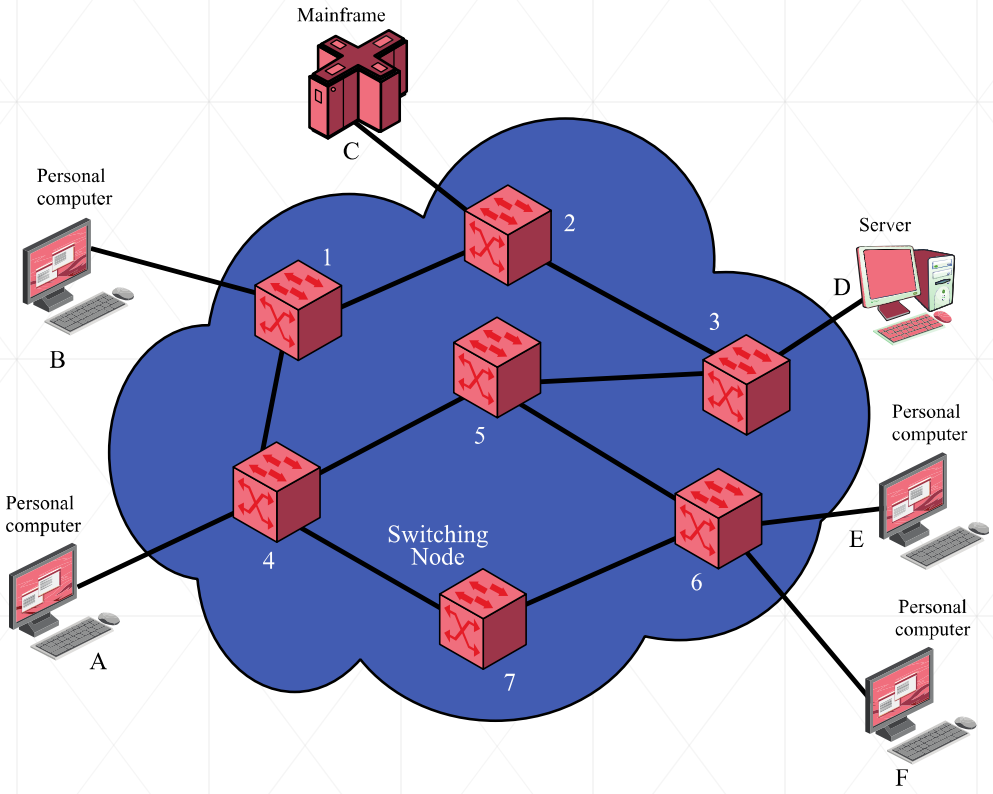
Fundamental concepts in communication :

Communication protocol and architecture

Communication Protocol Architectures



Communication Protocol Architectures

- When a communication occurs between two nodes
  - May involve direct link or via communication network
  - It is an executions of set of tasks, which are organized in a set of communication layers
    - These tasks are performed by each node
    - Each communication layer “talk” to the same layer of its peer
  - Communication between layers should be occurring in the same fashion
    - The peer layers communicate by means of formatted blocks of data that obey a set of rules or conventions known as protocol
- Key Features
  - Syntax : → Concerns the format of the data blocks
  - Semantics : → Includes control information for coordination and error handling
  - Timing : → Includes speed matching and sequencing

Open system interconnection (OSI)

- Conceptual model of communication functions without regard to underlying technology
  - Was initially developed by two different bodies: ISO (International Organization for Standardization) and International Telegraph and Telephone Consultative Committee
  - Then both standards are merged to form a standard called The Basic Reference Model for Open Systems Interconnection
    - Referred to as OSI Reference Model

Layers of the OSI Model

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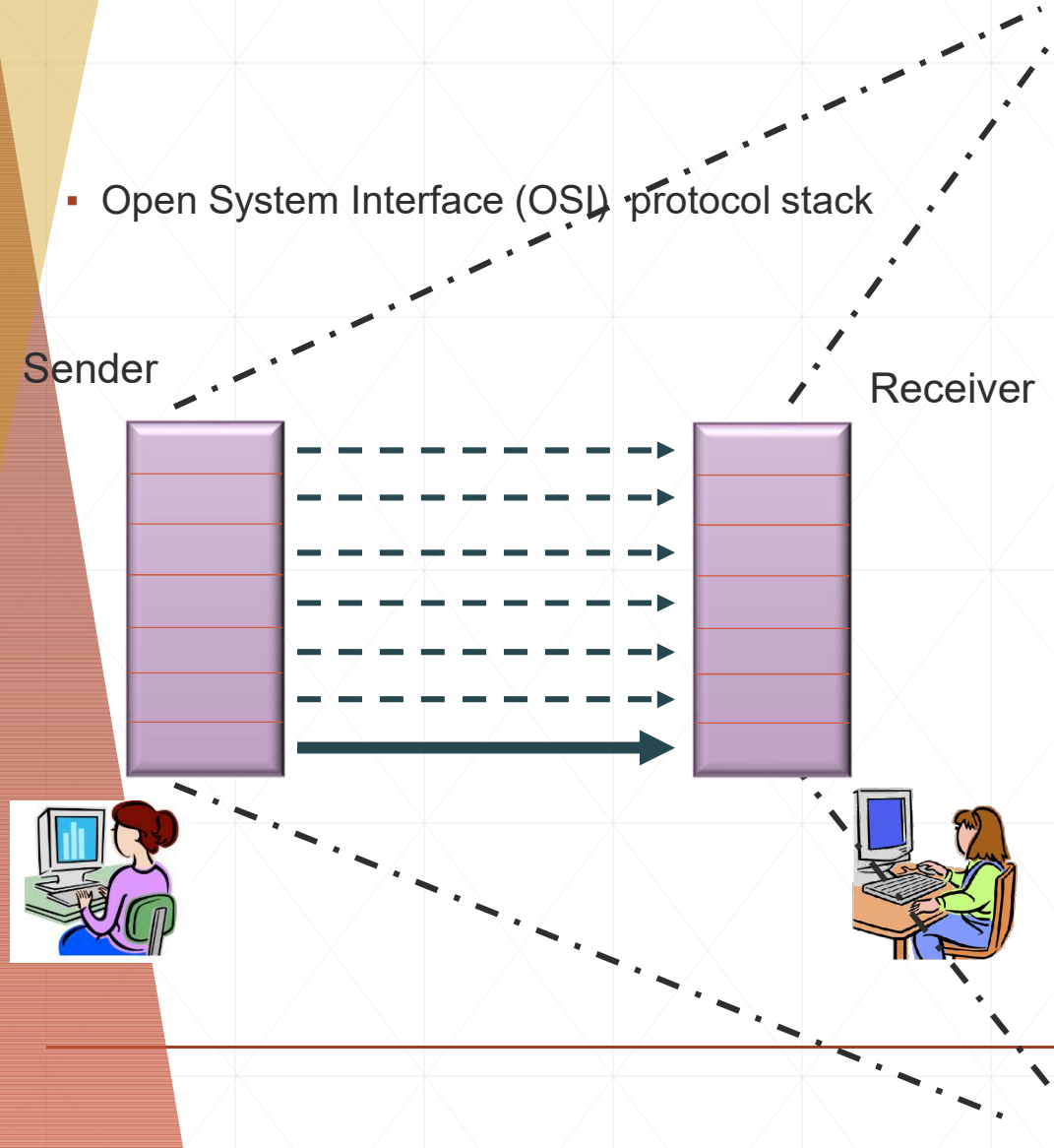
- Layers of communication functions in OSI reference model :
  1. Application
  2. Presentation
  3. Session
  4. Transport
  5. Network
  6. Data link
  7. Physical

OSI Stacks

- Open System Interface (OSI) protocol stack



Application

Provides access to the OSI environment for users and also provides distributed information services.

Presentation

Provides independence to the application processes from differences in data representation (syntax).

Session

Provides the control structure for communication between applications; establishes, manages, and terminates connections (sessions) between cooperating applications.

Transport

Provides reliable, transparent transfer of data between end points; provides end-to-end error recovery and flow control.

Network

Provides upper layers with independence from the data transmission and switching technologies used to connect systems; responsible for establishing, maintaining, and terminating connections.

Data Link

Provides for the reliable transfer of information across the physical link; sends blocks (frames) with the necessary synchronization, error control, and flow control.

Physical

Concerned with transmission of unstructured bit stream over physical medium; deals with the mechanical, electrical, functional, and procedural characteristics to access the physical medium.

Layers of the OSI Model

- Application Layer
  - Provides access to the OSI environment for users
- Presentation Layer
  - Provides independence to the application processes from differences in data representation (syntax)
- Session Layer
  - Provides the control structure for communication between applications
  - Establishes, manages, and terminates connections (sessions) between cooperating applications
- Transport Layer
  - Provides reliable, transparent transfer of data between end points
  - Provides end-to-end error recovery and flow control

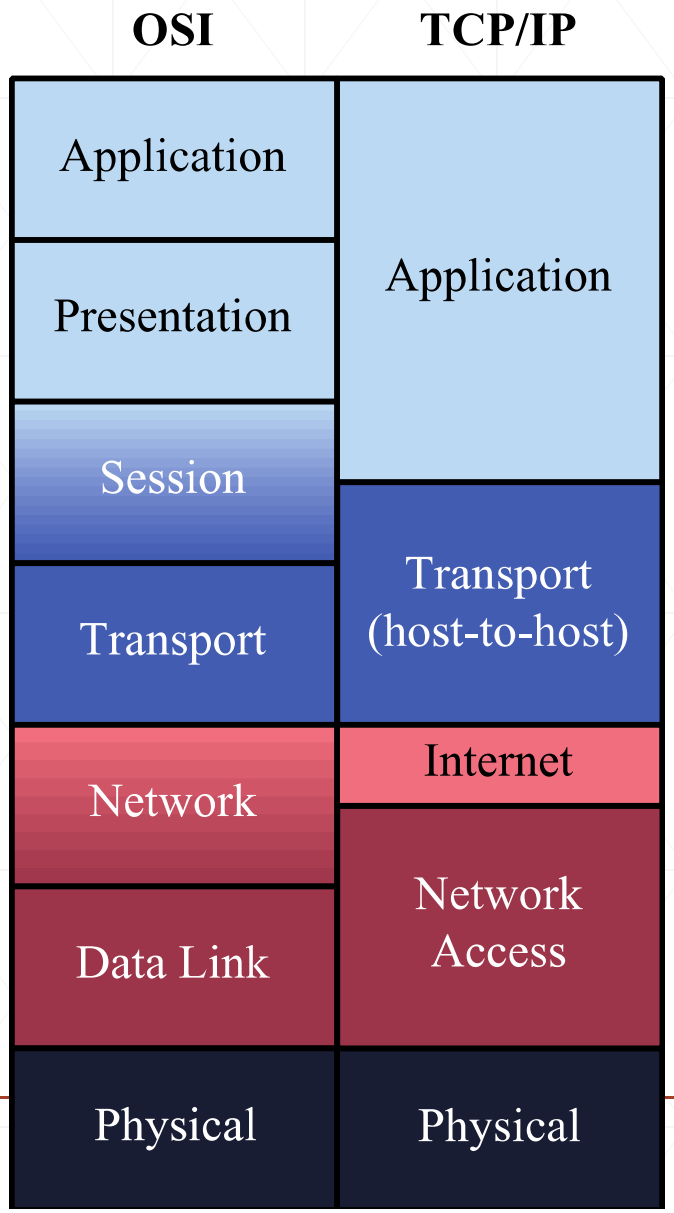
Layers of the OSI Model

- Network Layer
  - Provides upper layers with independence from the data transmission and switching technologies used to connect systems
  - Responsible for establishing, maintaining, and terminating connections
- Data Link Layer
  - Provides for the reliable transfer of information across the physical link
  - Sends blocks (frames) with the necessary synchronization, error control, and flow control
- Physical Layer
  - Concerned with transmission of unstructured bit stream over physical medium
  - Deals with accessing the physical medium
    - Electrical characteristics
    - Functional characteristics
    - Procedural characteristics

TCP/IP Protocol Suit

- Resulted from protocol research and development conducted on the experimental packet-switched network, ARPANET
  - Consists of a large collection of protocols that have been issued as Internet standards by the Internet Architecture Board
  - Three involving agents : application, computer, and network
    - Cover physical, datalink, network, and host to host communication
    - “Smooth” interfacing between layers across different type of protocols
- TCP/IP protocol layers top-down
  - Application layer
  - Host-to-host, or transport layer
  - Internet layer
  - Network access layer
  - Physical layer

TCP/IP Protocol



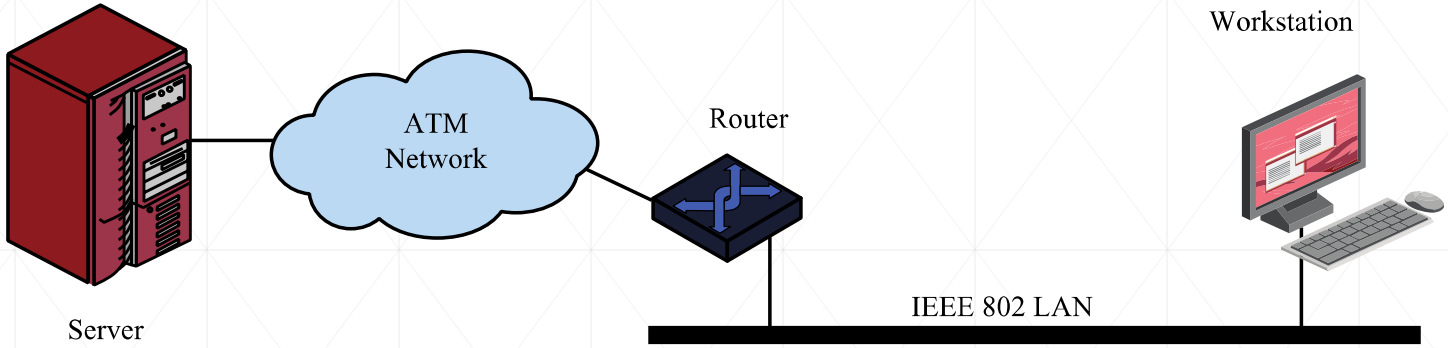
TCP/IP Protocol Suit

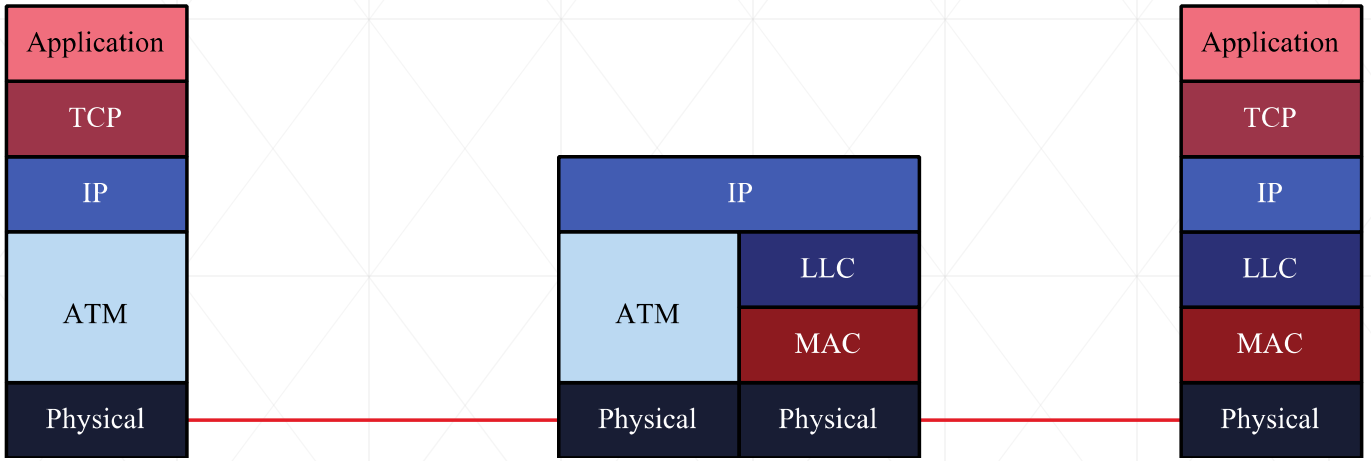
- Physical Layer
  - Covers the physical interface between a data transmission device and a transmission medium or network
  - Physical layer specifies:
    - Characteristics of the transmission medium
    - The nature of the signals
    - The data rate
    - Other related matters
- Network Access Layer
  - Concerned with the exchange of data between an end system and the network to which it's attached ➔ Involves link between switching nodes
  - May use the device network interface identifier → MAC Address
  - Technology standard used depends on type of network
    - Circuit switching
    - Packet switching (e.g., X.25)
    - LANs (e.g., Ethernet, IEEE 802.11)

TCP/IP Protocol Suit

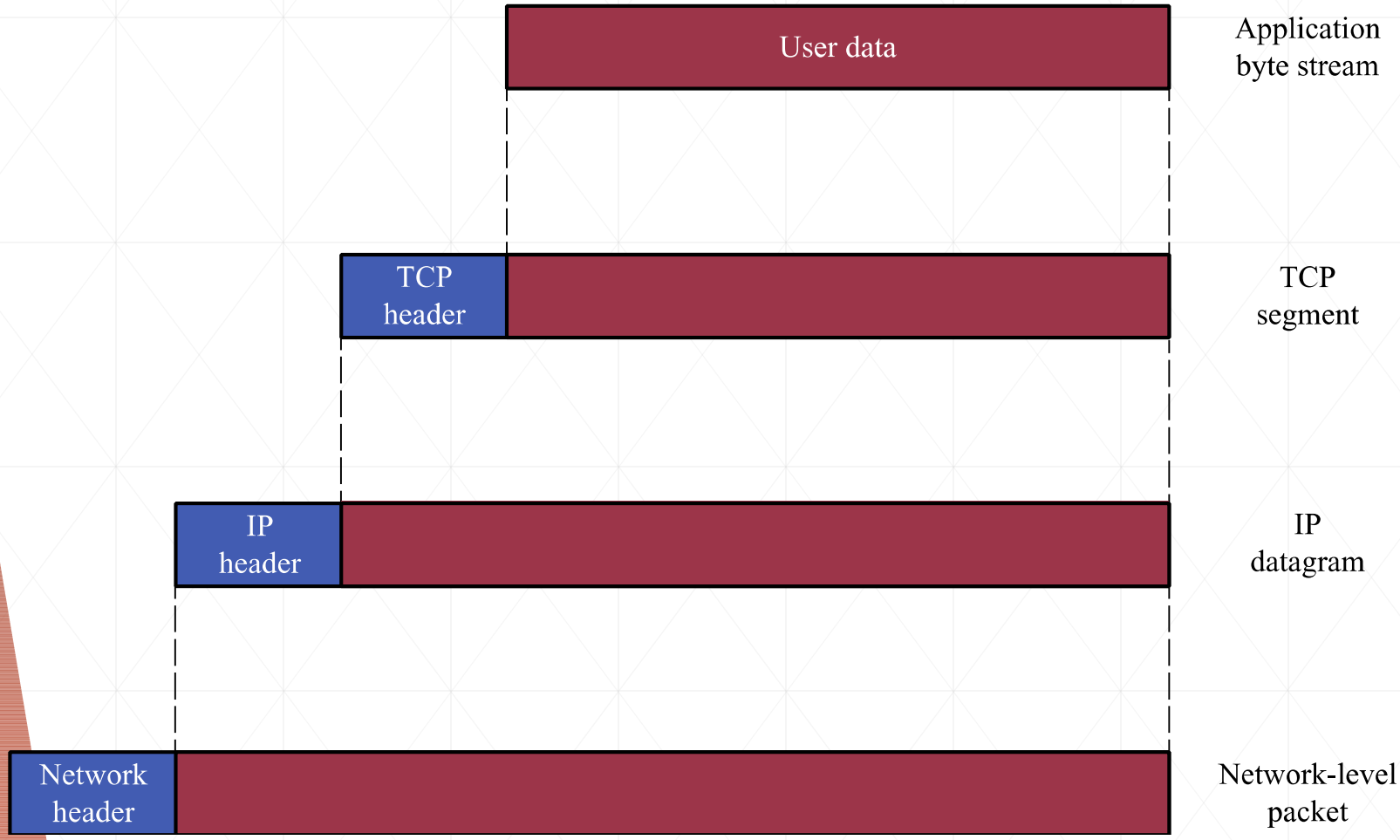
- Internet Layer
  - Deals with how to manage a packet through a network
    - Addressing scheme
    - Provides routing functions to allow data to traverse multiple interconnected networks
    - Managing the diversity of networks
  - Uses Internet Protocol (IP).
    - IPv4 and IPv6
- Transport Layer
  - Commonly uses Transport Control Protocol (TCP) and User Datagram Protocol (UDP
  - TCP provides reliability during data exchange while UDP doesn't
- Application Layer
  - Logic supports user applications
  - Uses separate modules that are peculiar to each different type of application

Example


Workstation
ATM
Network
Router
Server
IEEE 802 LAN


Application
TCP
IP
ATM
Physical
IP
LLC
ATM
MAC
Physical
Physical
Application
TCP
IP
LLC
MAC
Physical

Protocol Data Unit (PDU) and Service Data Unit (SDU)



TCP/IP: Action at Sender

1. Preparing the data. The application protocol prepares a block of data for transmission. For example, an email message (SMTP), a file (FTP), or a block of user input (TELNET).

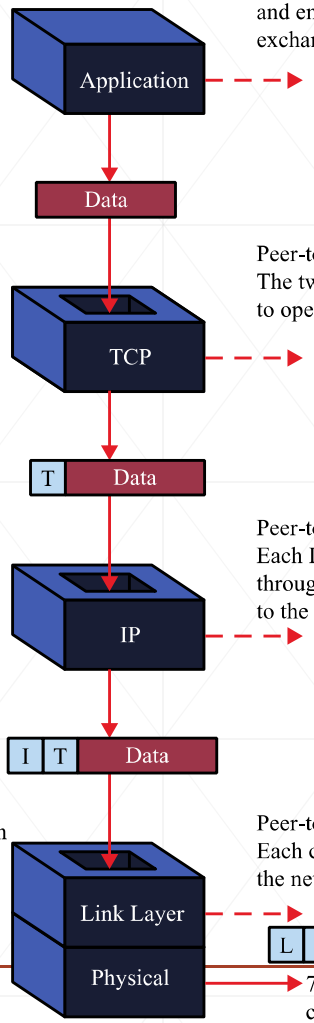
2. Using a common syntax. If necessary, the data are converted to a form expected by the destination. This may include a different character code, the use of encryption, and/or compression.

3. Segmenting the data. TCP may break the data block into a number of segments, keeping track of their sequence. Each TCP segment includes a header containing a sequence number and a **frame check sequence** to detect errors.

4. Duplicating segments. A copy is made of each TCP segment, in case the loss or damage of a segment necessitates retransmission. When an acknowledgment is received from the other TCP entity, a segment is erased.

5. Fragmenting the segments. IP may break a TCP segment into a number of datagrams to meet size requirements of the intervening networks. Each datagram includes a header containing a destination address, a frame check sequence, and other control information.

6. Framing. A link layer header is added to each IP datagram to form a frame. The header contains a connection identifier and a header error control field.



Peer-to-peer dialogue. Before data are sent, the sending and receiving applications agree on format and encoding and agree to exchange data.

Peer-to-peer dialogue. The two TCP entities agree to open a connection.

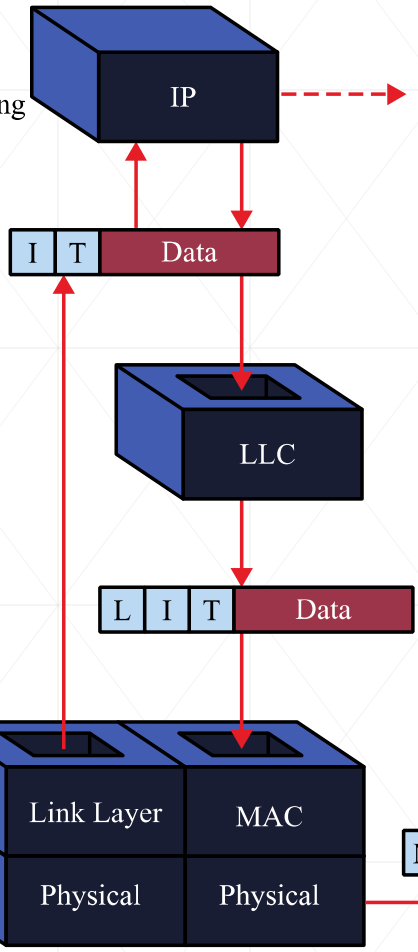
Peer-to-peer dialogue. Each IP datagram is forwarded through networks and routers to the destination system.

Peer-to-peer dialogue. Each cell is forwarded through the network.

7. Transmission. Each cell is transmitted over the medium as a sequence of bits.

TCP/IP: Action at Router

10. Routing the packet. IP examines the IP header and makes a routing decision. It determines which outgoing link is to be used and then passes the datagram back to the link layer for transmission on that link.



Peer-to-peer dialogue. The router will pass this datagram onto another router or to the destination system.

11. Forming LLC PDU. An LLC header is added to each IP datagram to form an LLC PDU. The header contains sequence number and address information.

12. Framing. A MAC header and trailer is added to each LLC PDU, forming a MAC frame. The header contains address information and the trailer contains a frame check sequence.

M L I T Data M

13. Transmission. Each frame is transmitted over the medium as a sequence of bits.

9. Processing the cell. The link layer removes the frame header and processes it. The header error control is used for error detection. The connection number identifies the source.

L I T Data

8. Arriving at router. The incoming signal is received over the transmission medium and interpreted as a cell of bits.

TCP/IP: Action at Receiver

20. Delivering the data. The application performs any needed transformations, including decompression and decryption, and directs the data to the appropriate file or other destination.

19. Reassembling user data. If TCP has broken the user data into multiple segments, these are reassembled and the block is passed up to the application.

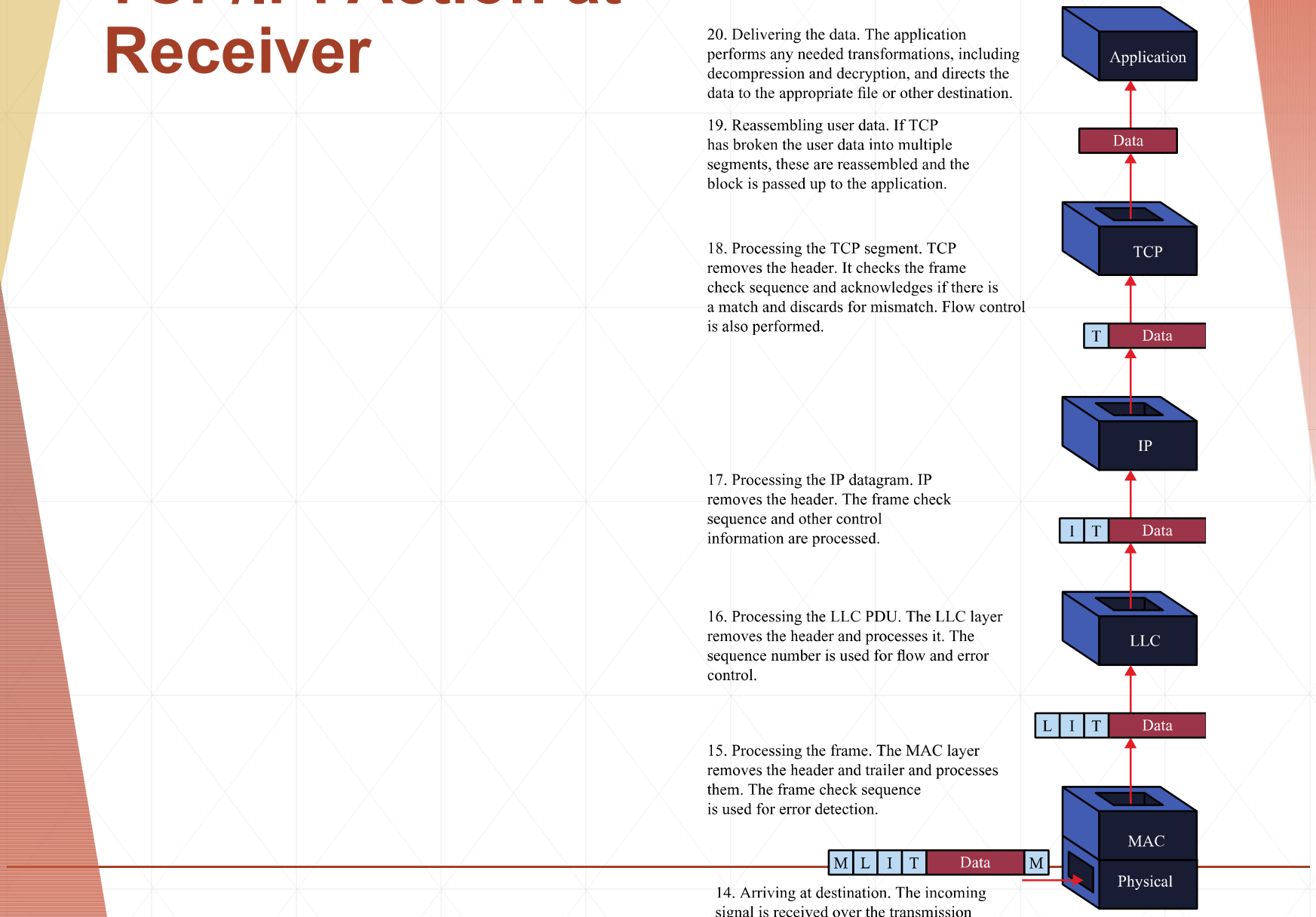
18. Processing the TCP segment. TCP removes the header. It checks the frame check sequence and acknowledges if there is a match and discards for mismatch. Flow control is also performed.

17. Processing the IP datagram. IP removes the header. The frame check sequence and other control information are processed.

16. Processing the LLC PDU. The LLC layer removes the header and processes it. The sequence number is used for flow and error control.

15. Processing the frame. The MAC layer removes the header and trailer and processes them. The frame check sequence is used for error detection.

14. Arriving at destination. The incoming signal is received over the transmission medium and interpreted as a frame of bits.



Common Set of TCP/IP Protocols

TCP/IP Protocol Layer	Protocol Examples
Application	HTTP, Simple Mail Transfer Protocol, File Transfer Protocol
End to End protocol/ Transport Protocol	Transport Control Protocol (TCP), User Datagram Protocol (UDP), Stream Control Transmission Protocol (SCTP)
Internet	IPv4, IPv6, Address Resolution Protocol (ARP), DHCP, DNS
Network Access	IEEE 802 standards, Token Ring

Notes on TCP IP

- TCP/IP protocols matured quicker than similar OSI protocols
  - When the need for interoperability across networks was recognized, only TCP/IP was available and ready to go
- OSI model is unnecessarily complex
  - Accomplishes in seven layers what TCP/IP does with fewer layers

Technology Standards

- PAN, LAN, MAN, and WAN encompass number of communication technologies.
  - Proliferation of these networks today raises a concern of compatibility of communication device and network as well as satisfying the application quality of service requirement
- Example : IEEE 802 technology standards
  - IEEE is an association of technical professional in the field of electrical, electronic, telecommunication, computer and allied disciplines
  - IEEE 802 standards mainly emphasizes on the functionality of the lowest two stack on OSI protocols on standards at physical and data link stack of OSI protocol
  - IEEE 802 also covers the management, security optional features of these layers.

Technology Standards

- Personal Area Network
  - IEEE 802.15 : Communication technology standard for wireless personal network
- Local Area Network
  - IEEE 802.3: Ethernet standard for wired local network
  - IEEE 802.11 : Wireless Local Area Network
- Metropolitan Area Network
  - IEEE 802.16 : Wireless Metropolitan Area Network, it is commercially named as WiMAX (Worldwide interoperability for Microwave Access)
- Mobile Communication
  - IEEE 802.20 : Mobile Broadband Wireless Access, but it is not active now