Computer Networks

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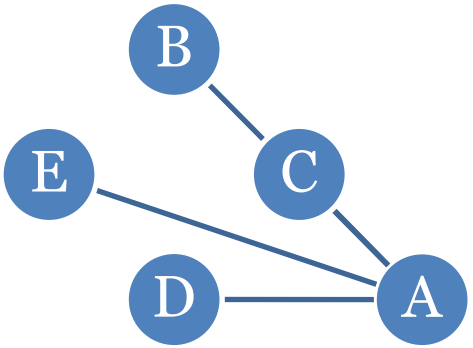
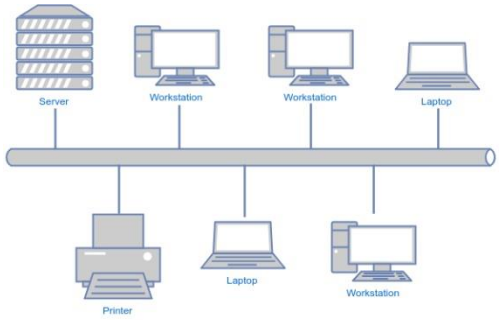
What is a computer network?

- It is an **interconnection** of **autonomous** **devices**.
- **Interconnection:** able to exchange meaningful information. (Protocols).
- **Autonomous**: do not control each other (independent)
- **Devices**: Any computing device eg. Computer, laptop, mobile.....

What are the type of network?

- Point to point network: communication link will be used by the two peers only





Bus Topology Network

- Multipoint Network (Shared Network): nodes are sharing communication link

Other Classification

- Based on the communication medium we can classify a network as:
  - Wired network
  - Wireless network
- Based on the span of the network we can classify a network as:
  - PAN (1 -10mts)
  - LAN (1 km – 10 kms)
  - MAN(10 kms – 100 kms)
  - WAN(more than 100 Kms)

What are the advantages of Computer Networks?

- Resource and data sharing
- Resources: Hard disk space, RAM, Printer, CD/DVD-Drive, any other hardware connected to the host.
- Data Sharing: File sharing, chat (voice / Video)….
- Distributed processing
- Parallel processing
- Eg. Cloud Computing:
  - Infrastructure as service
  - Software as service
  - Computing as service

Disadvantages?

- Privacy
- All kind security attack on hosts are possible over the network. Eg. Man in middle attack, Denial of service attack, data stealing etc.

Important Terms

- Packet Switching (Analogous to Postal Service)
- Circuit Switching (Analogous to Telephone Service)

- Over Packet Switching Network we can have
  - Connection Less service
  - Connection Oriented service

Motivation of Layering

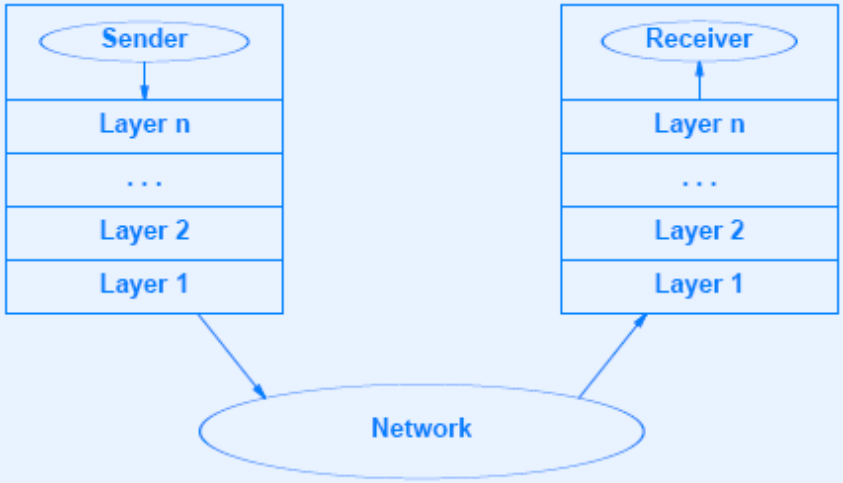
- Preparing data for successful and meaningful communication was a big programming task because it has the following problems:
  - Hardware failure
  - Network congestion
  - Packet delay or loss
  - Data corruption
  - Data duplication or inverted arrivals

Solving The Problem

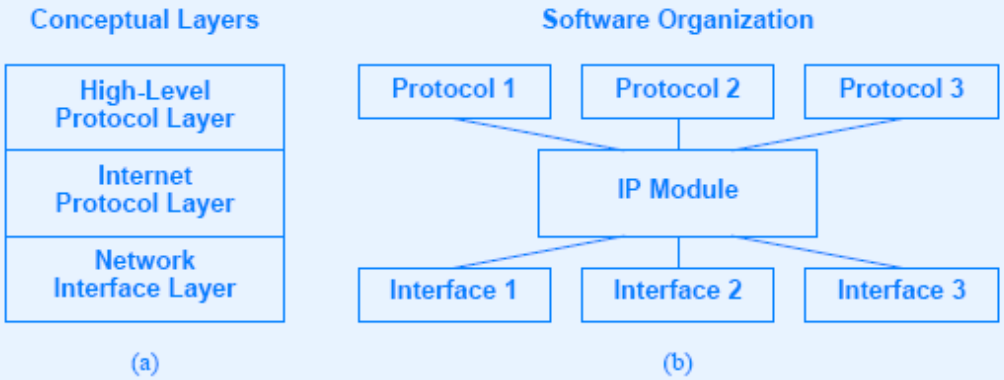
- **To solve big problem:**
  - Divide the problem into pieces
  - Solve sub problems separately
  - Combine into integrated whole
  - Result is layered protocols

- **Protocol Layering**
  - Separates protocol functionality
  - Each layer solves one part of the communication problem
  - Intended primarily for protocol designers
  - Set of layers is called a protocol stack

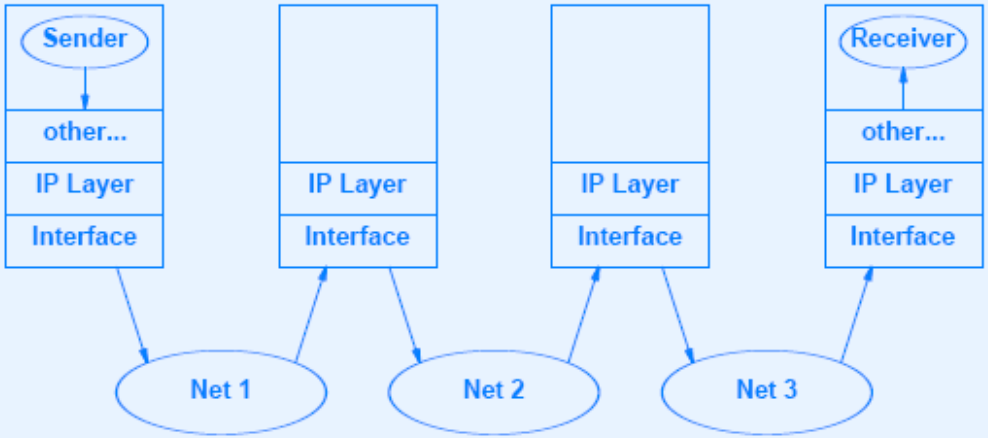
Concept Of Layering



More Realistic Layering



Layering In An Internet



Examples Of Layering

- Two models exist
- ISO 7-layer reference model for *Open System Interconnection* (*OSI*)
  - Predates TCP/IP
  - Does not include an Internet layer
  - Prescriptive (designed before protocols)
- Internet 5-layer reference model
  - Designed for TCP/IP
  - Descriptive (designed along with actual protocols)

Illustration Of Layering In An Internet

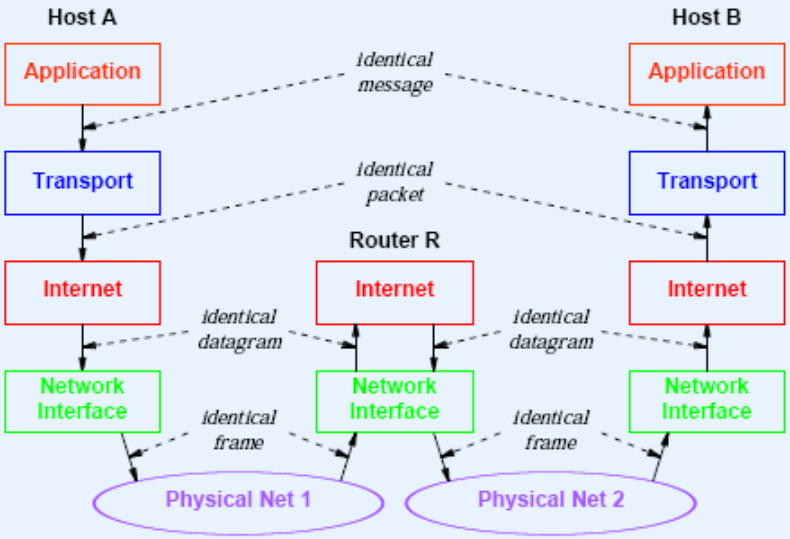
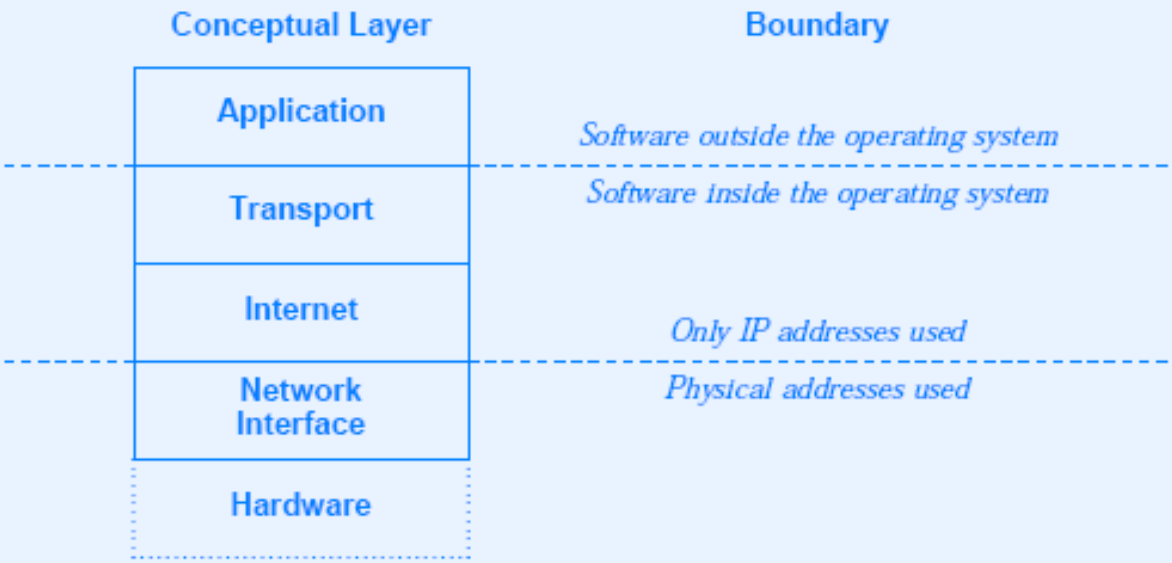


Illustration Of The Two Boundaries



OSI Reference Model

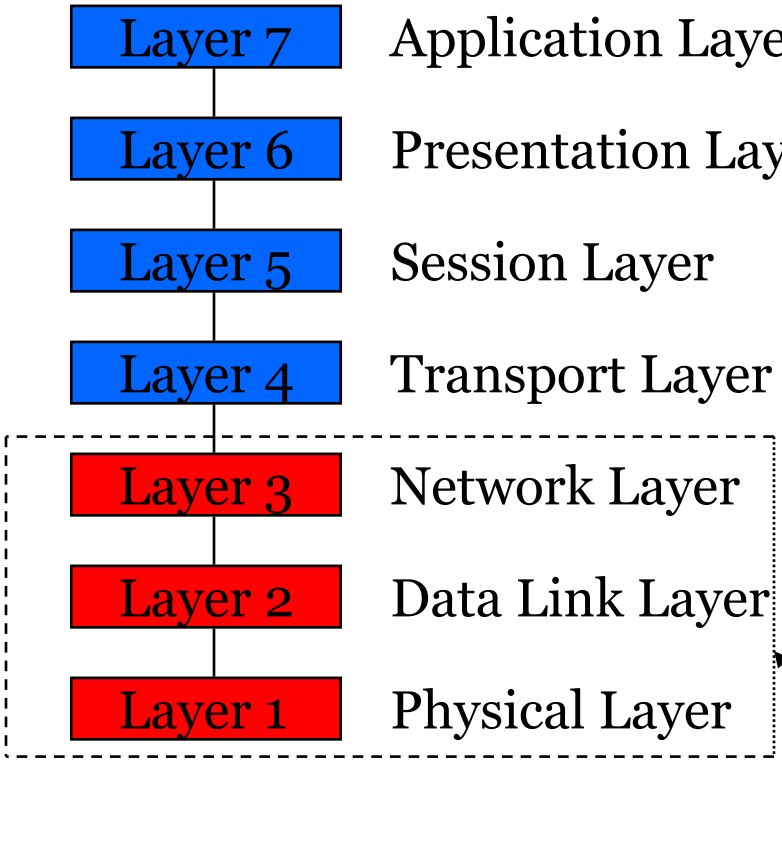
- OSI = *Open Systems Interconnection*: deals with *open systems*, i.e. systems open for communications with other systems.
- Specified in ISO 7498.
- Model has 7 layers.

A 7- Layer ISO –OSI Model for Networking

Application Layer	High-level APIs, including resource sharing, remote file access.
Presentation Layer	Translation of data between a networking service and an application; including character encoding, data compression and encryption/decryption.
Session Layer	Managing communication sessions, i.e., continuous exchange of information in the form of multiple back-and-forth transmissions between two nodes.
Transport Layer	Reliable transmission of data segments between points on a network, including segmentation, acknowledgement and multiplexing
Network Layer	Structuring and managing a multi-node network, including addressing, routing and traffic control
Data Link Layer	Reliable transmission of data frames between two nodes connected by a physical layer
Physical Layer	Transmission and reception of raw bit streams over a physical medium

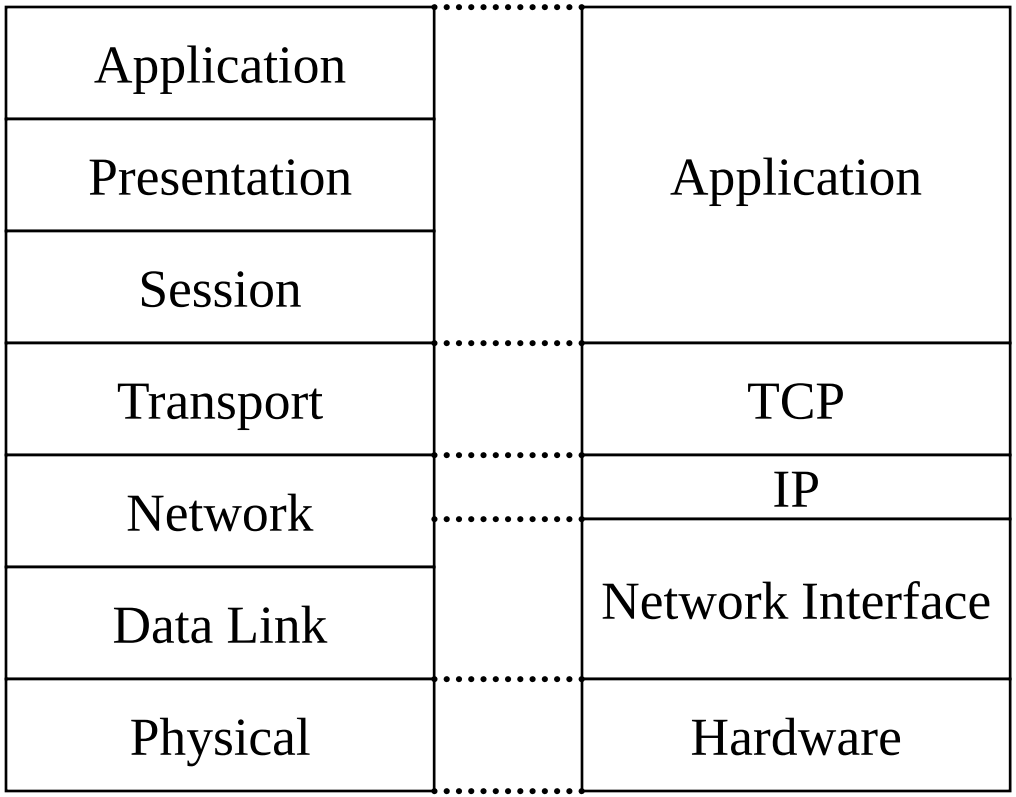
International Organization for Standardization (ISO) created the Open System Interconnection (OSI) protocol architecture starting in the late 1970s and matured by the early 1990s.

7-Layer OSI Model



- Layers 1-3 are relate to communications technology.
- Layers 4-7 are relate to user applications.

TCP/IP vs OSI



- Explicit Presentation and session layers missing in Internet Protocols
- Data Link and Network Layers redesigned

Layer 1: Physical Layer

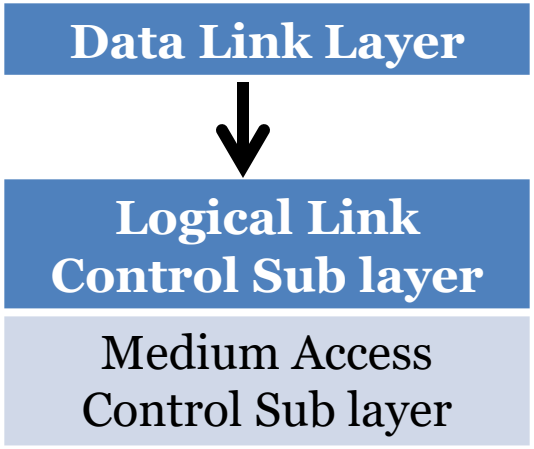
- Define medium of communication.
- Regulates the transmission of a stream of bits over a medium Wired/Wireless.
- Transmits bits from one computer to another (Converting bits into signal)
- Defines how the cable is attached to the network adapter and what transmission technique is used to send data over the cable. Deals with issues like
  - The definition of 0 and 1, e.g. how many volts represents a 1, and how long a bit lasts?
  - Whether the channel is simplex or duplex?
  - How many pins a connector has, and what the function of each pin is?

Layer 1: Physical Layer

- Protocols:
- Encoding techniques
- Modulation techniques
- Interface Standards
- Transmission media
  - Wired
  - Wireless
- The physical layer is also concerned with:
  - Bit rate
  - Point-to-point, multipoint or point-to-multipoint line configuration
  - Physical network topology, for example bus, ring, mesh or star network
  - Serial or parallel communication
  - Simplex, half duplex or full duplex transmission mode

Layer 2: Data Link Layer

- Provides reliable transmission of frames on node to node basis
  - Provides frame abstraction (Framing Protocols)
  - Provides physical address to the nodes in the network
  - Provides Flow Control
    - It waits for an acknowledgment from the receiving computer.
    - Retransmits frames for which acknowledgement not received
  - Provides Error Control
  - Provides Medium Access Control



Layer 2: Data Link Layer

- Protocols
  - ARP and InARP: Address Resolution Protocol and Inverse ARP.
  - RARP: Reverse Address Resolution Protocol
  - Stop and Wait Protocol
  - Sliding Window Protocol
  - PPP
  - DDCMP
  - IEEE 802.3 onwards
  - CRC, Checksum, Hamming Codes…

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.

Layer 3: Network Layer

- Provides connectionless best effort data delivery services to upper layer protocols
- Best effort data delivery services means:
  - Packets may follow different path to reach to the destination
  - Packet may be lost in the network
  - Packet may experience unexpected delay in reaching the destination
  - Packets may reach out of order at the destination
- Protocols
  - IP: Internet Protocol (IPv4)
  - IPv6: Internet Protocol version 6
  - ICMP & ICMPv6: Internet Message Control Protocol and ICMP version 6
  - Mobile IP: IP Mobility Support Protocol for IPv4 & IPv6
  - IPSec: IP Security Protocol

Layer 3: Network Layer

- OSPF: Open Shortest Path First Protocol (version 2)
- RIP: Routing Information Protocol (RIP2)
- RIPng: Routing Information Protocol next generation for IPv6
- RSVP: Resource Reservation Protocol
- BGP: Border Gateway Protocol

Layer 4: Transport Layer

- 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
  - Provides Connection less and Connection Oriented data delivery services
  - Provide port number to identify sockets of the connection

Layer 4: Transport Layer

- Protocols
  - TCP: Transmission Control Protocol
  - UDP: User Datagram Protocol
  - RDP: Reliable Data Protocol
  - RUDP: Reliable User Datagram Protocol (Reliable UDP)

Layer 5: Session Layer

- Allows two applications on different computers to establish, use, and end a session.
  - e.g. file transfer, remote login
- Establishes dialog control
  - Regulates which side transmits, plus when and how long it transmits.
- Performs *token management* and *synchronization*.

Protocols:

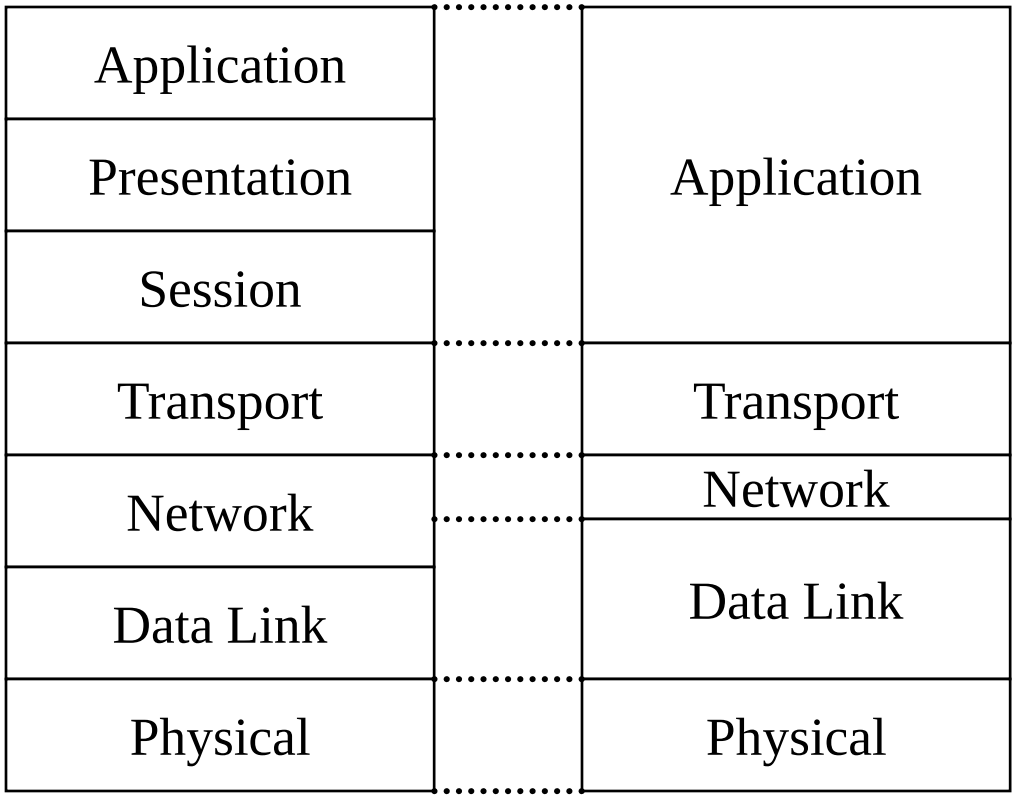
RPC: Remote Procedure Call Protocol

Layer 7: Application Layer

- Level at which applications access network services.
  - Represents services API
  - directly support software applications for file transfers, database access, and electronic mail etc.

  Protocols:
  - BOOTP: Bootstrap Protocol,
  - DCAP: Data Link Switching Client Access Protocol,
  - DHCP: Dynamic Host Configuration Protocol,
  - DNS: Domain Name System (Service) Protocol

OSI vs TCP/IP



- Explicit Presentation and session layers missing in Internet Protocols
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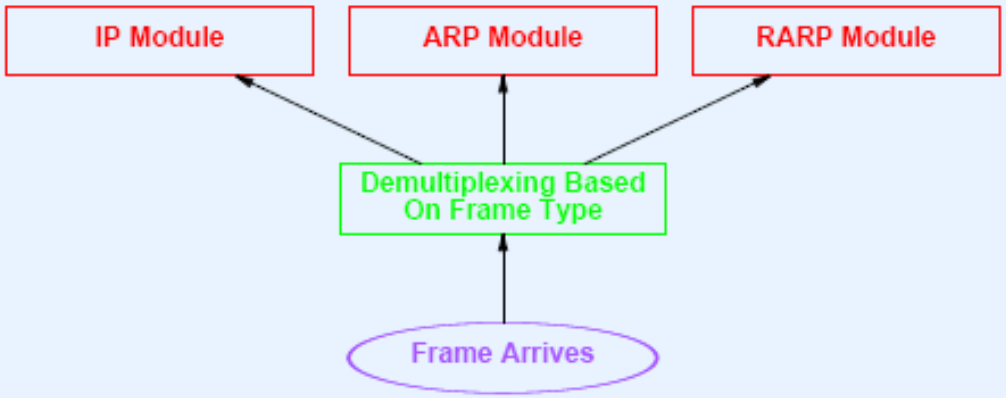
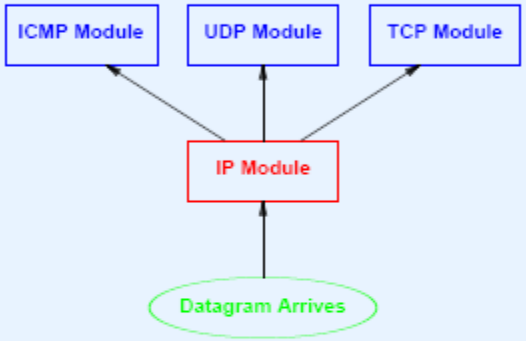
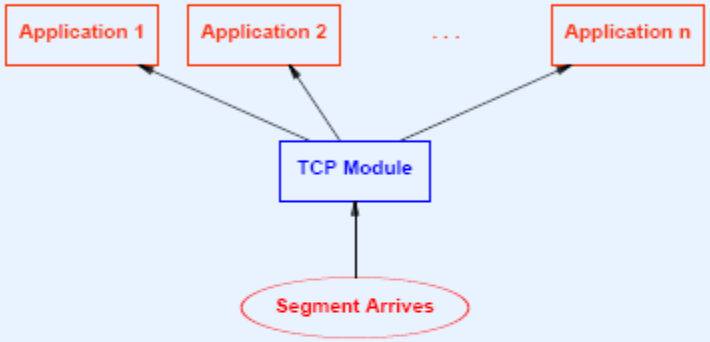
Example Of Demultiplexing An Incoming Frame



Example Of Demultiplexing Performed By IP



Example Of Demultiplexing Performed By TCP



- TCP is part of operating system
- Transfer to application program must cross operating system boundary

Connections

- Layers can offer *connection-oriented* or *connectionless* services.
- Connection-oriented like telephone system Circuit Switching.
- Connectionless like postal system Packet Switching.
- Each service has an associated *Quality-of-service* (e.g. reliable or unreliable).

Reliability

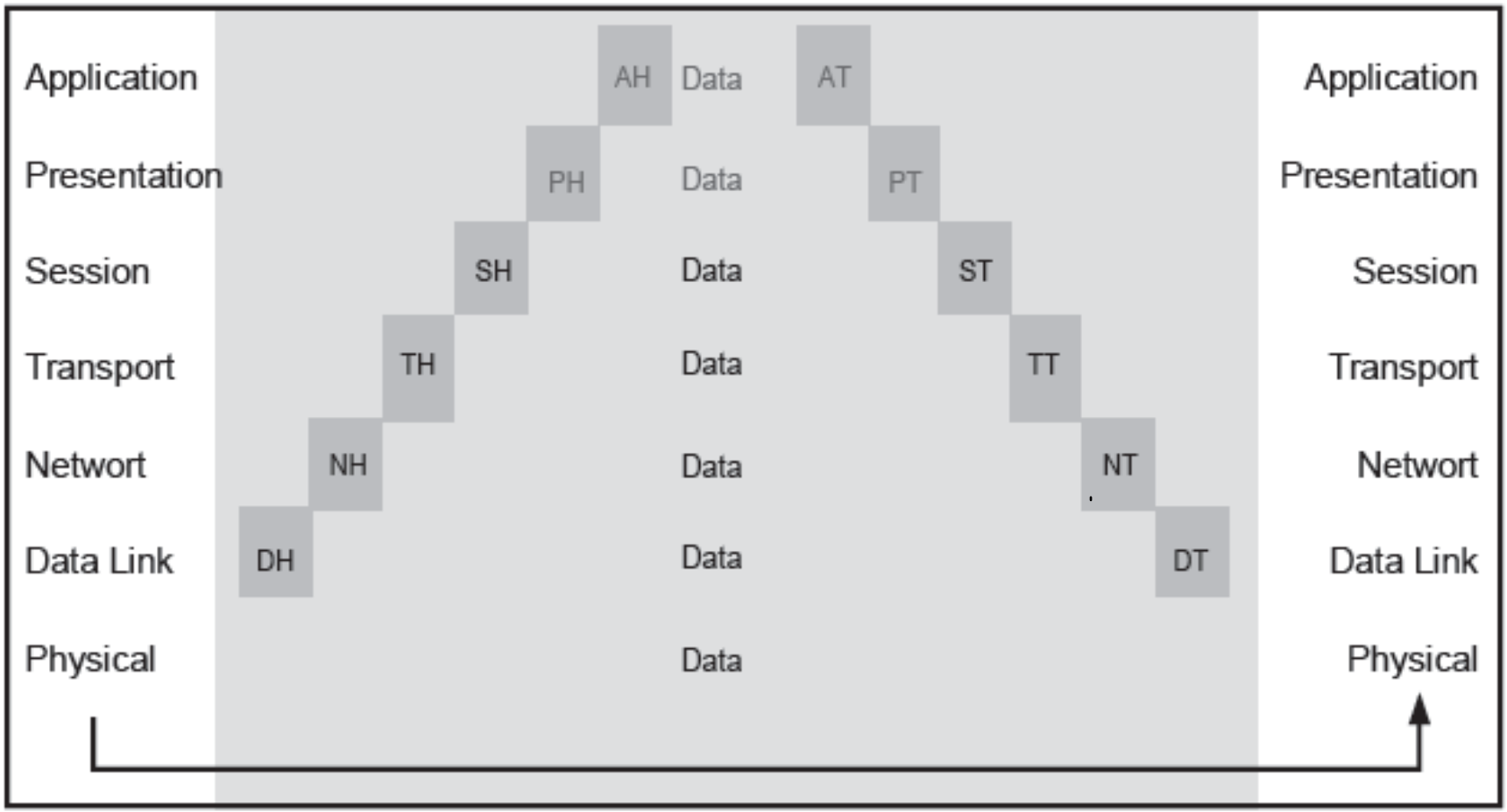
- Reliable services never lose/corrupt data.
- Reliable service costs more.
- Typical application for reliable service is file transfer.
- Typical application not needing reliable service is voice traffic.

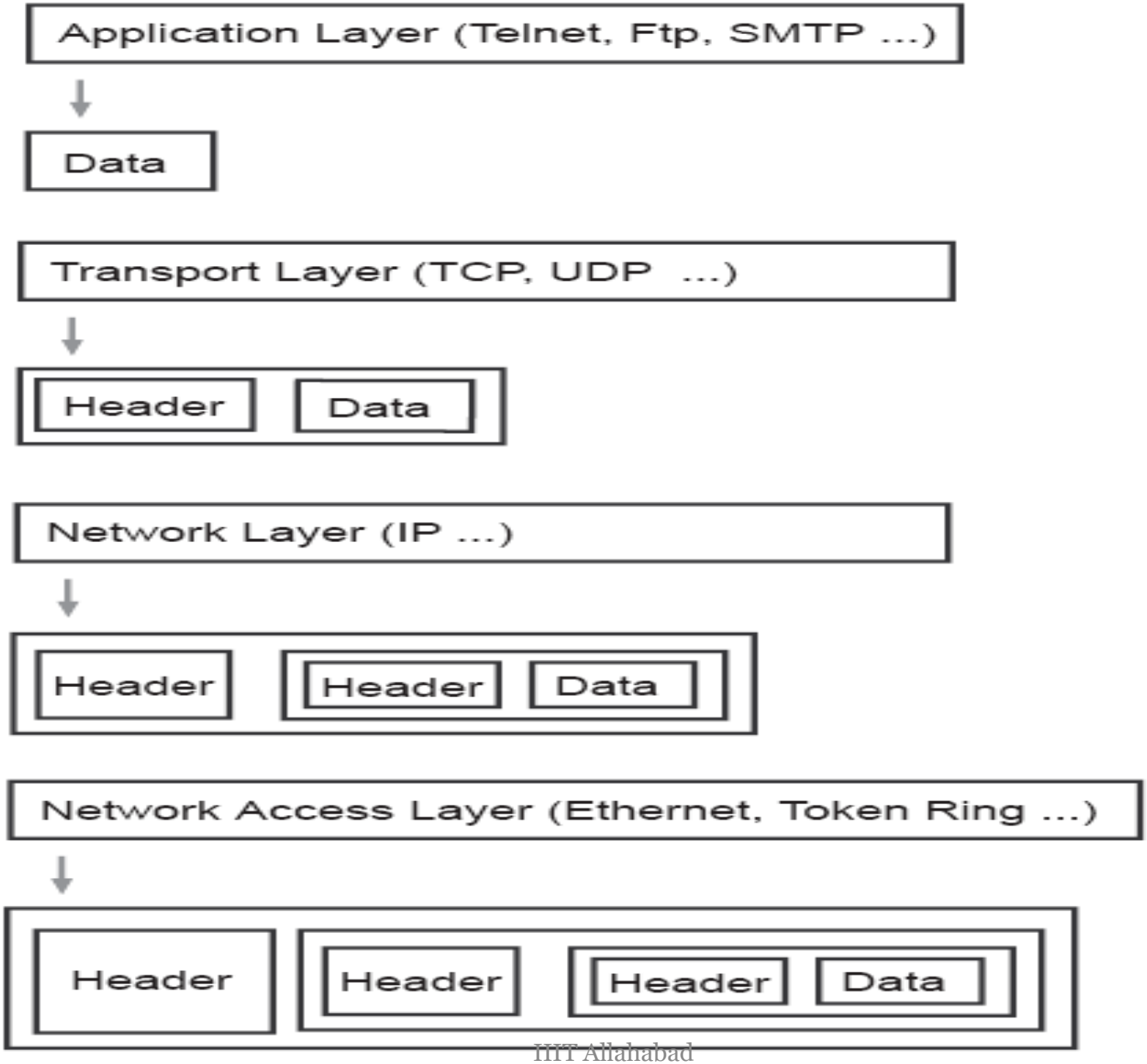
Protocols

- Protocol = set of rules governing data communication between peer entities, i.e. format and meaning of frames/packets.

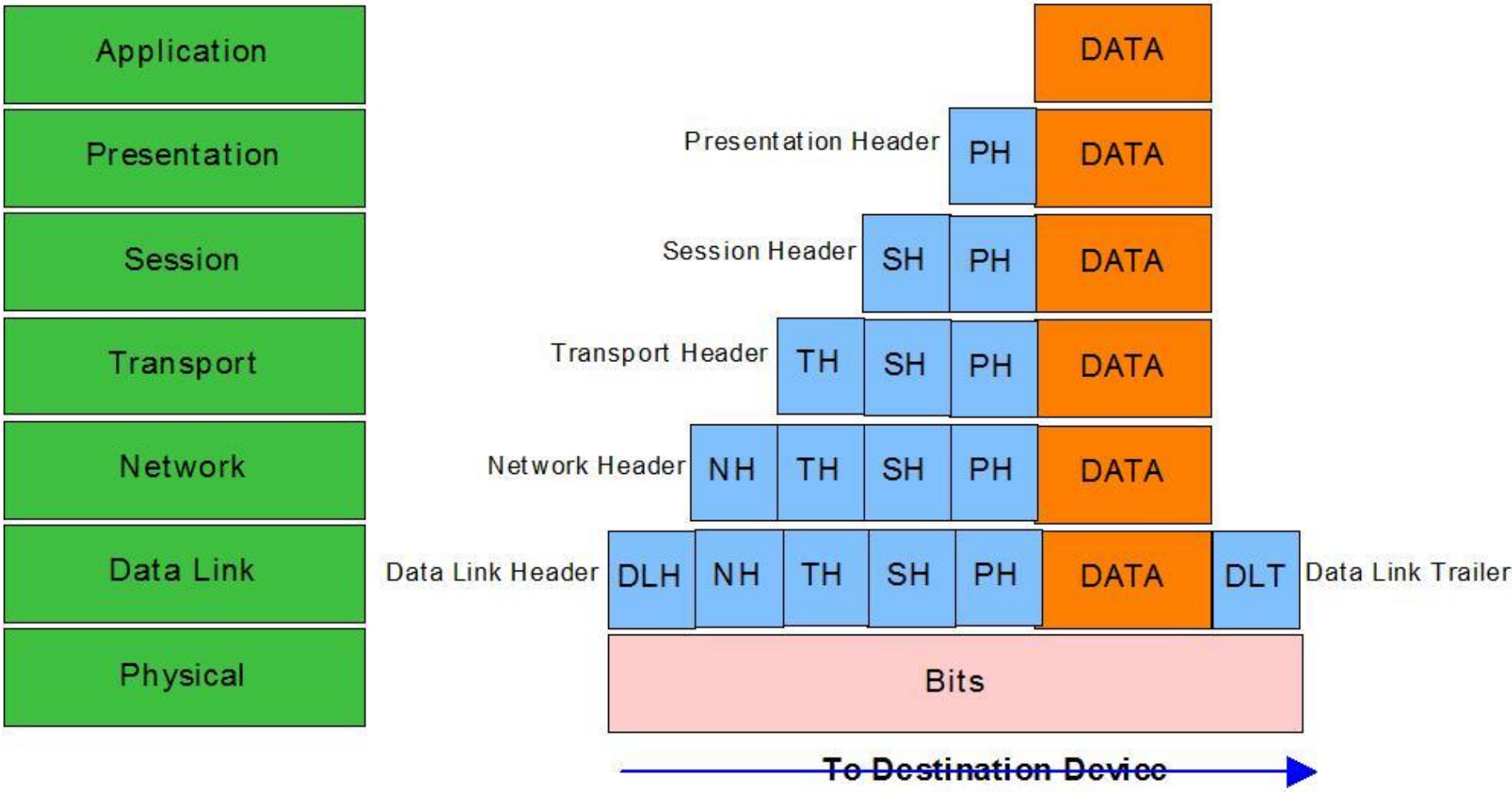
- Service/protocol decoupling very important.

Header Encapsulation




Application Layer (Telnet, Ftp, SMTP ...)
Data
Transport Layer (TCP, UDP ...)
Header
Data
Network Layer (IP ...)
Header
Header
Data
Network Access Layer (Ethernet, Token Ring ...)
Header
Header
Header
Data

Encapsulation



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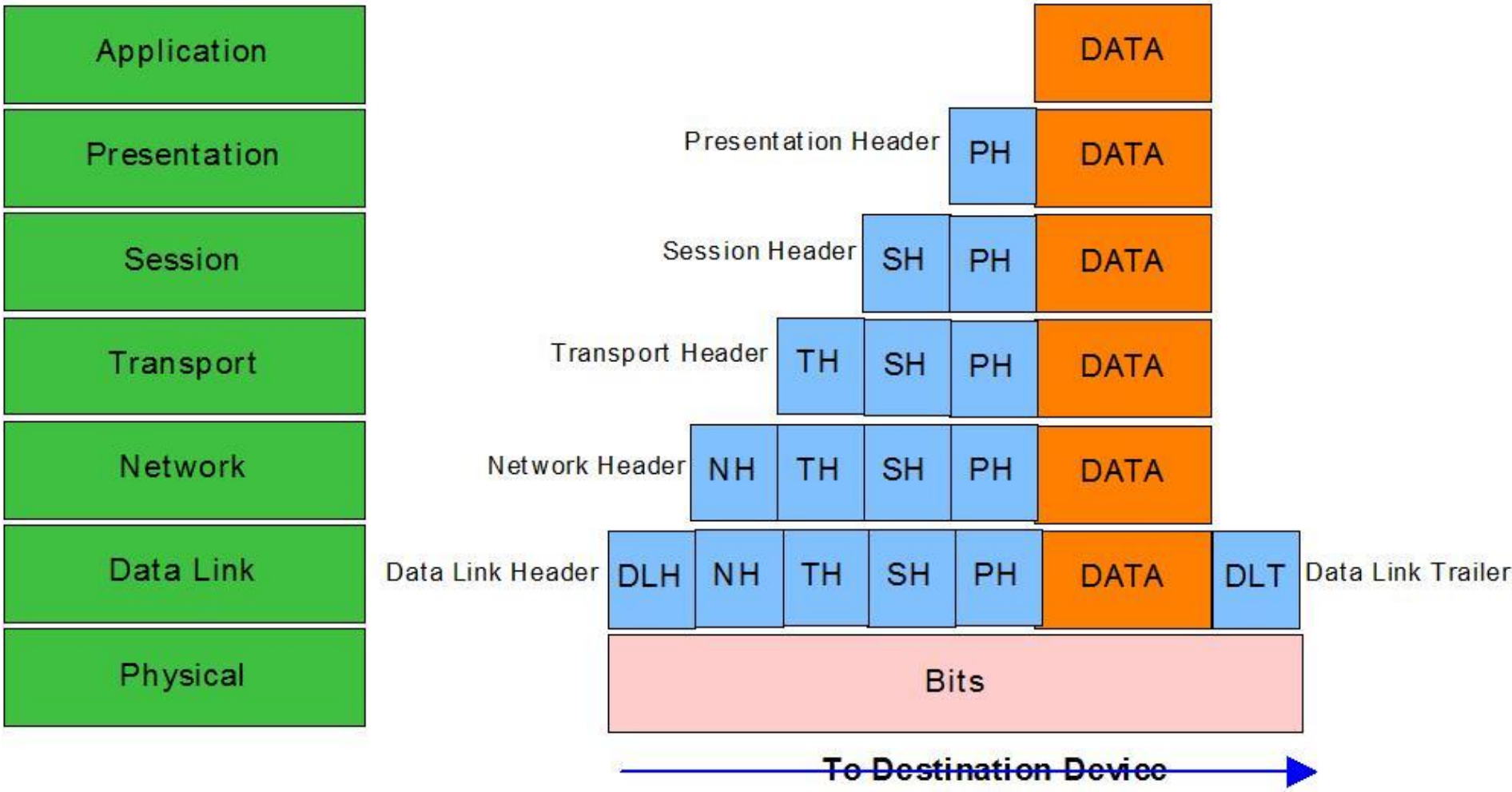
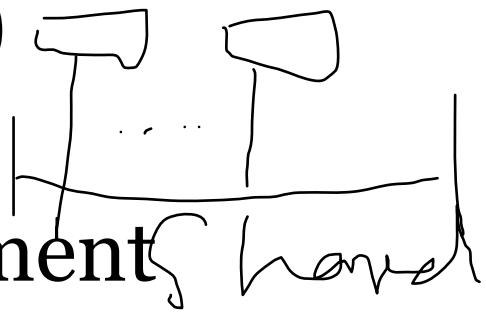
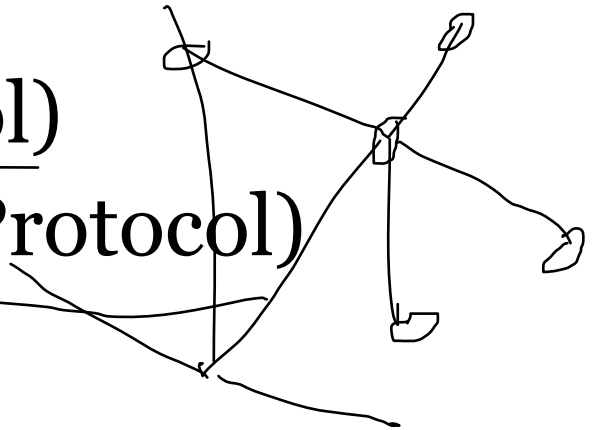


Other Protocols of Interest

- VoIP (Voice over IP)
- RTP (Real Time Transfer Protocol)
- SIP (Session Initiation Protocol)
- SSH (Secure Shell)
- IGMP (Internet Group Management Protocol)
- PPP (Point to Point Protocol)
- SLIP (Serial Line Internet Protocol)





Questions Please?