# Computer Networks and Security

## BO CDA 301 Sem5 (3rd Yr)

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# What is a NETWORK?

***A network is a set of devices (often referred to as nodes) connected by communication links. A node can be a computer, printer, or any other device capable of sending and/or receiving data generated by other nodes on the network. A link can be a cable, air, optical fiber, or any medium which can transport a signal carrying information.***

***Topics discussed in this section:***

- **Network Criteria**
- **Physical Structures**
- **Categories of Networks**

# What is a NETWORK?

**A network can be:**

- **as simple as two computers connected together, or**
- **as complex as 150 Million connected together (The Internet).**

**Other devices can be connected to a network:**

**For example, printers, disk drives, terminal server and communication servers.**

# Why NETWORK – Service offerings

- Efficient way to share resources
  - Cost
  - Accessibility
- Efficient way to exchange information
  - Time
  - Size
  - Correctness

# Data Communication – State of Art

- Tremendous service level transformation in various domain, e.g., Business, Industries, Utility services, Science, Education etc.
  - Requires immediate access to accurate information
  - Advancement of Communication media
    - Bandwidth increases – links can carry more and faster signals
    - New services are being evolved to use the expanded capacities
- Goal: Efficient technologies to exchange various form of data with less delay and higher throughput

# Data Communication Characteristics

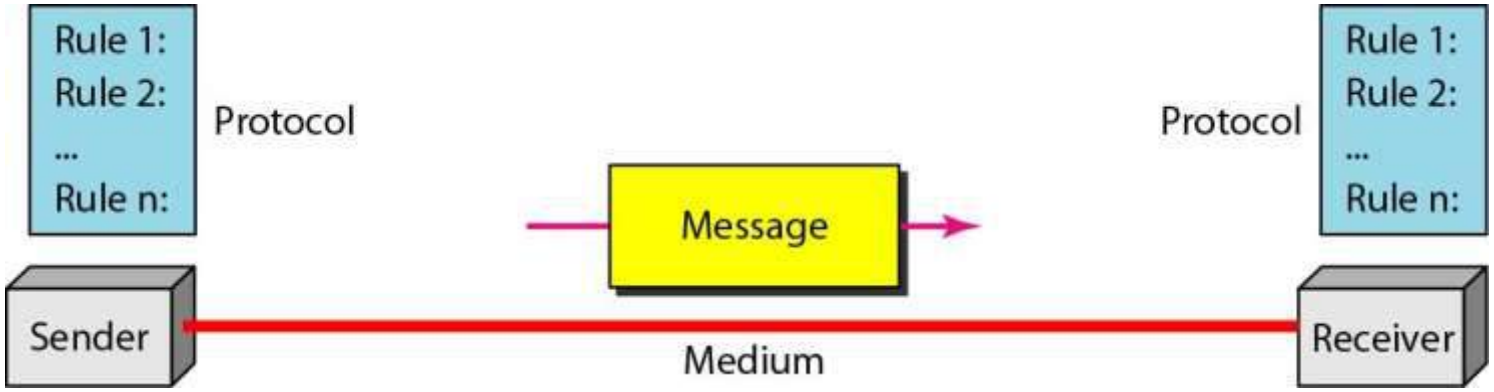
- Delivery
- Accuracy
- Timeliness

# 1-1 DATA COMMUNICATIONS

***The term telecommunication means communication at a distance. The word data refers to information presented in whatever form is agreed upon by the parties creating and using the data. Data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable.***

- **Components of a data communications system**
- **Data Flow**

## Figure 1.1 *Components of a data communication system*



# Need of Network Protocol

**A set of rules is needed for any means of communication:**

**•Human intercommunication (in pairs or larger groups) requires**

**Rules of conversation (do not speak if someone else is speaking) To function effectively.**

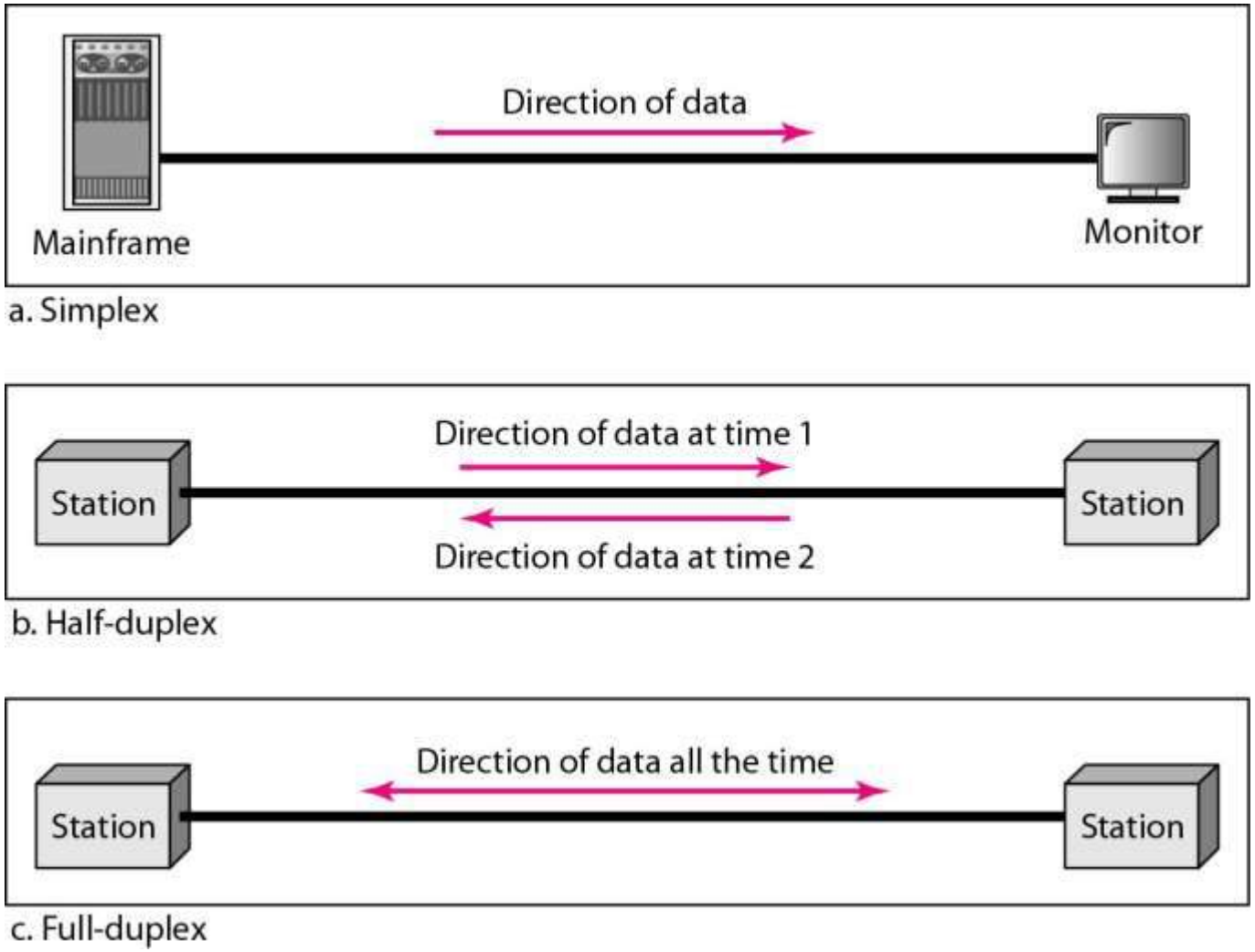
**•Computers are no different.**

**For any inter-computer communcation, we need regulations and Rules to how we communicate over a computer network.**

**Example: remote login (telnet), FTP, email, access web pages (HTTP,CGI)**

**•The set of rules and regulations is called a Protocol.**

## Figure 1.2 *Data flow (simplex, half-duplex, and full-duplex)*



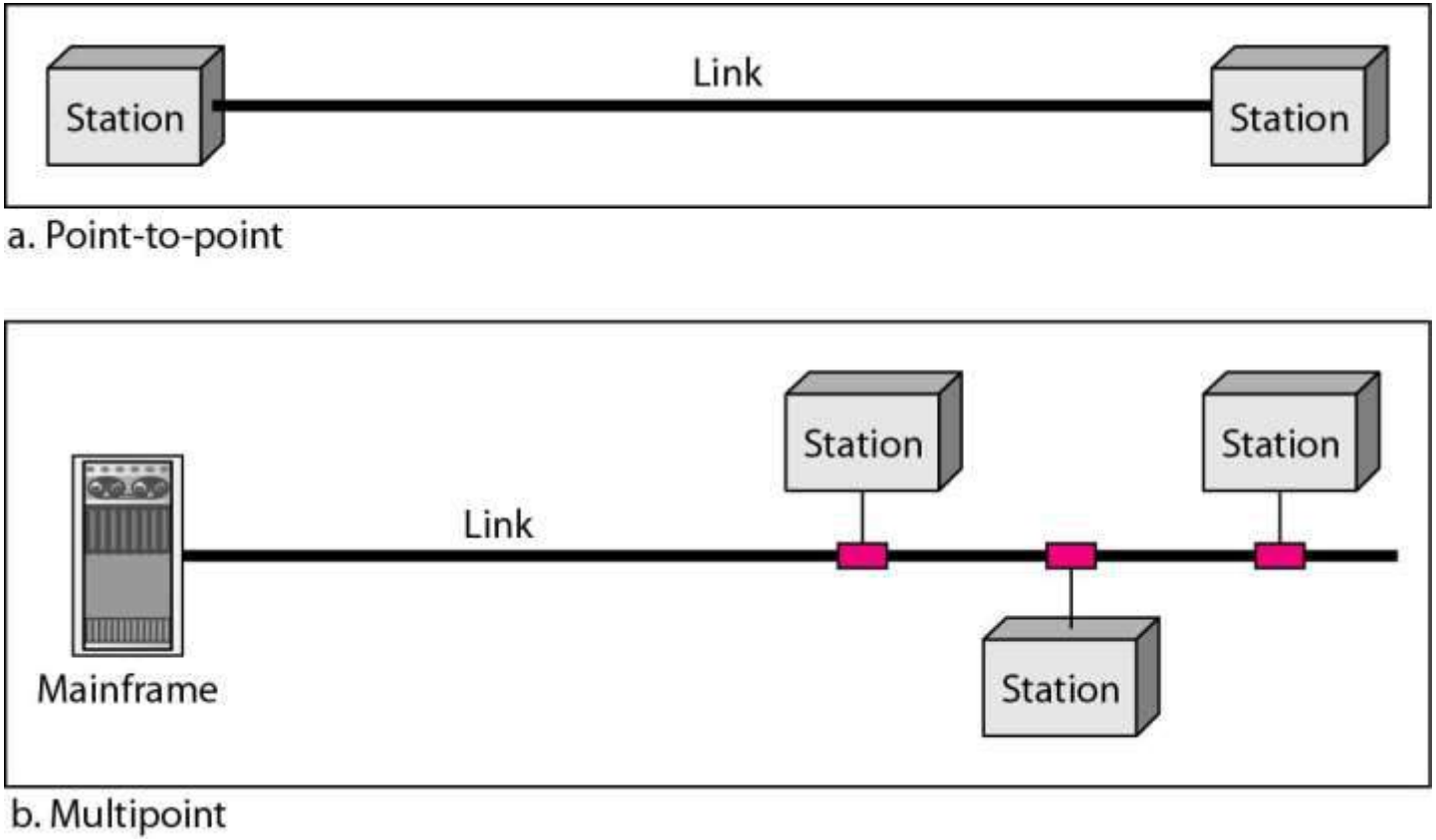
# Network Criteria

- **Performance**
  - **Depends on Network Elements**
  - **Measured in terms of Delay and Throughput**
- **Reliability**
  - **Failure rate of network components**
  - **Measured in terms of availability/robustness**
- **Security**
  - **Data protection against corruption/loss of data due to:**
    - **Errors**
    - **Malicious users**

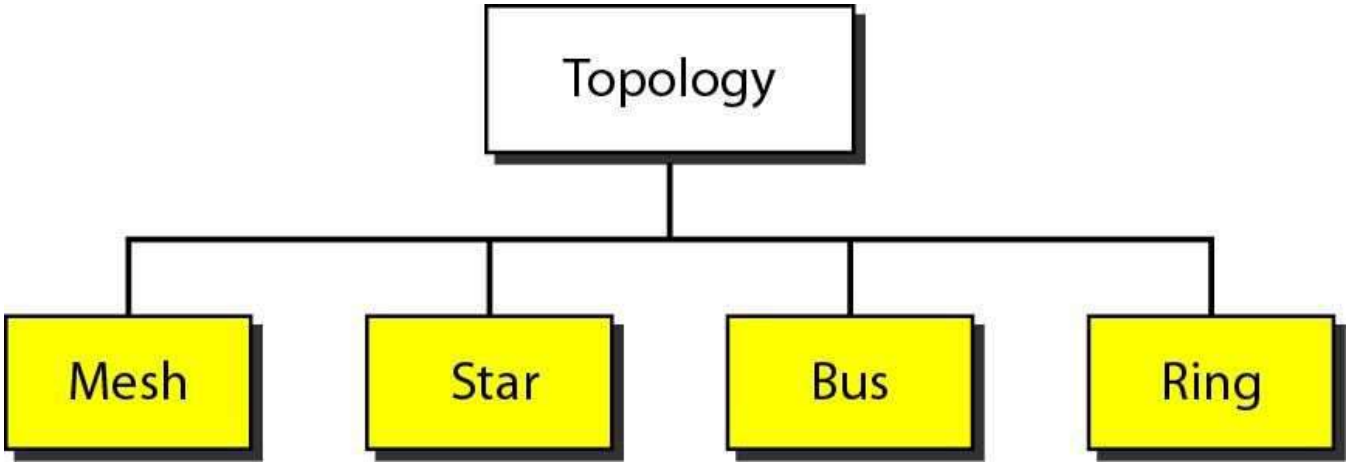
# Physical Structures

- **Type of Connection**
  - **Point to Point - single transmitter and receiver**
  - **Multipoint - multiple recipients of single transmission**
- **Physical Topology**
  - **Connection of devices**
  - **Type of transmission - unicast, mulitcast, broadcast**

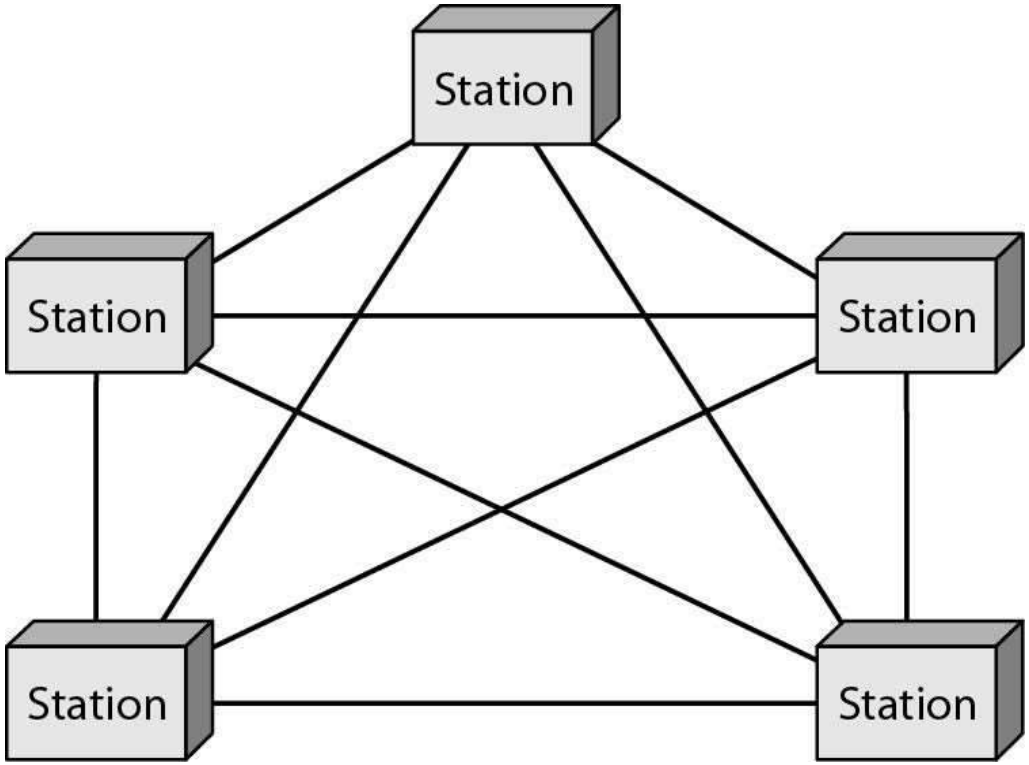
## Figure 1.3 *Types of connections: point-to-point and multipoint*



## Figure 1.4 *Categories of topology*

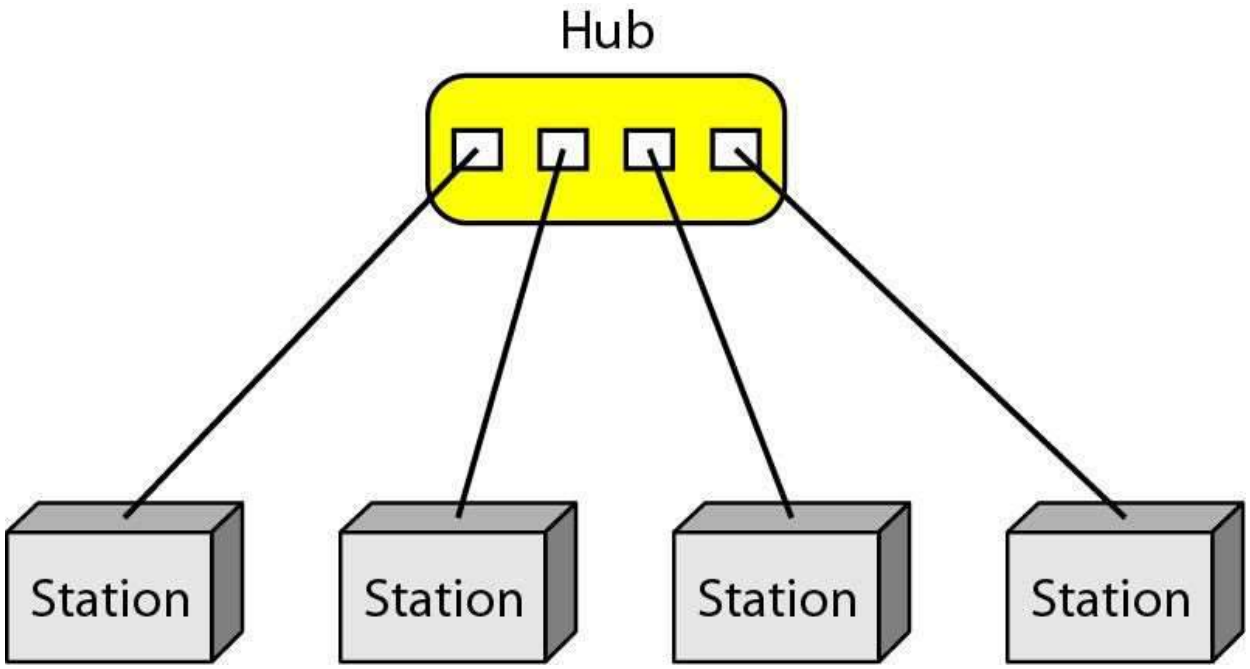


## Figure 1.5 *A fully connected mesh topology (five devices)*



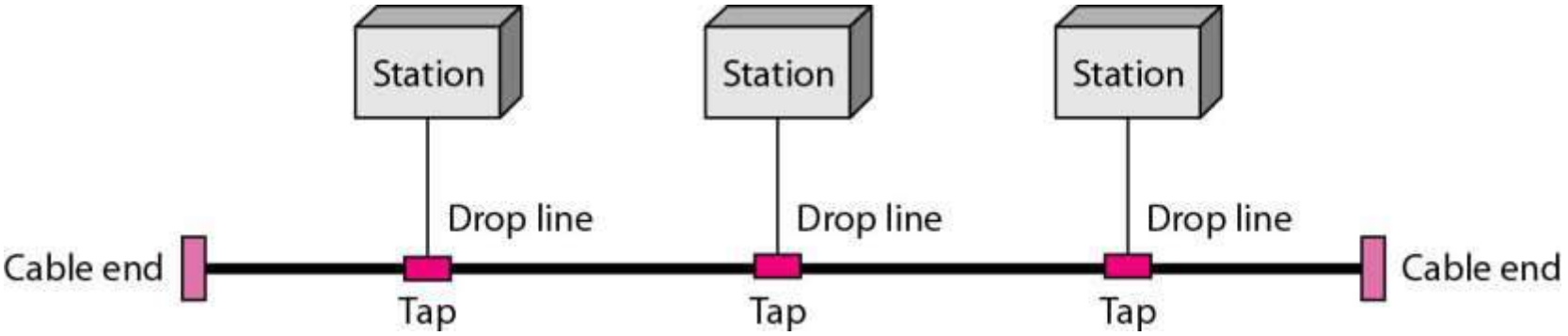

A mesh topology is secure, resilient, and adaptable, but it has high complexity, high overhead, and high resource consumption.

## Figure 1.6 *A star topology connecting four stations*



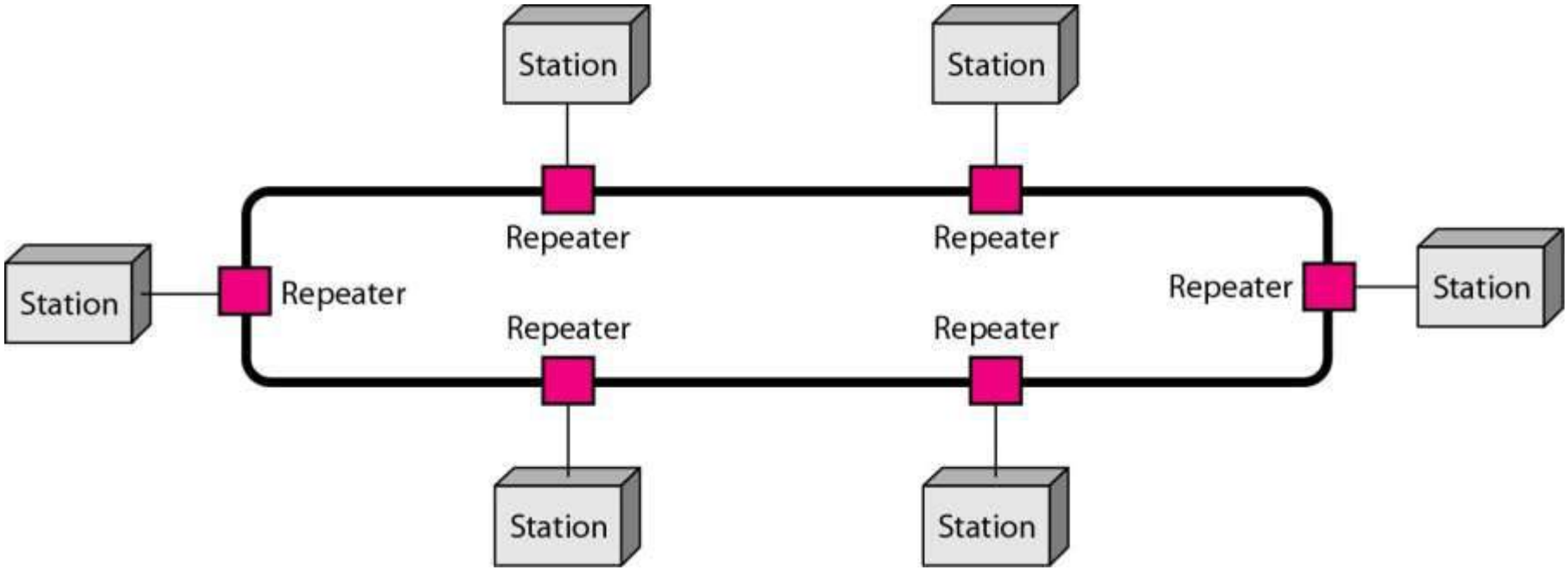

A star topology is fast, flexible, and robust, but it has high cost, high maintenance, and dependency on the hub

## Figure 1.7 *A bus topology connecting three stations*



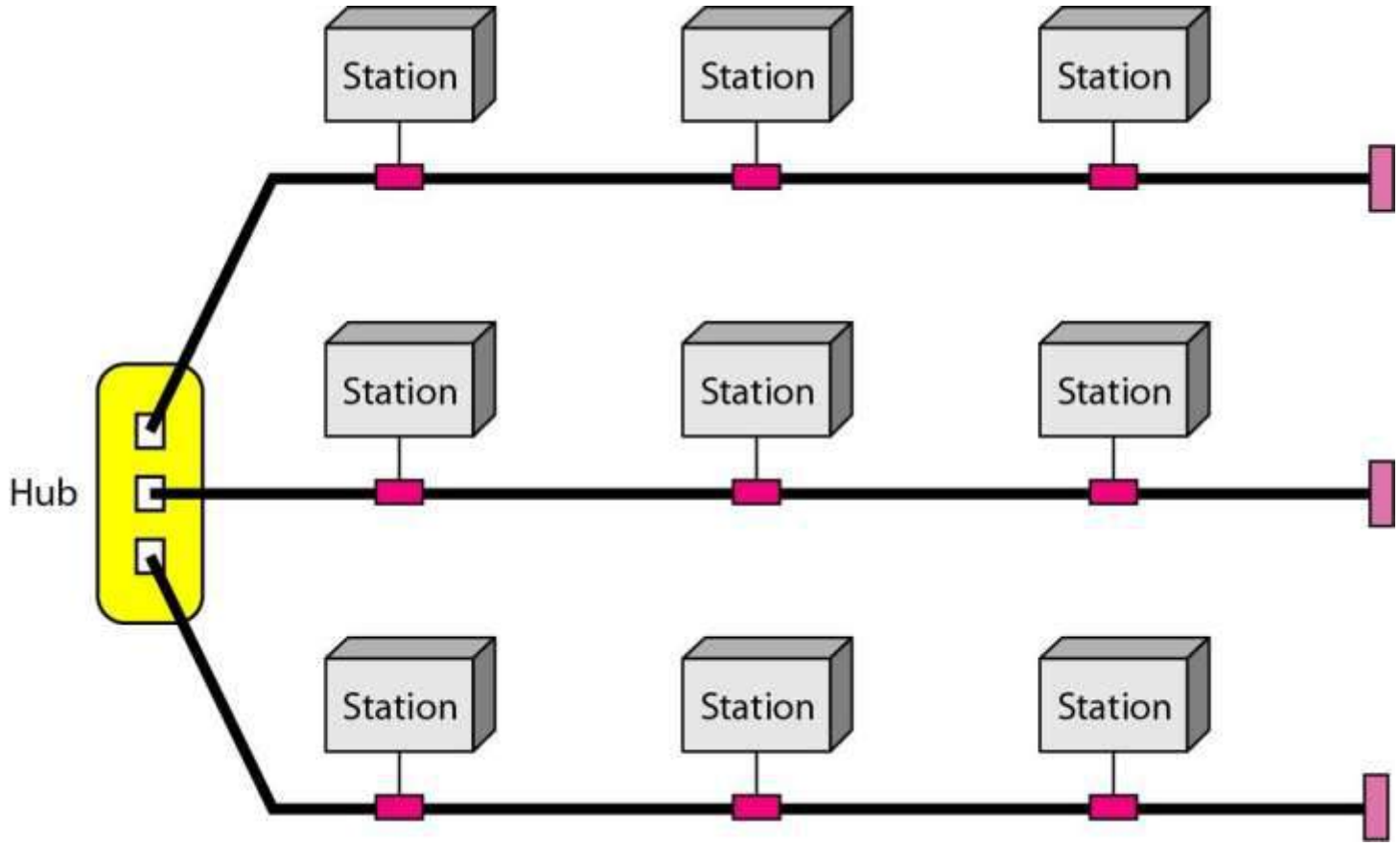

In a bus topology, expansion is easier. A bus topology is simple, cheap, and easy to install, but it has low bandwidth, high collision rate, and poor fault tolerance.

## Figure 1.8 *A ring topology connecting six stations*




A ring topology is efficient, reliable, and easy to troubleshoot, but it has low scalability, high latency, and single point of failure.

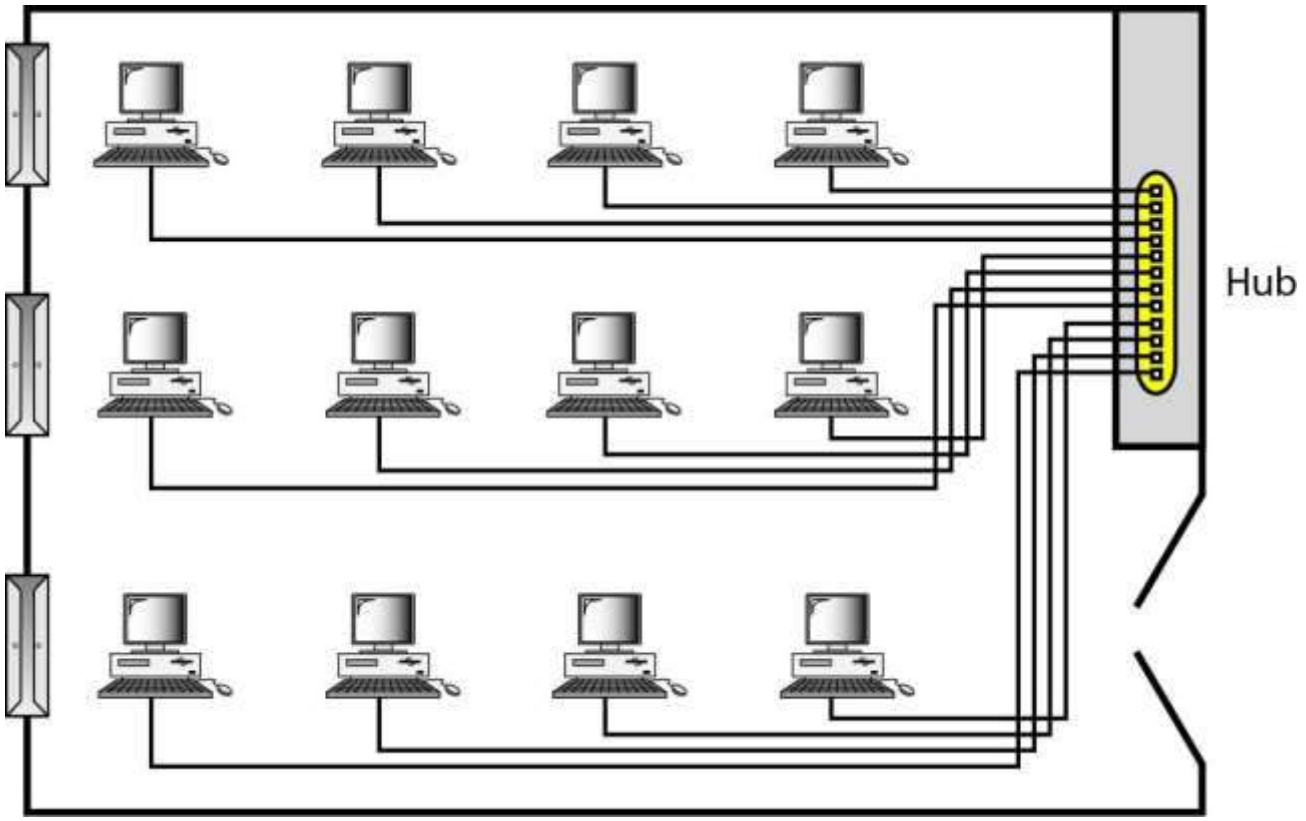
**Figure 1.9** *A hybrid topology: a star backbone with three bus networks*



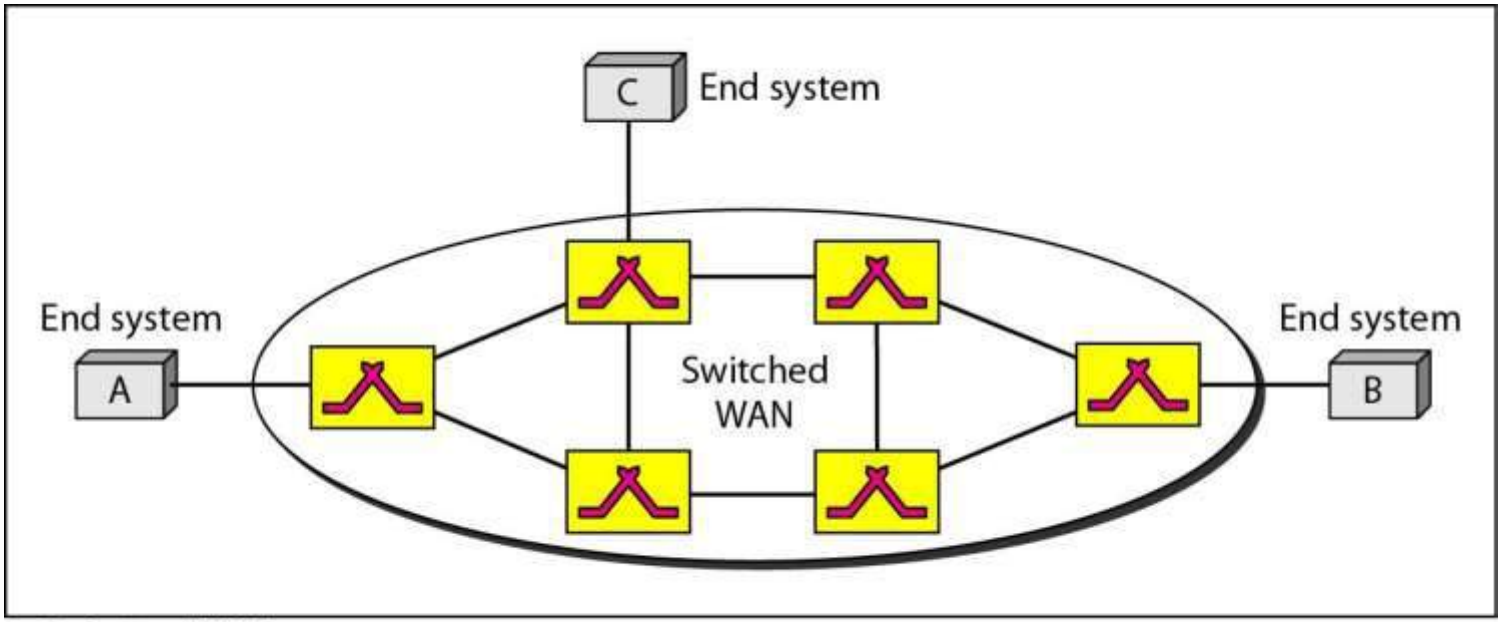
# Categories of Networks

- **Local Area Networks (LANs)**
  - **Short distances**
  - **Designed to provide local interconnectivity**
- **Wide Area Networks (WANs)**
  - **Long distances**
  - **Provide connectivity over large areas**
- **Metropolitan Area Networks (MANs)**
  - **Provide connectivity over areas such as a city, a campus**

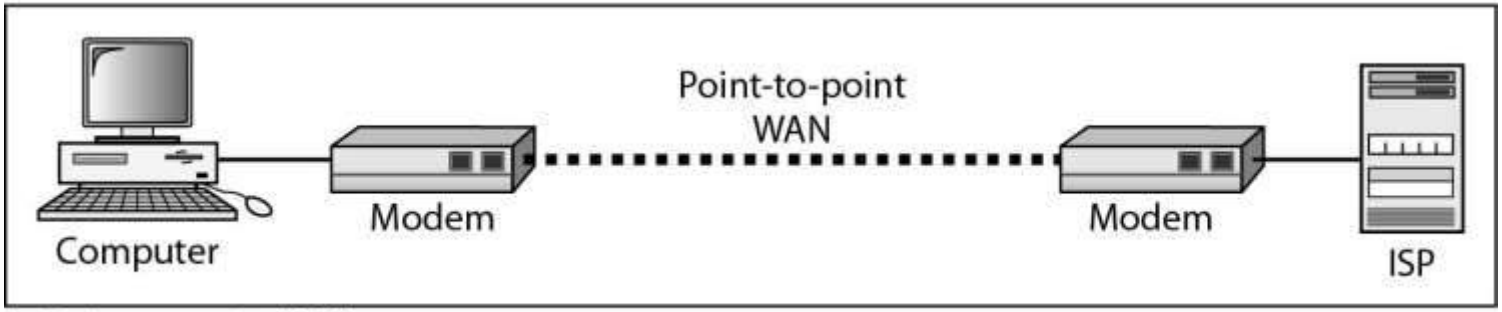
**Figure 1.10** *An isolated LAN connecting 12 computers to a hub in a closet*



## Figure 1.11 *WANs: a switched WAN and a point-to-point WAN*

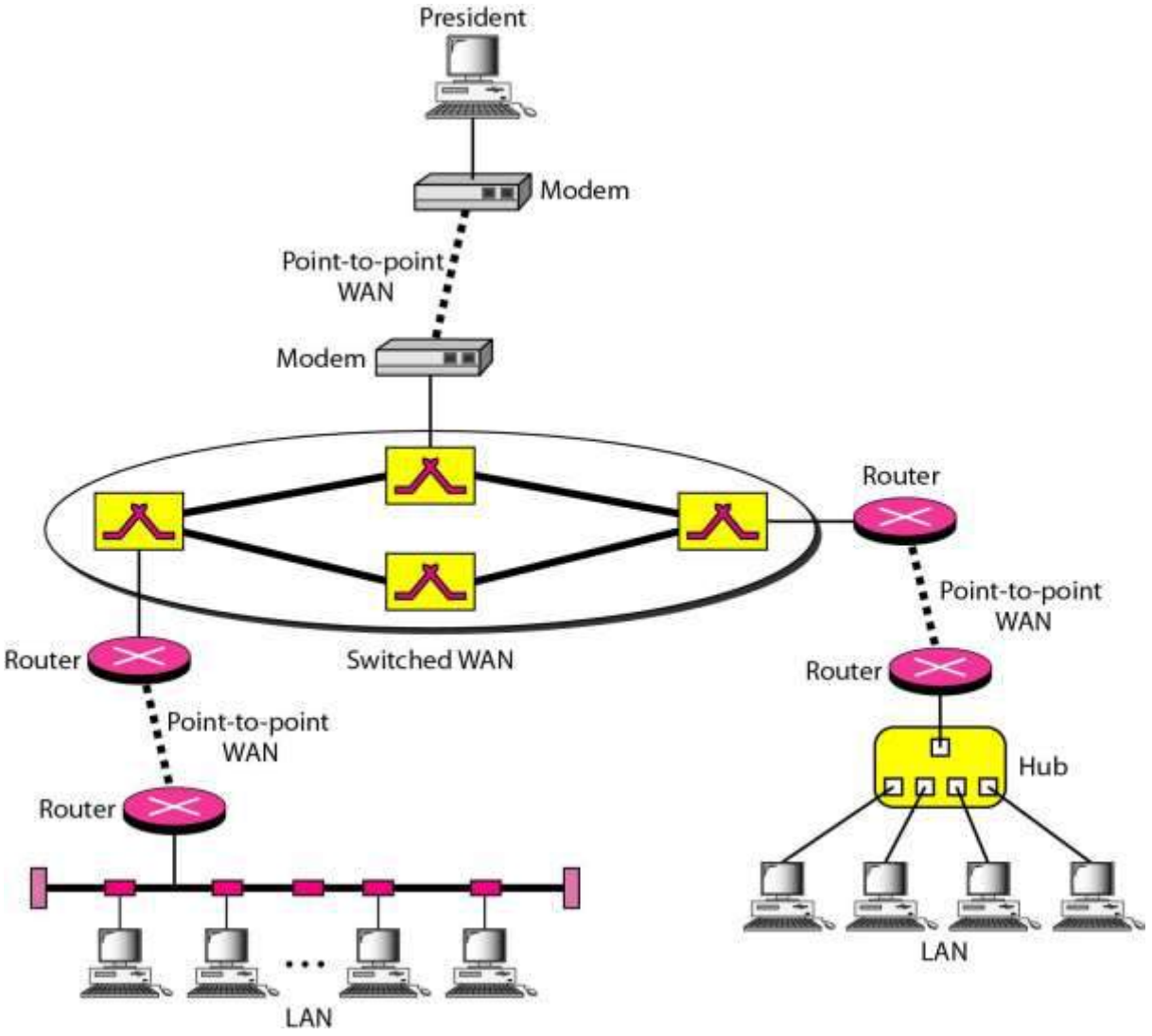



a. Switched WAN




b. Point-to-point WAN

**Figure 1.12** *A heterogeneous network made of four WANs and two LANs*



# 1-3 THE INTERNET

***The Internet has revolutionized many aspects of our daily lives. It has affected the way we do business as well as the way we spend our leisure time. The Internet is a communication system that has brought a wealth of information to our fingertips and organized it for our use.***

# 1-4 PROTOCOLS

***A protocol is synonymous with rule. It consists of a set of rules that govern data communications. It determines what is communicated, how it is communicated and when it is communicated. The key elements of a protocol are syntax, semantics and timing***

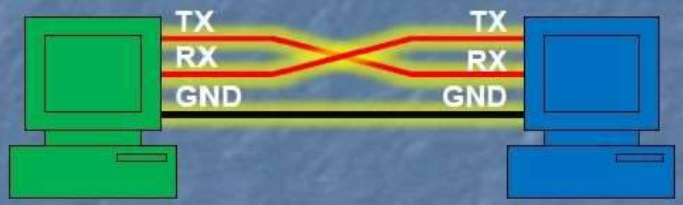
- **Syntax**
- **Semantics**
- **Timing**

# Elements of a Protocol

- **Syntax**
  - **Structure or format of the data**
  - **Indicates how to read the bits - field delineation**
- **Semantics**
  - **Interprets the meaning of the bits**
  - **Knows which fields define what action**
- **Timing**
  - **When data should be sent and what**
  - **Speed at which data should be sent or speed at which it is being received.**

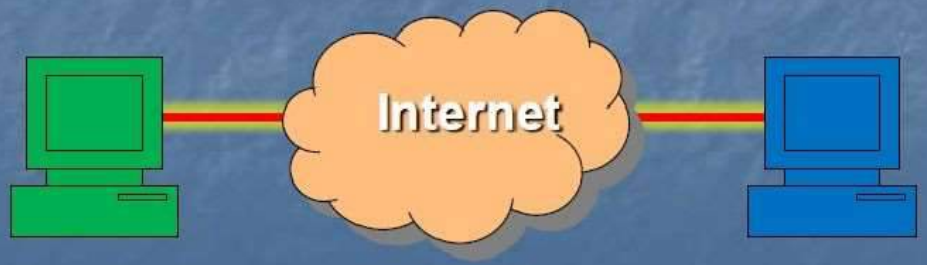
# End-to-End Communication

- Direct communication
  - Most basic form of communication



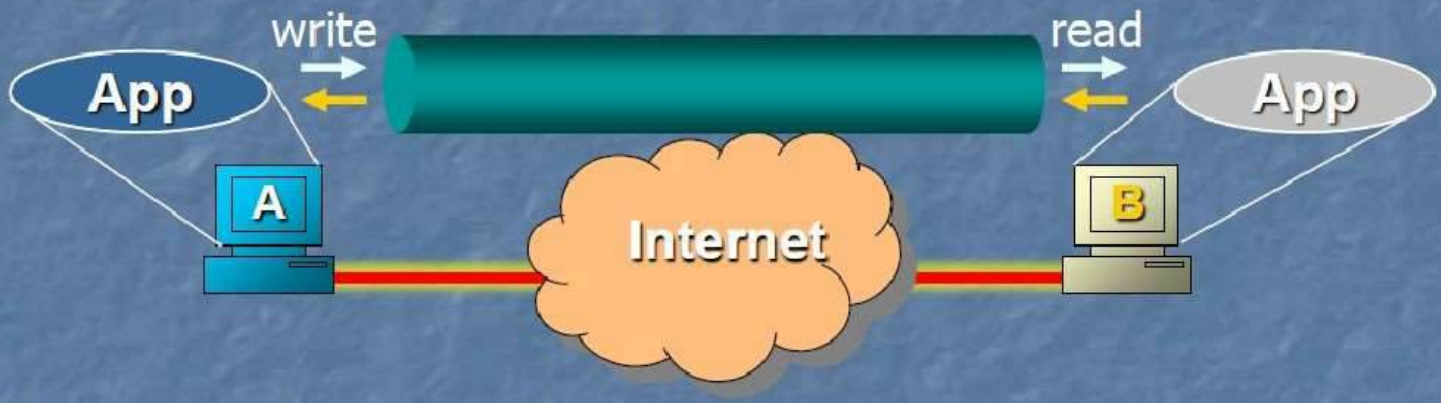

Serial Port

- Internet communication
  - Communication is performed over the Internet



# Internet Comm. - *App's Viewpoint*

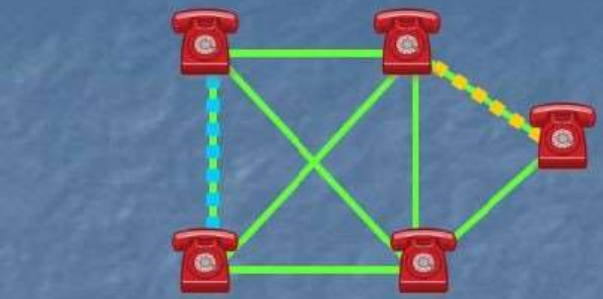
- Two network applications should interact as if they were directly connected

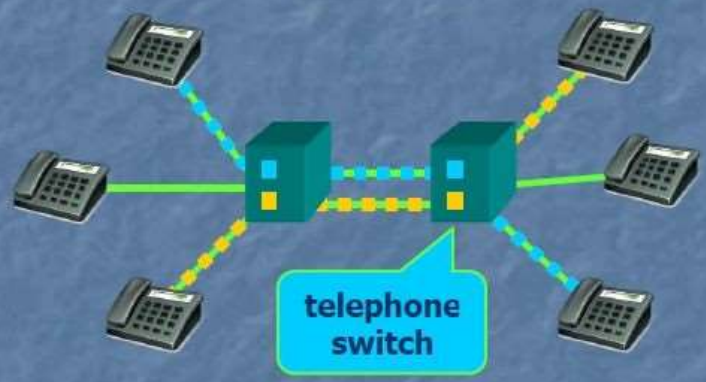


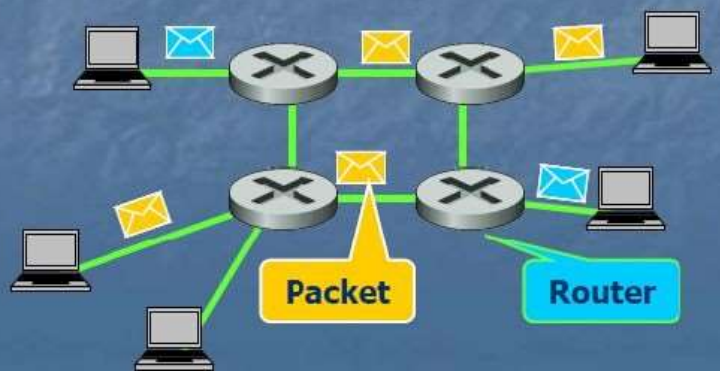

- But what's going on underneath?
  - What is inside the "cloud"?

# Circuit vs. Packet Switching

- Dedicated circuits
- Circuit switching
  - Telephone switches establish circuits for communication
- Packet switching
  - Data are put into packets
  - Each stamped with source and destination addresses
  - Routers know where to forward packets





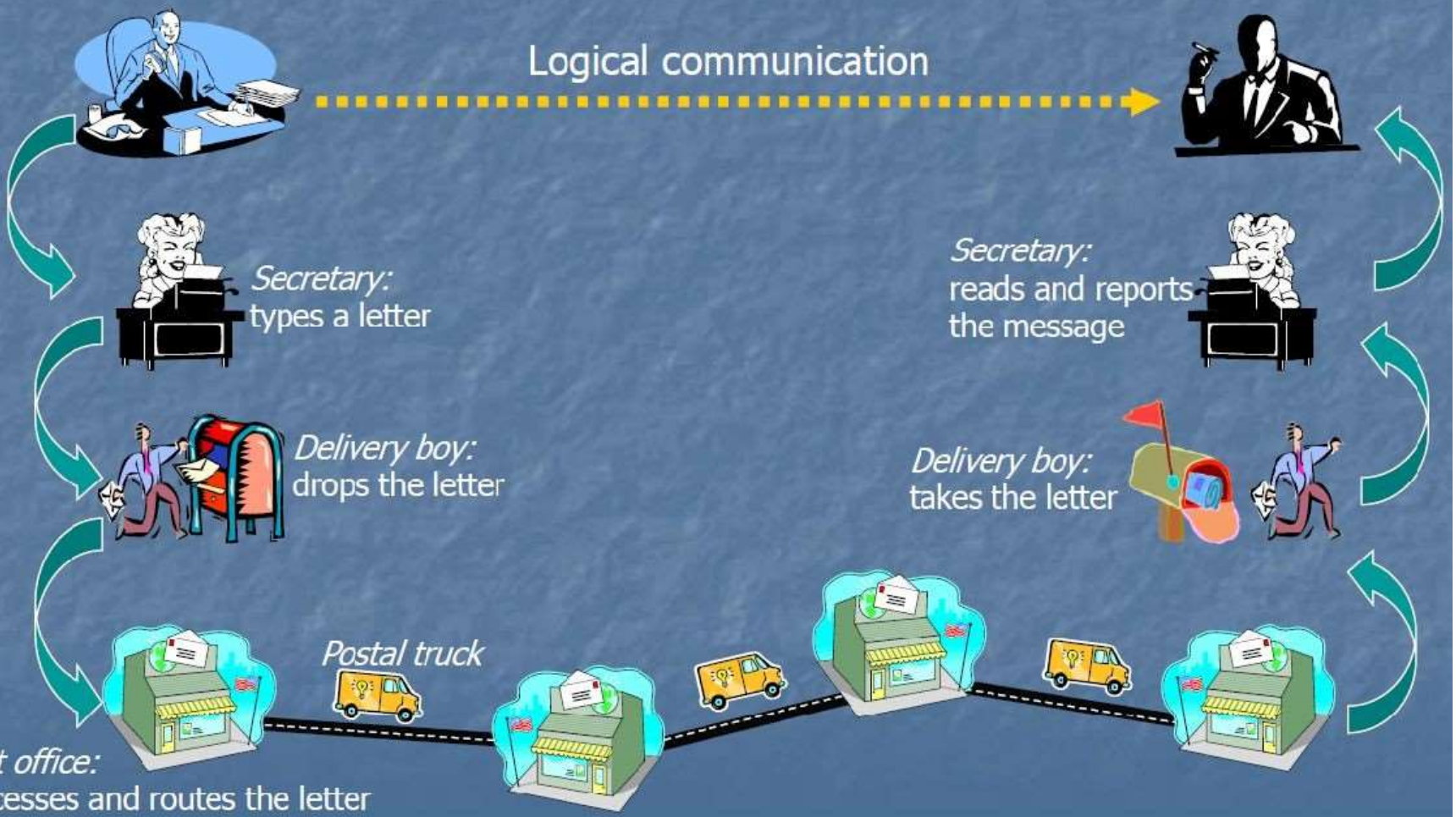



# Layered Tasks

- Computer networks are complex systems
  - Tasks involve varieties of hardware and software components, and protocols
- Networking task is divided into several subtasks, or layers

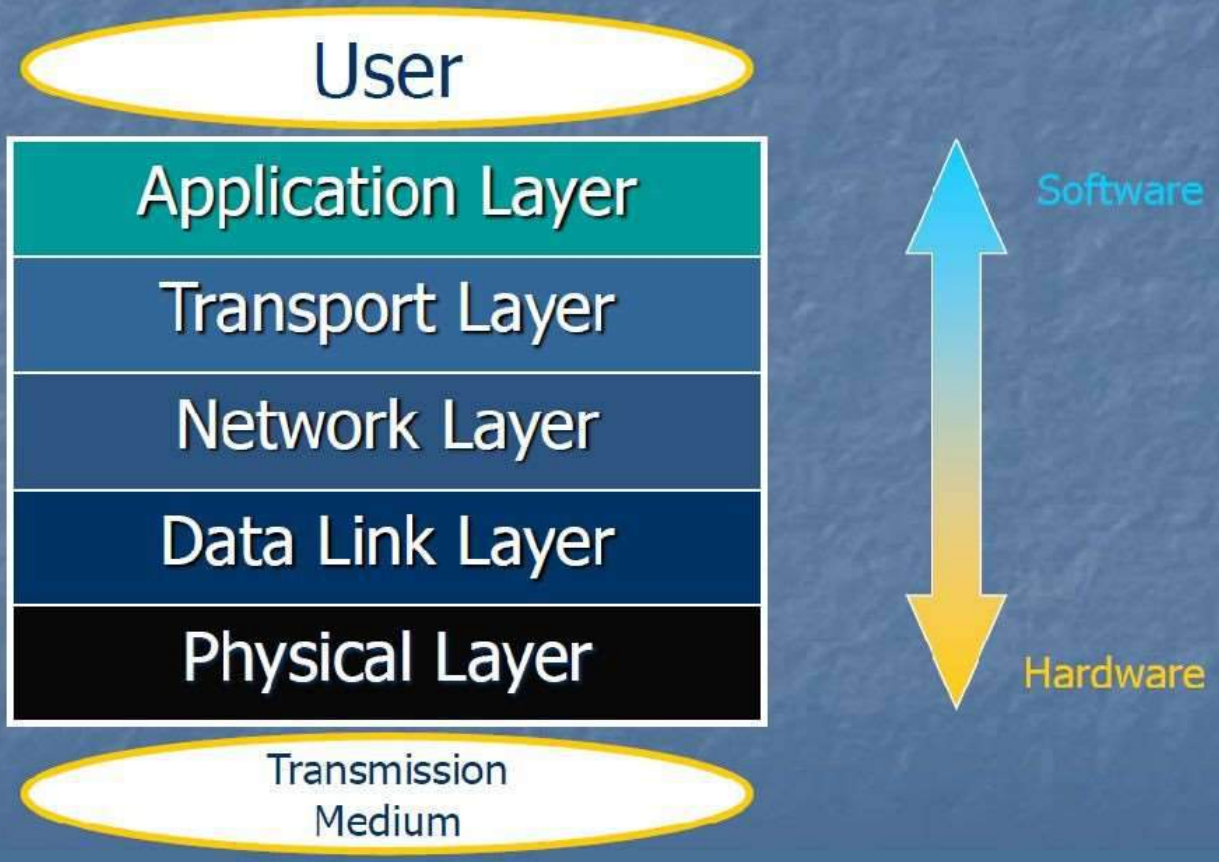
# What Actually Happens

- Communication takes place thru many layers



# Internet Layer Model

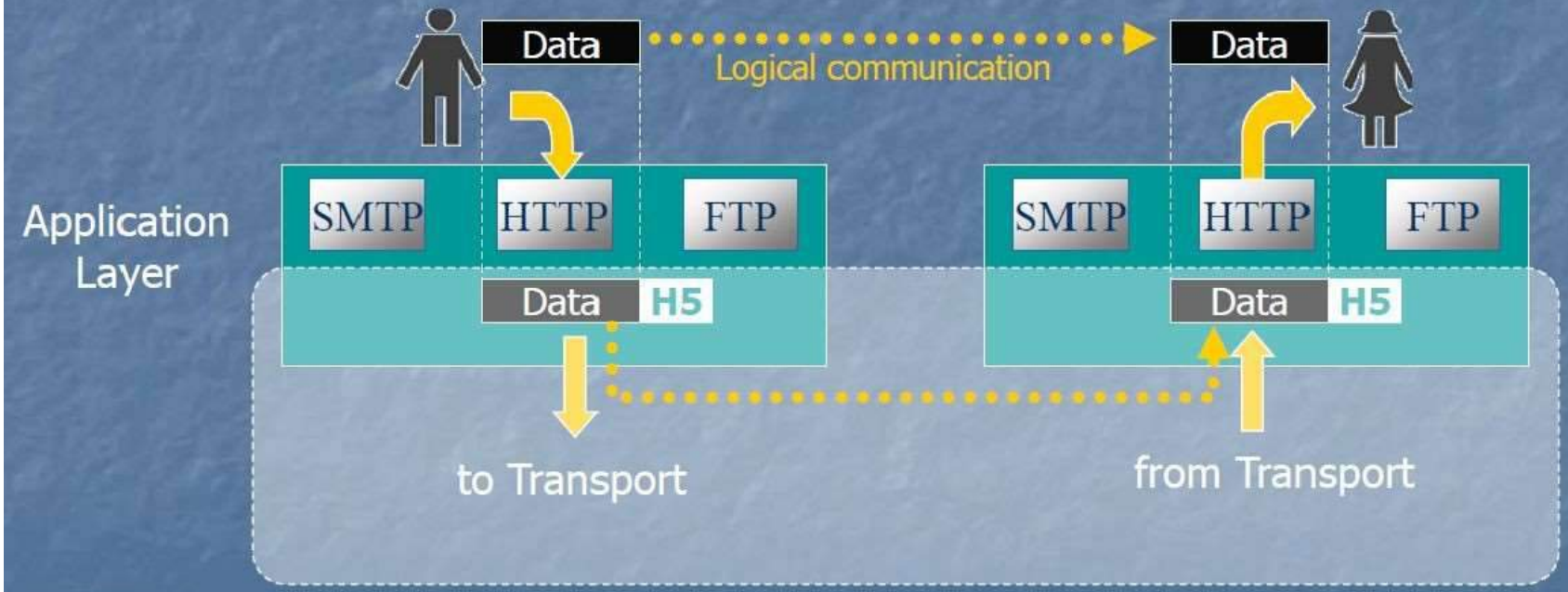
- The Internet Protocol Stack



# Application Layer

***Responsible for providing services to the user***

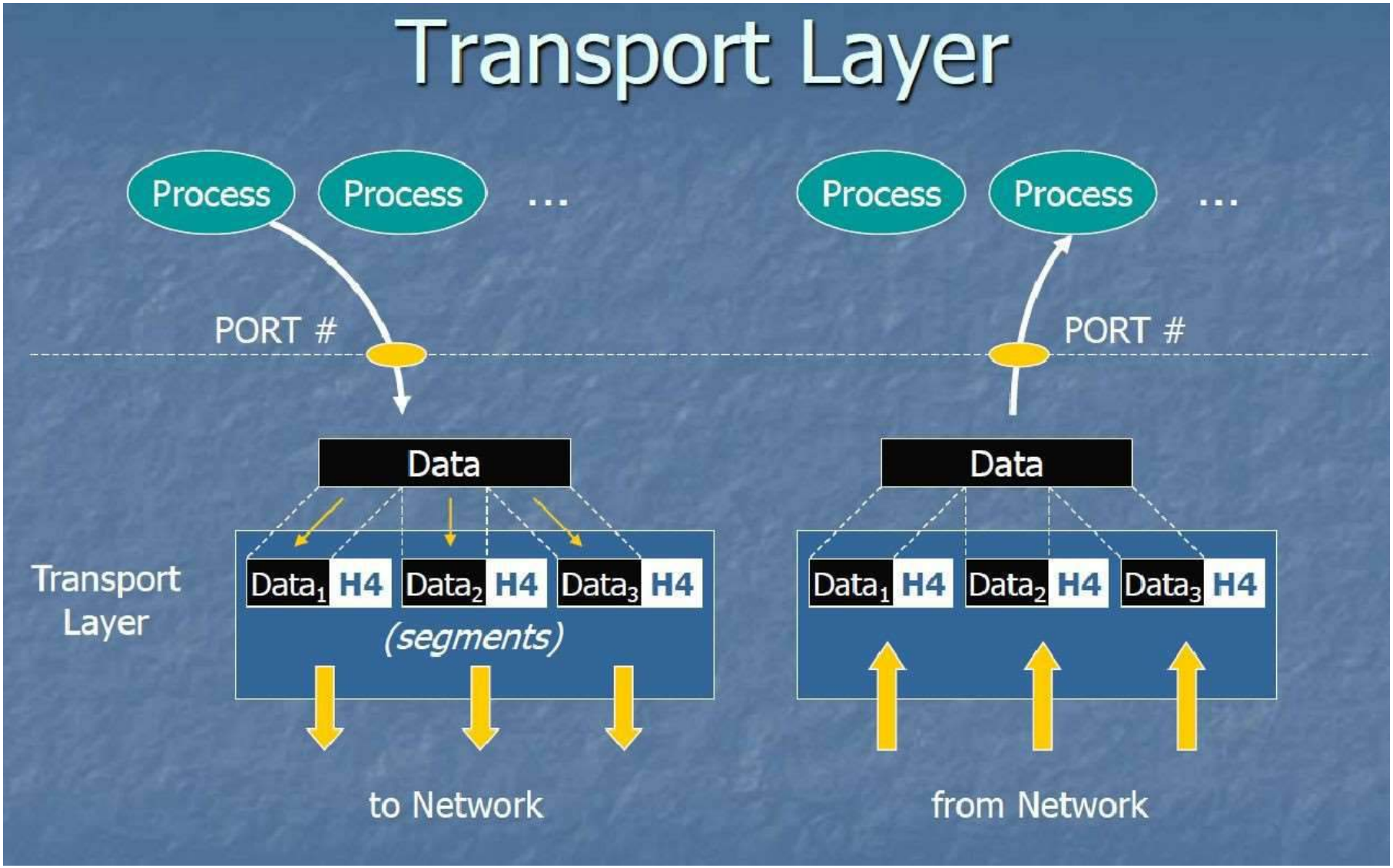
- The only layer to interact with user



# Transport Layer

***Responsible for delivery of a message from one process to another***

- Duties/services
  - Port addressing
  - Segmentation and reassembly
  - Connection control
  - Flow control (end-to-end)
  - Error control (end-to-end)



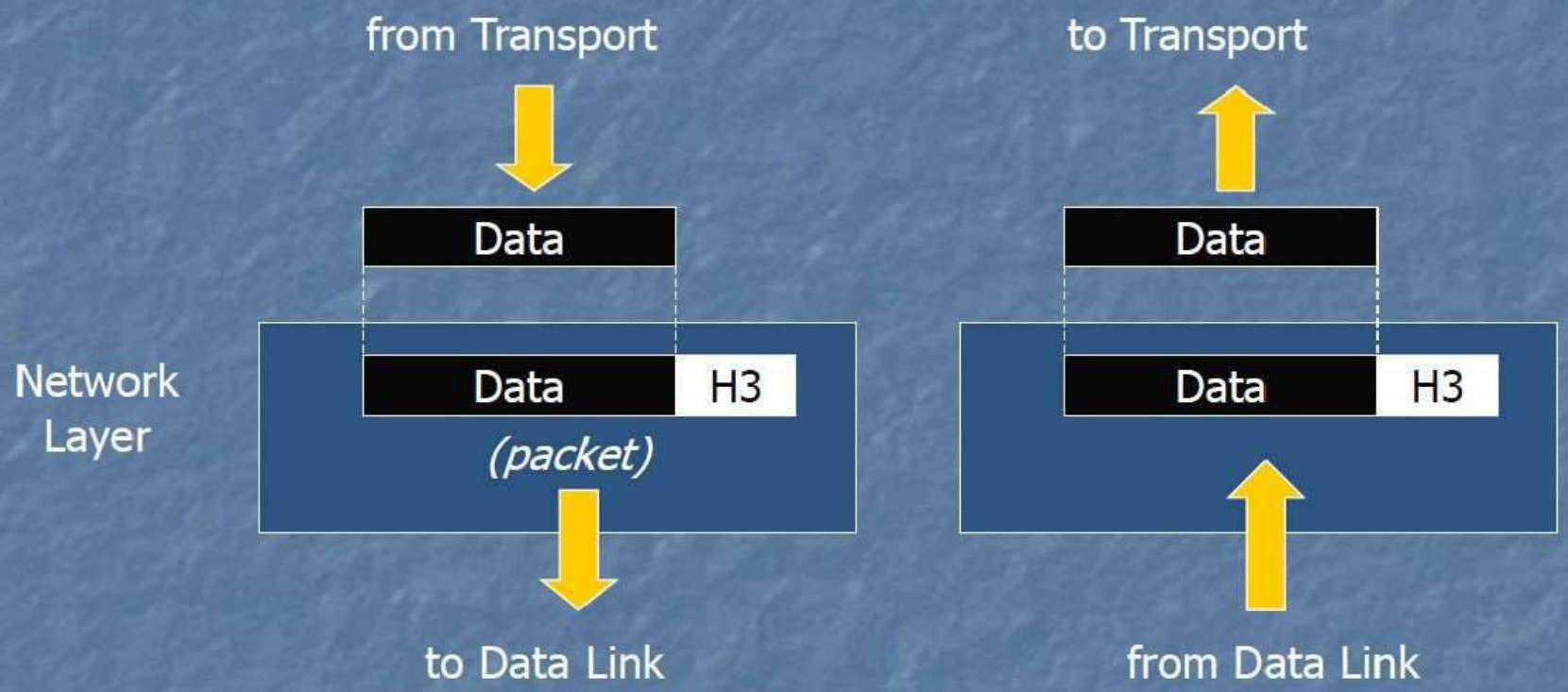

**# 23 – Telnet, # 80 – HTTP, #21 – FTP etc.**

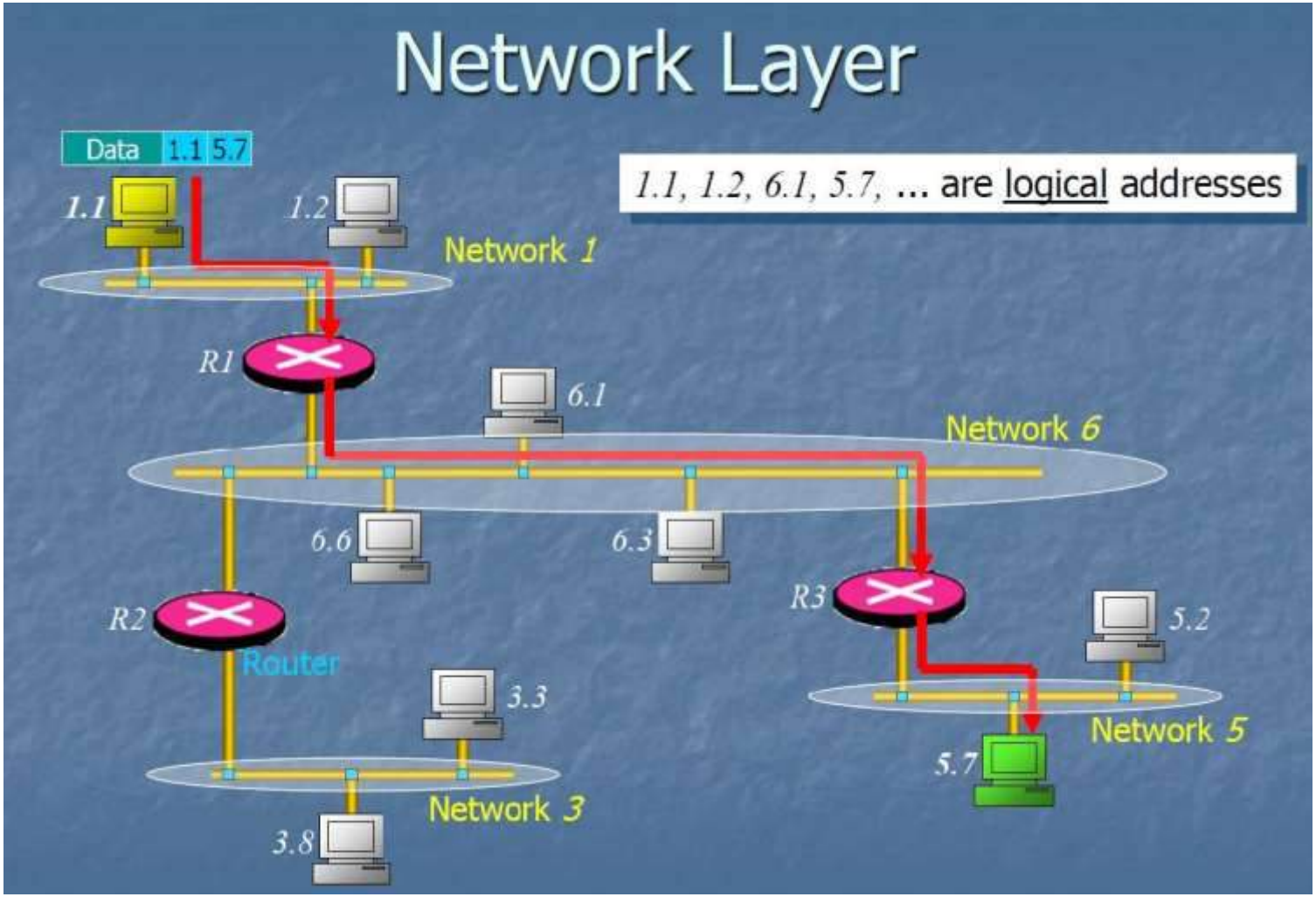
# Network Layer

***Responsible for the delivery of packets from the original source to the destination***

- Duties/services
  - Logical addressing
  - Routing

# Network Layer






The IPv4 address is a 32-bit number that uniquely identifies a network interface on a machine. An IPv4 address is typically written in decimal digits, formatted as four 8-bit fields that are separated by periods. A subnet mask is a 32 bit number is used to divide IP address into network address and host address. Example: 192.168.23.2; 10.0.1.1/24; 216.202.192.66/22. Routers run specific routing protocol to forward packets to destinations through next hops. Example: OSPF, RIP

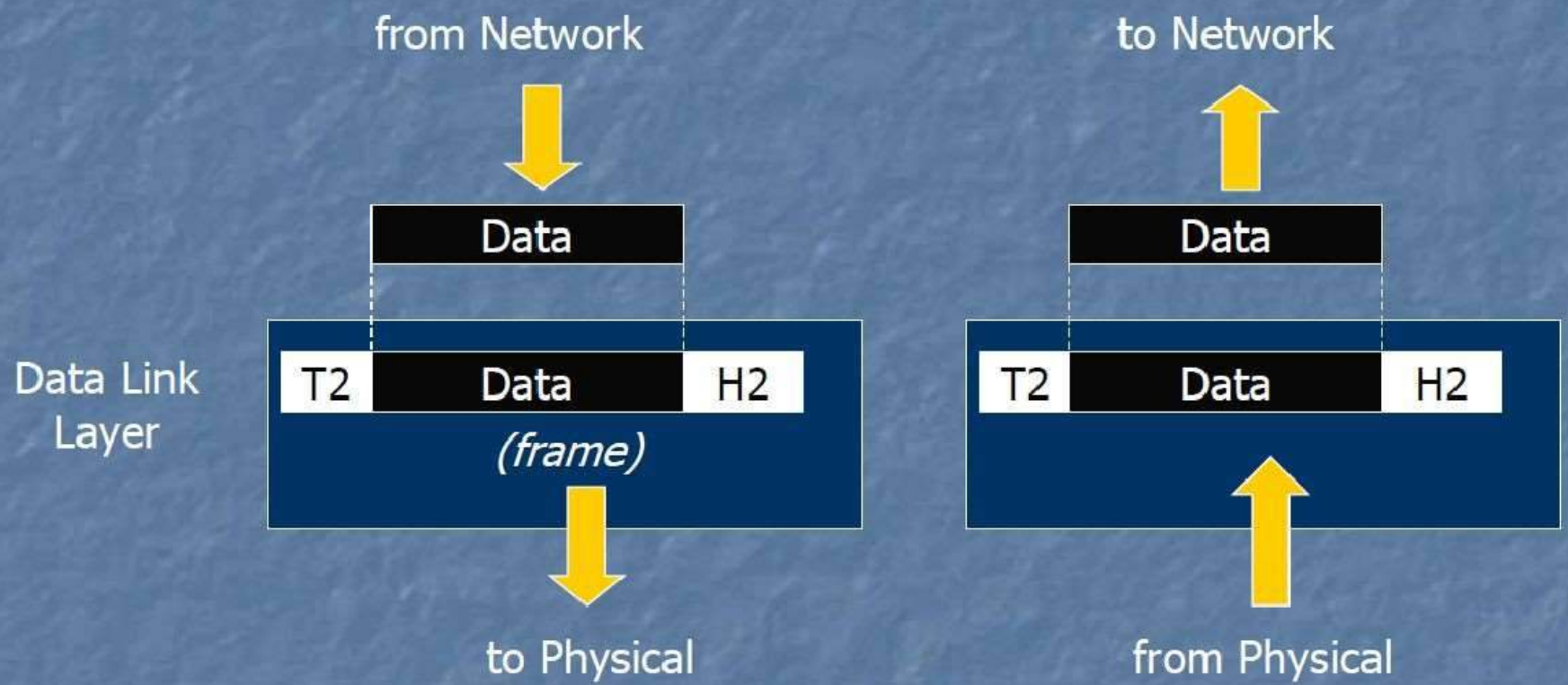
# Data Link Layer

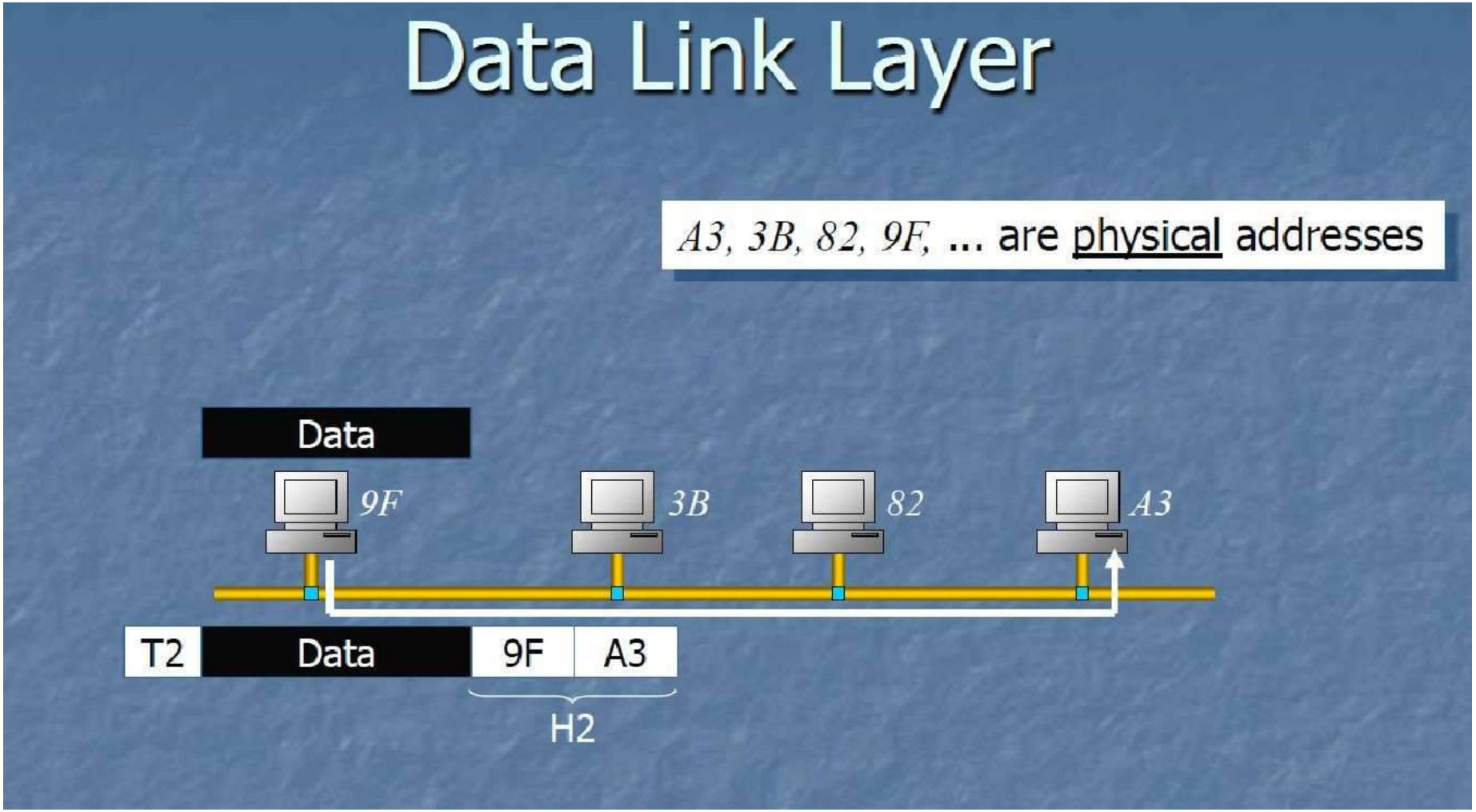
***Responsible for transmitting frames from one node to the next***

- Duties/services
  - Framing
  - Physical addressing
  - Flow control (hop-to-hop)
  - Error control (hop-to-hop)
  - Access control

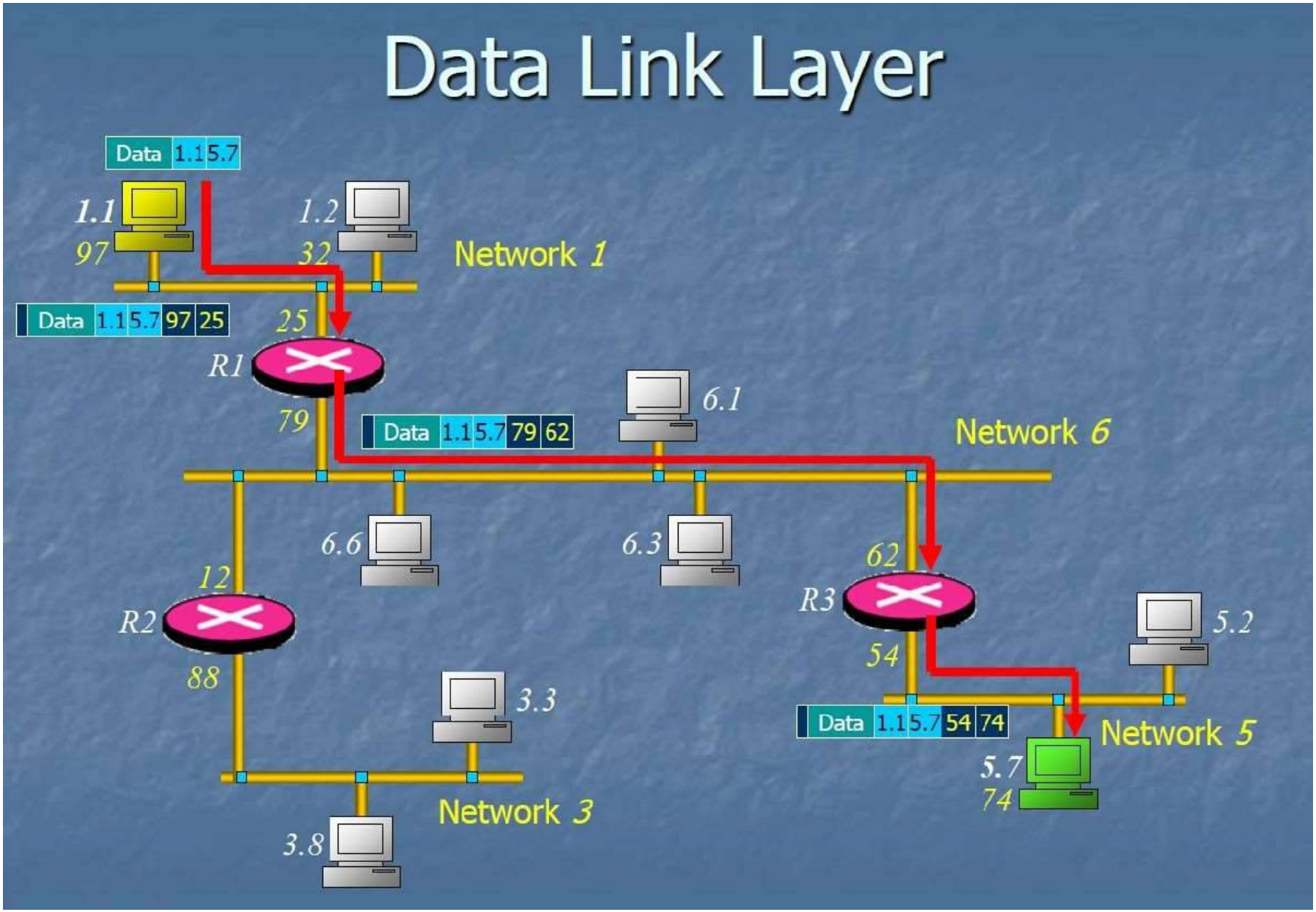
FC Protocols – Stop-n-wait, sliding window
EC Protocols – CRC, Stop-n-wait, go-back-N, Selective repeat
MAC Protocol – ALOHA, CSMA, CSMA/CD, MACAW

# Data Link Layer





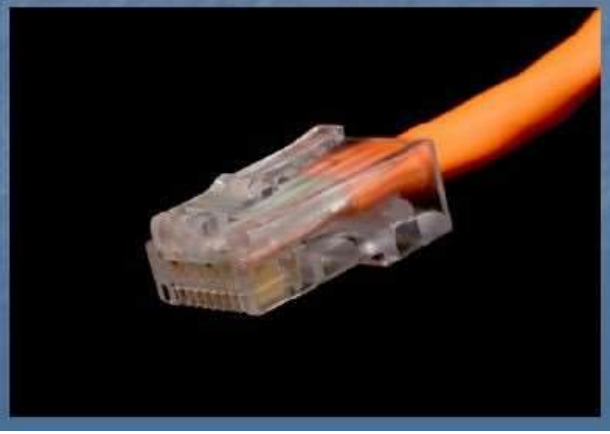

**MAC Addresses** are unique **48-bit** hardware numbers of a computer that are embedded into a network card (known as a **Network Interface Card**) during manufacturing. The MAC Address is also known as the **Physical Address** of a network device. Example: 01-80-C2-FF-FF-FF


Data Link Layer
Data 1.15.7
1.1
97
1.2
32
Network 1
Data 1.15.7 97 25
25
R1
79
Data 1.15.7 79 62
6.1
Network 6
6.6
6.3
12
R2
88
62
R3
5.2
54
3.3
Data 1.15.7 54 74
Network 5
5.7
74
Network 3
3.8

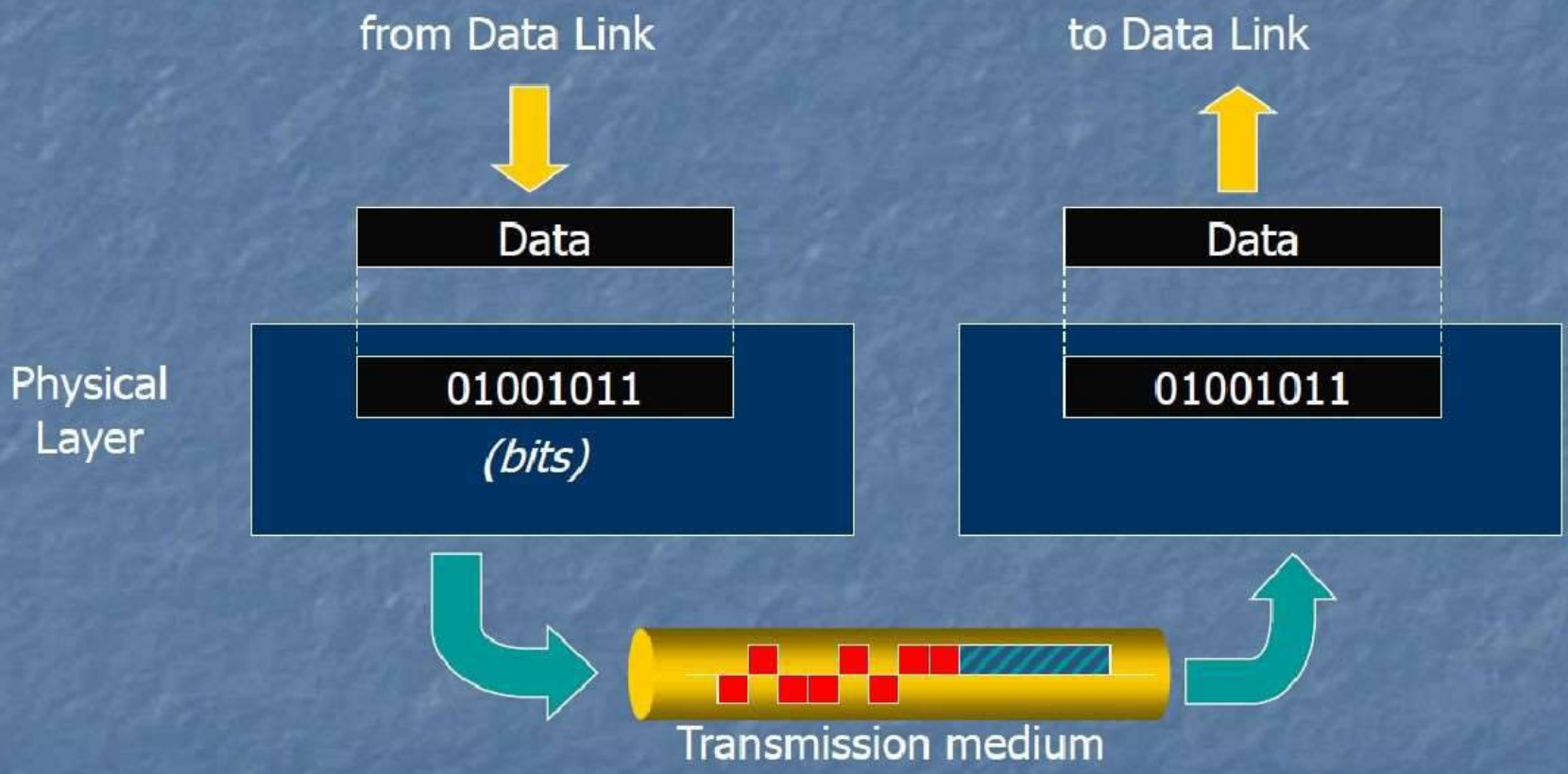
# Physical Layer

***Responsible for transmitting individual bits from one node to the next***

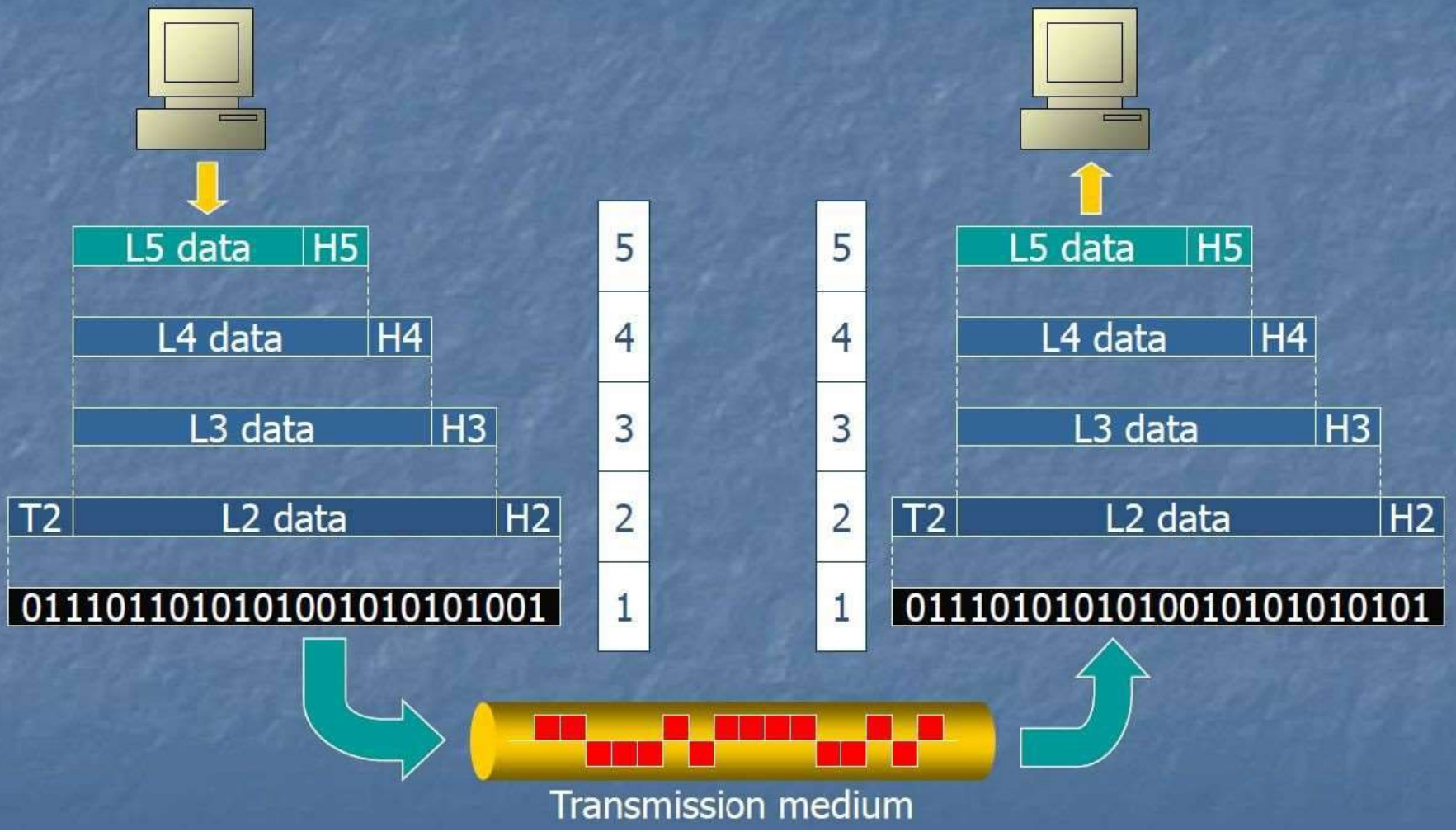
- Duties/services
  - Physical characteristics of interfaces and media
  - Representation of bits
  - Data rate (transmission rate)
  - Synchronization of bits

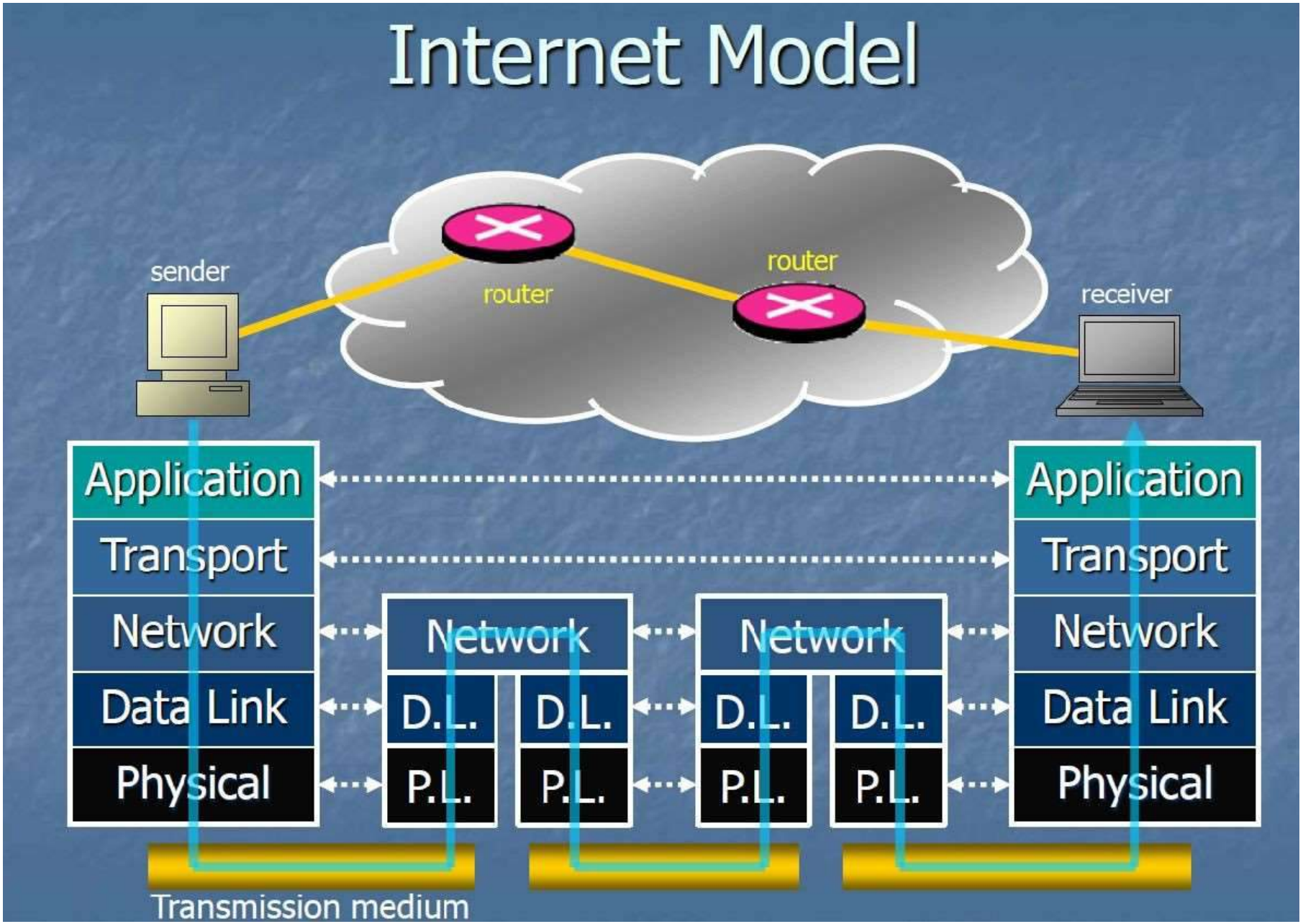


# Physical Layer

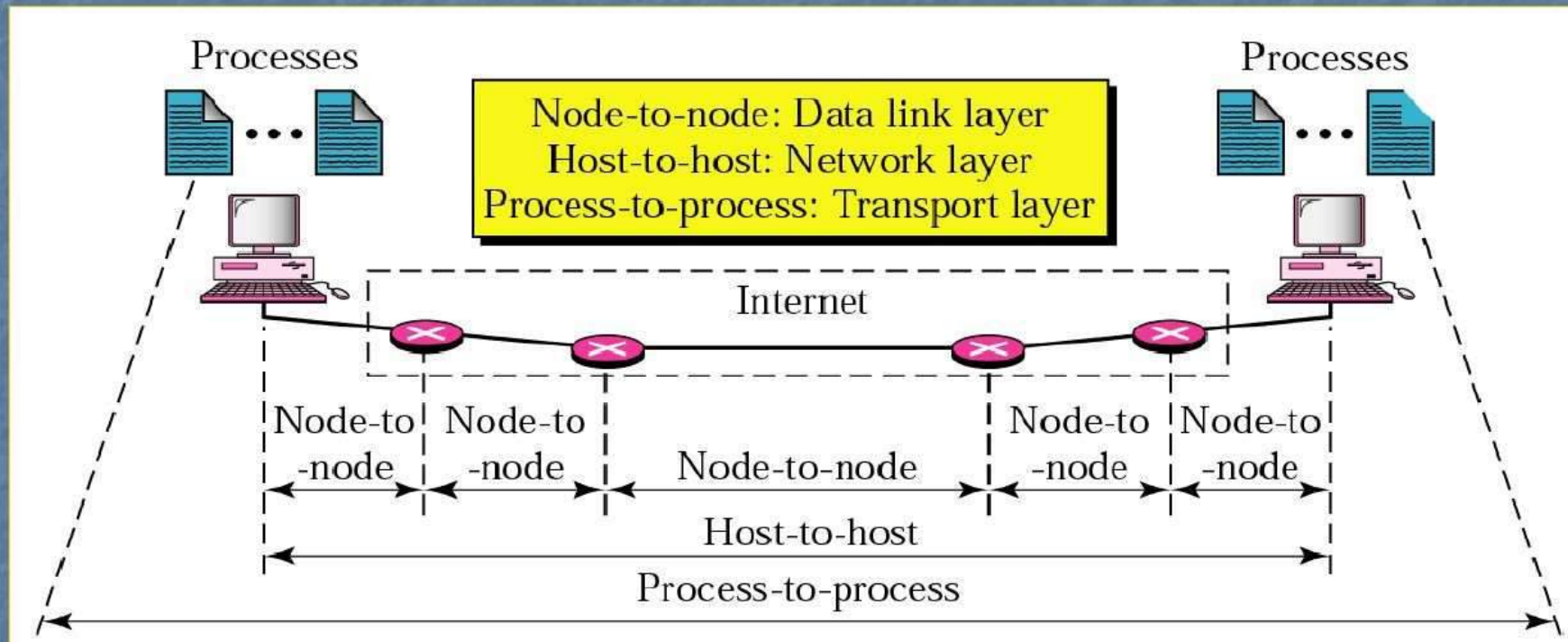


# The Big Picture




Internet Model
sender
router
router
receiver
Application
Transport
Network
Data Link
Physical
Network
D.L.
D.L.
P.L.
P.L.
Network
D.L.
D.L.
P.L.
P.L.
Application
Transport
Network
Data Link
Physical
Transmission medium

# Internet Model



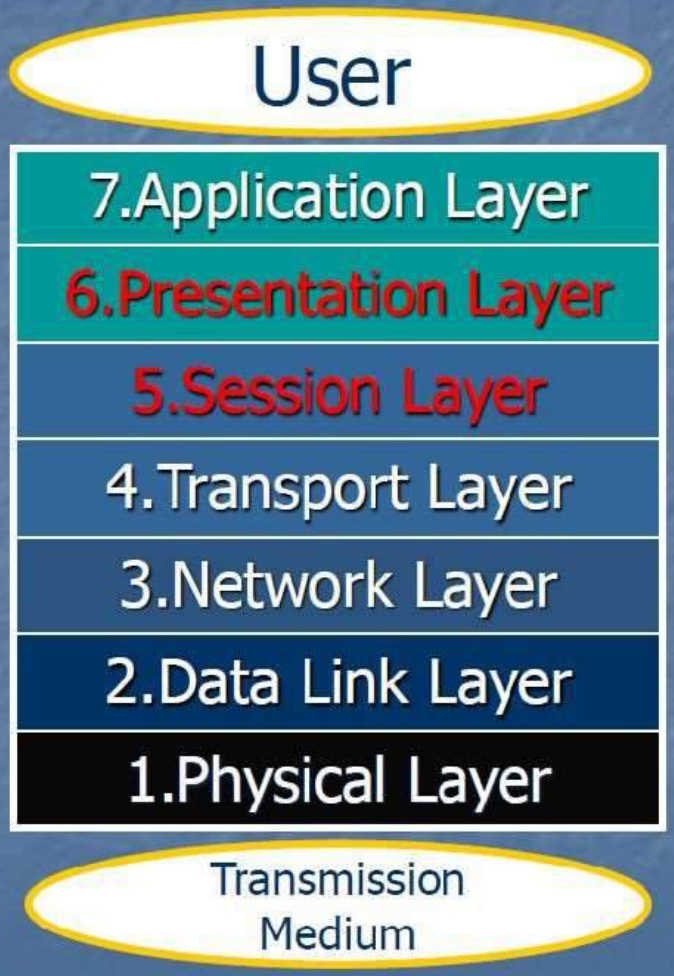
# Protocol Suites

- A set of protocols must be constructed
  - to ensure that the resulting communication system is complete and efficient
- Each protocol should handle a part of communication not handled by other protocols
- How can we guarantee that protocols work well together?
  - Instead of creating each protocol in isolation, protocols are designed in complete, cooperative sets called suites or families

# Internet Protocol Suite

| Layer | Protocols |
| --- | --- |
| Application | HTTP, FTP, Telnet, SMTP, ... |
| Transport | TCP, UDP, SCTP, ... |
| Network | IP (IPv4), IPv6, ICMP, IGMP, ... |
| Data Link | Ethernet, Wi-Fi, PPP, ... |
| Physical | RS-232, DSL, 10Base-T, ... |

# OSI Model




- OSI – ***O**pen **S**ystems **I**nterconnection*
- Developed by the ***I**nternational **S**tandards **O**rganizations* (ISO)

- Two additional layers
  - Presentation layer
  - Session layer

# Session Layer

***Responsible for establishing, managing and terminating connections between applications***

- Duties/services
  - Interaction management
    - ⇨ Simplex, half-duplex, full-duplex
  - Session recovery

# Presentation Layer

***Responsible for handling differences in data representation to applications***

- Duties/services
  - Data translation
  - Encryption
  - Decryption
  - Compression

Thank you