The OSI Model

Based on Computer Networks and Internets

CompTIA Network+

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OSI or ISO

- The layering model is OSI, which stands for **O**pen **S**ystem **I**nterconnection.
- The organization that developed the model is ISO, **I**nternational **O**rganization for **S**tandardization.
  - ANSI (American National Standards Institute) is a member of ISO.
    - ANSI farms out much of the hardware standardization to the IEEE.

Communications Layering

- The communication between two (or more) users on a network similarly is broken down into layers.
- A reference model is a conceptual blueprint of how communications should take place ,it addresses all the processes into logical grouping called layers

What is OSI?

- OSI serves as a "reference model" for how information is transmitted between any two points in a network.
- It guides manufacturers (vendors) so they can create interoperable network devices and Software in form of protocols or standards ,so that different vendors networks could become compatible and work together
- The OSI model is comprised of seven layers that are involved in communicating between two nodes of a network.

OSI's Purpose

- Even if manufacturers do not restrict themselves to a particular OSI layer, they usually think of and describe their products in relationship to the OSI model.
- It provides a language and framework for discussion of networks, so it persists and continues to be taught.

TCP/IP model

- Another model for understanding communications networks is the TCP/IP model.
- It also is broken into layers
  - It has no equivalent of the OSI model's physical layer.
  - The next three layers of the OSI model and the TCP/IP model are roughly equivalent.
  - The top three layers of the OSI model are combined into one layer in the TCP/IP model.

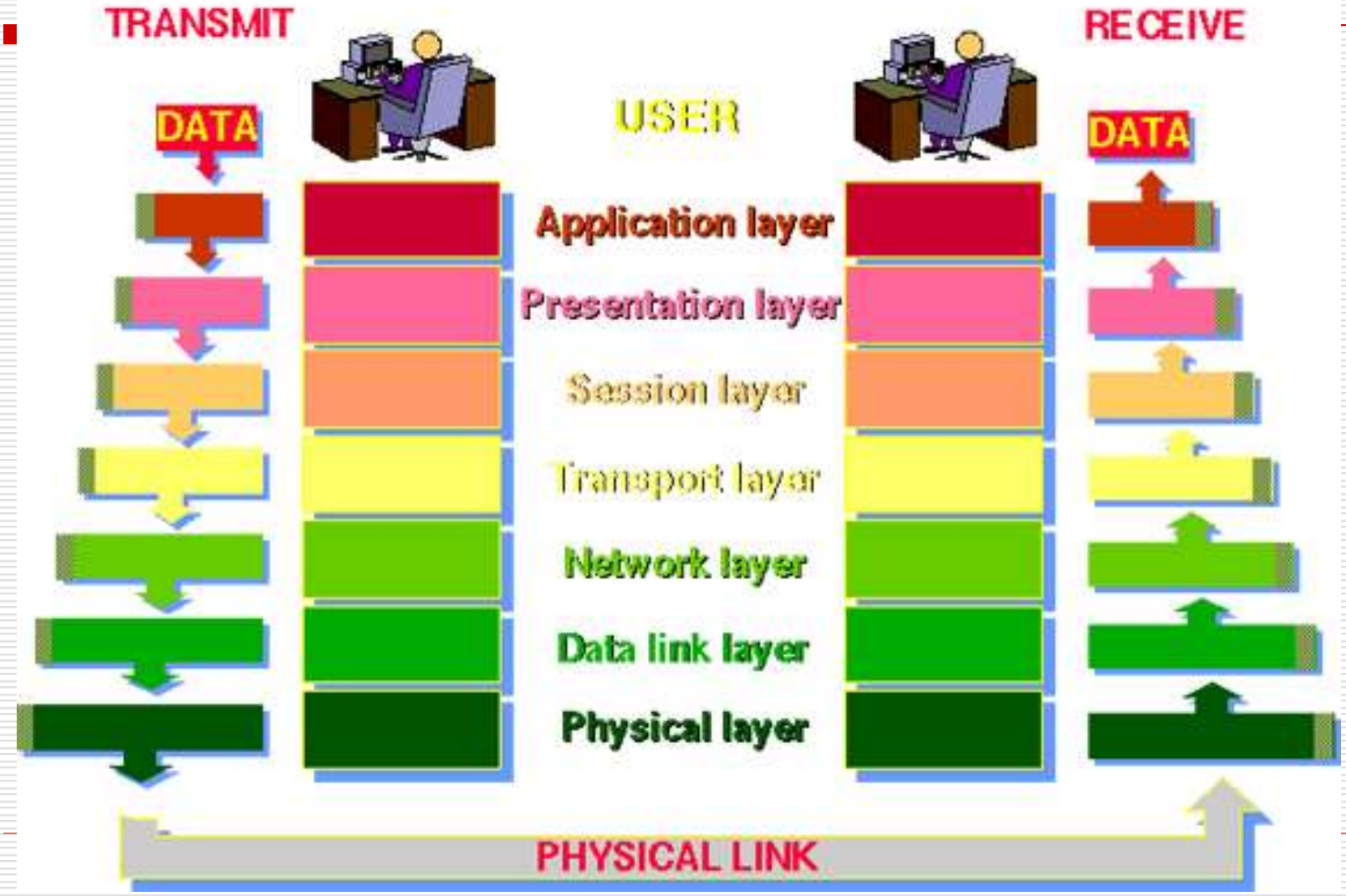
The main idea

- The communication between computers can be broken down into layers.
  - Each layer is characterized by its functions and how it interfaces with the adjacent layers.
- Within the source's computer and starting at the user level, the communication is passed down through the layers to the lowest layer where it is sent through some transmission medium.

The main idea (Cont.)

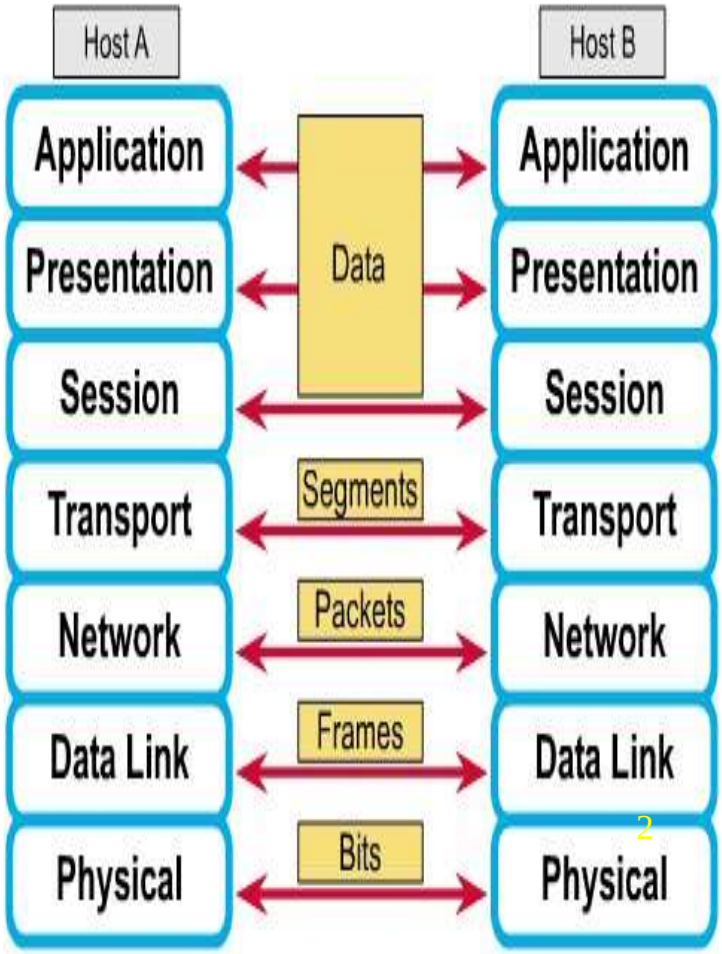
- The communication travels at the lowest layer (physical), occasionally rising up to the second layer (bridge) or third layer (router) until it reaches the destination.
- The communication now passes up through the layers.

THE 7 LAYERS OF OSI

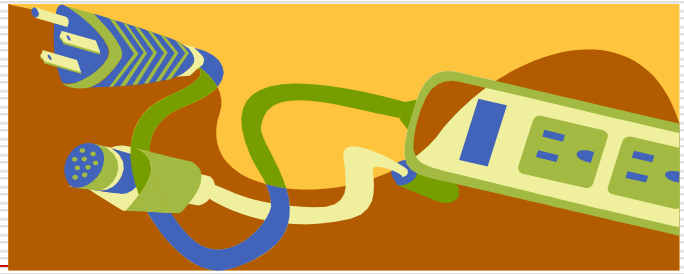


How Does It All Work Together

- Each layer contains a Protocol Data Unit (PDU)
  - PDU's are used for peer-to-peer contact between corresponding layers.
  - Data is handled by the top three layers, then Segmented by the Transport layer.
  - The Network layer places it into packets and the Data Link frames the packets for transmission.
  - Physical layer converts it to bits and sends it out over the media.
  - The receiving computer reverses the process using the information contained in the PDU.

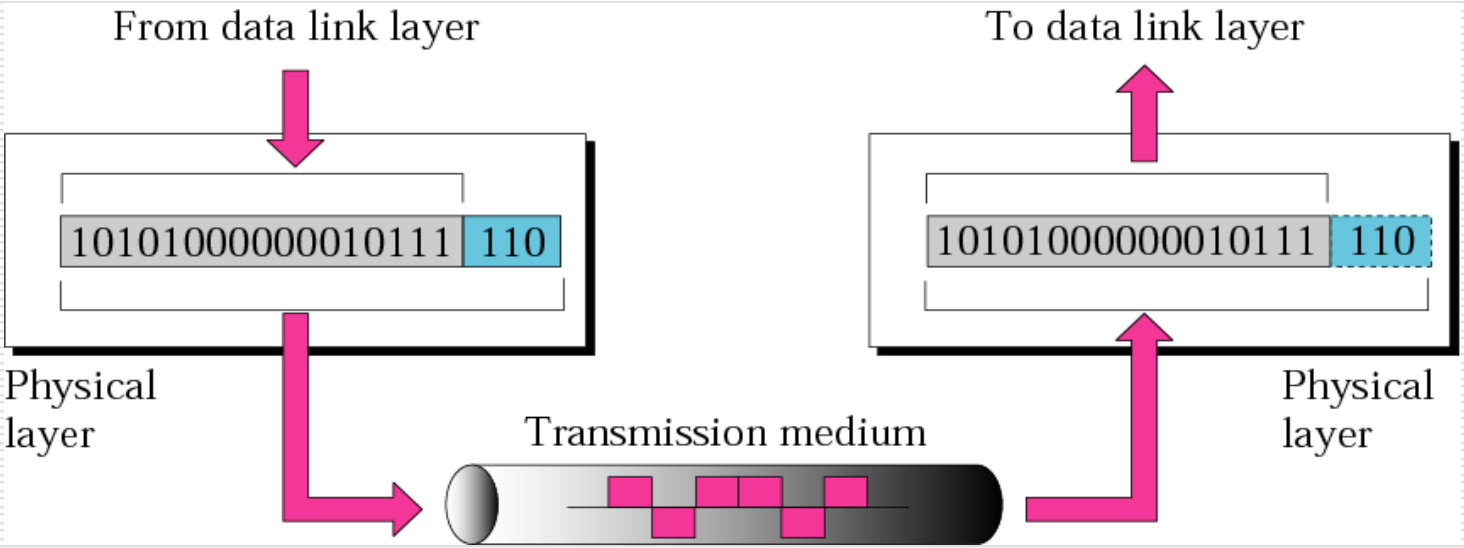


Layer 1: Physical



- There is no interpretation at this level, a stream of 1's and 0's are put into a form convenient for transmission.
- This level is the most hardware oriented. It includes specifications about
  - NIC card speeds
  - Types and lengths of cable
  - Voltage characteristics (range, level or edge)

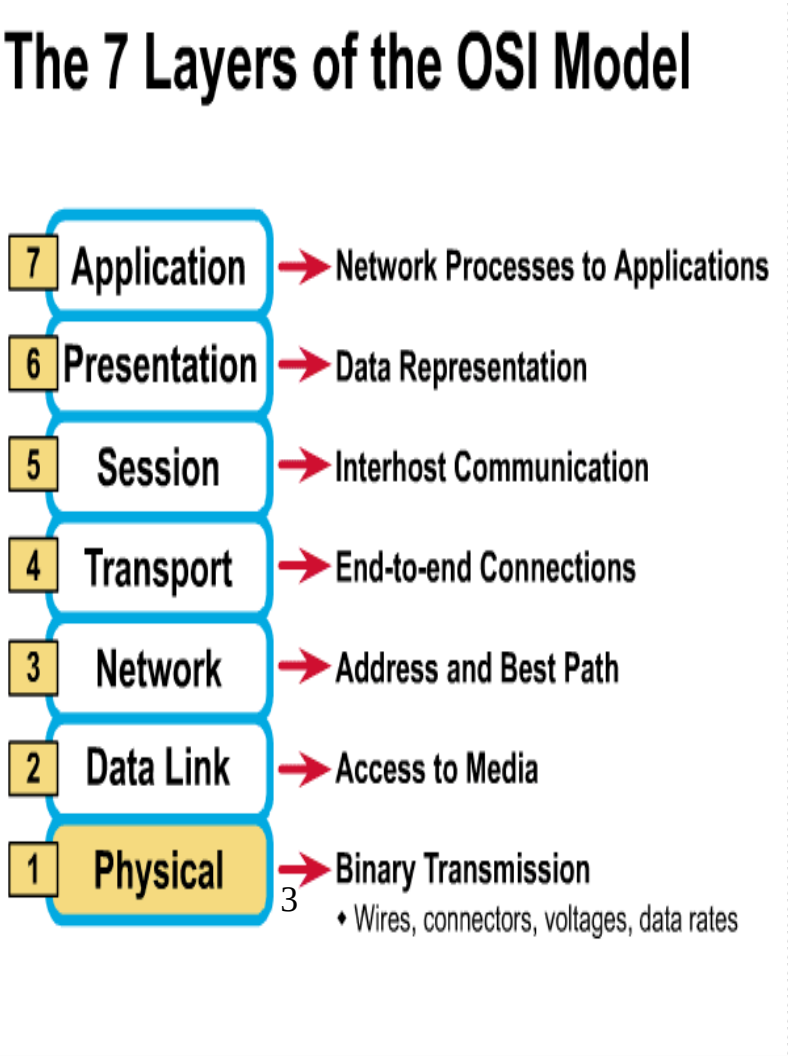
Physical layer



The physical layer is responsible for the movement of individual bits from one hop (node) to the next.

Physical Layer

- Determines the specs for all physical components
  - Cabling
  - Interconnect methods (topology / devices)
  - Data encoding (bits to waves)
  - Electrical properties
- Examples:
  - Ethernet (IEEE 802.3)
  - Token Ring(FDDI) (IEEE 802.5)
  - Wireless (IEEE 802.11b)



Physical Layer (cont)

- What are the Physical Layer components on my computer?
- NIC
  - Network Interface Card
  - Has a unique 12 character Hexadecimal number permanently burned into it at the manufacturer.
  - The number is the MAC Address/Physical address of a computer
- Cabling
  - Twister Pair
  - Fiber Optic
  - Coax Cable

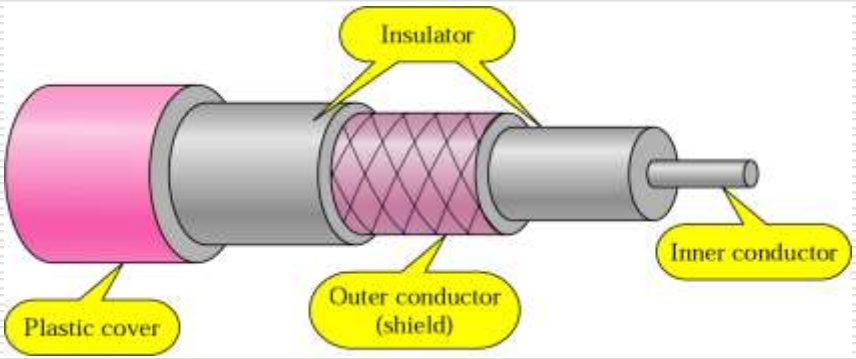
Transmission Media

- **Two main categories:**
  - **Guided — wires, cables**
  - **Unguided — wireless transmission, e.g. radio, microwave, infrared, sound, sonar**
- **We will concentrate on guided media here:**
  - **Twisted-Pair cables:**
    - **Unshielded Twisted-Pair (UTP) cables**
    - **Shielded Twisted-Pair (STP) cables**
  - **Coaxial cables**
  - **Fiber-optic cables**

Coaxial cable

Copper Media: Coaxial Cable

- Coaxial cable is a copper-cored cable surrounded by a heavy shielding and is used to connect computers in a network.
- Outer conductor shields the inner conductor from picking up stray signal from the air تداخل الإشارة وتقويتها.
- High bandwidth but lossy channel.
- Repeater is used to regenerate the weakened signals.

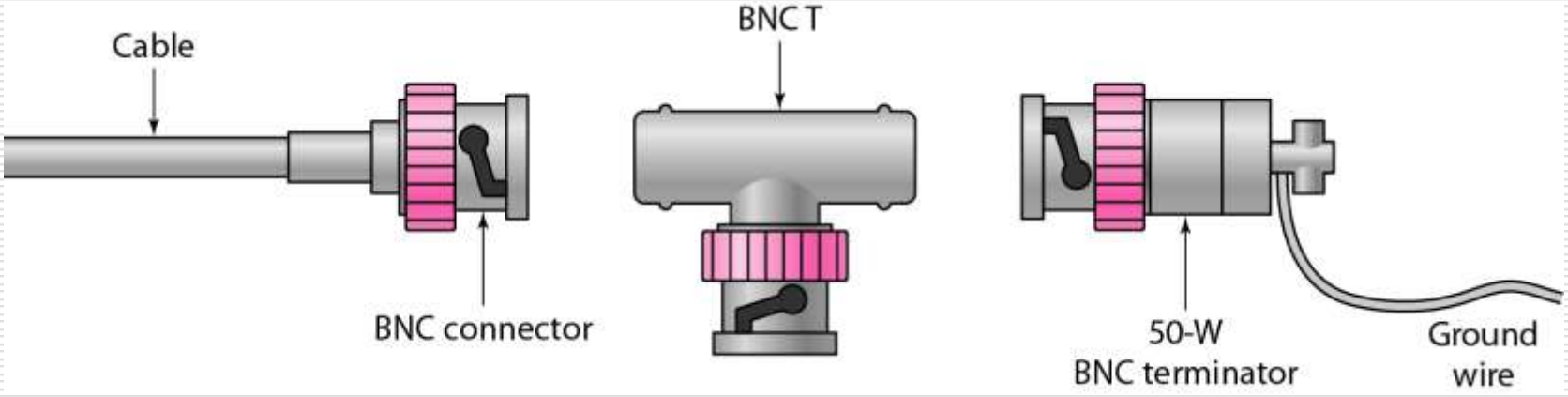


Category	Impedance	Use
RG-59	75 Ω	Cable TV
RG-58	50 Ω	Thin Ethernet
RG-11	50 Ω	Thick Ethernet

Coaxial Cables

- In general, coaxial cables, or coax, carry signals of higher freq (low volt)(100KHz–500MHz) than UTP cables
- Outer metallic wrapping serves both as a shield against noise and as the second conductor that completes the circuit
- Plastic jacket(pvc , Teflon) to avoid noise.
- Used in TV receivers ,radio, telephone networks

Figure 7.8 *BNC connectors*



Male and Female coax cables

Coaxial Cable Applications

- Most versatile medium
- Television distribution
  - Ariel to TV
  - Cable TV
- Long distance telephone transmission
  - Can carry 10,000 voice calls simultaneously
  - Being replaced by fiber optic
- Short distance computer systems links

Coaxial Cables Advantages

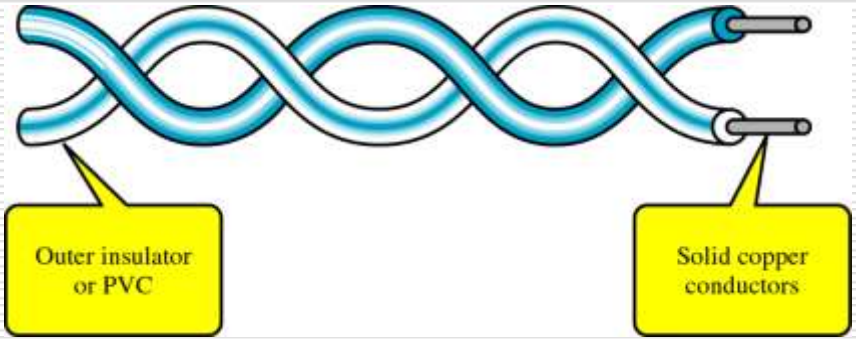
- The cost of coaxial cable is less.
- It is less susceptible to noise or interference compare to twisted pair cable.
- It supports high bandwidth signal transmission compare to twisted pair.
- It allows high transfer rates with coaxial cable having better shielding materials.
- its shielded design, which allows the cable's copper core to transmit data quickly, without succumbing to interference or damage from environment factors.

Coaxial Cables Disdvantages

- It is expensive to install for longer distances due to its thickness and stiffness.
- It must be grounded to prevent interference.

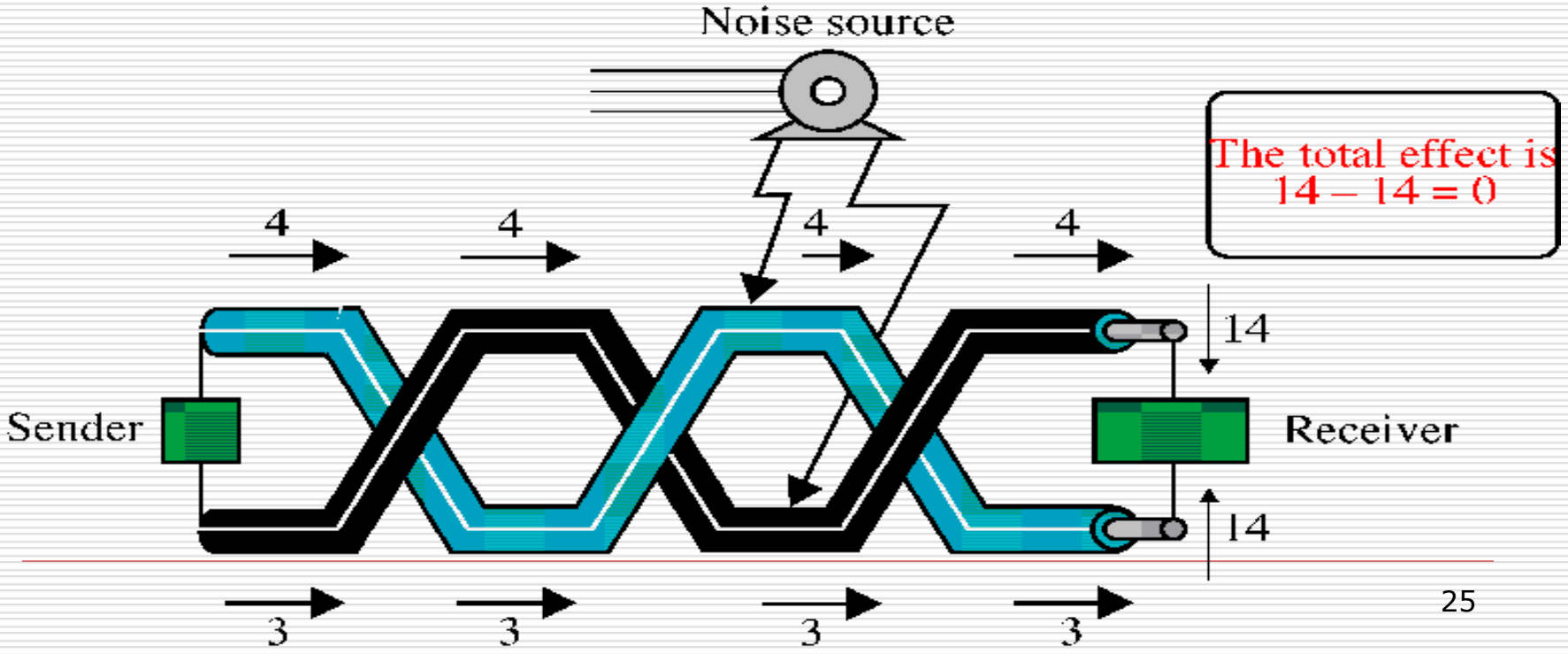
Copper Media: Twisted Pair

- Twisted-pair is a type of cabling that is used for telephone communications and most modern Ethernet networks.
- A pair of wires forms a circuit that can transmit data. The pairs are twisted to provide protection against crosstalk(minimize interference), the noise generated by adjacent pairs.
- Multiple individually insulated wires that are twisted together in pairs .



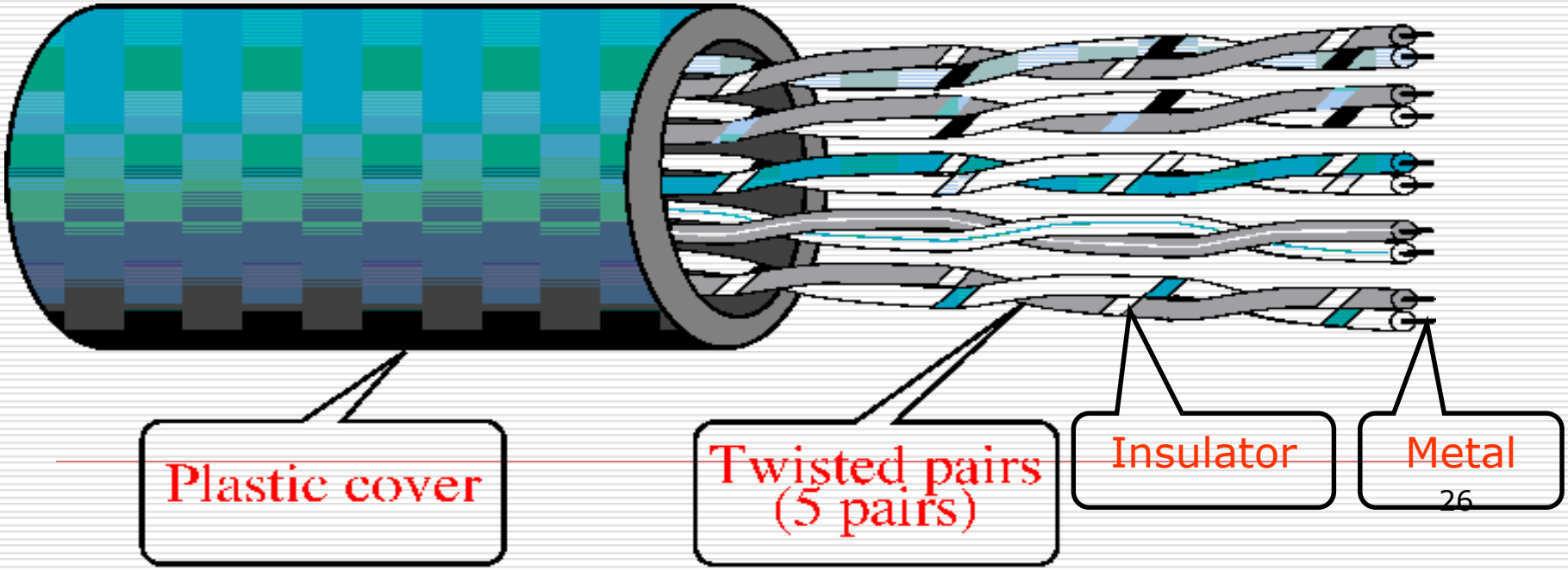
Twisted-Pair Cables

- If the pair of wires are not twisted, electromagnetic noises from, e.g., motors, will affect the closer wire more than the further one, thereby causing errors

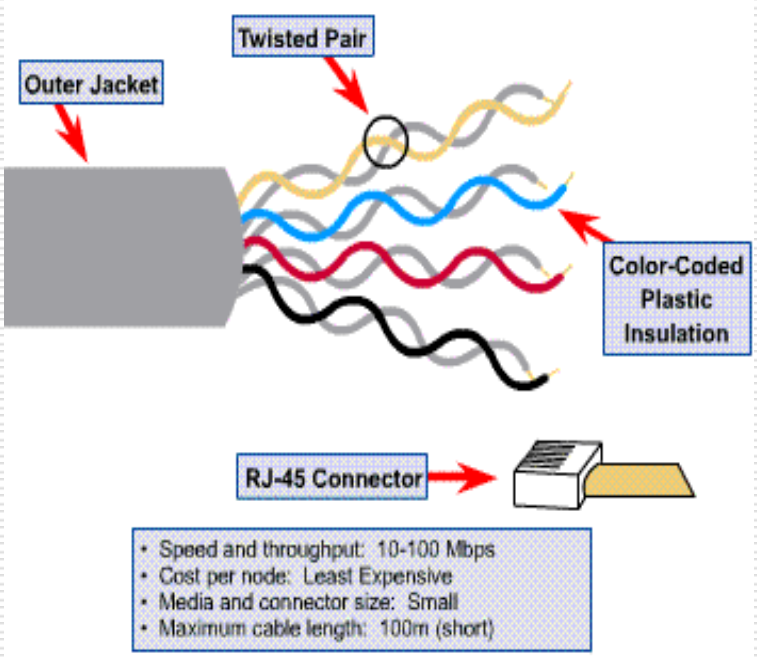


Unshielded Twisted-Pair (UTP)

- Typically wrapped inside a plastic cover (for mechanical protection)
- A sample UTP cable with 5 unshielded twisted pairs of wires

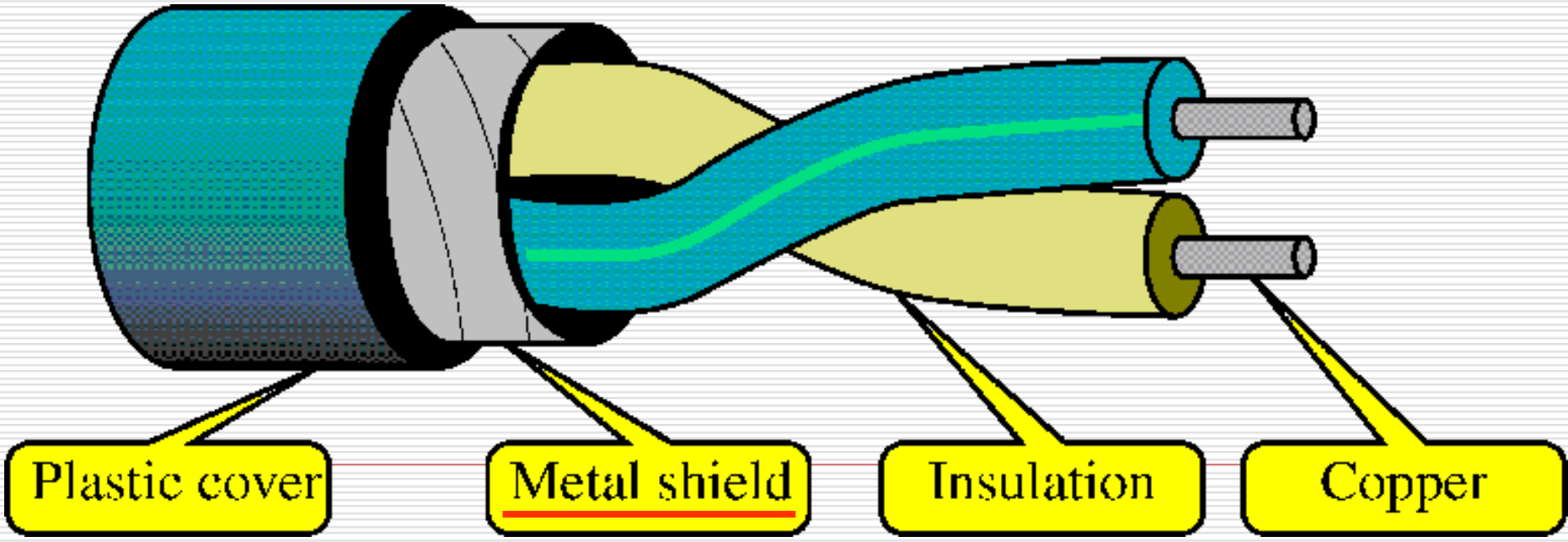


Unshielded Twisted Pair (UTP)

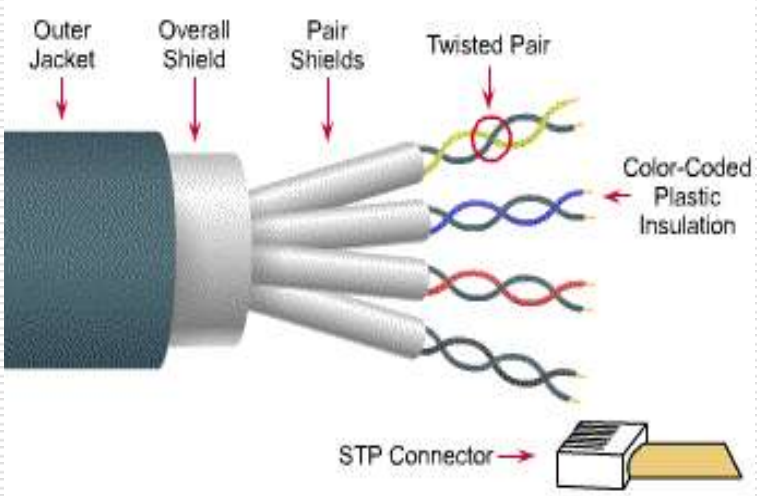


Shielded Twisted-Pair (STP)

- **STP cables are similar to UTP cables, except there is a metal foil or braided-metal-mesh cover that encases each pair of insulated wires**



Shielded Twisted Pair (STP)



Twisted Pair (Cat 5/5e, Cat 6)

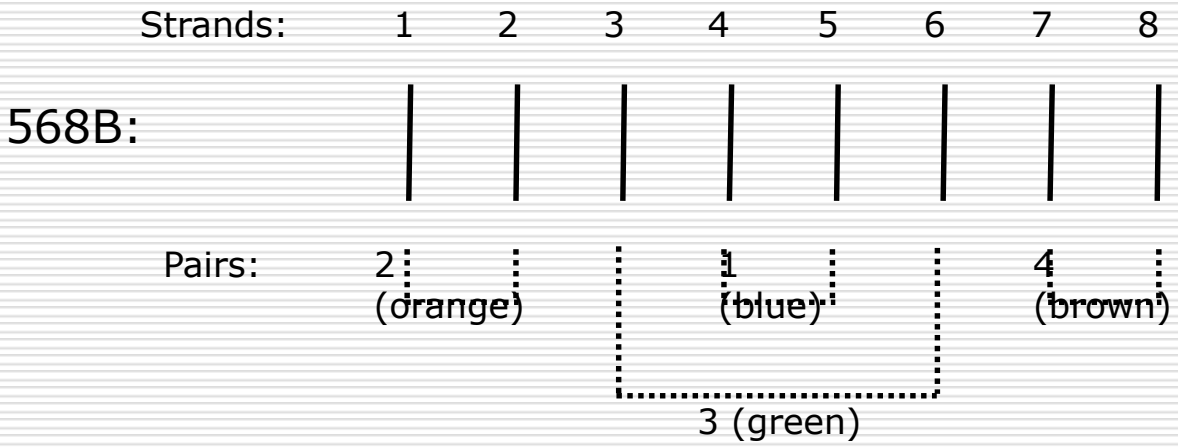
- Unshielded twisted pairs. Twists in wire keep down interference (from fluorescent lights, for example). Cat5e has more twists than Cat5, costs a bit more, works better for Gigabit, can exceed the 100m limitation for 100Mbit ethernet. Cat6 even more so.
- Cat3 and 4 are older, fewer twists, similar to phone, only good for 10Mbit. Phones work on Cat5/5e so current University standard is Cat5e (or Cat6 for special situations) everywhere. You can mix them, so don't worry about buying Cat6 jumpers if you want.

Twisted Pair (Cat 5/5e, Cat 6)

- Good for up to 100m, we don’t like to go over 80m when wiring a building though.
- Standard connecter: RJ45.
- Star topology: each user gets their own path, easy to troubleshoot, costs more than a shared topology. Troubleshooting costs so much that bus and ring (shared) topologies are functionally dead.

Twisted Pair (continued)

- Common Terms: 10BaseT, 100BaseT, 1000BaseT. The "T" is for Twisted pair, the number is the speed, the base is "baseband".
- 8 strands, 4 pairs. A couple of different standards, but 568A and 568B are the most common. Stanford uses 568B (for 568A, swap the labels for pairs 2 and 3, but no real functional difference):



10BaseT and 100BaseT only use pairs 2 and 3, so you may see some cables with only 4 strands, but since 1000T (gigabit) uses all pairs, don't keep those cables.

Categories of UTP Cables

EIA classifies UTP cables according to the quality:

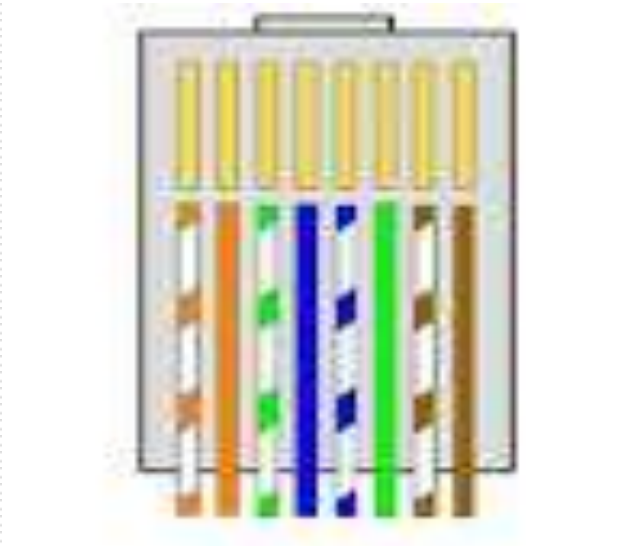
- *Category 1* — ((four twisted wire pairs)(8 wires))the lowest quality, only good for voice, mainly found in very old buildings, not recommended now
- *Category 2* — ((four twisted wire pairs)(8 wires)) good for voice and low data rates (up to 4Mbps for low-speed token ring networks)
- *Category 3* — ((four twisted wire pairs)(8 wires) at least 3 twists per foot, for up to 10 Mbps (common in phone networks in residential buildings)

Categories of UTP Cables

- *Category 4* — ((four twisted wire pairs)(8 wires) up to 16 Mbps (mainly for token rings)
- *Category 5* (or *5e*) — ((four twisted wire pairs)(8 wires) up to 100 Mbps (common for networks targeted for high-speed data communications)
- *Category 6* — ((four twisted wire pairs)(8 wires) more twists than Cat 5, up to 1 Gbps
- *Category 6a* — ((four twisted wire pairs)(8 wires) more twists than Cat 6, up to 10 Gbps,improve cross talk

Connecting UTP

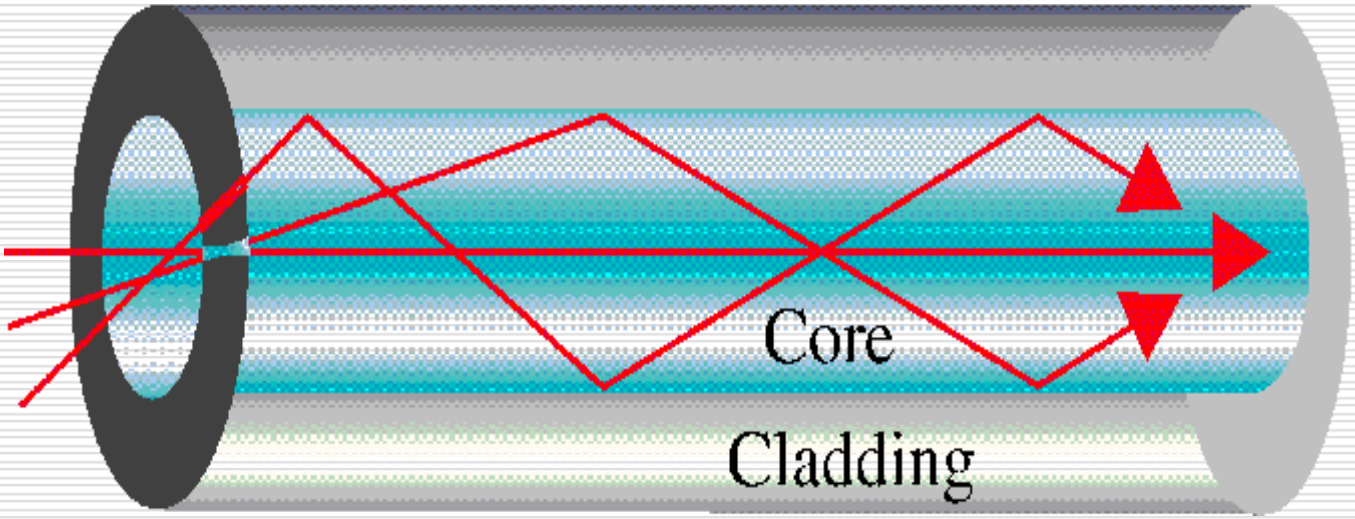
- *We use RJ(registered jack) connector .*
- *RJ11 used with UTP cable for phones that use 4 wires(in home).*
- *RJ45 used in LANs.*



Fiber-Optic Cables

- Light travels at 3×10^8 ms^{-1} in free space and is the fastest possible speed in the Universe
- Light slows down in denser media, e.g. glass
- Refraction occurs at interface, with light bending away from the normal when it enters a less dense medium
- Fiber optic cabel transmits digital signals using light impulses.

- An optical fiber consists of a core (denser material glass or plastic) and a cladding (less dense material)
- Glass travels for long distance but plastic is cheaper.
- The cabel is either single mode fiber(SMF)or multimode fiber(MMF)
- Simplest one is a multimode step-index optical fiber cladding)
- Light bounces back and forth along the core
- Common light sources: LEDs and lasers


Core
Cladding

Advantages and Disadvantages

- ☺ Noise resistance — external light is blocked by outer jacket
- ☺ Less signal attenuation — a signal can run for miles without regeneration (currently, the lowest measured loss is about ~4% or 0.16dB per km)
- ☺ Higher bandwidth — currently, limits on data rates come from the signal generation/reception technology, not the fiber itself
- ☺ It can transmit up to 40km.
- ☹ Cost — Optical fibers are expensive
- ☹ Installation/maintenance — any crack in the core will degrade the signal, and all connections must be perfectly aligned

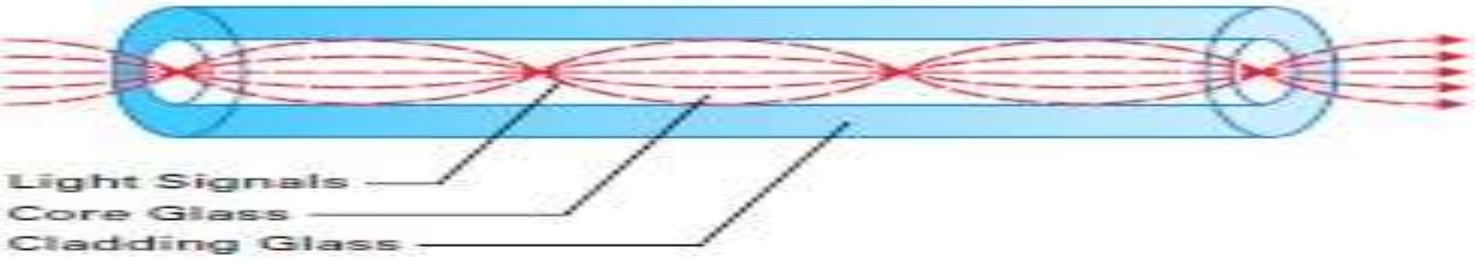
Single –Mode Fiber

- is a common type of optical fiber that is used to transmit over longer distances with very high speed
- is a single glass fiber strand used to transmit a single mode or ray of light.
- Light-emitting diodes (LEDs) and laser are light sources in SMF.
- Single-mode fiber provides users with a greater transmission rate in addition to nearly 50 times longer distance as opposed to multi-mode fiber.

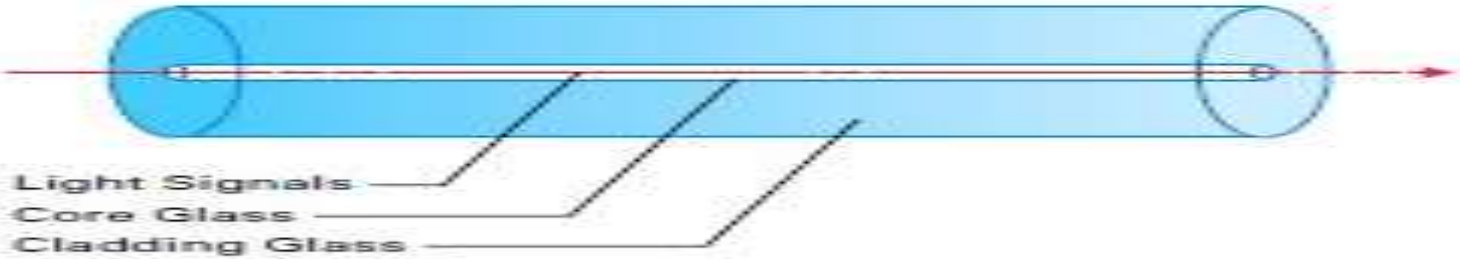
Multi –Mode Fiber

- Is designed to carry multiple light rays or modes simultaneously on numerous paths as it travels through the core and is reflected back, each at a marginally different reflection angle inside the optical fiber core.
- Multi-mode fiber provides users with high bandwidth at high speeds across moderate distances
- Multi-mode fibers may not be suitable for high-speed data transmission. It is not advisable to mix and match fibers either. Attempting to connect a single-mode fiber with a multi-mode fiber may result in a 20-dB loss, which is 99% of the total power.

Optical Multi Mode - OM



Optical Single Mode - OS



Optical fibre diameters relative size comparison

Fiber optic connectors

- ST (straight tip) was probably still most popular connector for multimode networks .
- SC(square connector) was the connector standardized in TIA-568-A, but was not widely used at first because it was twice as expensive as a ST. Now it's only a bit more expensive and much more common

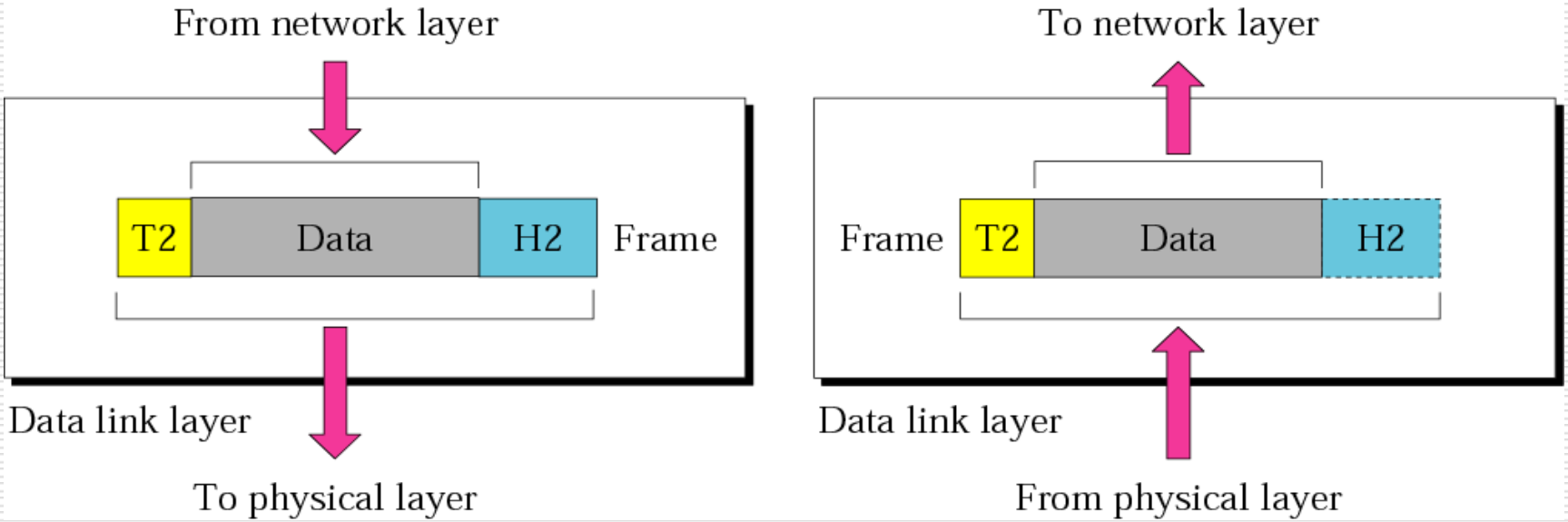
Layer 2: The data-link layer

- At this layer one begins to consider bytes instead of just bits, one examines some of the information content of the signal (at least the address and some of the error detection sequencing)
- Recall that bridges operate at this level
  - They know where a packet is headed.
  - They know whether or not it has been involved in a collision.
  - Bit stuffing occurs at this level.

Layer 2: Data Link Layer

- Packages raw bits from the Physical layer into frames (logical, structured packets for data).
- Provides reliable transmission of frames
  - It waits for an acknowledgment from the receiving computer.(use Mac address to ensure it delivers to right device)
  - Retransmits frames for which acknowledgement not received
- It handles synchronization (timing).
  - It must know where one bit ends and the next one begins.
  - It must know where one byte ends and the next one begins

Data link layer



The data link layer is responsible for moving frames from one hop (node) to the next.

Header contain source and destination address

Data Link Layer

- Data link layer attempts to provide reliable communication over the physical layer interface.
- Breaks the outgoing data into frames and reassemble the received frames.
- Create and detect frame boundaries.
- Handle errors by implementing an acknowledgement and retransmission scheme.
- Implement flow control.
- Supports points-to-point as well as broadcast communication.
- Supports simplex, half-duplex or full-duplex communication.

Data link sublayers

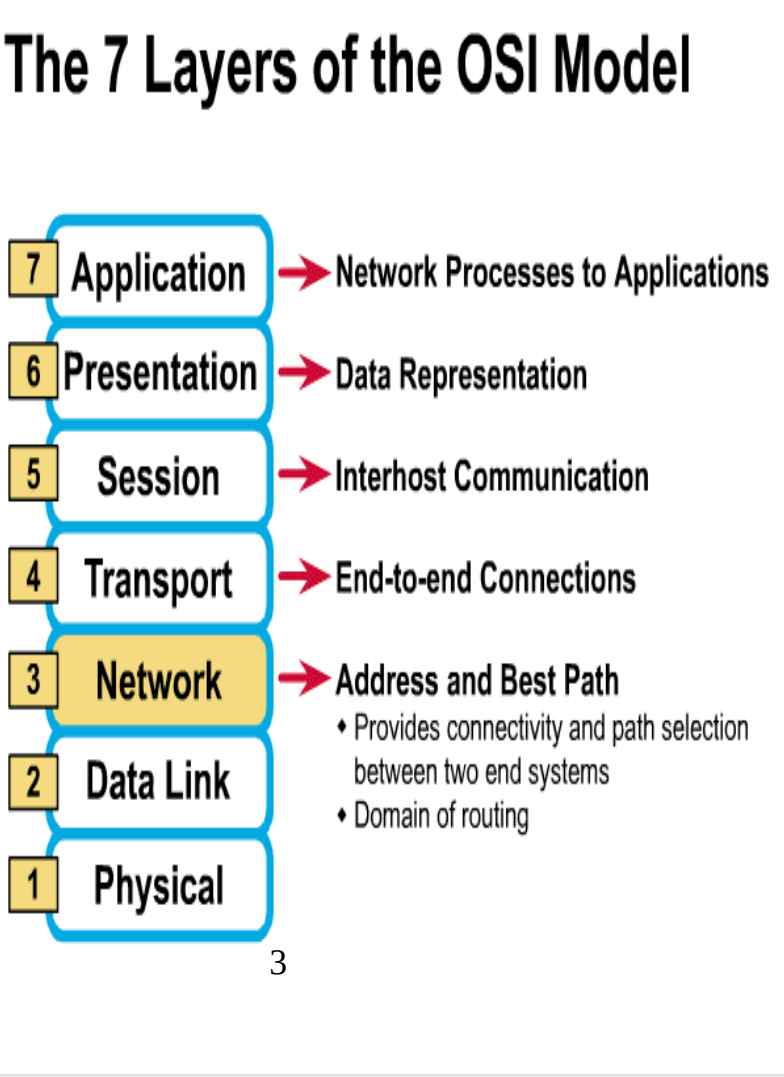
- The data link layer is divided into two sublayers:
  - The **MAC** (Media Access Control) sublayer: takes the signal from or puts the signal onto the transmission line ("touches" physical layer).
  - The LLC (Logical Link Control) sublayer: starts to interpret the signal as data, includes timing (synchronization) and error checking.

Sub-layers of the Data Link Layer

- MAC (Media Access Control)
  - Gives data to the NIC
  - Controls access to the media through:
    - CSMA/CD Carrier Sense Multiple Access/Collision Detection
    - Token passing
- LLC (Logical Link Layer(802.2)
  - A host receives a frame and looks in the LLC header to find out where the packet is destined.
  - Can detect some transmission errors using a Cyclic Redundancy Check (CRC). If the packet is bad the LLC will request the sender to resend that particular packet.

Network Layer

- Provides network-wide addressing and a mechanism to move packets between networks (routing)
- Responsibilities:
  - Network addressing
  - Routing
- Example:
  - IP from TCP/IP



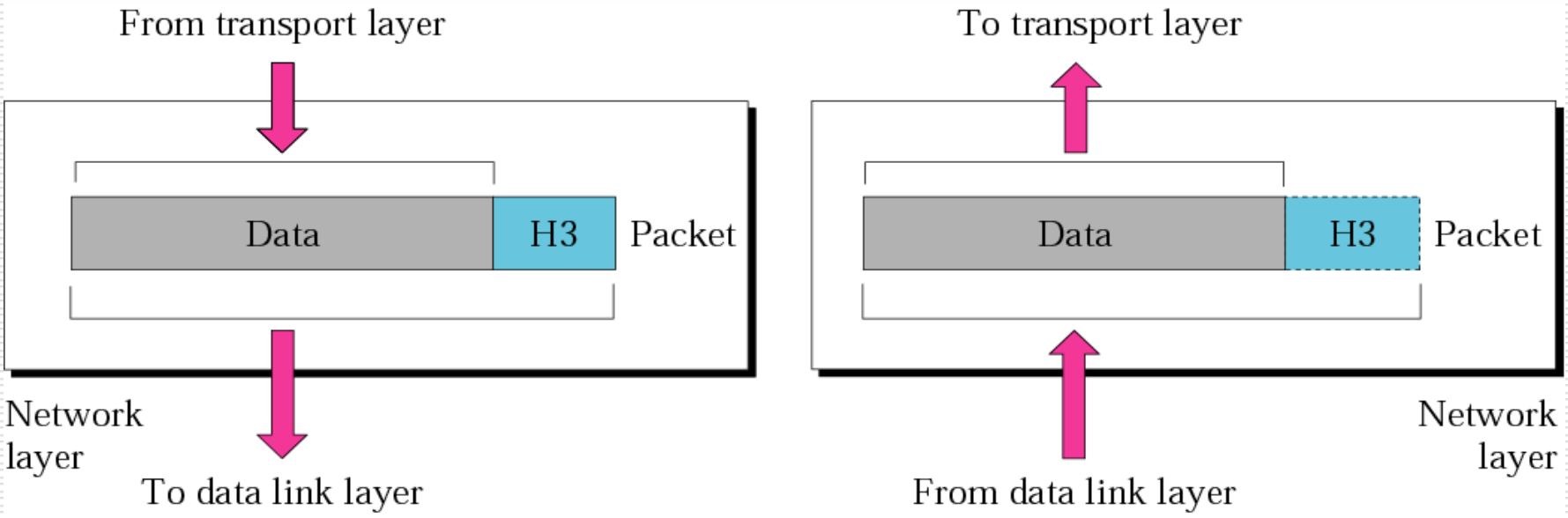
Layer 3: The network layer

- The router acted at this layer.
- One of the main functions of the layer is routing. Store and forward are network layer functions.
- Building the routing tables, troubleshooting the routing tables when there is a lot of traffic or if a connection goes down.
- The network layer also gathers related packets (packet sequencing).

Layer 3: Network Layer

- Manages addressing/routing of data within the subnet
  - Addresses messages and translates logical addresses and names into physical addresses.
  - Determines the route from the source to the destination computer
  - Manages traffic problems, such as switching, routing, and controlling the congestion of data packets.
- Routing can be:
  - Based on static tables
  - determined at start of each session
  - Individually determined for each packet, reflecting the current network load.

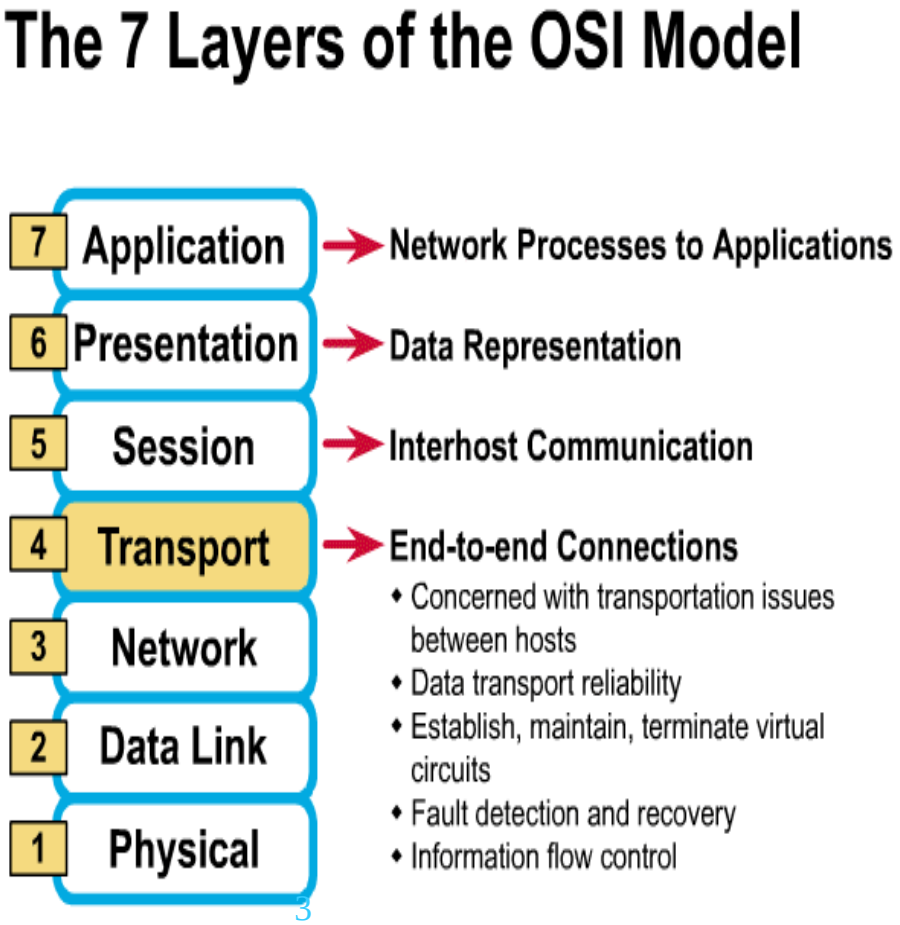
Network layer



The network layer is responsible for the delivery of individual packets from the source host to the destination host.

Transport Layer

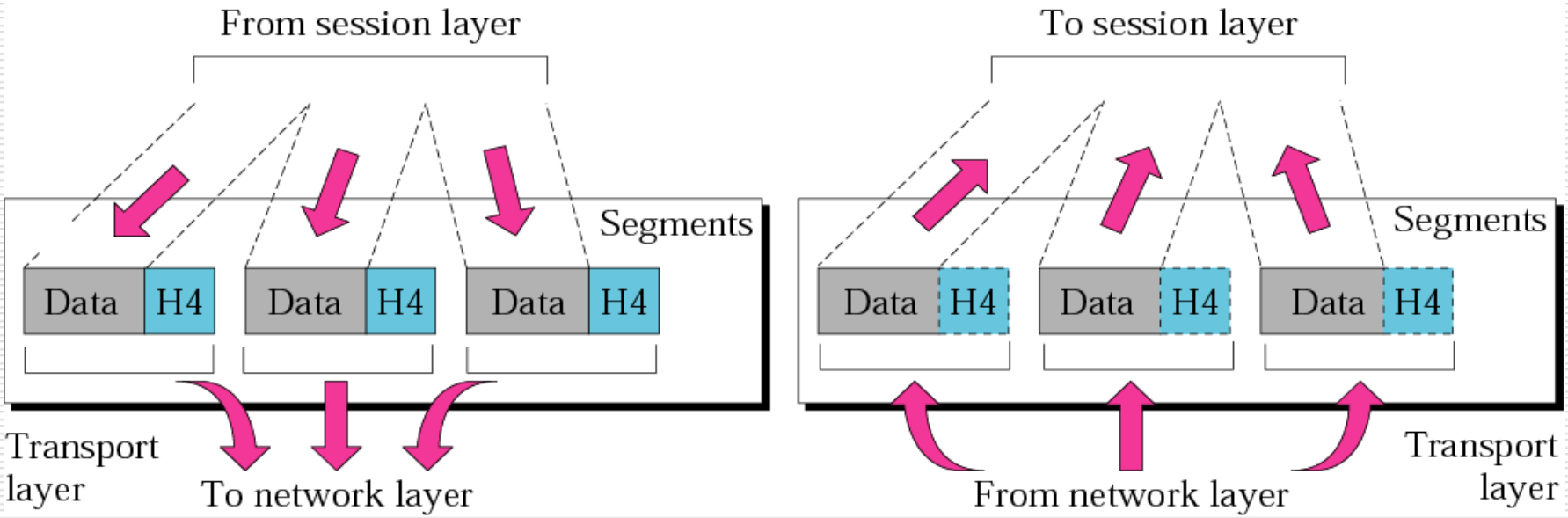
- Provides reliable data delivery
- It's the TCP in TCP/IP
- Receives info from upper layers and segments it into packets
- Can provide error detection and correction



Transport Layer

- Purpose of this layer is to provide a reliable mechanism for the exchange of data between two processes in different computers.
- Ensures that the data units are delivered error free.
- Ensures that data units are delivered in sequence.
- Ensures that there is no loss or duplication of data units.
- Provides connectionless or connection oriented service(logical connection between sending host TCP and destination host TCP) called virtual circuit.
- acknowledgments

Transport layer(cont)



The transport layer is responsible for the delivery of a message from one process to another.

Transport layer (cont)

- As stated before, Layer 4 is the dividing line between inter-computer transactions and intra-computer transactions.
- Layer 4 manages end-to-end verification.
  - The lower layers make a "best effort" but if data is lost so be it. Layer 4 must ensure that the information was received intact.
- It does a higher-order error-checking.
- The transfer should be "transparent." The higher layers do not know the data came from another computer.

Transport layer (cont)

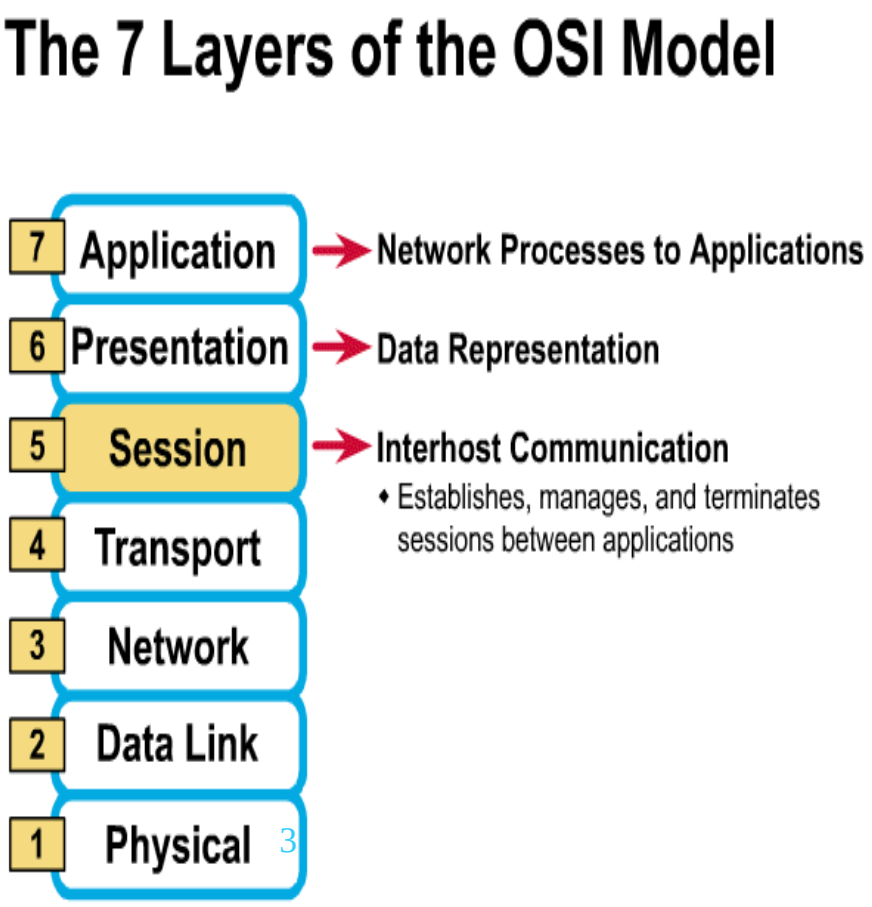
- At a node Layer 3 collects associated packets if one was dropped it may throw them all away.
- It is the responsibility of the source's Layer 4 to look for some acknowledgement that all packets arrived. If no acknowledgment is received, it should retransmit.

Transport layer (cont)

- Manages transmission packets
  - Repackages long messages when necessary into small packets for transmission
  - Reassembles packets in correct order to get the original message.
- Handles error recognition and recovery.
  - Transport layer at receiving acknowledges packet delivery.
  - Resends missing packets

Session Layer

- Allows applications to maintain an ongoing session
- Where is it on my computer?
  - Workstation and Server Service (MS)
  - Windows Client for NetWare (NetWare)



Layer 5: The session layer

- Recall when discussing connection-oriented schemes, we mentioned the idea of a "session."
- It is an agreement between a source and destination to communicate.
- This layer establishes, manages and terminates sessions between applications (they could be on the same computer or on different computers).

Session Layer(cont)

- Session layer provides mechanism for controlling the dialogue between the two end systems. It defines how to start, control and end conversations (called sessions) between applications.

- This layer requests for a logical connection to be established on an end-user's request.
- Any necessary log-on or password validation is also handled by this layer.

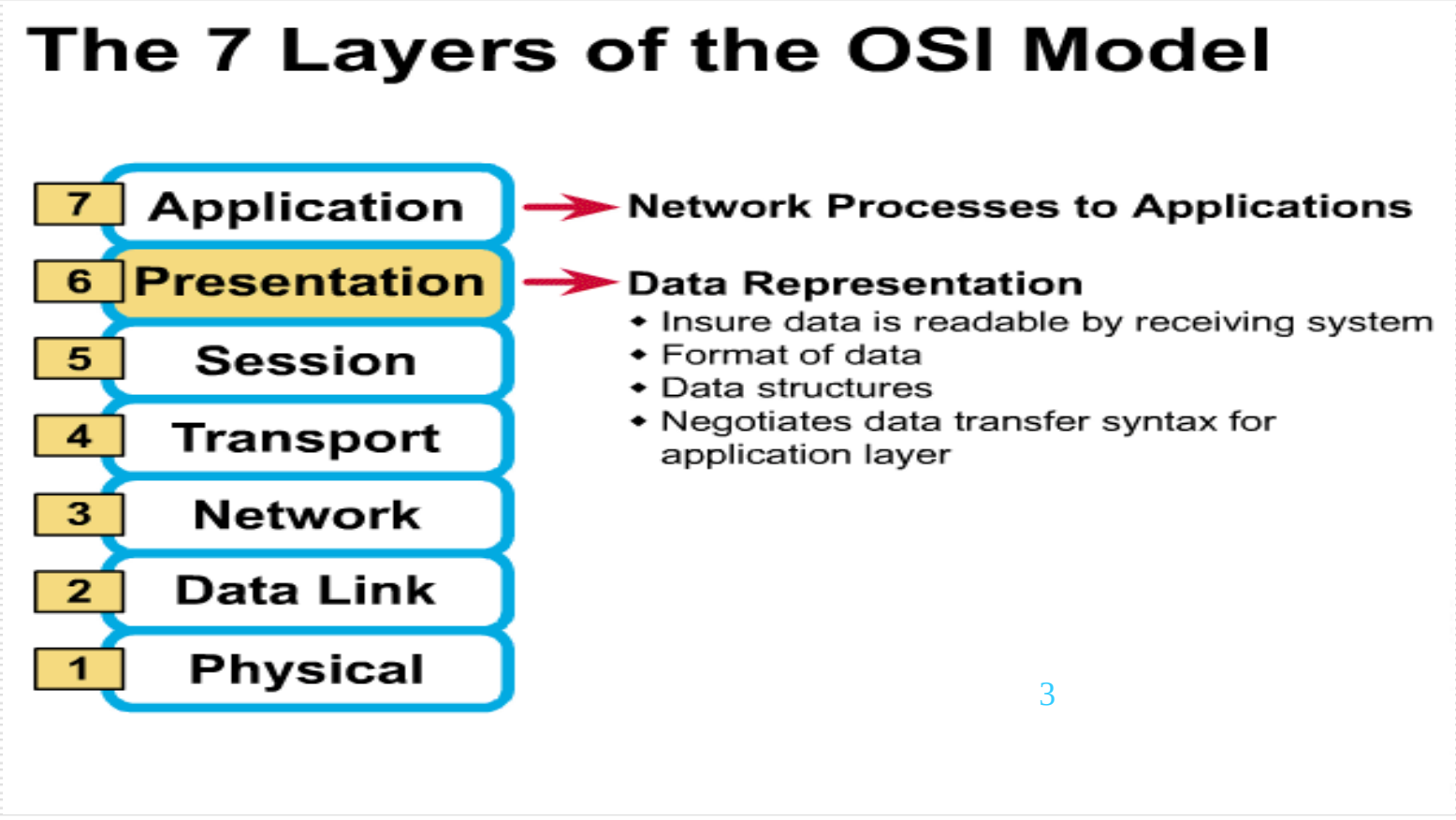
Session Layer(cont)

- Session layer is also responsible for terminating the connection.
- This layer provides services like dialogue discipline which can be full duplex or half duplex.
- Session layer can also provide check-pointing mechanism such that if a failure of some sort occurs between checkpoints, all data can be retransmitted from the last checkpoint.

Transmission Modes

- there are three modes of transmission(flow of signal between two connected devices):-
  - **simplex** mode :-the communication is unidirectional
  - **half-duplex** mode :-the communication is two directional but the channel is alternately used by the both the connected device
  - **full duplex** mode :-the communication is bi-directional, and the channel is used by both the connected device simultaneously.

Presentation Layer



Layer 6: The presentation layer

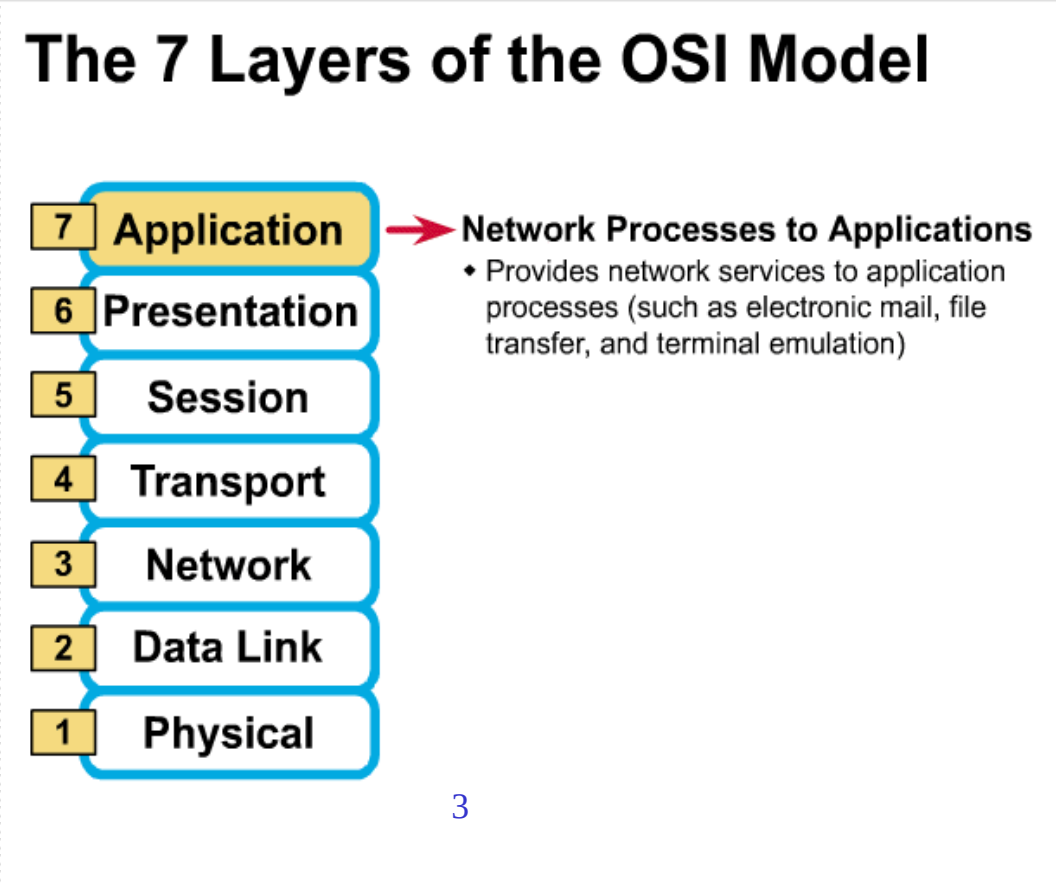
- This layer provides independence from differences in data representation (e.g., encryption) by translating from application to network format, and vice versa.
- The presentation layer works to transform data into the form that the application layer can accept. This layer formats and encrypts data to be sent across a network, providing freedom from compatibility problems. It is sometimes called the “syntax layer.”

Presentation Layer(cont)

- Related to representation of transmitted data
  - Translates different data representations from the Application layer into uniform standard format
- Providing services for secure efficient data transmission
  - e.g. data encryption(**cryptography**), and data compression.

The application layer

- Gives end-user applications access to network resources



Layer 7: The application layer

- This layer supports application and end-user processes.
- Communication partners are identified, quality of service is identified, user authentication and privacy are considered, and any constraints on data syntax are identified.

The application layer(cont)

- Everything at this layer is application-specific. This layer provides application services for file transfers, e-mail, and other network software services. Telnet and FTP are applications that exist entirely in the application level.
- These are **not applications** (like Word and Excel) but **services for** such **applications**!

Other References

- http://www.whatis.com
- http://www.webopedia.com
- MCSE TCP/IP for Dummies, Brandon
- http://www.iso.ch/iso/en/ISOOnline.frontpage