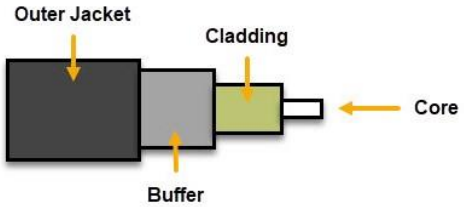
Fiber Optic Cabling

- Glass or plastic fiber that carries light (photons)
  - **High Bandwidth**: Photons travel faster than electrons.
  - **Long Distances**: Less attenuation.
  - Immune to Electromagnetic Interference (EMI)
  - Doesn't Emanate Signals
- Two Types
  - **Multi-mode Fiber (MMF)**
    - Shorter Distances (LAN / Building-to-Building)
    - Up to 2 Kilometers
  - **Single-mode Fiber (SMF)**
    - More expensive than multi-mode
    - Longer Distances (WAN / Across Town)
    - Up to 200 Kilometers

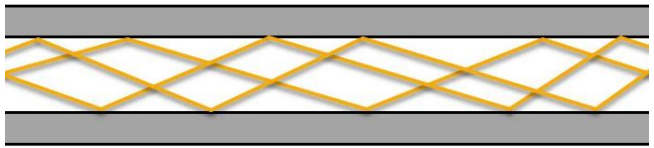


Informational Note: 9-micron Single-Mode Fiber can travel 75 miles at 400 Gbps

MMF versus SMF

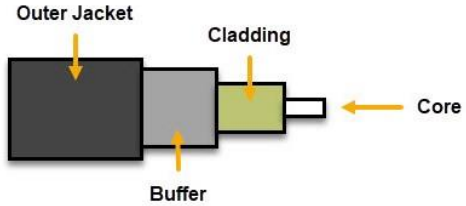
Multi-Mode Fiber (MMF)

- Many photons of light travel through the cable at once, and bounce off the walls, which reduces the distance and speed.
- **Larger Core**: 50 to 62.5 microns



Single-Mode Fiber (SMF)

- A single direct photon of light travels through the cable, which allows greater distances and speed.
- **Smaller Core**: 8 to 10 microns



Fiber Optic Cable Connectors

Lucent Connector (LC)

- Small form-factor design that has a flange on the top, similar to an RJ-45 connector.
- Commonly used in MMF & SMF gigabit and 10-gigabit Ethernet networks.

Subscriber Connector (SC)

- Square connector that uses a push-pull connector similar to A/V equipment.
- Commonly used in MMF & SMF gigabit Ethernet networks.

Straight Tip (ST)

- BNC style connector with a half-twist bayonet locking mechanism.
- Was used in MMF networks but not commonly used anymore.

Mech. Transfer Register Jack (MTRJ)

- Similar to the RJ-45 connector, and houses two fiber optics cables.
- Designed for MMF networks.

Why use Fiber?

- Fiber cable is more expensive than twisted pair, as is the equipment
- But you can perform much longer network cable runs with fiber.
  - 100m versus up to 200 Kilometers
- So you have decreased network equipment costs
  - Switches, routers, etc.
- Plus fiber is:
  - Immune to EMI and signal emanations
  - Has lower signal attenuation
  - Making it more reliable and secure
- Costs are steadily decreasing as more people adopt fiber

Cable Selection Criteria

Cost Constraints

- What is your budget?

Transmission Speed Requirements

- How fast does your network need to be?
- 10Mbps, 100Mbps, 1Gbps, 10Gbps?

Distance Requirements

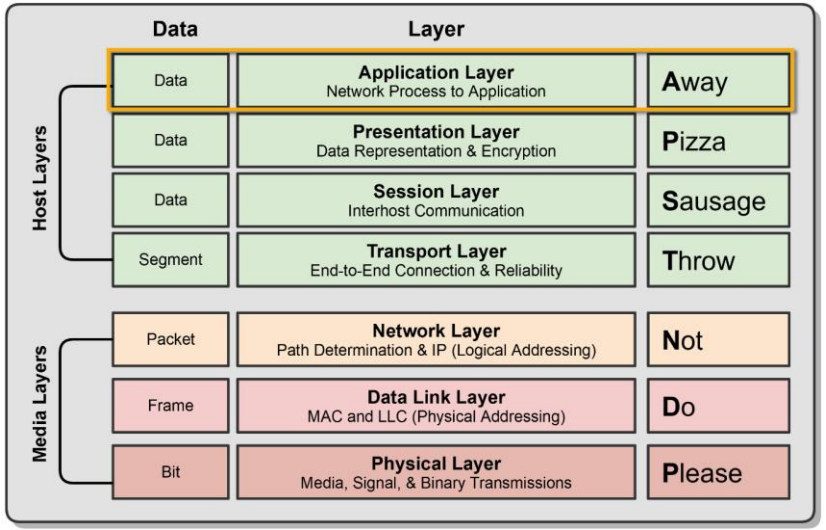
- Electrical signals degrade relatively quickly (100 meters)
- Fiber can transmit over long distances

Noise & Interference Immunity (Crosstalk, EMI, Security)

- Interference is all around us: power cables, microwaves, mobile phones, motors, etc.

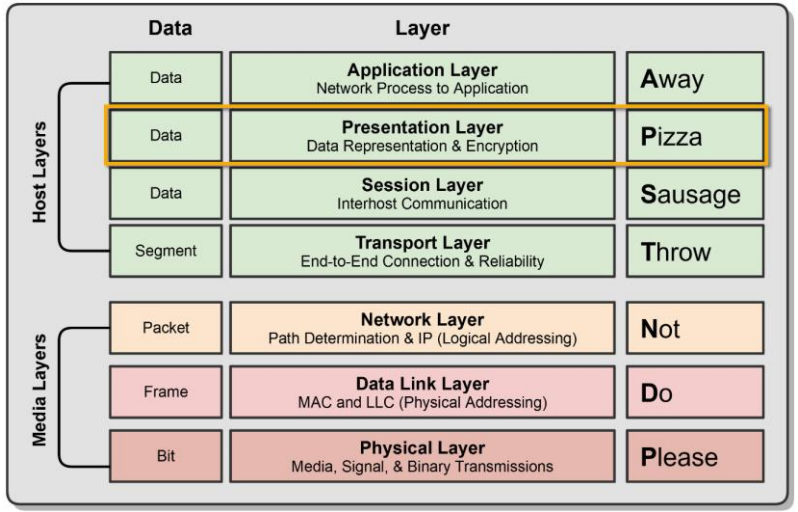
Layer 7 – Application Layer

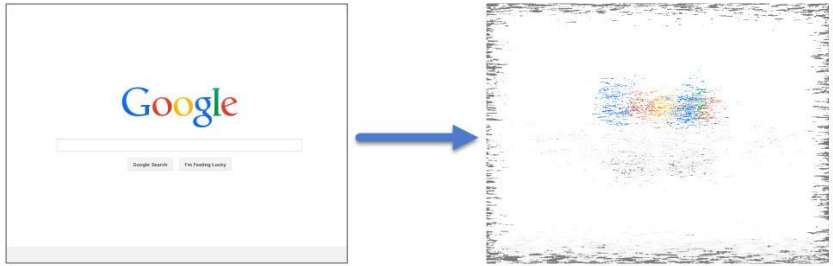
- Where users interact with the computer.
- Acts as an interface between an application and end-user protocols.
- Provides an interface to communicate with the network (Outlook, Chrome, etc.).
- Applications don't reside in the application layer but instead interfaces with application-layer protocols.
- Example Application Layer Protocols:
  - **E-Mail**: IMAP4, POP3, SMTP
  - **Web Browsers**: HTTP, HTTPS
  - **Remote Access**: SSH, Telnet



Layer 6 – Presentation Layer

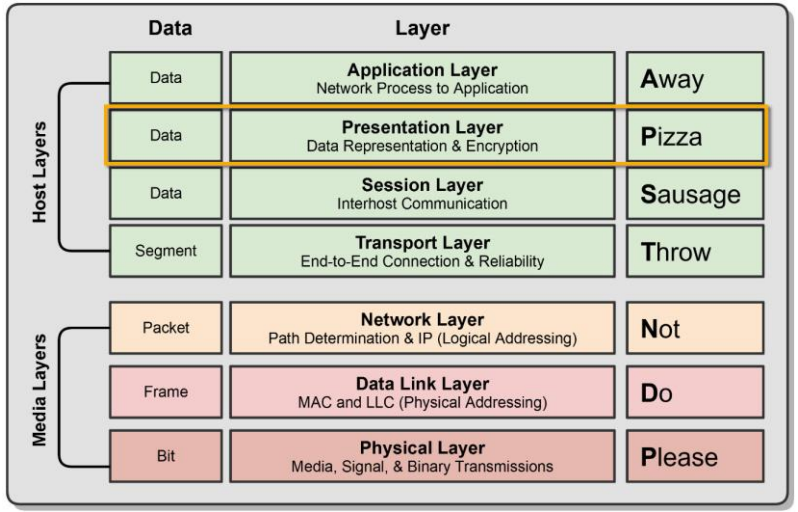
- Ensures that data transferred from one system's Application Layer can be read by the Application Layer on another one.
- Provides character code conversion, data compression, and data encryption/decryption.
- **Example**: Google Chrome HTML converted to ASCII Format.

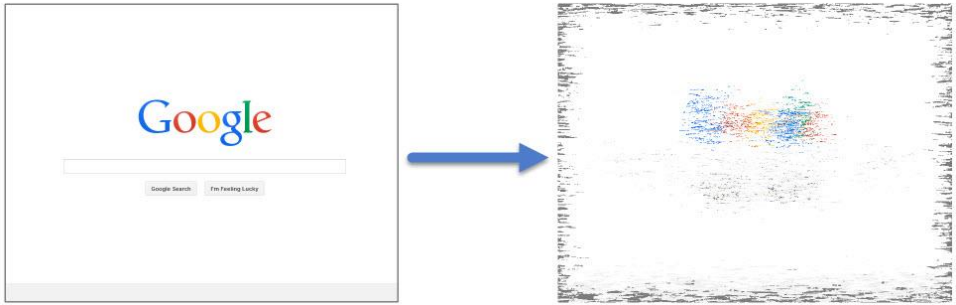




Layer 6 – Presentation Layer

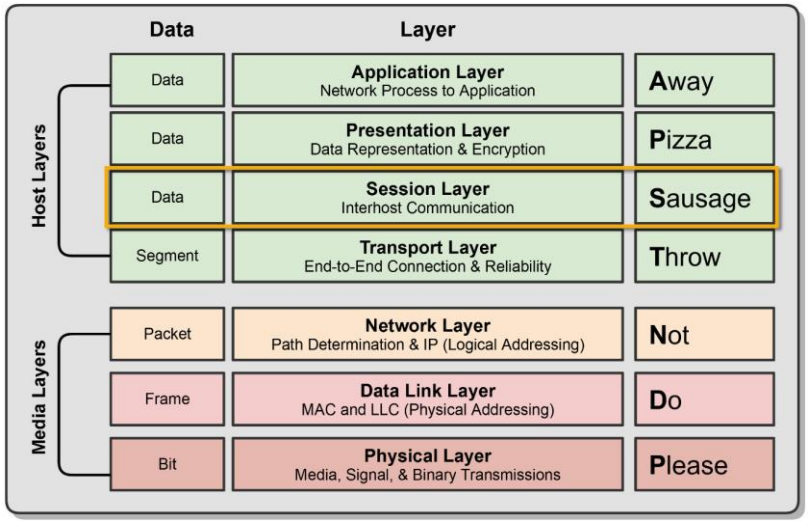
- Example Layer 6 File Formats:
  - **Web Browser**: HTML, XML, JavaScript
  - **Graphics Files**: JPEG, GIF, PNG
  - **Audio/Video**: MPEG, MP3
  - **Encryption**: TLS, SSL
  - **Text/Data**: ASCII, EBCDIC

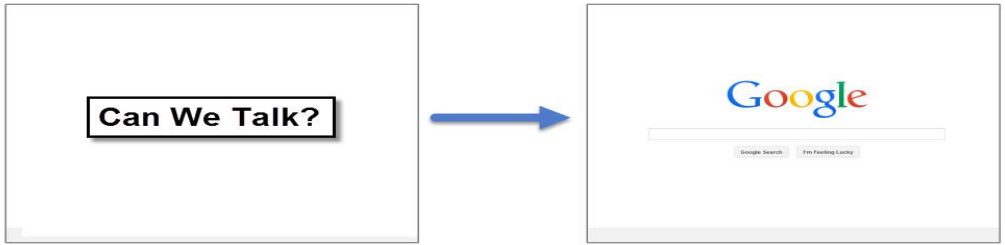




Layer 5 – Session Layer

- Responsible for setting up, managing, and then tearing down sessions between network devices.
- Ensures data from different application sessions are kept separate.
- Utilizes Application Program Interfaces (APIs) to communicate with TCP/IP protocols.
- Coordinates communication between systems.
    - Start, Stop, Restart

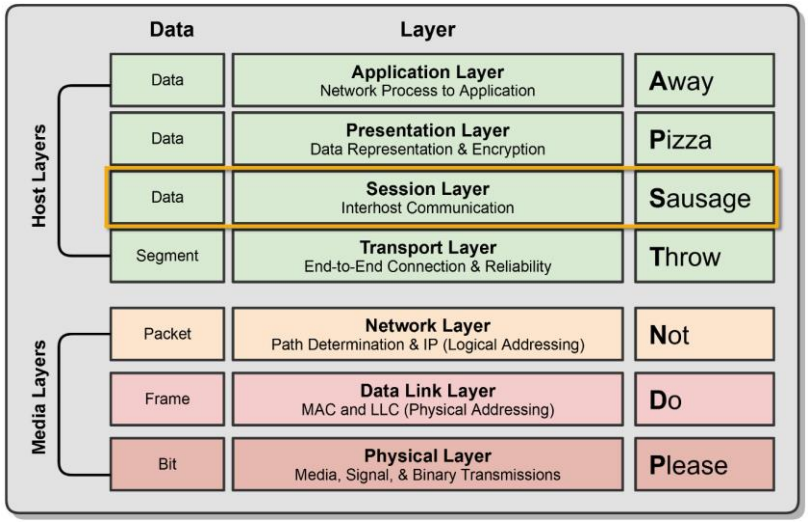




Layer 5 – Session Layer

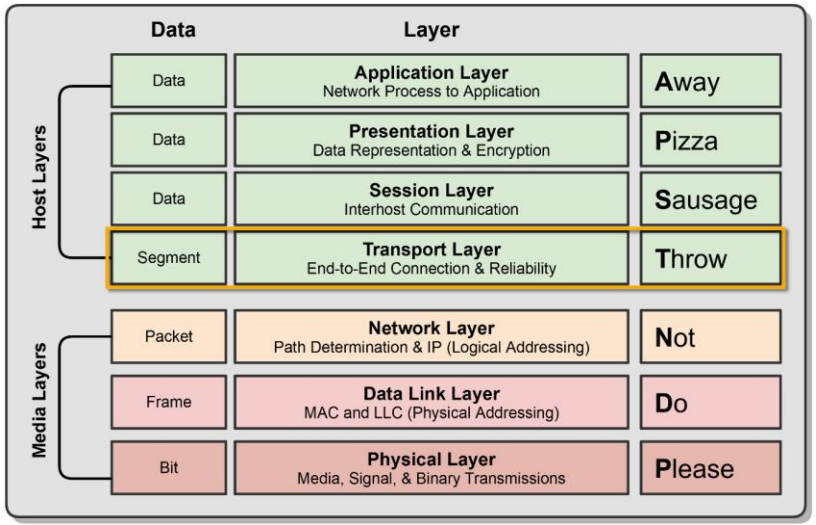
Can provide three different methods of communication between devices:

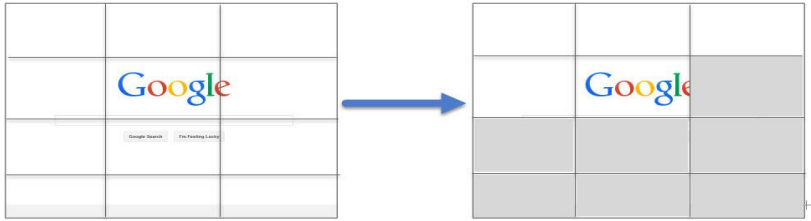
- **Simplex**: One-way communication between two devices, like listening to a radio station.
- **Half Duplex**: Two-way communication between two devices, but only one device can communicate at a time.
- **Full Duplex**: Two-way communication between two devices, where both sides can communicate at the same time.



Layer 4 - Transport Layer

- Ensures data is delivered error-free and in sequence.
- Segments data and reassembles correctly.
- Can be connection-oriented or connectionless.
- Considered the “Post Office” Layer
  - **TCP** (Transmission Control Protocol)
  - **UDP** (User Datagram Protocol)
  - Covered in detail in the next section.

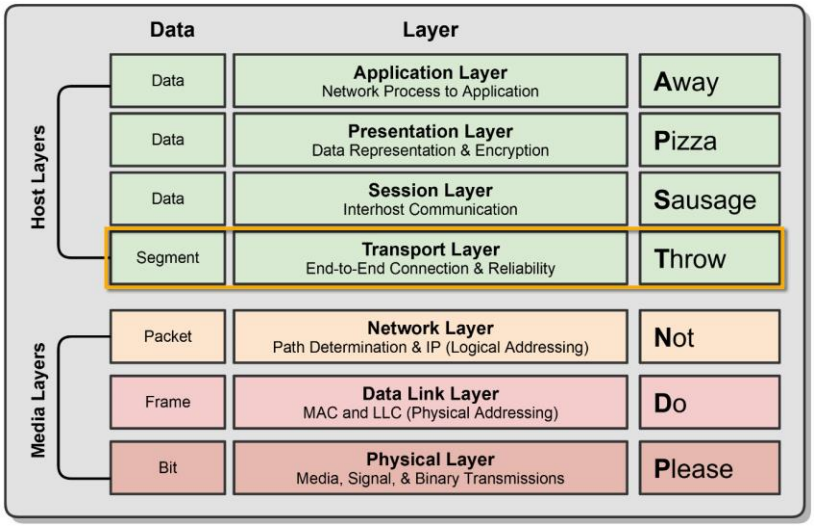




Layer 4 - Transport Layer

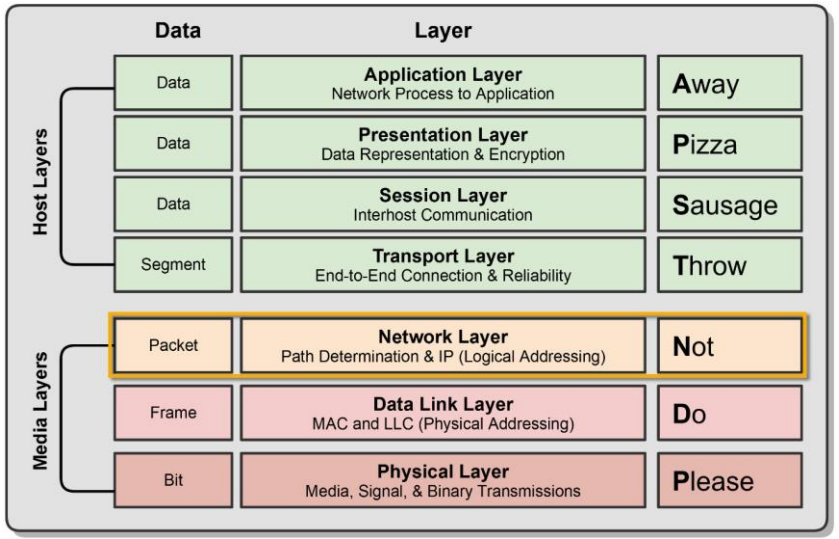
Responsible for two data flow control measures:

- **Buffering**
  - Stores data in memory buffers until destination device is available.
- **Windowing**
  - Allows devices in session to determine the “window” size of data segments sent.



Layer 3 – Network Layer

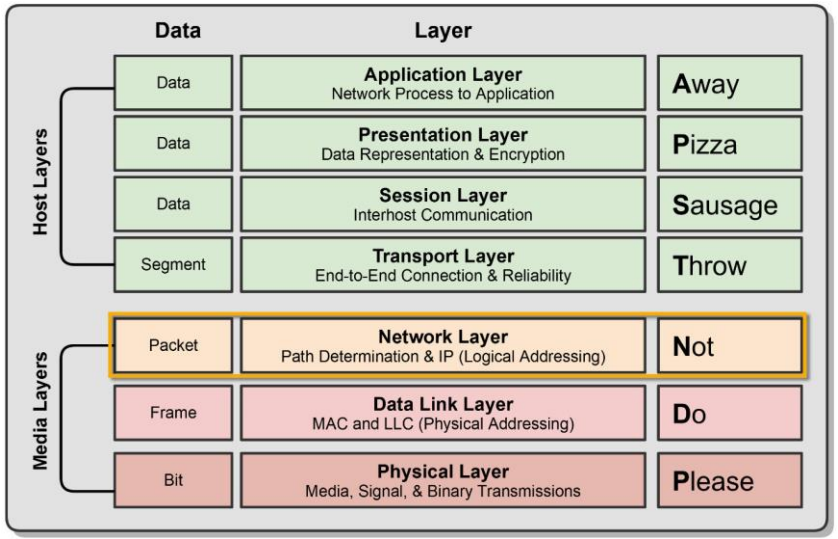
- The “Routing” Layer
- Provides logical addressing (IP Addressing) and routing services.
- Places two IP addresses into a packet:
  - Source Address & Destination IP Address
- Internet Protocol (IP)
  - The primary network protocol used on the Internet, IPv4, IPv6 Logical Addresses



Layer 3 – Network Layer

Types of Packets at Network Layer:

- **Data Packets**
  - Routed Internet Protocol (IP) data packets.
    - IPv4 & IPv6
- **Route-Update Packets**
  - Routing protocols designed to update neighboring routers with router information for path determination.
    - RIP, OSPF, EIGRP, etc.

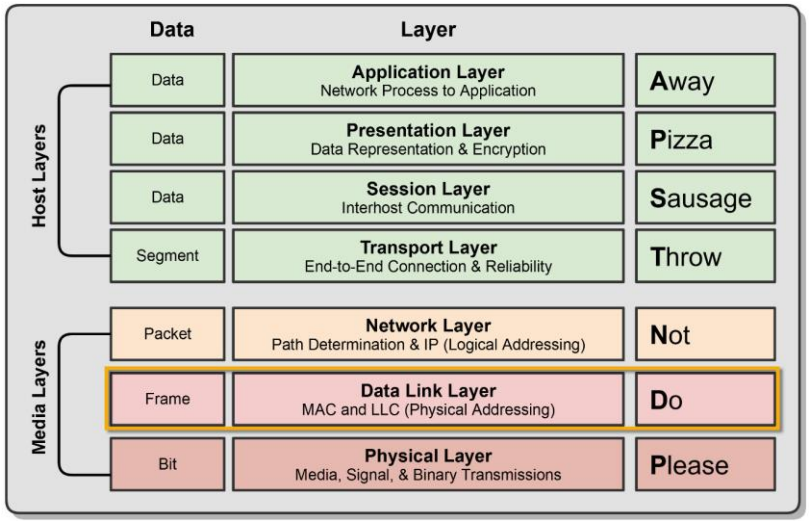


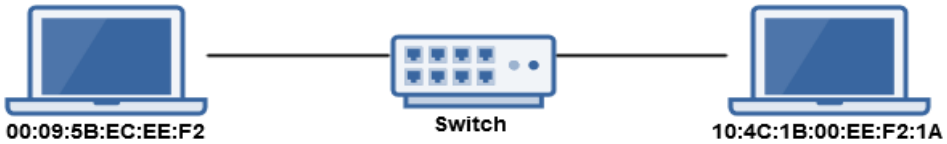
Layer 3 Devices & Protocols:

- Routers & Multi-Layer Switches
- IPv4 & IPv6
- Internet Control Message Protocol (ICMP), i.e., Ping

Layer 2 – Data Link Layer

- The “Switching” Layer
- Ensures that messages are delivered to the proper device on a LAN using hardware addresses.
  - MAC (Media Access Control) Address
  - Only concerned with the local delivery of frames on the same network.
- Responsible for packaging the data into frames for the physical layer.
- Translates messages from the Network layer into bits for the Physical layer.

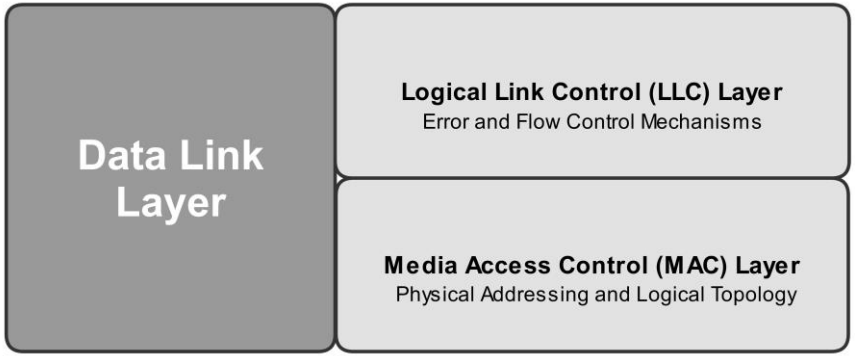




Layer 2 – Data Link Layer

Has two Sub-Layers

- **Logical Link Control (LLC) Layer**
  - Error Control and Flow Control
    - Detect and correct corrupted data frames.
    - Limits amount of data sent so devices aren't overwhelmed.
- **Media Access Control (MAC) Layer**
  - Physical Addressing (MAC Address)
    - 48-Bit MAC Address burned on NIC.
  - Logical Topology and Media Access
    - Ethernet, Token Ring, etc.
    - CSMA/CD & CSMA/CA

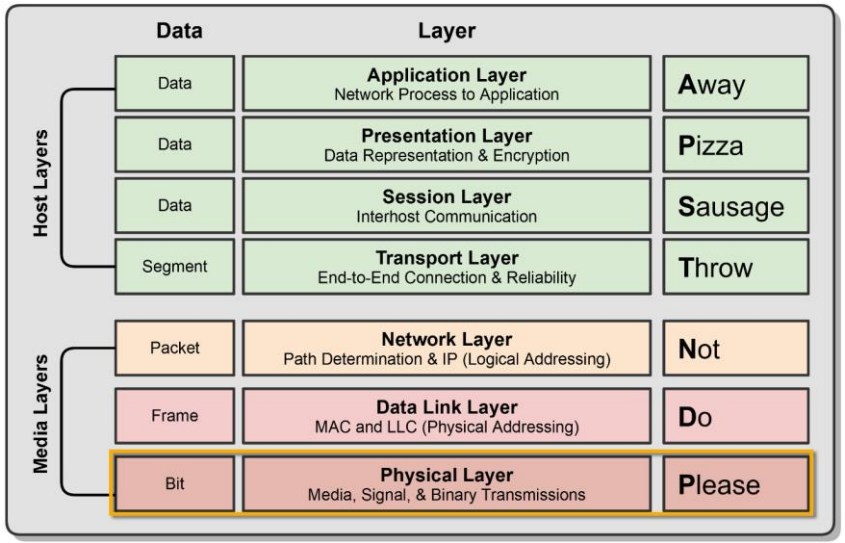


Layer 1 – Physical Layer

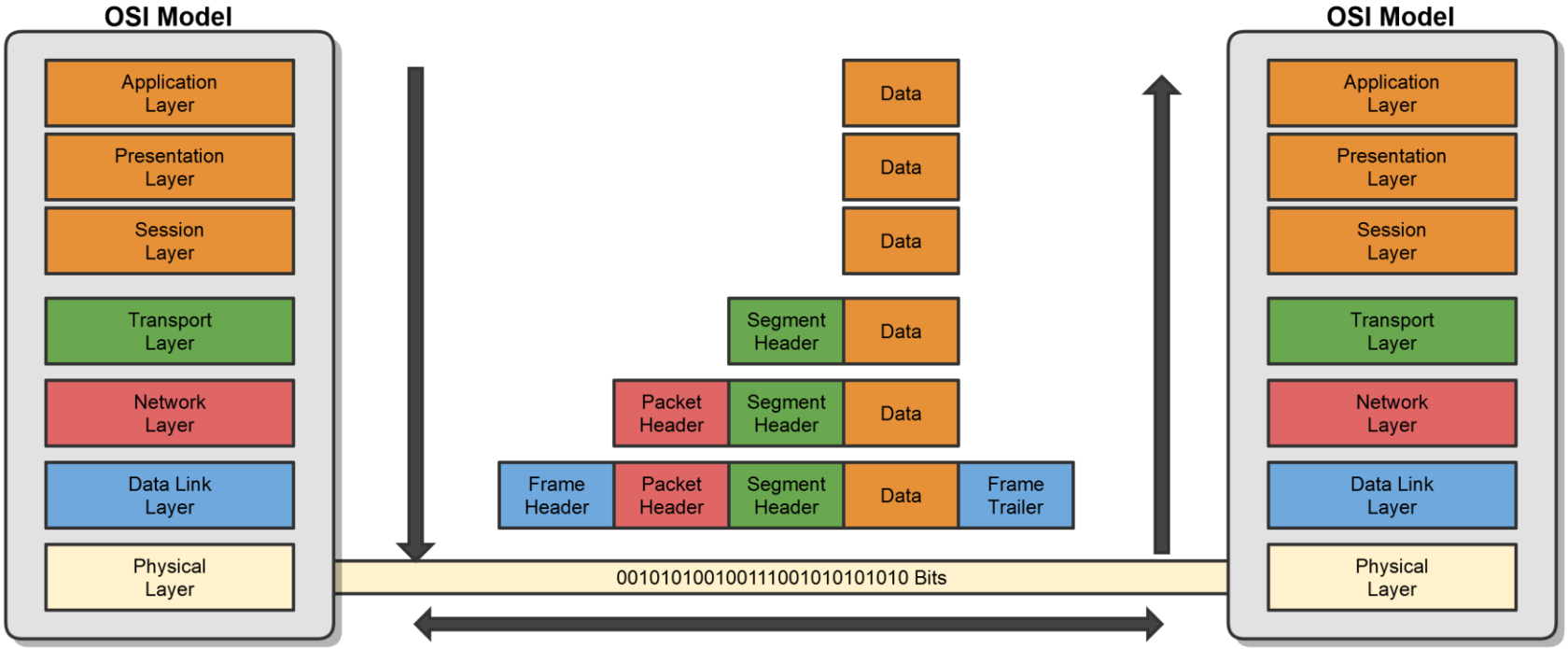
Defines the physical and electrical medium for network communication:

- Sending and receiving bits (1 or 0)
- Encoding Signal Types
  - Electricity, radio waves, light
- Network Cabling, Jacks, Patch Panels, etc.
  - Copper or Fiber
- Physical Network Topology
  - Star, Mesh, Ring, etc.
- Ethernet IEEE 802.3 Standard
- Layer 1 Equipment
  - Hubs, Media Converters, Modems

It's responsible for the network hardware and physical topology.



OSI Encapsulation & De-Encapsulation



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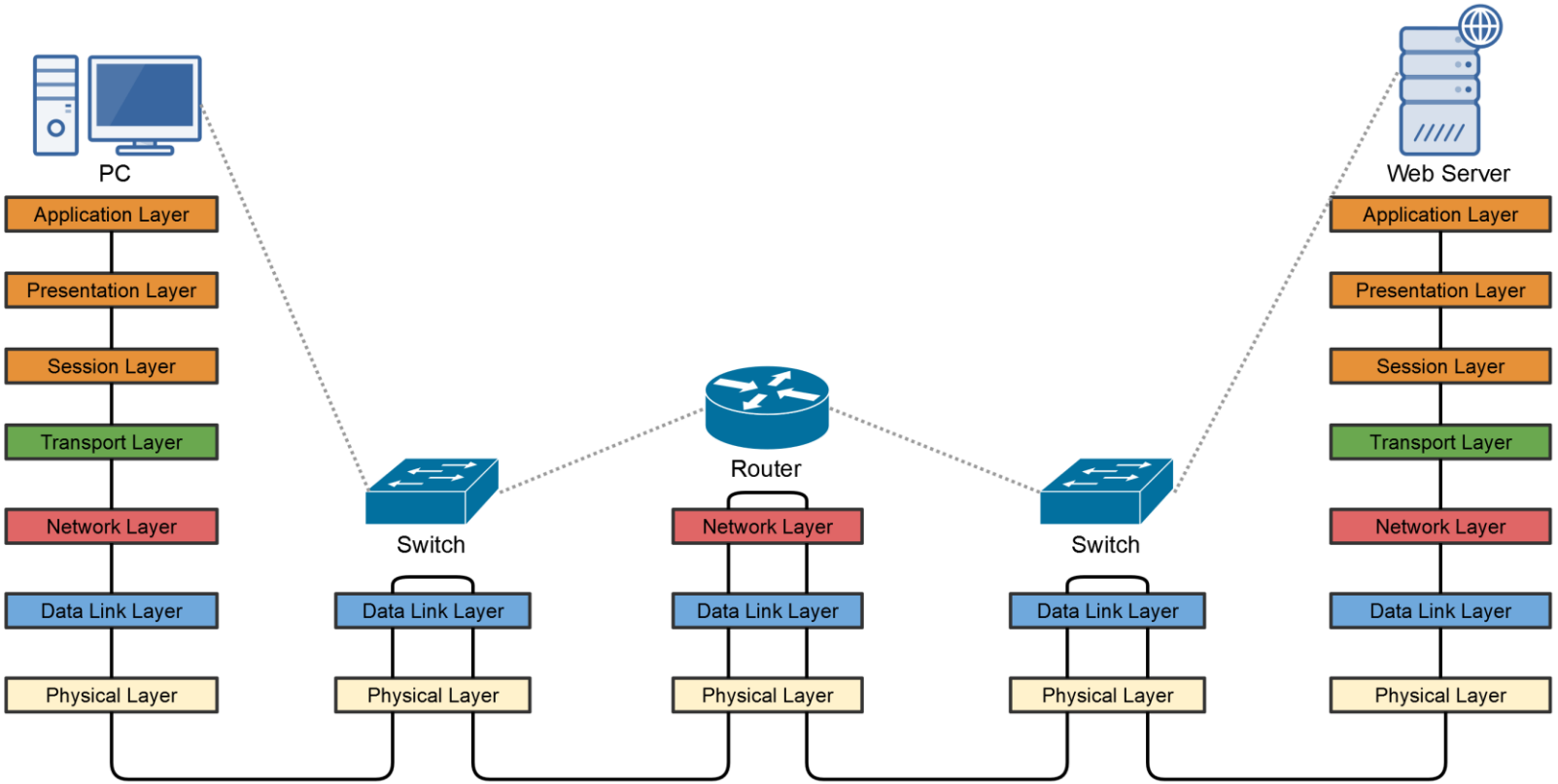

What is TCP/IP?

- Transmission Control Protocol/Internet Protocol
- Commonly called the **Internet Protocol** suite because it was designed for the Internet, but LANs use it too.
- First Two Protocols Defined in the Suite Were:
  - TCP & IP, hence TCP/IP
- Similar to the OSI Model, but Simpler:
  - OSI is Conceptual
  - TCP/IP was Implemented