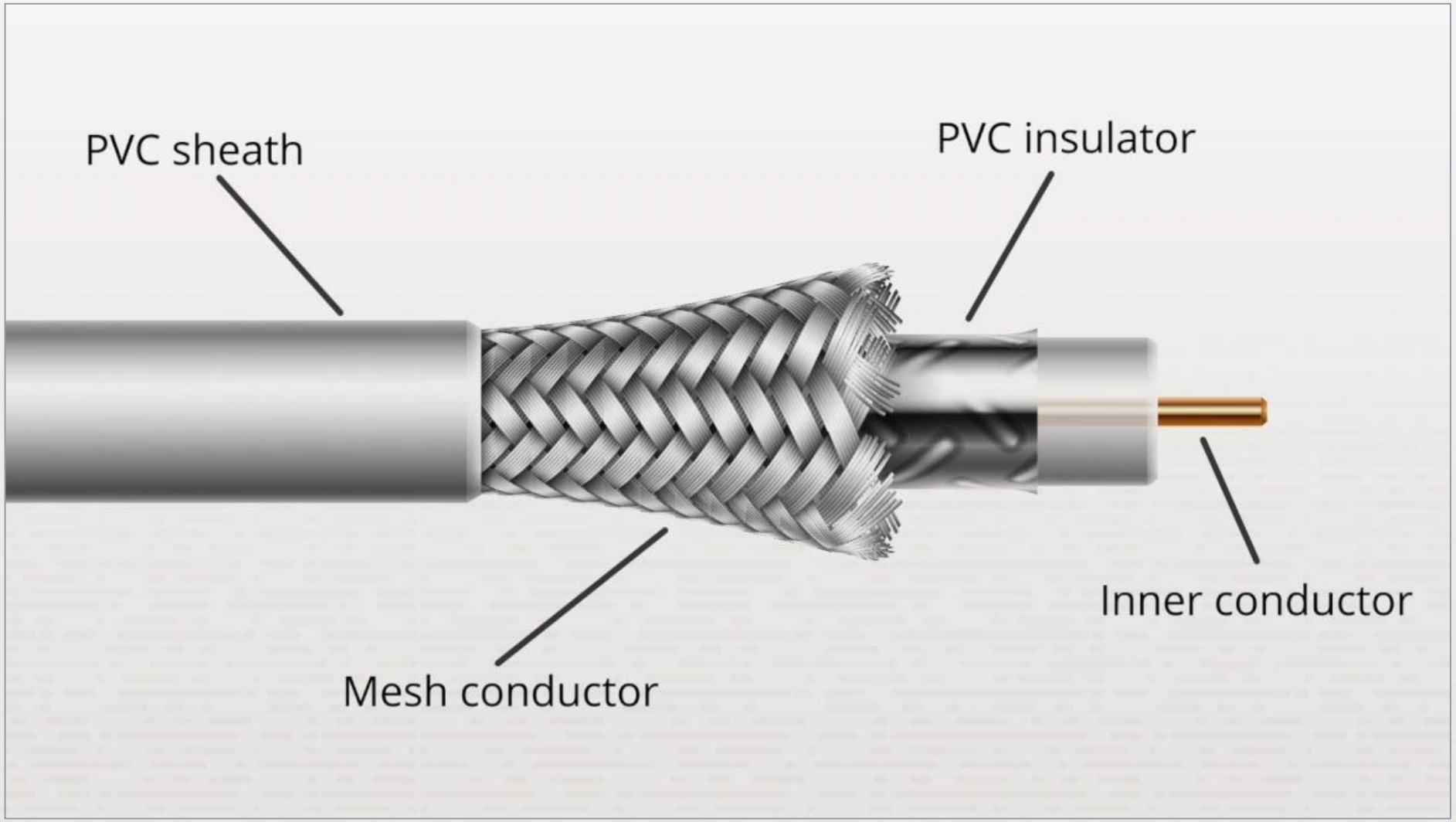
- Reduces crosstalk
- Shielding reduces EMI
- Plenum-rated cables
- Categories 5-8
- Available connectors

Coaxial

Coaxial



Coaxial



Advantages

- Resistant to EMI
- Resistant to damage

Disadvantages

- Expensive to implement
- Thick - less flexible
- Harder to install

Cable Grades

- RG58 - Thinnet
- RG-59 - Cable TV
- RG-6 - Satellite TV and cable modems

Coaxial

BNC connector

BNC coupler

F-Type connector

Summary

- Coaxial - Core, outer conductor
- Types: RG-58, RG-59, RG-6
- Connectors: BNC, F-Type
- RG-58 and BNC - Thinnet

In-Class Practice

Do the following labs:

- 3.1.3 Connect to an Ethernet Network
- 3.1.6 Connect a Cable Modem

Class Discussion

- Why are wires twisted together in twisted-pair cables?
- What is the difference between STP cabling and UTP cabling?
- What is the difference between Cat 3, Cat 5e, and Cat 6a cables?
- How can you tell the difference between RJ11 and RJ45 connectors?
- You have an installation that requires Cat 5 cabling. Which cable ratings could you use for the installation?

3.2 NETWORK CABLING AND HARDWARE DEVICES

Fiber Optic Cables and Connectors

Section Skill Overview

- Connect fiber optic cables

Key Terms

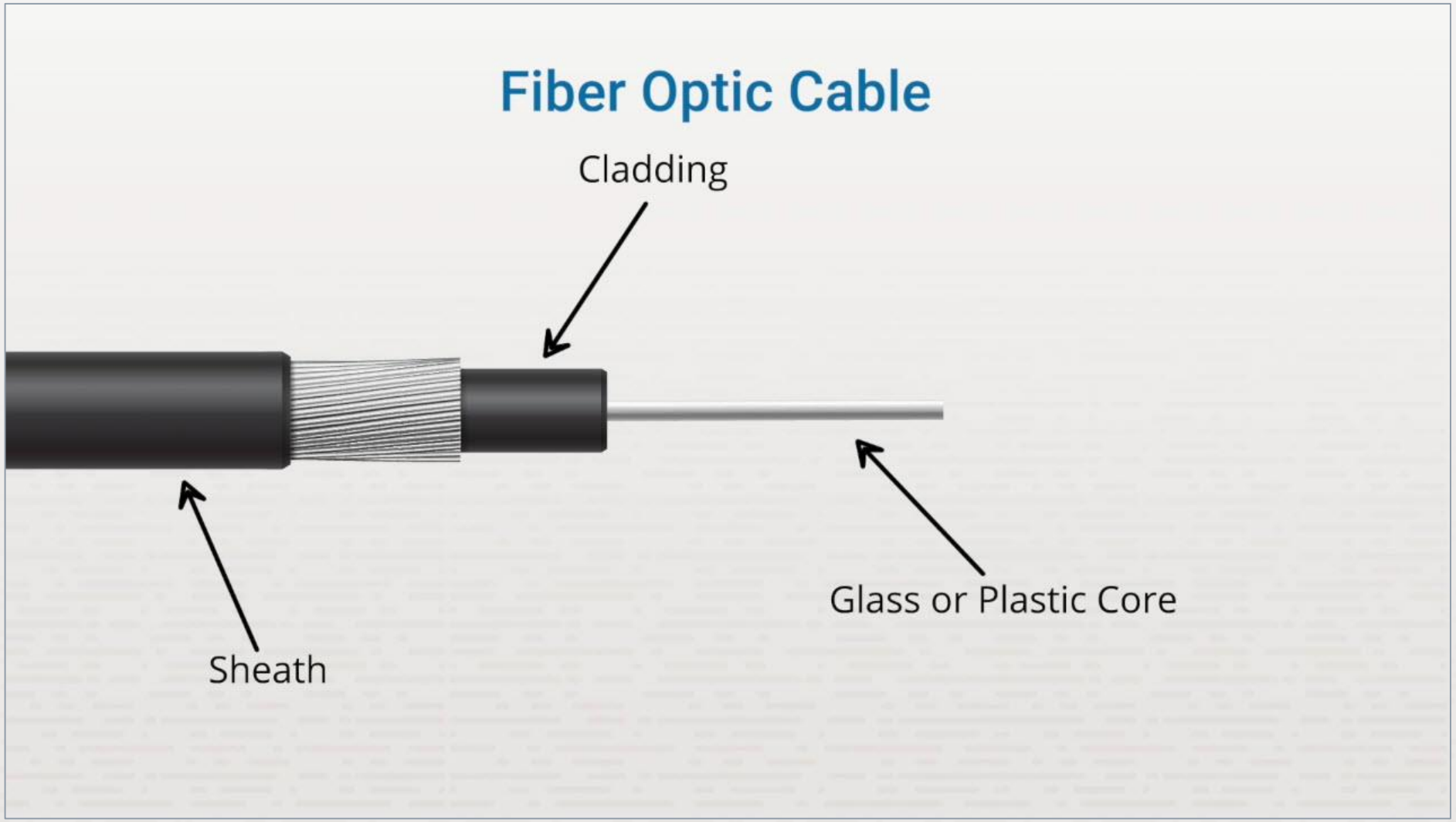
- Light-emitting diode (LED)
- Wavelength division multiplexing (WDM)

Key Definitions

- **Light-emitting diode (LED):** A light-emitting diode is a two-lead semiconductor light source that emits visible light when an electric current passes through it.
- **Wavelength division multiplexing (WDM):** WDM joins several light wavelengths (colors) onto a single strand of fiber by using different wavelengths of laser light.

Fiber Optic

Fiber Optic



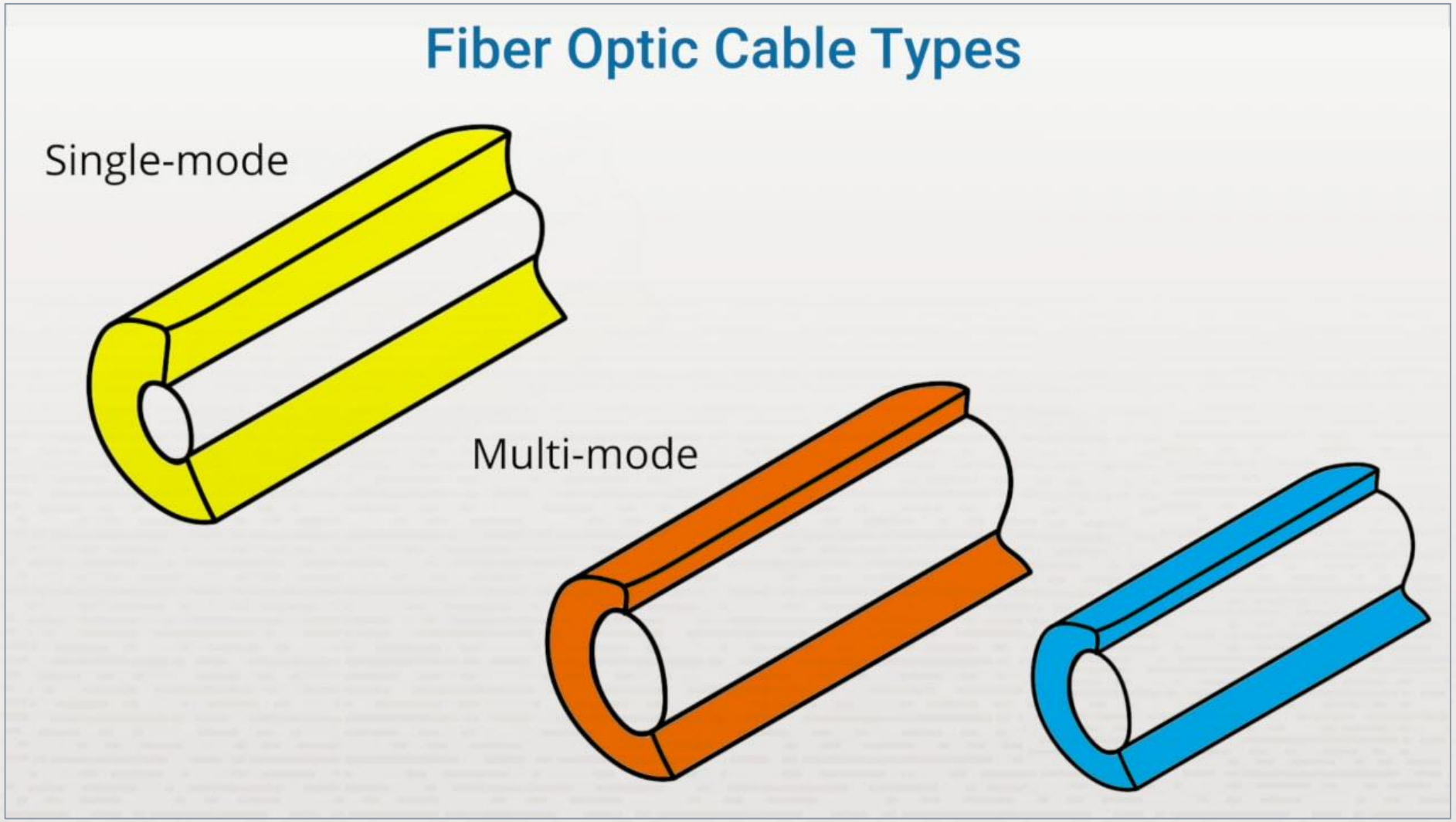
Advantages

- Immune to EMI
- High transmission rates

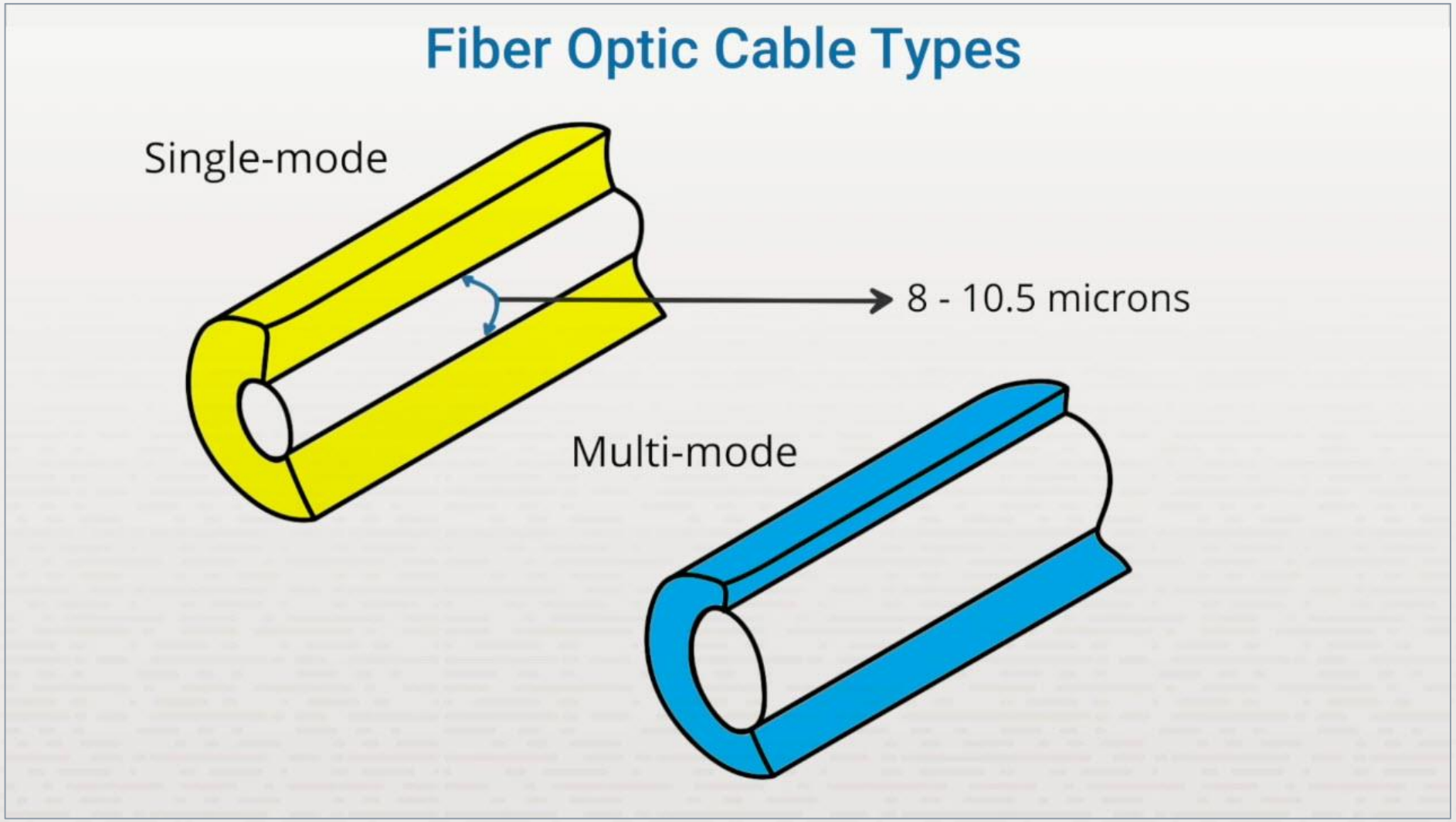
Disadvantages

- Very expensive
- Difficult to work with

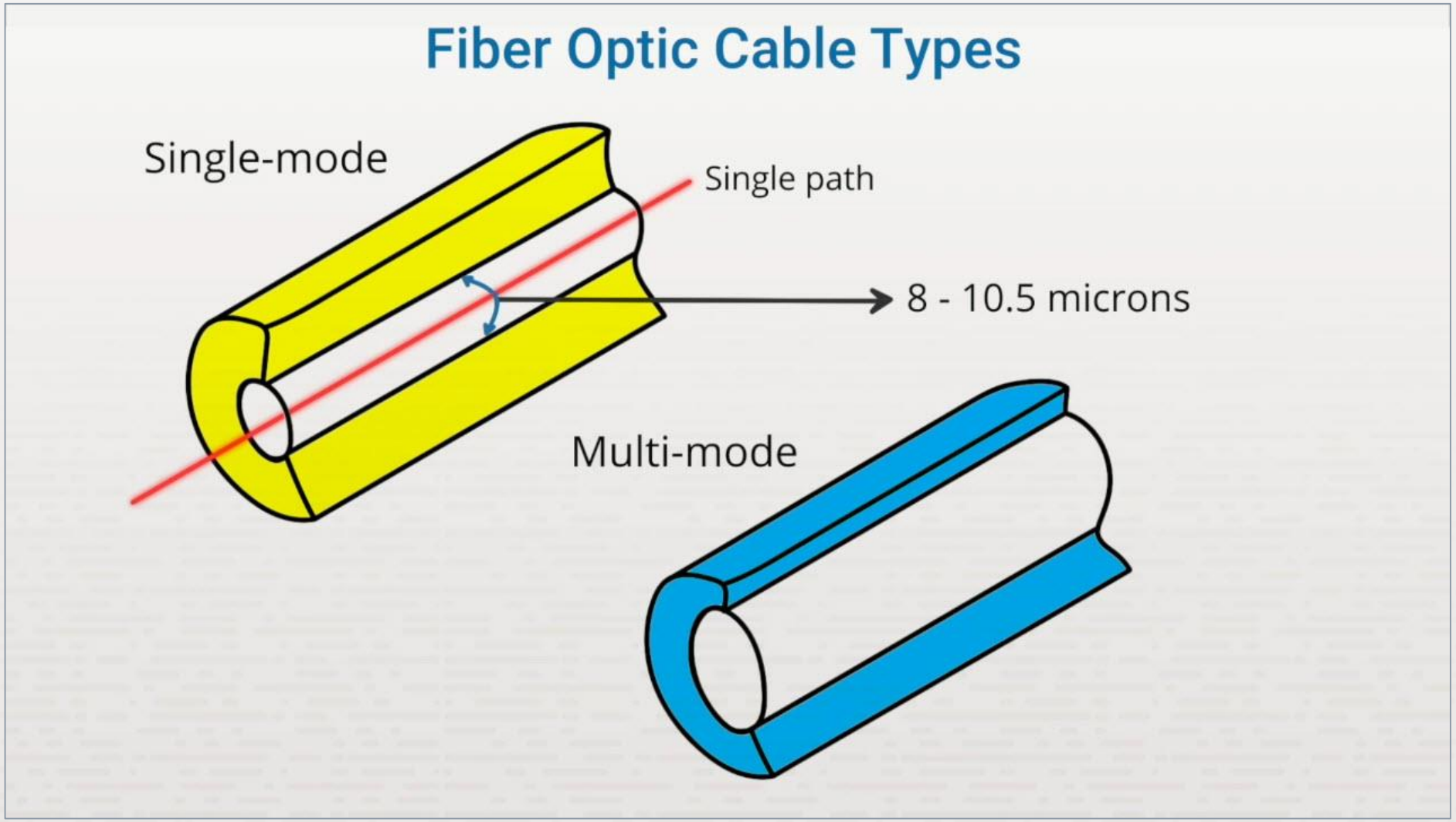
Fiber Optic



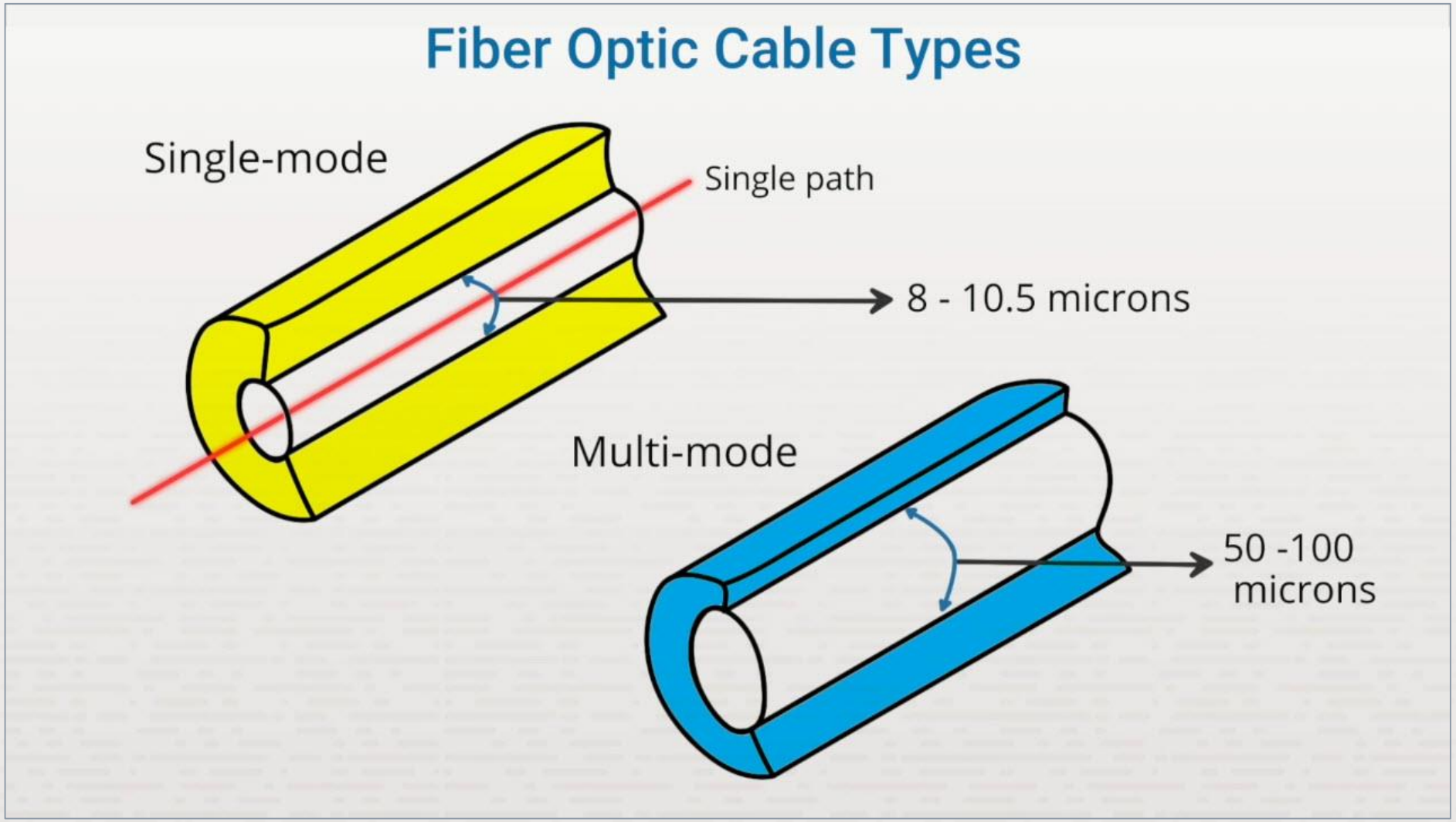
Fiber Optic


Fiber Optic Cable Types
Single-mode
8 - 10.5 microns
Multi-mode

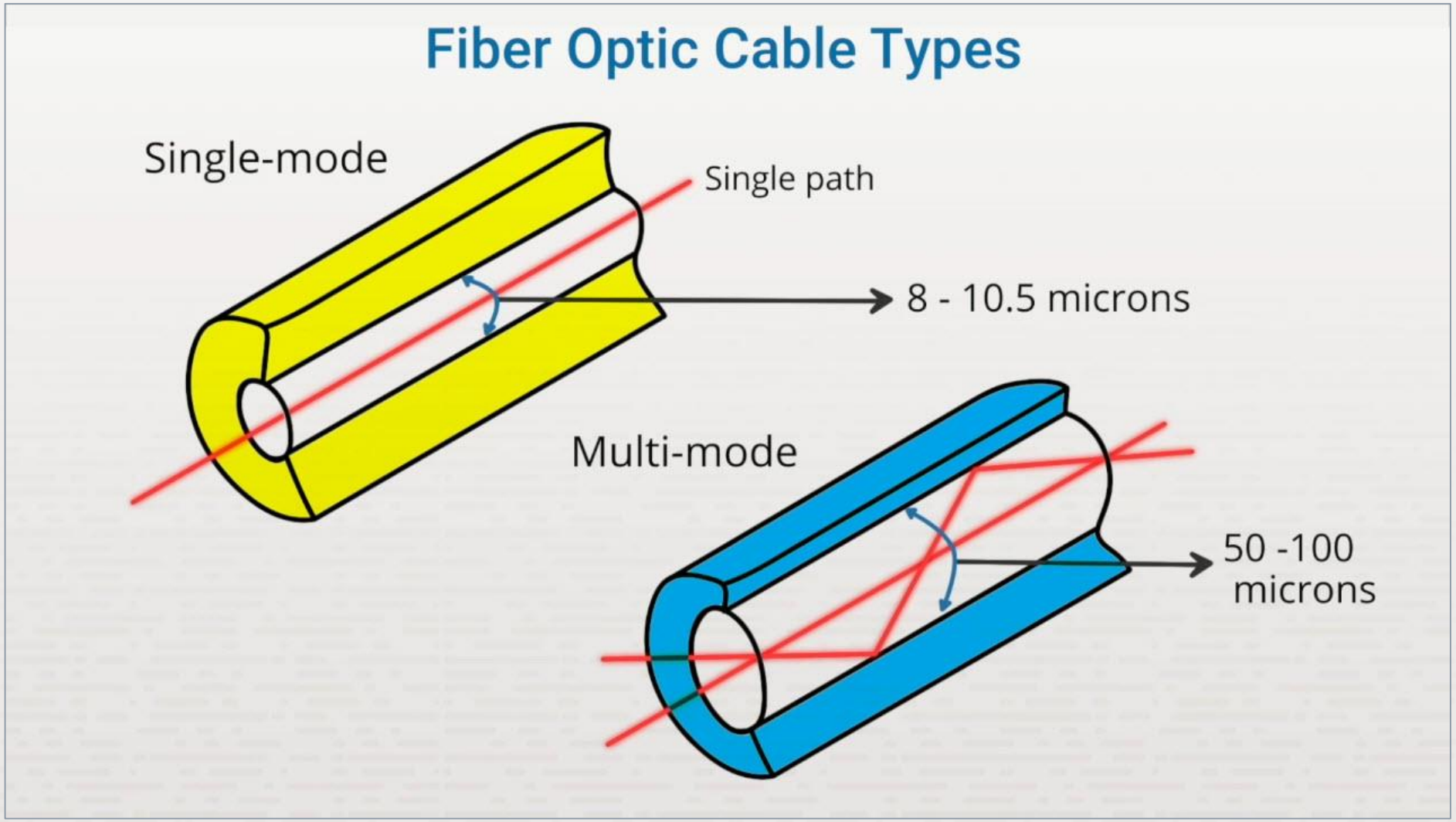
Fiber Optic


Fiber Optic Cable Types
Single-mode
Single path
8 - 10.5 microns
Multi-mode

Fiber Optic


Fiber Optic Cable Types
Single-mode
Single path
8 - 10.5 microns
Multi-mode
50 -100
microns

Fiber Optic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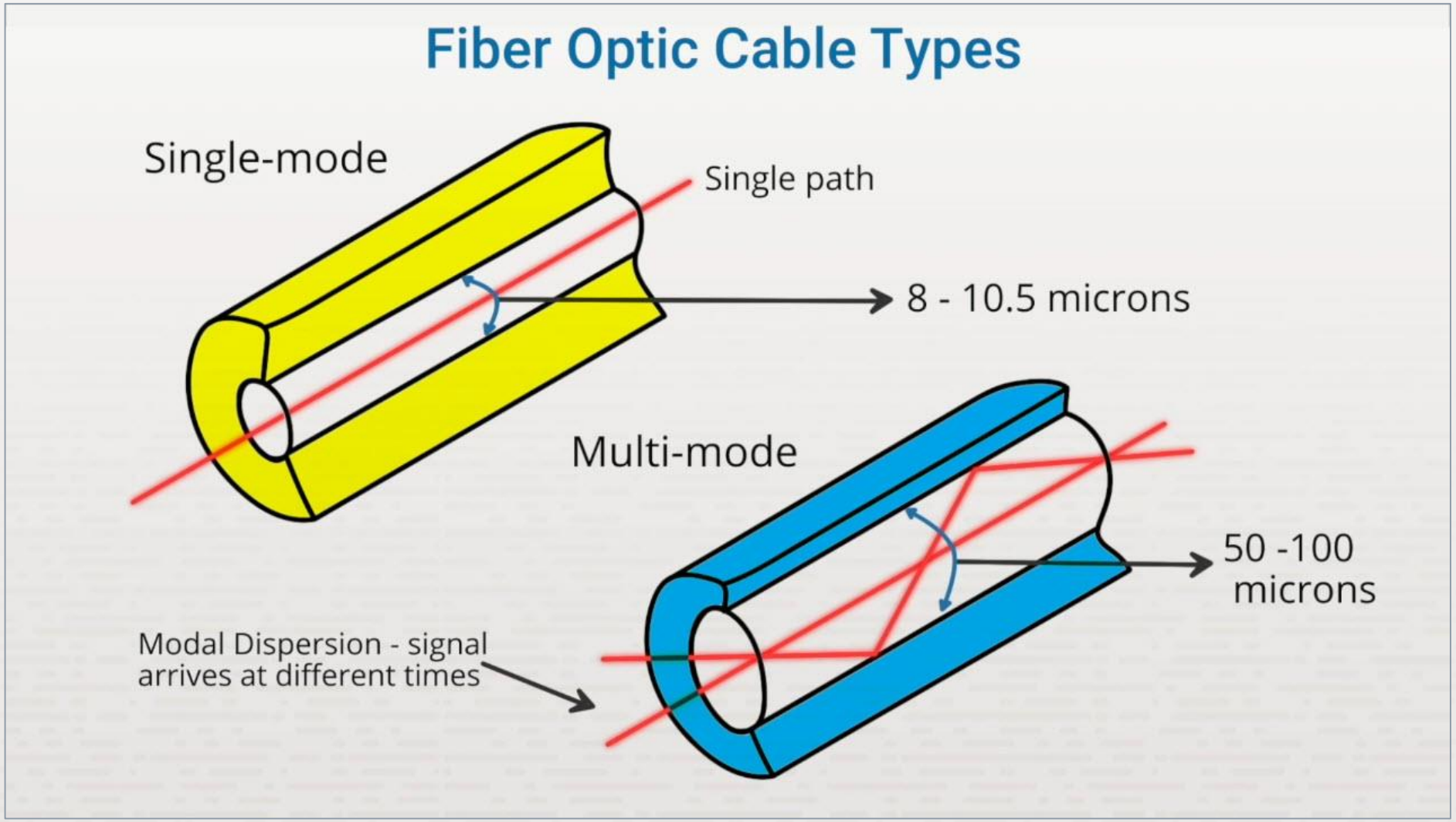
Single path
8 - 10.5 microns
Multi-mode
50 -100
microns

Fiber Optic

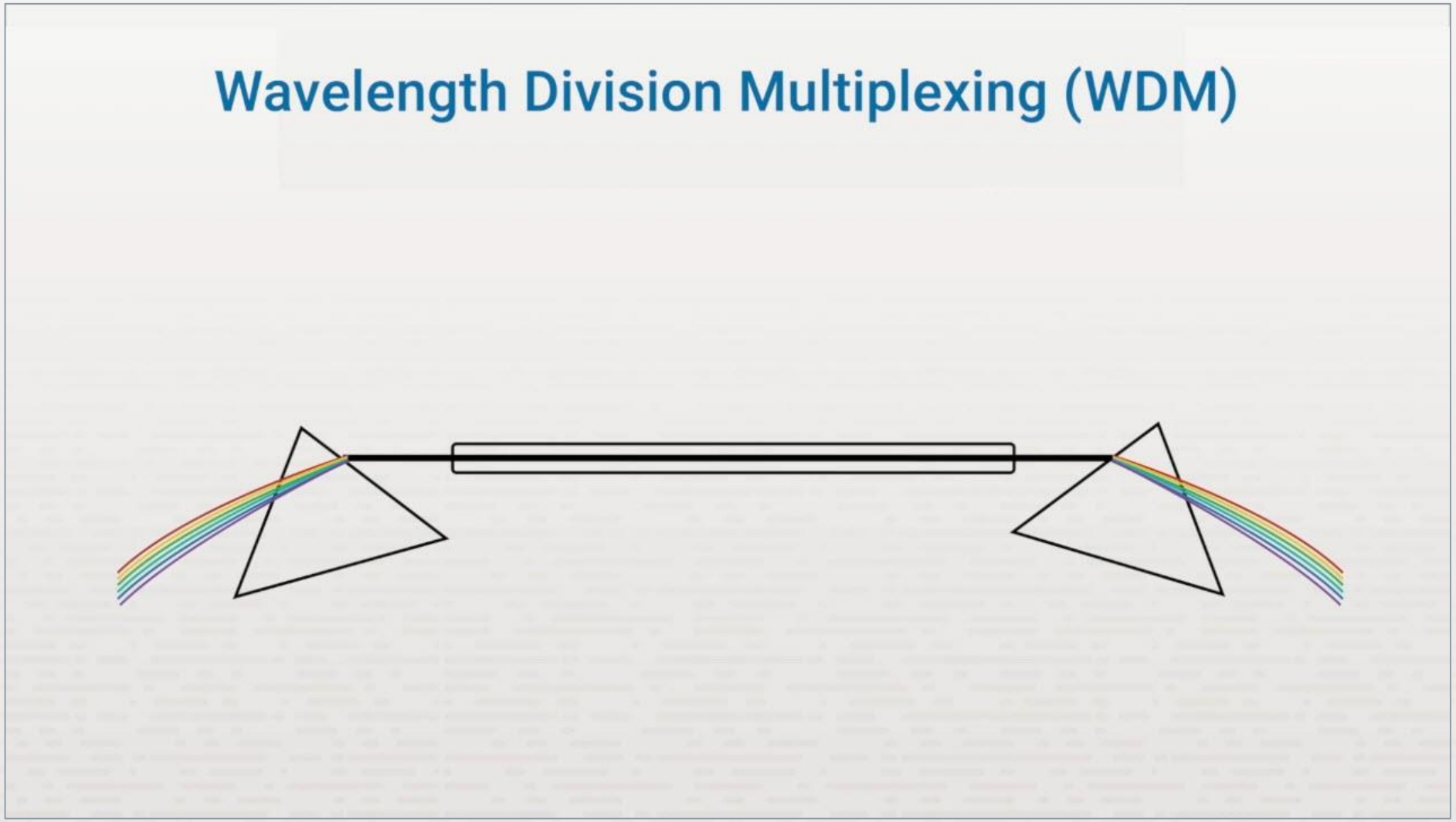

Fiber Optic Cable Types
Single-mode
Single path
8 - 10.5 microns
Multi-mode
50 -100 microns
Modal Dispersion - signal arrives at different times

Fiber Optic

Fiber Optic Cable Types

Single-Mode	Multi-Mode
Less affected by modal dispersion	Most affected by modal dispersion
Longer distances	Shorter distances
Higher speeds	Lower speeds
Precise connections	Simpler connections
Higher cost electronics	Lower cost electronics

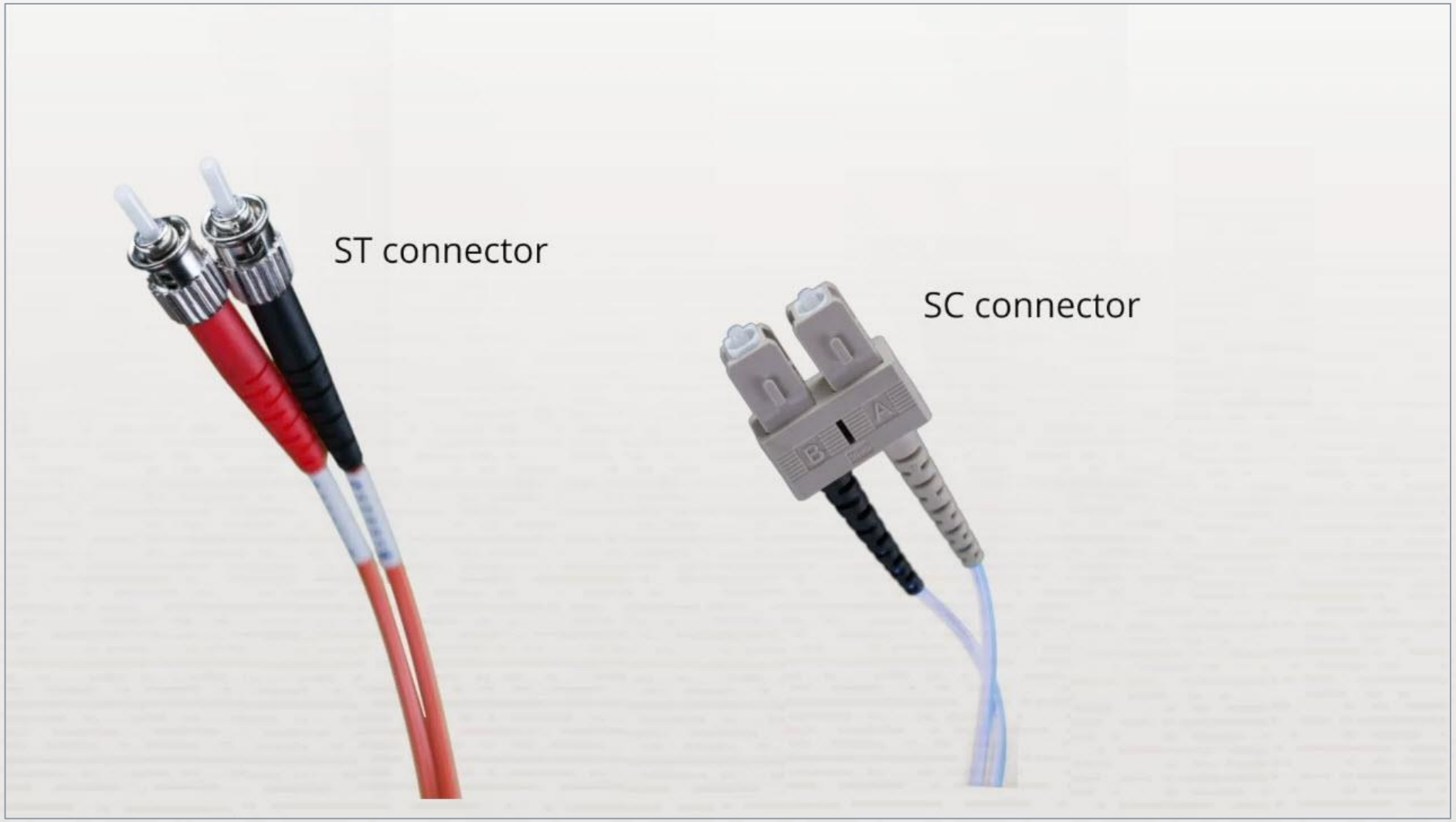
Fiber Optic



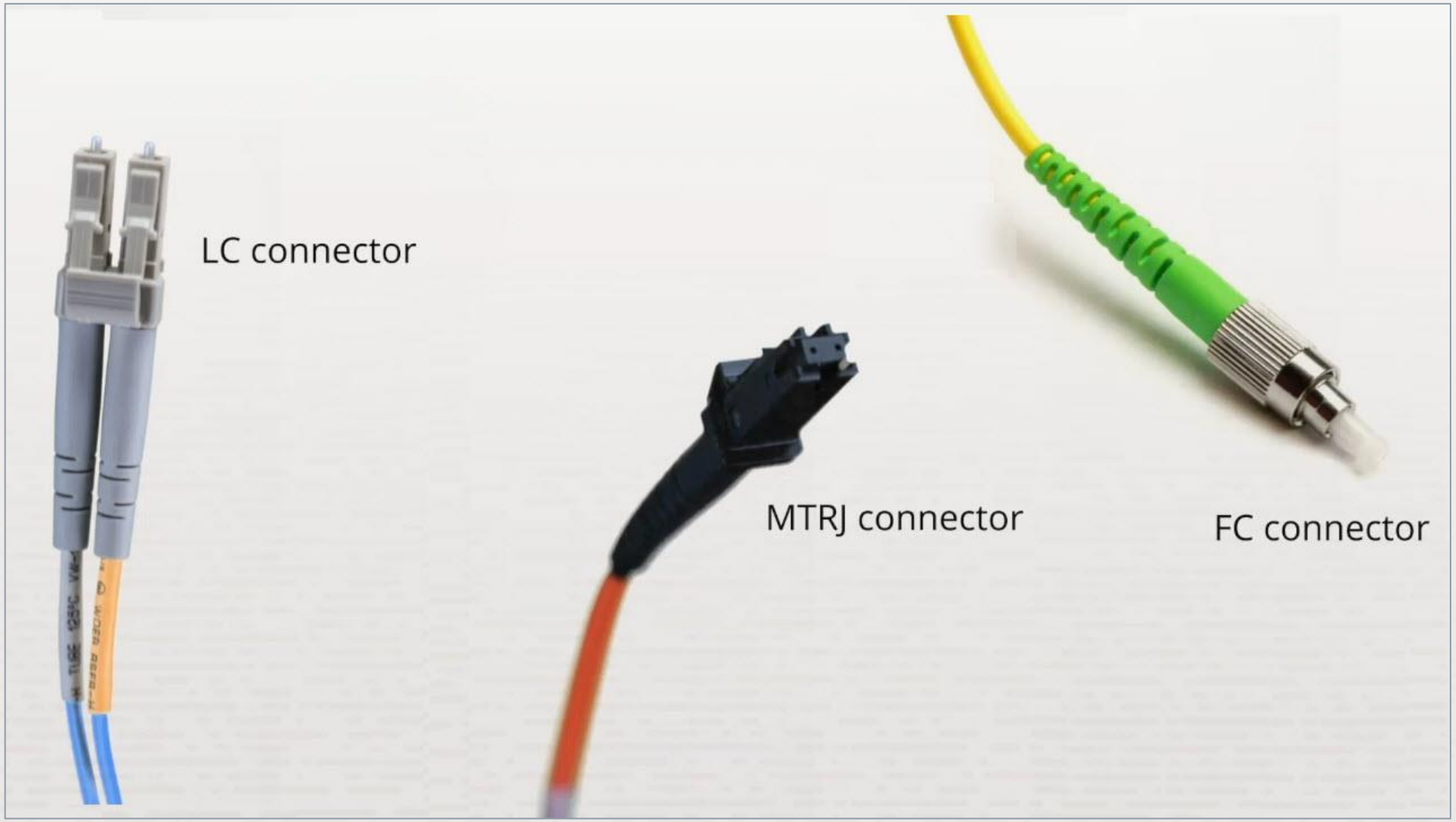
WDM Systems

- Can multiplex 160 signals
- Long-haul and high-speed
- Can transmit 16 prs
- Uses single-mode fiber

Fiber Optic



Fiber Optic



Polish Ratings

- Rated by optical return loss
- PC = physical contact
- SPC = super physical contact
- UPC = ultra physical contact
- APC = angled physical contact

Fiber Optic


Media Converters
1000
LNK
TX
RX
RCV FD
1000
Auto MDI
1000
LNK
TX
RX
RCV FD
1000
Auto MDI
Speed
Link/Act
Speed
Link/Act

Summary

- Single-mode and multi-mode
- WDM transmits multiple signals
- SC, ST, LC, FC, MTRJ connectors
- PC, SPC, UPC, and APC ratings

In-Class Practice

Do the following labs:

- 3.2.3 Connect Fiber Optic Cables (reuse was 2.3.3)

Class Discussion

- How do light waves within a fiber optic cable travel around corners?
- What advantages do fiber optic cables offer over twisted-pair cables and other media choices? What are the disadvantages of implementing fiber optic cables?
- What is the difference between single-mode and multi-mode cables?
- How can you tell the difference between an ST connector and an SC connector?
- Which connector types combine two strands of fiber into a single connector?
- What are media converters used for?

Wiring Implementation

Section Skill Overview

- Use punchdown blocks
- Connect patch panel cables

Key Terms

- Krone LSA-PLUS
- Building Industry Cross-Connect (BIX)
- Power over Ethernet (PoE)
- Pinout
- Local exchange carrier (LEC)
- Demarcation point (demarc)
- Main distribution frame (MDF)
- Punchdown block
- Patch panel

Key Definitions

- **Krone LSA-PLUS**: A krone is a European-style telecommunications connector.
- **Building Industry Cross-Connect (BIX)**: BIX is a cross-connect system. It consists of various sizes of punchdown blocks, cable distribution accessories, and a punchdown tool to terminate wires on the punchdown block.
- **Power over Ethernet (PoE)**: PoE is a technology that allows a single cable to provide both data and electrical power to devices such as wireless access points, IP cameras, and VoIP phones.
- **Pinout**: When connecting two devices using twisted-pair cabling, the pinout determines which wire goes to which pin of the connector.

Key Definitions

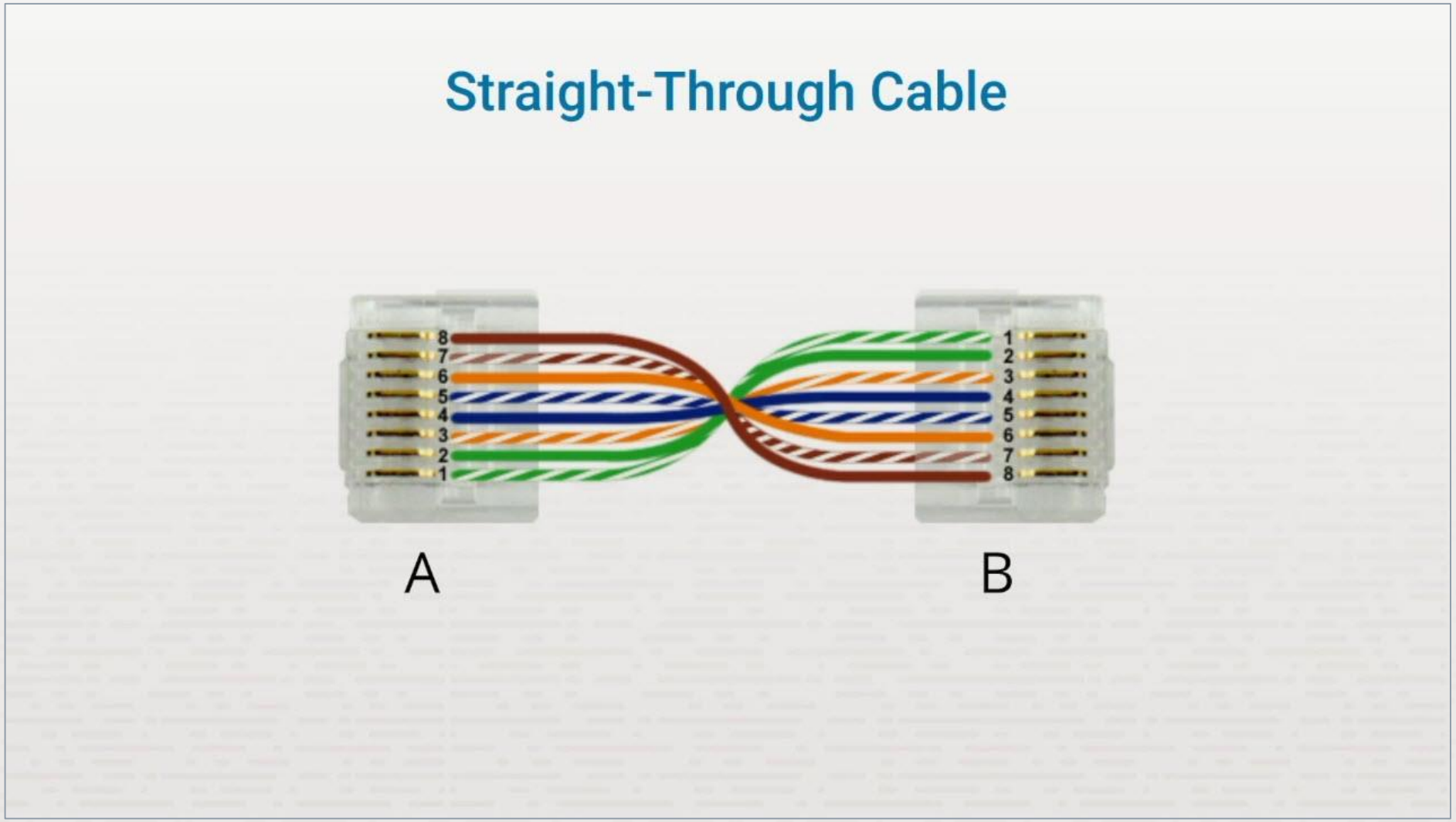
- **Local exchange carrier (LEC)**: In the United States, LEC is a term used for a public telephone company that provides local services. LECs are sometimes called telcos.
- **Demarcation point (demarc)**: The demarc is the line that marks the boundary between the telecommunications (telco) equipment and your private network or telephone system.
- **Main distribution frame (MDF)**: A frame or rack that is used to interconnect and manage telecommunication wiring in a building. It functions like an old-time telephone switchboard, where operators used connecting wires to route telephone calls. MDF can also refer to the room that houses the traditional MDF along with networking patch panels.

Key Definitions

- **Punchdown block**: A device that connects one group of wires to another through a system of metal pegs.
- **Patch panel**: Patch panels permit circuits to be arranged and rearranged by plugging and unplugging respective patch cords on a mounted hardware assembly.

Twisted-Pair Cable Construction

Twisted-Pair Cable Construction



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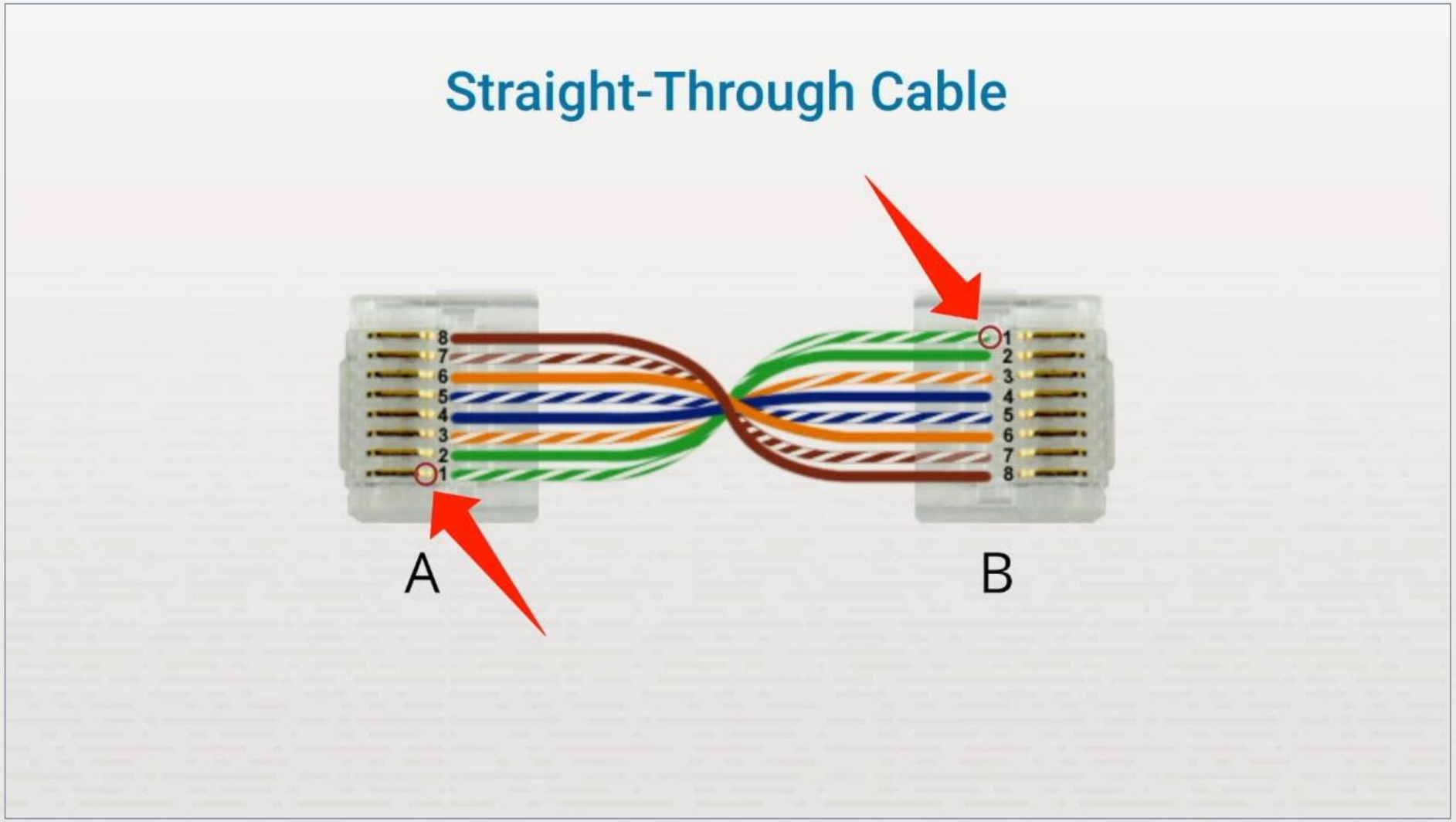

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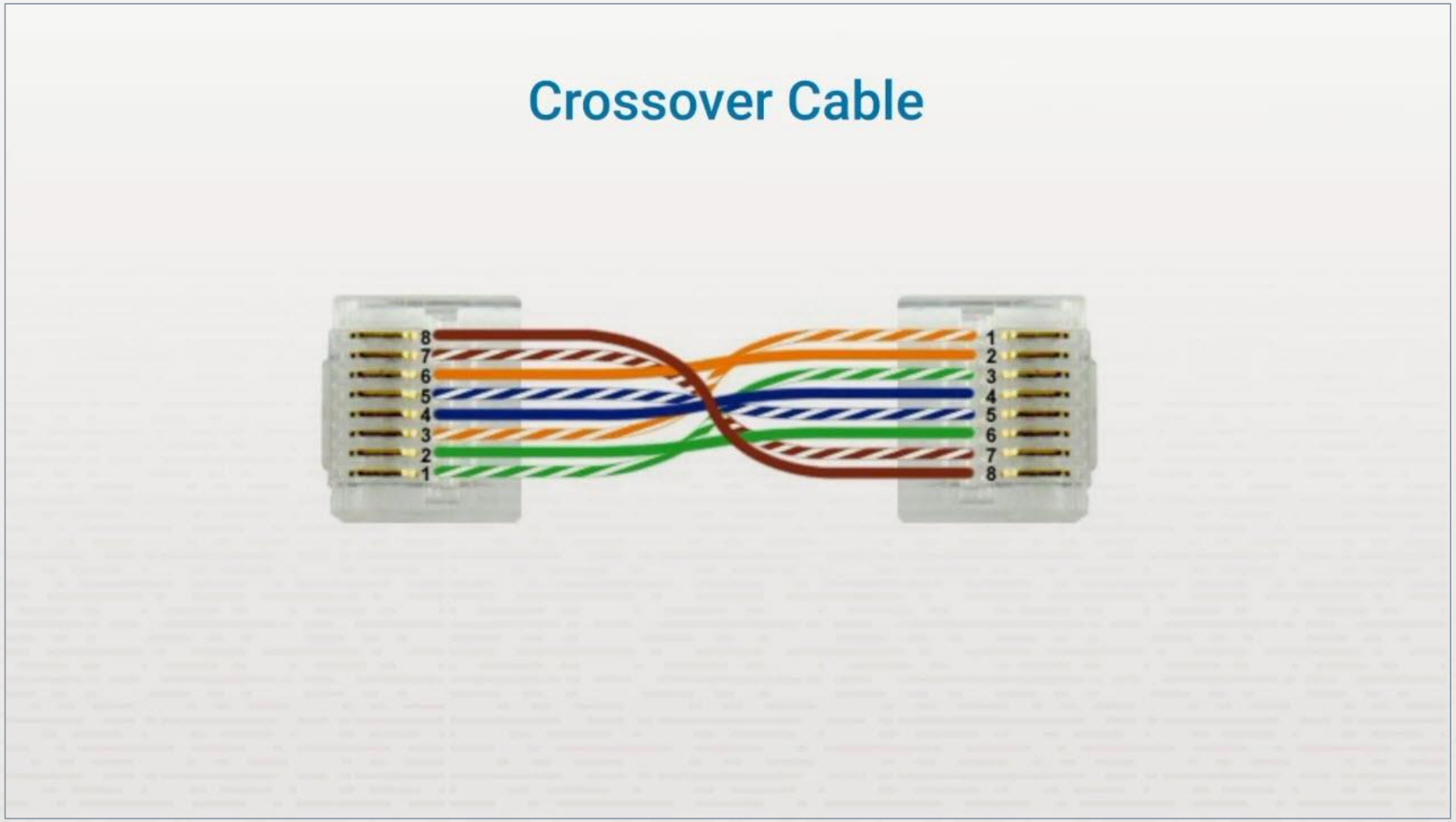

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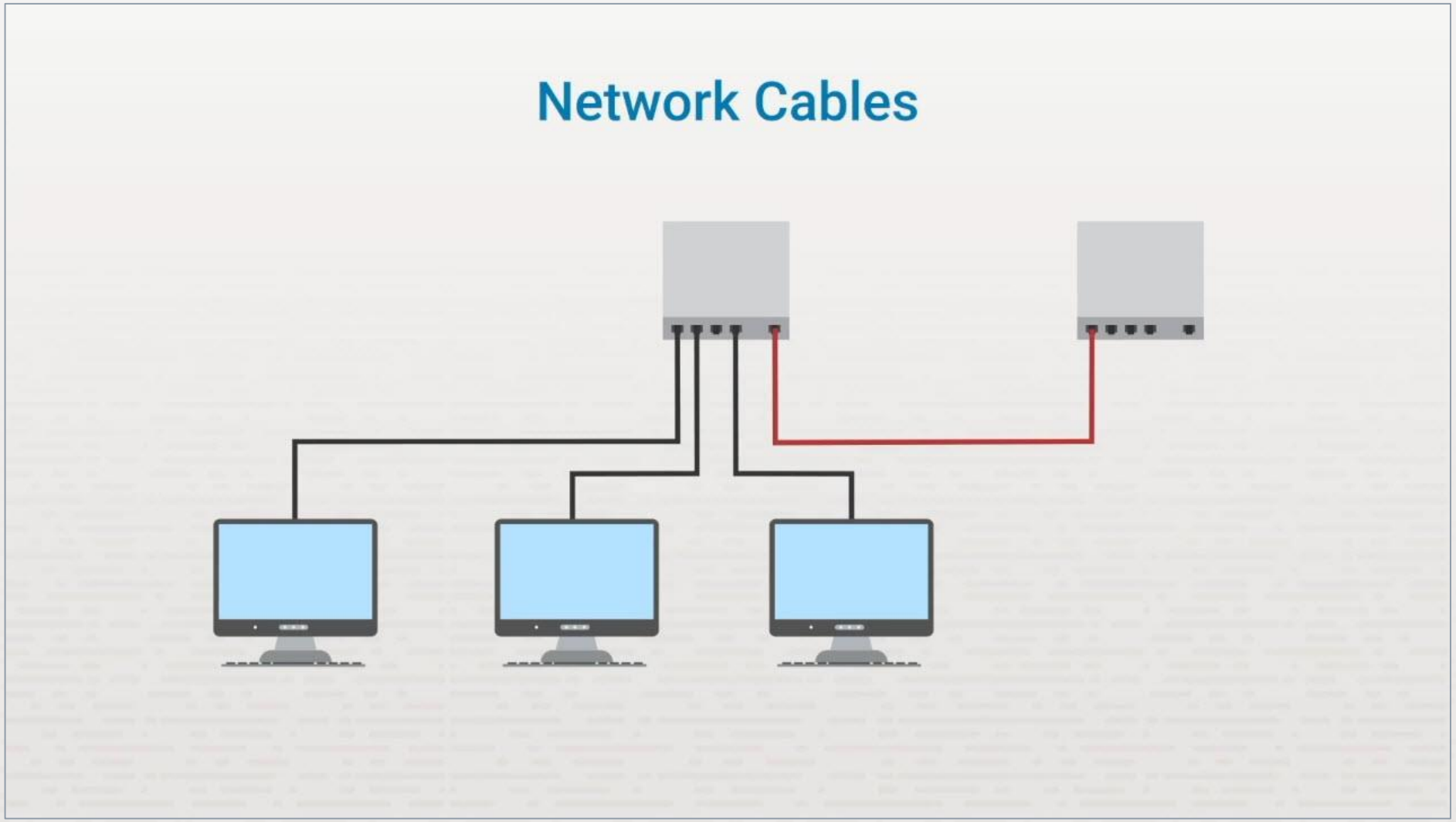

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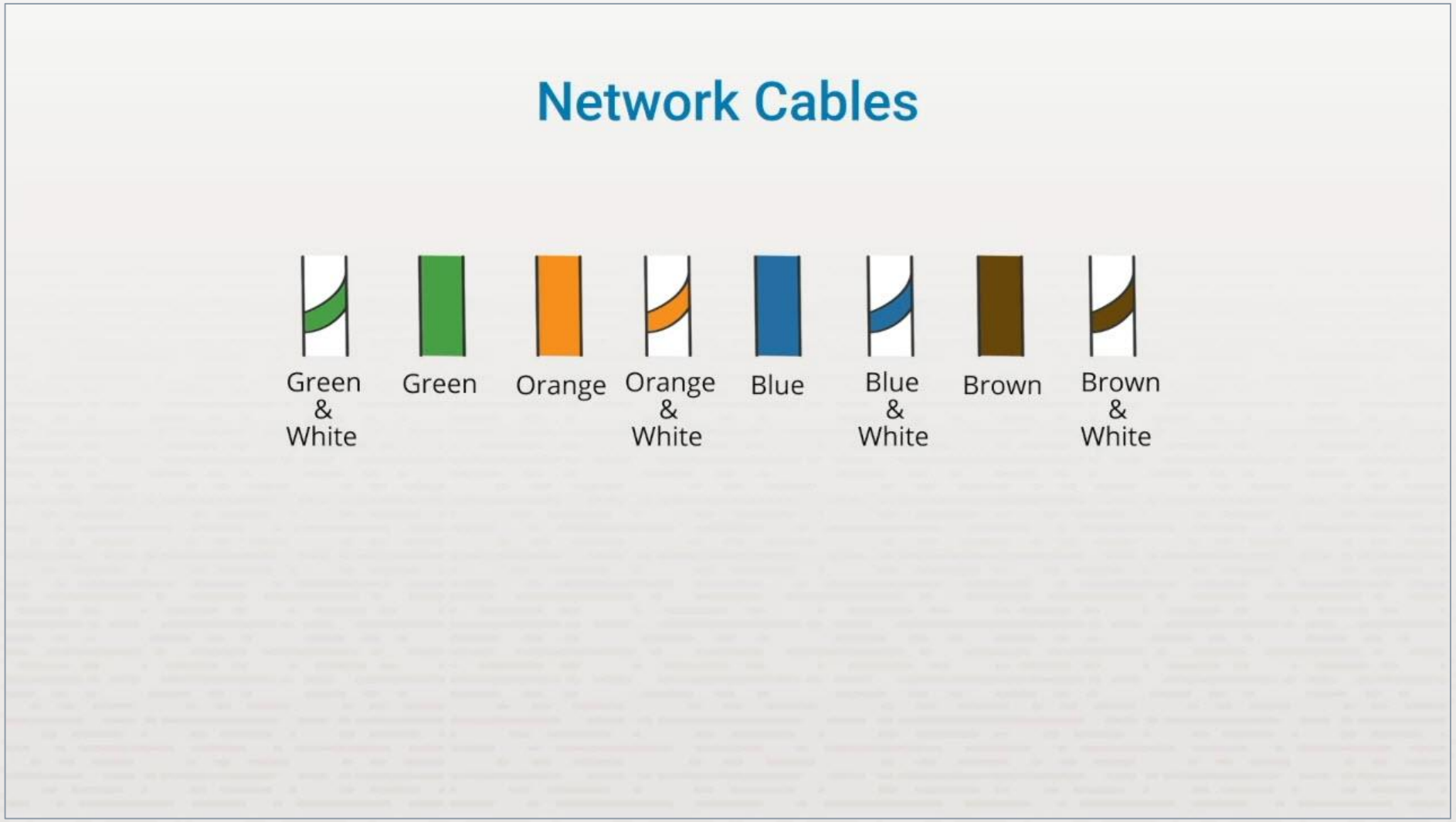

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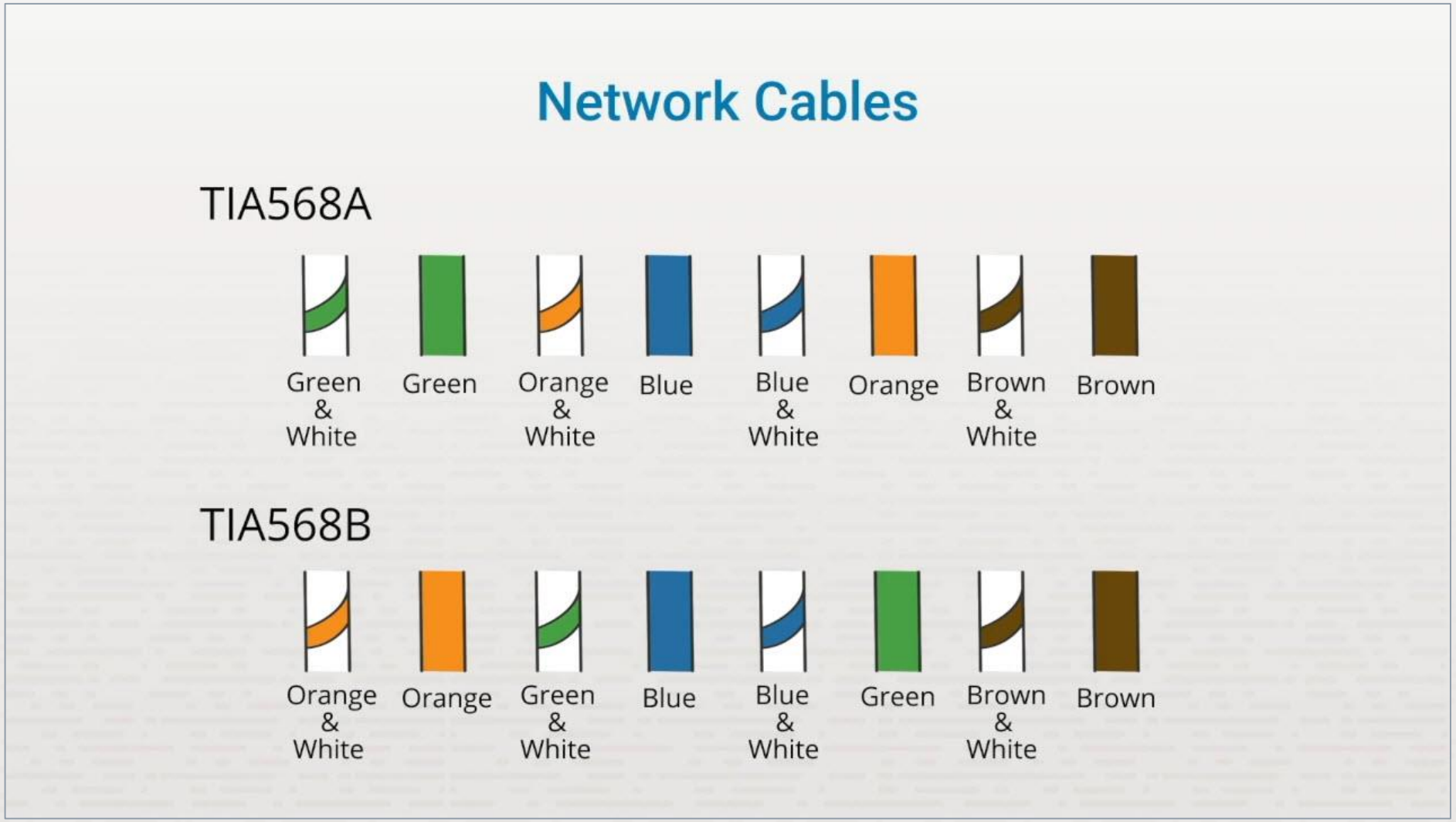

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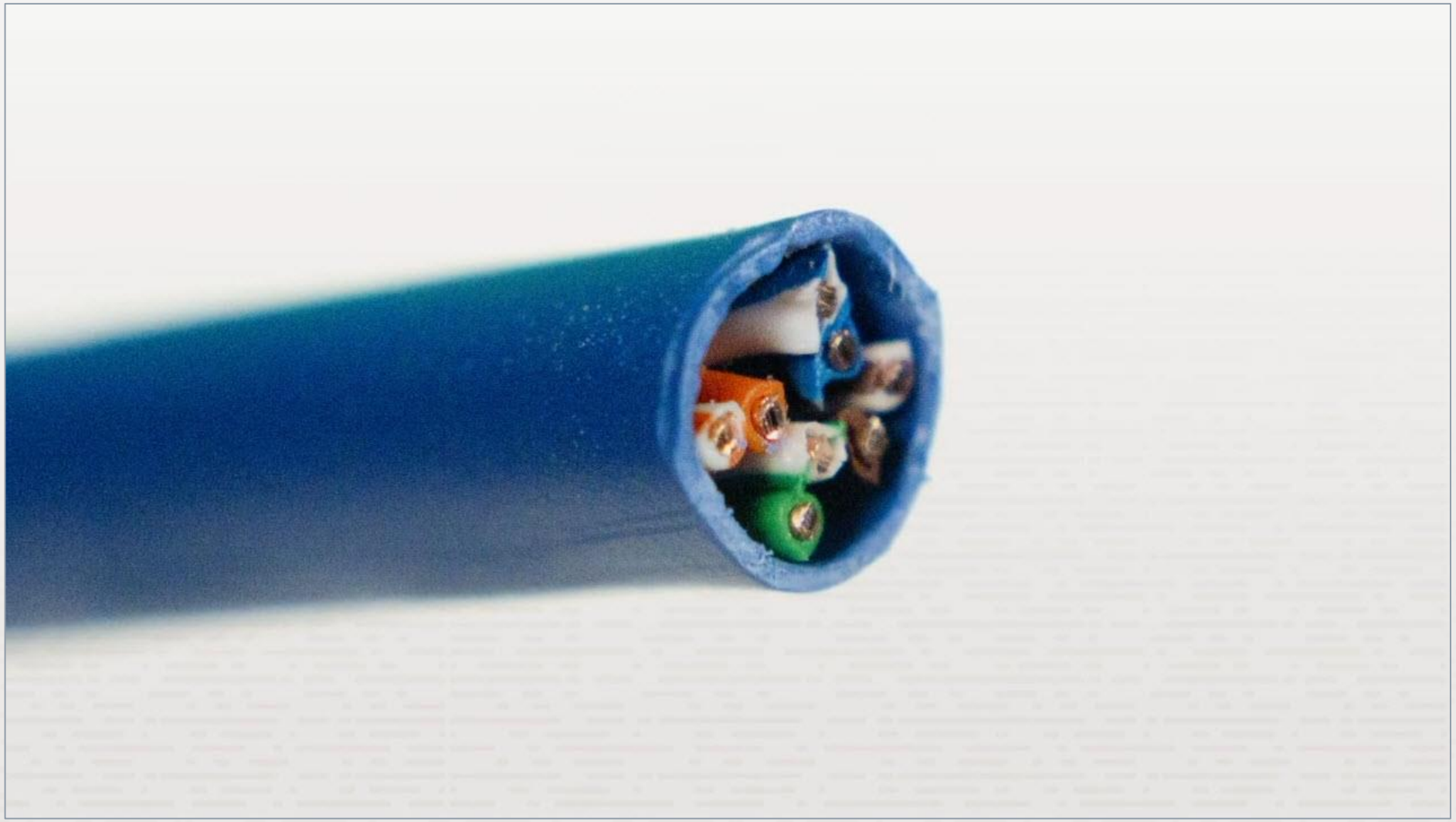

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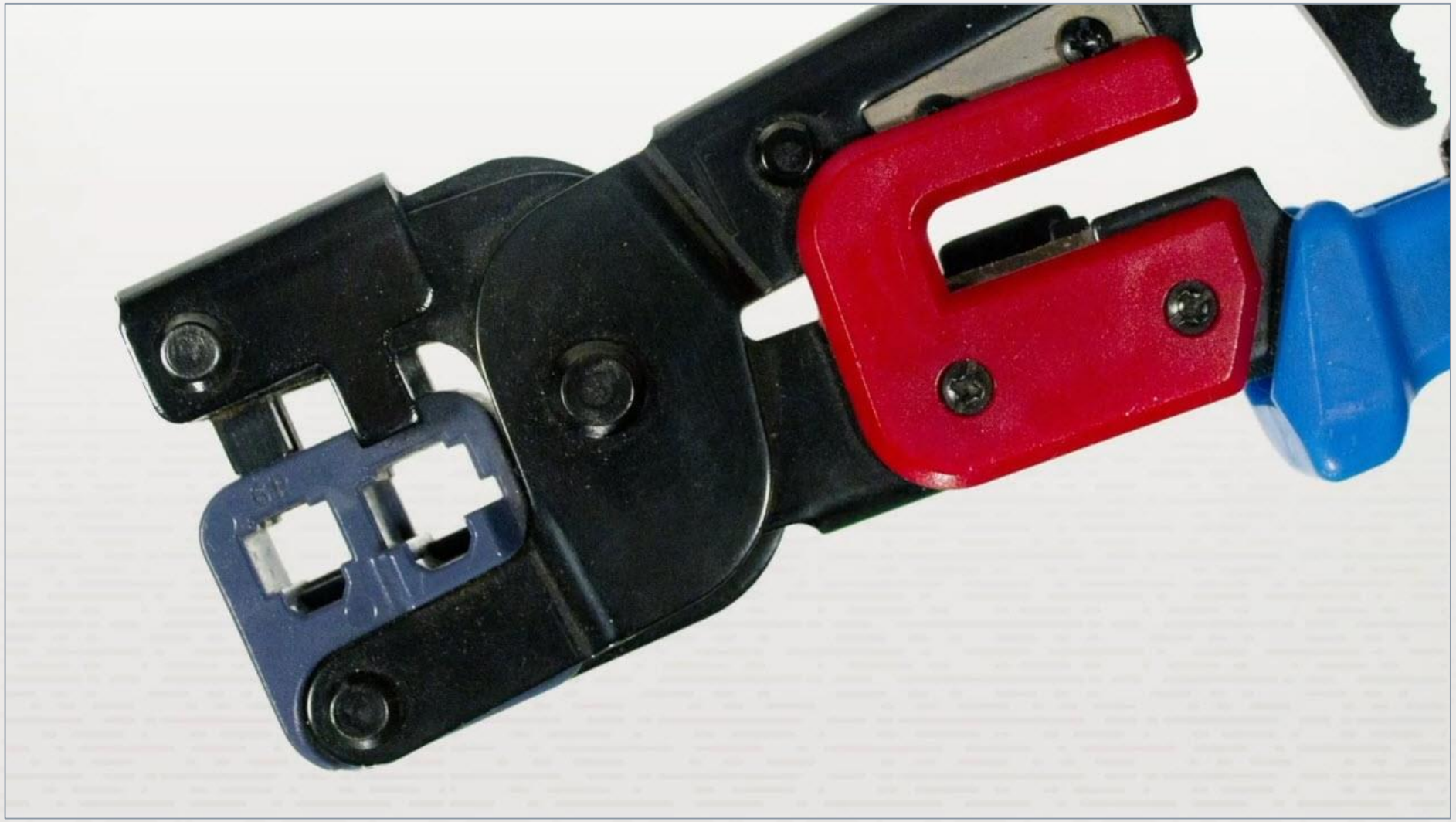

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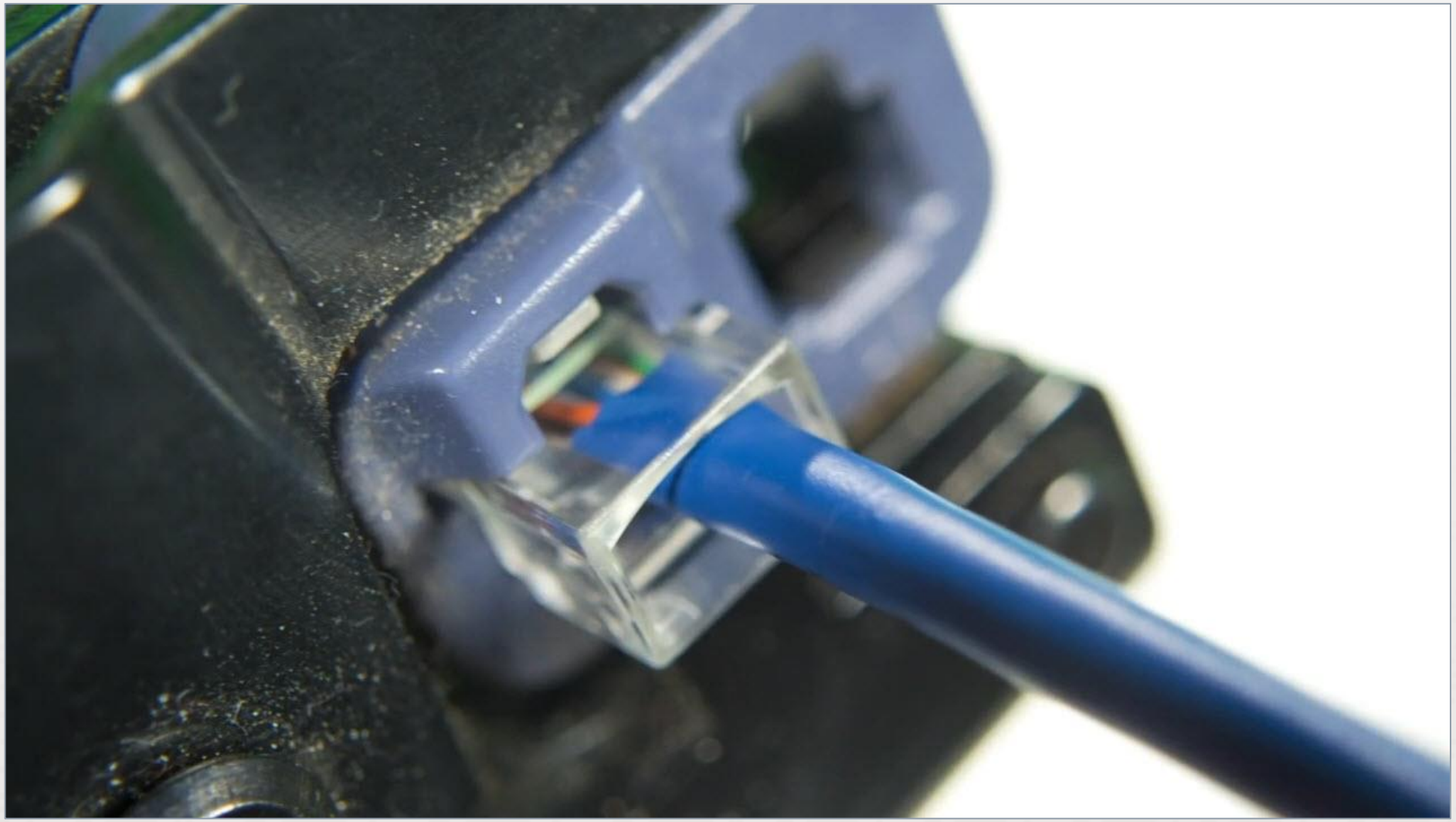

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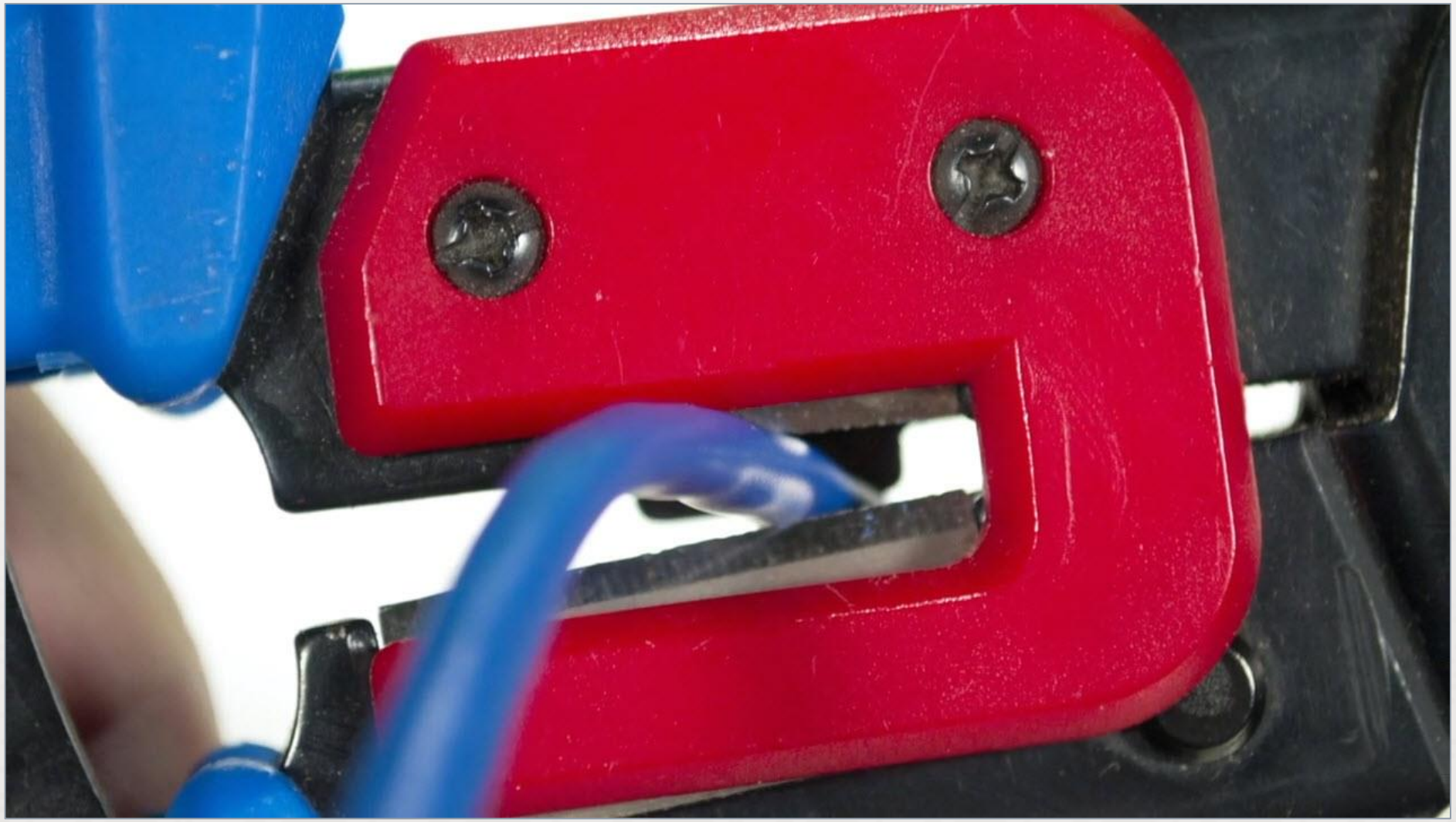

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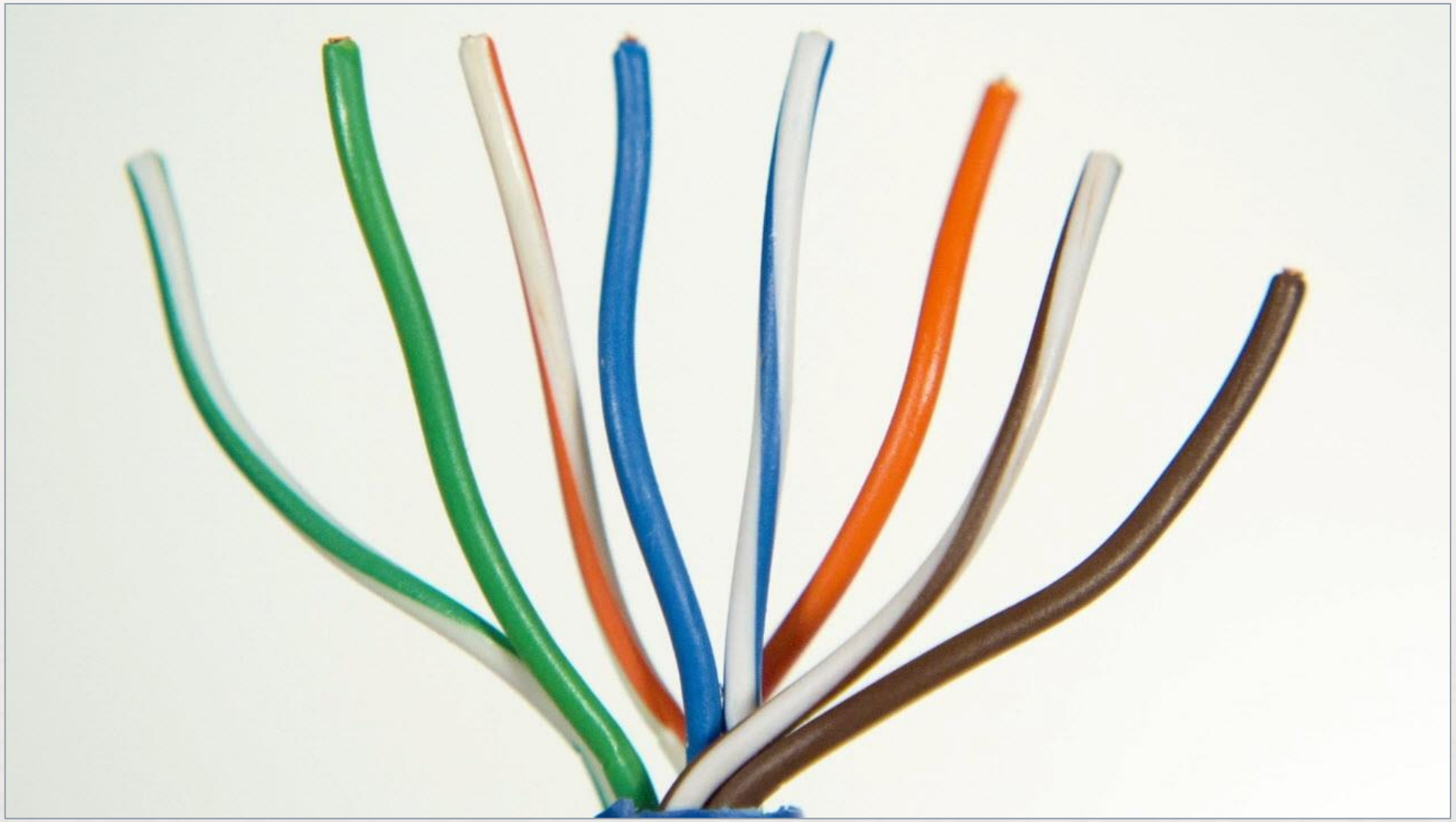

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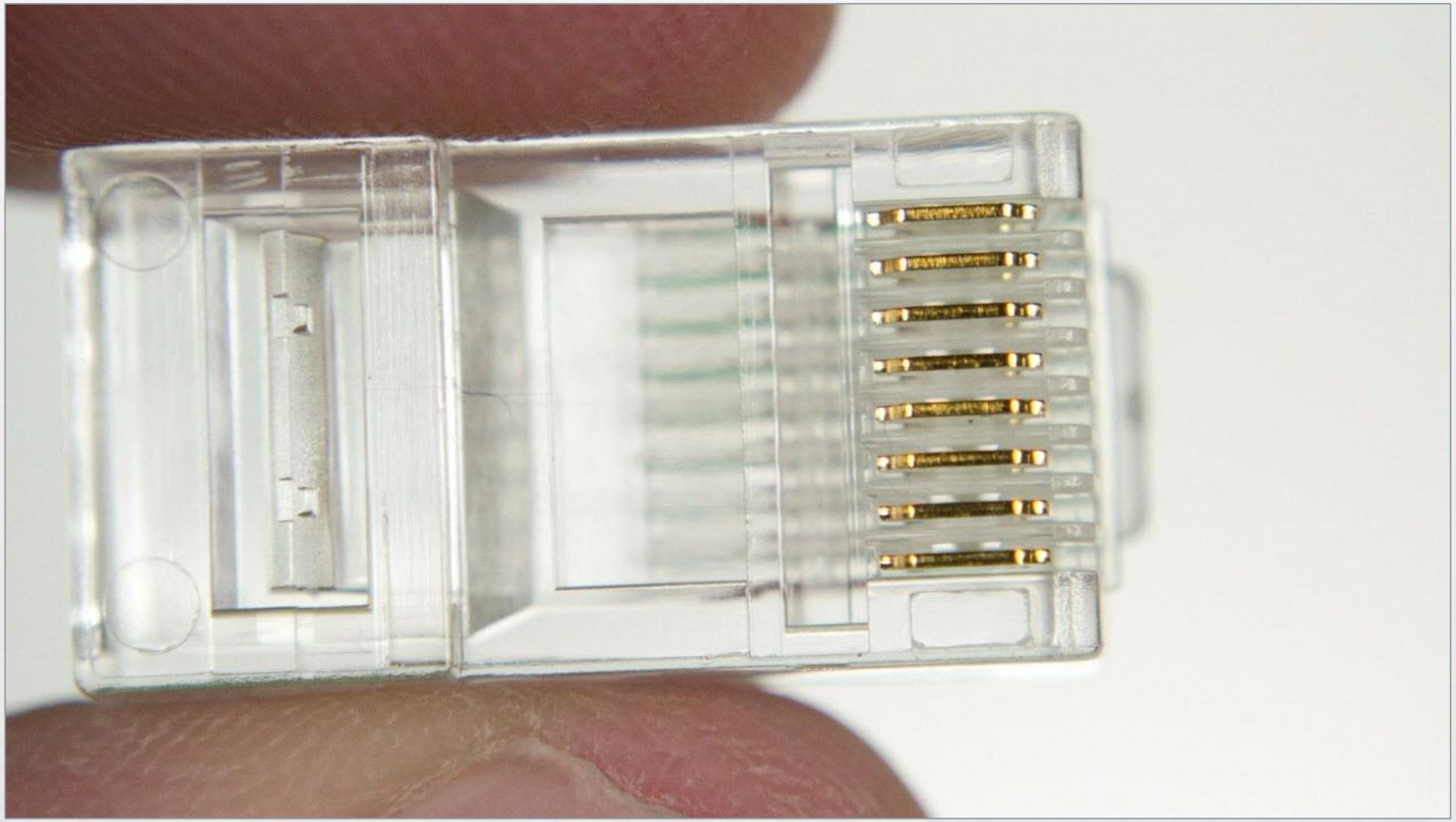

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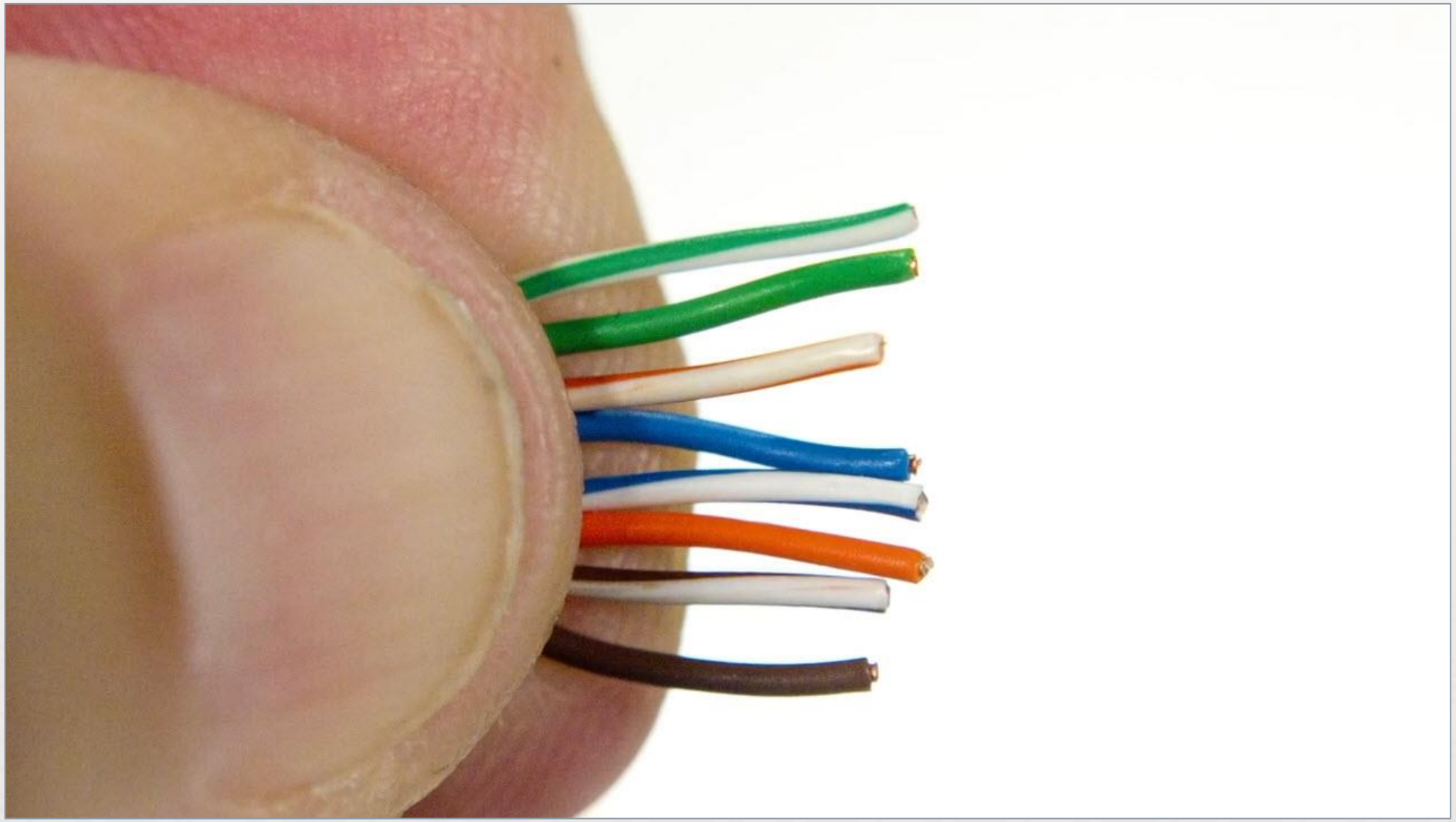

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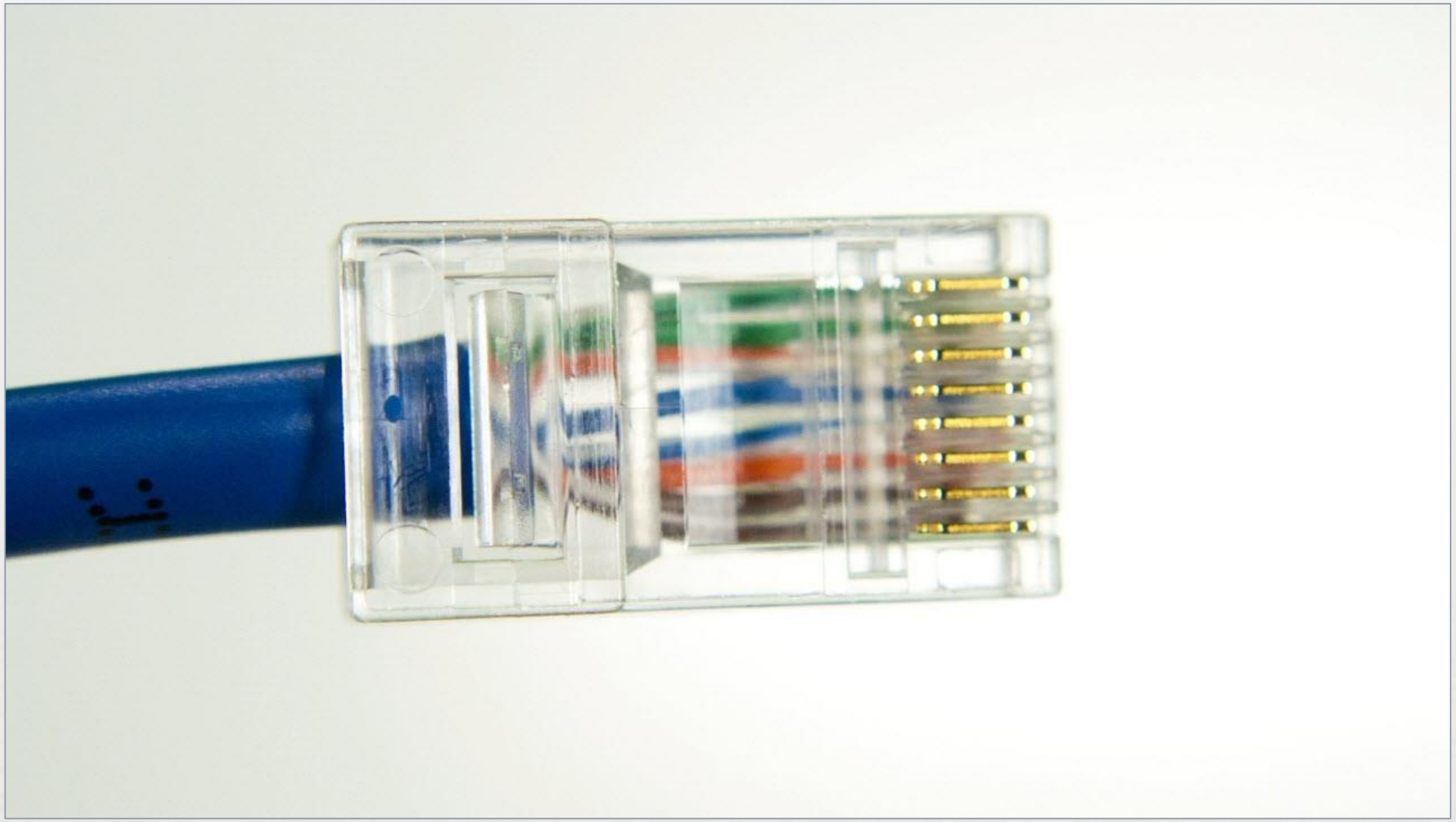

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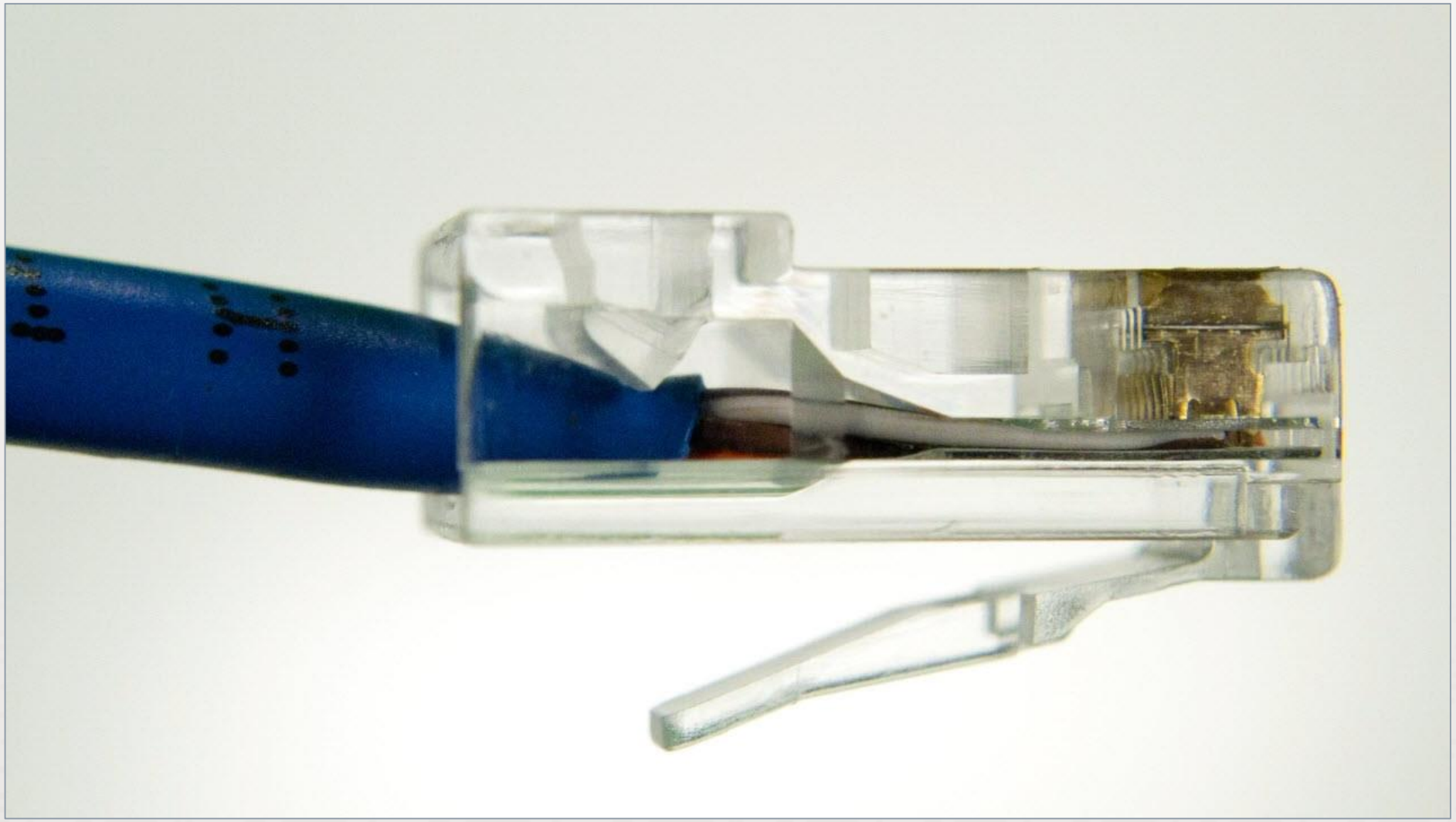
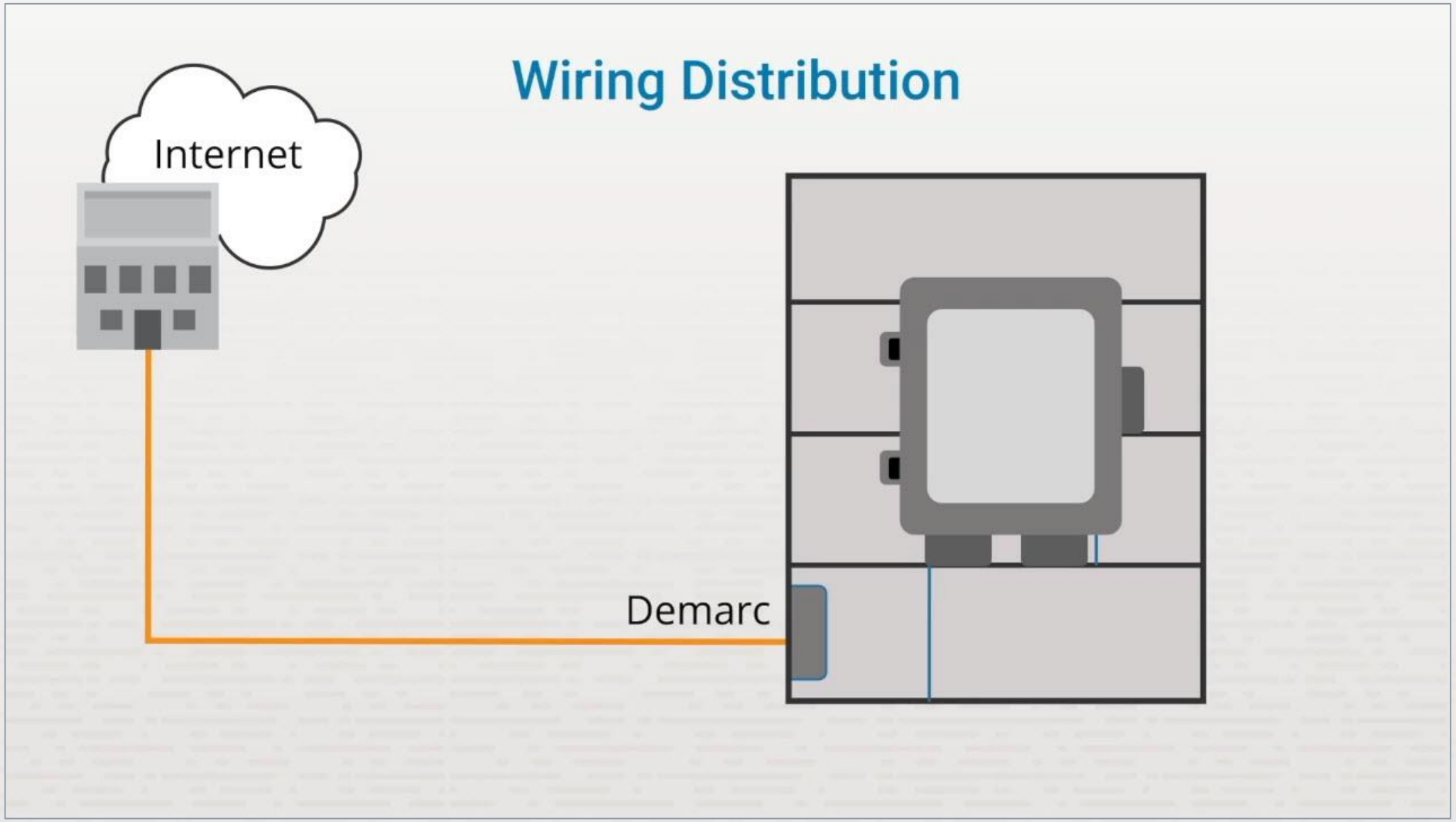


Summary

- Straight-through cable
- Crossover cable
- TIA568A
- TIA56BB
- Make our own

Wiring Distribution

Wiring Distribution



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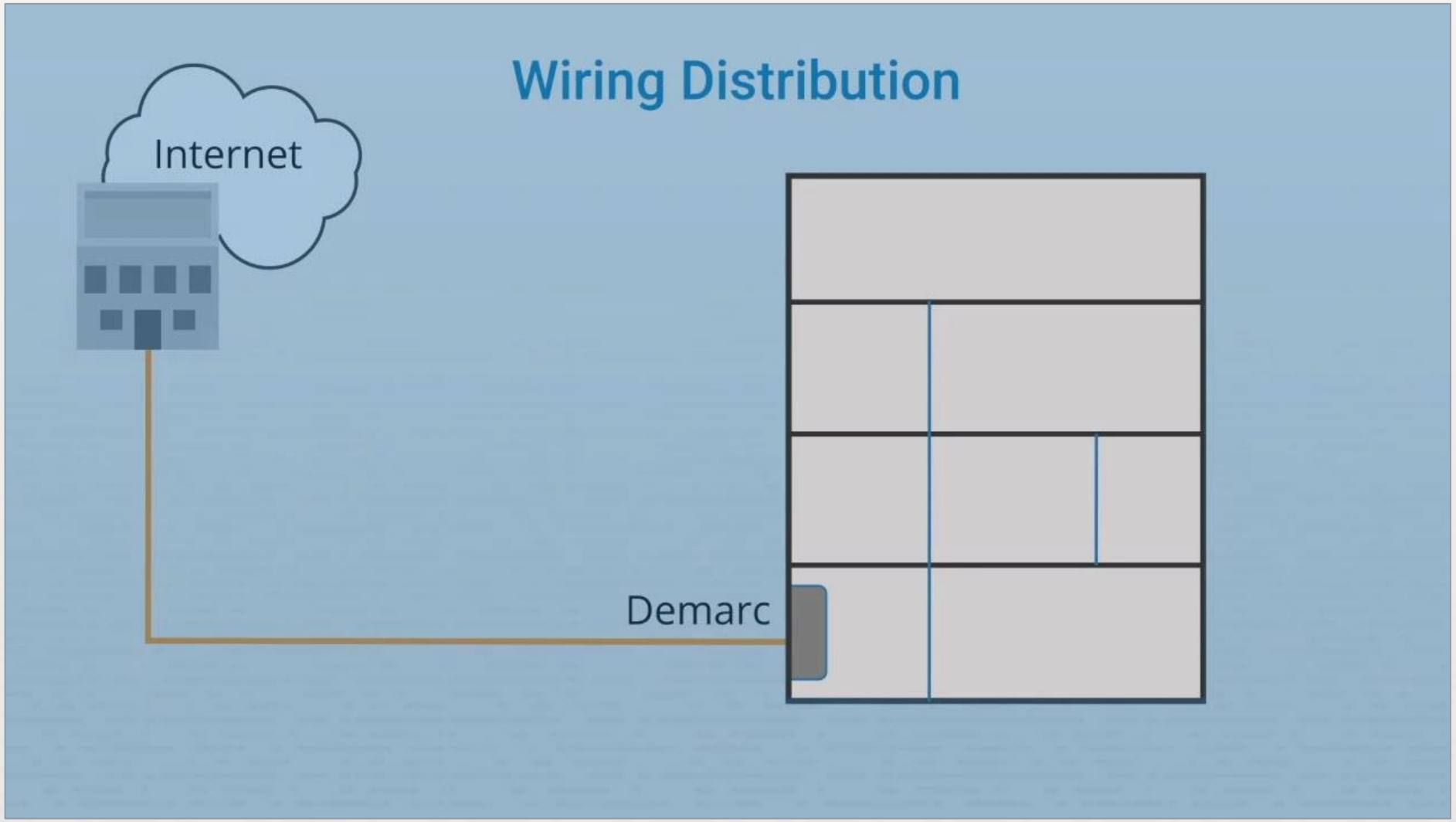

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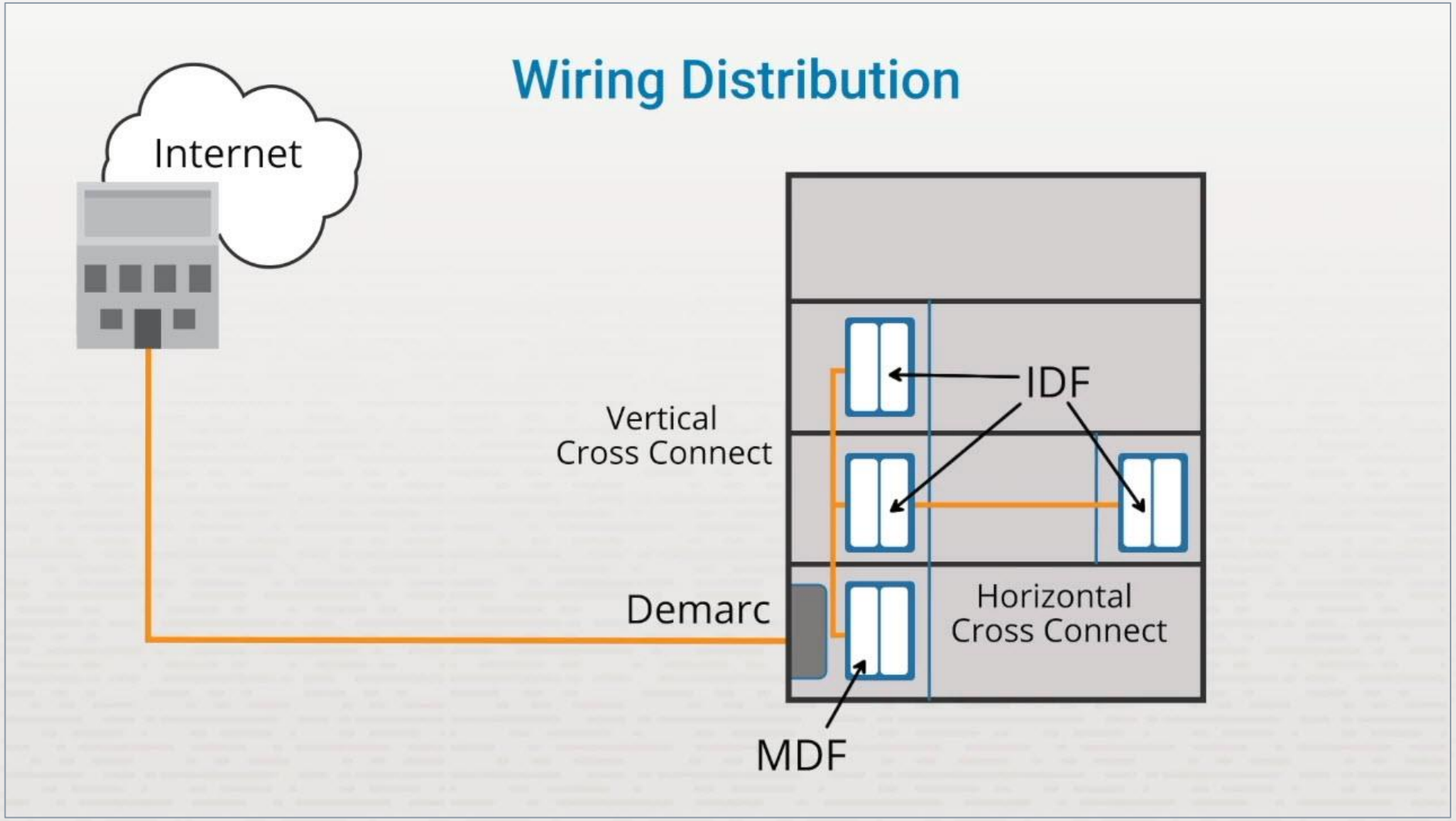
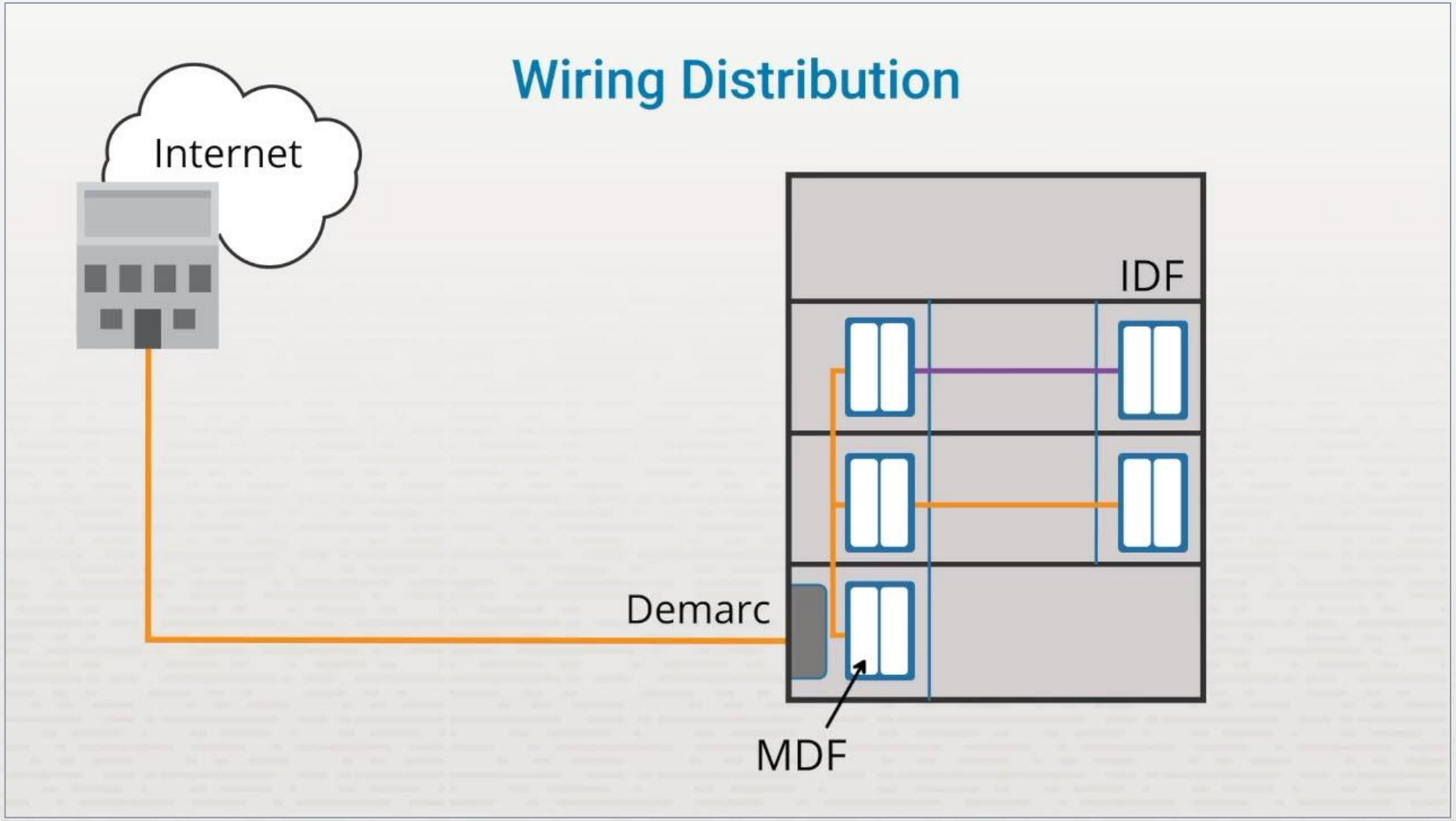


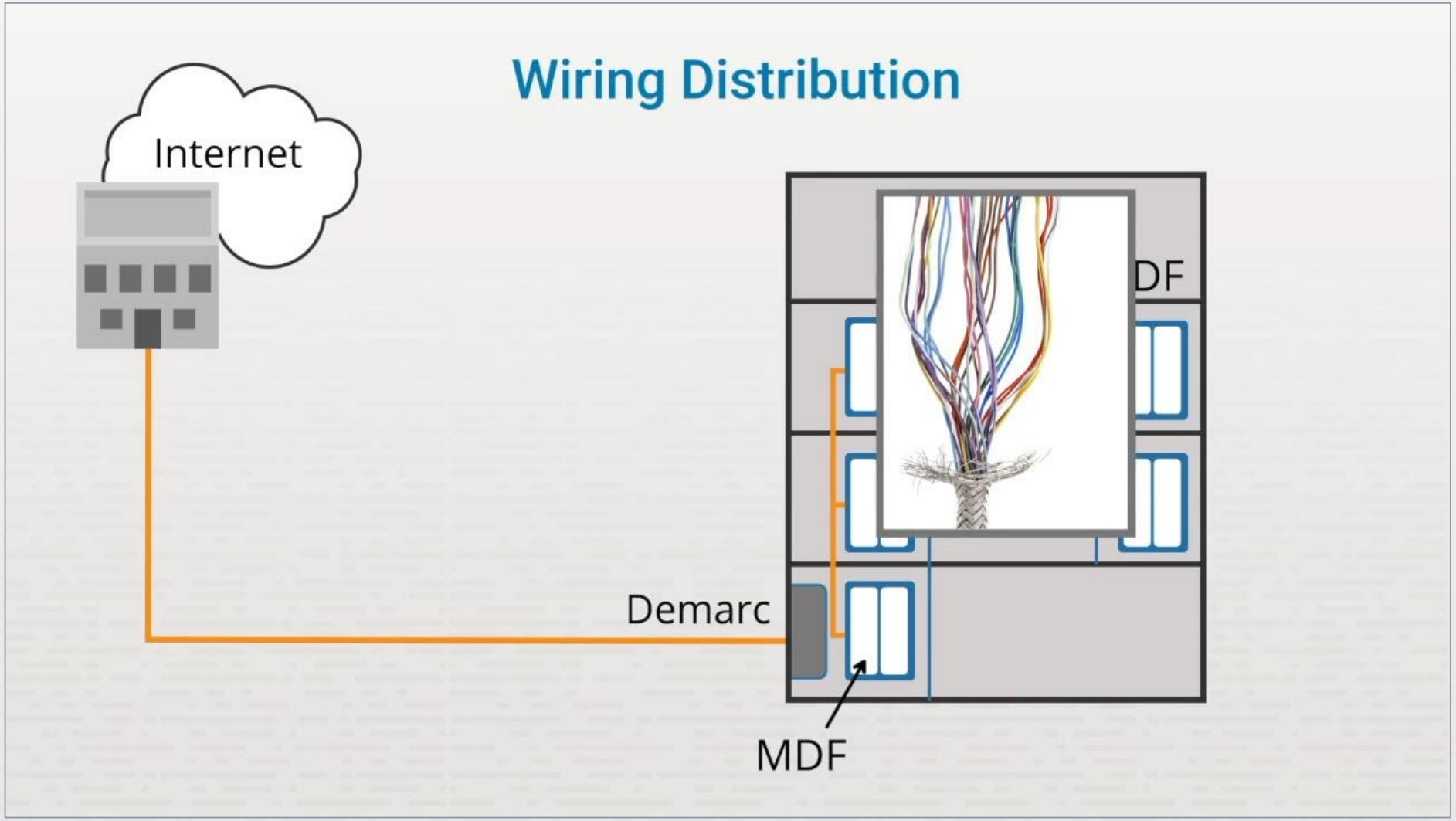
Demarc Extension

- Extends the demarc
- Extra cost

Wiring Distribution



Wiring Distribution



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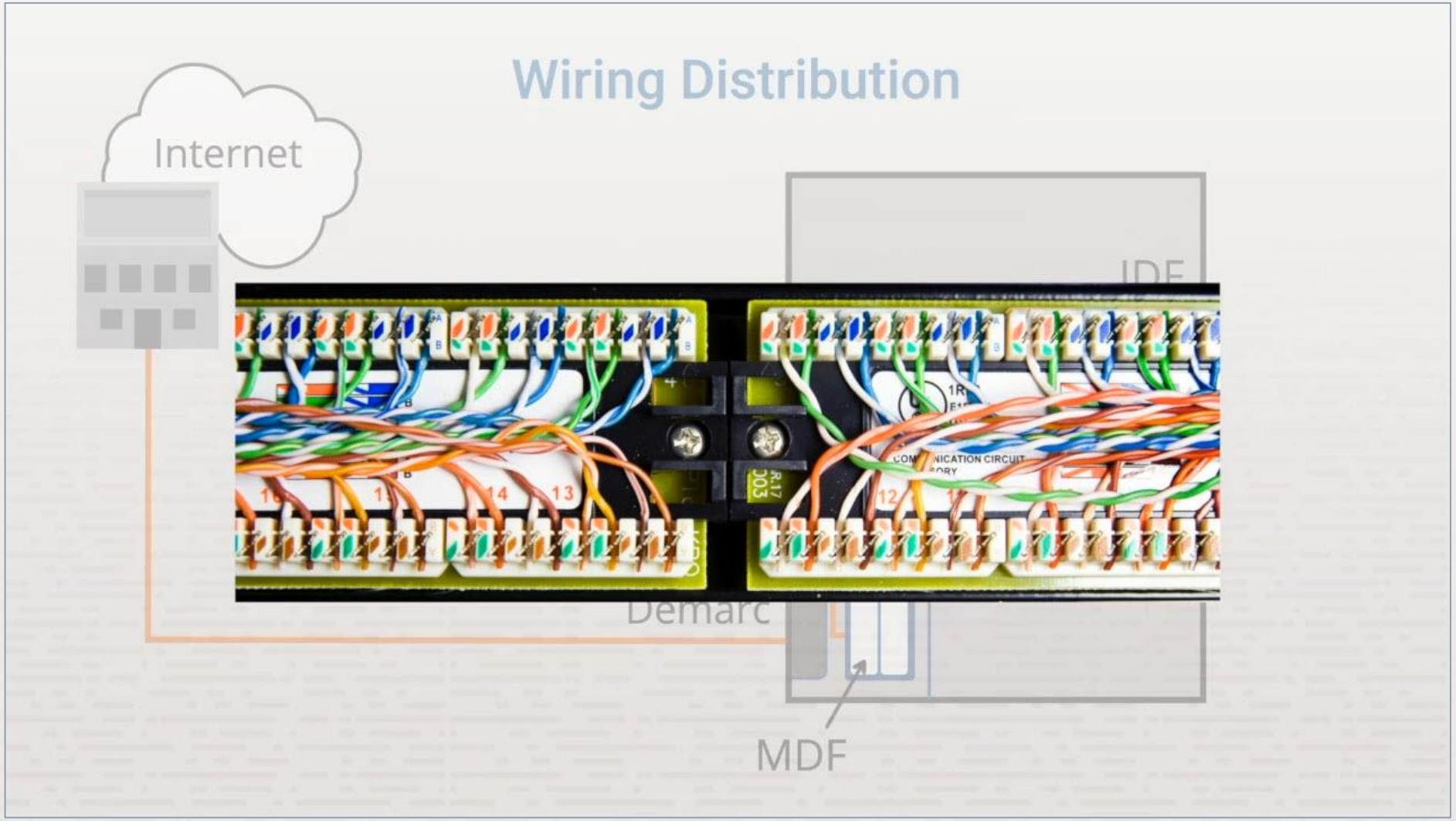
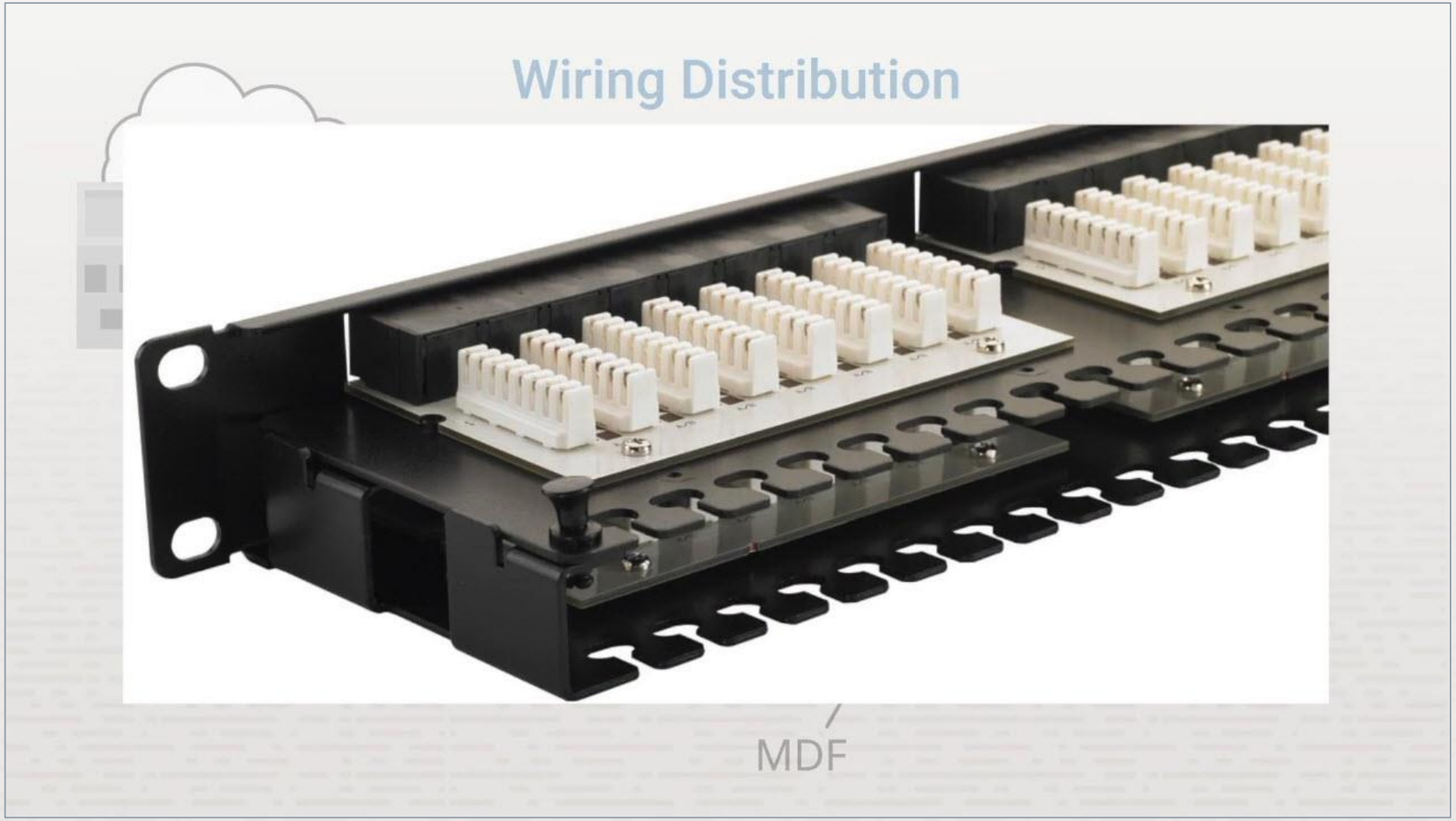


Wiring Distribution

Wiring Distribution



Summary

- Demarc
- MDF
- IDF
- Demarc extension
- 25- or 100-pair cables

In-Class Practice

Do the following labs:

- 3.3.6 Connect Patch Panel Cables 1
- 3.3.7 Connect Patch Panel Cables 2

Class Discussion

- What is the difference between the T568A and T568B standards? When should you use both standards?
- What type of cable would you use to connect two hosts together in a back-to-back configuration using twisted pair cable?
- When should you use stranded core twisted pair cable instead of solid core twisted pair?
- What is the difference between the MDF and an IDF?
- What type of cable connects an IDF to the MDF?

Class Discussion

- Who is typically responsible for installing a demarc extension?
- What is the difference between a 25 pair block and a 50 pair block? What can you use to make the 50 pair block function like a 25 pair block?
- When you use a punch down tool, which way should the blade be facing?
- For what purpose is a patch panel used?

3.4 NETWORK CABLING AND HARDWARE DEVICES

Troubleshoot Network Media

TESTOUT NETWORK PRO

Key Terms

- Electromagnetic Interference (EMI)
- Crosstalk
- Attenuation
- Electrical Short
- Open Circuit

Key Definitions

- **Electromagnetic Interference (EMI):** EMI are external signals that interfere with normal network communications. When working with the radio frequency spectrum, this is known as Radio Frequency Interference (RFI).
- **Crosstalk:** Crosstalk is interference that is caused by signals within twisted pairs of wires (for example, current flow on one twisted pair causing a current flow on an adjacent pair).
- **Attenuation:** Attenuation is the loss of signal strength from one end of a cable to the other. This is also known as dB loss.

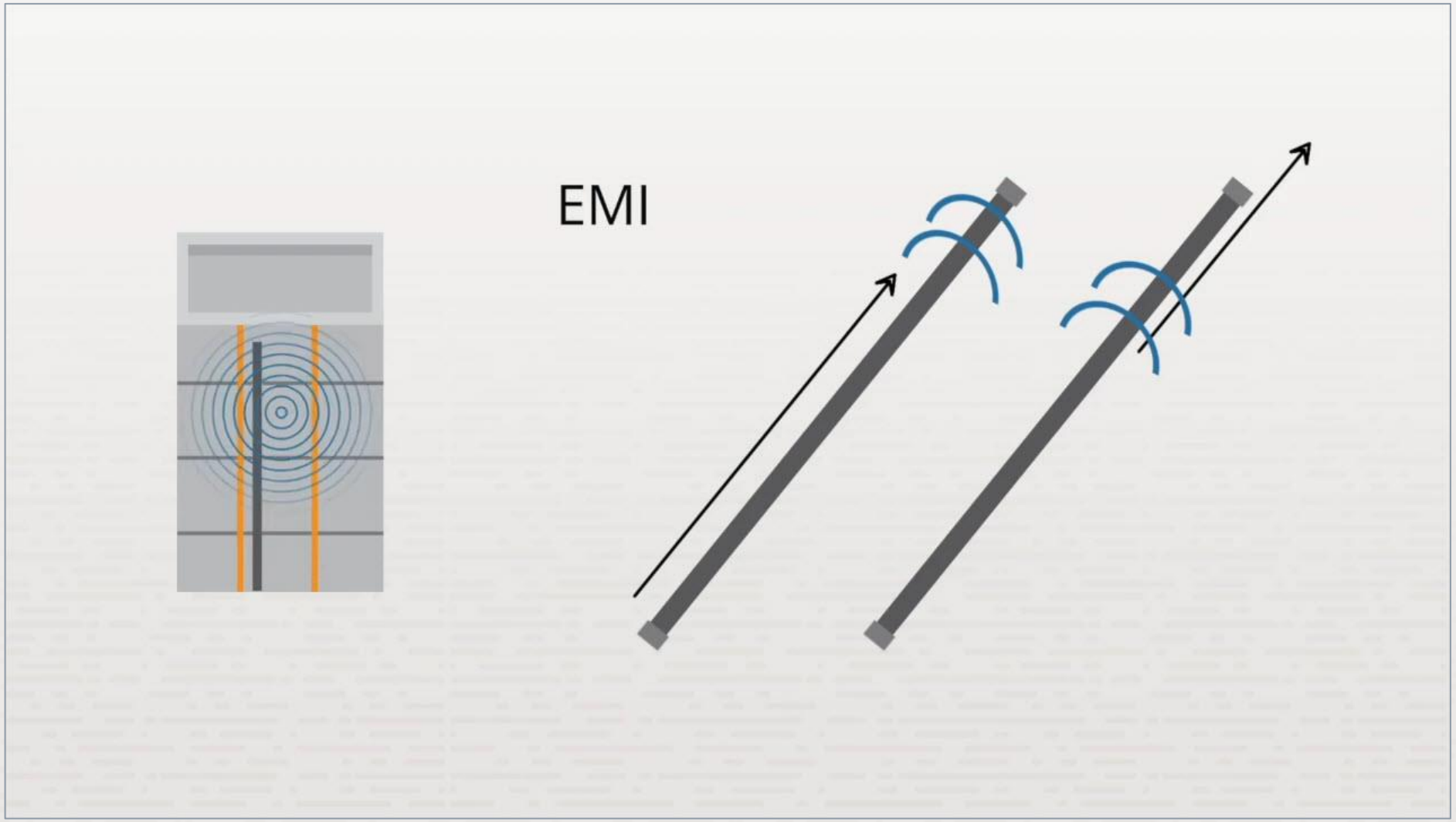
Key Definitions

- **Electrical Short:** An electrical short occurs when electrical signals take a path other than the intended path. In the case of twisted pair wiring, a short means that a signal sent on one wire arrives on a different wire.
- **Open Circuit:** An open circuit is when a cut in the wire prevents the original signal from reaching the end of the wire. An open circuit is different from a short in that the signal stops (electricity cannot flow because the path is disconnected).

Troubleshoot Copper Wiring Issues

Troubleshoot Copper Wiring Issues

Troubleshoot Copper Wiring Issues



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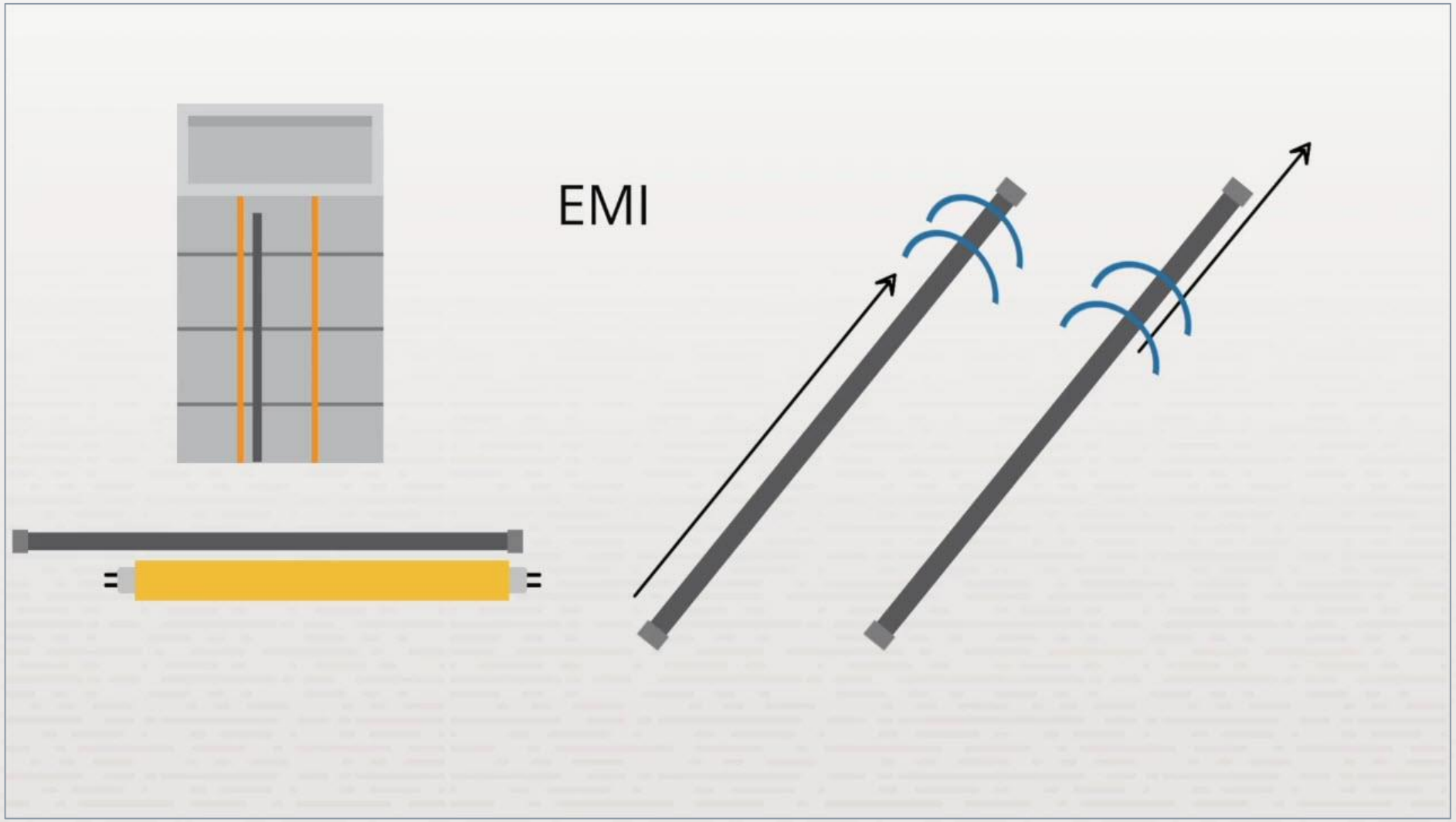

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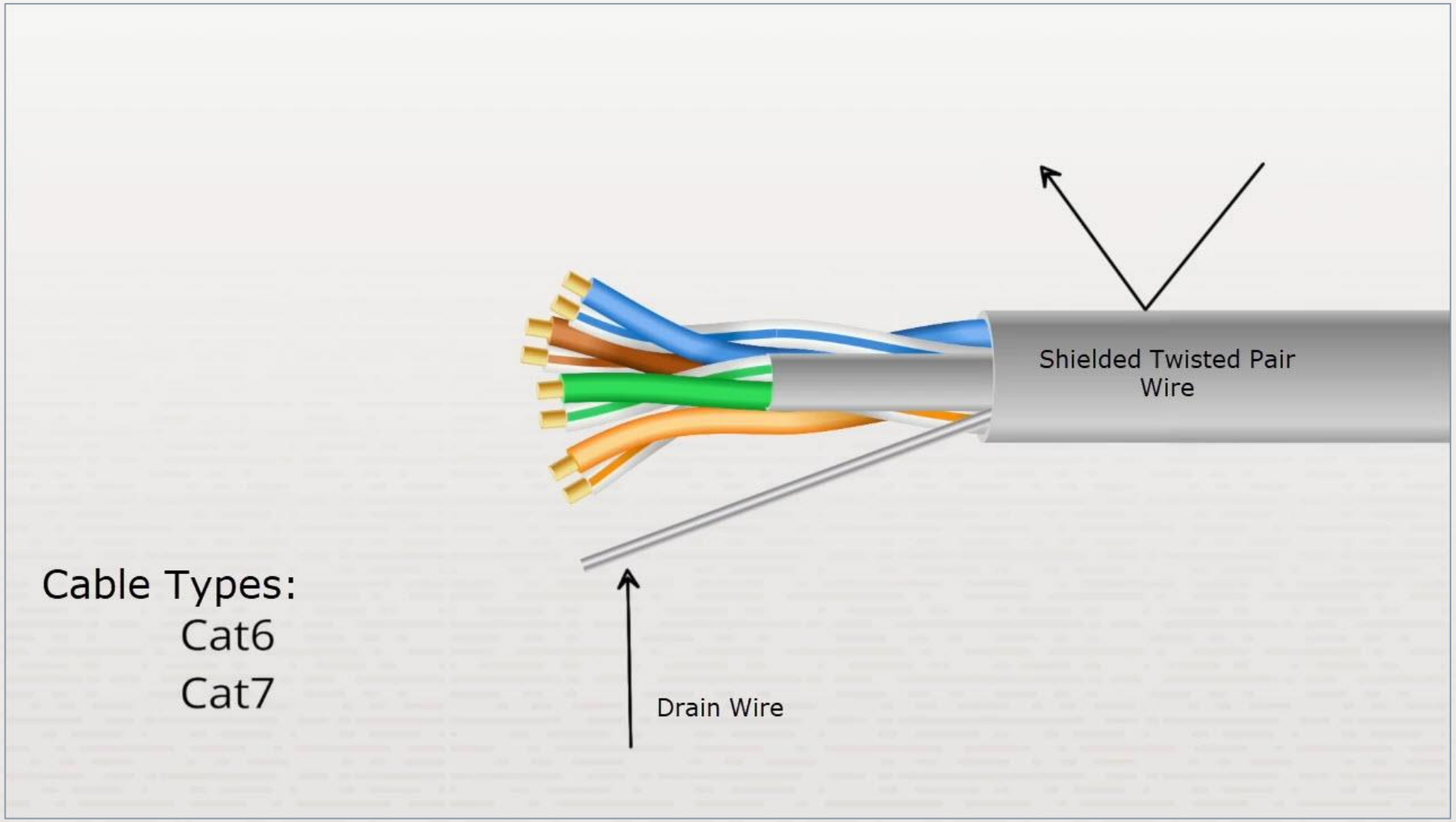
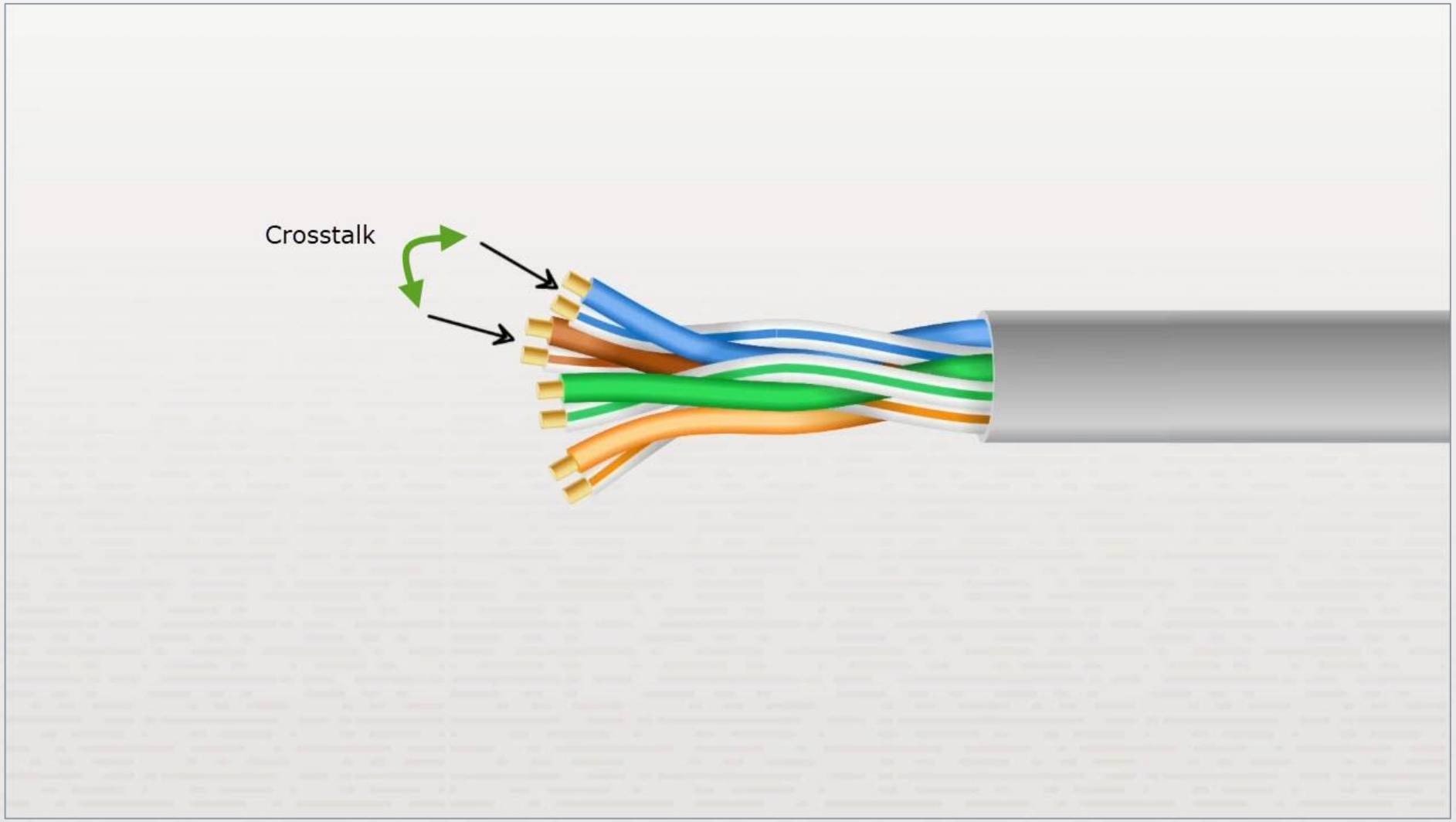


Cable Types:

Cat6

Cat7

Troubleshoot Copper Wiring Issues



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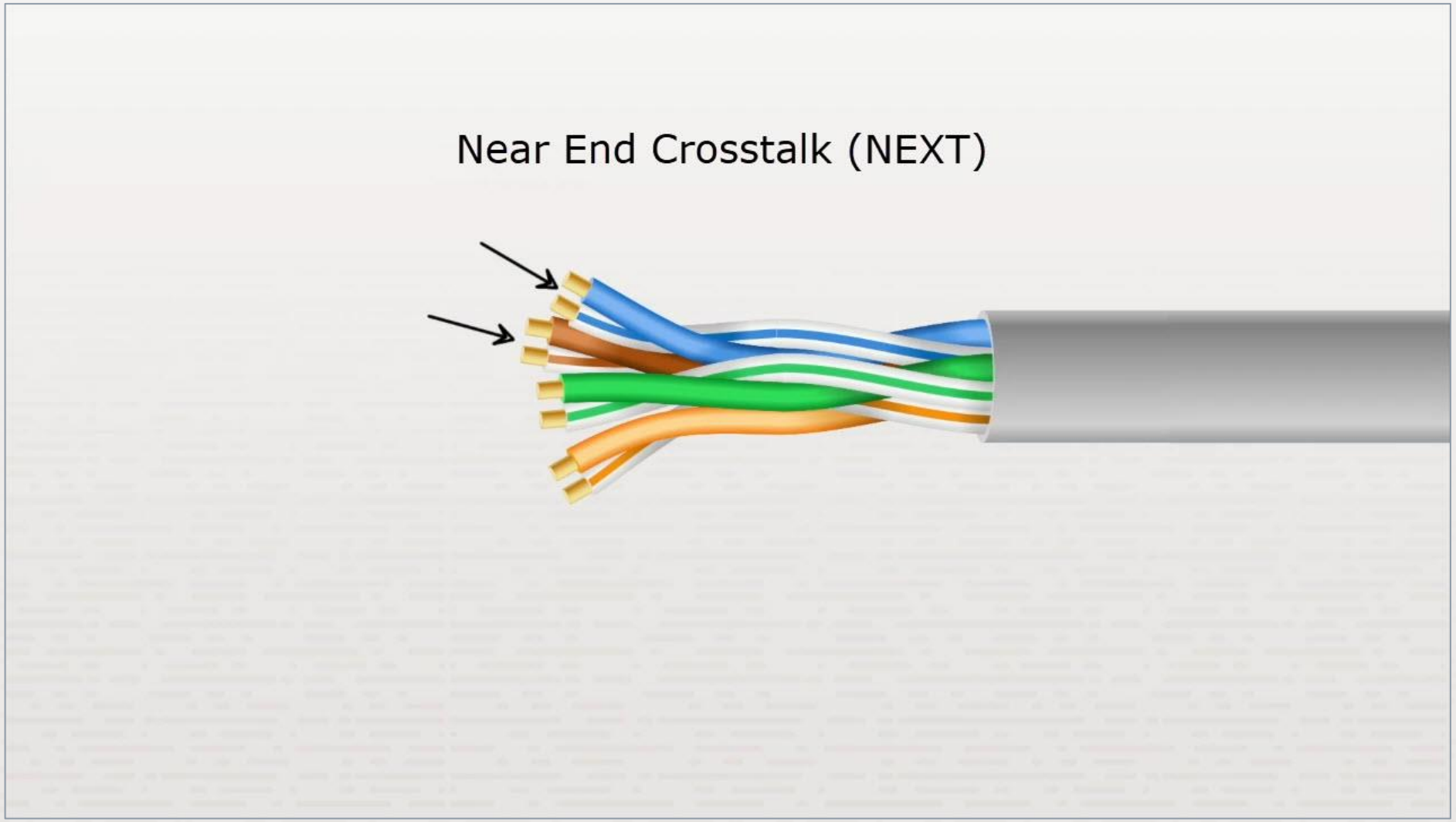

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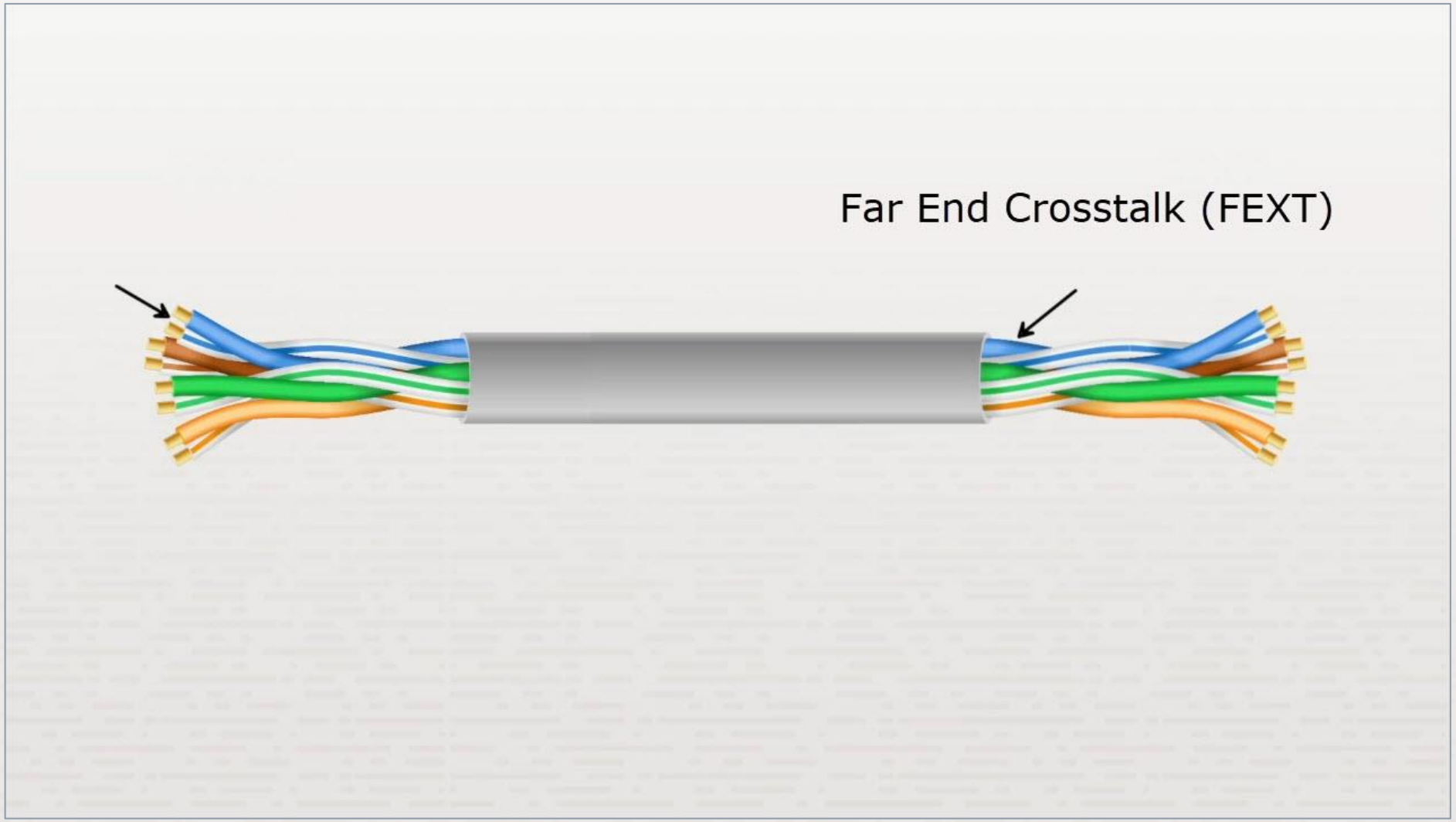

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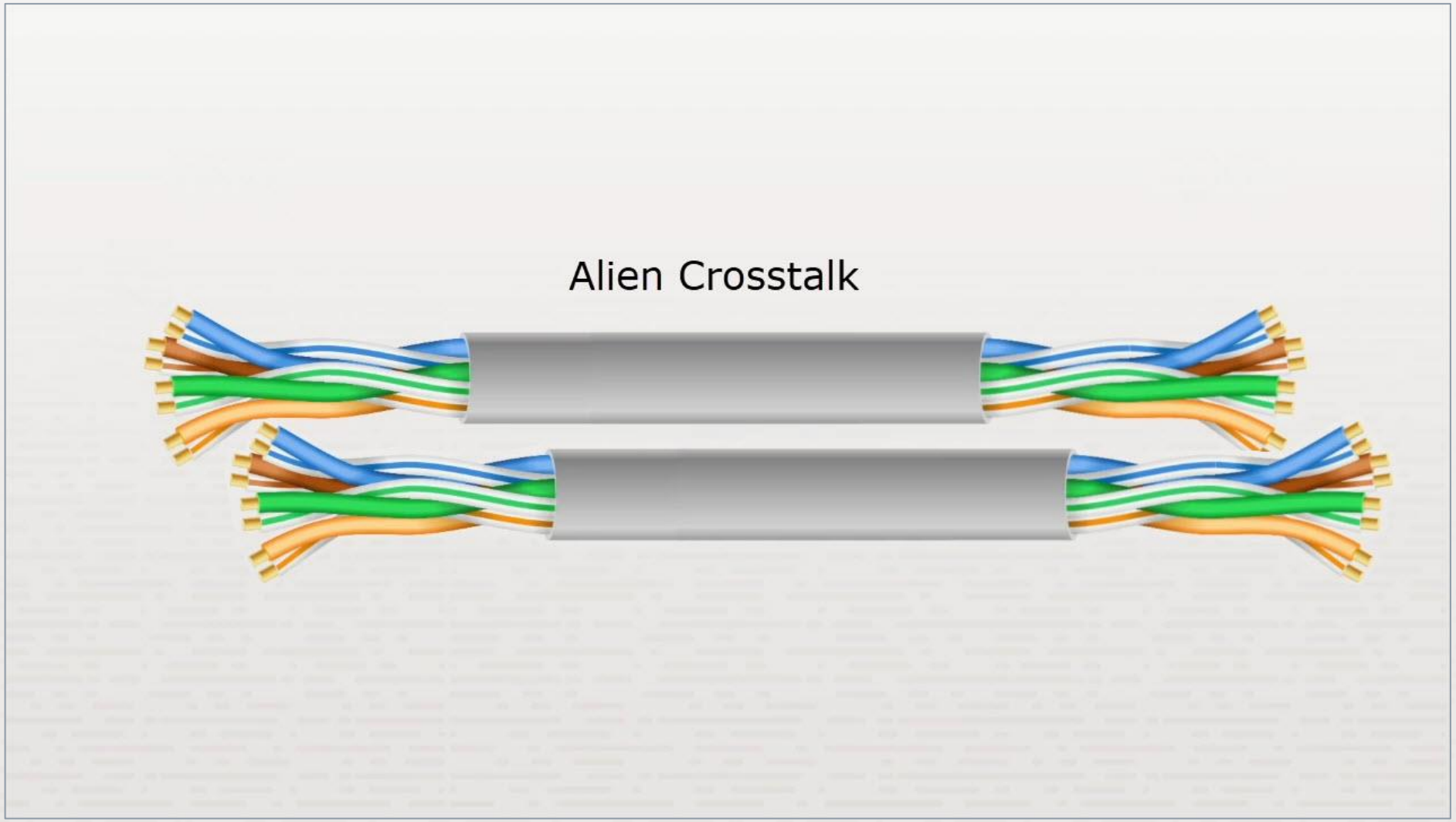

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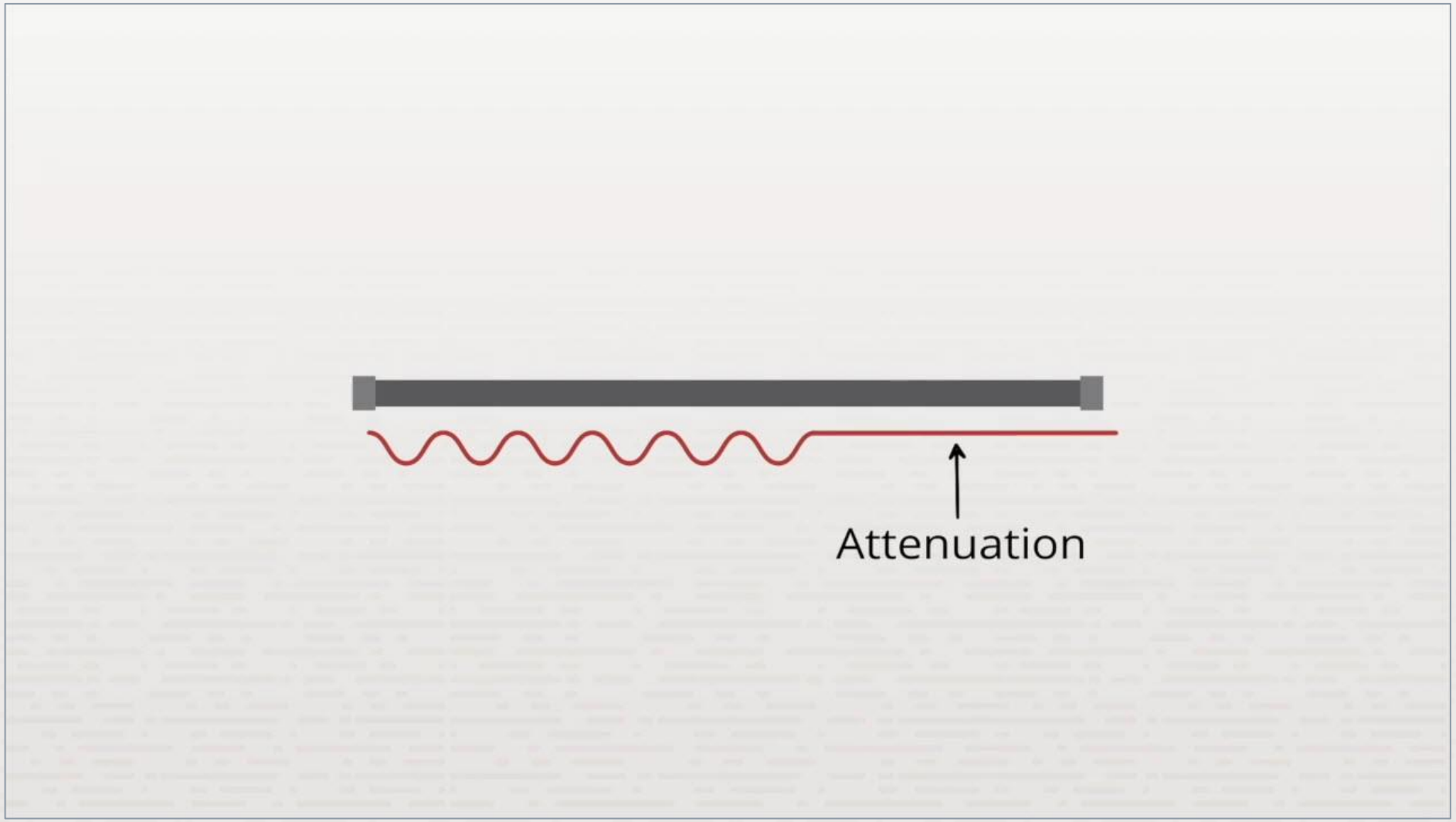

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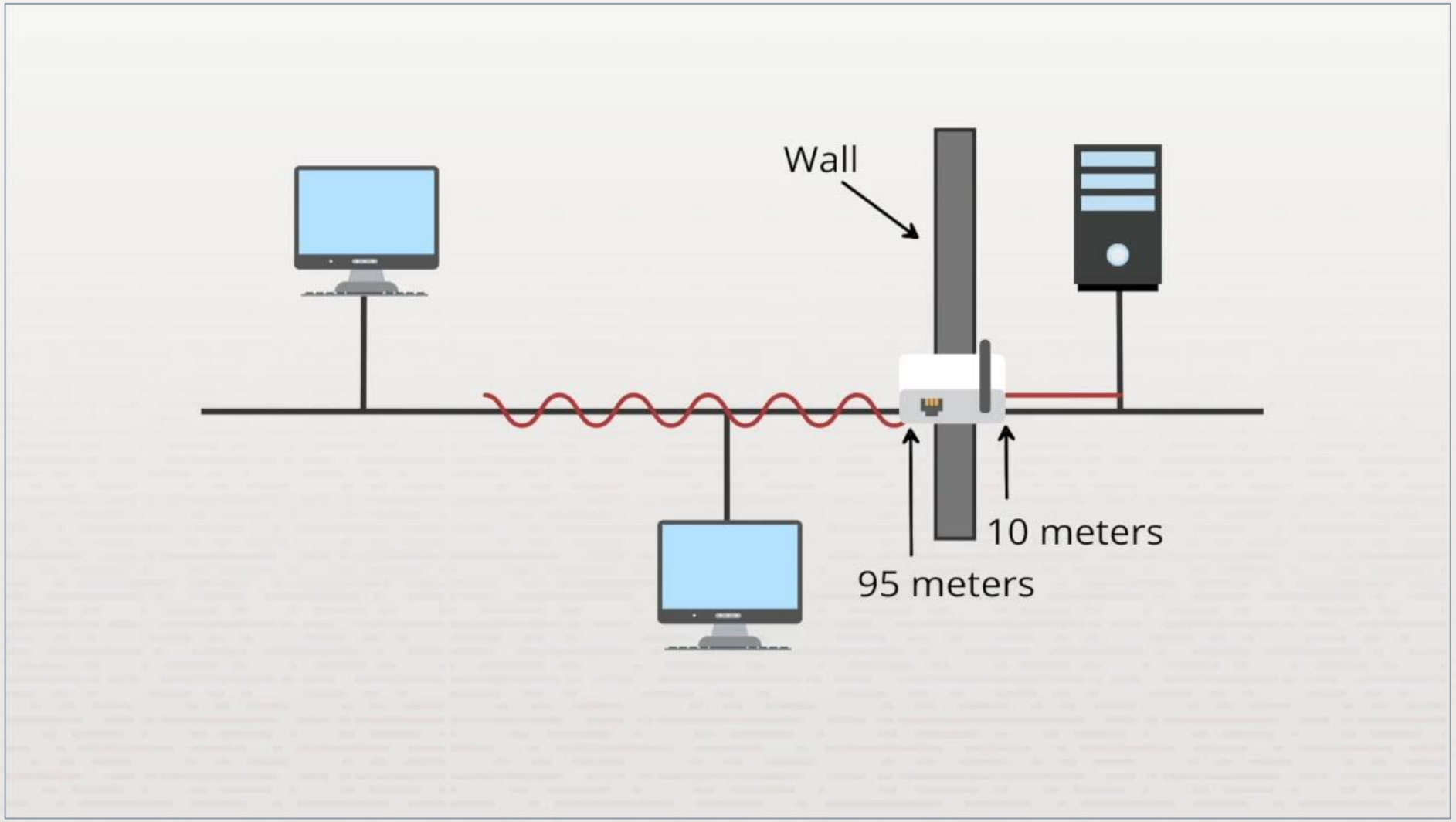

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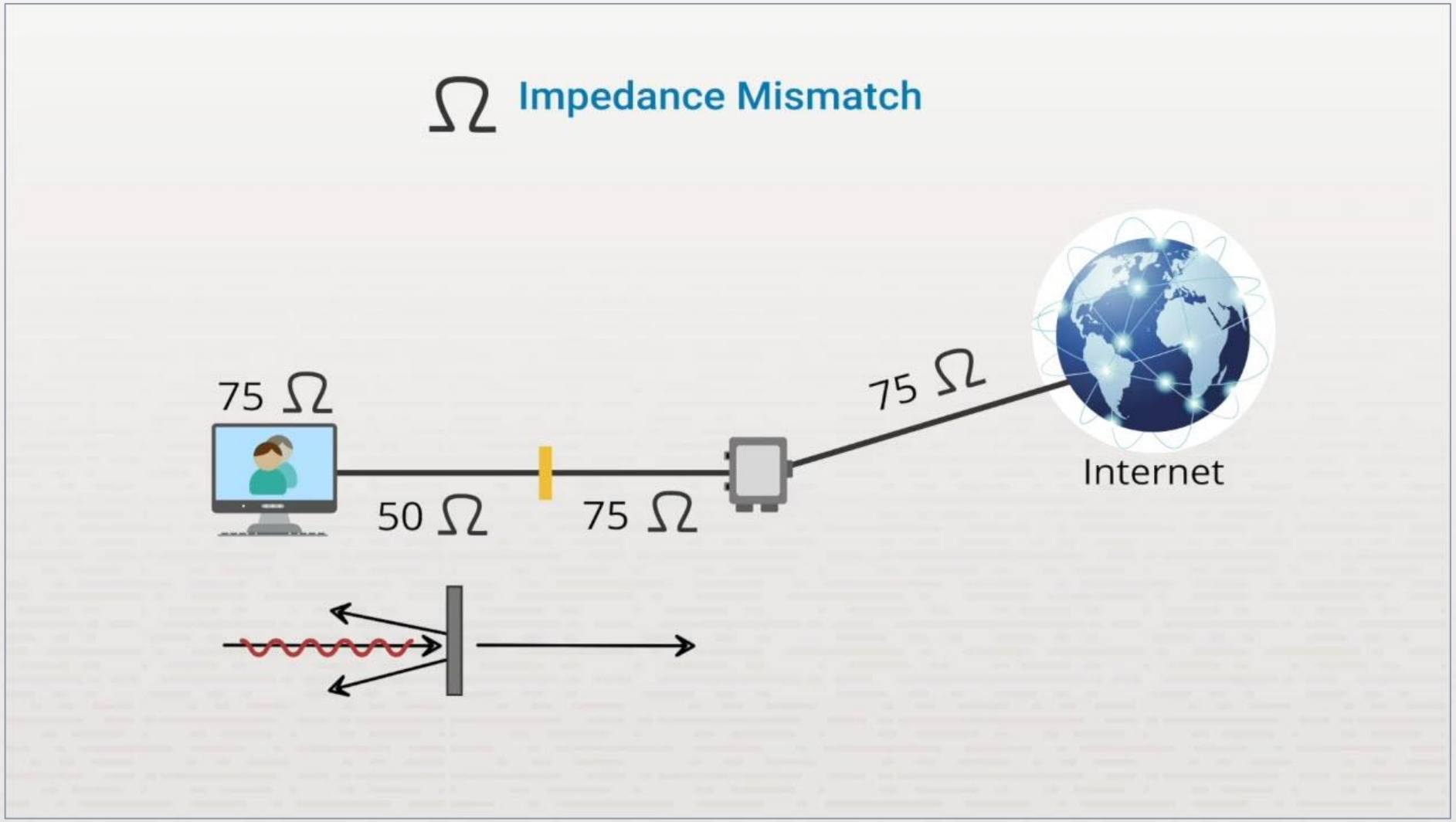

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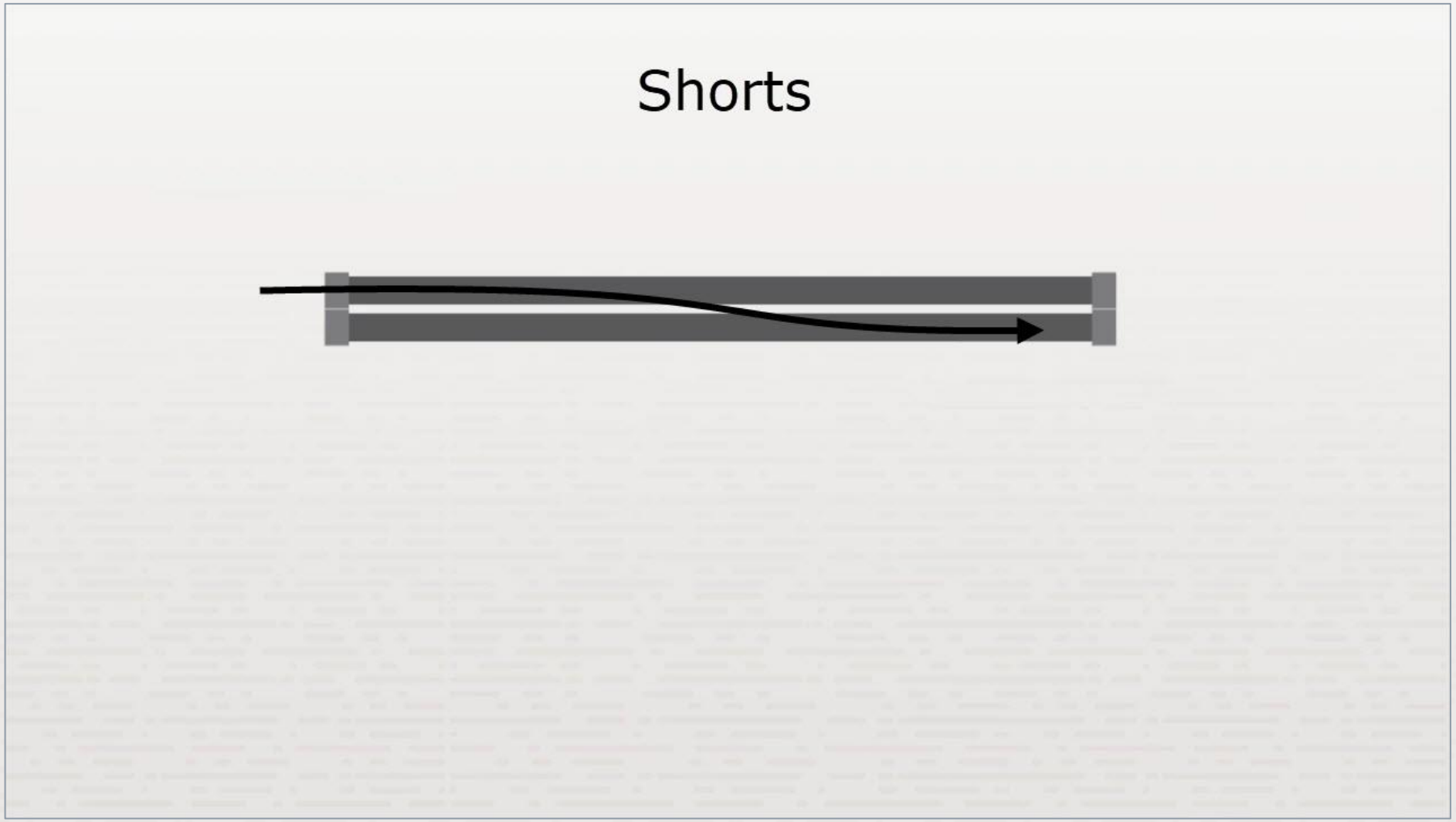

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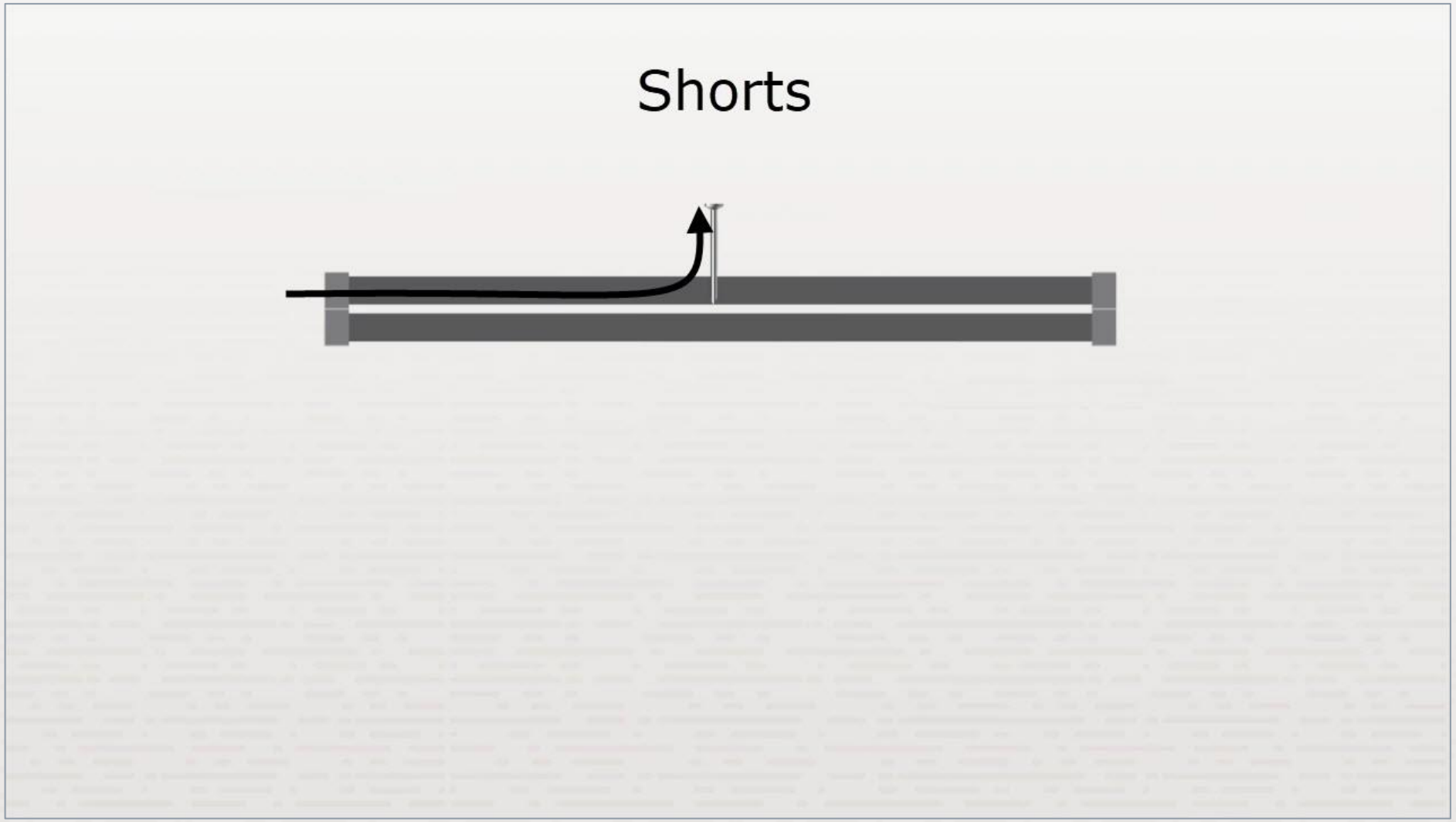

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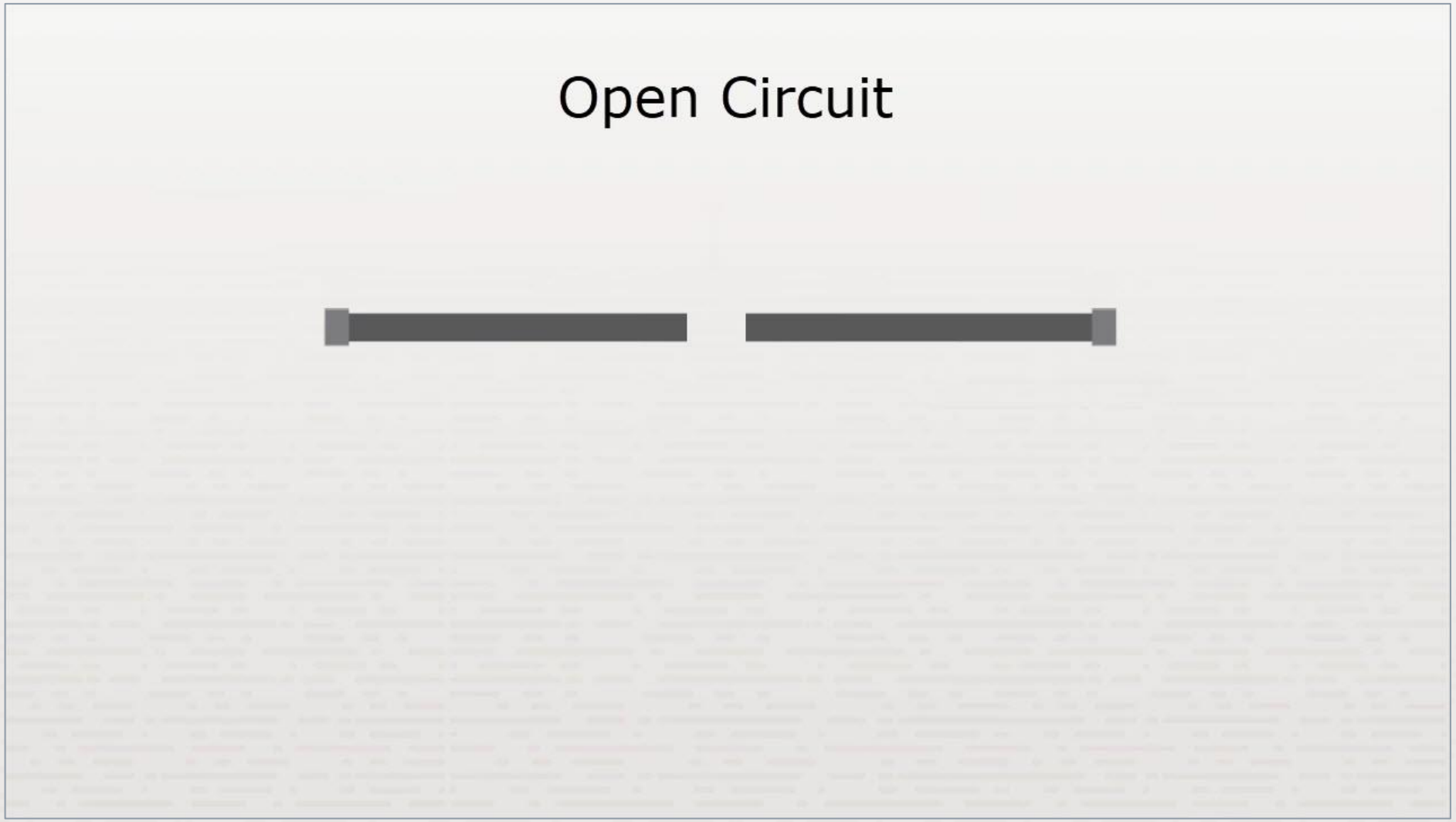


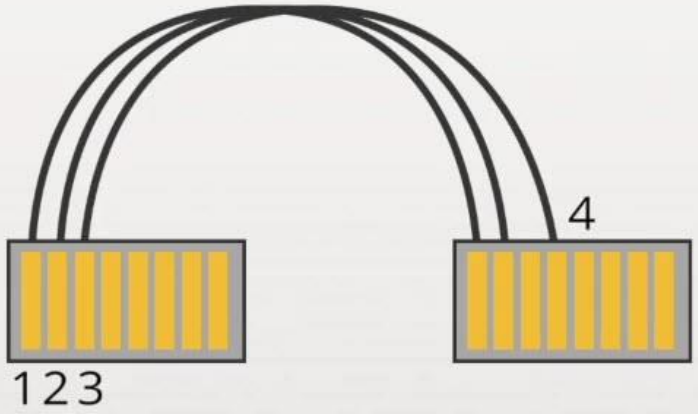
Troubleshoot Copper Wiring Issues

Reversal

Troubleshoot Copper Wiring Issues

Reversal

Wiremapping



Troubleshoot Copper Wiring Issues

Reversal

Wiremapping

Split pair

Troubleshoot Copper Wiring Issues

Reversal

Wiremapping

Split pair

Crosstalk

Summary

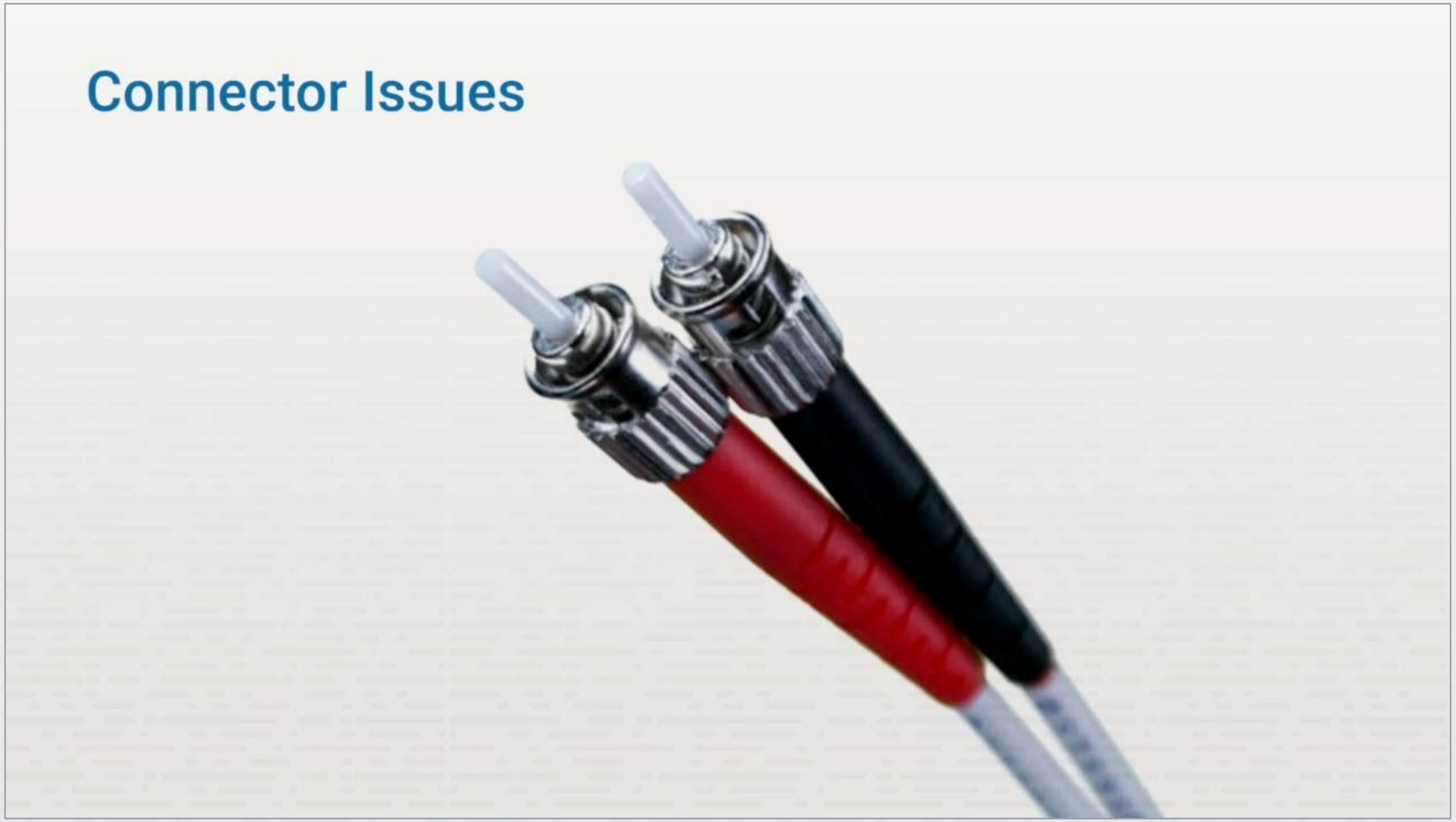
- Troubleshooting common wire issues

Troubleshoot Fiber Optic Wiring Issues

Common Issues

- Connector issues
- Cable issues
- Media adapter issues
- Attenuation

Troubleshoot Fiber Optic Wiring Issues



Troubleshoot Fiber Optic Wiring Issues

Connector Issues

Troubleshoot Fiber Optic Wiring Issues

Connector Issues

Troubleshoot Fiber Optic Wiring Issues

Connector Issues

Troubleshoot Fiber Optic Wiring Issues

Polishing Types

Physical Contact (PC)

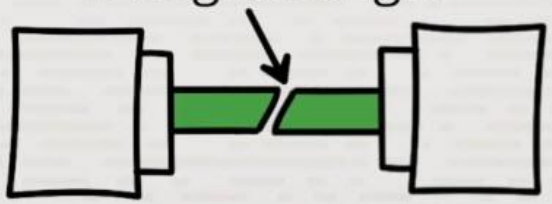
Higher polish grade

Super Physical Contact (SPC)

Ultra Physical Contact (UPC)

8 degree angle

Angled Physical Contact (APC)



Signal Loss

- Cable length
- Connectors
- Splices

Loss Budget

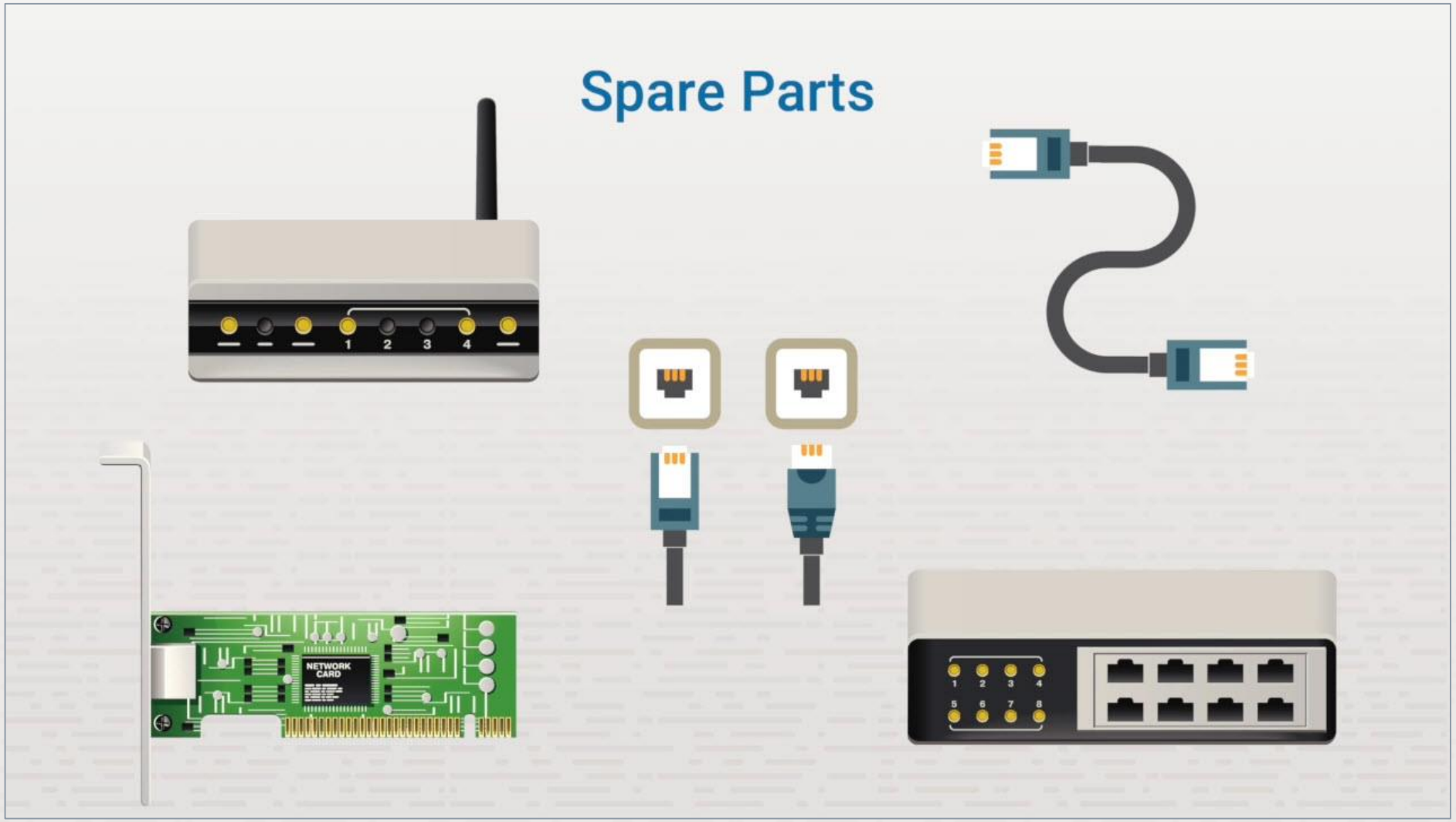
- Connectors: 0.3 dB loss each
- Splices: 0.3 dB loss each
- Multimode: < 3 dB loss/km
- Single mode: < .5 dB loss/km

Summary

- Connector issues
- Cable issues
- Media adapter issues
- Attenuation

Troubleshooting Tools

Troubleshooting Tools



Troubleshooting Tools

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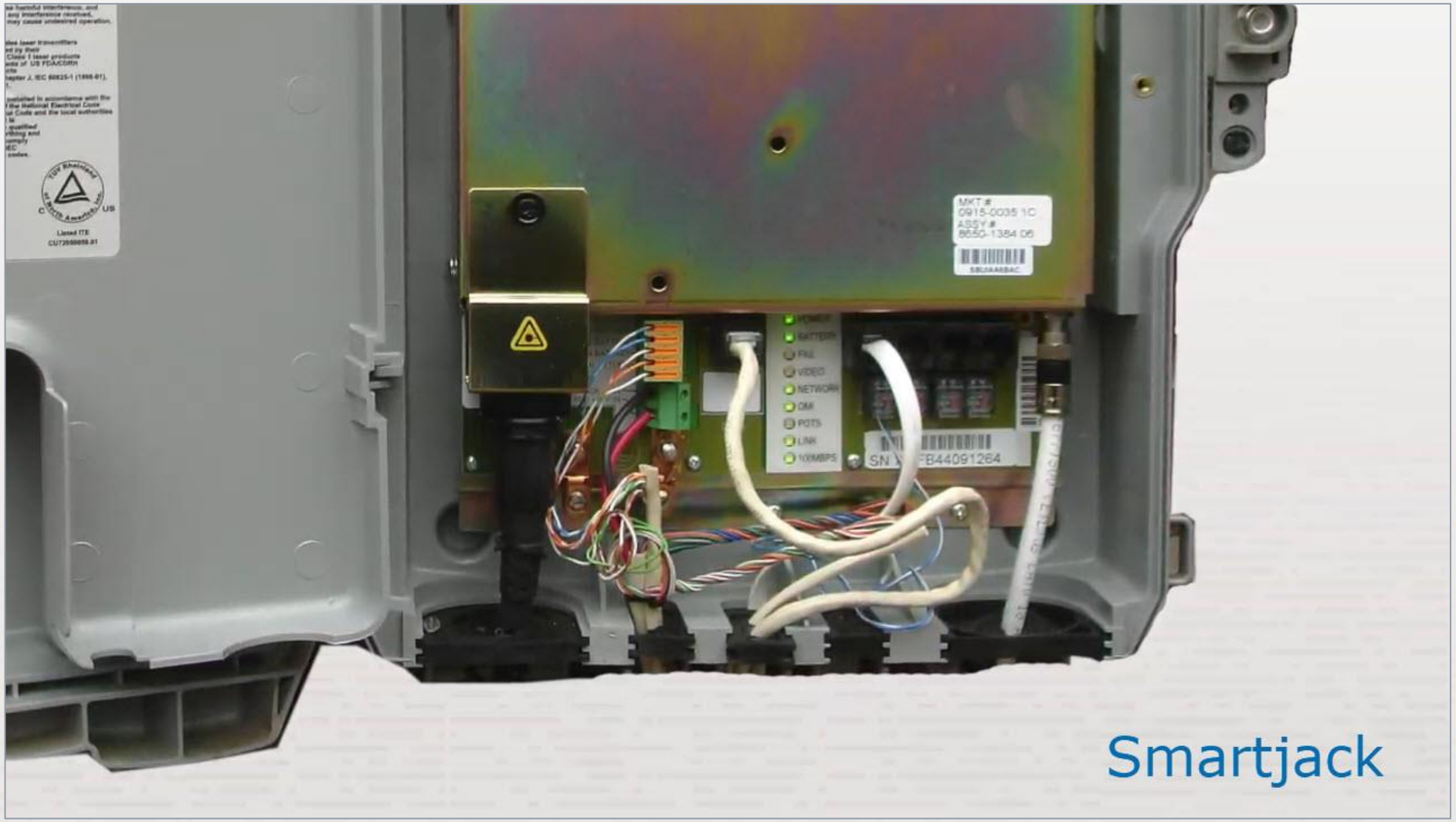

Troubleshooting Tools

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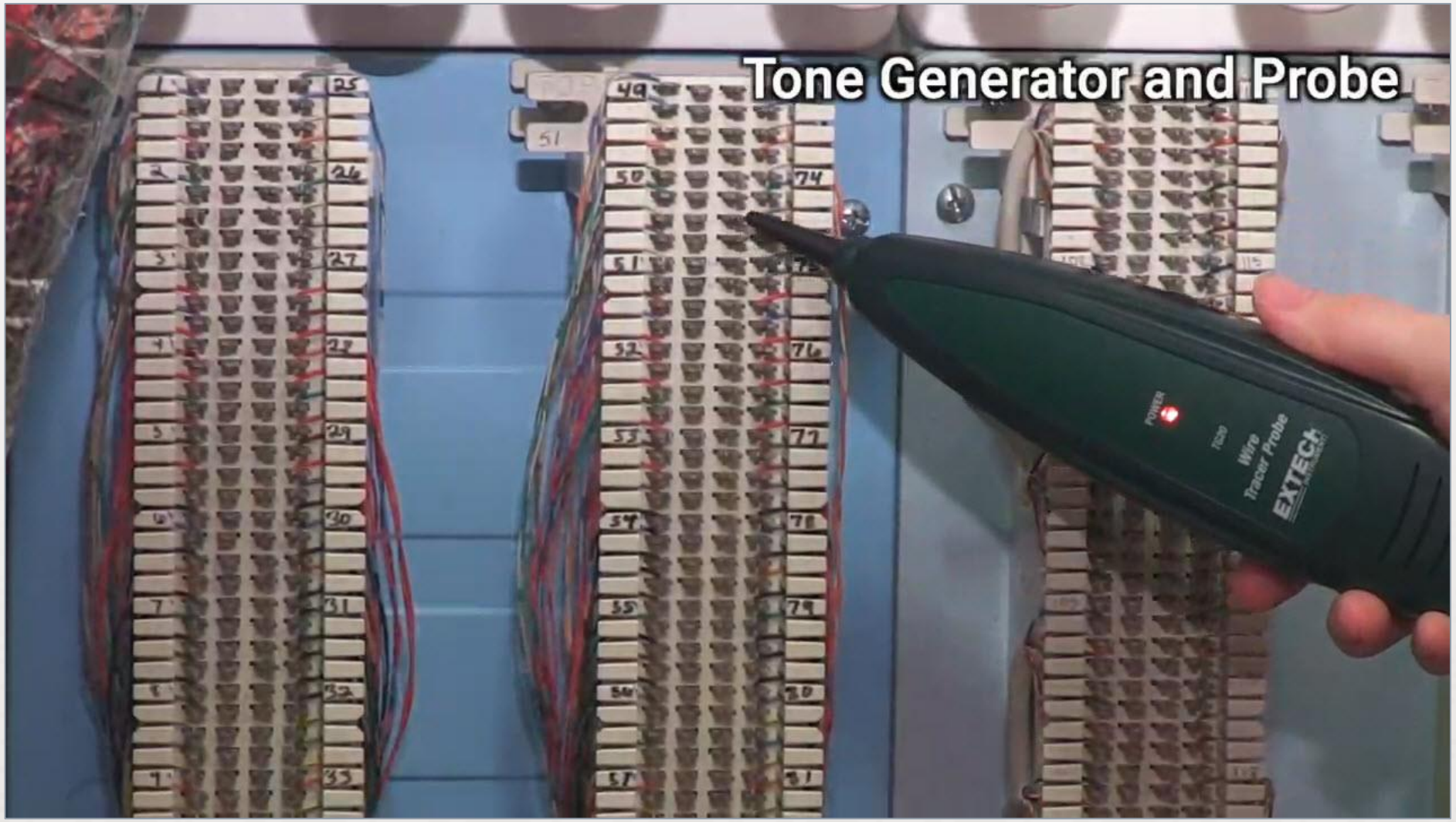

Troubleshooting Tools

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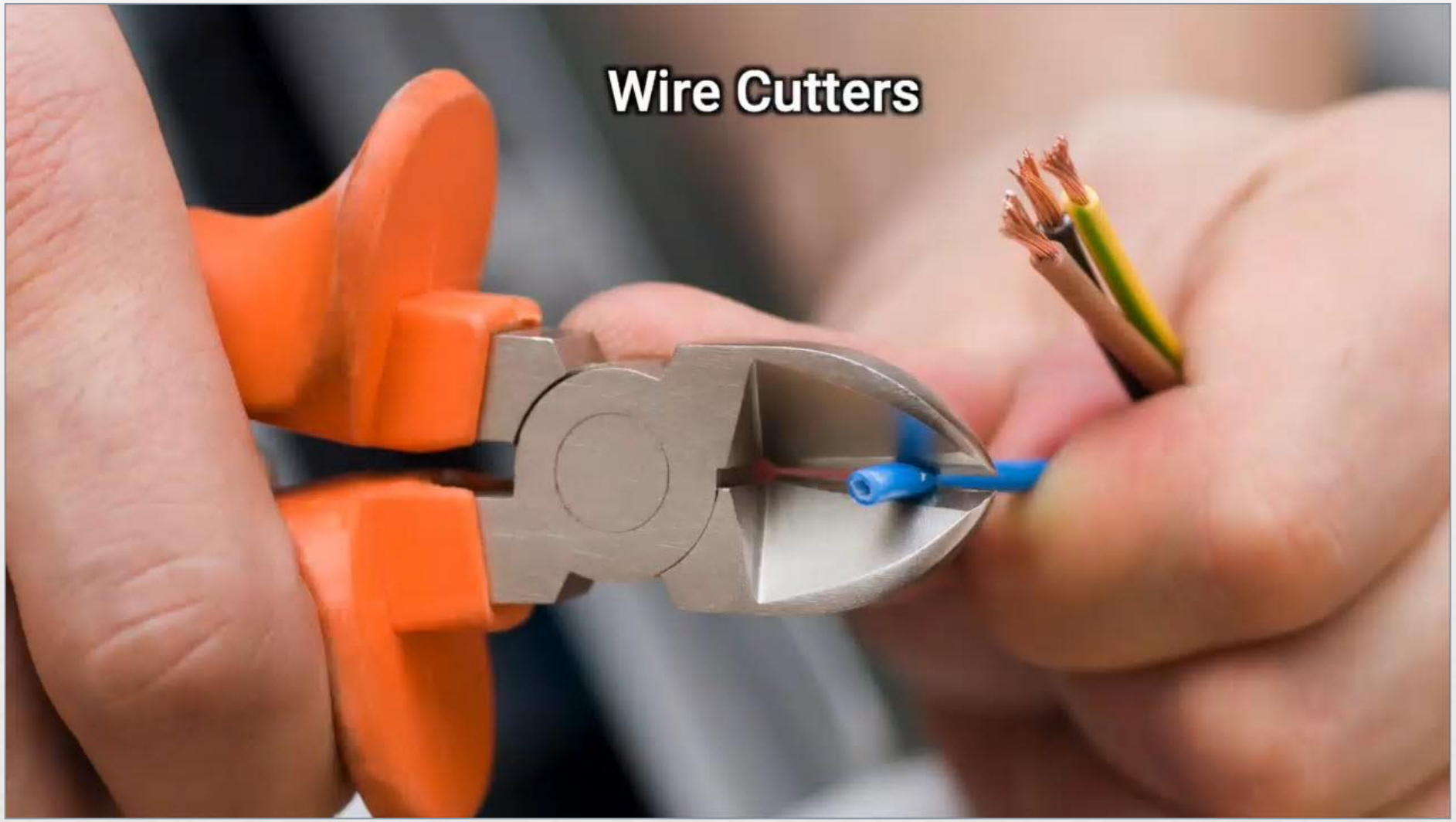
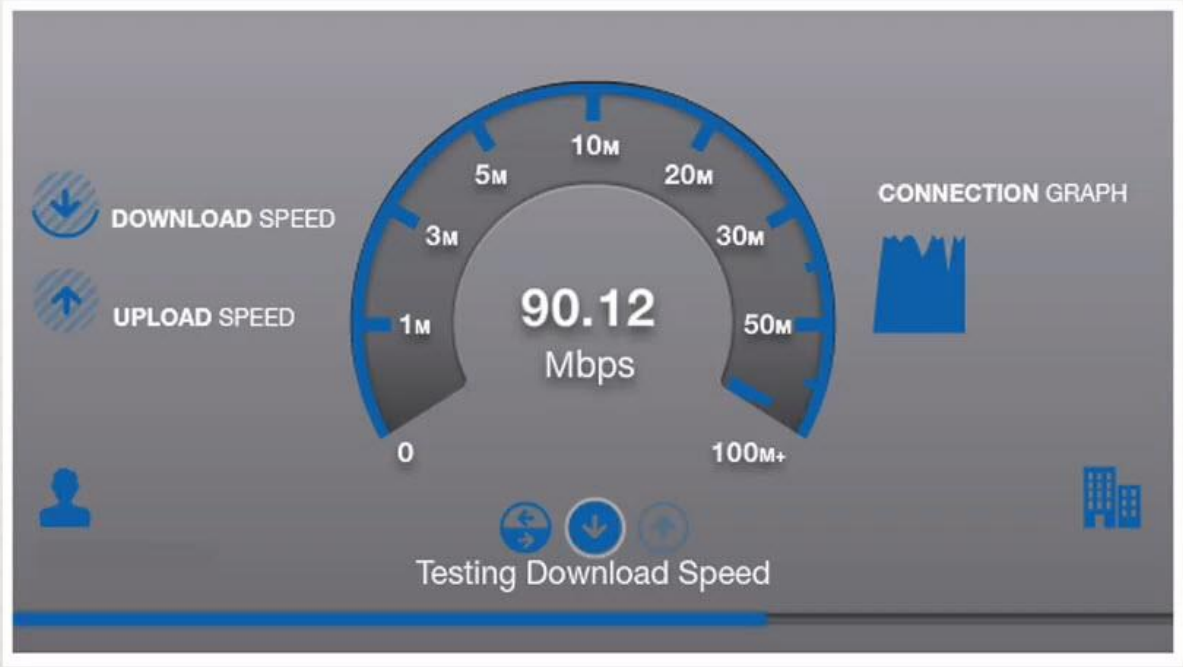
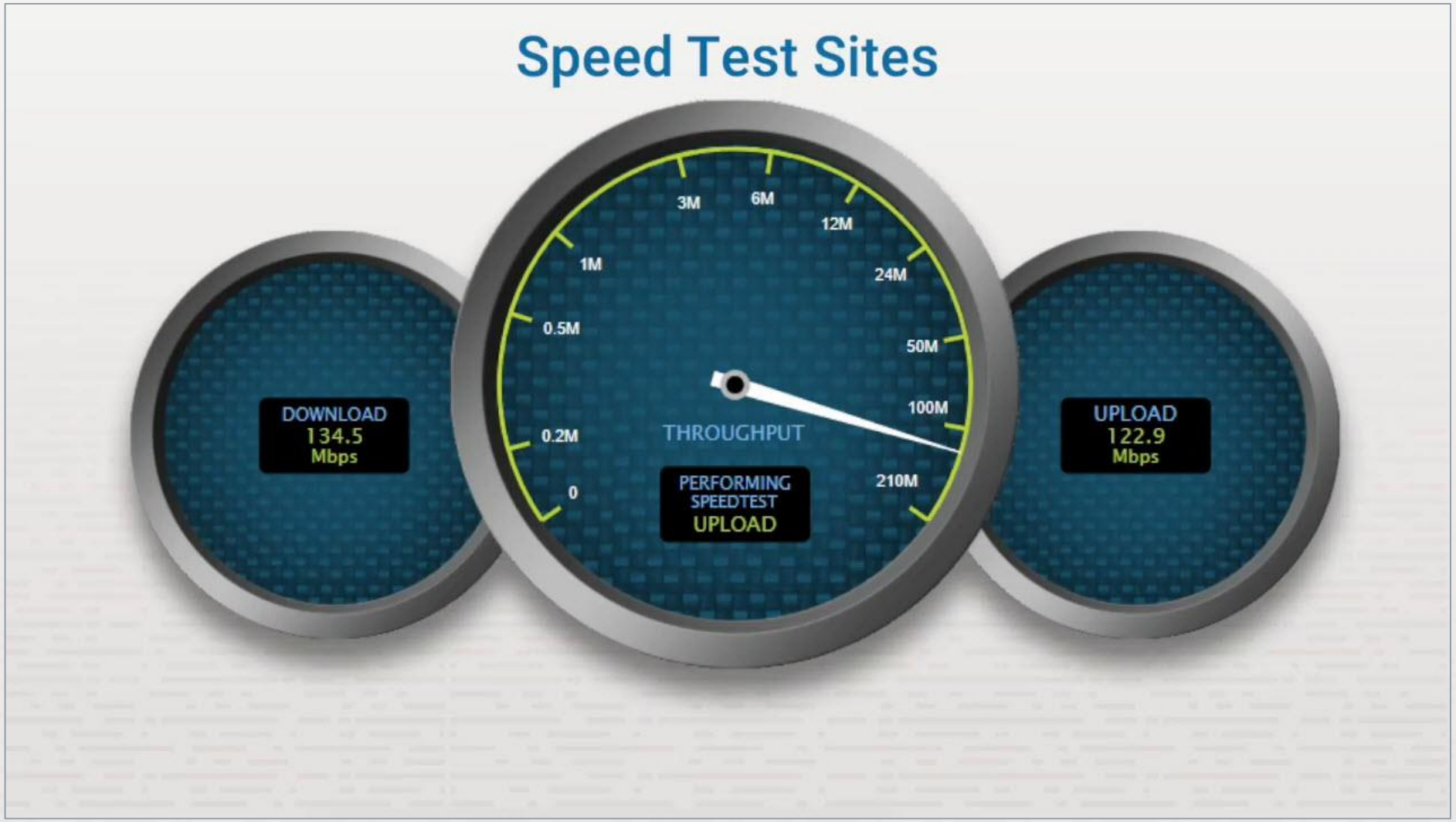


Troubleshooting Tools

Speed Test Sites



Troubleshooting Tools



Summary

- Loopback plugs
- Smartjacks
- Cable testers
- TDRs and OTDRs
- Cable certifiers
- Tone generator and probes
- Multimeters
- Wiring tools
- Speed test sites

Class Discussion

- How do you prevent back reflection and optical return loss?
- What is the difference between a short circuit and an open circuit?
- What happens when you connect a single mode fiber to multimode fiber?
- What is the difference between a time-domain reflectometer and an optical time-domain reflectometer?
- Which tool would you use to test the bandwidth of your internet connection?
- Which cable types are immune to the effects of EMI?

Class Discussion

- How does distance affect attenuation? How does distance affect impedance?
- What is the single best method to reduce the effects of an impedance mismatch?
- What is the difference between a regular cable tester and a cable certifier?
- Which tool would you use to find the end of a specific cable within a wiring closet?

3.5 NETWORK CABLING AND HARDWARE DEVICES

Network Adapters

TESTOUT NETWORK PRO

Section Skill Overview

- Select and install a network adapter
- Connect a media converter

Key Terms

- Network interface card (NIC)
- Gigabit interface converter (GBIC)
- Small form-factor pluggable (SFP)
- XFP
- QSFP
- Media Access Control (MAC)
- Address Resolution Protocol (ARP)
- Reverse Address Resolution Protocol (RARP)

Key Definitions

- **Network interface card (NIC)**: A NIC is a hardware device that provides a way to connect a computer to the network medium. It is responsible for converting binary data into a format that can be sent on the network medium. A NIC is also called a network adapter.
- **Gigabit interface converter (GBIC)**: In fiber optic and Ethernet systems, a GBIC is a transceiver that converts electrical signals to optical signals and vice versa.
- **Small form-factor pluggable (SFP)**: An SFP is similar to a GBIC but is smaller in size. An SFP is sometimes called a mini-GBIC.

Key Definitions

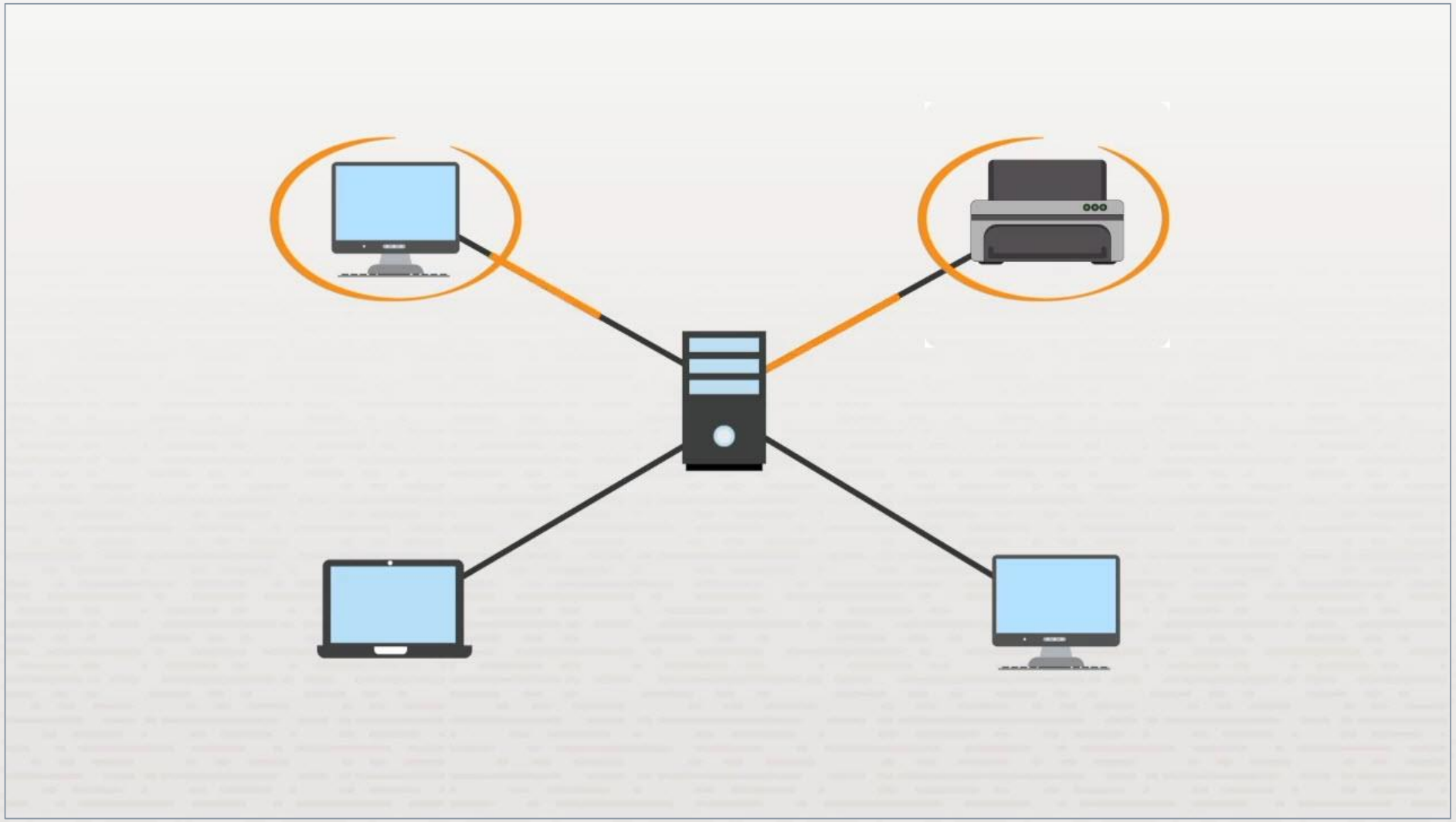
- **XFP**: An XFP (a 10-Gigabit small form-factor pluggable) transceiver is similar to an SFP in size but is used for 10-Gigabit networking.
- **QSFP**: QSFP (a quad, or 4-channel, small form-factor pluggable) is a compact hot-pluggable transceiver that is also used for data communication applications.
- **Media Access Control (MAC)**: A Media Access Control (MAC) address is a unique identifier burned into the ROM of every Ethernet NIC. The first half of the MAC address (the first six digits) is assigned to each manufacturer. The manufacturer determines the rest of the address, assigning a unique value that identifies the host address.

Key Definitions

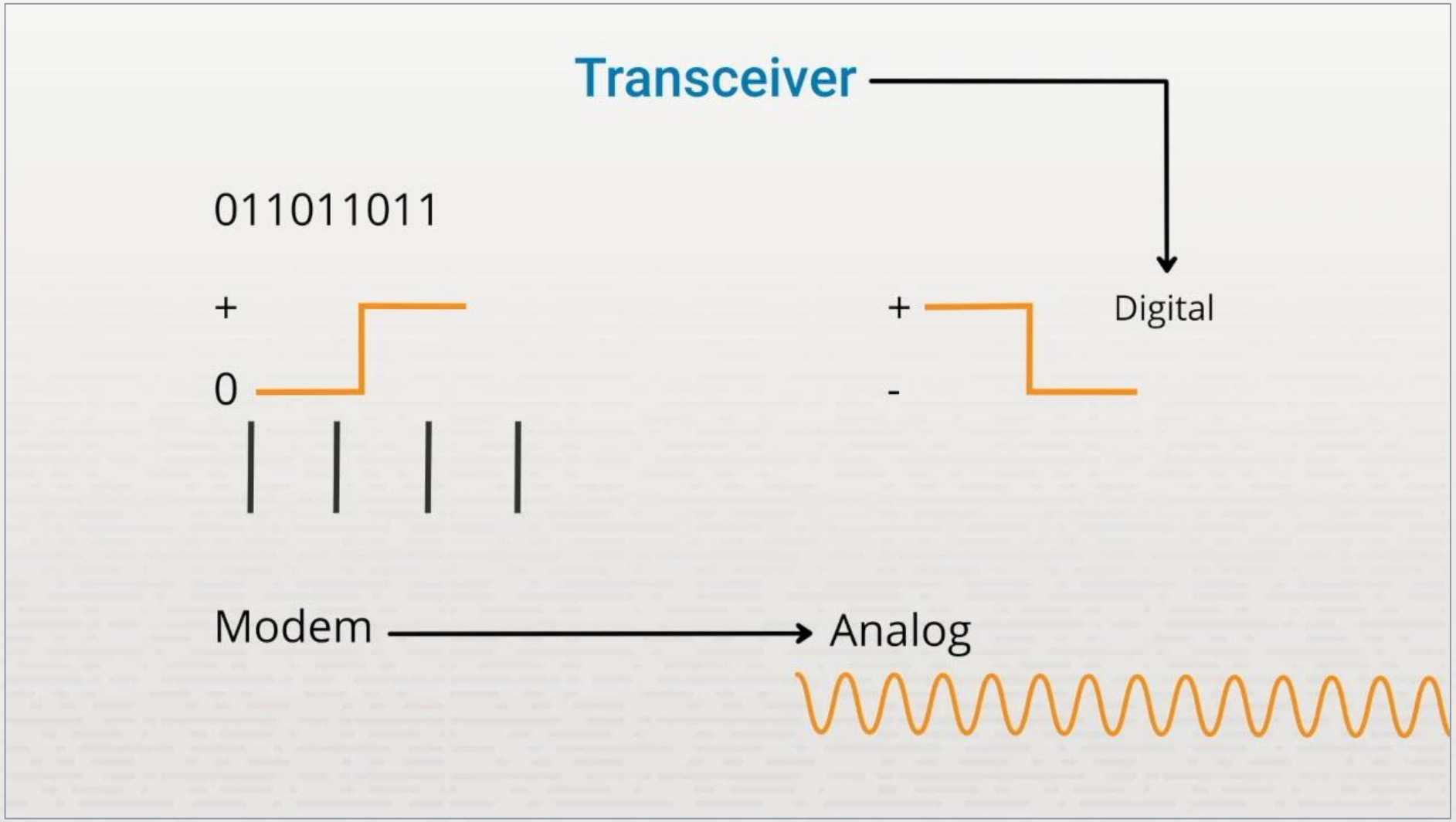
- **Address Resolution Protocol (ARP)**: Hosts use ARP to discover the MAC address of a device from its IP address.
- **Reverse Address Resolution Protocol (RARP)**: Hosts use Reverse Address Resolution Protocol (RARP) to find the IP address of a host with a known MAC address.

Network Adapters

Network Adapters



Network Adapters



Network Adapters

SFP

Network Adapters

Network Adapters

BiDi transceiver

Common transceiver

Network Adapters

BiDi optical transceiver

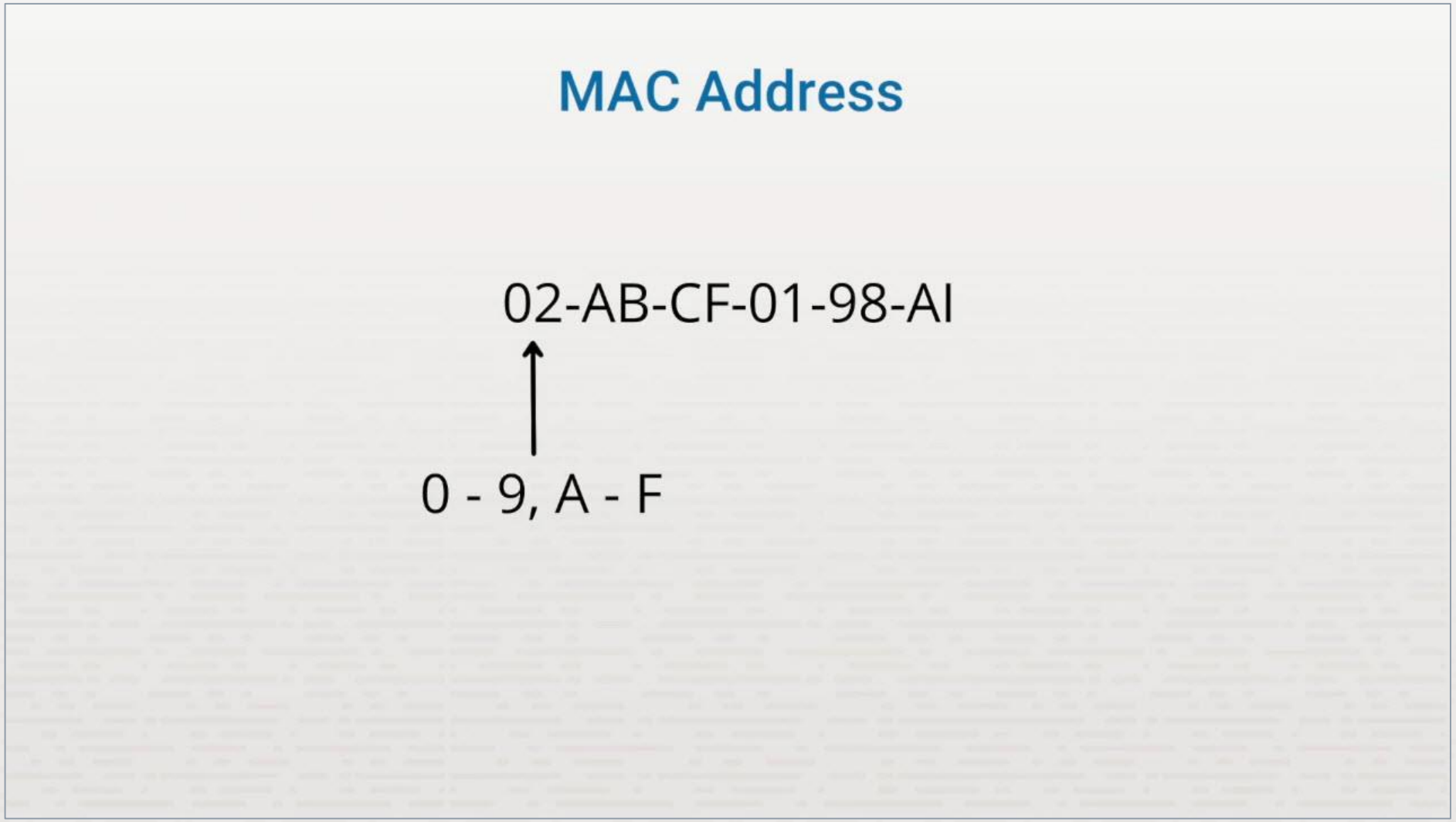
Common optical transceiver

Network Adapters

Media converter

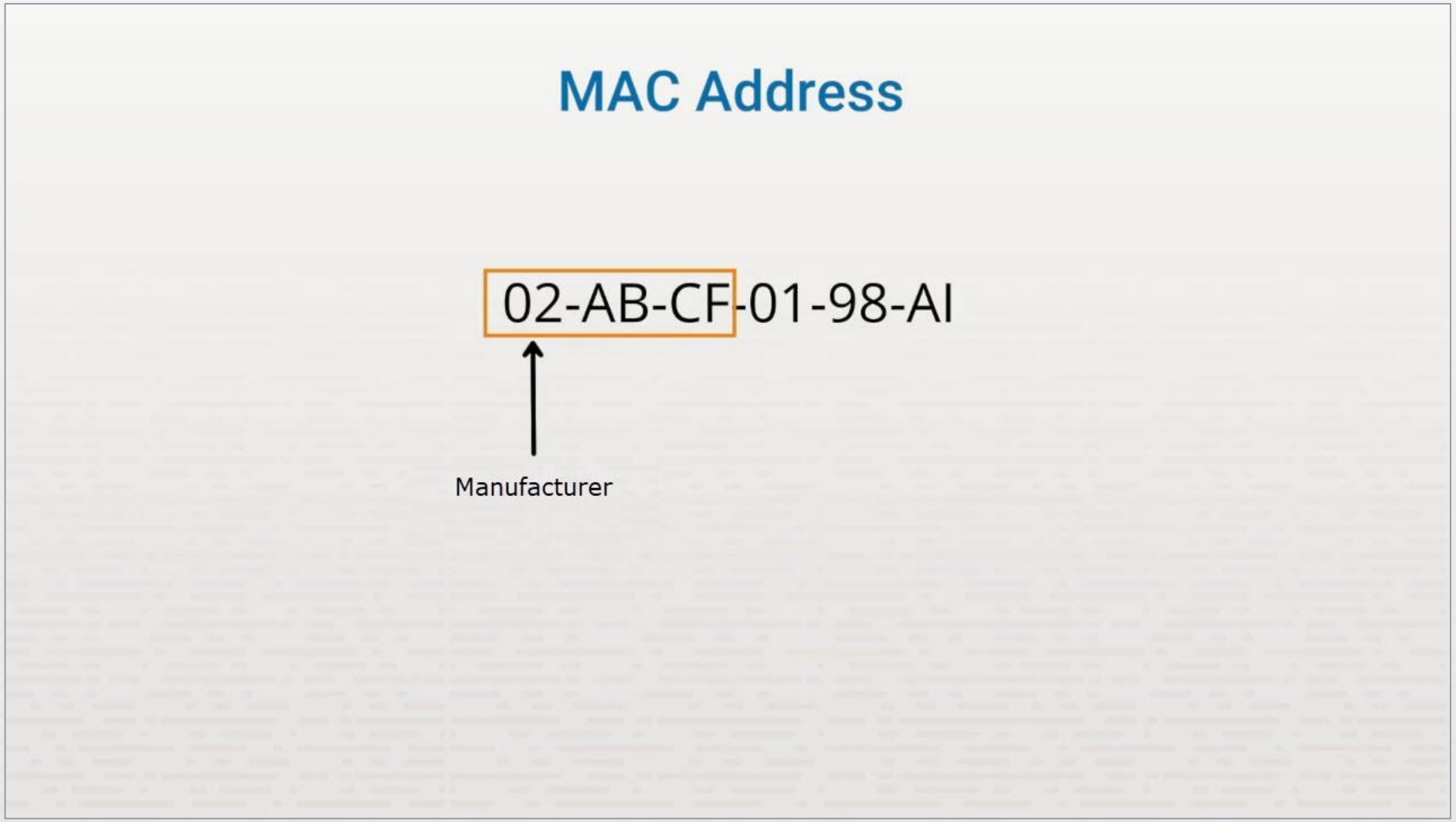
Network Adapters

Network Adapters

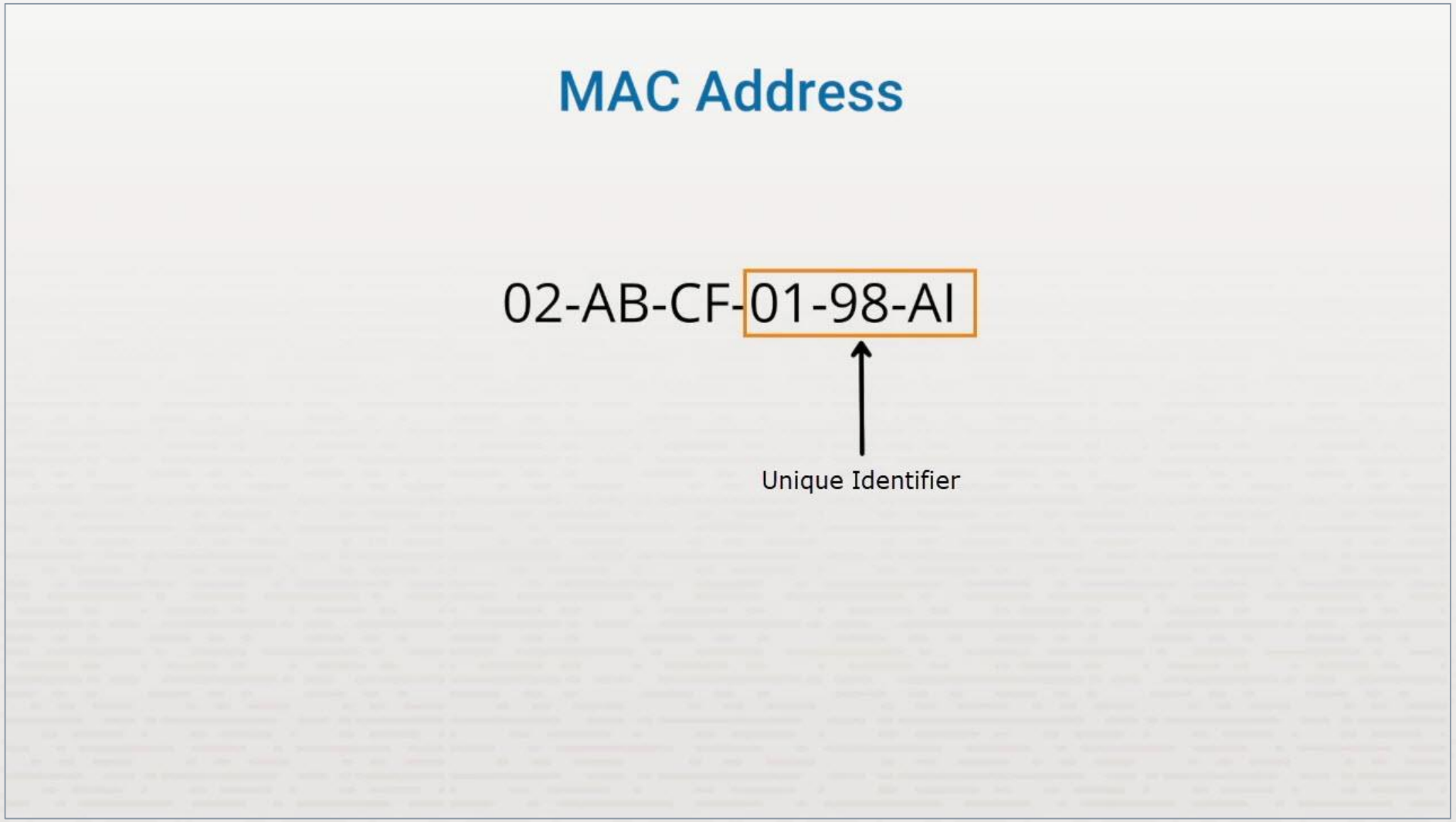


Network Adapters

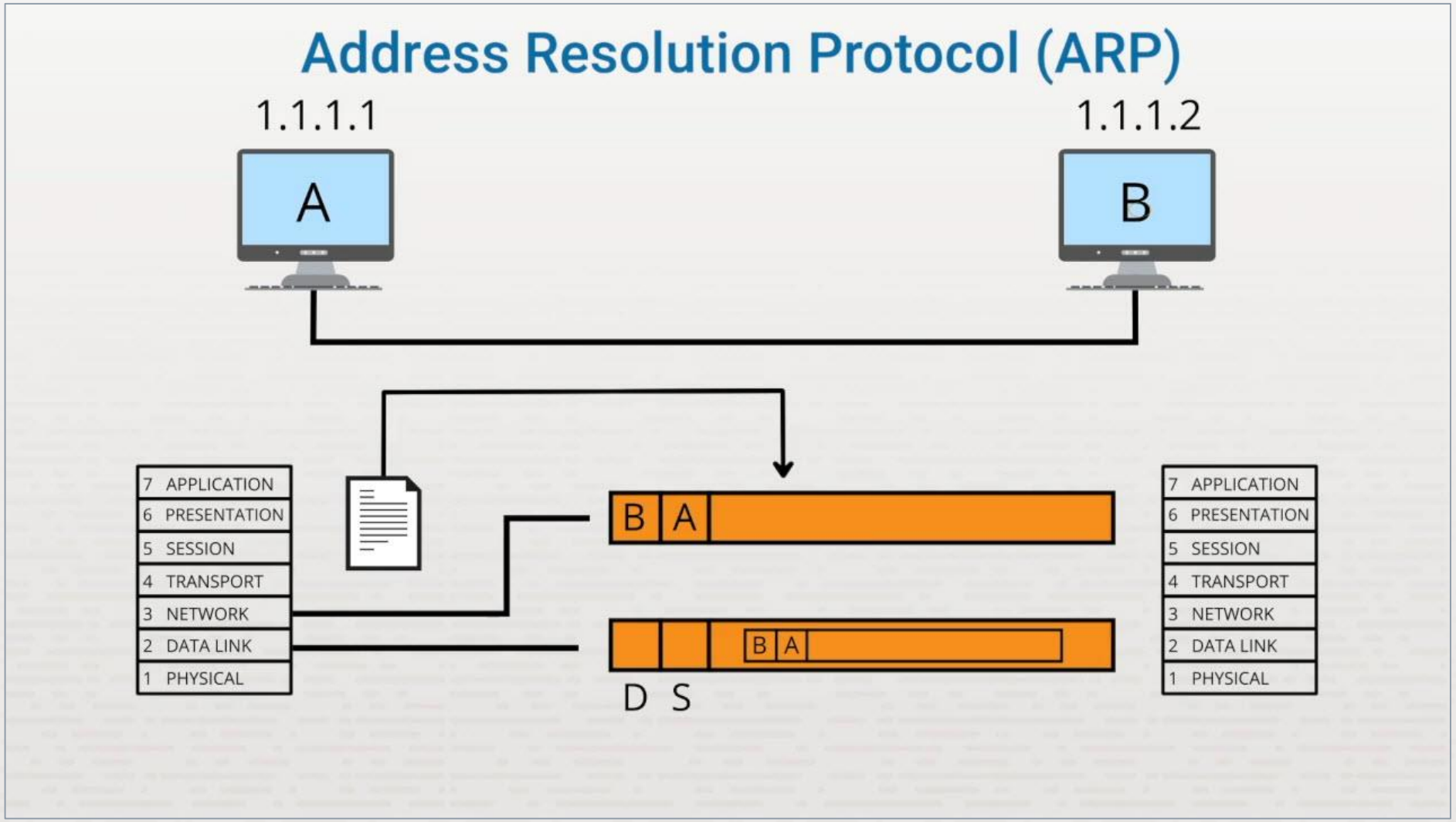
Network Adapters



Network Adapters



Network Adapters



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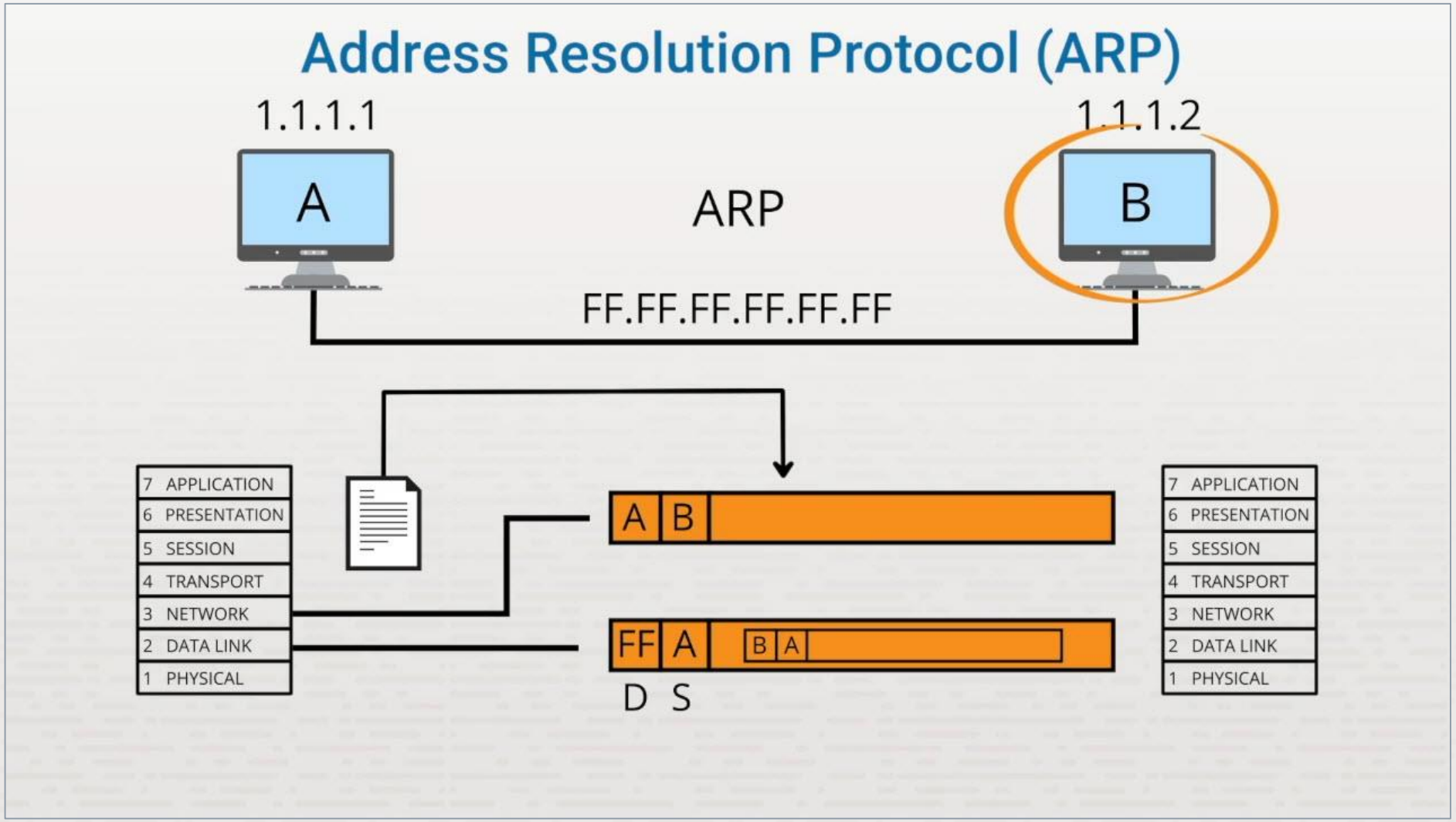
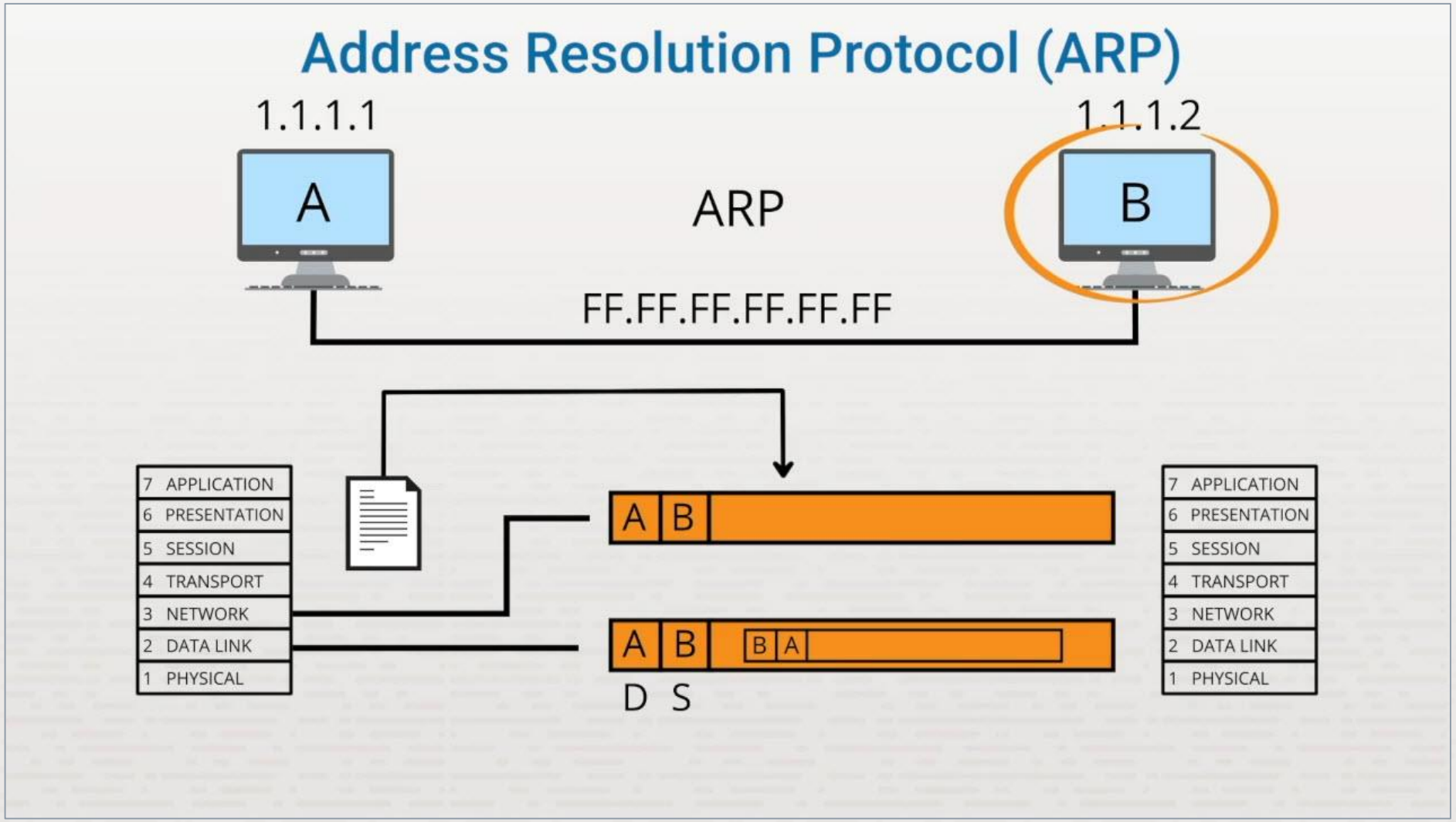
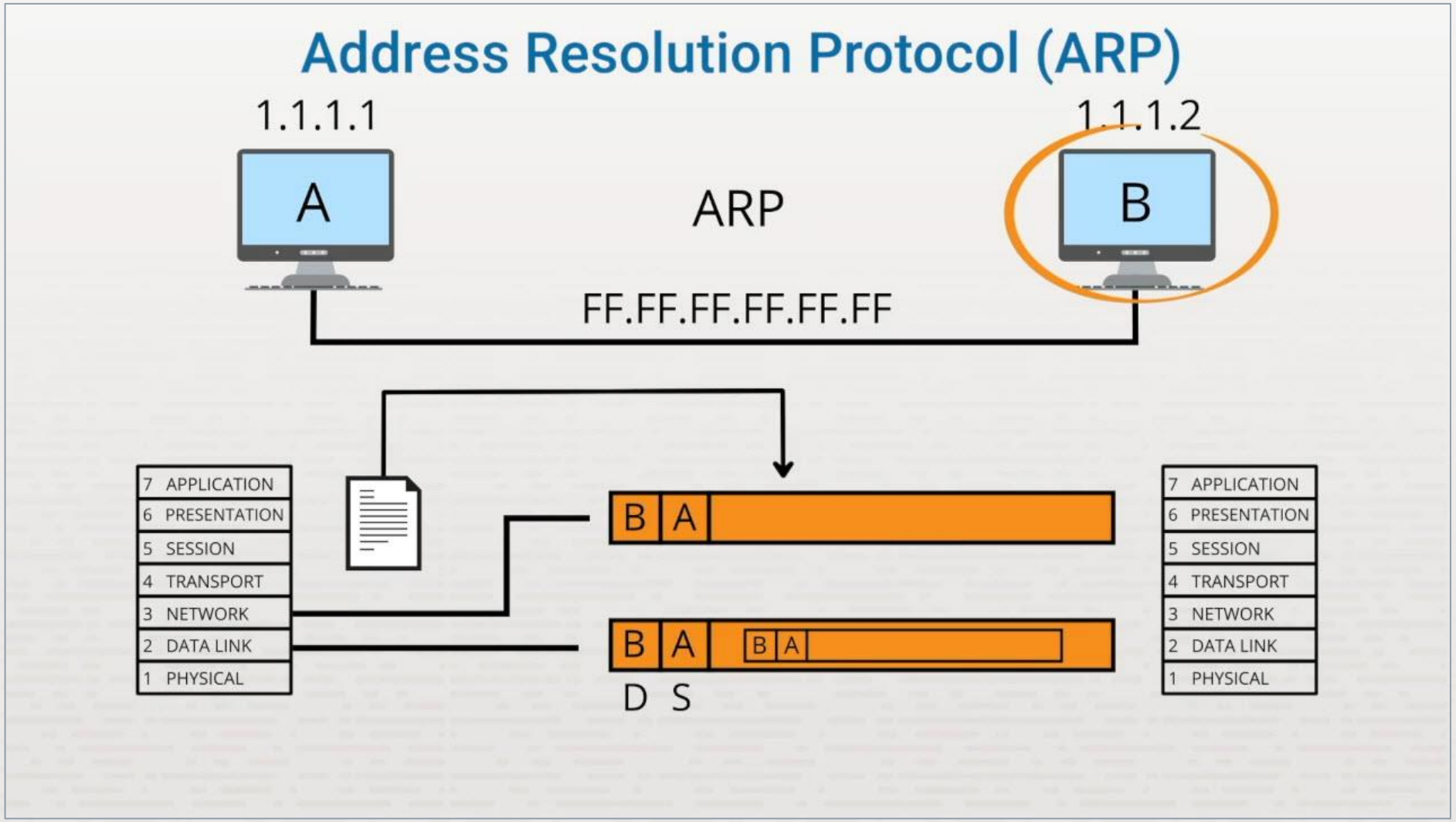


Network Adapters



Network Adapters



Summary

- Network adapters
- How data is transmitted
- Transceivers
- Media converters
- MAC addresses
- Address Resolution Protocol (ARP)

In-Class Practice

Do the following labs:

- 3.5.3 Select and Install a Network Adapter
- 3.5.4 Connect a Media Converter

Class Discussion

- What are two major differences between a modem and an Ethernet NIC?
- How can you identify a network card manufacturer from its MAC address?
- What is the function of a transceiver?
- What is the purpose of the CRC?
- At which OSI layer does a network adapter card operate? At which layer does a media converter work?
- Can you use a media converter to connect network segments that are using different architecture types? Why or why not?

Class Discussion

- How does a computer find the MAC address of another device on the same subnet?
- What does the MAC address FF-FF-FF-FF-FF-FF indicate?

3.6 NETWORK CABLING AND HARDWARE DEVICES

Networking Devices

TESTOUT NETWORK PRO

Section Skill Overview

- Install a switch
- Select a networking device
- Select a home router

Key Terms

- Hub
- Bridge
- Switch
- Router
- Wireless access point (AP)
- Firewall
- Layer 3 switch

Key Definitions

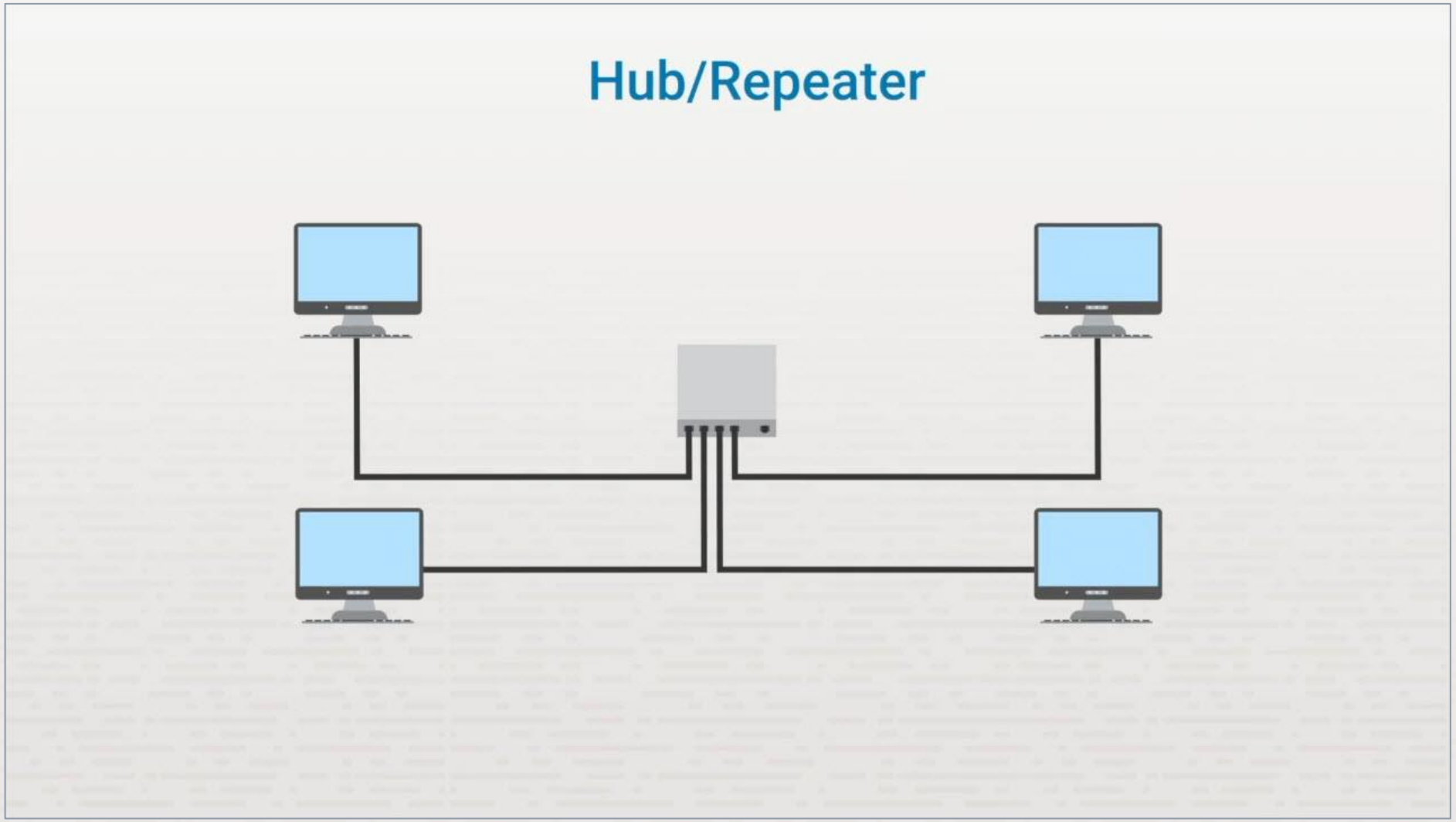
- **Hub:** The central connecting point of a physical star. It uses a logical bus topology.
- **Bridge:** A device that connects two (or more) media segments on the same subnet. It filters traffic between both segments based on the MAC address in the frame.
- **Switch:** A multi-port bridge that performs filtering based on MAC addresses and provides additional features not found in a bridge.
- **Router:** A device that connects two or more network segments or subnets.

Key Definitions

- **Wireless access point (AP):** A hub for a wireless network. As with a hub, any message sent to any wireless host connected to the AP can be received by all other wireless hosts.
- **Firewall:** A network security system that monitors and controls incoming and outgoing network traffic based on predetermined security rules.
- **Layer 3 switch:** A switch that is capable of reading Layer 3 (network) addresses and routing packets between subnets.

Networking Devices

Networking Devices



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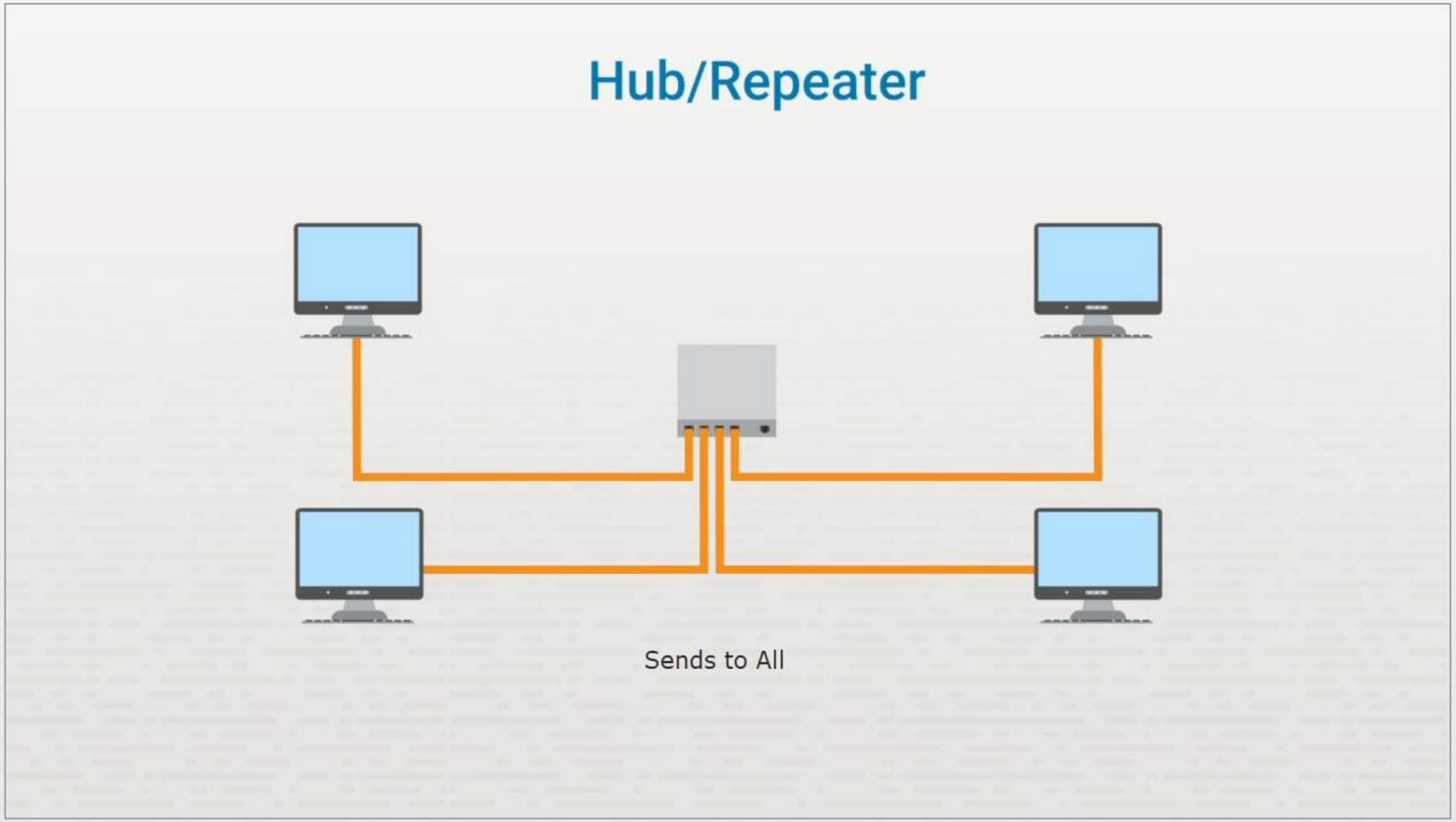

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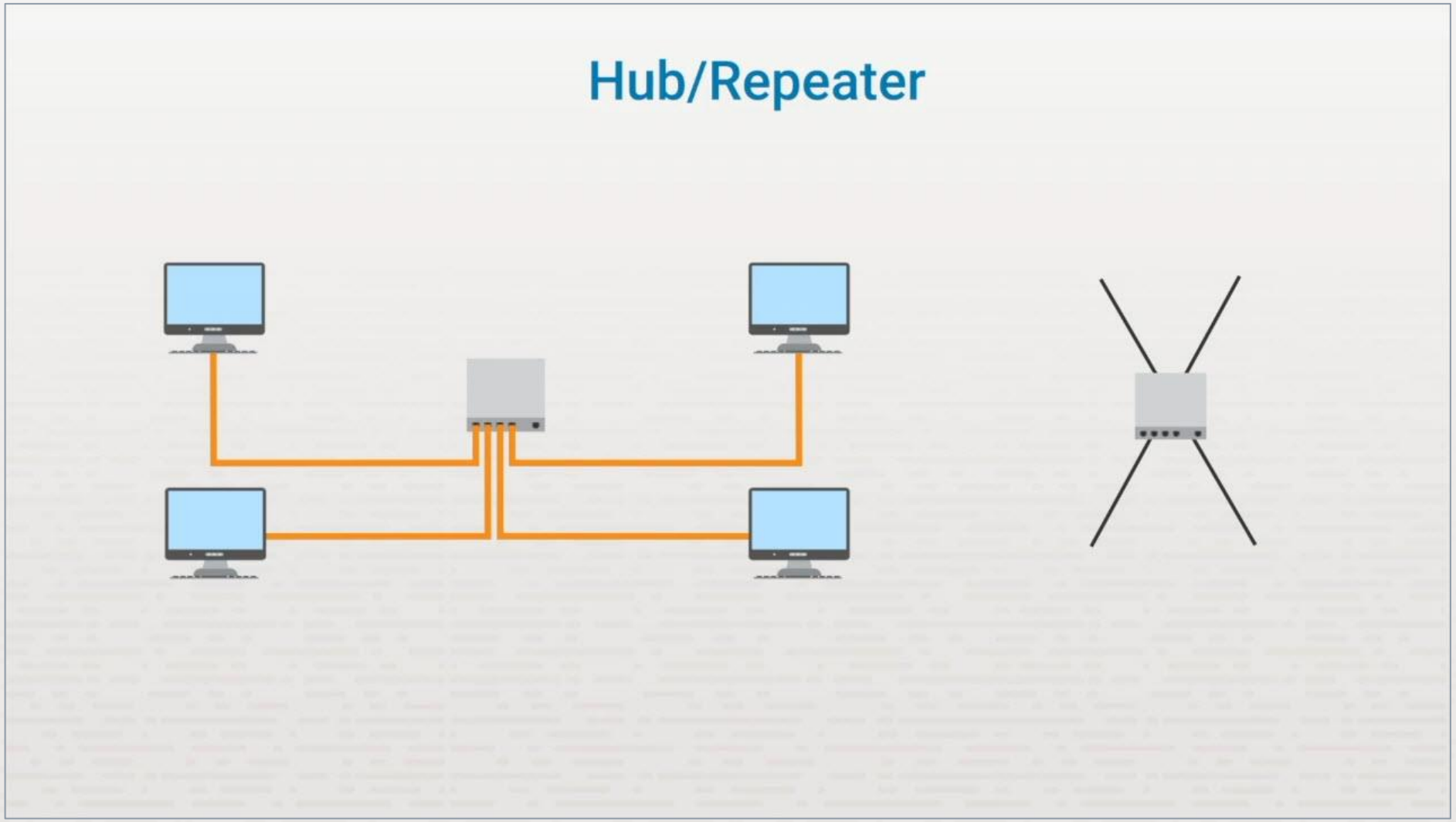

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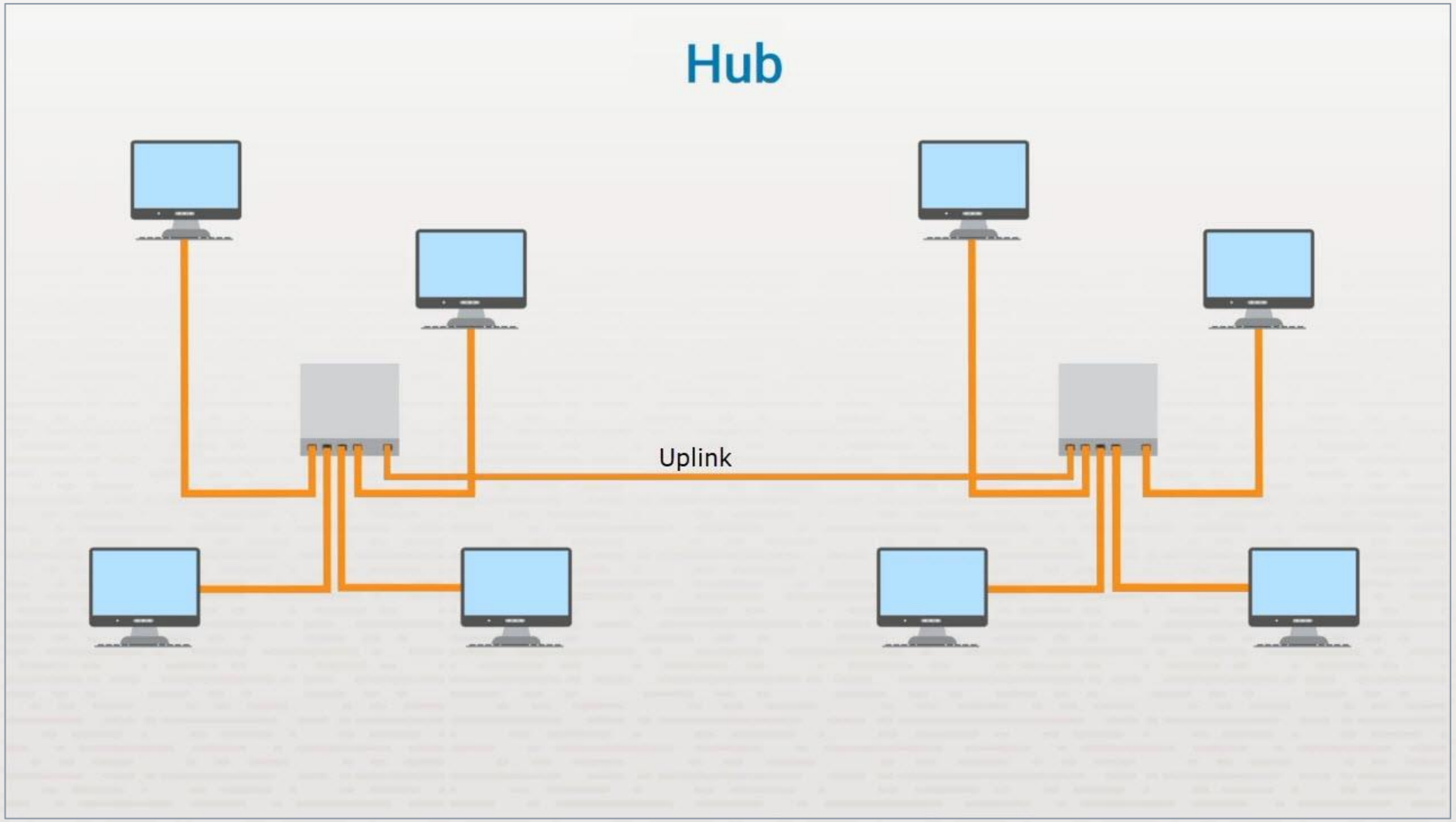

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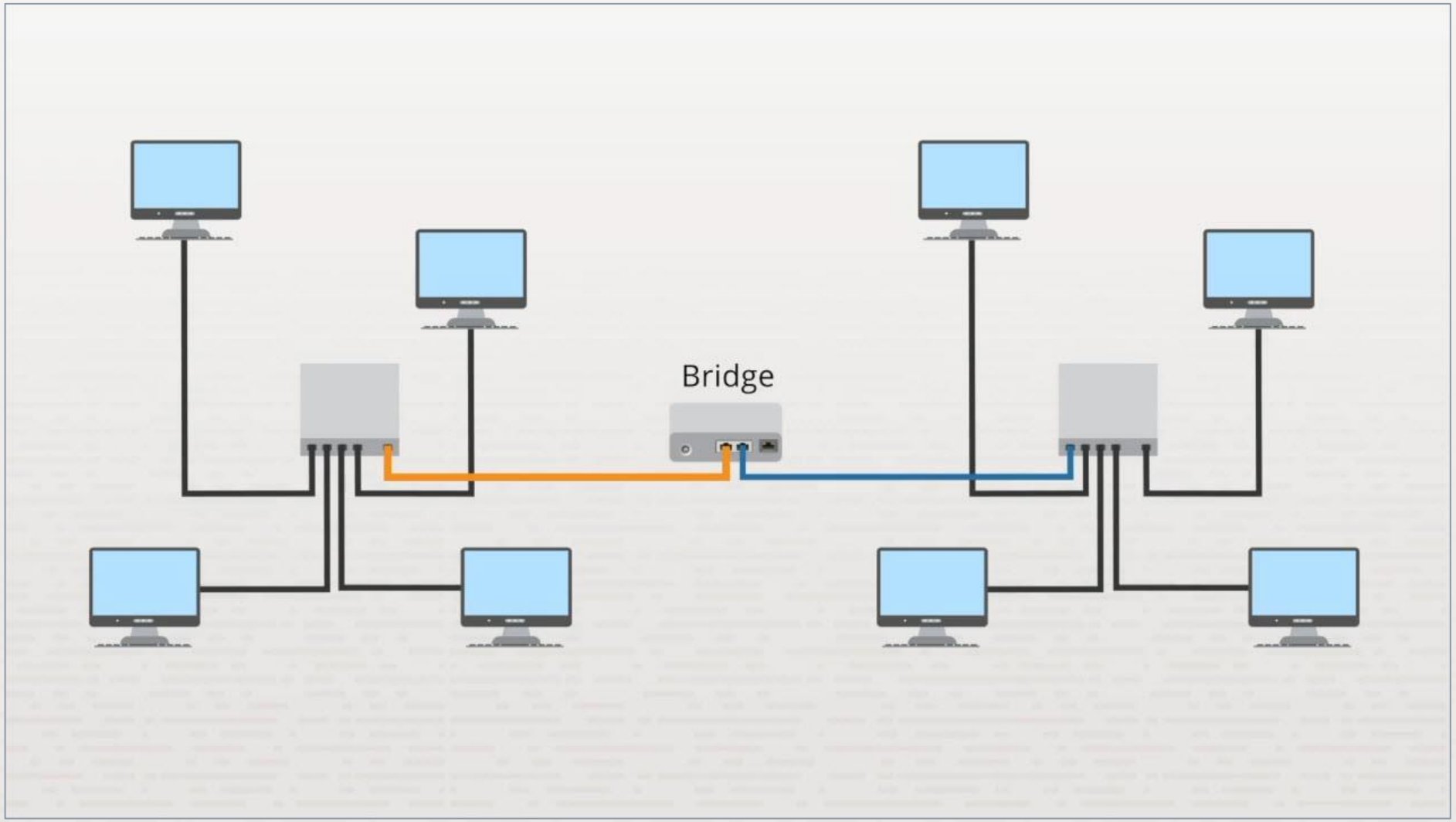

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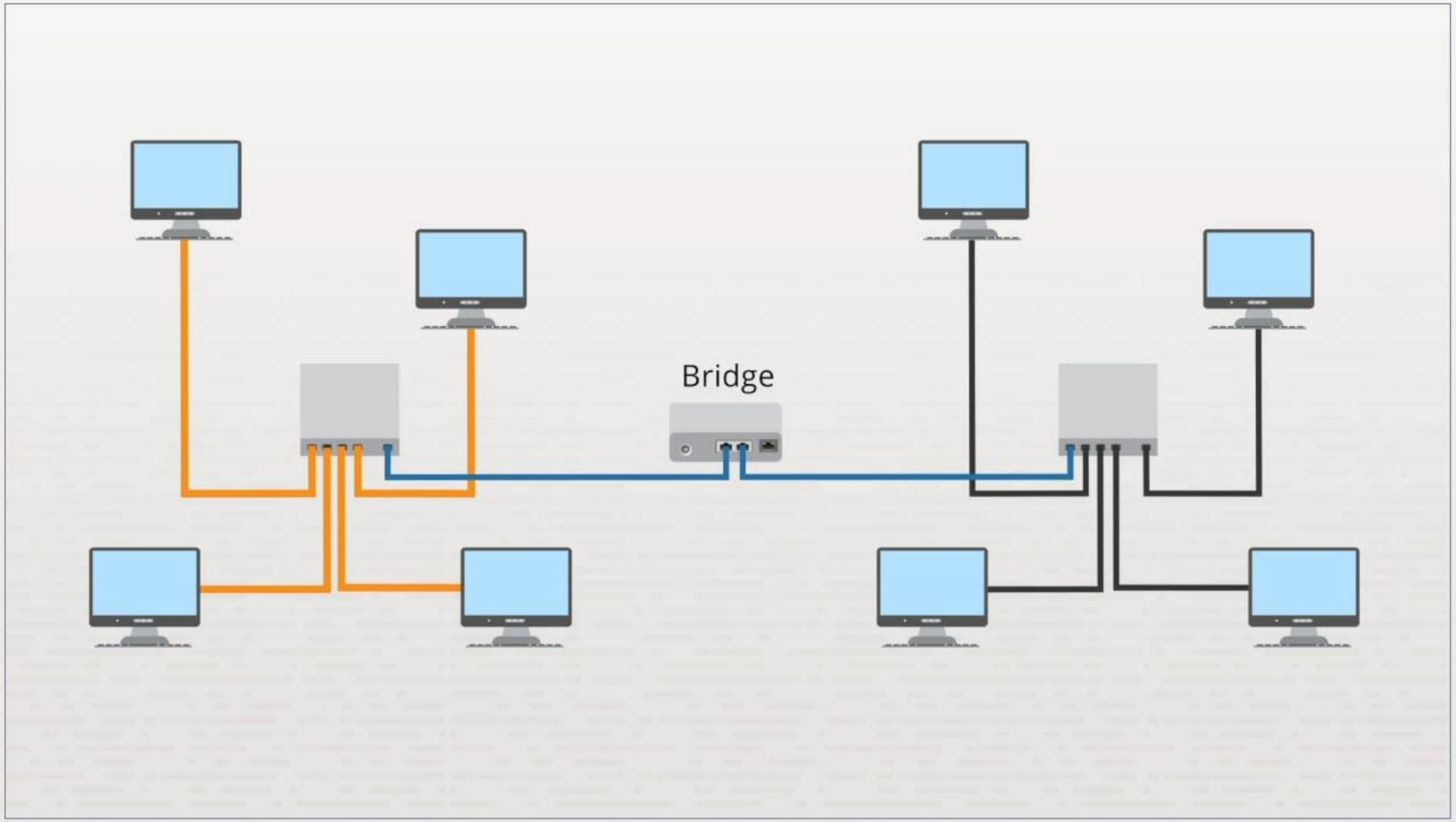

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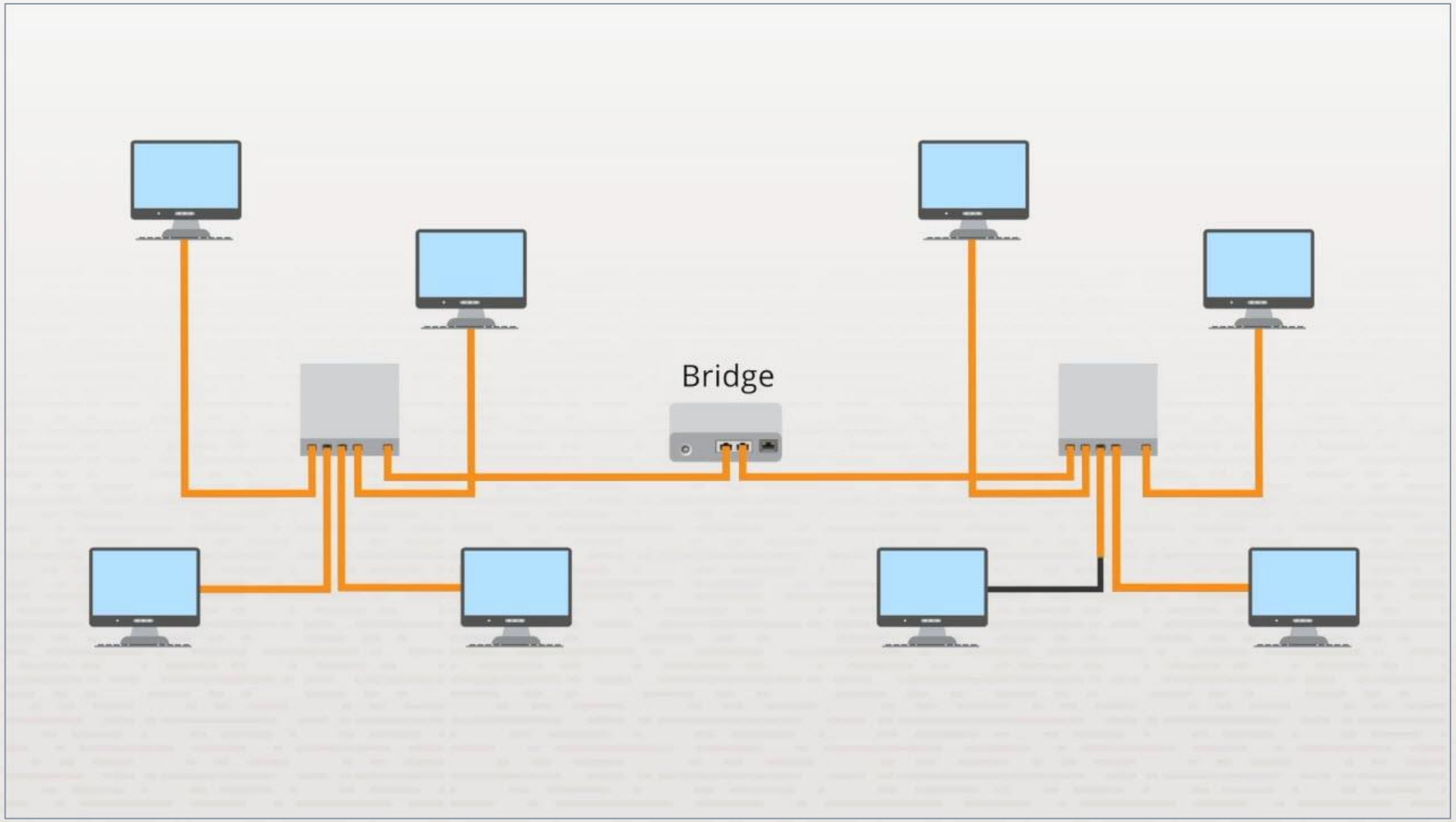

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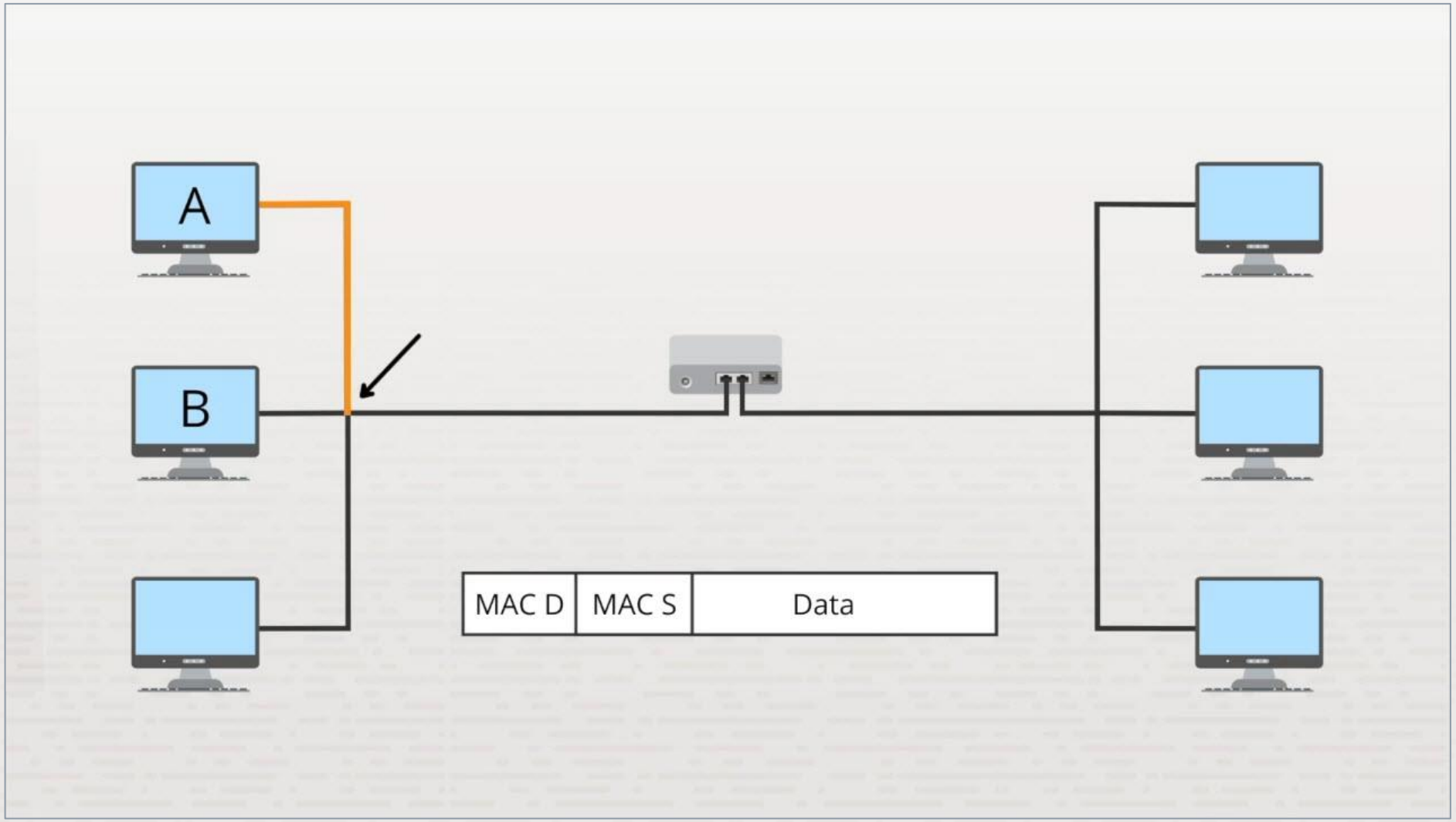

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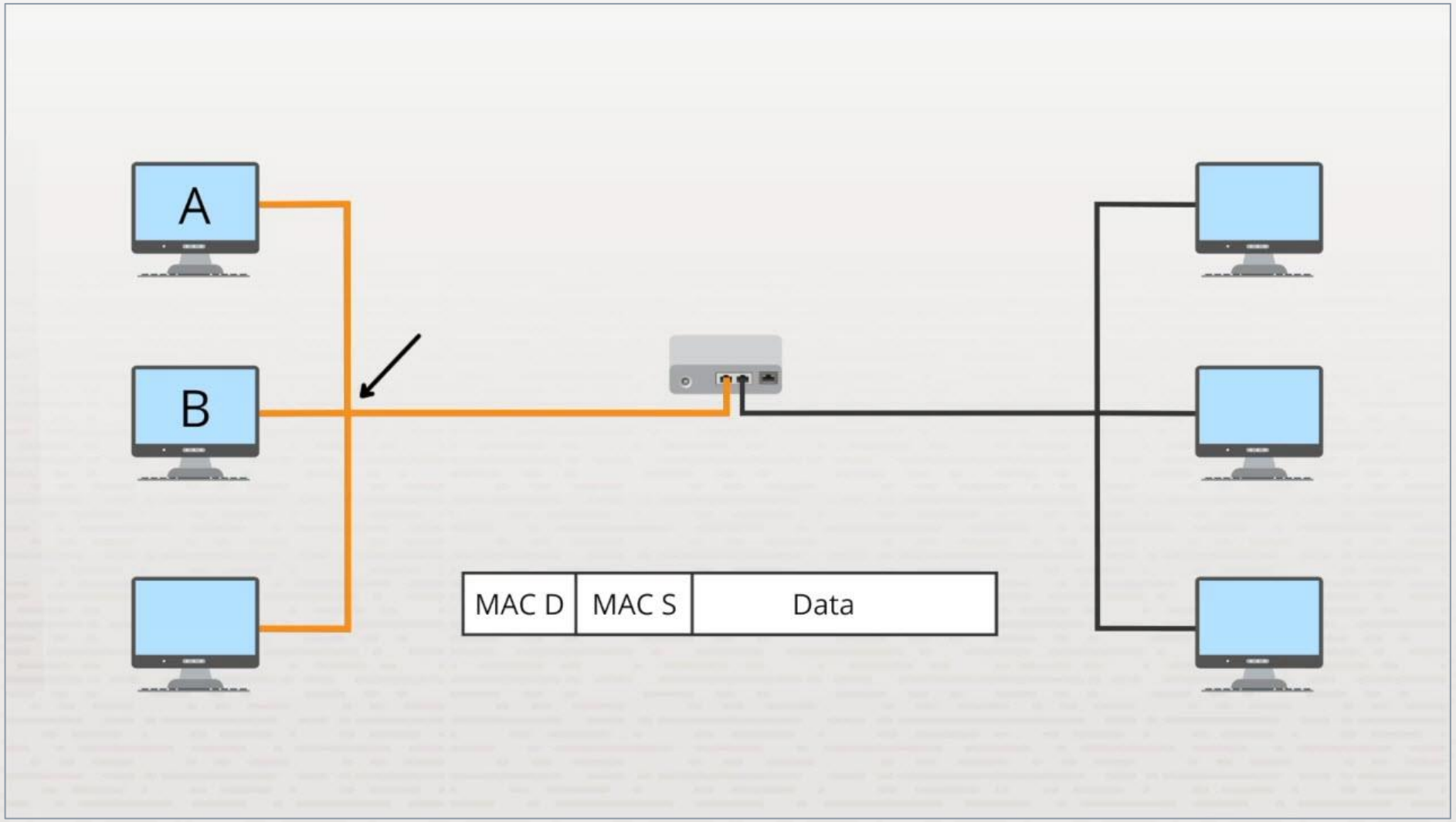

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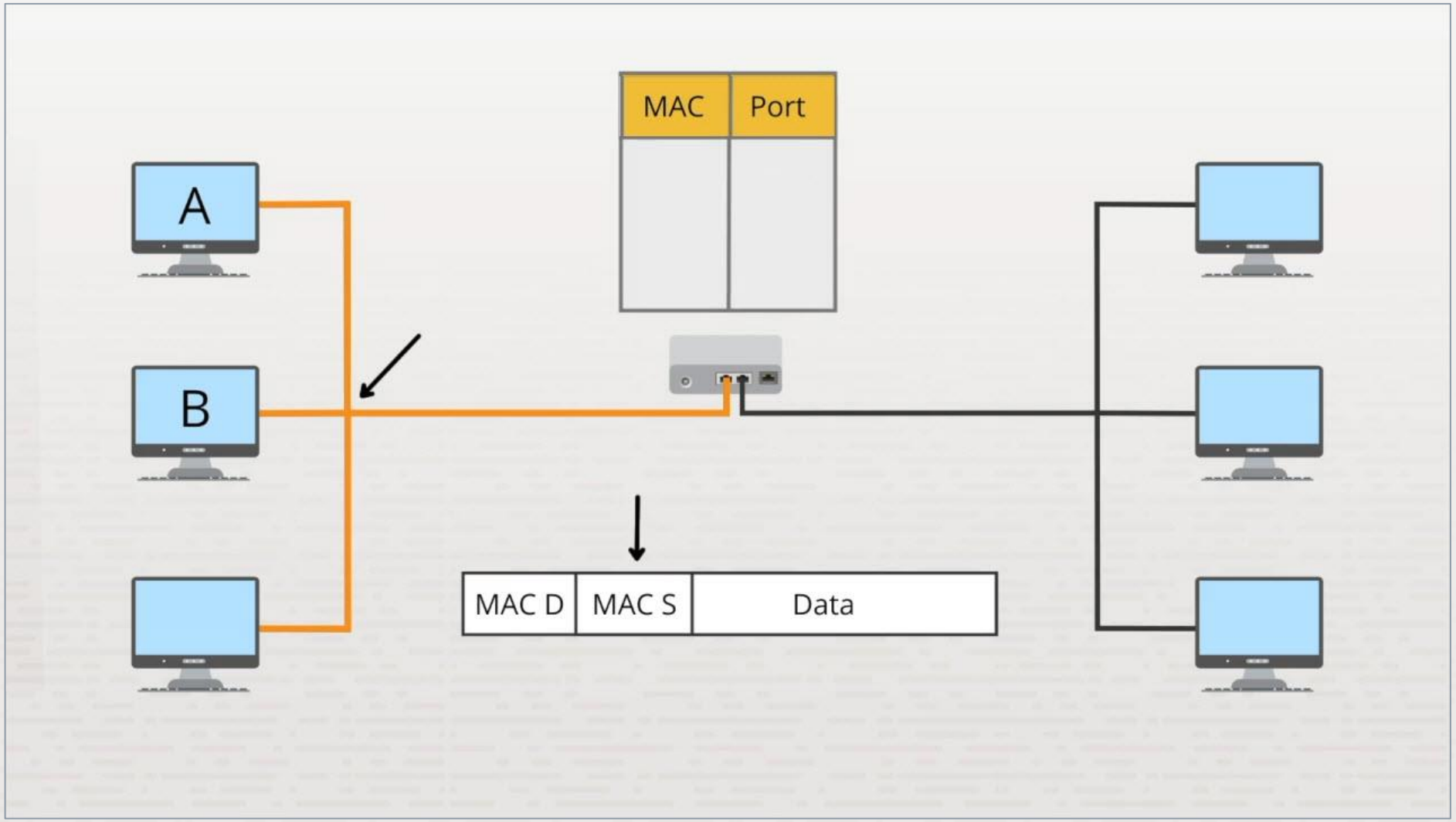

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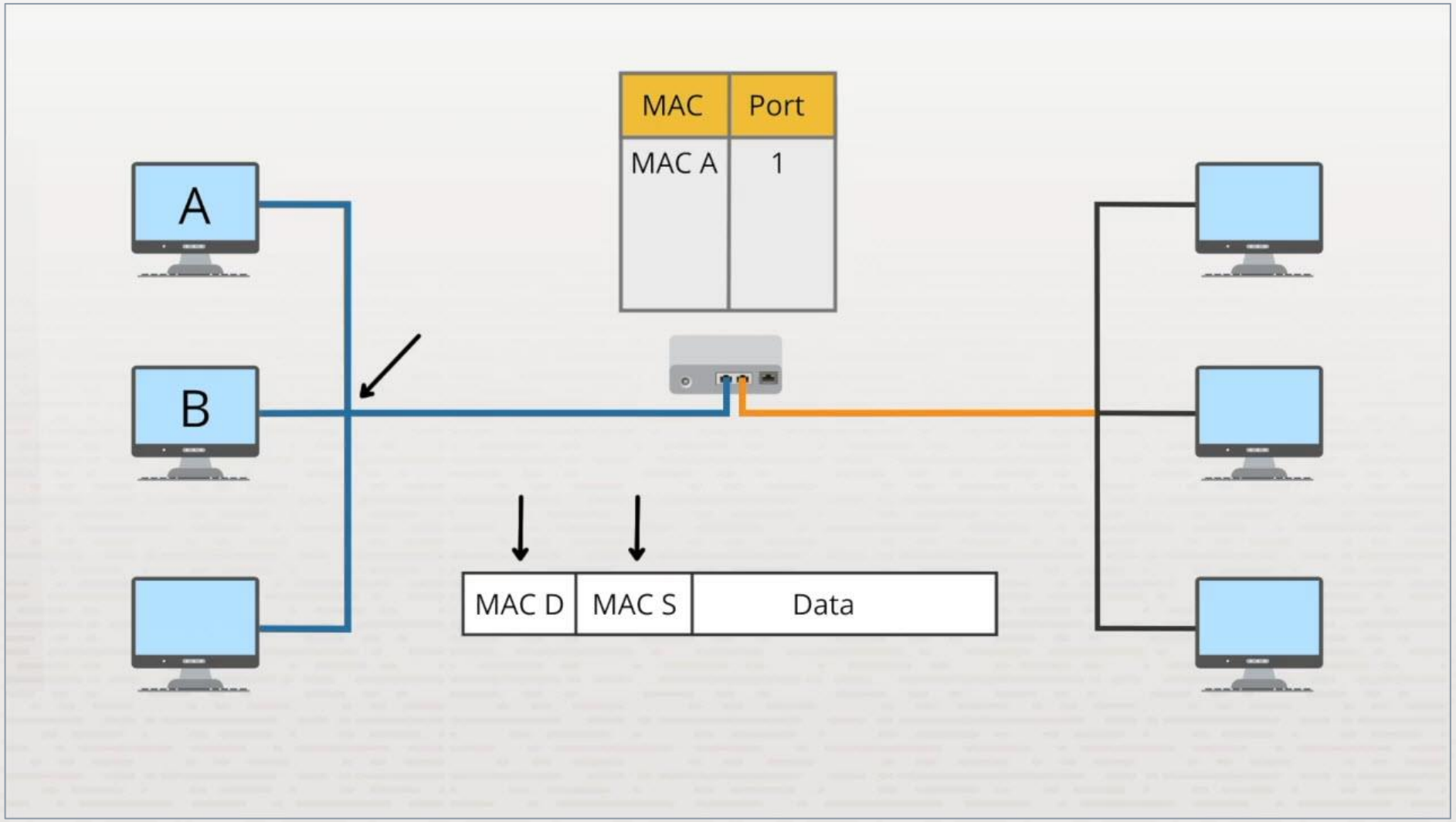

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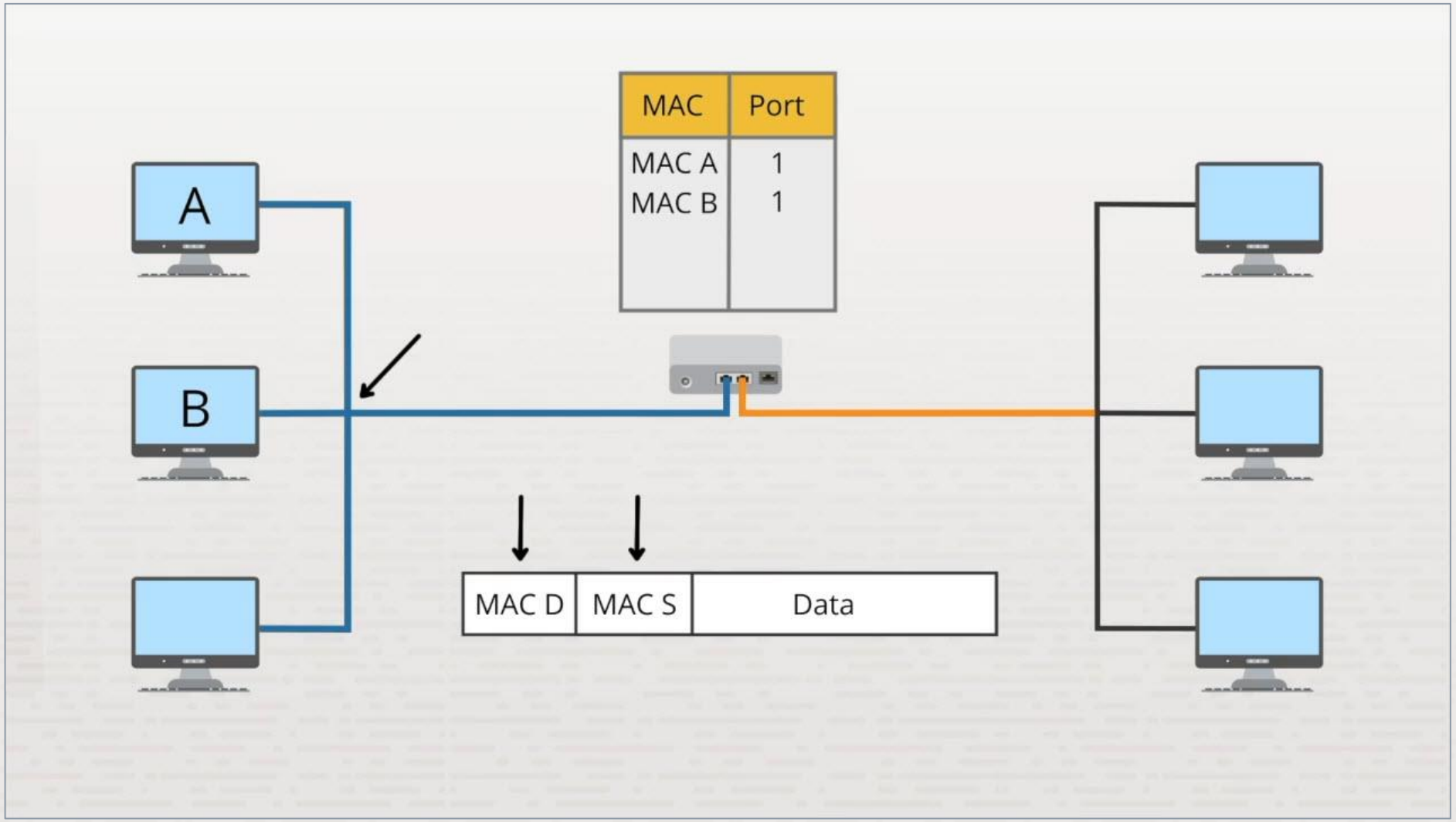

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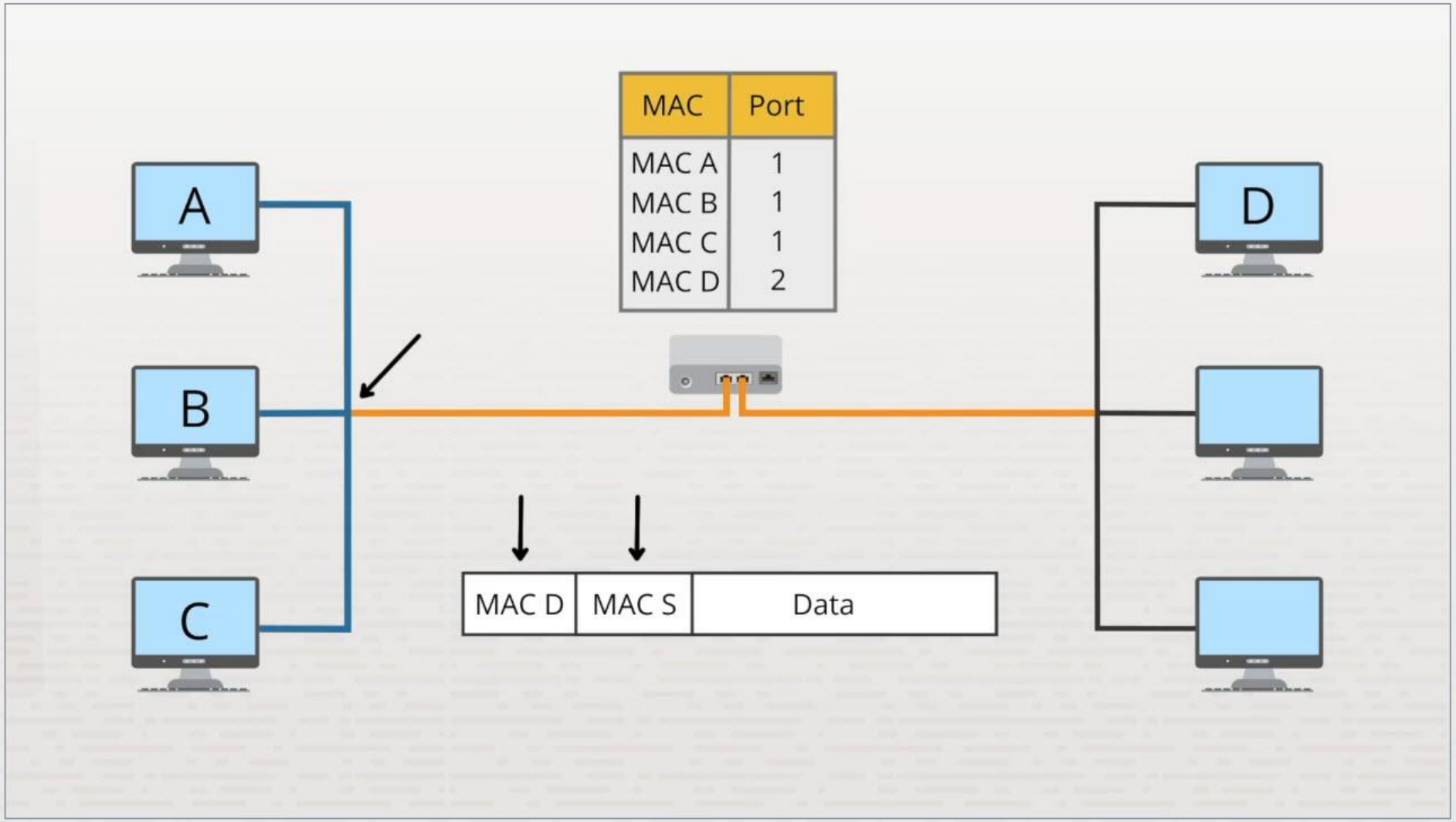

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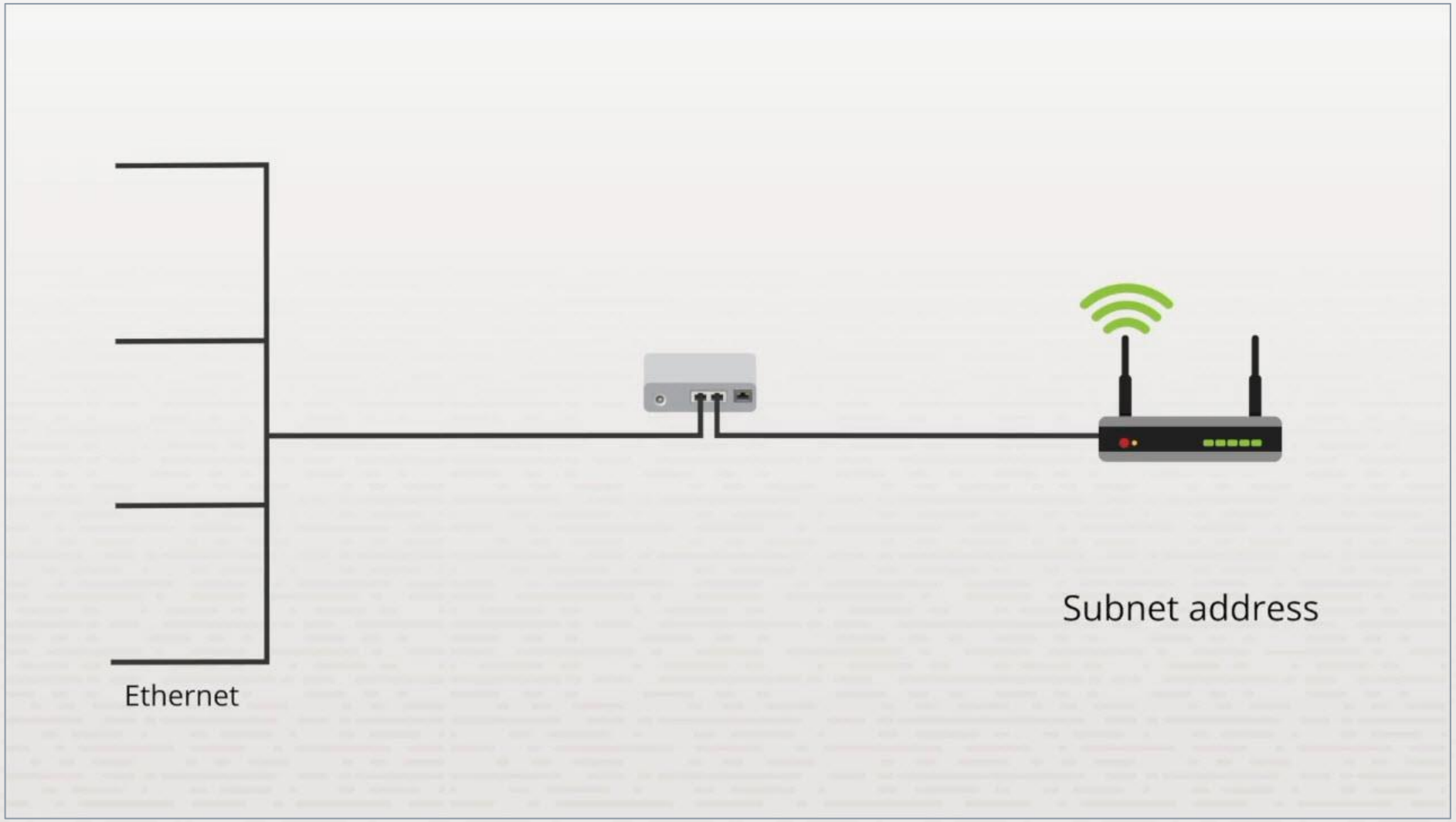

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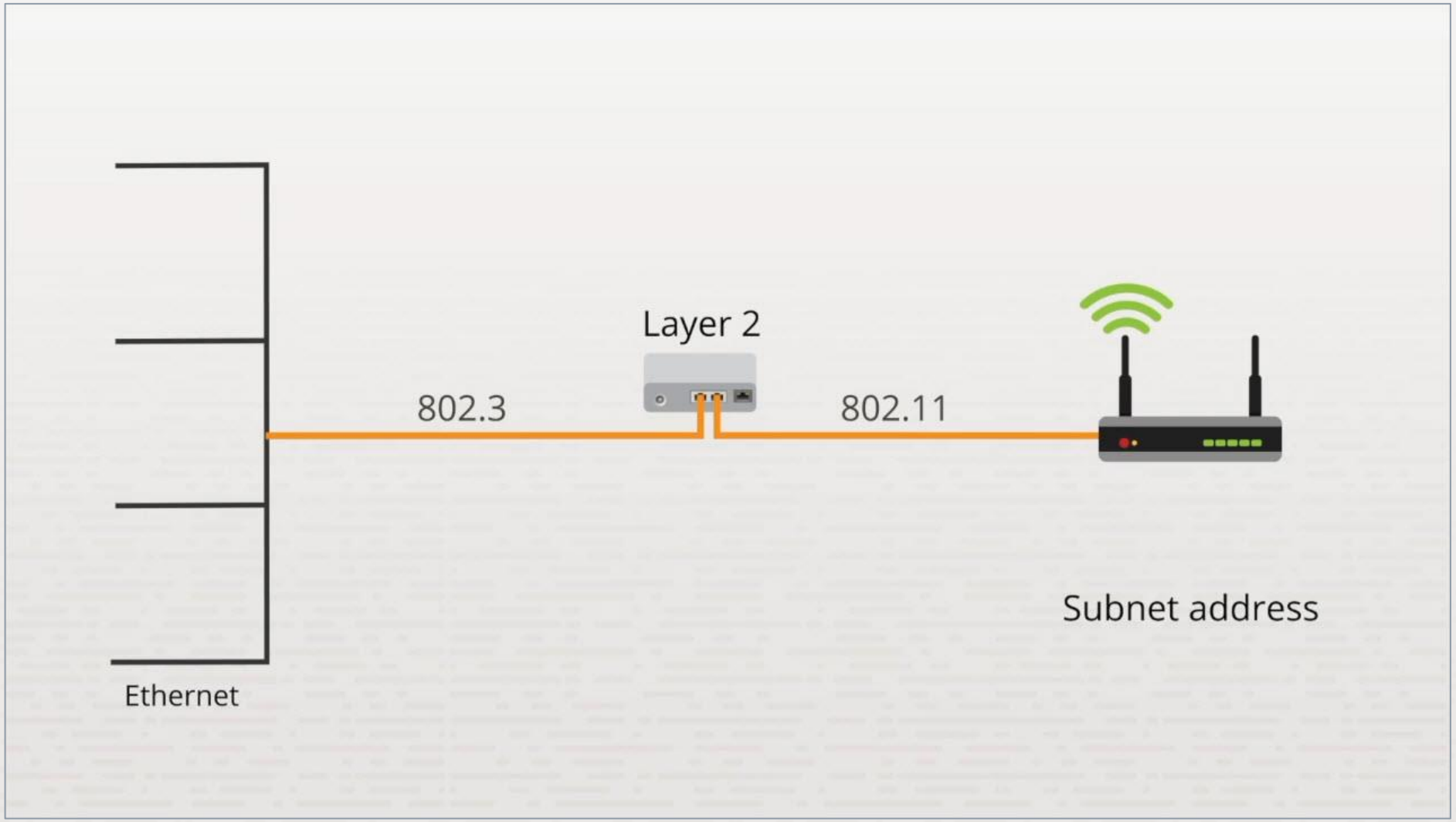
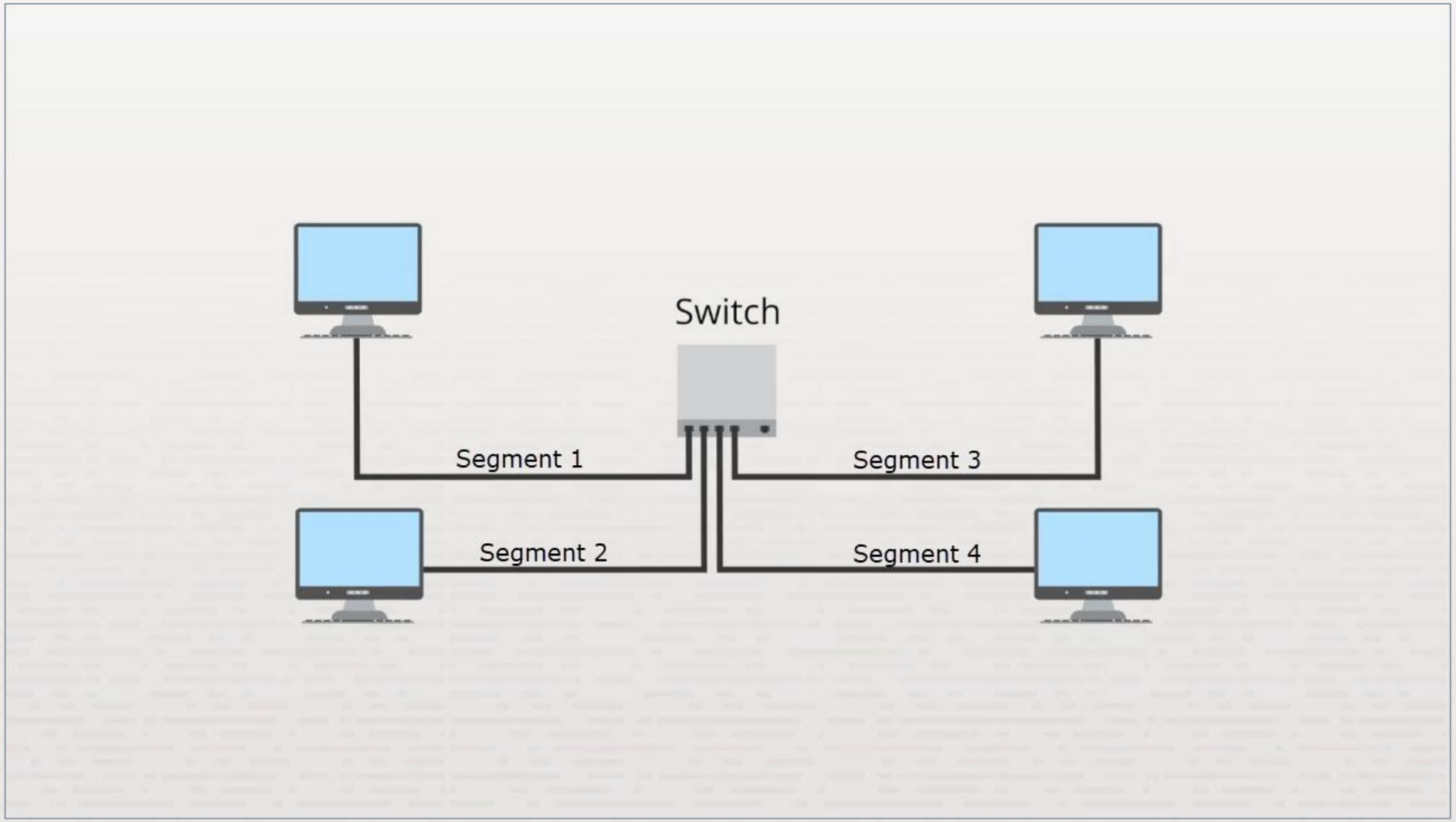


Networking Devices



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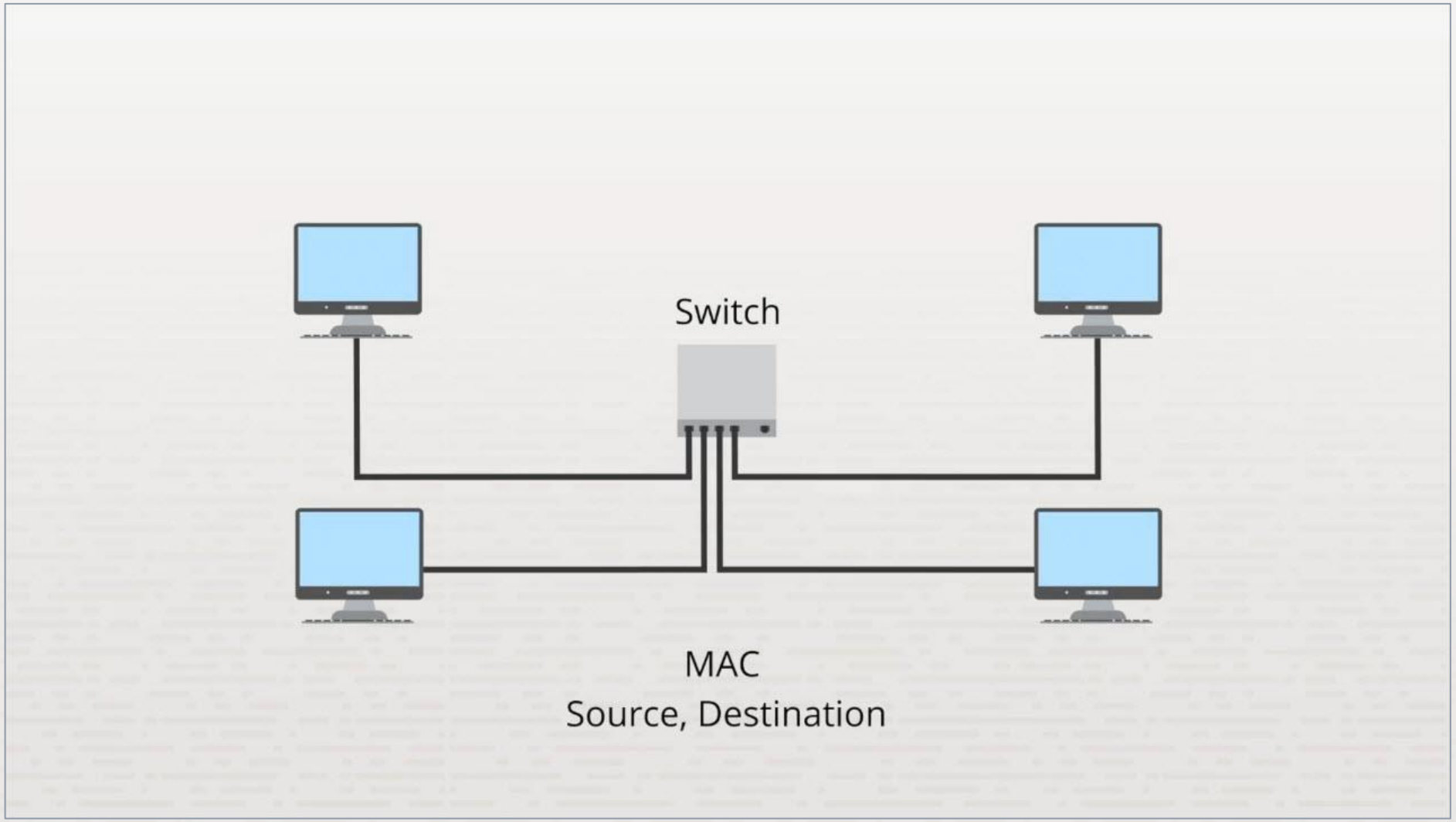

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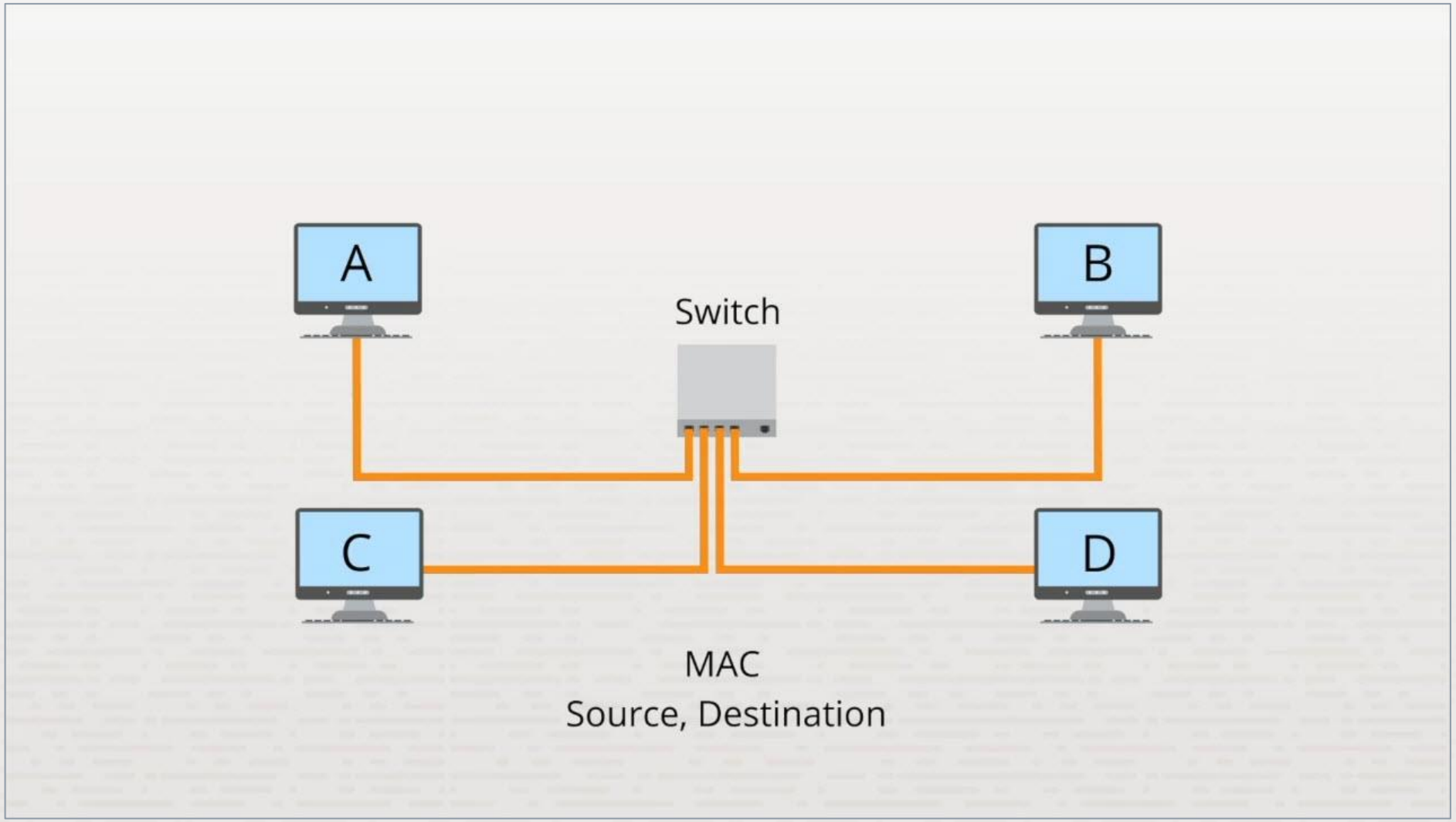

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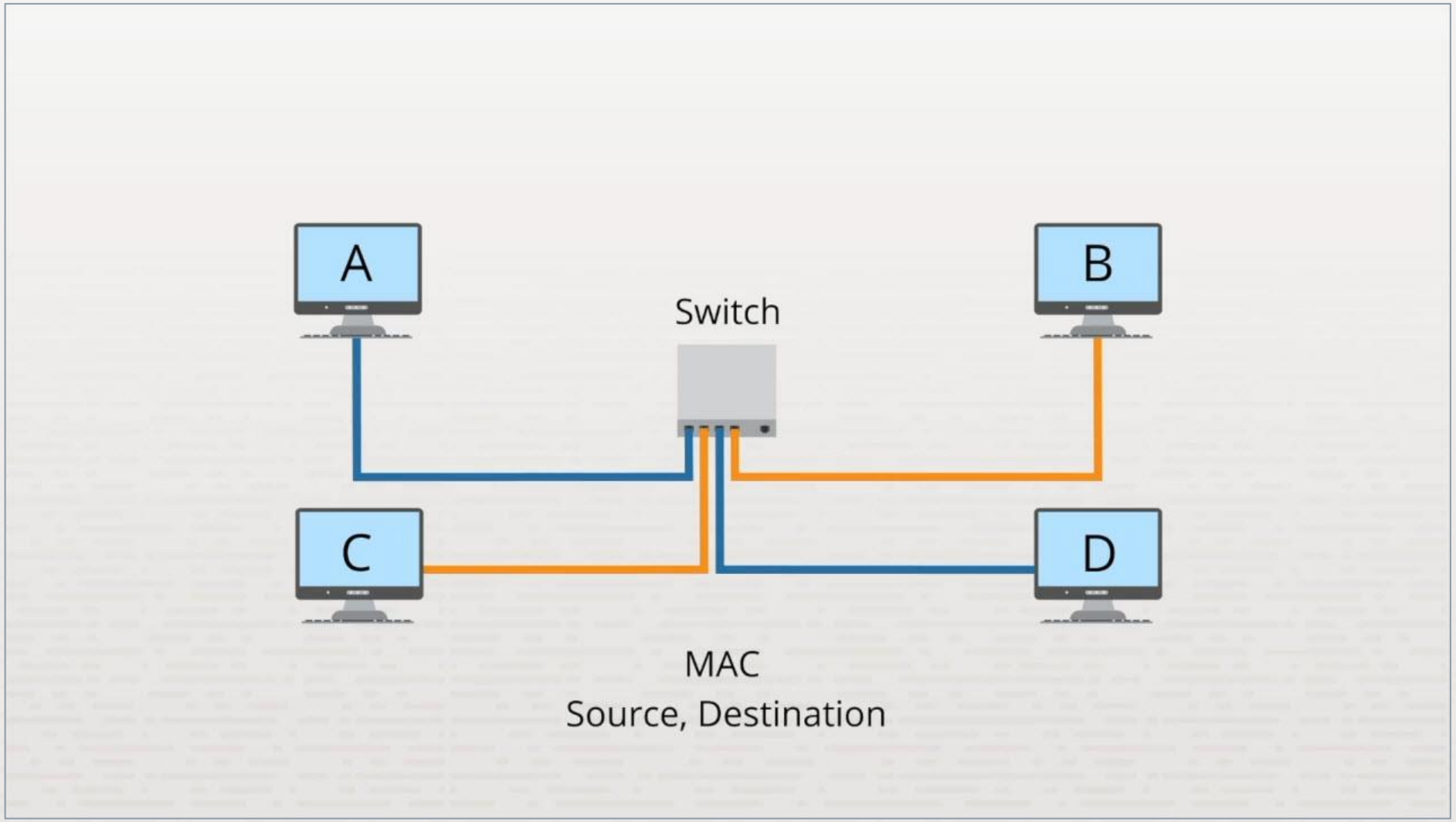

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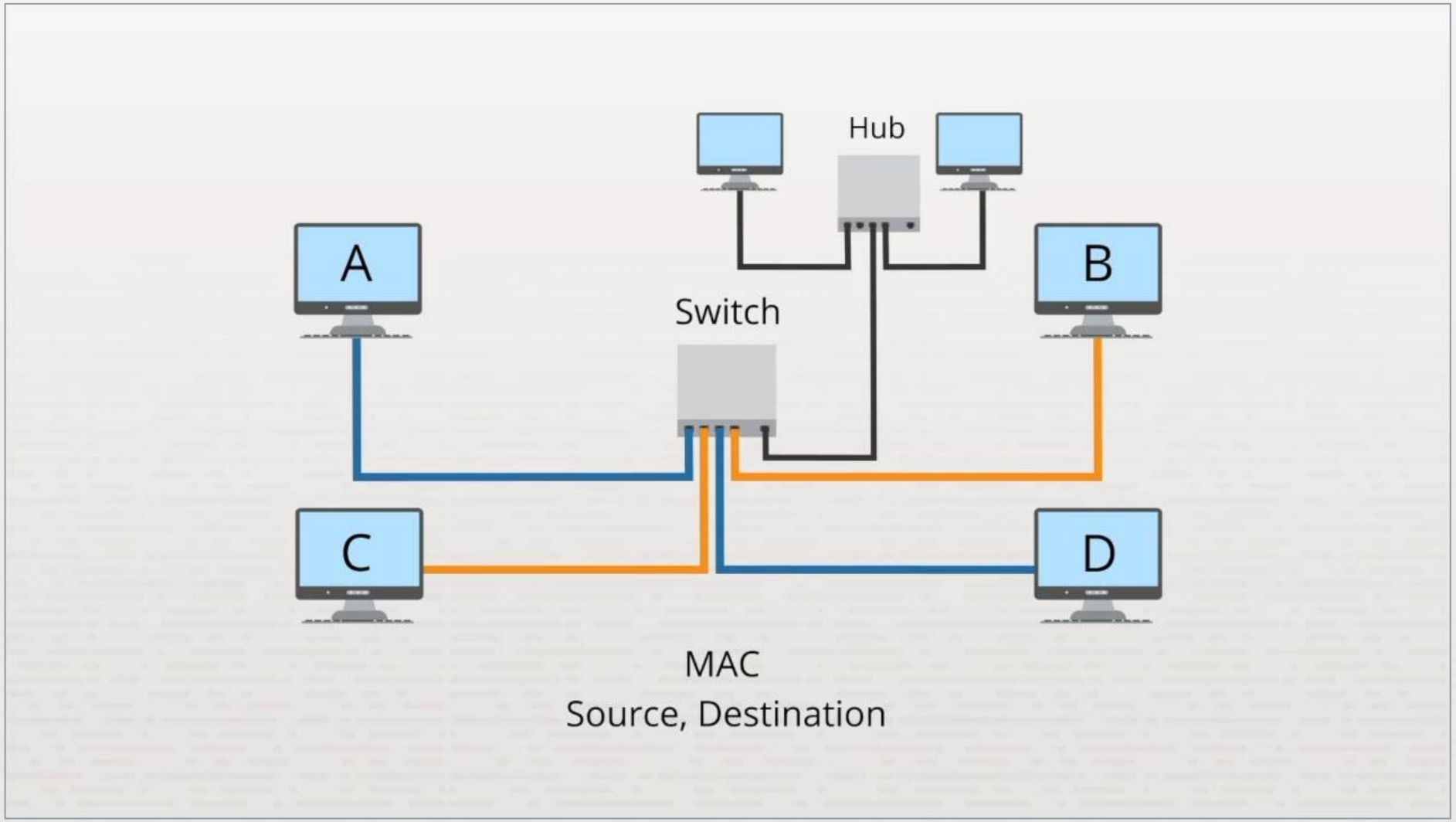
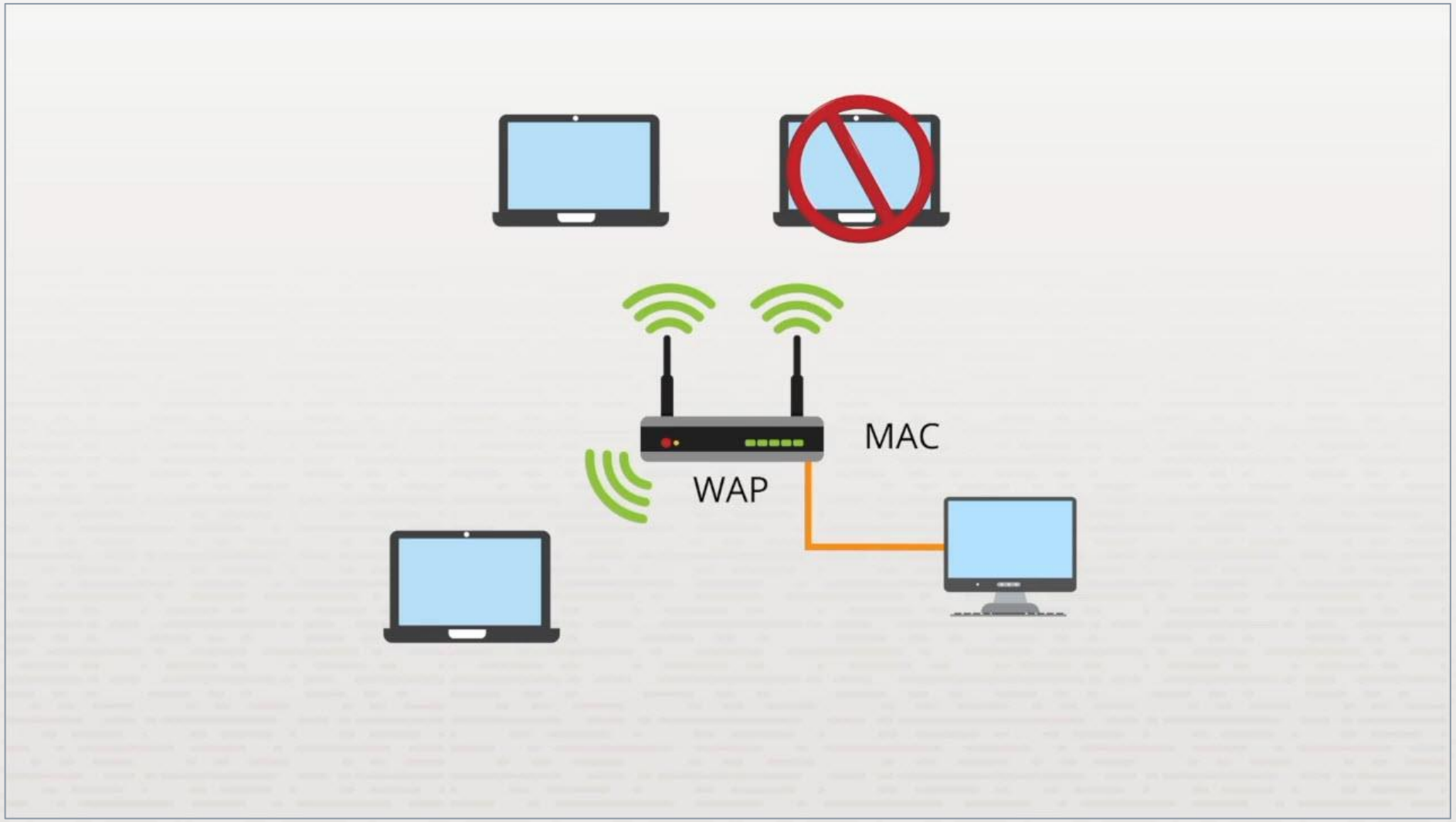


Networking Devices

Networking Devices

Networking Devices



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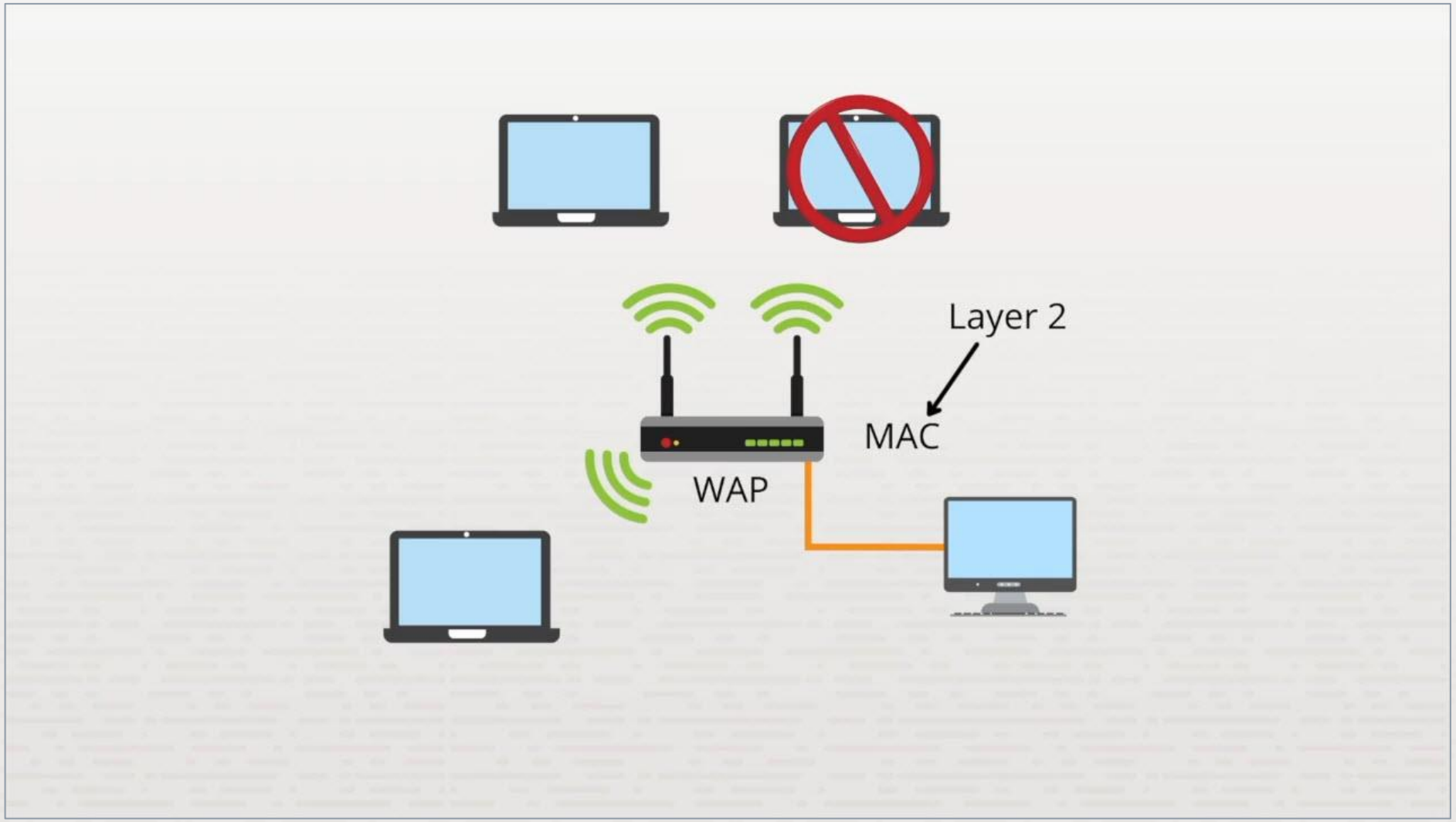

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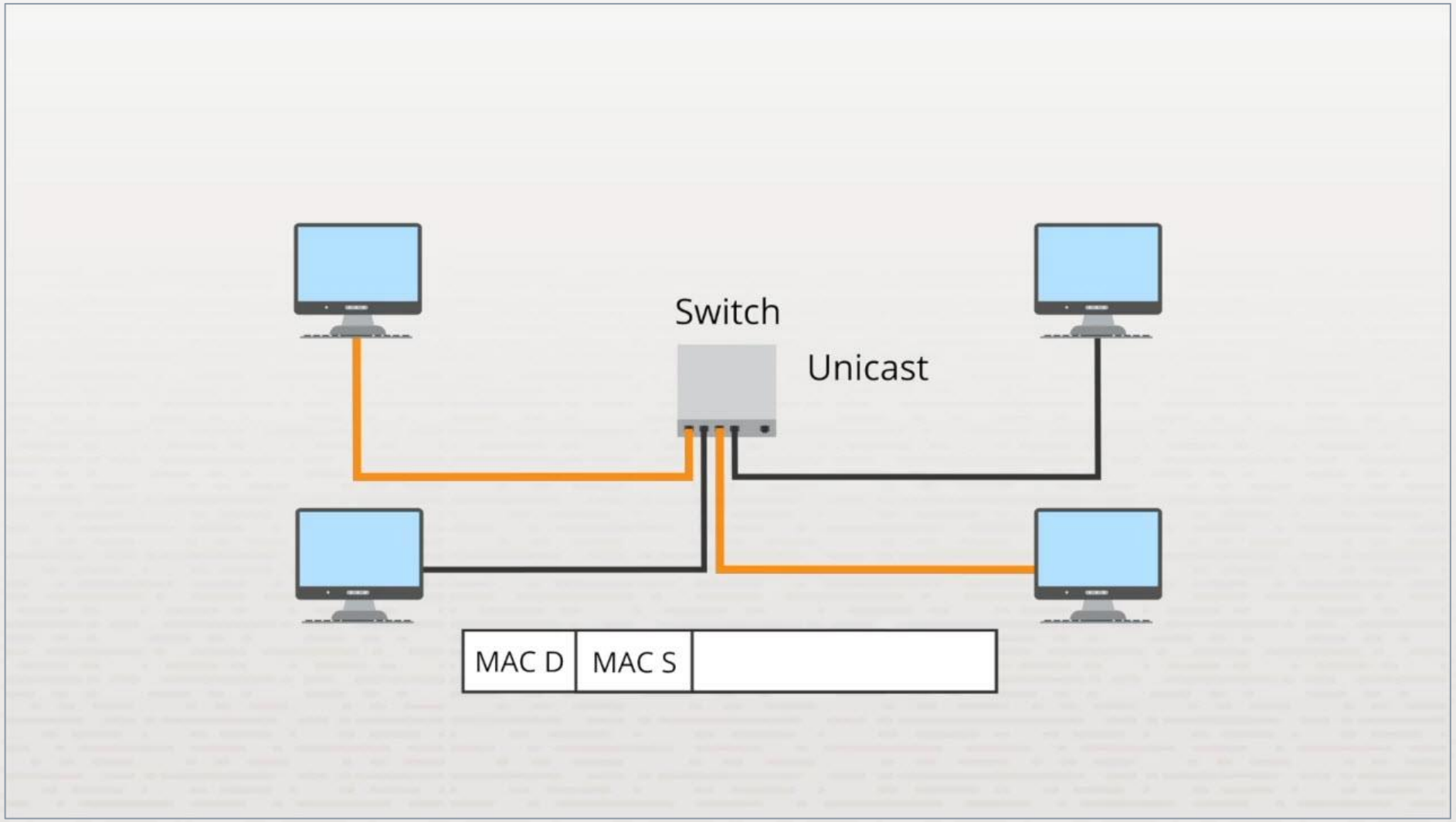

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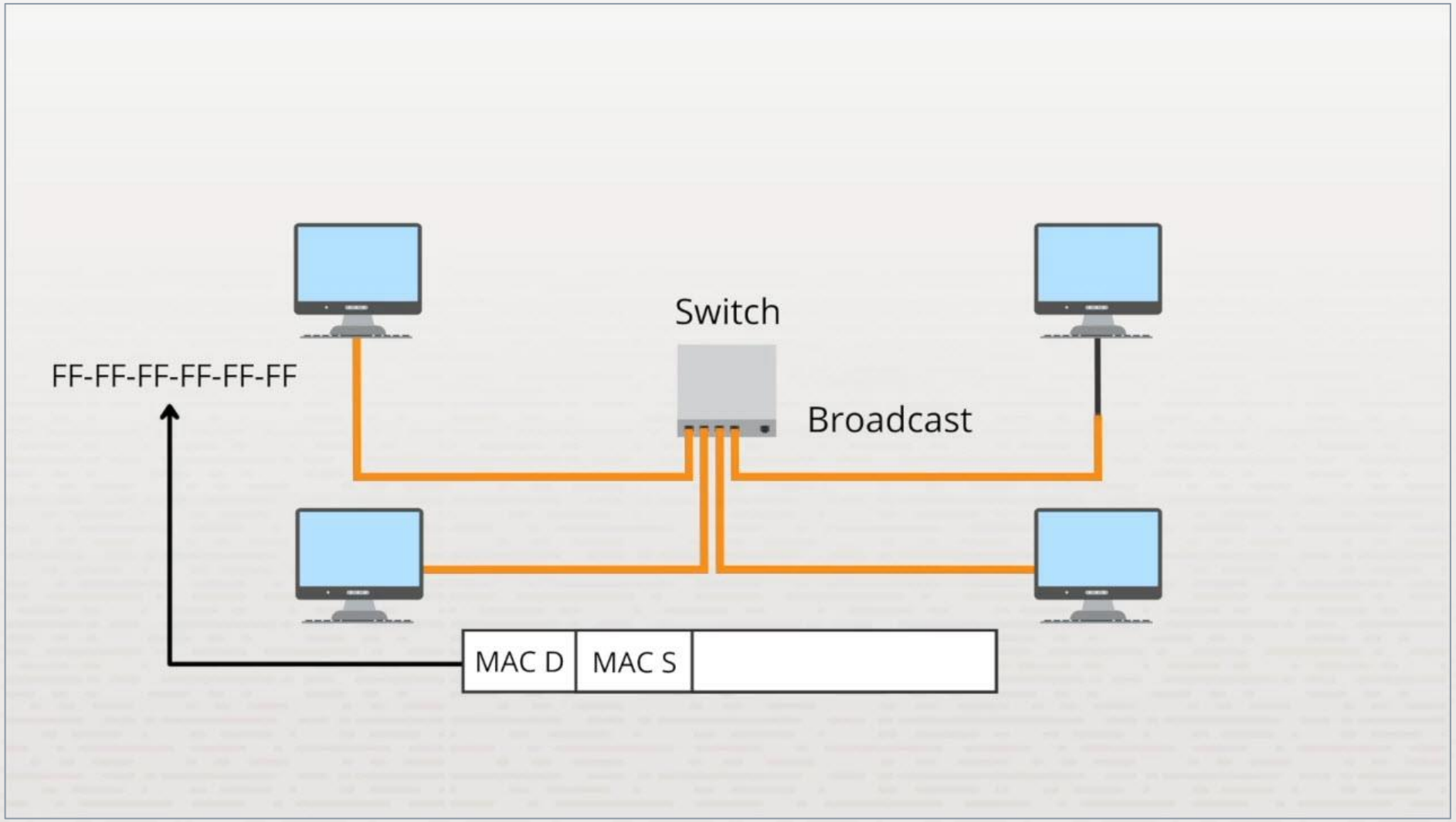
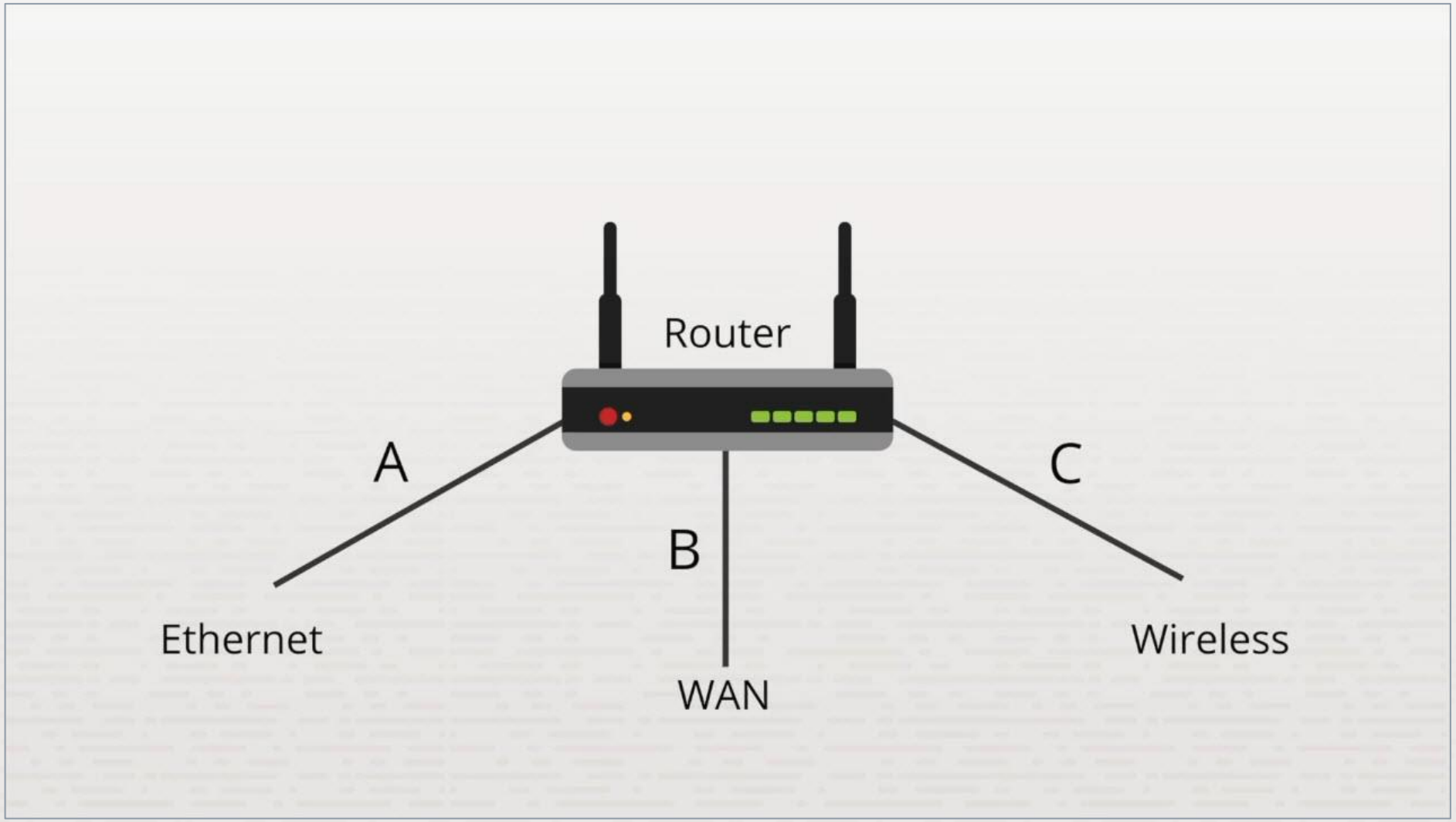


Summary

- Hubs
- Bridges
- Switches
- Wireless access points

Internetwork Devices

Internetwork Devices



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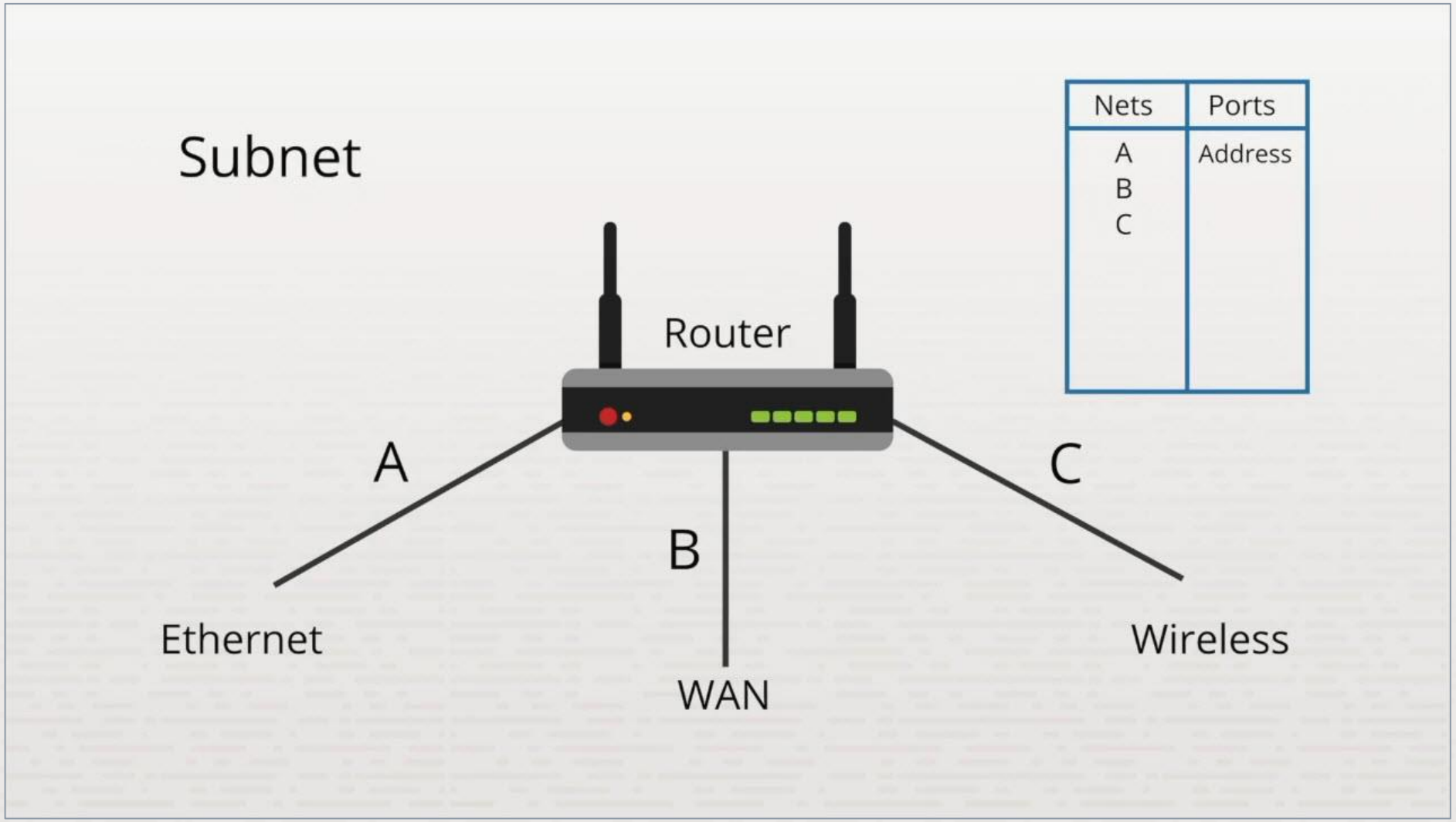

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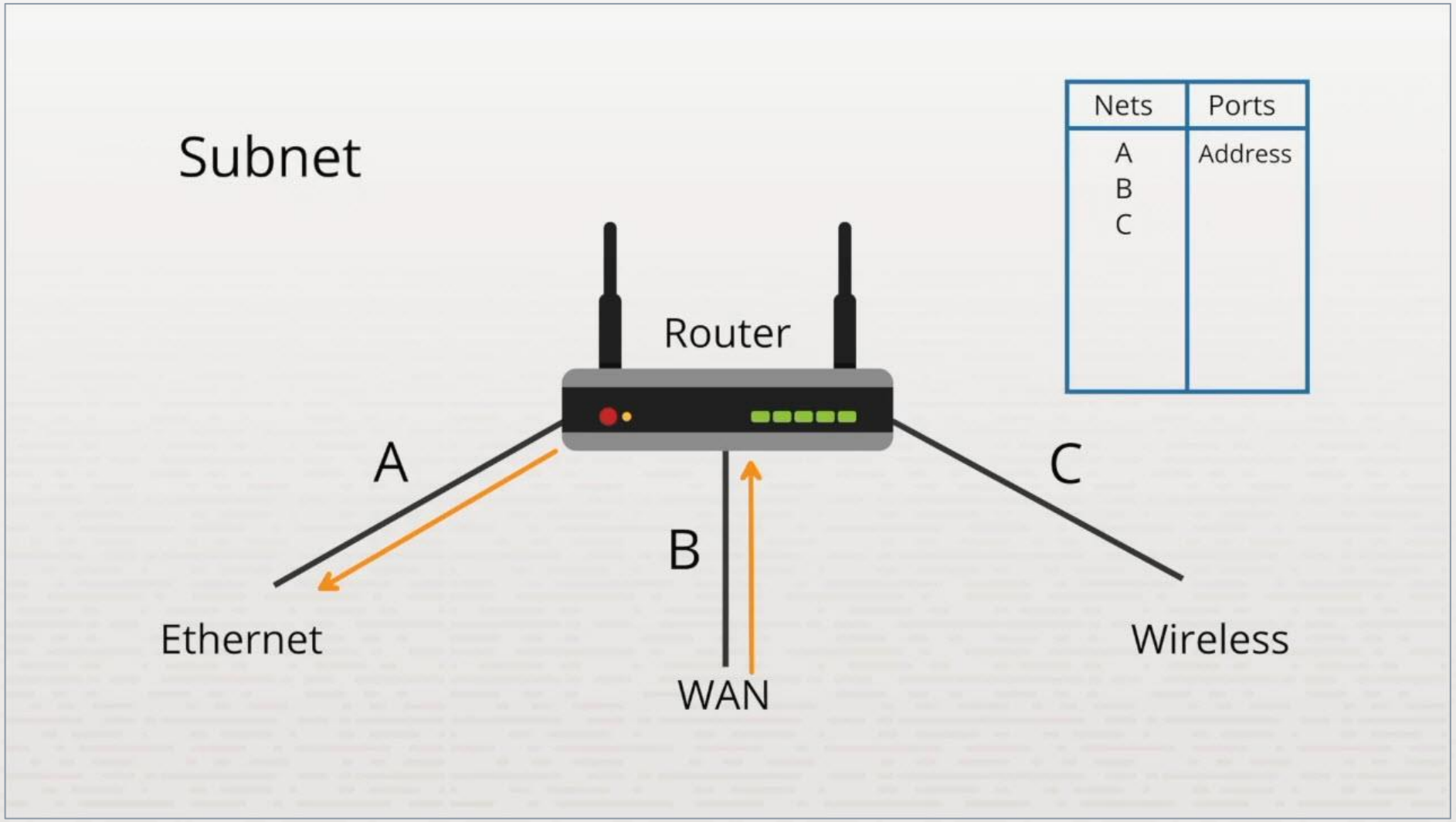

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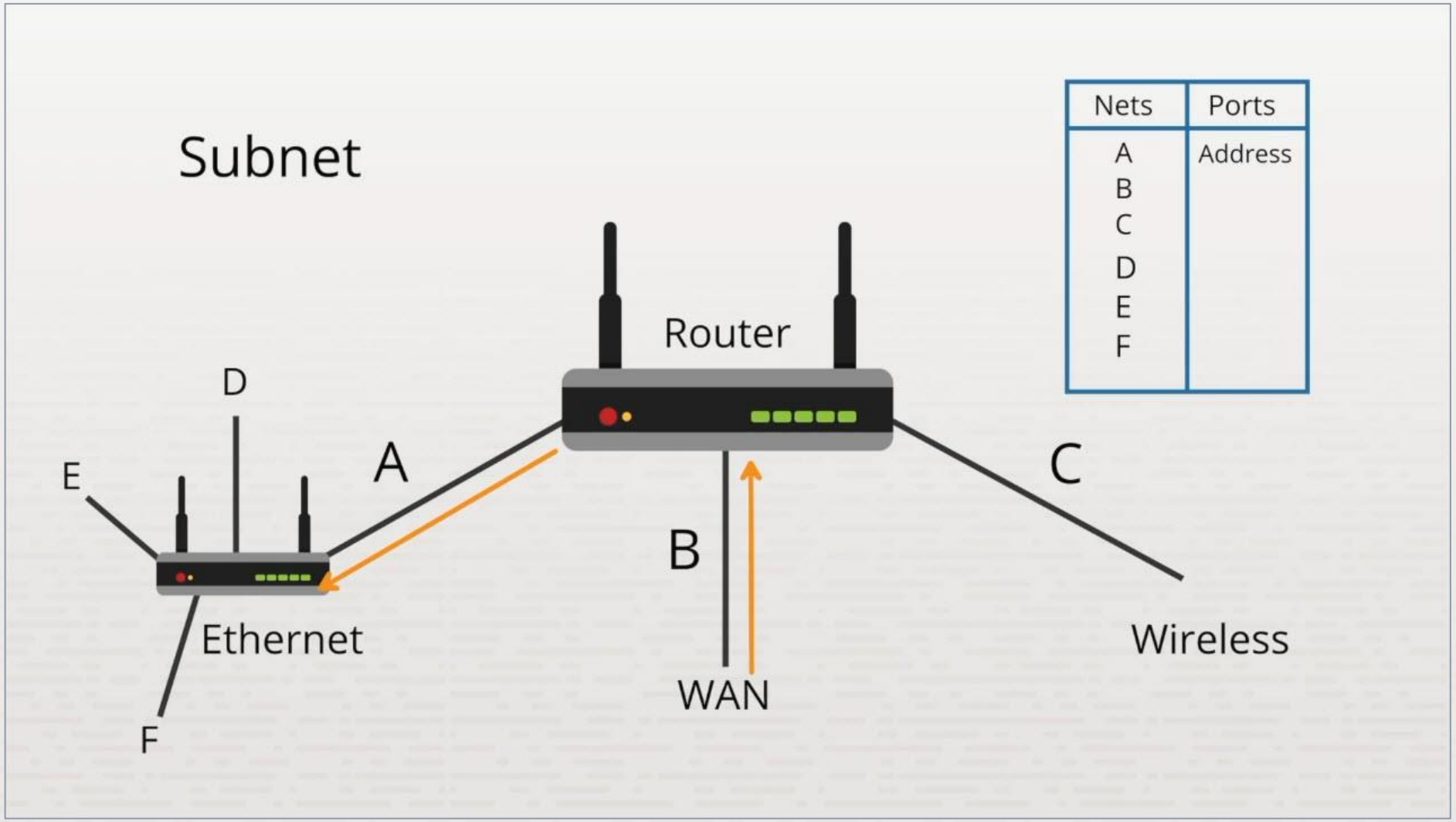

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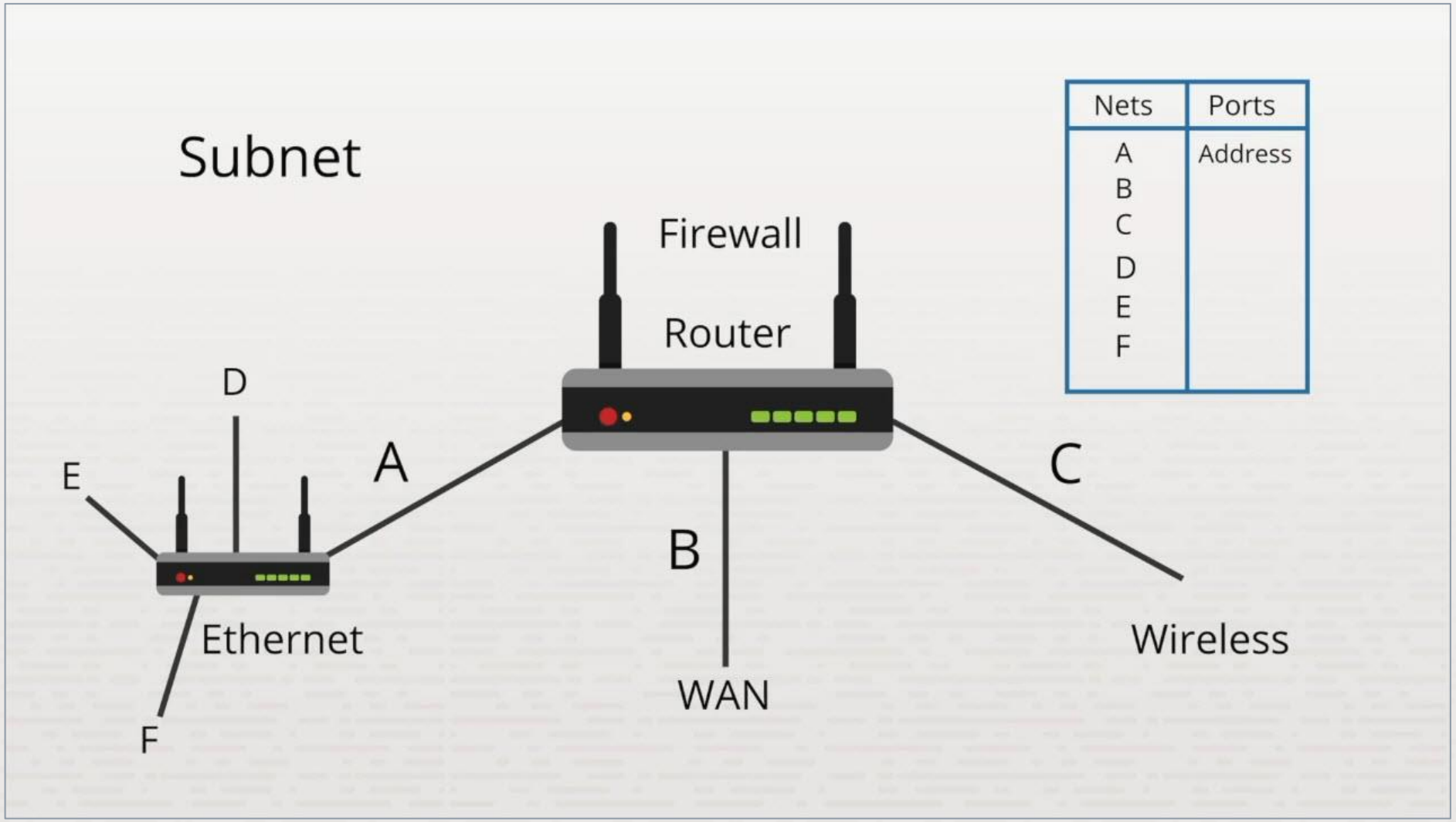

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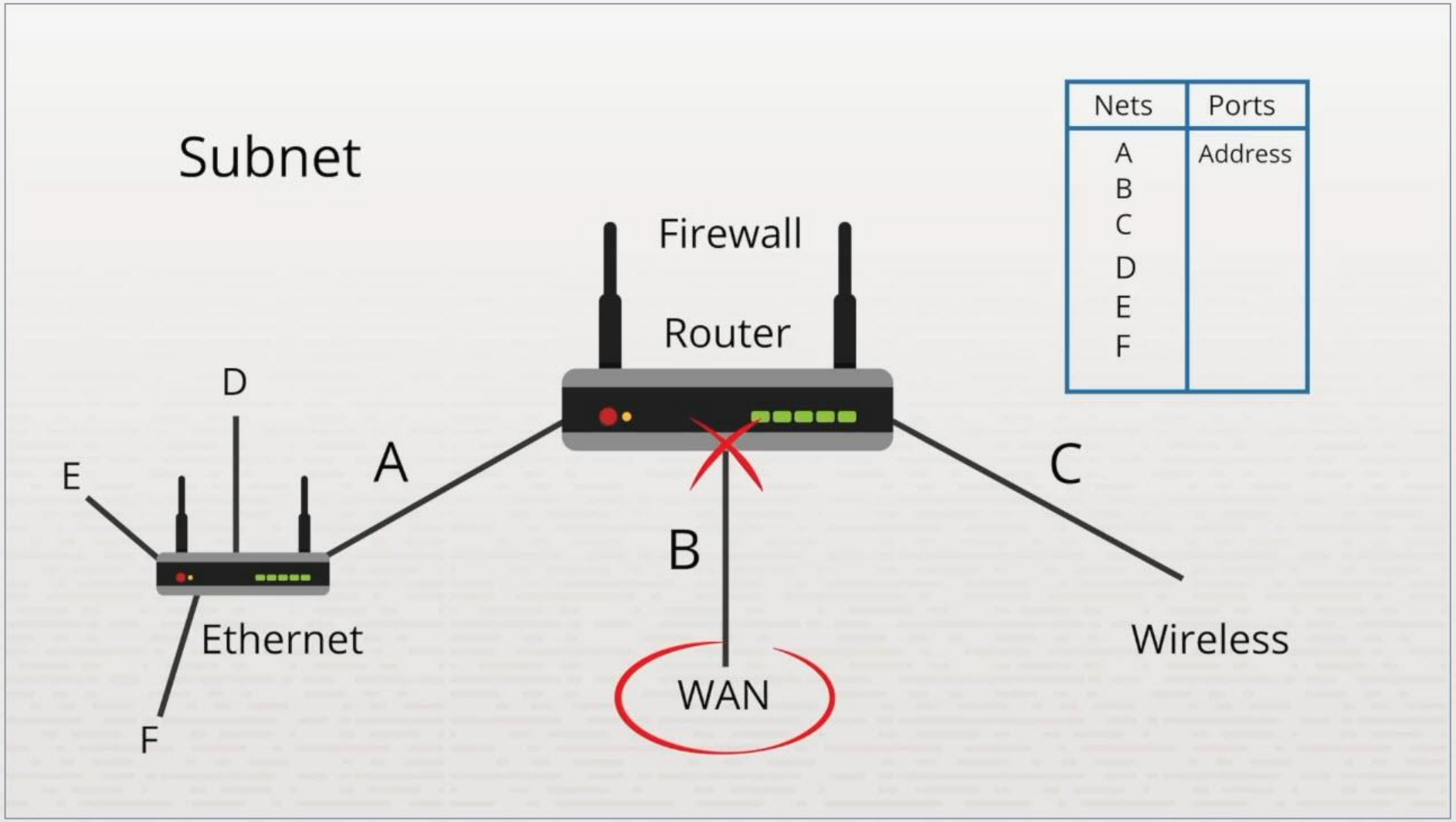

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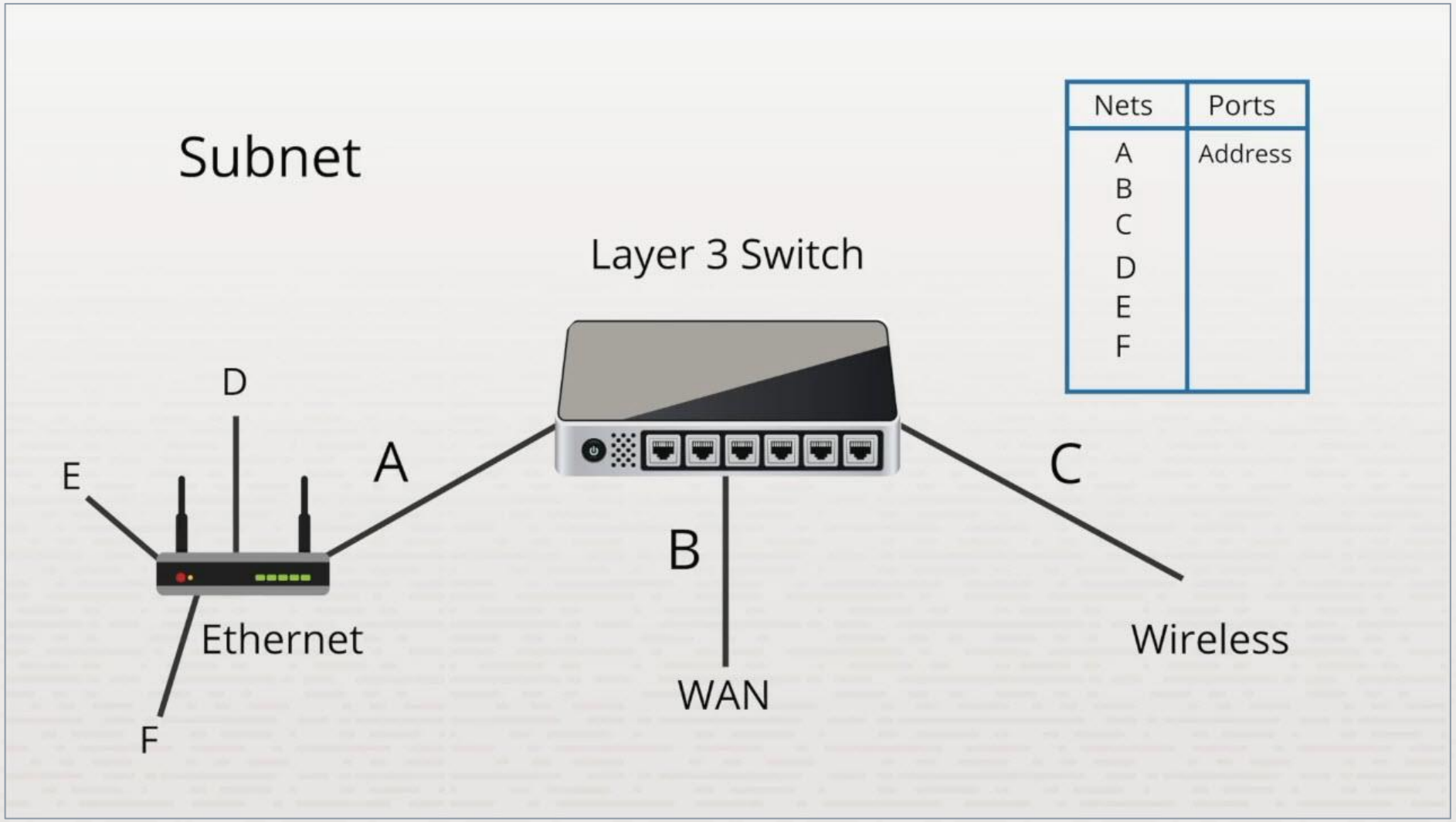

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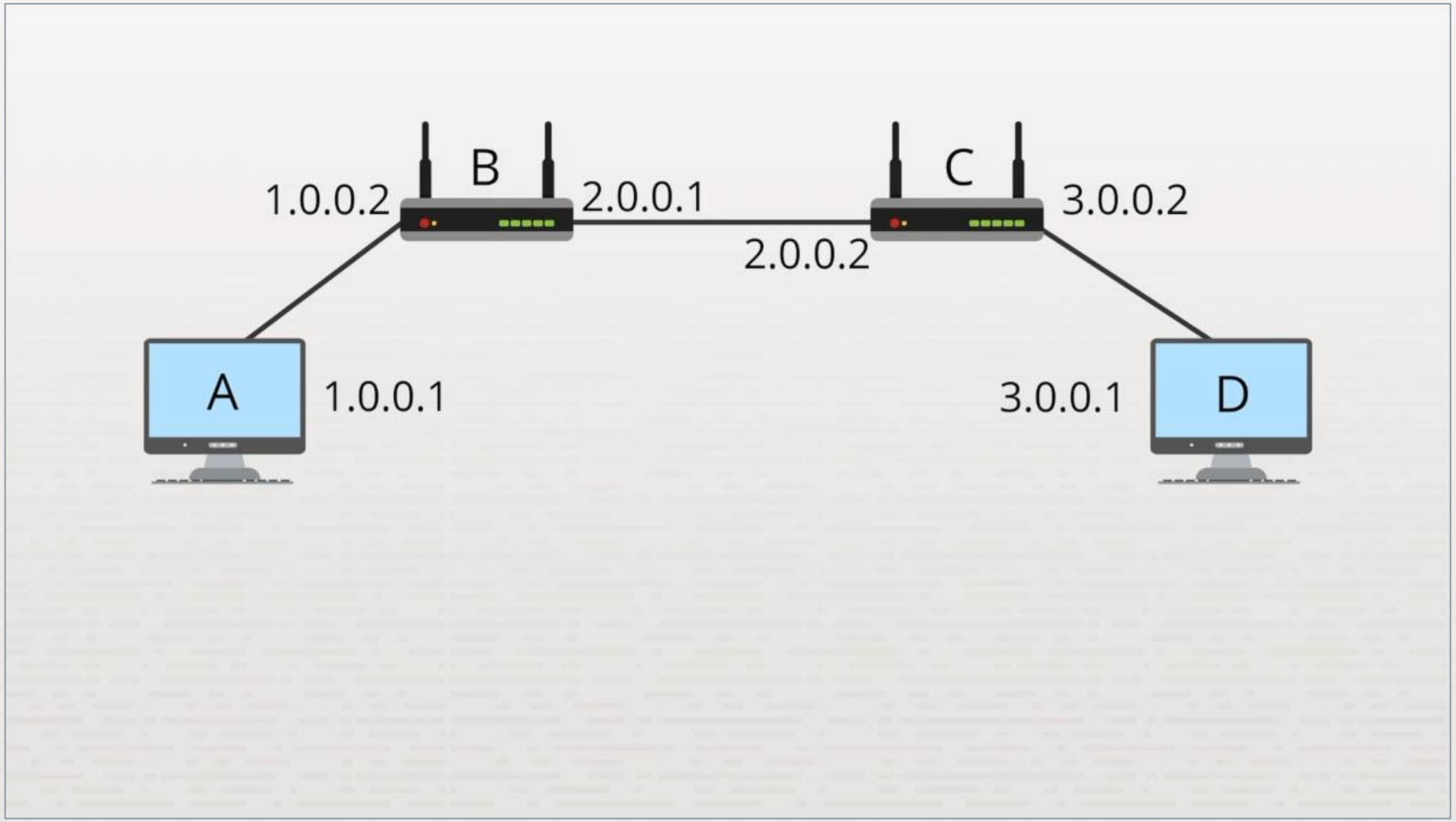

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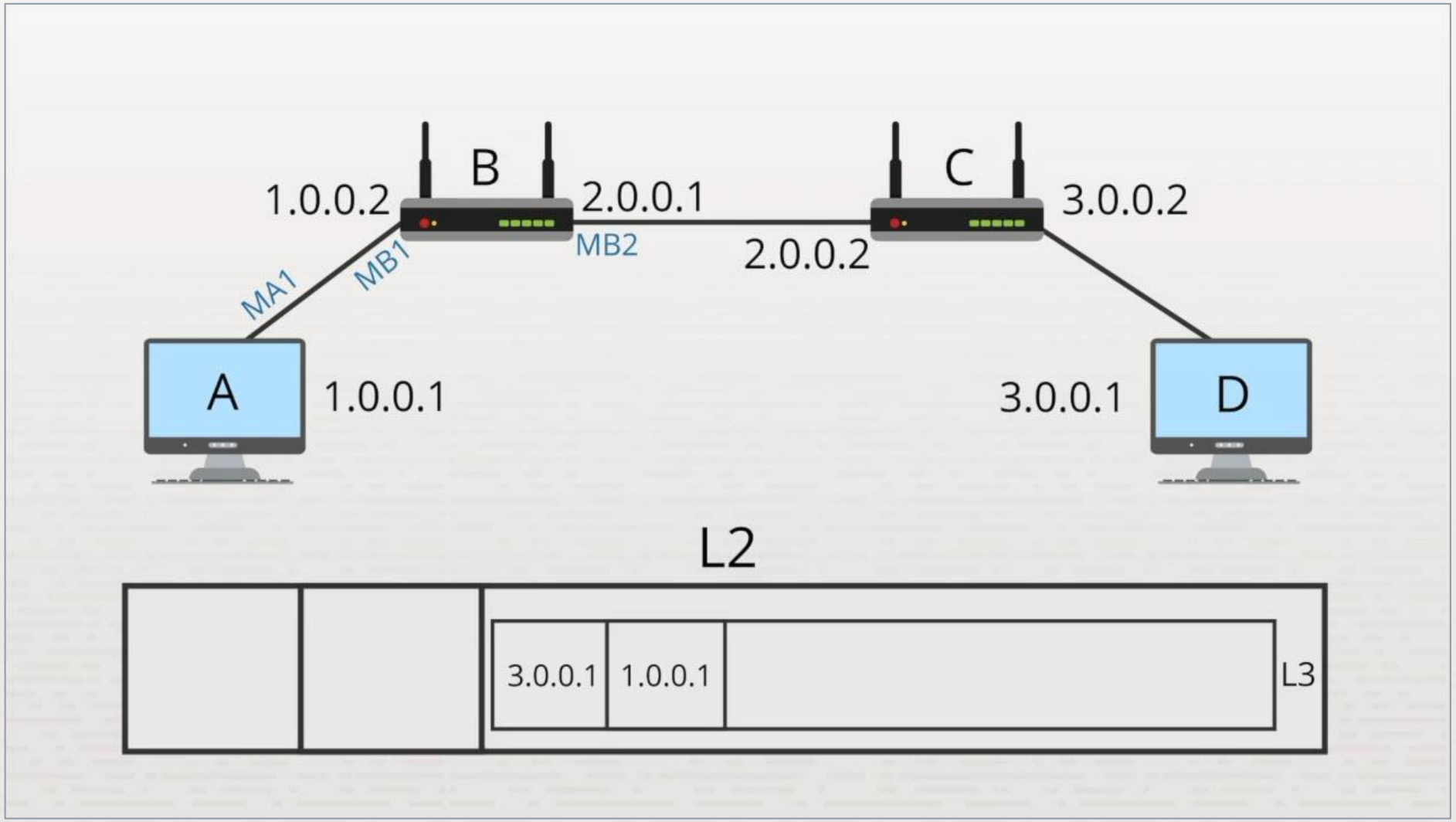

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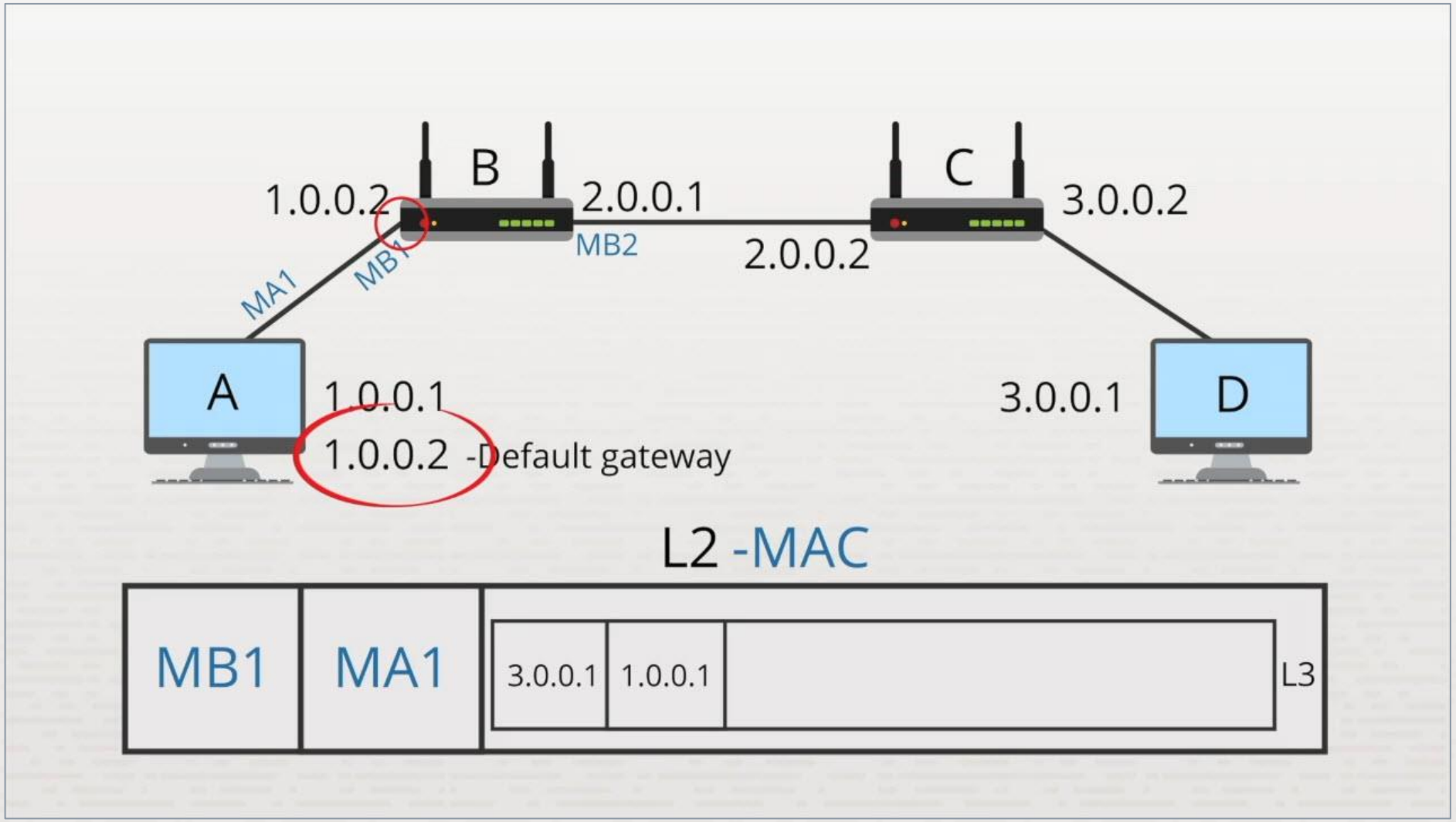

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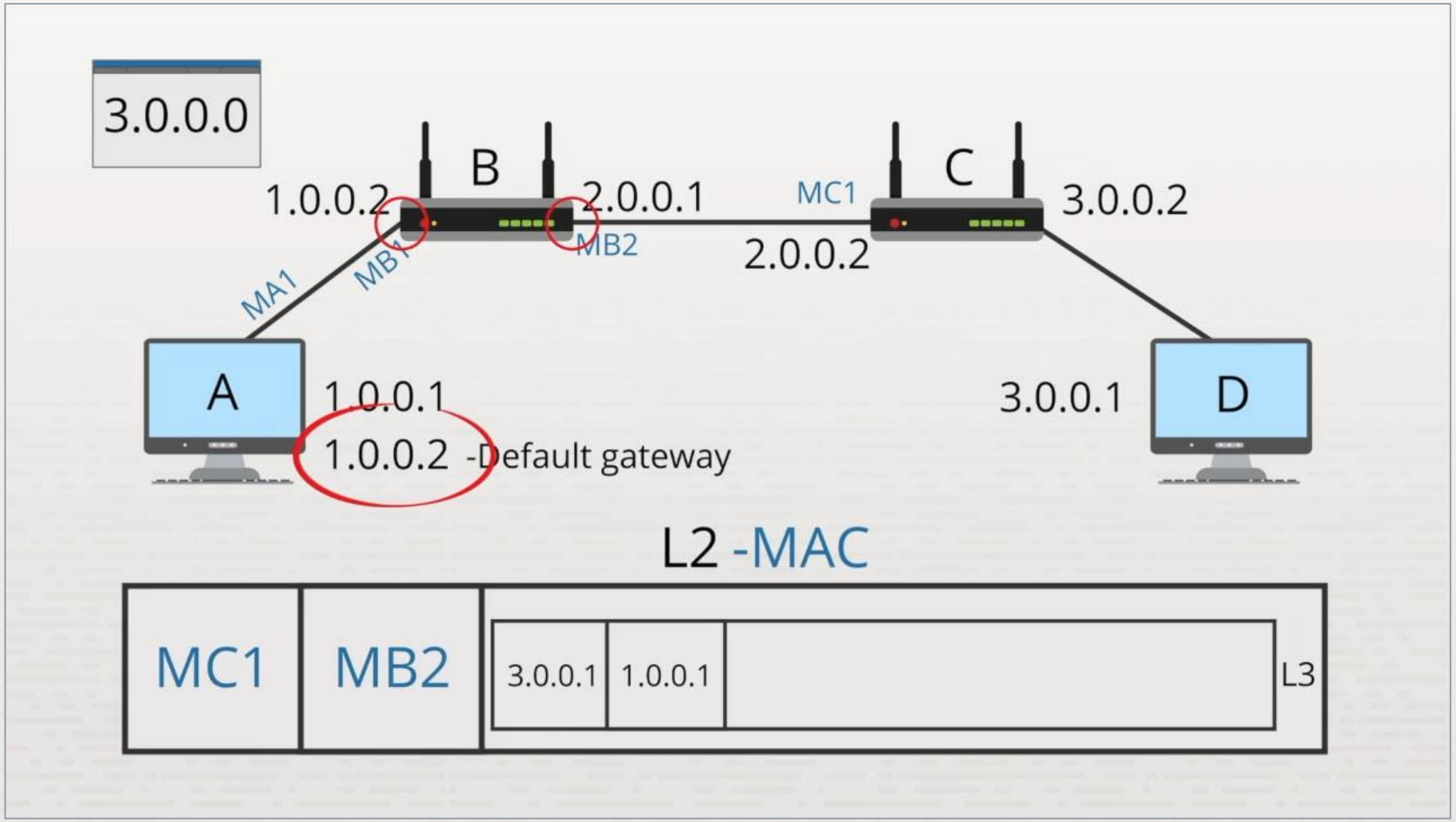

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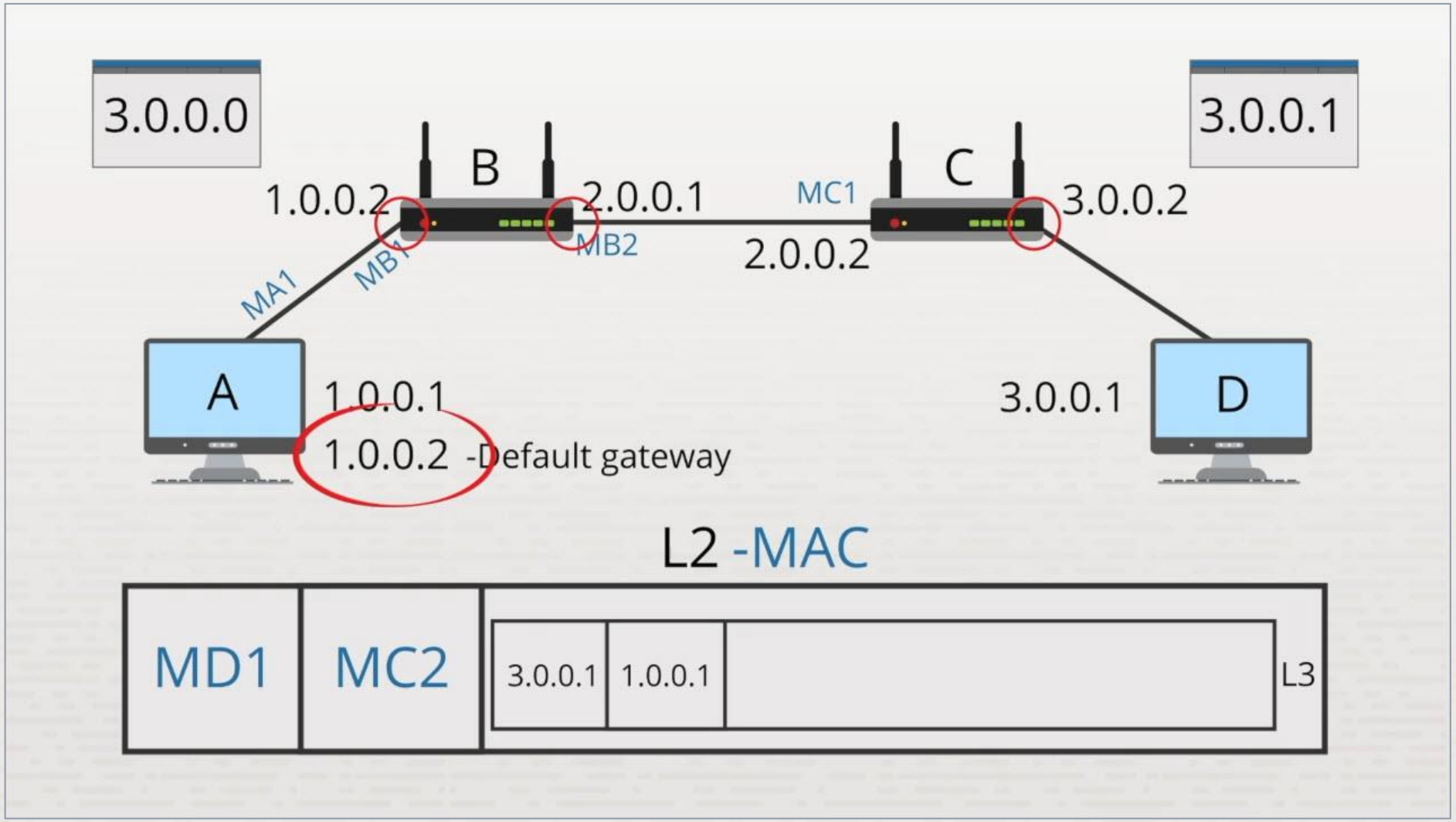
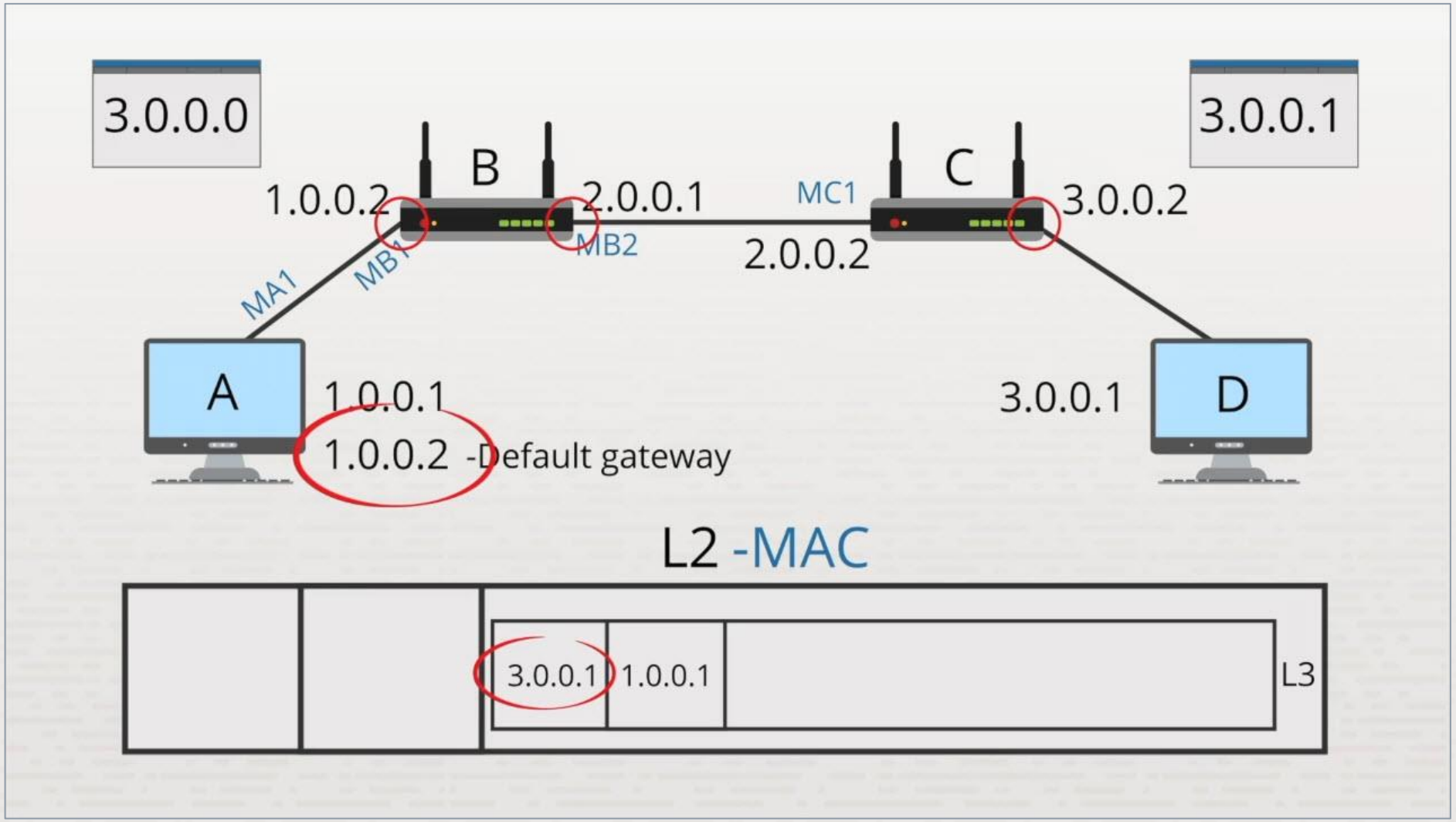


Internetwork Devices



Summary

- Routers
- Firewalls
- Layer 3 switches

Data Center Device Installation

Data Center Device Installation

Data Center Device Installation

Racks

- Cooling fans
- Power supplies
- Peripherals using a KVM

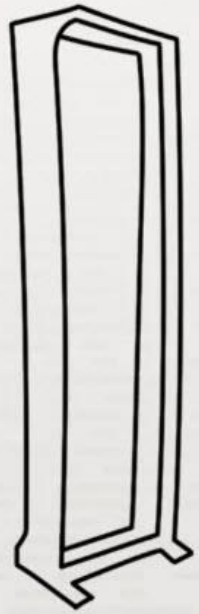
Rack Unit (U)

1U = 1.75 inches

2U server = 3.5 inches

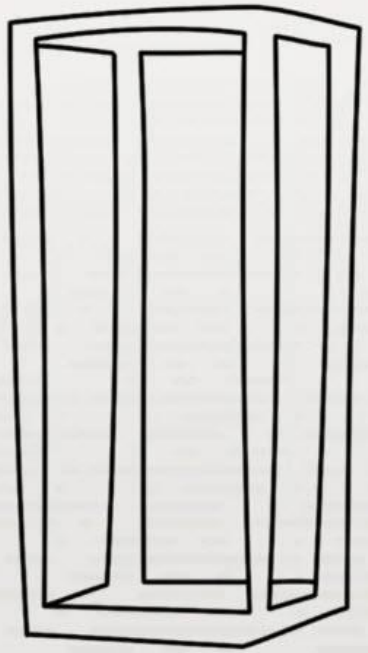
Data Center Device Installation

Two-Post Rack



Data Center Device Installation

Four-Post Rack



Data Center Device Installation

Blade Devices

Blade Devices

- Consolidated fan resources
- Mounted power supplies

Data Center Device Installation

Rack-Mounted Equipment

Rack-Mounted Equipment

- Creates hot and cold aisles
- Ensures adequate ventilation and cooling capacity
- Directly supplies cool air
- Keeps temperature within specs

Data Center Device Installation

Disorderly Data Center

Disorderly Data Center

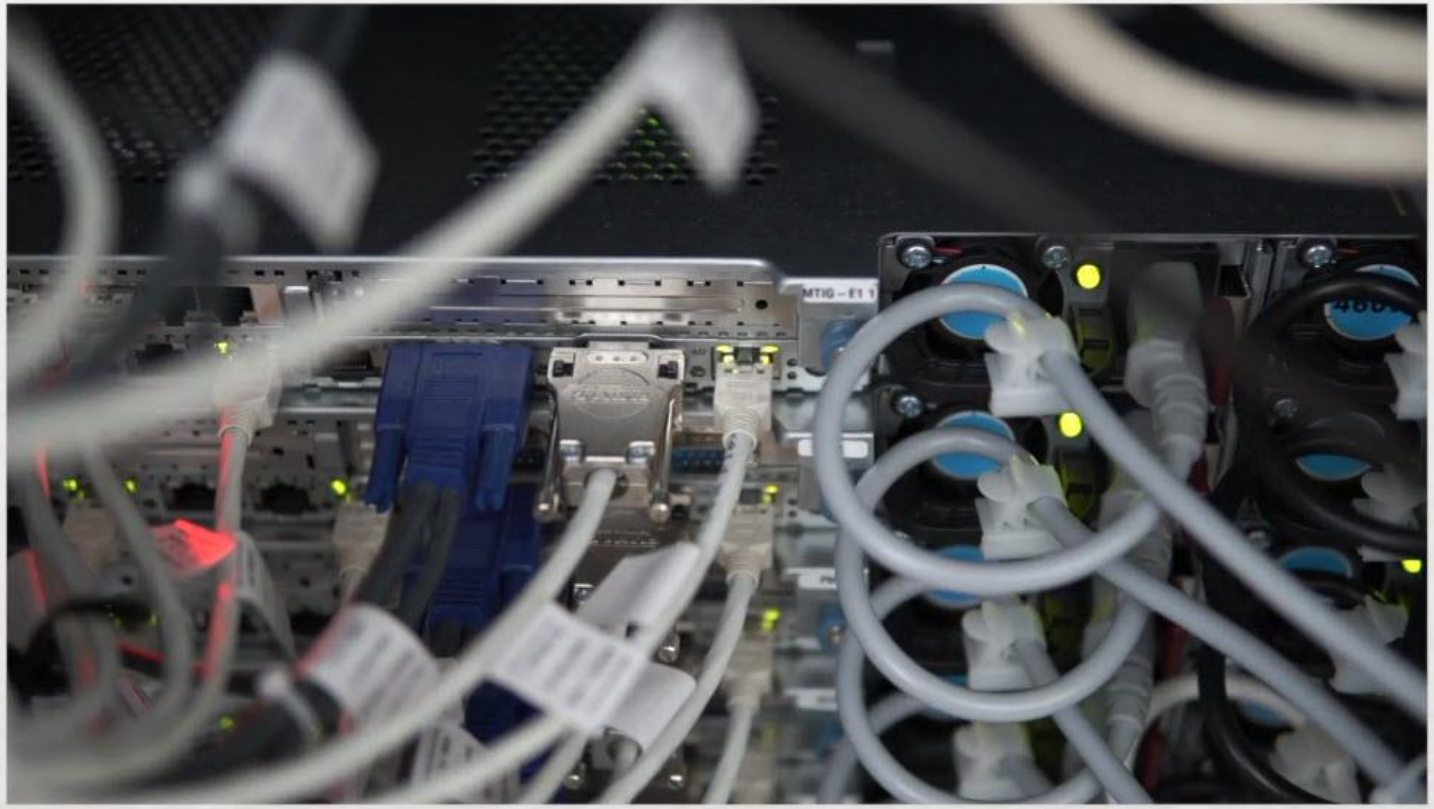
- More prone to failure
- More difficult to manage
- Less secure

Organized Data Center

- Consolidate hardware
- Use a trunk cable
- Label everything
  - Switch ports
  - Patch panel connections
  - Wall jacks
  - Electrical circuits
  - Devices and systems

Data Center Device Installation

Naming Conventions



Naming Conventions

- All file servers are named FSx
- All printers are named PTRx
- All workstations are named WSx
- All switches are named SWx
- All routers are named RTRx

Summary

- Rack advantages
- Rack sizes
- Labeling and naming

In-Class Practice

Do the following labs:

- 3.6.3 Install a Switch
- 3.6.4 Select a Networking Device
- 3.6.7 Select a Home Router

Class Discussion

- A host on a network sends a frame to the hub. Which other devices on the network will see this frame?
- A host on a network sends a frame to a switch. Which other devices on the network will see this frame?
- What are the similarities and differences between a bridge and a switch?
- What are the advantages of using switches instead of hubs?
- At which OSI model layer do wireless access points operate?
- Which type of device do you use to translate from one network architecture to another?