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- Introduction
  - What is Ethernet?
  - Market Analysis Data
- Technology
  - MAC Types
    - What is CSMA/CD?
    - Variables of CSMA
  - What is OSI Model?
  - What is TCP/IP Model?
  - Ethernet Frames
  - Ethernet PHY Specs
  - Ethernet MAC
  - Ethernet Cabling and Connectors
  - Ethernet Devices
- Ethernet & Home Networking
  - Motivation for home networking
  - Ethernet in HN
- Xilinx Solution
- Alliances
  - Gigabit Ethernet
  - IEEE 802.3
- Summary

MAC Types

- There are two Media Access Control(MAC) protocols defined for Ethernet:
  - Half-Duplex and Full-Duplex
- Half-Duplex is the traditional form of Ethernet that uses the CSMA/CD protocol
- Full-Duplex bypasses the CSMA/CD protocol
- Full-duplex mode allows two stations to simultaneously exchange data over a point to point link that provides independent transmit and receive paths

MAC Types (Half-Duplex)

- Refers to the transmission of data in just one direction at a time
- Half-Duplex Ethernet is the traditional form of Ethernet that uses the CSMA/CD
- Half duplex Ethernet assumes that all the "normal" rules of Ethernet are in effect on the local network

Carrier Sense Multiple Access Collision Detect(Half-Duplex)

- The network is monitored for presence of a transmitting station (carrier sense)
- The transmission is deferred if an active carrier is detected.
  - The station continues to monitor the network until the carrier ceases.
- If an active carrier is not detected, and the period of no carrier is equal to or greater than the interframe gap, then the station immediately begins transmission of the frame

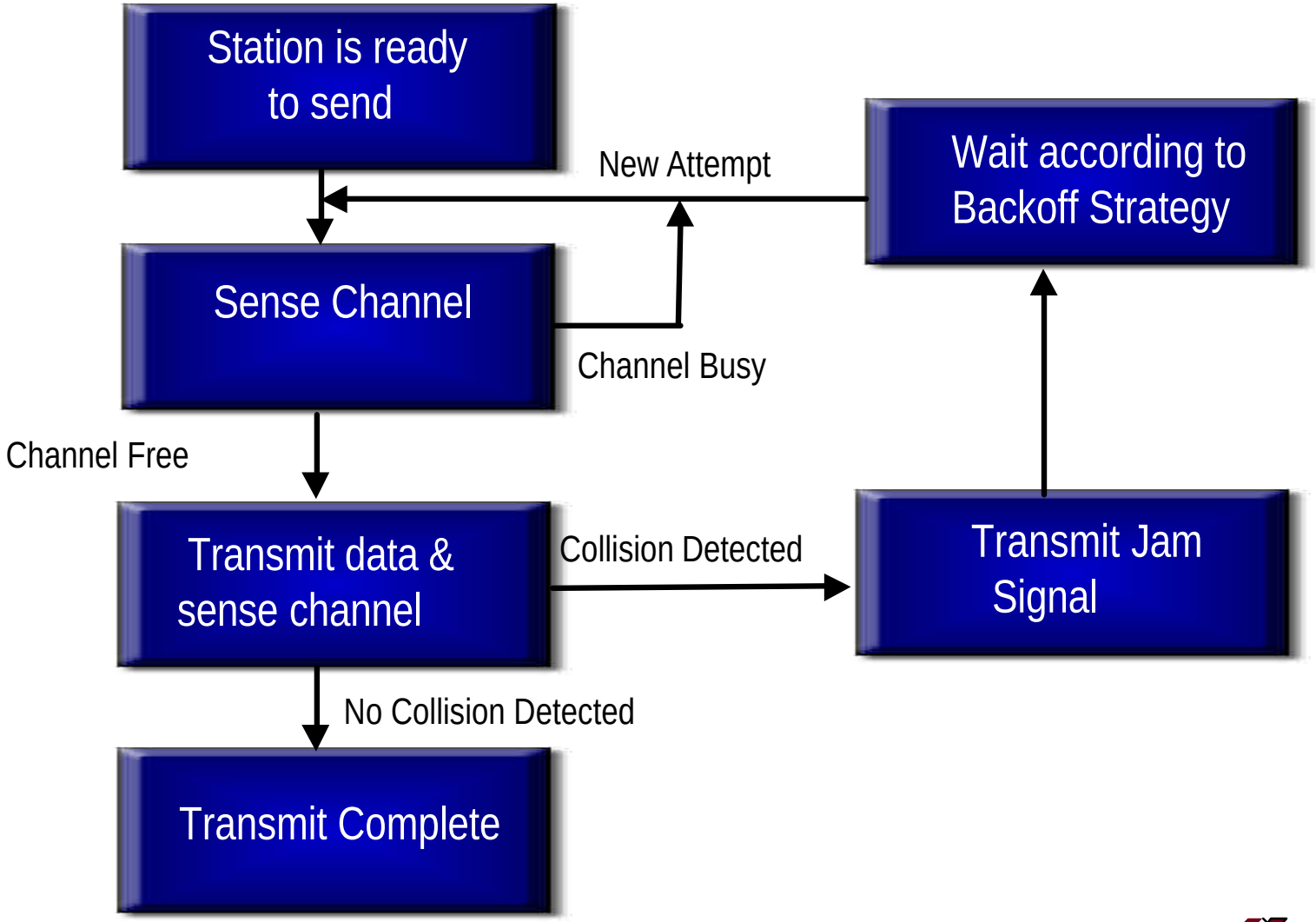
Carrier Sense Multiple Access Collision Detect (Half-Duplex)

- While the transmitting station is sending the frame, it monitors the medium for a collision
- If a collision is detected, the transmitting station stops sending the frame data and sends a 32-bit "jam sequence
  - The sequence jam is transmitted to ensure that the length of the collision is sufficient to be noticed by the other transmitting stations
- After sending the jam sequence the transmitting station waits a random period of time
  - This process is called "backoff"

Carrier Sense Multiple Access Collision Detect (Half-Duplex)

- If repeated collisions occur, then transmission is repeated
  - But the random delay is increased with each attempt
- This process repeats until a station transmits a frame without collision
- Once a station successfully transmits a frame, it clears the collision counter it uses to increase the backoff time after each repeated collision

CSMA/CD Flow


Station is ready to send
New Attempt
Wait according to Backoff Strategy
Sense Channel
Channel Busy
Channel Free
Transmit data & sense channel
Collision Detected
Transmit Jam Signal
No Collision Detected
Transmit Complete

Variations of CSMA Protocol (Half-Duplex)

- 1- persistent CSMA
  - When a station has frames to transmit, it first listens to the channel, if the channel is idle, the frame is sent
  - If the channel is busy, the station waits and transmit its frame as soon as the channel is idle
  - If a collision occurs, the stations waits a random amount of time and starts all over again
  - The station transmits with a probability of 1 whenever it finds the channel idle

Variations of CSMA Protocol (Half-Duplex)

- Non-persistent CSMA
  - When the channel is busy, the station simply gives up and tries at a later time
- p-persistent CSMA
  - When the channel is busy, the station will keep listening until the channel becomes idle (like 1- persistent)
  - Then the station transmits the frame with a probability of p
  - The station backs off with the probability of q = 1 - p

Slot Time (Half-Duplex)

- The "slot time" is a key parameter for half-duplex Ethernet network operation
- It is defined as 512 bit times for Ethernet networks operating at 10/100 Mbps, and 4096 bit times for Gigabit Ethernet
  - The 512 bit slot time establishes the minimum size of an Ethernet frame as 64-bytes
  - The 4096 bit slot time establishes the minimum size of a Gigabit Ethernet frame as 512-bytes
- The minimum transmission time for a complete frame must be at least one slot time

Slot Time (Half-Duplex)

- The slot time establishes a limit on the size of a network in terms of the maximum cable segment lengths and number of repeaters that can be in a path
  - If the size of a network grows too big, a phenomenon known as "late collisions" can occur
  - Late collisions are considered a failure in the network
- The slot time ensures that if a collision is going to occur, it will be detected within the first 512 bits (4096 for Gigabit Ethernet) of the frame transmission

MAC Types (Full-Duplex)

- Based on the IEEE 802.3x standard, “Full-Duplex” MAC type bypasses the CSMA/CD protocol
- Full-duplex mode allows two stations to simultaneously exchange data over a point to point link
- The aggregate throughput of the link is effectively doubled
  - A full-Duplex 100 Mb/s station provides 200 Mb/s of bandwidth

MAC Types (Full-Duplex)

- Full-Duplex operation is supported by:
  - 10-Base-T, 10Base-FL, 100Base-TX, 100Base-FX, 100Base-T2, 1000Base-CX, 1000Base-SX, 1000Base-LS, and 1000Base-T.
- Full-Duplex operation is NOT supported by:
  - 10Base5, 10Base2, 10Base-FP, 10Base-FB, and 100Base-T4.
- Full-Duplex operation is restricted to point to point links connecting exactly two stations

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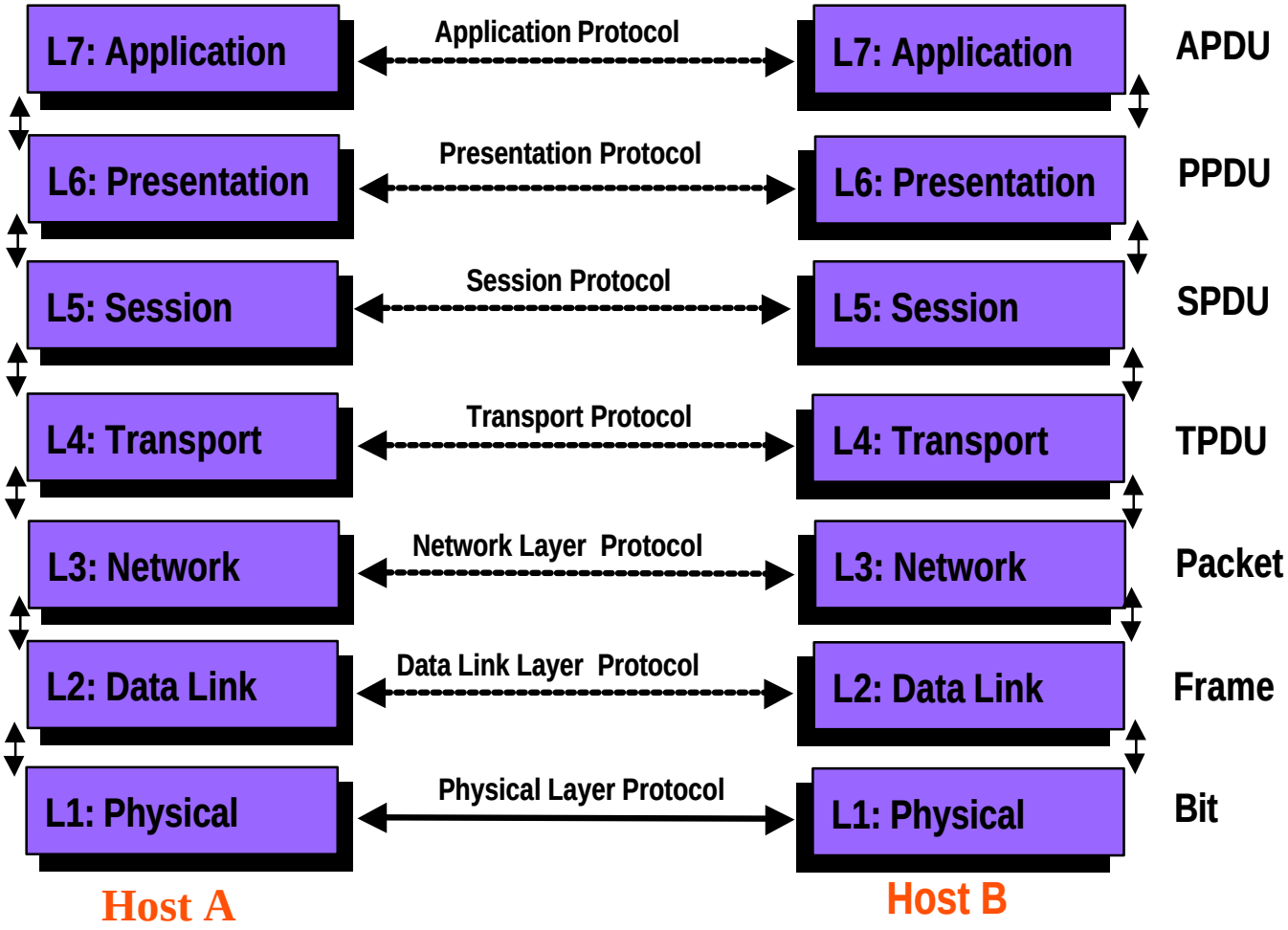
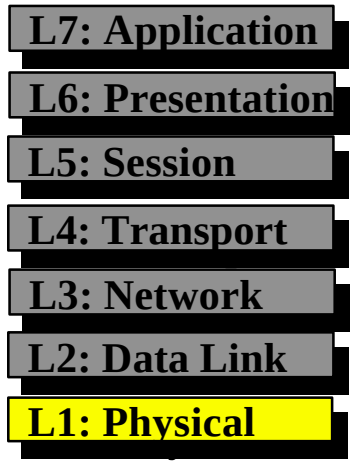
The OSI Reference Model



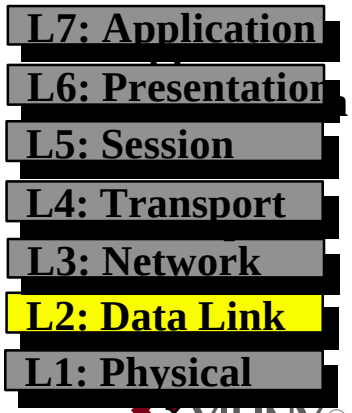
OSI Model

- The Open Systems Interconnect (OSI) reference model outlines 7 layers for an ideal network architecture.
- Physical Layer
  - The nuts and bolts layer, where the cable, connector and signaling specifications are defined
  - Describes the electrical, mechanical, and functional interface to the carrier
  - It includes:
    - Voltages and pulse coding of bits
    - Media and media interface
    - Line discipline (full or half duplex)
    - Pin Assignments



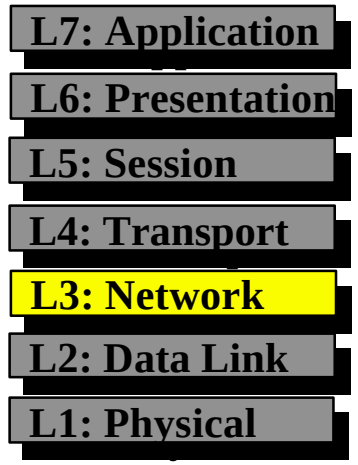
OSI Model- Data Link Layer

- Gets data packets on and off the wire
- Does error detection and correction and retransmission
- The primary purpose of the Data Link Layer is to provide error-free transmission of information between two end stations
- The MAC (Medium Access Control) on the lower half, deals with getting the data on and off the wire
- The LLC (Logical Link Control) on the upper half, does the error checking



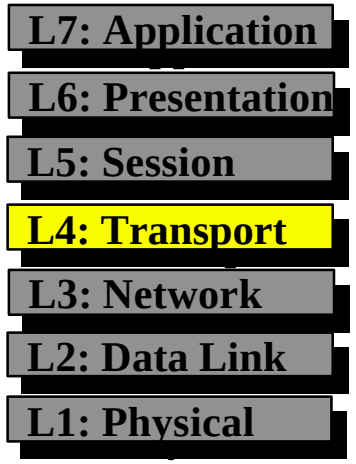
OSI Model (cont.)

- Network Layer
  - The Network Layer controls the operation of the network or sub-network
  - Routing and flow control are performed here
  - This is the lowest layer of the OSI model that can remain ignorant of the physical network
  - The general functions are:
    - Addressing messages
    - Routing messages
    - Controlling congestion
    - Translating addresses
    - Counting packets



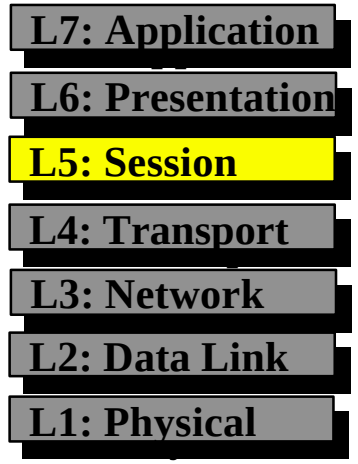
OSI Model (cont.)

- Transport Layer
  - Ensures the performance of the lower 3 layers
  - It provides a transparent, logical data stream between the end user and the network service
  - This is the lower layer that provides local user services
  - It provides the session layer with reliable message transfer facilities



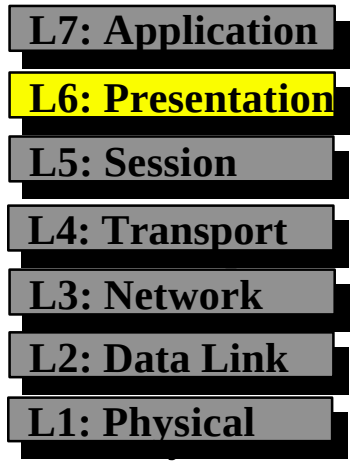
OSI Model (cont.)

- Session Layer
  - Control the communications between applications across a network
  - Testing for out-of-sequence packets and handling two-way communication are handled here



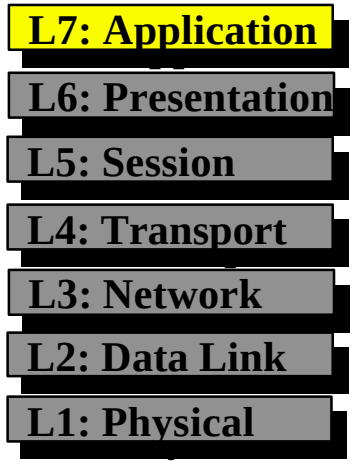
OSI Model (cont.)

- Presentation Layer
  - The Presentation Layer formats the data to be presented to the Application Layer
  - Differences in data representation are dealt with at this level
    - For example, UNIX-style line endings (CR only) might be converted to MS-DOS style (CRLF), or EBCIDIC to ASCII character sets
  - It can be viewed as the translator for the network
  - It also does:
    - Encryption
    - Encoding
    - Compression of data



OSI Model (cont.)

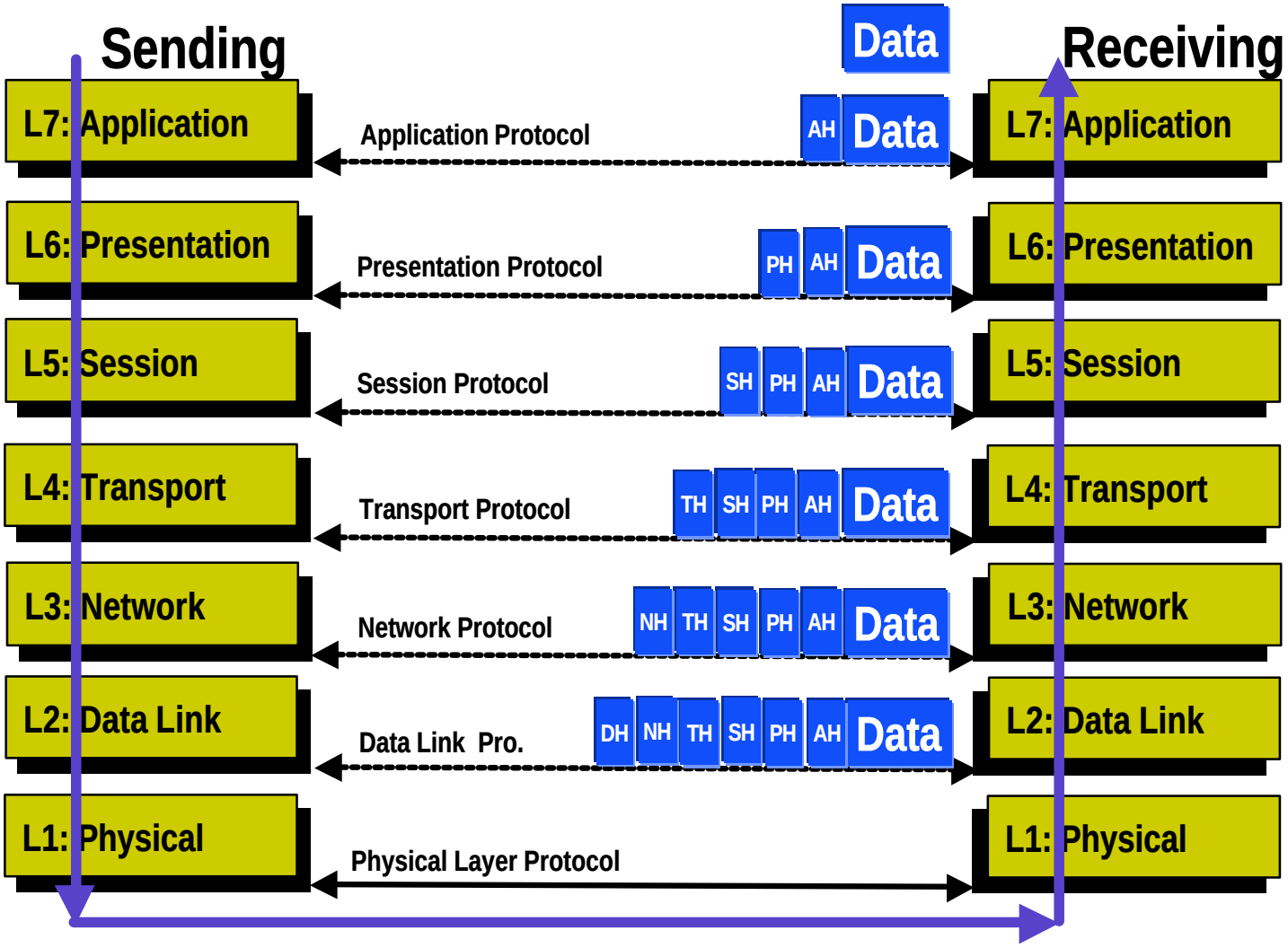
- Applications Layer
  - Where the user applications software lies
  - Handles issues such as:
    - File access and transfer
    - Virtual terminal emulation
    - Inter process communication
    - Electronic Mail
    - Network Management



OSI Model (Summary)

OSI Layer	Purpose	Features	Benefits
Physical	Electrical Interconnection	• Support for various media	• Installation • Performance • Reliability
Link	Media Access and Framing	• Democratic media access • scheme and priority • Large Packet size	• Low latency for critical nodes, uniformly democratic access for all other nodes • Support for discrete, analog, as well as configuration and diagnostic data without fragmentation and performance impact
Network	Destination Addressing	• Support for routers	• Size and interconnectivity –support for large networks • Reliability – traffic filtering, segmenting network into functional clusters, while allowing transparent communication across clusters when needed • Installation ease and reliability • Reliability – crating additional paths between communicating nodes
Transport	End-To-End Reliability	• Unacknowledged service, with and without repeat • Acknowledged service • Multi cast service with and without acknowledgment from each node, and the ability to re-transmit selectively • Duplicate detection	• Optimal communication to a large number of devices, or devices unable to acknowledge. Maintains network reliability in these conditions • Reliable delivery • Performance and reliability
Session	Remote Actions	• Request/Response	• Reliability – to ensure acknowledgement of action • Reliability – to ensure sender legitimacy
Presentation	Data Interpretation	• Standard Data type	• Ability to exchange and interpret standard data regardless of applications
Application	Sensor/Actuator Appellation compatibility	• High level standard object interface definitions • Standard configuration properties	• Representation of any sensor , actuator, or controller interface as aggregations of high level objects • Interpretability with standard sensor interface

Data Transmission



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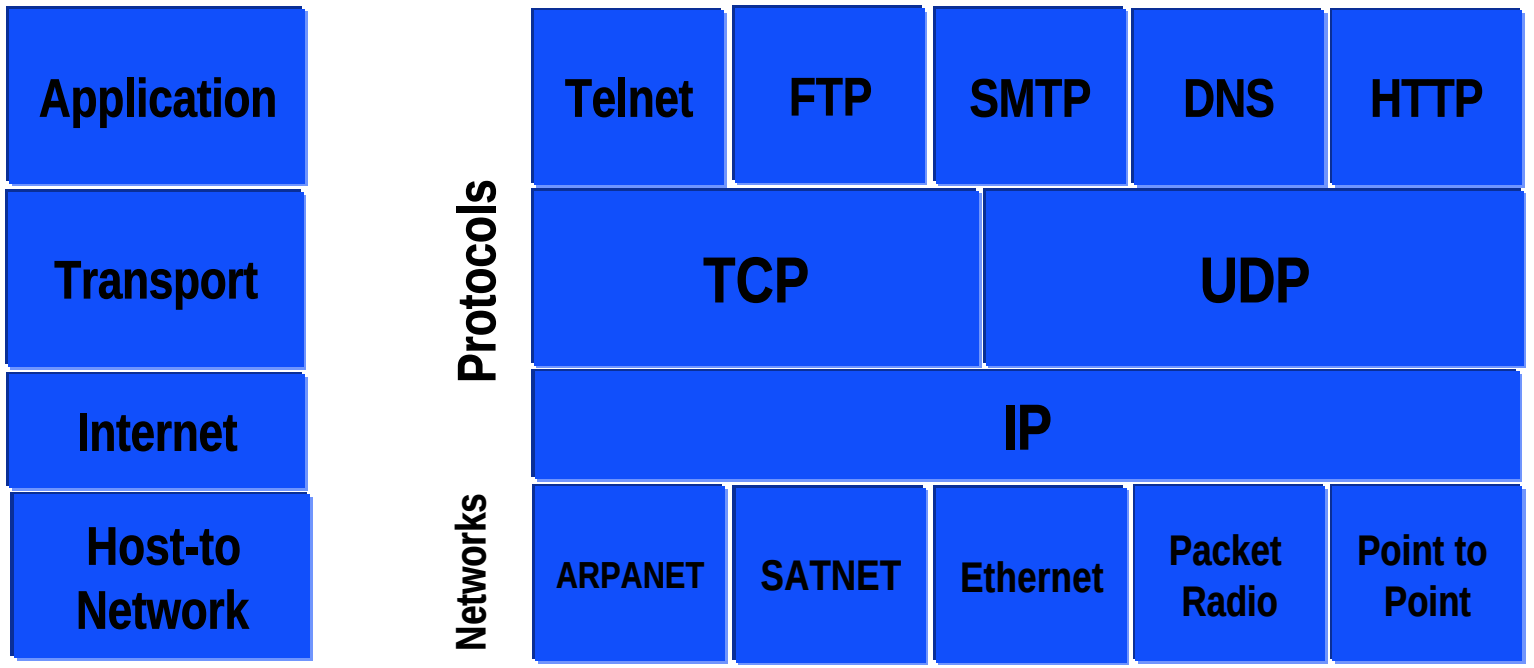
What is TCP/IP?

- TCP/IP = Transmission Control Protocol/Internet Protocol
- Is the basic communication language or protocol of the Internet
- It can also be used as a communications protocol in the private networks (intranets and in extranets)
- TCP/IP is a two-layered program
  - Transmission Control Protocol - Manages the assembling of a message or file into smaller packets
  - Internet Protocol- Handles the address part of each packet so that it gets to the right destination

What is TCP/IP Reference Model?

TCP/IP: Transmission Control Protocol / Internet Protocol



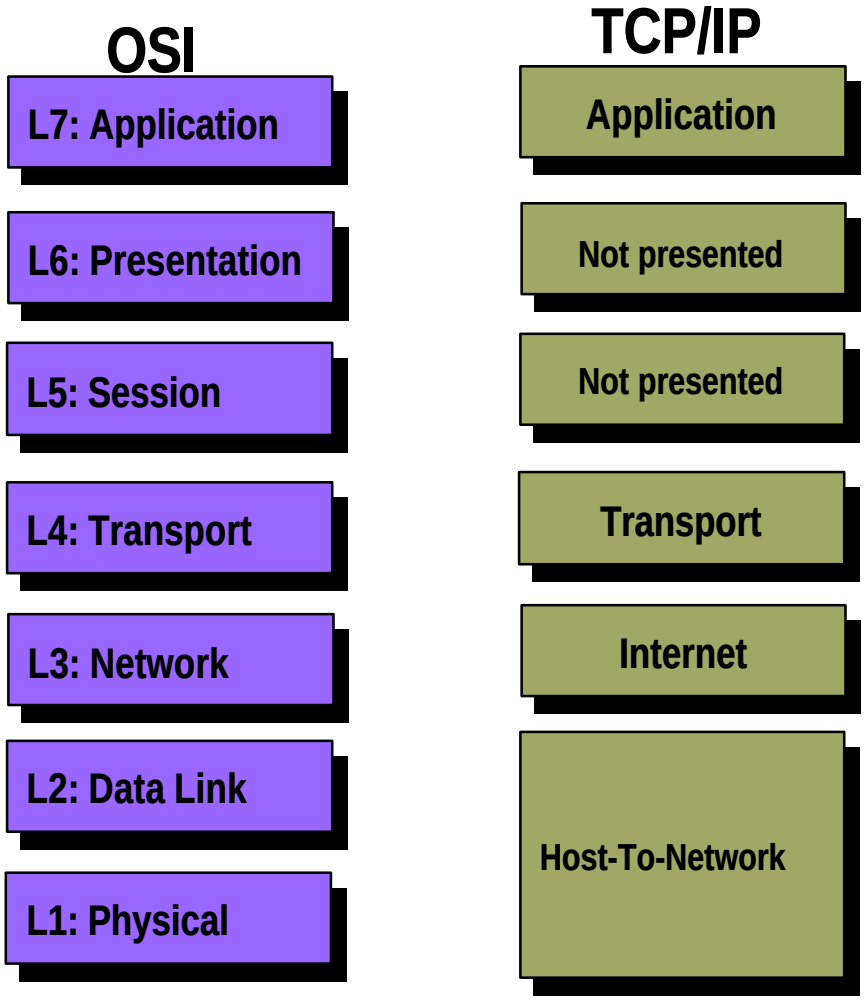
What is TCP/IP Reference Model?

- Application Layer
  - It contains all the higher level protocols such as Telnet, File Transfer (FTP), Simple Mail Transfer(SMTP), Domain Name Service(DNS), Hypertext Transfer (HTTP)
- Transport Layer
  - Designed to allow peer entities on the source and destination hosts carry on a conversation
  - TCP and UDP(end-to-end Protocols)defined here
    - TCP(Transmission Control) manages the assembling of a message or file into smaller packets that are transmitted over the Internet
    - UDP(User Datagram) - Connectionless protocol for applications that do not want TCP's sequencing or flow control(Speech or Video)

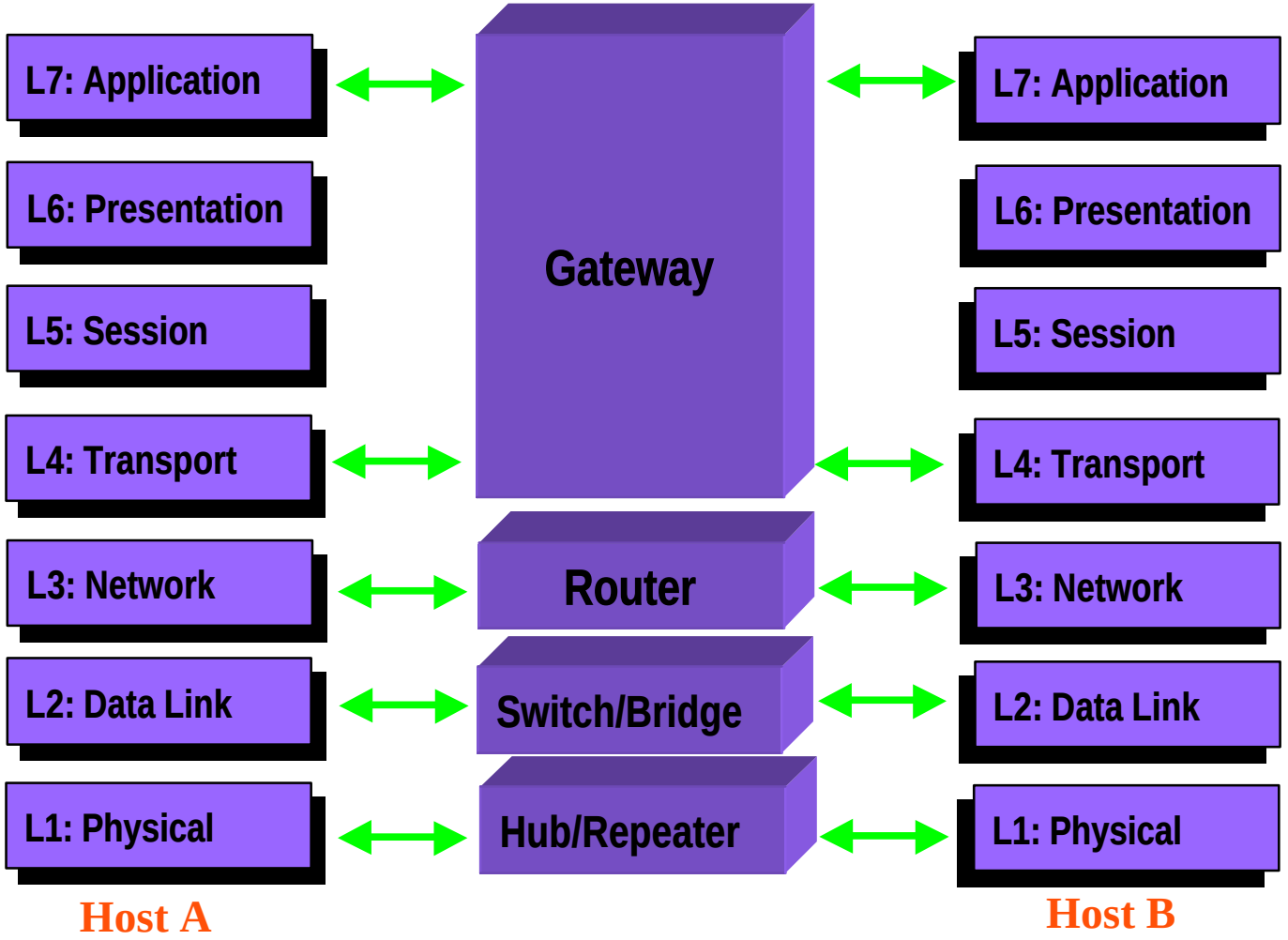
What is TCP/IP Reference Model?

- Internet Layer
  - Defines an official packet format and protocol called IP(Internet Protocol)
  - Internet Layer delivers IP packets to where they are supposed to go(packet routing)
- Host-to-Network Layer
  - Host connects to the network using relevant protocols so it can send IP packets over it

OSI & TCP/IP


OSI
L7: Application
L6: Presentation
L5: Session
L4: Transport
L3: Network
L2: Data Link
L1: Physical
TCP/IP
Application
Not presented
Not presented
Transport
Internet
Host-To-Network

Interconnection Devices



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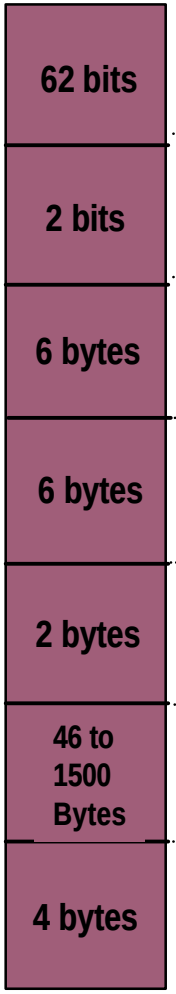
Ethernet (IEEE802.3) Frames



Preamble - A series of alternating 1's and 0's used by the Ethernet receiver to acquire bit synchronization.

Start Of Frame Delimiter - Two consecutive 1 bits used to acquire byte alignment.

Destination Ethernet Address - Address of the intended receiver. The broadcast address is all 1's.

Source Ethernet Address -The unique Ethernet address of the sending station.

Length or Type field - For IEEE 802.3 this is the number of bytes of data. For Ethernet I&II this is the type of packet.

Data - Short packets must be padded to 46 bytes.

Frame Check Sequence - The FCS is a 32 bit CRC calculated using the AUTODIN II polynomial.

Ethernet (IEEE 802.3) Frames

- Preamble
  - A sequences of 64 bits used for synchronization
  - Give components in the network time to detect the presence of a signal
  - Begin reading the signal before the frame data arrives
- Destination & Source MAC Addresses
  - The Destination MAC Address field identifies the station or stations that are to receive the frame
  - The Source MAC Address identifies the station that originated the frame

Ethernet (IEEE 802.3) Frames

- Length/Type
- If the value of this field is less than or equal to 1500, then the Length/Type field indicates the number of bytes in the subsequent MAC Client Data field
  - If the value of this field is greater than or equal to 1536, then the Length/Type field indicates the nature of the MAC client protocol (protocol type)
- MAC Client Data
  - Contains the data transferred from the source station to the destination station or stations
  - If the size < 46 bytes, then use of the subsequent "Pad" field is necessary to bring the frame size up to the minimum length.

Ethernet (IEEE 802.3) Frames

- Pad
  - If necessary, extra data bytes are appended in this field to bring the frame length up to its minimum size
- Frame Check Sequence
  - Contains a 4-byte cyclical redundancy check (CRC) value used for error checking
  - A source station performs CRC when assembling a MAC frame
    - from the Destination MAC Address through the Pad fields
  - A destination station performs CRC when receiving a frame

Ethernet (IEEE 802.3) Frames

- Interframe Gap (IFG)
  - A minimum idle period between transmission of Ethernet frames
  - Provides a brief recovery time between frames to allow devices to prepare for reception of the next frame
  - The minimum interframe gap is 96 bit times
    - = 9.6 microseconds for 10 Mb/s Ethernet
    - = 960 nanoseconds for 100 Mb/s Ethernet
    - = 96 nanoseconds for 1 Gb/s Ethernet

Ethernet Frame Format Extensions

- VLAN Tagging
  - Frame format extensions to support Virtual Local Area Network (VLAN) Tagging
  - The VLAN protocol permits insertion of an identifier, or "tag", into the Ethernet frame format
  - VLAN Tagging provides various benefits
    - Easing network administration
    - Allowing formation of work groups
    - Enhancing network security
  - The 4-byte VLAN tag is inserted between the “Source” MAC Address field and the “Length/Type” field

Ethernet Frame Format Extensions

- Extension Field
  - Added to the end of the Ethernet frame to ensure it would be long enough for collisions to propagate to all stations in the network
  - The extension field is appended as needed to bring the minimum length of the transmission up to 512 bytes
  - It is required only in half-duplex mode, as the collision protocol is not used in full-duplex mode

Ethernet Frame Format Extensions

- Frame Bursting
  - Optionally allows a station to transmit a series of frames without relinquishing control of the transmission medium
  - Burst mode applies to half-duplex mode only
  - It improves the performance of Gigabit Ethernet when transmitting short frames
- Jumbo Frames
  - Increase the maximum size of the MAC Client Data field from 1500-bytes to 9000-bytes
    - Larger frames would provide a more efficient use of the network bandwidth while reducing the number of frames that have to be processed.

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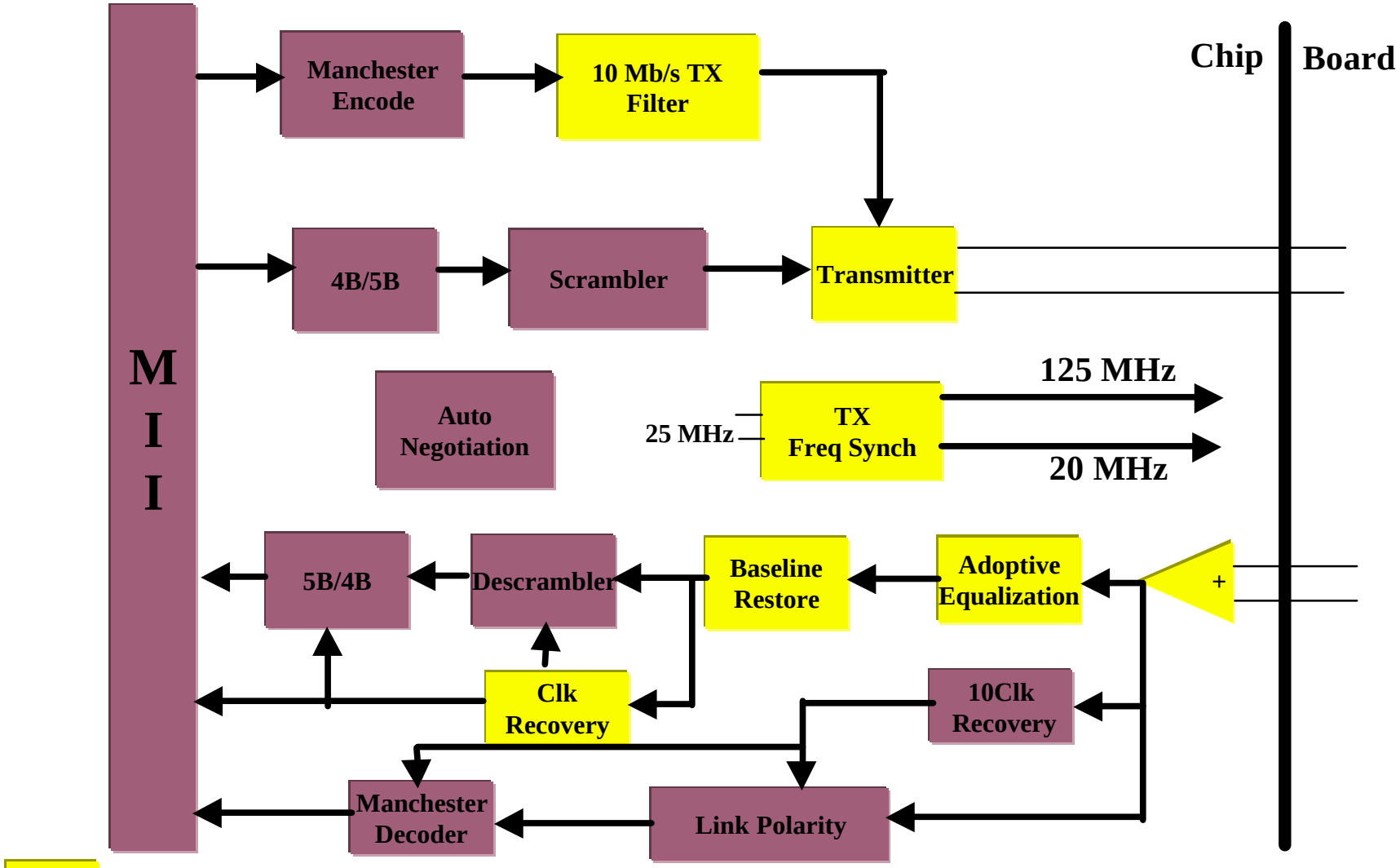
Ethernet PHY



IEEE 802.3 PHY Specifications

Standard	IEEE	Data Rate	Medium	Topology	Max. Cable Length	
					Half Duplex	Full Duplex
1Base5	802.3e	1 Mb/s	Two pairs of twisted telephone cable	Star	250M	N/A
10Base5	802.3	10Mb/s	Single 50-ohm coaxial cable (thick Ethernet)	Bus	500 M	N/A
10Base2	802.3a	10Mb/s	Single 50-ohm RG 58 coaxial cable (thin Ethernet)	Bus	185M	N/A
10Broad36	802.3b	10Mb/s	Single 75-ohm CATV broadband cable	Bus	1800M	N/A
FOIRL	802.3d	10Mb/s	Two Optical Fibers	Star	1000M	>1000
10Base-T	802.3i	10Mb/s	Two pairs of 100-ohm Category 3 or better UTP cable	Star	100M	100M
10Base-FL	802.3j	10Mb/s	Two optical fibers	Star	2000M	>2000M
10Base-FB	802.3j	10Mb/s	Two Optical Fibers	Star	2000M	N/A
10Base-FP	802.3j	10Mb/s	Two Optical Fibers	Star	1000M	N/A
100Base-TX	802.3u	100Mb/s	Two pairs of 100-ohm Category 5 UTP cable	Star	100M	100M
100Base-FX	802.3u	100Mb/s	Two Optical Fibers	Star	412M	2000M
100Base-T4	802.3u	100Mb/s	Four pairs of 100-ohm Category 3 or better UTP cable	Star	100M	N/A
100Base-T2	802.3y	100Mb/s	Two pairs of 100-ohm Category 3 or better UTP cable	Star	100M	100M
1000Base-LX	802.3z	1Gb/s	Long wavelength laser (1300nm) over 62.5um multi-mode fiber	Star	316M	550M
1000Base-LX	802.3z	1Gb/s	Long wavelength laser (1300nm) over 50um multi-mode fiber	Star	316M	550M
1000Base-LX	802.3z	1Gb/s	Long wavelength laser (1300nm) over 10um Single mode fiber	Star	316M	5000M
1000Base-SX	802.3z	1Gb/s	Short wavelength laser (850nm) over 62.5um multi mode fiber	Star	275M	275M
1000Base-SX	802.3z	1Gb/s	Short wavelength laser (850nm) over 50um multi mode fiber	Star	316M	550M
1000Base-CX	802.3z	1Gb/s	Specialty shielded balanced copper jumper cable assemblies	Star	25M	25M
1000Base-T	802.3ab	1Gb/s	Four pairs of 100-ohm Category 5 or better cable	Star	100M	100M

10Base5 Overview

- Transmission Rate:10 Mb/s(full-duplex not supported)
- Cable Type: A single "thick" (10mm) coaxial cable with 50 ± 2 ohms impedance
- Max. Segment Length: 500 meters (1640 feet)
- Max. TX Cable Length: 50 meters (164 feet)
- Max. # of TX / Segment: 100
- Connector Technology: N-type coaxial connectors, barrel connectors, & terminators
- Signal Encoding: Manchester encoding

10Base2 Overview

- Transmission Rate:10 Mb/s(full-duplex not supported)
- Cable Type: A single "thin" (5mm) coaxial cable with 50 ± 2 ohms impedance
- Max. Segment Length:185 meters (606.9 feet)
- Max. Spacing Between Stations: 0.5 meters (164 feet)
- Max. # of TX / Segment: 30
- Connector Technology: BNC Tee coaxial connectors, barrel connectors, & terminators
- Signal Encoding: Manchester encoding

10BaseT Overview

- Transmission Rate: 10 Mb/s (20 Mb/s in optional full duplex mode)
- Cable Type:Two pairs of Category 3 or better unshielded twisted pair (UTP) cabling
  - 100-ohm impedance rating
- Max. Segment Length:100 meters (328 feet)
- Max. # of TX / Segment: 2
- Connector Technology: RJ-45 style modular jack
- Signal Encoding: Manchester encoding

10Broad36 Overview

- Transmission Rate: 10 Mb/s (full-duplex not supported)
- Cable Type: Single 75-ohm CATV broadband cable
- Max. Segment Length: 1800 meters (5905 feet)
- Maximum Total Span: 3600 meters (11811 feet)
- Signal Encoding: Modulated radio frequency (RF)

10Base-FL Overview

- Transmission Rate : 10 Mb/s (20 Mb/s in optional full-duplex mode)
- Cable Type: Two multi-mode fiber optic cables, typically 62.5/125 fiber, 850 nanometer light wavelength
- Max. Segment Length: 2000 meters (6561 feet)
- Max. # of TX per Segment: 2
- Connector Technology : ST connector (BFOC/2.5)
- Signal Encoding: Manchester encoding

100BaseTX Overview

- Transmission Rate: 100 Mb/s (200 Mb/s in optional full-duplex mode)
- Cable Type: Two pairs of Category 5 unshielded twisted pair (UTP) cabling, 100-ohm impedance rating
- Max. Segment Length: 100 meters (328 feet)
- Max. # of TX per Segment: 2
- Connector Technology: RJ-45 style modular jack (8-pins) for UTP cabling
- Signal Encoding: 4B/5B

100BaseFX Overview

- Transmission Rate:100 Mb/s (200 Mb/s in FD mode)
- Cable Type:Two multi-mode optical fibers (MMF),1300 nanometer light wavelength
- Max. Segment Length: 412 meters (Half-Duplex), 2000 meters (Full-Duplex)
- Max. # of TX/ Segment: 2
- Connector Technology: Duplex SC connector preferred, ST and FDDI MIC connectors also permitted
- Signal Encoding: 4B/5B

100BaseT4 Overview

- Transmission Rate:100 Mb/s(full-duplex not supported)
- Cable Type: Four pairs of Category 3 or better unshielded twisted pair (UTP) cabling ,100-ohm impedance rating
- Max. Segment Length: 100 meters (328 feet)
- Max. # of TX/ Segment: 2
- Connector Technology: RJ-45 style modular jack
- Signal Encoding: 8B6T

100BaseT2 Overview

- Transmission Rate: 100 Mb/s (200 Mb/s in optional full-duplex mode)
- Cable Type: Two pairs of Category 3 unshielded twisted pair (UTP) cabling, 100-ohm impedance rating
- Max. Segment Length: 100 meters (328 feet)
- Max. # of TX/ Segment: 2
- Connector Technology: RJ-45 style modular jack (8-pins)
- Signal Encoding: PAM5x5

1000BaseLX Overview

- Transmission Rate: 1000 Mb/s (2000 Mb/s in FD mode)
- Cable Types:
  - Two 62.5/125 or 50/125 multi-mode optical fibers (MMF)
  - Two 10 micron single mode optical fibers (SMF)
- Maximum Segment Length:
  - Half-Duplex MMF & SMF: 316 meters (1036 ft)
  - Full-Duplex MMF: 550 meters (1804 ft)
  - Full-Duplex SMF: 5000 meters (16,404 ft)
- Connector Technology: Duplex SC connector
- Signal Encoding: 8B/10B

1000BaseSX Overview

- Transmission Rate:1000 Mb/s (2000 Mb/s in FD mode)
- Cable Types: Two 62.5/125 or 50/125 multi-mode optical fibers, 770 to 860 nanometer light wavelength
- Maximum Segment Length:
  - Half-Duplex 62.5/125: 275 meters (902 ft)
  - Half-Duplex 50/125: 316 meters (1036 ft)
  - Full-Duplex 62.5/125: 275 meters (902 ft)
  - Full-Duplex 50/125: 550 meters (1804 ft)
- Max. # of TX/ Segment: 2
- Signal Encoding: 8B/10B

1000BaseT Overview

- Transmission Rate:1000 Mb/s (2000 Mb/s in FD mode)
- Cable Types:4-pairs of Category 5 or better cabling
  - 100-ohm impedance rating
- Max. Segment Length: 100 meters (328 ft)
- Max. # of TX/ Segment: 2
- Connector Technology: 8-Pin RJ-45 connector
- Signal Encoding: PAM5

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  - Ethernet Frames
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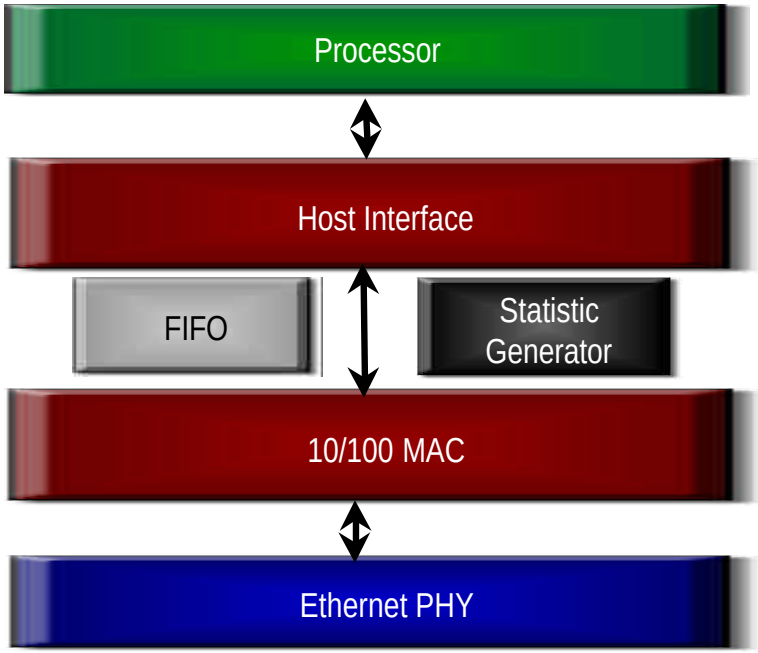
- Summary

Ethernet MAC

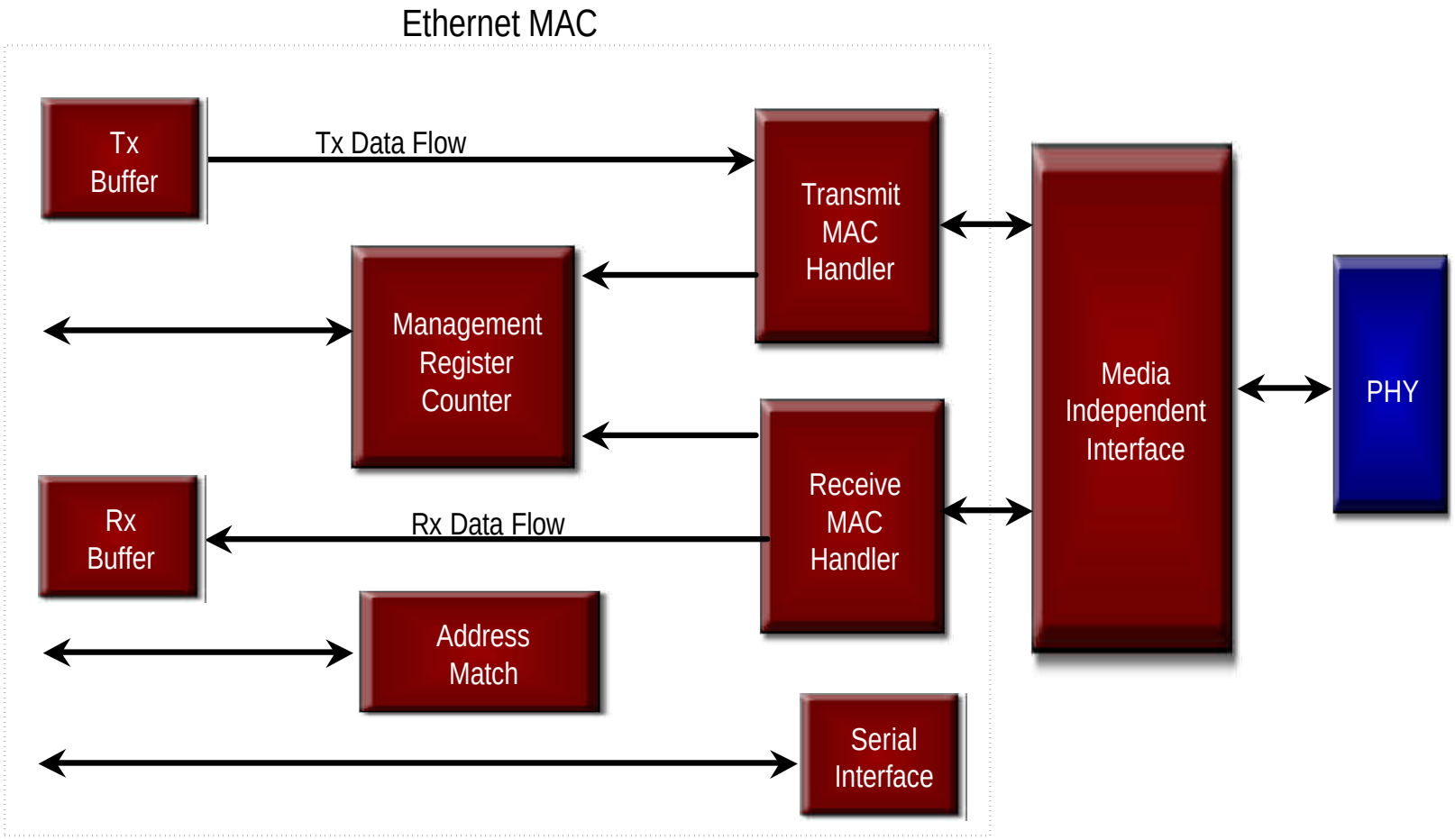
- Provides all functions necessary to attach an Ethernet physical layer to the host interface
- Any physical layer chip that supports the MII interface standard can attach to the 10/100 MAC



Ethernet MAC

- The 10/100 MAC provides all functions necessary to connect to the host bus
- The 10/100 MAC provides:
  - Both bus master and slave functions
  - Host buffer chaining capability for increased system performance
  - Internal FIFO management necessary for efficient bus utilization
  - The MAC (Medium Access Control) is on the lower half of the Data Link Layer which deals with getting the data on and off the wire

Ethernet MAC



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Ethernet Cabling(Twisted Pair)

- Twisted Pair Cables
  - Pairs of wires are twisted around one another
  - Each pair consists of two insulated copper wires twisted together
  - High quality twisted pair cables have about 1 to 3 twists per inch.
  - Twisted pair cables are used with the following Ethernet physical layers:
    - 10Base-T, 100Base-TX, 100Base-T2, 100Base-T4, and 1000Base-T

Ethernet Cabling (TP)

- Unshielded Twisted Pair (UTP)
  - Category 3 - 100 ohm impedance, supports transmission at frequencies up to 16 MHz
    - May be used with 10Base-T, 100Base-T4, and 100Base-T2
  - Category 4 - 100 ohm impedance, supports transmission at frequencies up to 20 MHz
    - May be used with 10Base-T, 100Base-T4, and 100Base-T2
  - Category 5 - 100 ohm impedance,supports transmission at frequencies up to 100 MHz
    - May be used with 10Base-T, 100Base-T4, 100Base-T2, and 100Base-TX

Ethernet Cabling (TP)

- Category 5e - it has improved specifications for NEXT (Near End Cross Talk), PSELFEXT (Power Sum Equal Level Far End Cross Talk), and Attenuation
  - Targeted for 1000Base-T, but also supports 10Base-T, 100Base-T4, 100Base-T2, and 100BaseTX.
- Category 6 - Category 6 is a proposed standard that aims to support transmission at frequencies up to 250 MHz over 100 ohm twisted pair
- Category 7 - Category 7 is a proposed standard that aims to support transmission at frequencies up to 600 MHz over 100 ohm twisted pair

Ethernet Cabling (TP)

- Screened Twisted Pair (ScTP)
  - ScTP is a 4-pair 100 ohm UTP
  - It has a single foil or braided screen surrounding all four pairs in order to minimize EMI radiation and susceptibility to outside noise.
  - ScTP can be viewed as a shielded version of the Category 3, 4, & 5 UTP cables
- Shielded Twisted Pair Cabling (STP)
  - The twisted pairs in 150 ohm STP are individually wrapped in a foil shield and enclosed in an overall outer braided wire shield
    - It minimizes EMI radiation and susceptibility to crosstalk

Ethernet Cabling (Coaxial)

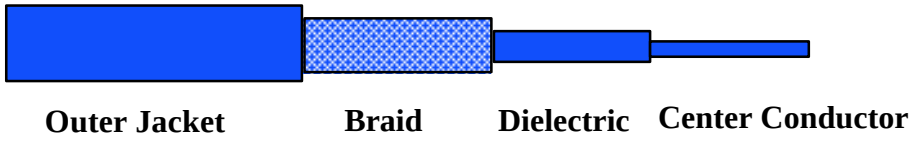
- Coaxial Cables
  - A solid center conductor is surrounded by an insulating spacer
    - insulating spacer in turn is surrounded by a tubular outer conductor (usually a braid, foil or both)
  - The entire assembly is then covered with an insulating and protective outer layer
  - Coaxial cables have a wide bandwidth and are capable of carrying many data, voice, and video conversations simultaneously

Ethernet Cabling (Coaxial)

- Thicknet
  - Thicknet is the 50-ohm "thick" (10mm) coaxial cable used with Ethernet 10Base5 networks
  - Includes a "mark" every 2.5 meters to indicate proper placement of the 10Base5 transceivers used to connect stations to the network
  - The standard allows a 10Base5 coaxial cable segment to be up to 500 meters in length
  - Up to 100 transceivers may be connected to a single segment at any multiple of 2.5 meters apart
  - 10Base5 coaxial cable segments are built using "N-type" connectors

Ethernet Cabling (Coaxial)

- Thinnet
  - Thinnet is the 50-ohm "thin" (5mm) coaxial cable used with Ethernet 10Base2 networks
  - It supports only a 185 meter maximum segment length (vs.. 500 meters for 10Base5) and a maximum of 30 stations per cable segment (vs. 100 for 10Base5)
  - 10Base2 transceivers (MAUs) are connected to the Thinnet cable segment through a "BNC Tee" connector
  - Each end of a 10Base2 coaxial segment must be terminated with a BNC 50-ohm terminator



Ethernet Cabling (Coaxial)

- CATV
  - A 75 ohm coaxial cabling commonly known for its use in transmission of Cable TV signals
  - It is also used with Ethernet 10Broad36 networks
  - CATV stands for ”Community Antenna Television"
  - CATV cabling is used for "broadband" transmission
  - A broadband cabling system supports transmission of multiple services over a single cable by dividing the bandwidth into separate frequencies
    - This technique is used in cable TV transmission systems to transmit multiple channels over a single cable
    - Each channel uses a different frequency range

Ethernet Cabling (Coaxial)

- Twinax
  - Consisted of two center conductors surrounded by an insulating spacer
  - insulating spacer is surrounded by a tubular outer conductor (usually a braid, foil or both)
  - The entire assembly is then covered with an insulating and protective outer layer
  - 150-ohm twinax is specified as a "short haul" cable that can be used with the 1000Base-CX media system
  - It supports segment lengths of only 25 meters for 1000Base-CX due to the very high 1.25 Gbaud signal transmission rate

Ethernet Cabling (Fiber Optic)

- Fiber Optic Cables
  - Fiber optic cabling is a technology where electrical signals are converted into optical signals, transmitted through a thin glass fiber, and re-converted into electrical signals
  - It is used on FOIRL, 10Base-FL, 10Base-FB, 10Base-FP, 100Base-FX, 1000Base-LX, and 1000Base-SX
  - Fiber optic cabling is constructed of three concentric layers:
    - The core : Is the central region of an optical fiber through which light is transmitted.
    - The cladding: Is the material in the middle layer.
    - The protective layer: serves to protect the core and cladding from damage.

Ethernet Cabling (Fiber Optic)

- Multi-Mode Fiber (MMF)
  - Allows many "modes" of light to propagate down the fiber optic path
  - Multi-mode fiber typically has a core diameter of 50 to 100 microns
  - The most popular fiber for networking is the 62.5/125(core diameter/cladding) micron multi-mode fiber
  - The primary advantage of multi-mode fiber over twisted pair cabling is that it supports longer segment lengths
  - Multi-mode fiber can support segment lengths as long as 2000 meters for 10 and 100 Mbps Ethernet, and 550 meters for 1 Gbps Ethernet

Ethernet Cabling (Fiber Optic)

- Single-Mode Fiber (SMF)
  - Single-mode fiber has a core diameter that is so small that only a single mode of light is propagated
  - This eliminates the main limitation to bandwidth, modal dispersion
  - The main limitation to the bandwidth of a single-mode fiber is material dispersion
  - Single-mode fiber is capable of supporting much longer segment lengths than multi-mode fiber
  - Segment lengths of 5000 meters and beyond are supported at all Ethernet data rates through 1 Gbps

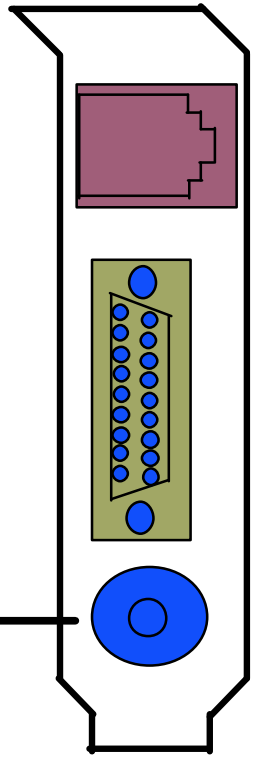
BNC Connectors

Used on 10Base2 Ethernet Standard

Male BNC

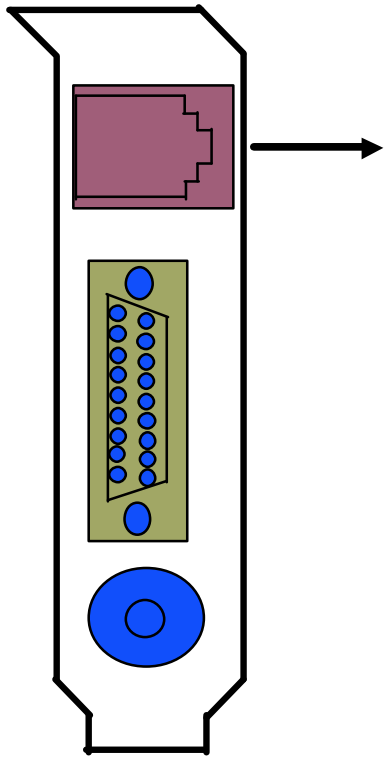
BNC Tee

Thin Coaxial Cable



RJ-45 Connectors

Used on Ethernet twisted pair links(10BaseT, 100BaseTX, 100BaseT4, 100BaseT2, and 1000BaseT)



RJ-45 Jack

Ethernet cabling connections

RJ45 Plug wiring diagram

Pin	Color	Function
1	White/Orange	TxData +
2	Orange	TxData -
3	White/Green	RxData +
4	Blue	100BT
5	White/Blue	100BT
6	Green	RxData -
7	White/Brown	100BT
8	Brown	100BT

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Interconnection Devices

- Repeater: PHY device that restores data and collision signals: a digital amplifier
- Hub: Multi-port repeater + fault detection
- Bridge: Data link layer device connecting two or more collision domains. MAC multicasts are propagated throughout “extended LAN”
- Router: Network layer device. IP, IPX, AppleTalk. Does not propagate MAC multicasts
- Switch: Multi-port bridge with parallel paths

What is a Repeater?

- Repeaters are low-level devices that amplify or regenerate weak signals
- Repeaters are needed to provide current to drive long cables
- Repeaters are used to join network segments together to increase the total length of the network
- Act at the physical layer and allow all traffic to cross LAN segments

What is a Hub?

- A place of convergence where data arrives from one or more directions and is forwarded out in one or more other directions
- Hub is a repeater with fault detection functionality
- It connects high-performance stations/devices to Ethernet local area networks and provides high-performance inter-LAN connectivity using switching technology
- A hub usually includes a switch of some kind

What is a Bridge?

- Connects a local area network (LAN) to another LAN that uses the same protocol (for example, Ethernet or Token Ring)
- A bridge works at the data-link (physical network) level of a network, copying a data frame from one network to the next network along the communications path.
- Bridges can make minor changes to the frame before forwarding it(such as adding and deleting some fields from the frame header)

What is a Router?

- Routers determine the next network point to which a packet should be forwarded on the way to its final destination
- Routers use the Network Layer Protocol Information within each packet to "route" it from one destination or LAN to another
  - This means that a router must be able to recognize all the different Network Layer Protocols that may be used on the networks it is linking together
- Routers communicate with one another to determine the best route through the complex connections of many LANs to increase speed and cut down on network traffic

What is a Switch?

- A network device that selects a path or circuit for sending a unit of data to its next destination
  - A switch is a simpler and has faster mechanism than a router
- A network device processing packets at layer 2 and 3
  - Layer 2 Switch:
    - Filters and forwards at the data link layer of the OSI model
    - Uses MAC addresses to determine where frames are sent.
  - Layer 3 Switch:
    - Routes packets at wire speed using Layer 3 (network layer) information.
- Simultaneous switching of packets between its ports increases the aggregate LAN bandwidth dramatically

What is a NIC Card?

- A NIC is an expansion card used to connect a PC, server, or workstation to a LAN
- NIC provides an interface between the network and the PC's bus
- Most NICs are designed for a particular type of network, protocol, and media
- The NIC segments outgoing messages into packet formats specified by the LAN protocol for transmission