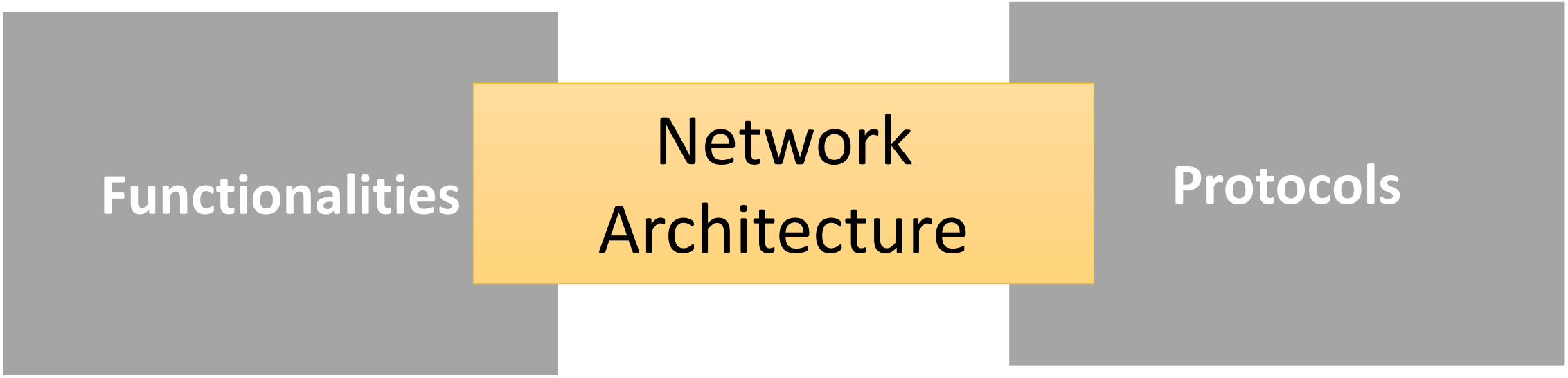
Computer Networks
CS 204

Introduction, Course Structure, Rules and Regulation

Course Objectives

- Understand how two computers in the Internet talk to each other
- Go through the basic functionalities of the computer networks
- Learn how to program the network
- Learn the future of the computer network – Do we need any further changes in the design?



CS 204

- **Prerequisites**: Programming in C, C++ (for CN Lab)
- **Class Hours and Location**:

  Monday 10:35 AM – 11:30 AM, **Tuesday** 11:35 AM:12:30 PM, **Wednesday** 9:30 AM – 10:25 AM;

  - **Room No.** 211
- **Instructor**: SNS, Office: Ground floor, Administrative Building

  Email: sibaswain@iitdh.ac.in

Textbook and References

- 1. Kurose, Ross, Computer Networking: A top-down approach, 6th Edition
- 2. Larry L. Peterson & Bruce S. Davie, Computer Networks: A Systems Approach
- 3. Andrew S. Tanenbaum, Computer Networks
- 4. Online Materials [NPTEL, Stanford, MIT lecture notes and videos- **This list is not exhaustive**]

****The lecture material used may refer to any of the above "textbooks and references" but is not limited to the material mentioned above. However, appropriate citations will be made in the lecture slides presented for possible reference by students.**

Grading Policy:

- Mid Semester Exam: 30% (During mid semester week)
- End Semester Exam: 30% (During Final Exam period)
- Quizzes: 20% [2 quizzes of equal weightage. Date, Time and Venue
- TBA]
- Assignments: 20% [4-5 Assignments/In-Classroom quizzes/Seminar PPTs/Case studies…and many more.]

Exam Pattern

- Subjective Questions
- Objective Questions such as MCQs, Fill in the blanks
- Numerical

Rules

- **Attendance**: As per Institute Policy
- **Copying in Exam:** Penalty as per Institute Policy
- Assignment Submission **deadlines** to be strictly followed
- Occasional re-scheduling of classes based on Slot availability
- **No** make-up exams
- **Course materials**: Slides and Assignments will uploaded on Moodle.
- All classes are interactive

Network Architecture

- **A way to visualize how two remote computers talk to each other**

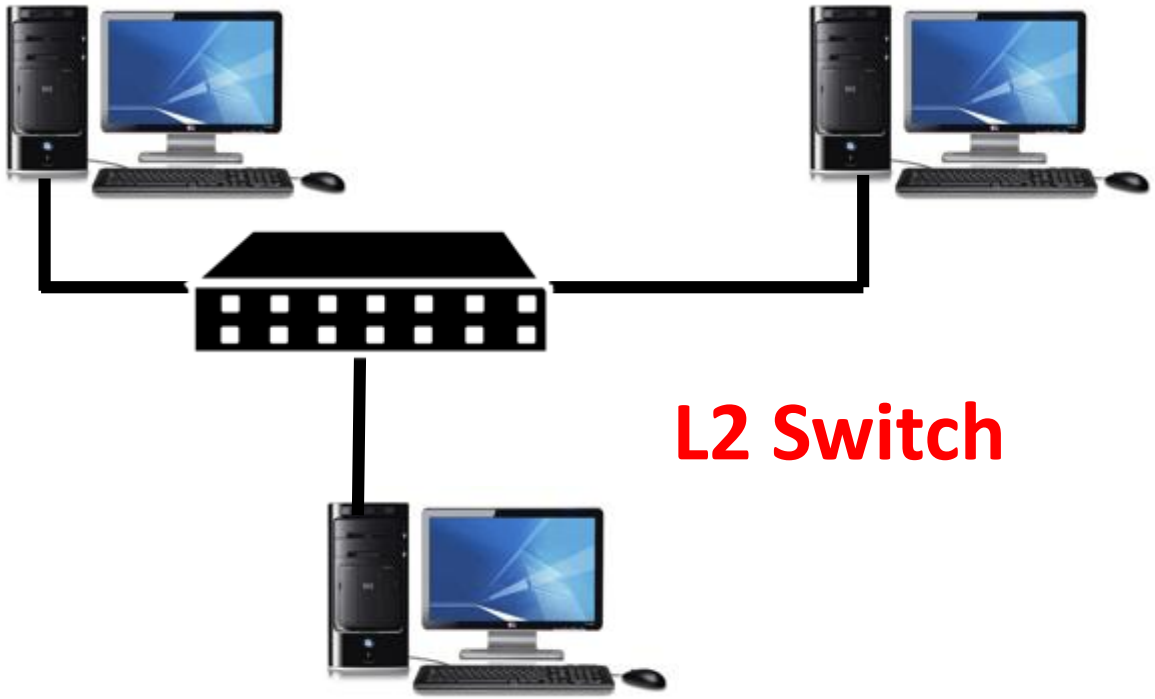
Network Protocol Stack

Network Architecture

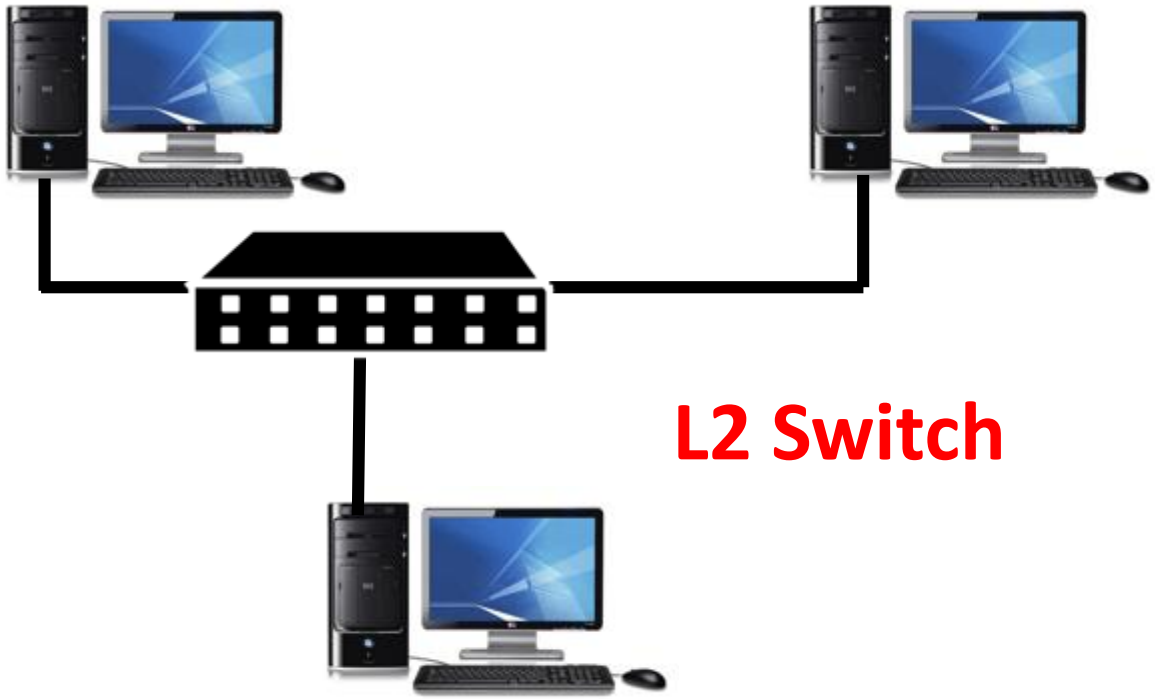
Requirement: Convert digital data to analog signal and vice versa

Physical

Network Architecture



Network Architecture



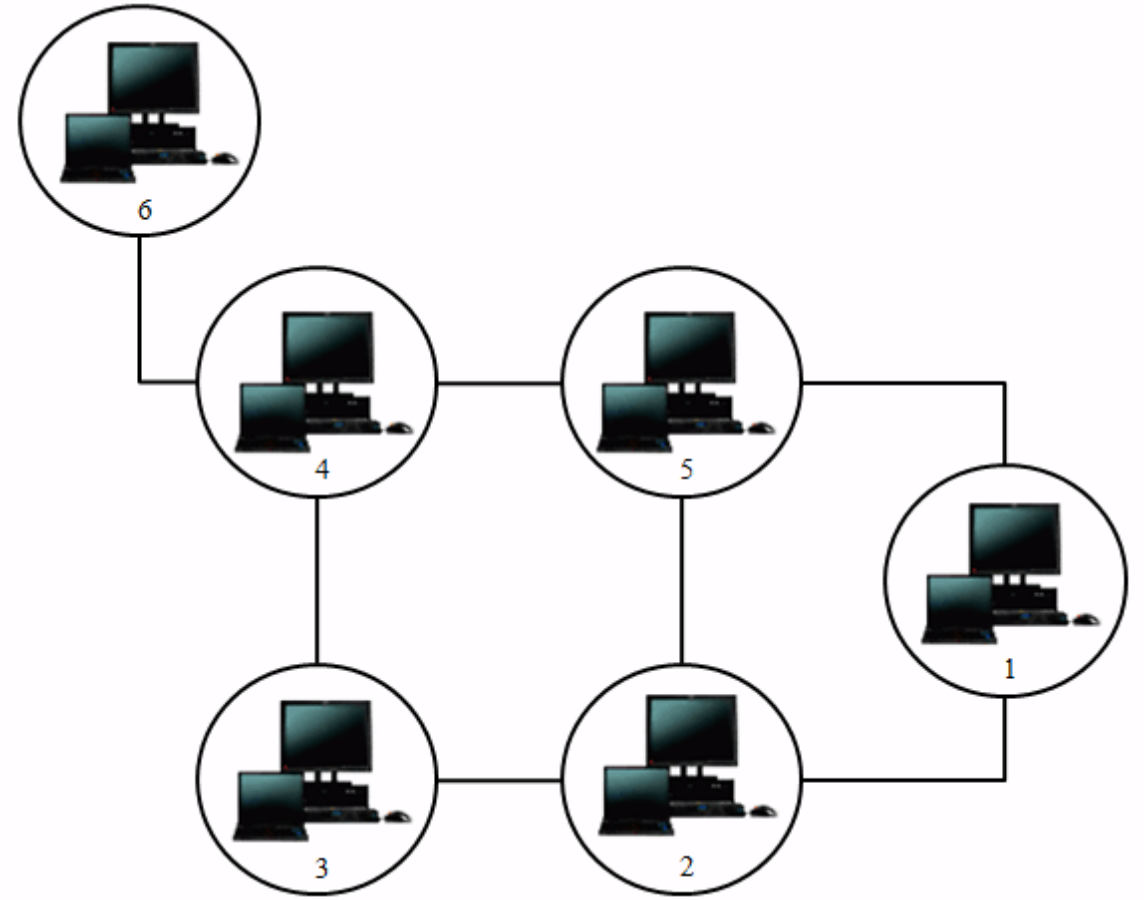
L2 Switch

Requirement: Ensure proper scheduling in media access

Data Link

Physical

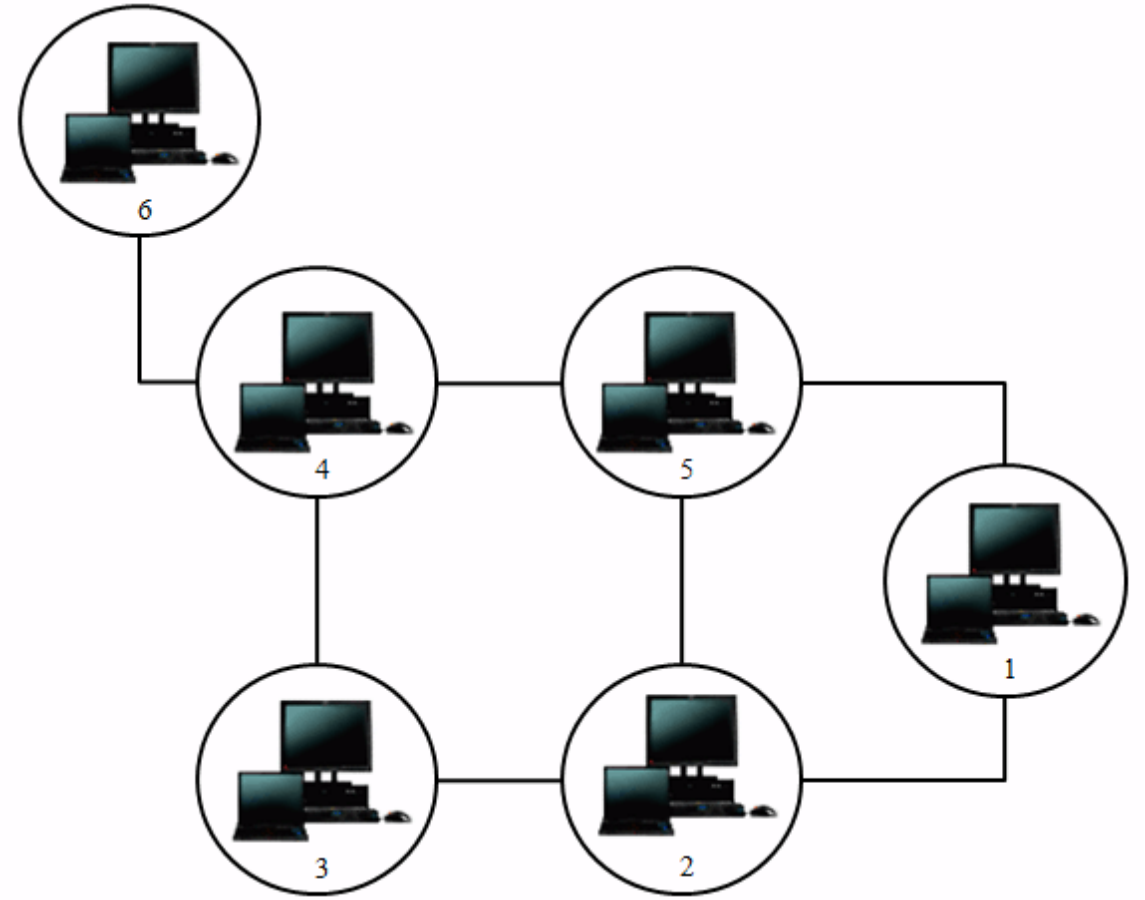
Network Architecture



Data Link

Physical

Network Architecture



Transport

Network

Data Link

Physical

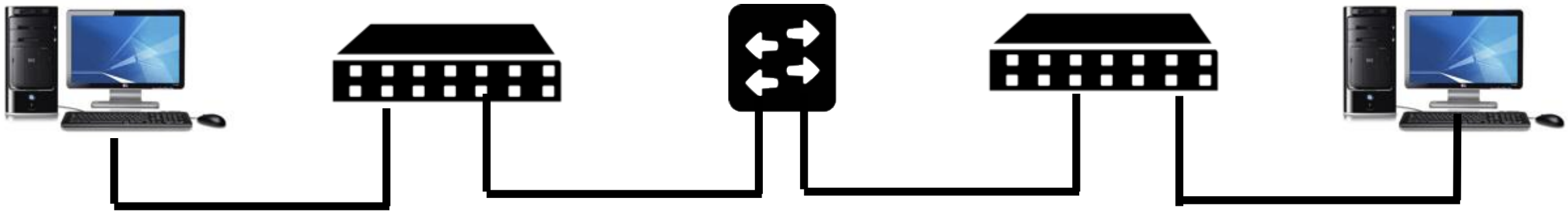
Requirement: End to end traffic control in the network

Network Architecture

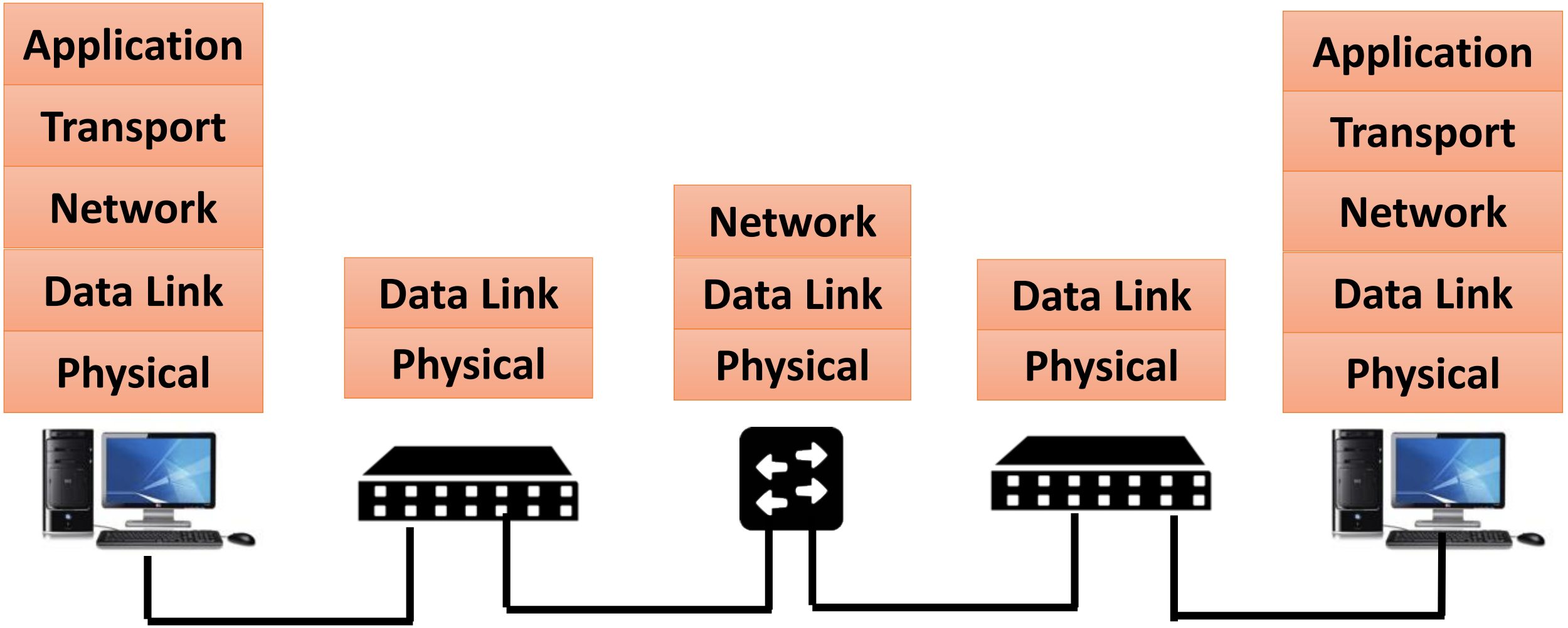
Network Protocol Stack

- **Application**
- **Transport**
- **Network**
- **Data Link**
- **Physical**

Data Transfer between two Machines



Data Transfer between two Machines



Protocols at Different Layers

Application	**HTTP, FTP, SMTP**
Transport	**TCP, UDP, RTP**
Network	**IPv4, IPv6, MPLS**
Data Link	**Ethernet, WiFi, Bluetooth, UMTS, LTE**
Physical	

Protocols

human protocols:

- “what’s the time?”
- “I have a question”
- introductions

… specific msgs sent

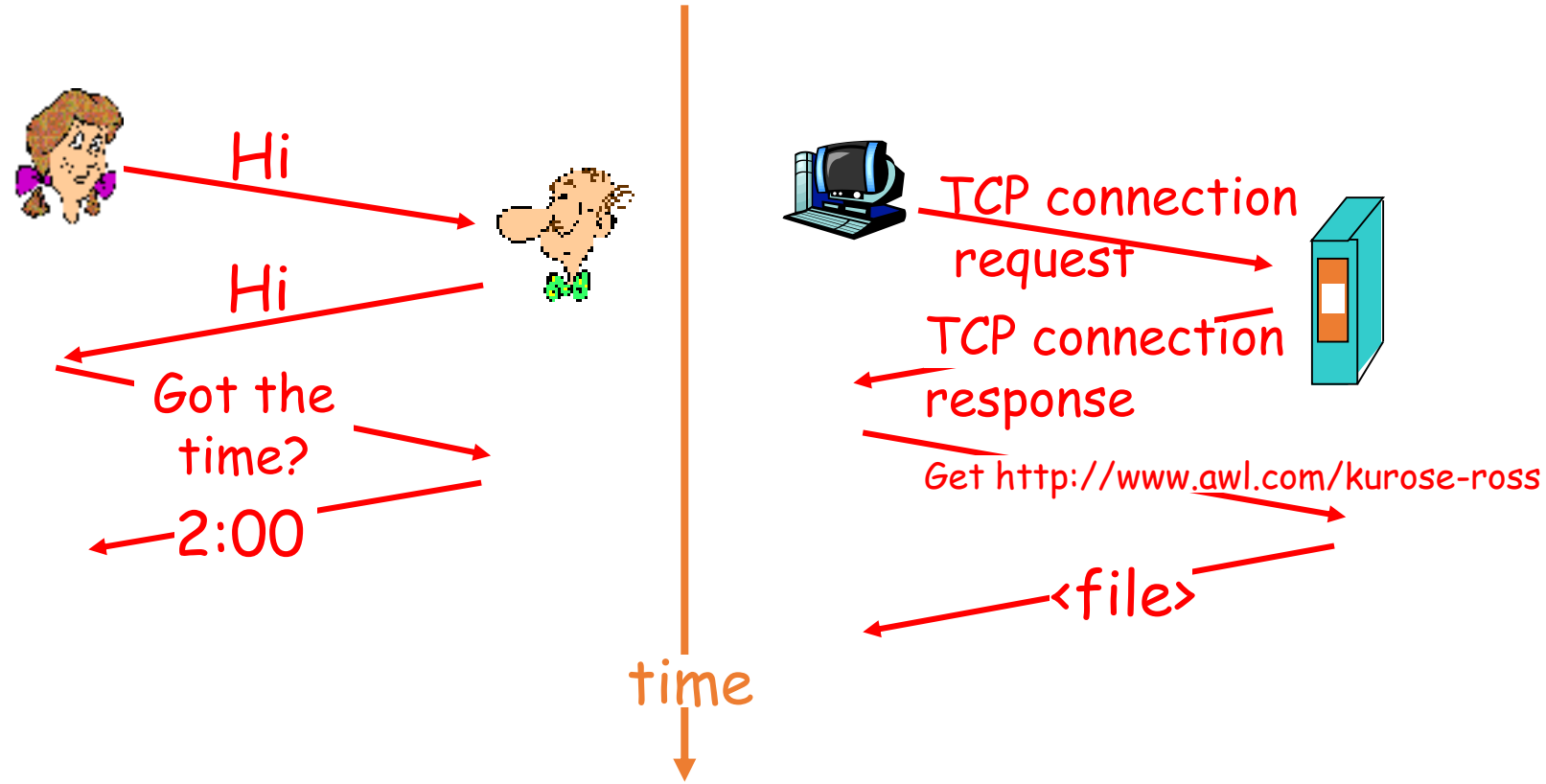
… specific actions taken when msgs received, or other events

network protocols:

- machines rather than humans
- all communication activity in Internet governed by protocols

Protocols

a human protocol and a computer network protocol:



Protocols

- *protocols define format, order of msgs sent and received among network entities, and actions taken on msg transmission, receipt*

Protocols at Different Layers

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Physical	

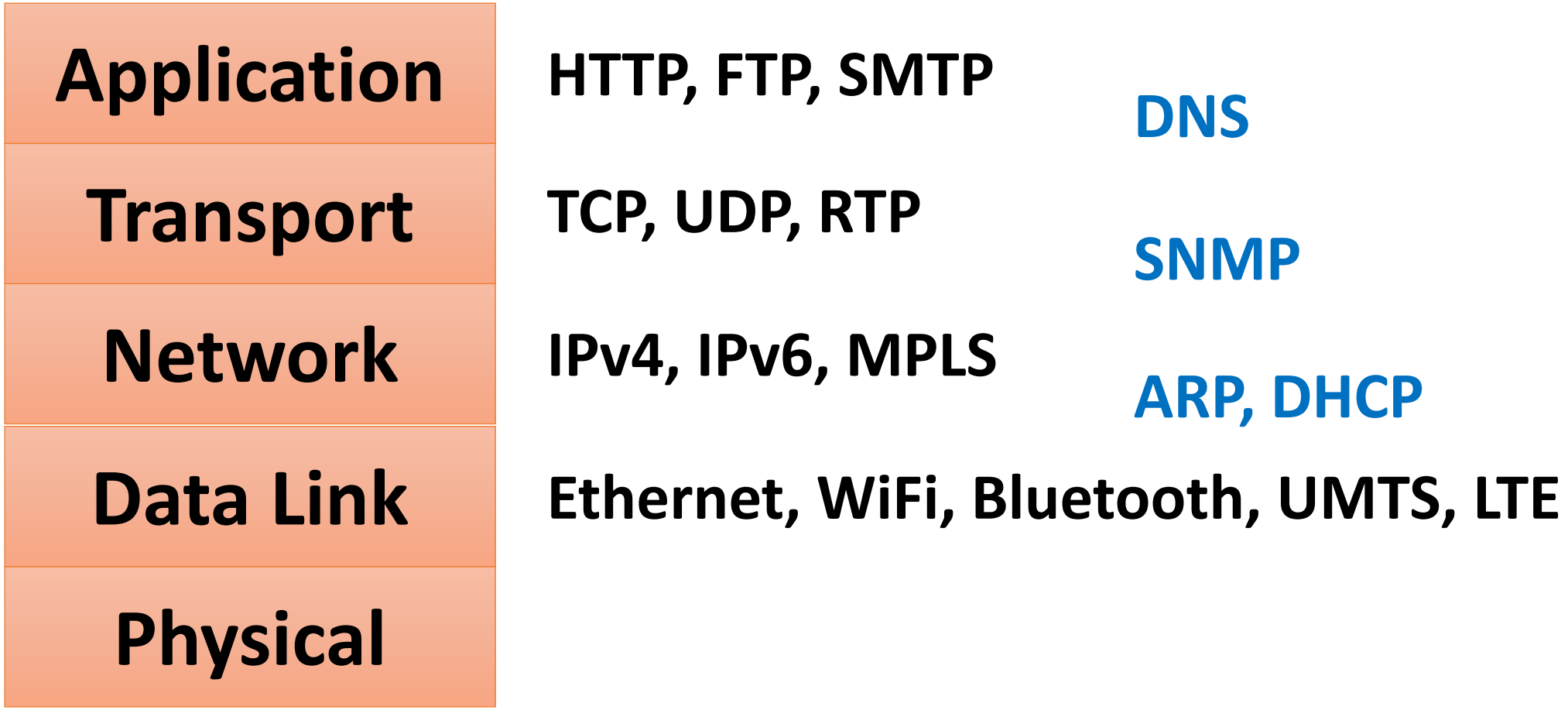
Protocols at Different Layers

- HTTP – For WEB Browsing
- FTP – For File Transmission
- SMTP – For eMail Applications
- TCP – Connection oriented reliable data transmission
- UDP – Connectionless unreliable data transmission
- RTP – For multimedia (audio/video) transmission
- IP – For routing and addressing packets from source to destination
- MPLS – Packet forwarding in telecommunication networks

Protocols at Different Layers

- Ethernet – Standard for LANs, WANs, and MANs
- WiFi – Standard for wireless networking LANs
- Bluetooth – Wireless standard for data exchange over short distances
- UMTS, LTE – Third Generation (3G) mobile communications
-

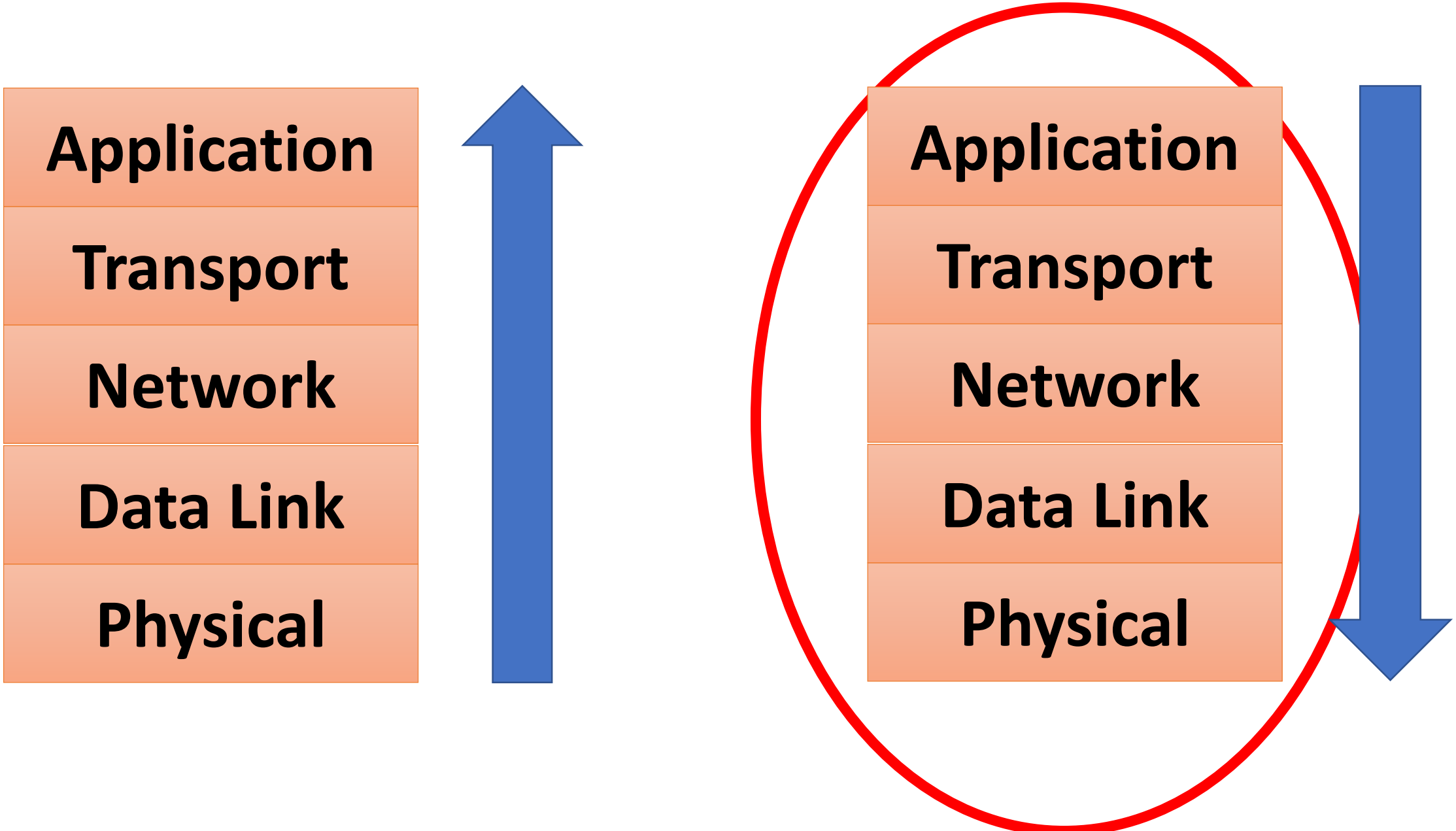
Network Management and Control – Cross Layer Protocols



Cross Layer Protocols

- DNS –
- SNMP –
- ARP –
- DHCP –

Two ways to learn Computer Networks

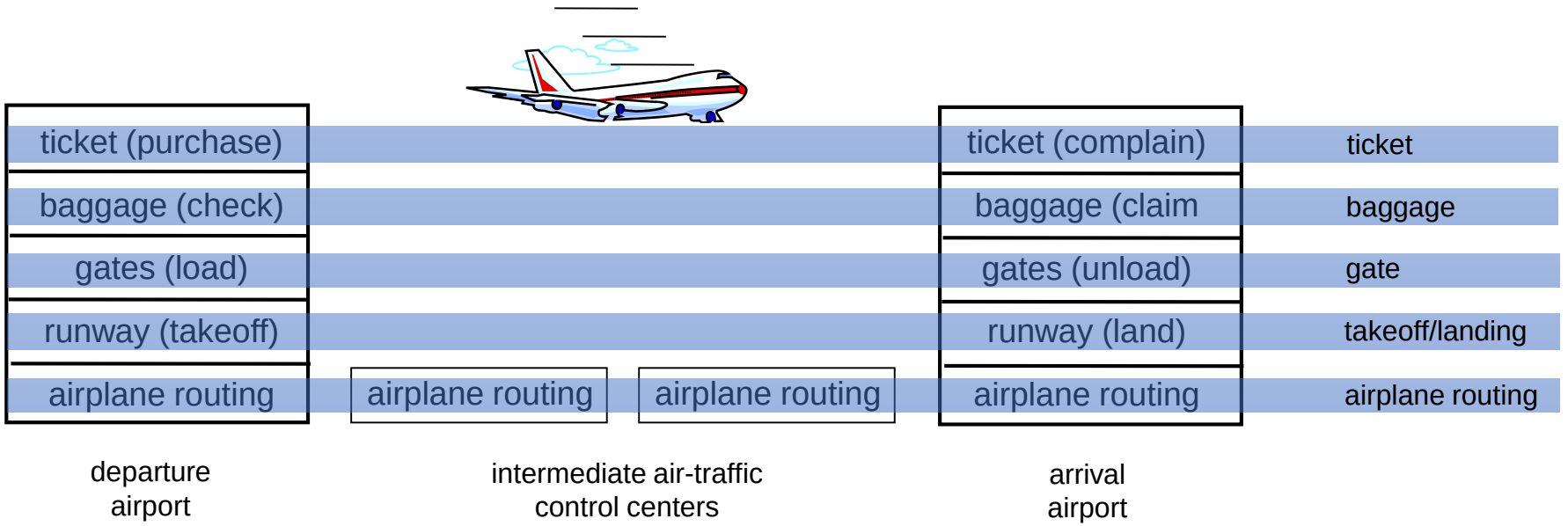


Why layering?

Dealing with complex systems:

- explicit structure allows identification, relationship of complex system's pieces
  - layered reference model for discussion
- modularization eases maintenance, updating of system
  - change of implementation of layer's service transparent to rest of system

Layering of airline functionality



Layers: each layer implements a service

- via its own internal-layer actions
- relying on services provided by layer below

Layered Models

- **OSI Reference Model**
- **TCP/IP Reference Model**

- OSI is more theoretical and focuses on standards only.
- Protocols of OSI are not popular
- However, Protocols of TCP/IP are popular and form the basis of modern Internet.

History

- Initial proposal developed by the **International Standards Organization (ISO)** as a first step toward international standardization of the protocols used in the various **layers (Day and Zimmermann, 1983).**
- **Revised** in **1995.**

- The model is called the ISO **OSI** (**Open Systems Interconnection**) Reference Model because it deals with connecting open systems—that is, systems that are open for communication with other systems.

OSI Model

- Open Systems Interconnections Model
- 7 layered network Architecture

- According to the ISO standards, networks have been divided into 7 layers depending on the complexity of the functionality each of these layers provide.

Principle behind Layering in OSI

- Layering in OSI is done based on the following principles:
  - A layer should be created where a **different abstraction is needed**.
  - Each layer should perform a **well-defined function**.
  - The function of each layer should be chosen with an eye toward defining **internationally standardized protocols**.
  - The layer boundaries should be chosen **to minimize the information flow across the interfaces**.
  - The number of layers should be large enough that **distinct functions need not be thrown together in the same layer out of necessity and small enough that the architecture does not become unwieldy**.

OSI Model

- The 7 Layers
  - Physical Layer
  - Data Link Layer
  - Network Layer
  - Transport Layer
  - Session Layer
  - Presentation Layer
  - Application Layer

OSI Model

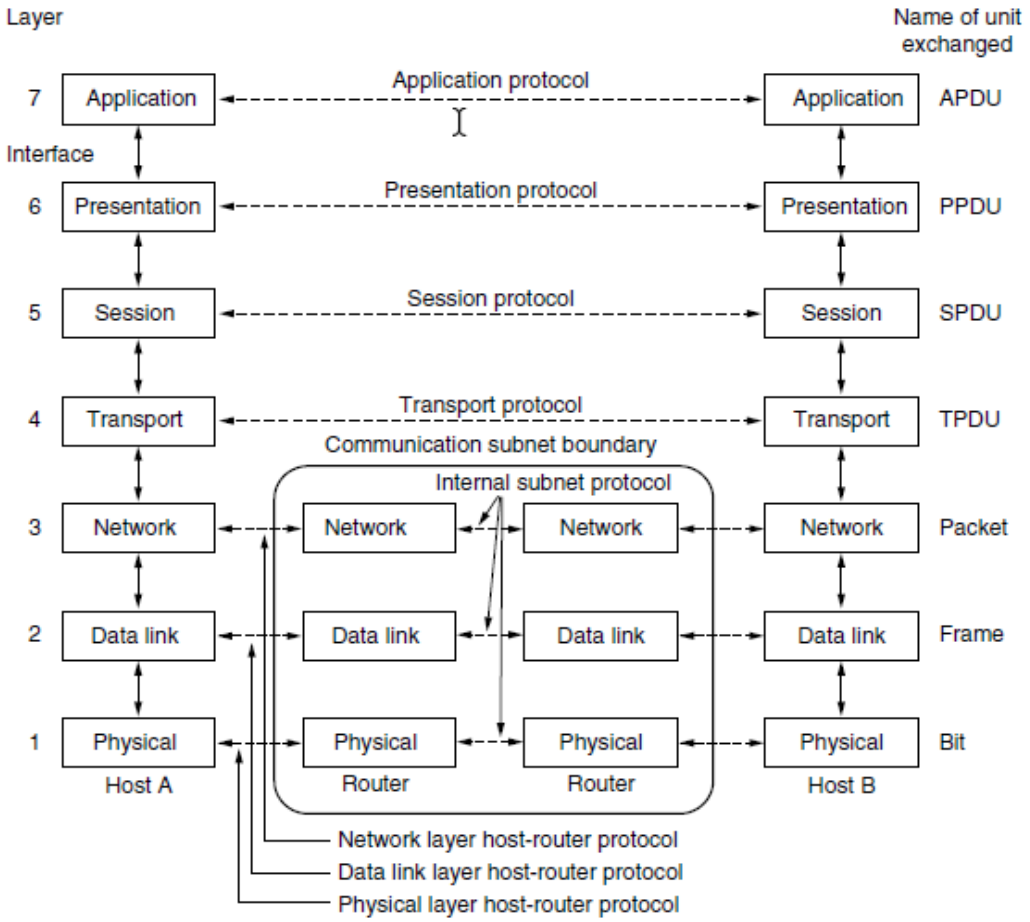


Figure 1-20. The OSI reference model.

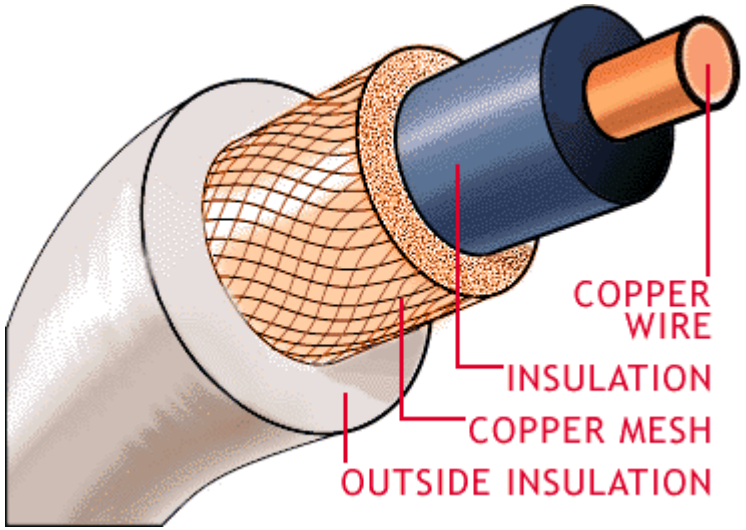
Physical Layer

- This layer is the lowest layer in the OSI model.

- It helps in the transmission of data between two machines that are communicating through a physical medium, which can be optical fibres,copper wire or wireless etc.

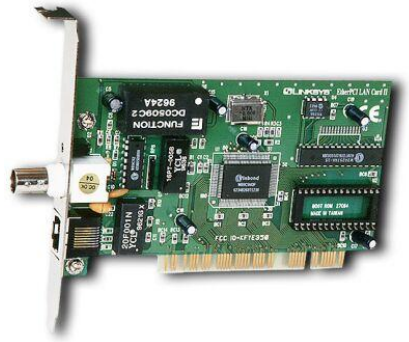
Physical Layer Functions

- **Hardware Specification:** The details of the physical cables, network interface cards, wireless radios, etc are a part of this layer.



Coaxial Cable

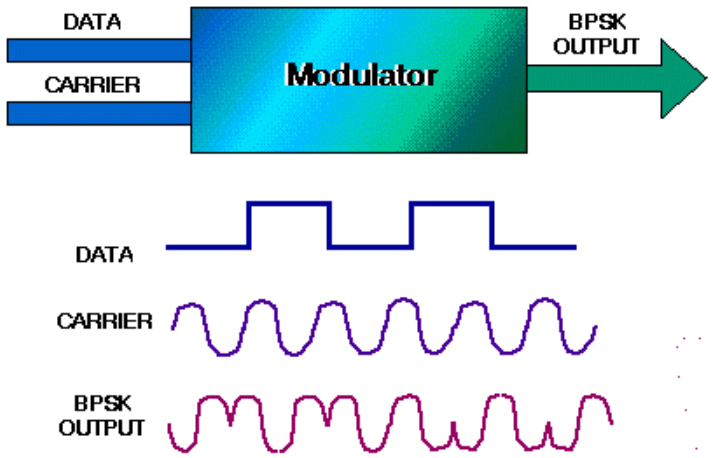
Wireless LAN Card



Network Card

Physical Layer Functions

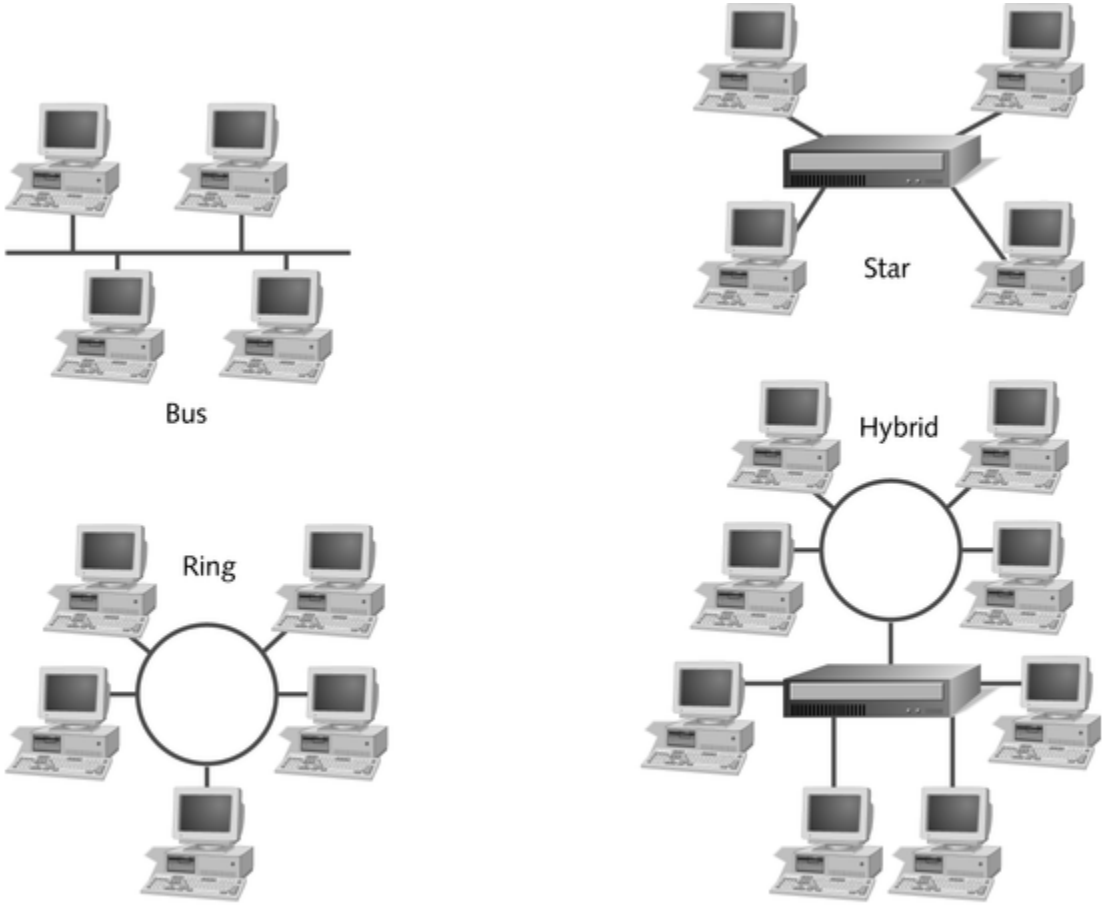
- **Encoding and Signaling:** Digital Modulation and Multiplexing



Physical Layer Functions

- **Digital Modulation:**
- Wires and wireless channels carry analog signals such as continuously varying voltage, light intensity, or sound intensity. To send digital information, we must devise analog signals to represent bits.
- The process of converting bits to analog signals that represent them is called **digital modulation.**

- **Topology and Network Design:**



Data Link Layer

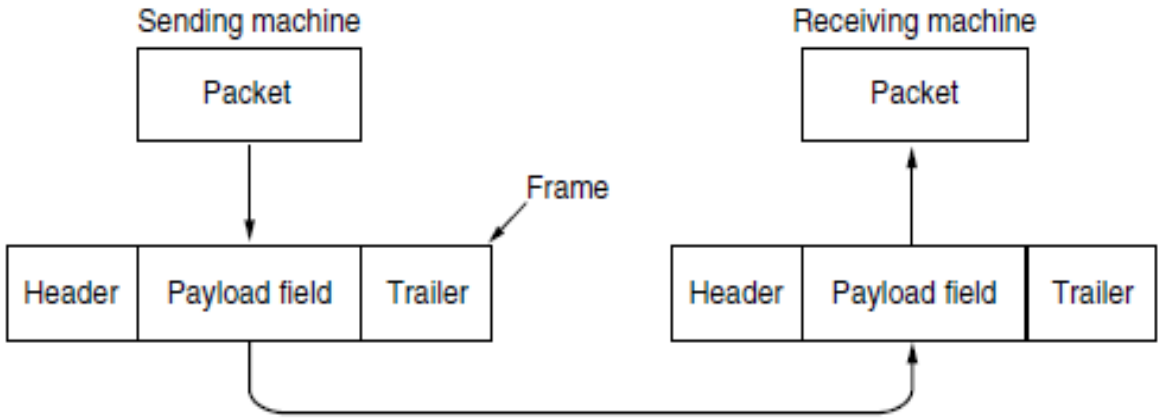
- This layer provides reliable transmission of a packet by using the services of the physical layer which transmits bits over the medium in an unreliable fashion.

Data link Layer Functions

- This layer is concerned with :
  - **Framing** : Breaking input data into frames (typically a few hundred bytes) and caring about the frame boundaries and the size of each frame.
  - Framing helps in dealing with transmission errors and flow control – instead of handling raw stream of bits, the data link layer will split the bits into frames and apply error detection algorithms (such as checksum computation, etc.) or flow control algorithms (such as feedback based flow control or rate based flow control.)

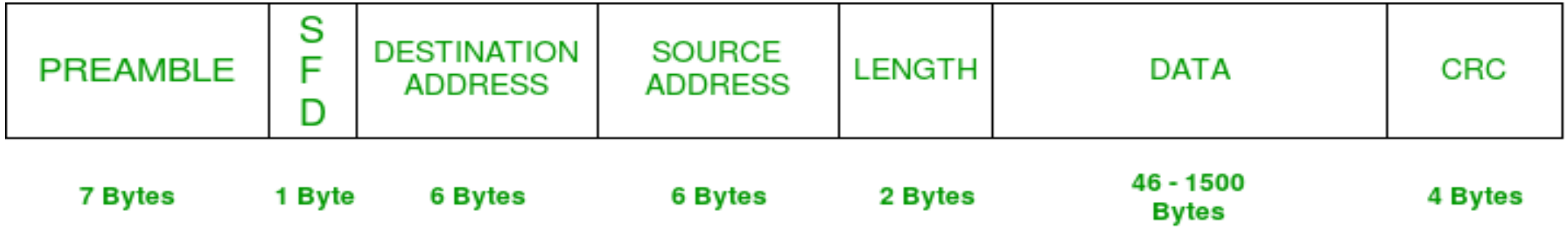
Data link Layer

- Frame structure



Relationship between packets and frames.

Data link Layer



IEEE 802.3 ETHERNET Frame Format

1. Preamble - alternative 0's and 1's which indicates starting of the frame and allow sender and receiver to establish bit synchronization
2. Start Frame Delimeter SFD - 1-Byte field which is always set to 10101011. SFD indicates that upcoming bits are starting of the frame, which is the destination address.
3. Destination Address – MAC address of the destination
4. Source Address – MAC Address of source
5. Length – Indicates the entire length of the ethernet frame
6. Data – Actual data. Also known as Payload
7. Cyclic Redundancy Check - This field contains a 32-bits hash code of data, which is generated over the Destination Address, Source Address, Length, and Data field. If the checksum computed by destination is not the same as sent checksum value, data received is corrupted.

Data Link Layer

- Error Detection and Control
  - The frames may be damaged, lost or duplicated leading to errors.
  - Basic strategy for dealing with errors:
    - Use of redundant information/bits for error detection and correction.
  - **Error Detection Codes:** Parity, Checksums, Cyclic Redundancy Check (CRC)
  - **Error Correction Codes** such as Hamming Codes, Binary Convolutional codes, Reed Solomon Codes, Low Density Parity Check Codes
  - **Acknowledgment** : Sent by the receiving end to inform the source that the frame was received without any error.

Data Link Layer

- **Flow Control** : Necessary for a fast transmitter to keep pace with a slow receiver.
- In such a case, the transmission is error free but due to slow processing power of receiver some of the frames are dropped.

- Two approaches: **Feedback based flow control** and **rate based flow control**

- **Stop and Wait, Sliding Window Protocols** come under feedback based flow control

Data Link Layer

- **Medium Access Control** is also another functionality of data link layer

- In fact, later on in this course, you will see that Data Link Layer is further subdivided into MAC sublayer and Logical Link Control (LLC) sublayer.

Logical Link Control (LLC)	**Error control and flow control**
Medium Access Control (MAC)	**Channel access and physical layer addressing**