TCP/IP Protocol Suite
Lecture _2

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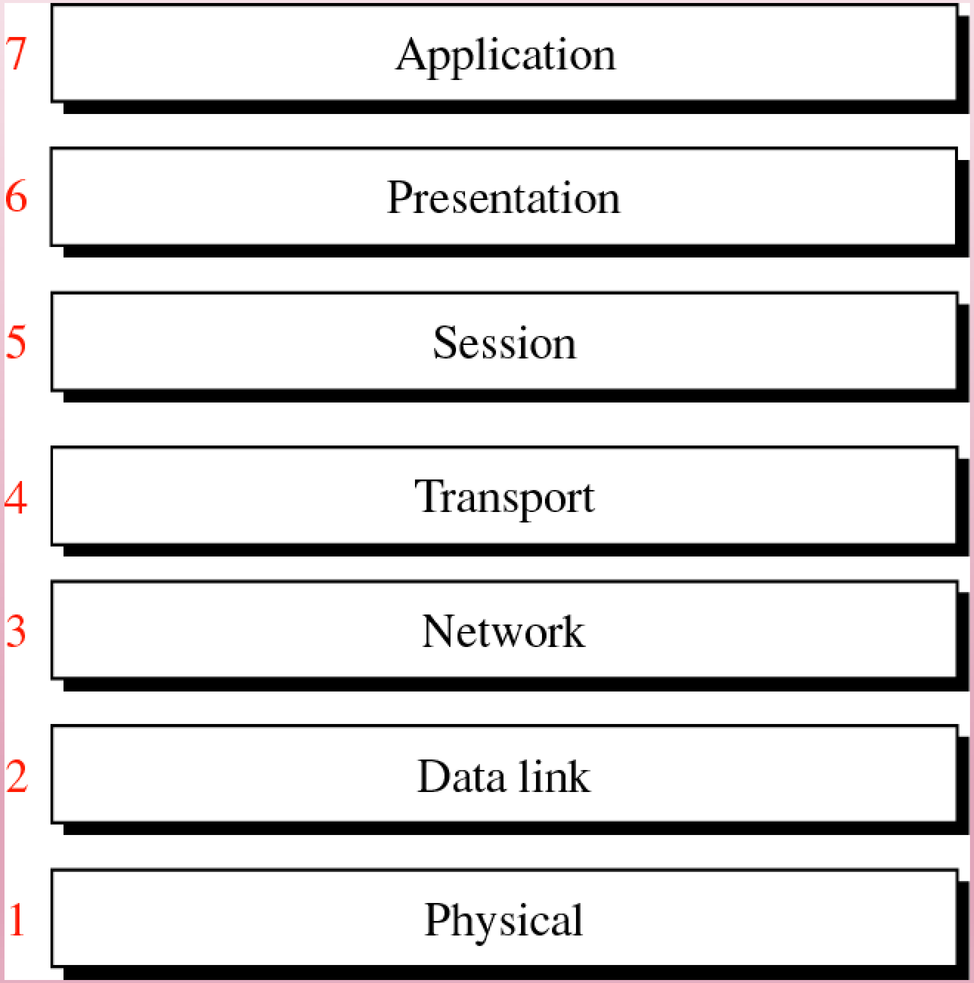
TCP/IP PROTOCOL SUITE

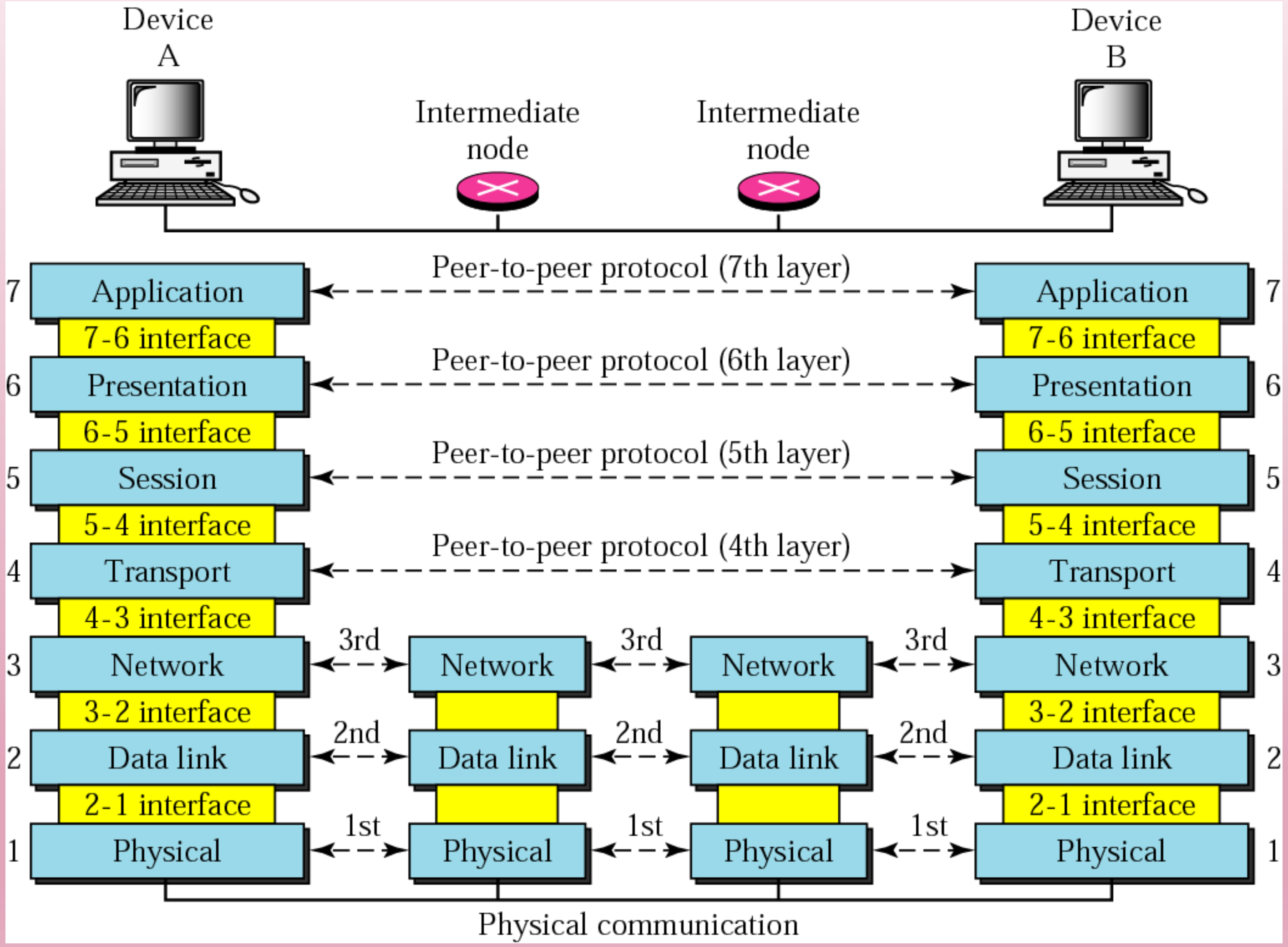
- The first layered protocol model for internetwork communications was created in the early 1970s and is referred to as the Internet model. It defines four categories of functions that must occur for communications to be successful. The architecture of the TCP/IP protocol suite follows the structure of this model. Because of this, the Internet model is commonly referred to as the TCP/IP model.
- The TCP/IP protocol suite was developed prior to the OSI model. Therefore, the layers in the TCP/IP protocol suite do not match exactly with those in the OSI model. The original TCP/IP protocol suite was defined as four software layers built upon the hardware.

OSI Model (cont'd)

- The OSI Model



OSI Layers

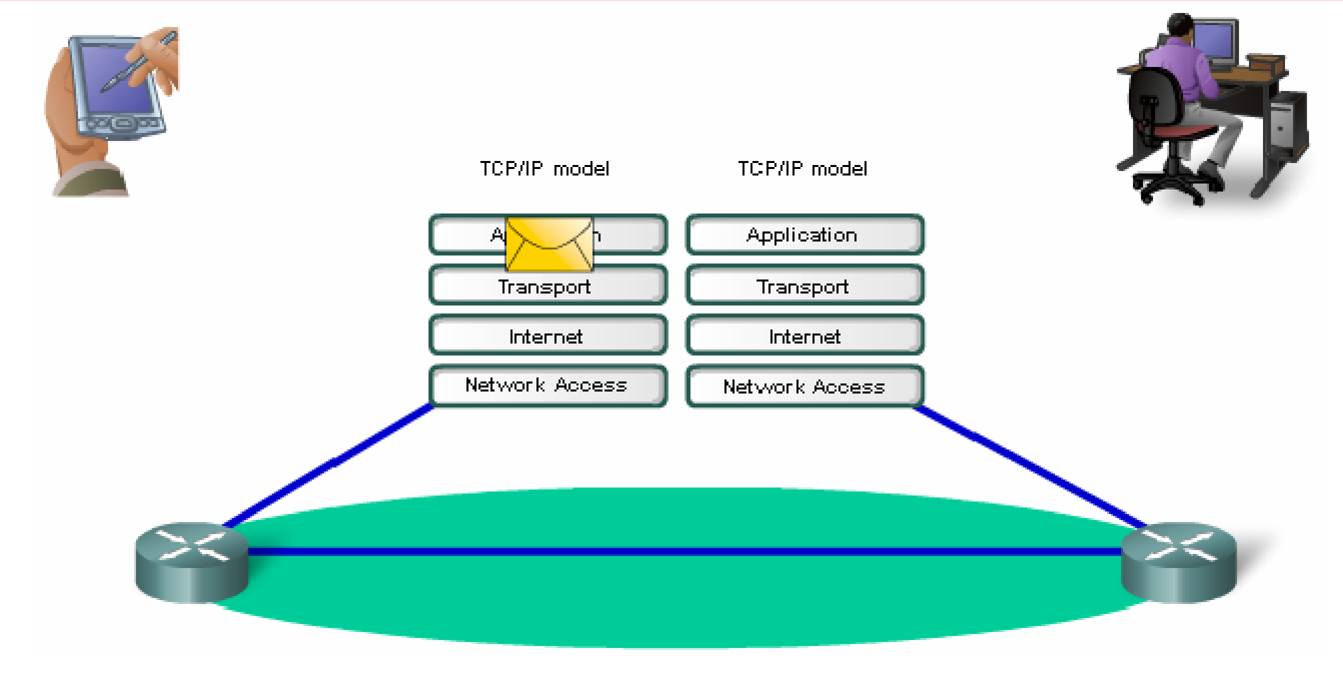

Device A
Device B
Intermediate node
Intermediate node
Peer-to-peer protocol (7th layer)
Peer-to-peer protocol (6th layer)
Peer-to-peer protocol (5th layer)
Peer-to-peer protocol (4th layer)
7 Application 7
7-6 interface
6 Presentation 6
6-5 interface
5 Session 5
5-4 interface
4 Transport 4
4-3 interface
3 Network 3
3-2 interface
2 Data link 2
2-1 interface
1 Physical 1
3rd
2nd
1st
Network
Data link
Physical
Physical communication

TCP/IP PROTOCOL SUITE

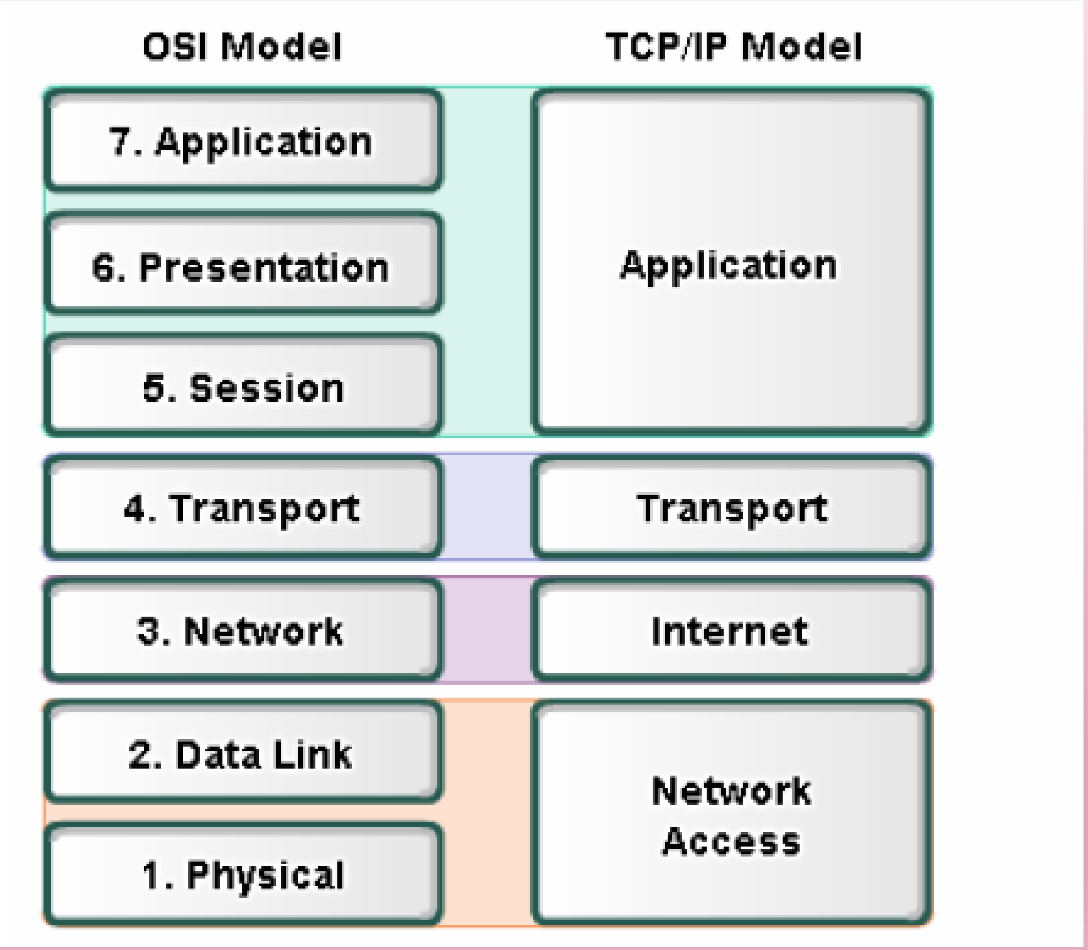
TCP/IP Model

Layer	Function
Application	Represents data to the user plus encoding and dialog control.
Transport	Supports communication between diverse devices across diverse networks.
Internet	Determines the best path through the network.
Network Access	Controls the hardware devices and media that make up the network.

TCP/IP PROTOCOL SUITE

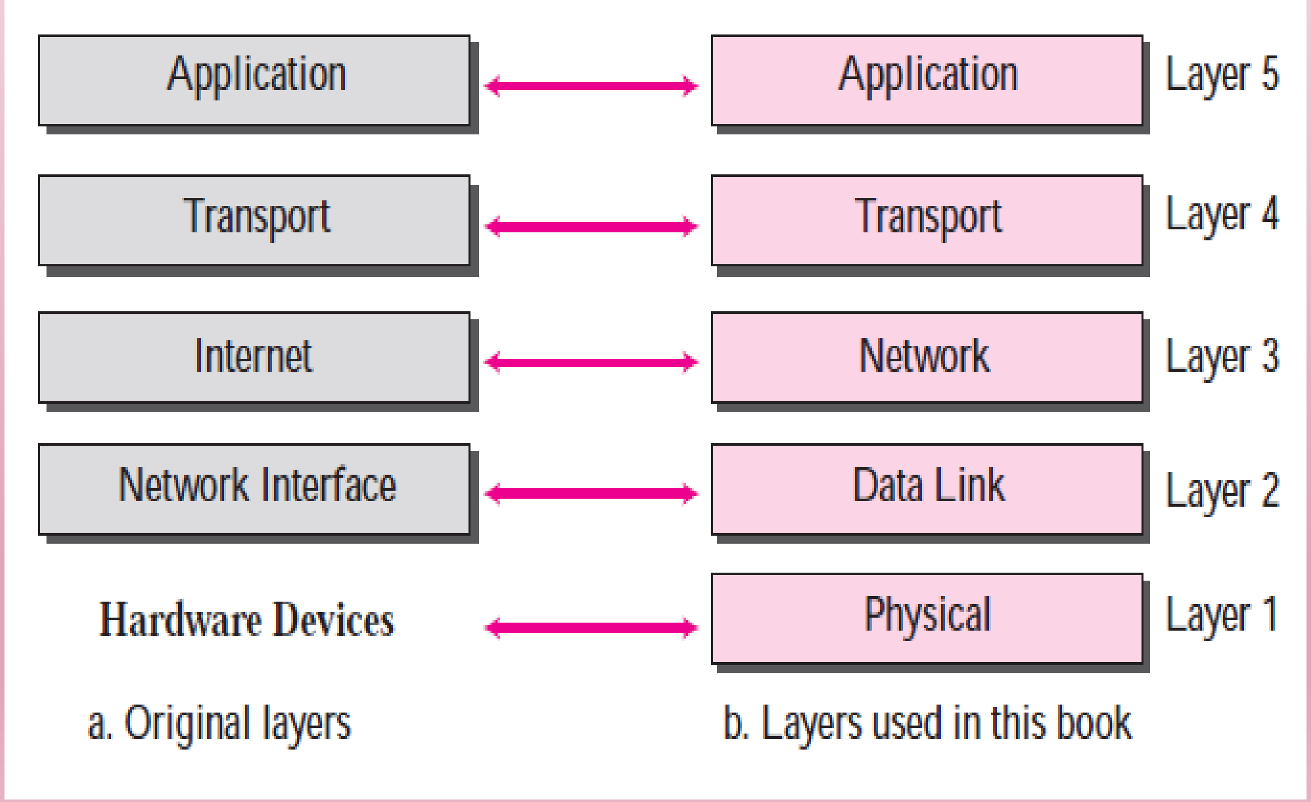


TCP/IP PROTOCOL SUITE

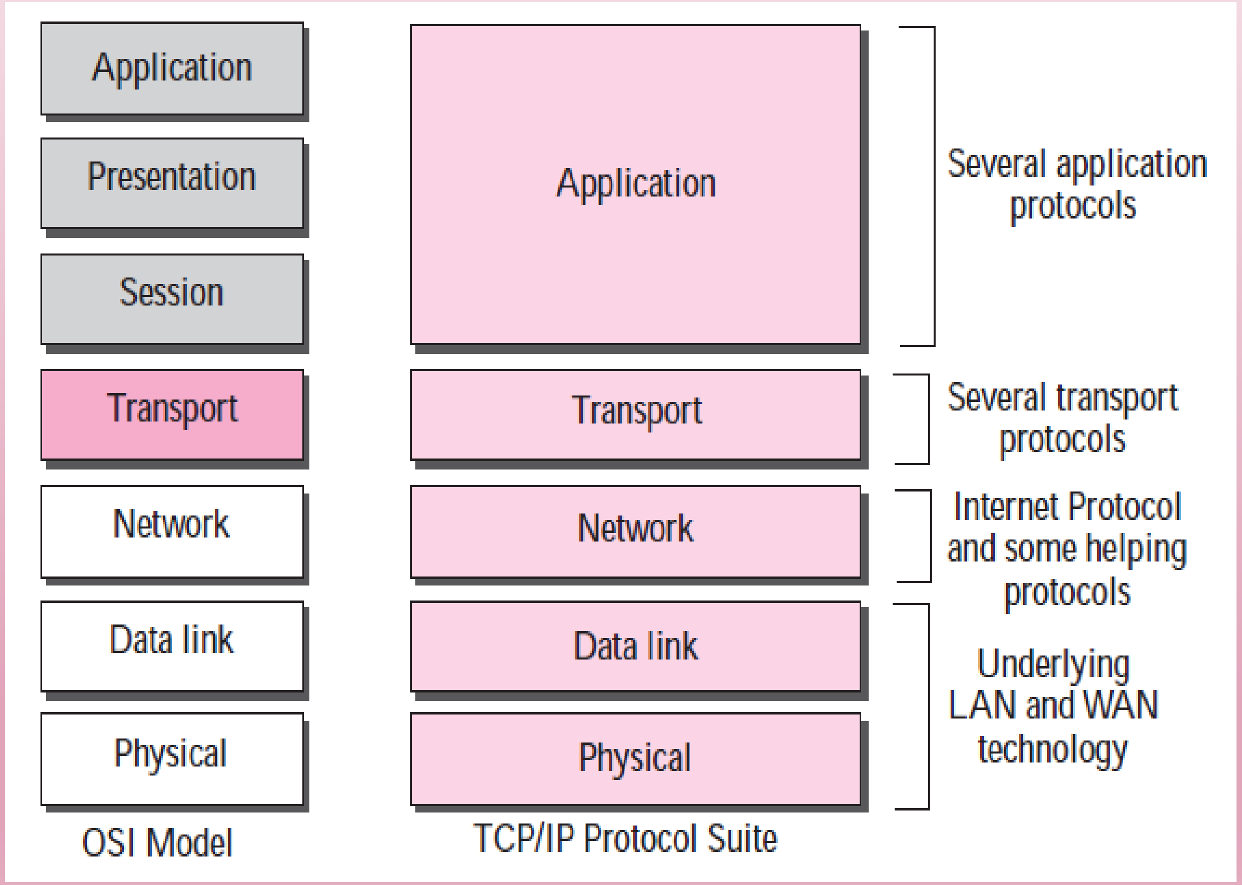


TCP/IP PROTOCOL SUITE

- Today, TCP/IP is thought of as a five-layer model with the layers named similarly to the ones in the OSI model.



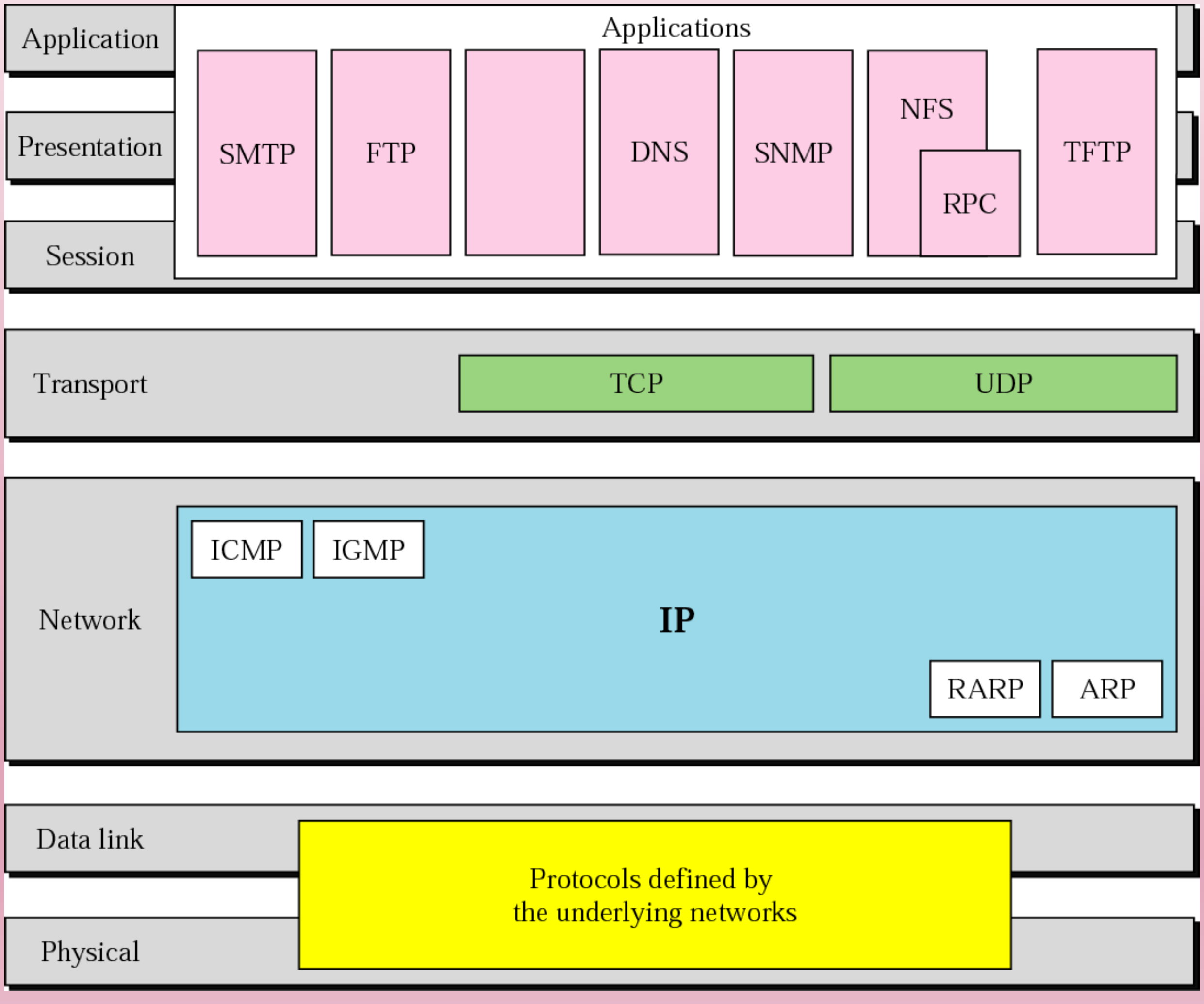
Comparison between OSI and TCP/IP Protocol Suite



- Here, two layers, session and presentation, are missing from the TCP/IP protocol suite. These two layers were not added to the TCP/IP protocol suite after the publication of the OSI model. The application layer in the suite is usually considered to be the combination of three layers in the OSI model.

TCP/IP Protocol Suite

Is made of five layers : physical, data link, network, transport, and application

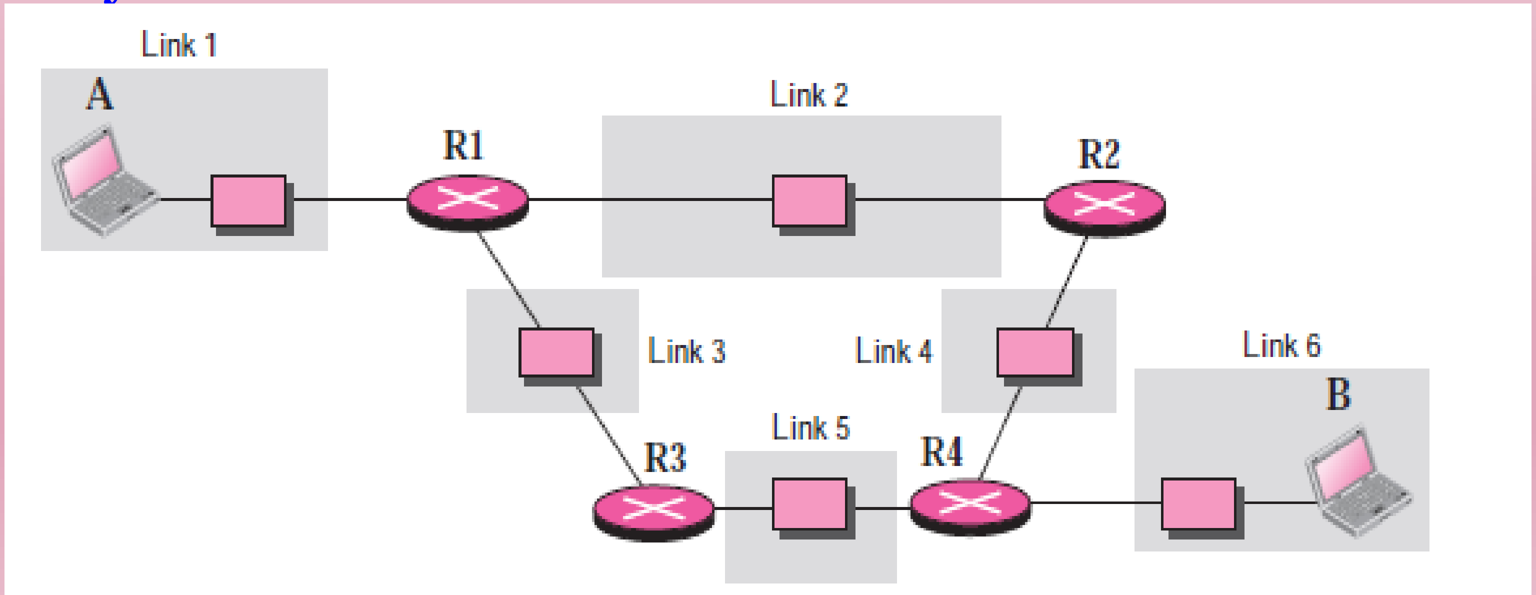


Comparison between OSI and TCP/IP Protocol Suite

- **Two reasons were mentioned for this decision.**
- **First**, TCP/IP has more than one transport-layer protocol. Some of the functionalities of the session layer are available in some of the transport layer protocols.
- **Second**, the application layer is not only one piece of software. Many applications can be developed at this layer. If some of the functionalities mentioned in the session and presentation are needed for a particular application, it can be included in the development of that piece of software.

Layers in the TCP/IP Protocol Suite

- When we study the purpose of each layer, it is easier to think of a private internet, instead of the global Internet. Such an internet is made up of several small networks called links.
- A link is a network that allows a set of computers to communicate with each other. A link can be a LAN or WAN.
- Our imaginary internet that is used to show the purpose of each layer.



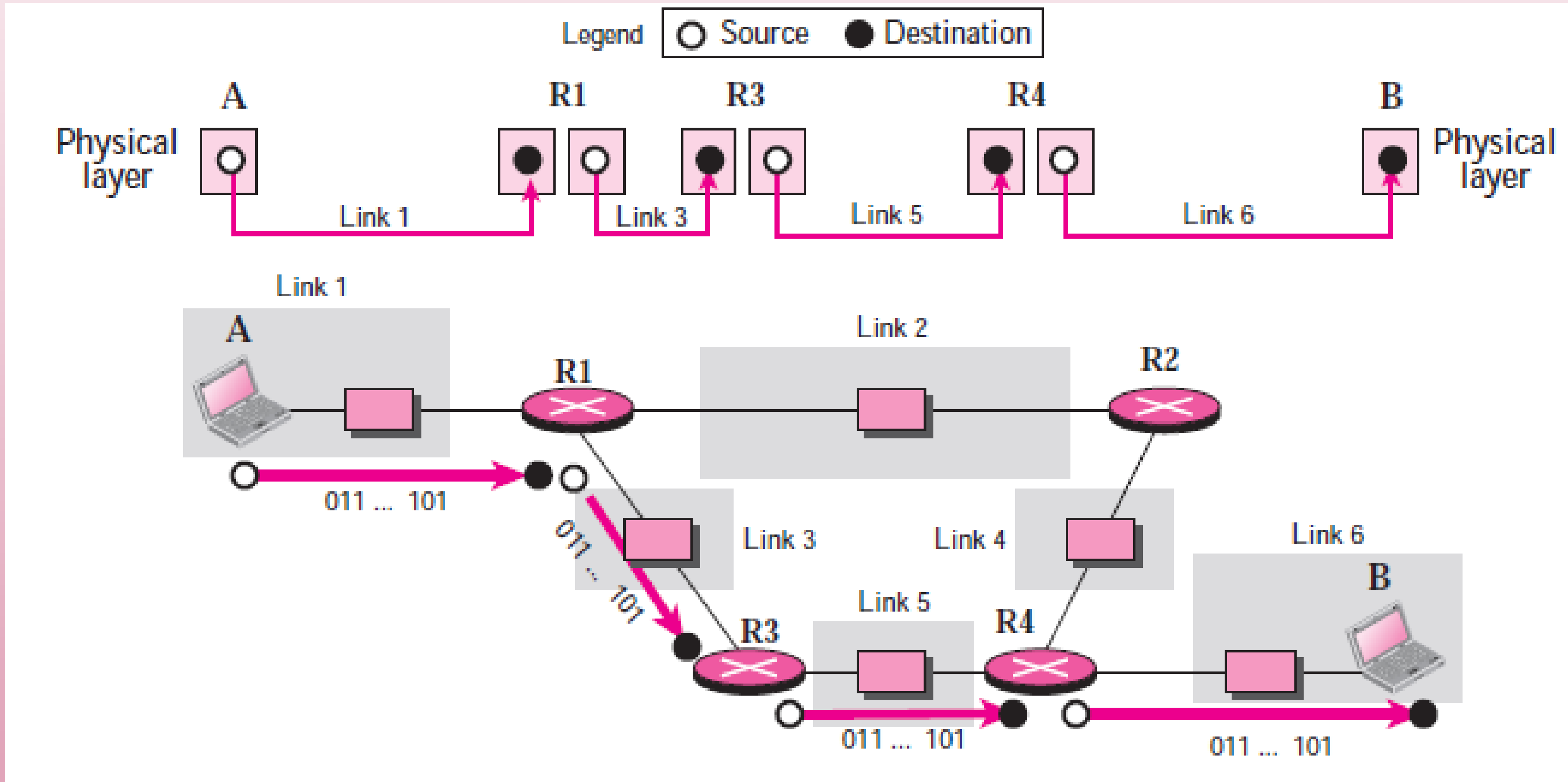
Physical Layer (1) *TCP/IP*

- TCP/IP does not define any specific protocol for the physical layer. It supports all of the standard and proprietary protocols.

- **At this level, the communication is between two hops or nodes, either a computer or router.**

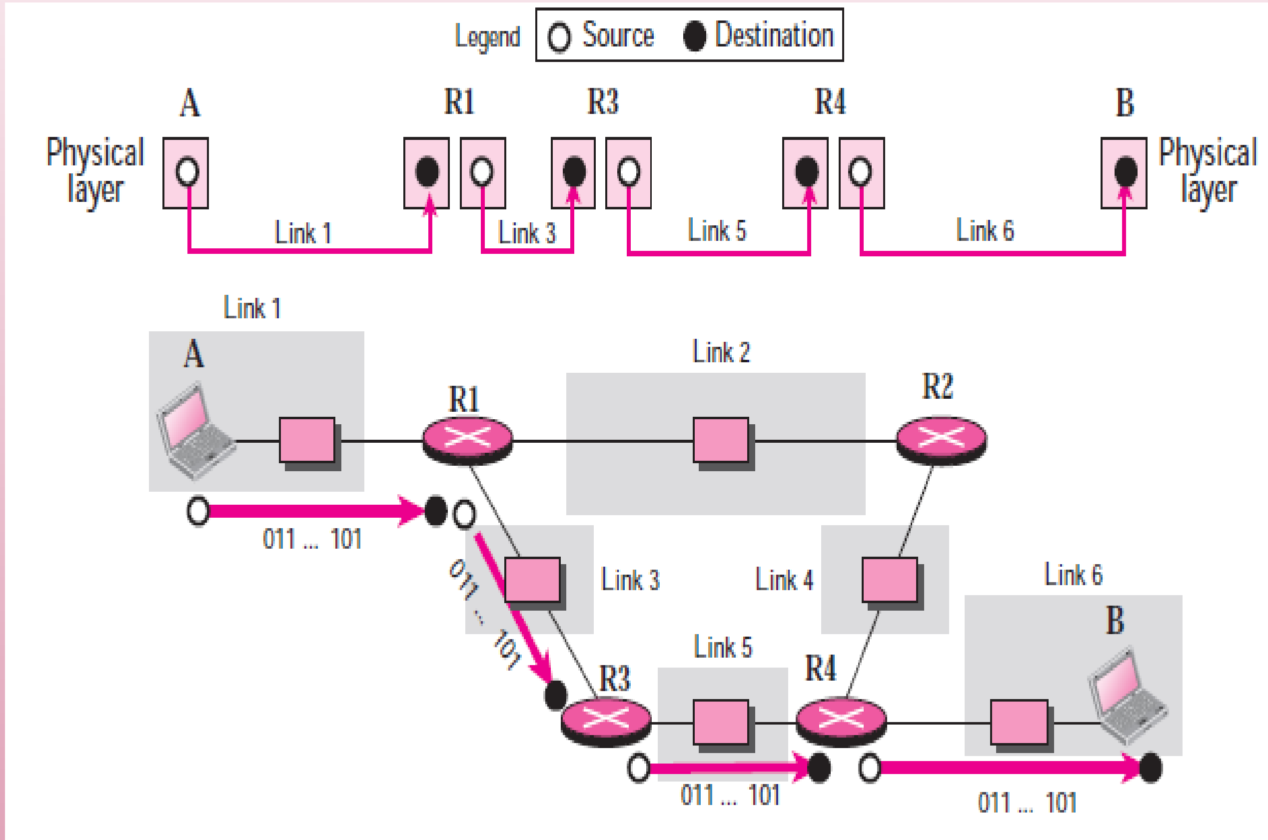
- The unit of communication is a **single bit**. When the connection is established between the two nodes, a stream of bits is flowing between them. The physical layer, however, treats each bit individually.

Physical Layer (1) *TCP/IP*



- We are assuming that at this moment the two computers have discovered that the most efficient way to communicate with each other is via routers R1, R3, and R4.

Physical Layer (1) TCP/IP



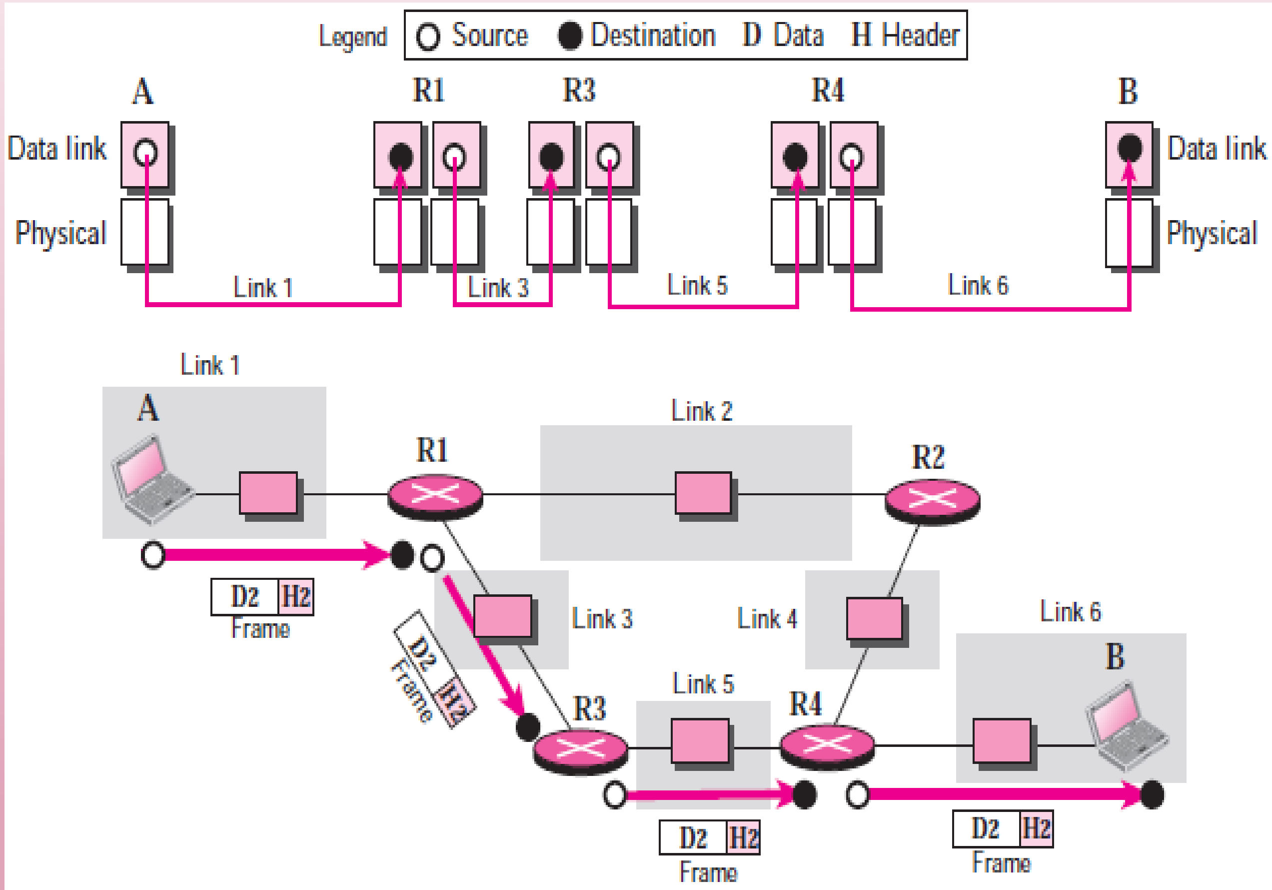
- Computer A sends each bit to router R1 in the format of the protocol used by link 1. Router 1 sends each bit to router R3 in the format dictated by the protocol used by link 3. And so on.
- Note that if a node is connected to n links, it needs n physical-layer protocols, one for each link.

Data Link Layer (2) *TCP/IP*

- TCP/IP does not define any specific protocol for the data link layer either. It supports all of the standard and proprietary protocols.
- **At this level, the communication is also between two hops or nodes. The unit of communication however, is a packet called a frame.**
- A frame is a packet that **encapsulates** the data received from the **network layer** with an added header and sometimes a trailer.
- The head includes the source and destination of frame. The **destination address** is needed to define the right recipient of the frame. The **source address** is needed for possible response or **acknowledgment** as may be required by some protocols.

Data Link Layer (2)

TCP/IP

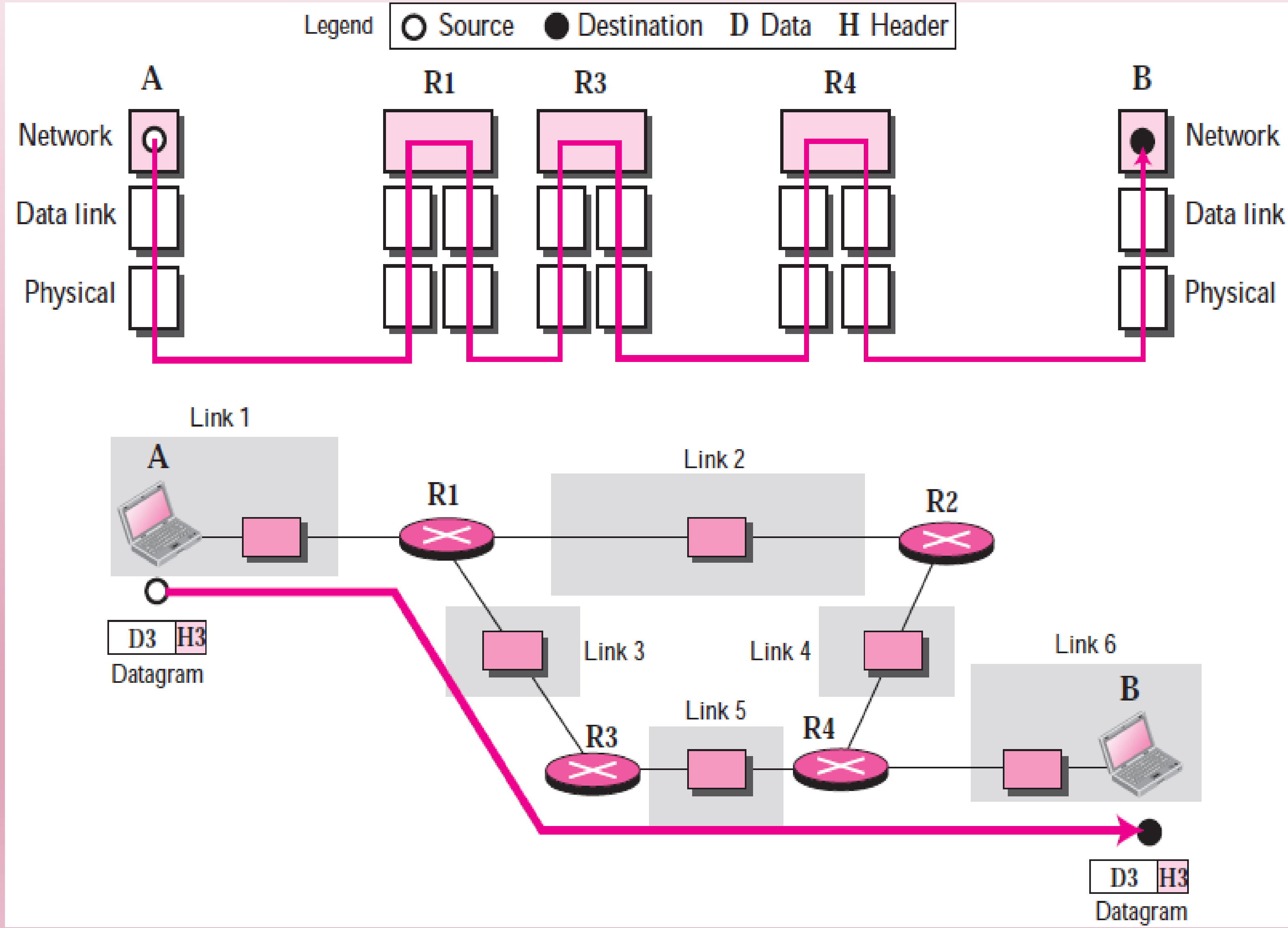


- Note that the frame that is travelling between computer A and router R1 may be different from the one travelling between router R1 and R3.
- When the frame is received by router R1, this router passes the frame to the data link layer protocol (left). The frame is opened, the data are removed.
- The data are then passed to the data link layer protocol (right) to create a **new frame** to be sent to the router R3.

Network Layer(3) TCP/IP

- At the network layer (or, more accurately, the internetwork layer), TCP/IP **supports the Internet Protocol (IP)**.
- The Internet Protocol (IP) is the transmission mechanism used by the TCP/IP protocols.
- IP transports data in packets called **Datagrams**, each of which is transported separately. Datagrams can travel along different routes and can arrive **out of sequence** or be **duplicated**.
- IP does not keep track of the routes and has no facility for reordering datagrams once they arrive at their destination.

Network Layer(3) TCP/IP



Network Layer(3) TCP/IP

- Note that there is a main difference between the communication at the network layer and the communication at data link or physical layers:

Communication at the **network layer is end to end** while the communication at the **other two layers are node to node**.

- The datagram started at **computer A** is the one that reaches **computer B**. The network layers of the routers can inspect (check) the source and destination of the packet for finding the best route, but they are **not allowed to change** the contents of the packet.

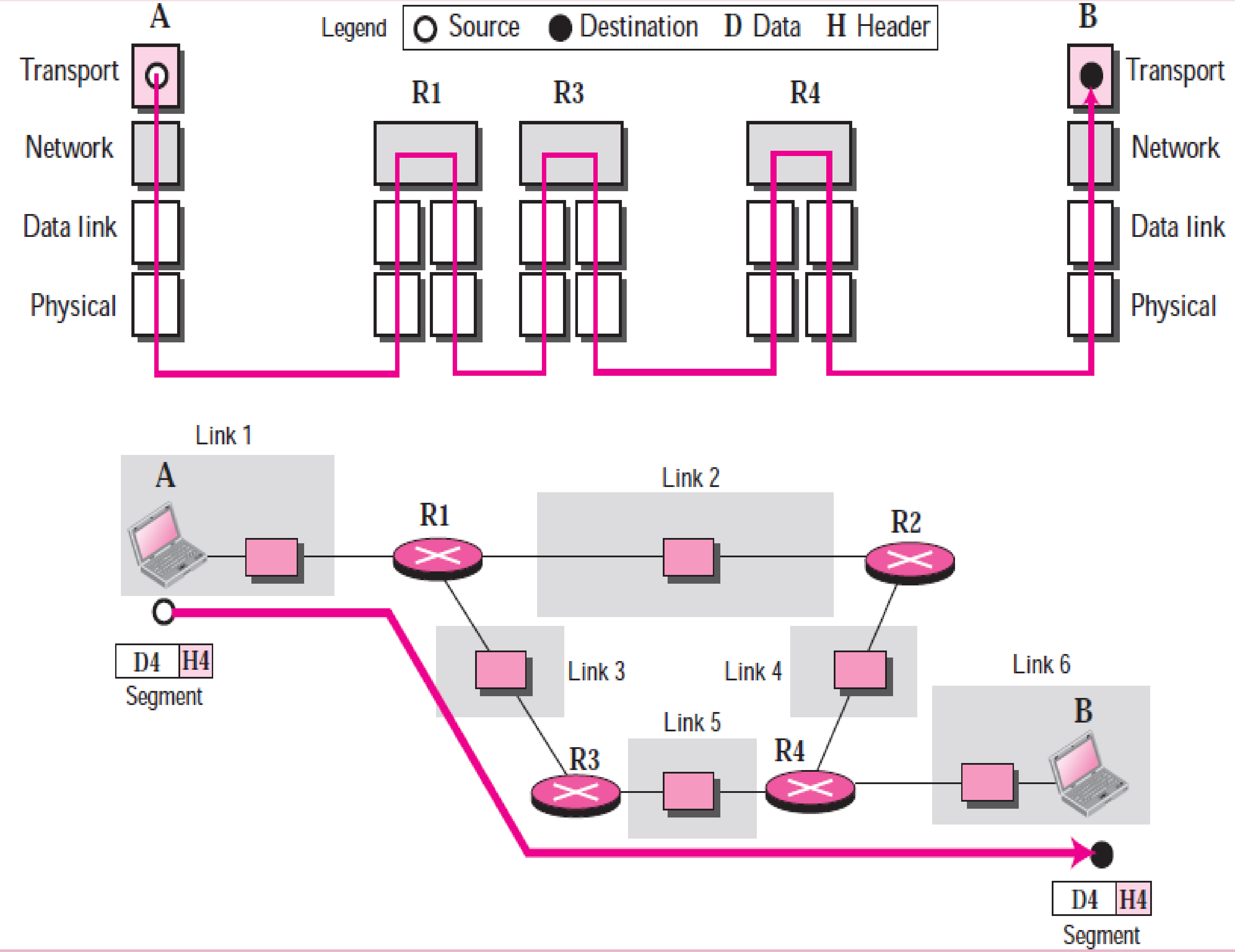
Transport Layer (4) TCP/IP

- There is a **main difference** between the transport layer and the network layer.

Although all nodes in a network need to have the network layer, only the two end computers need to have the transport layer.

- The network layer is responsible for sending individual datagrams from computer A to computer B; the transport layer is responsible for delivering the whole message, which is called a **Segment**, a user datagram, or a packet, from A to B.
- A segment may **consist of a few or tens of datagrams**. The segments need to be **broken** into datagrams and each **datagram** has to be delivered to the **network layer** for transmission.

Transport Layer (4) TCP/IP



- Since the Internet defines a different route for each datagram, the datagrams may arrive out of order and may be lost. The transport layer at computer B needs to wait until all of these datagrams to arrive, **assemble** them and make a segment out of them.

Transport Layer (4) TCP/IP

- **Traditionally, the transport layer was represented in the TCP/IP suite by two protocols:**

1- Transmission Control Protocol (TCP): is a **reliable connection-oriented protocol** that allows a byte stream originating on one machine to be delivered without error on any other machine in the internet. TCP also handles **flow control** to make sure a fast sender cannot swamp a slow receiver with more messages than it can handle.

2- User Datagram Protocol (UDP): UDP is an **unreliable, connectionless protocol** for applications that **do not want TCP's sequencing or flow control** and wish to provide their own. It is also widely used for **one-shot, client-server-type request-reply queries** and applications in which prompt delivery is more important than accurate delivery, such as transmitting speech or video. Its advantage **low overhead.**

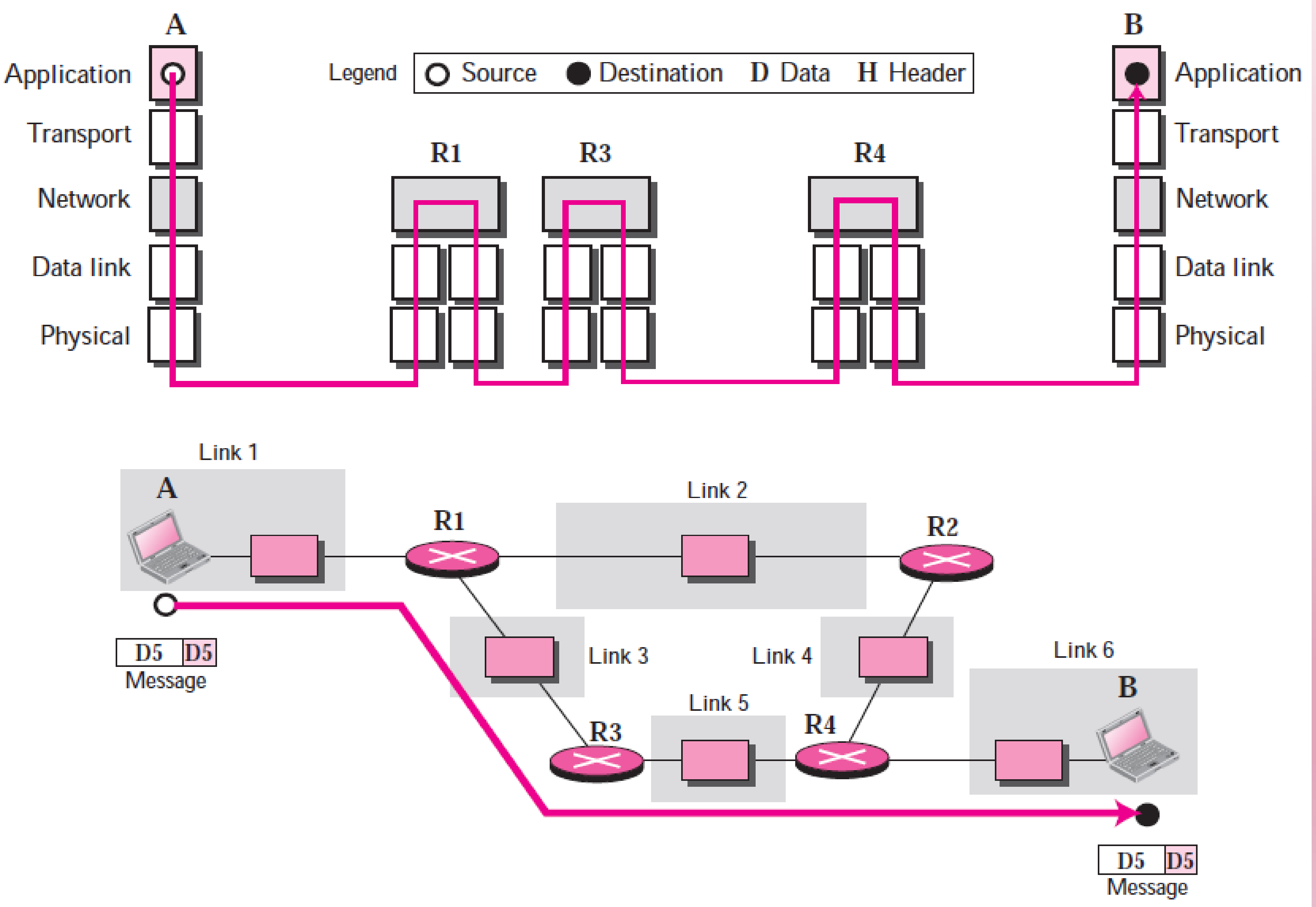
3- A new protocol called **Stream Control Transmission Protocol (SCTP)** has been introduced in the last few years.

Application Layer (5) TCP/IP

- The application layer in TCP/IP is **equivalent to the combined session, presentation, and application layers** in the OSI model. The application layer allows a user to access the services of our private internet or the global Internet. Many protocols are defined at this layer to provide services such as electronic mail, file transfer, accessing the World Wide Web, and so on.

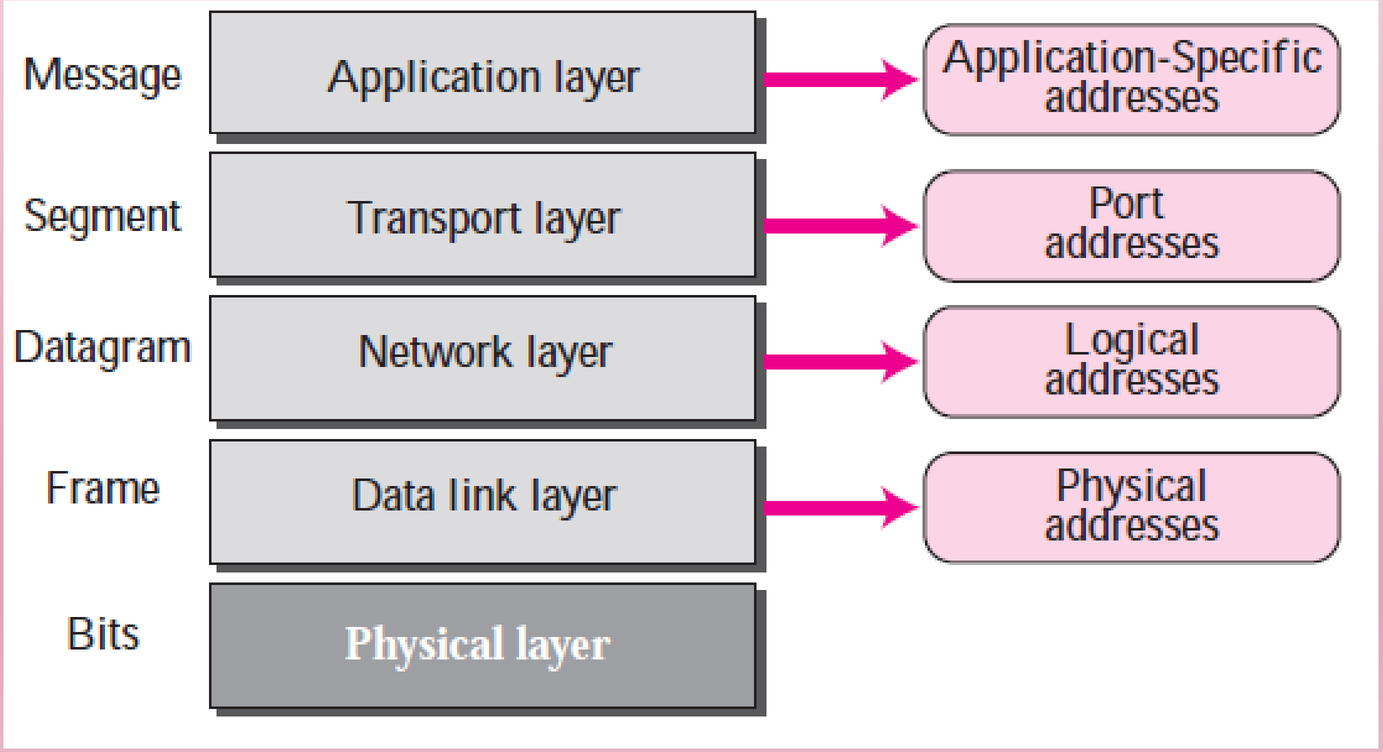
- Note that the communication at the application layer, like the one at the transport layer, is end to end. A message generated at computer A is sent to computer B without being changed during the transmission.

Transport Layer (5) TCP/IP



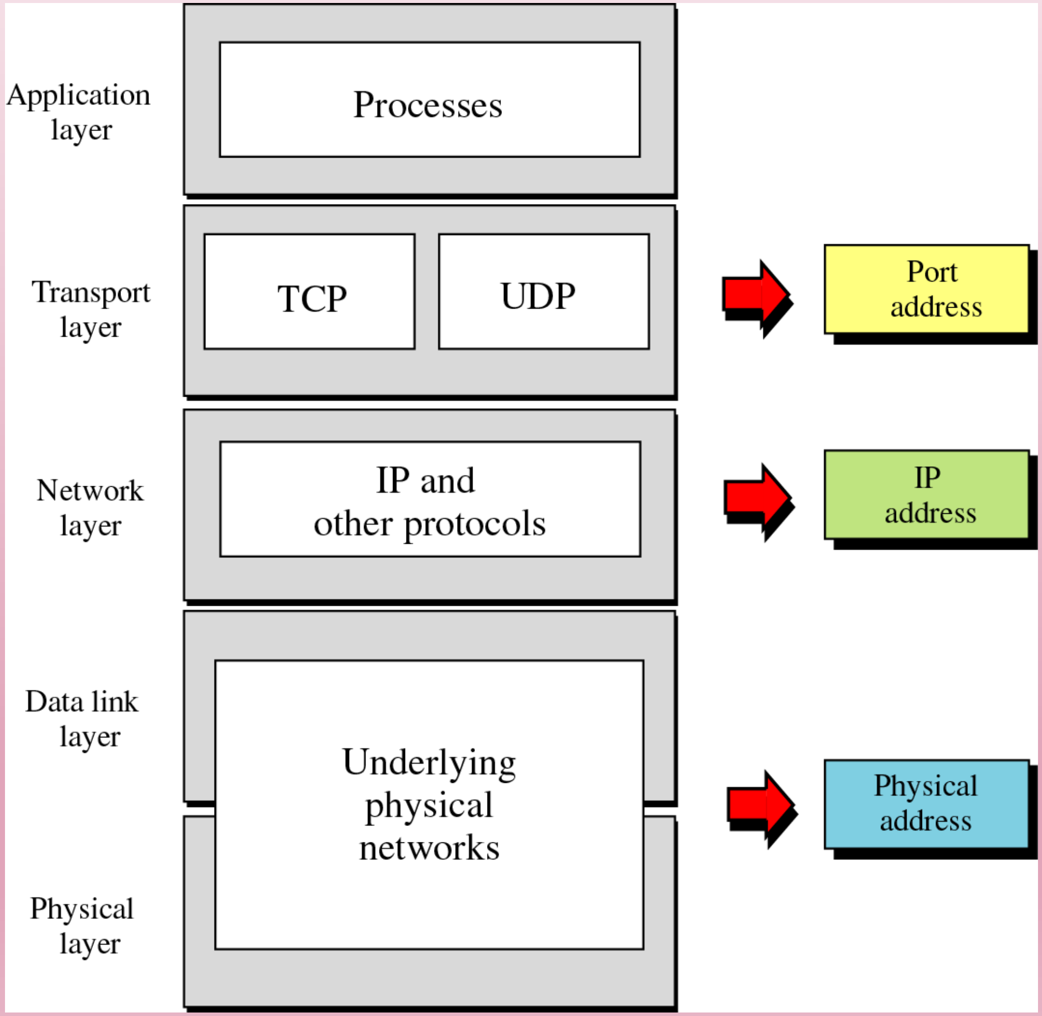
ADDRESSING

- Four levels of addresses are used in an internet employing the TCP/IP protocols: **physical address**, **logical address**, **port address**, and **application-specific address**. Each address is related to a one layer in the TCP/IP architecture:



Addressing (cont'd)

Relationship of layers and addresses in TCP/IP



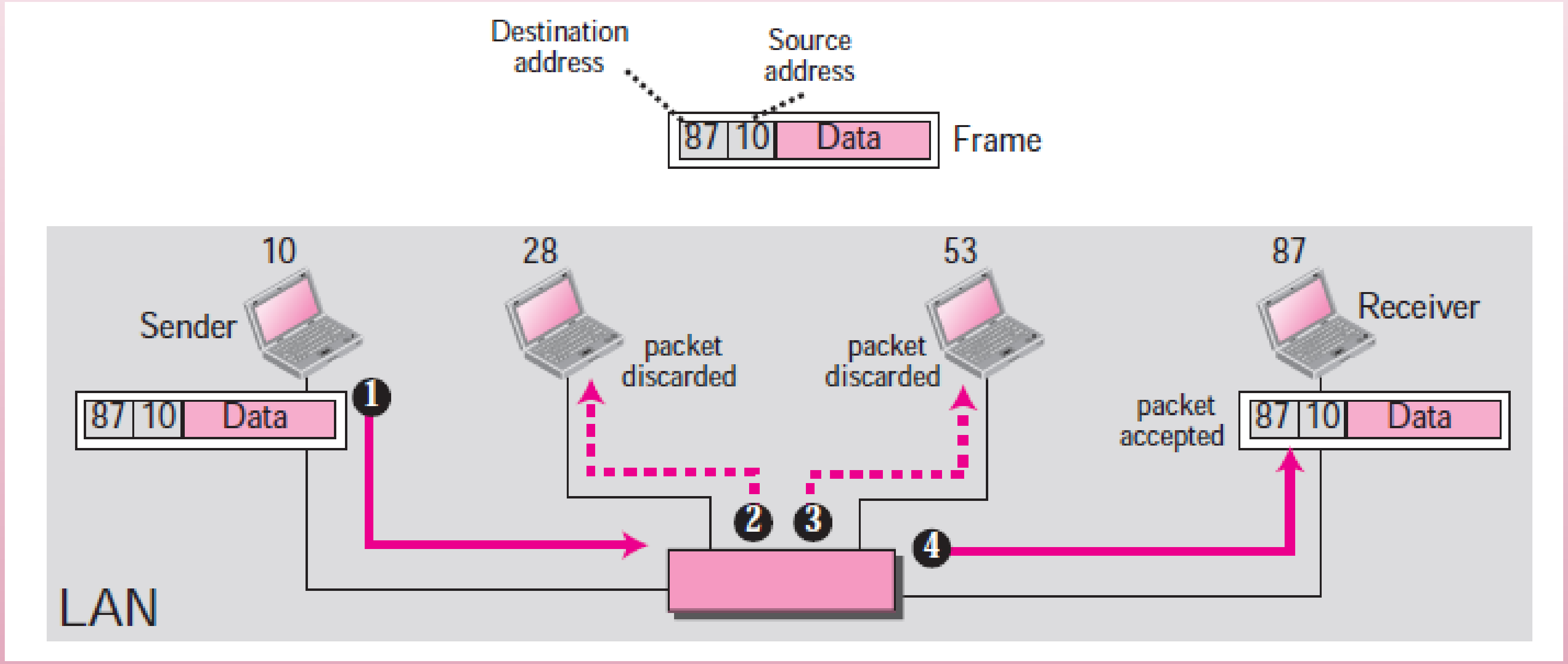
Physical Addresses

- The physical address, also known as the **link address**, is the **address of a node** as defined by its LAN or WAN. It is included in the **frame** used by the data link layer. It is the lowest-level address.
- The **size and format** of these addresses vary **depending on the network**. For example, **Ethernet** uses a **6-byte (48-bit) physical address** that is imprinted on the network interface card (NIC). LocalTalk (Apple), however, has a 1-byte dynamic address that changes each time the station comes up.

07:01:02:01:2C:4B

A 6-byte (12 hexadecimal digits) physical address

Physical Addresses



Layer 2 addresses are only used to communicate between devices on a single local network

Unicast, Multicast, and Broadcast Physical Addresses

- Physical addresses can be either **unicast** (one single recipient), **multicast** (a group of recipients), or **broadcast** (to be received by all systems in the network).

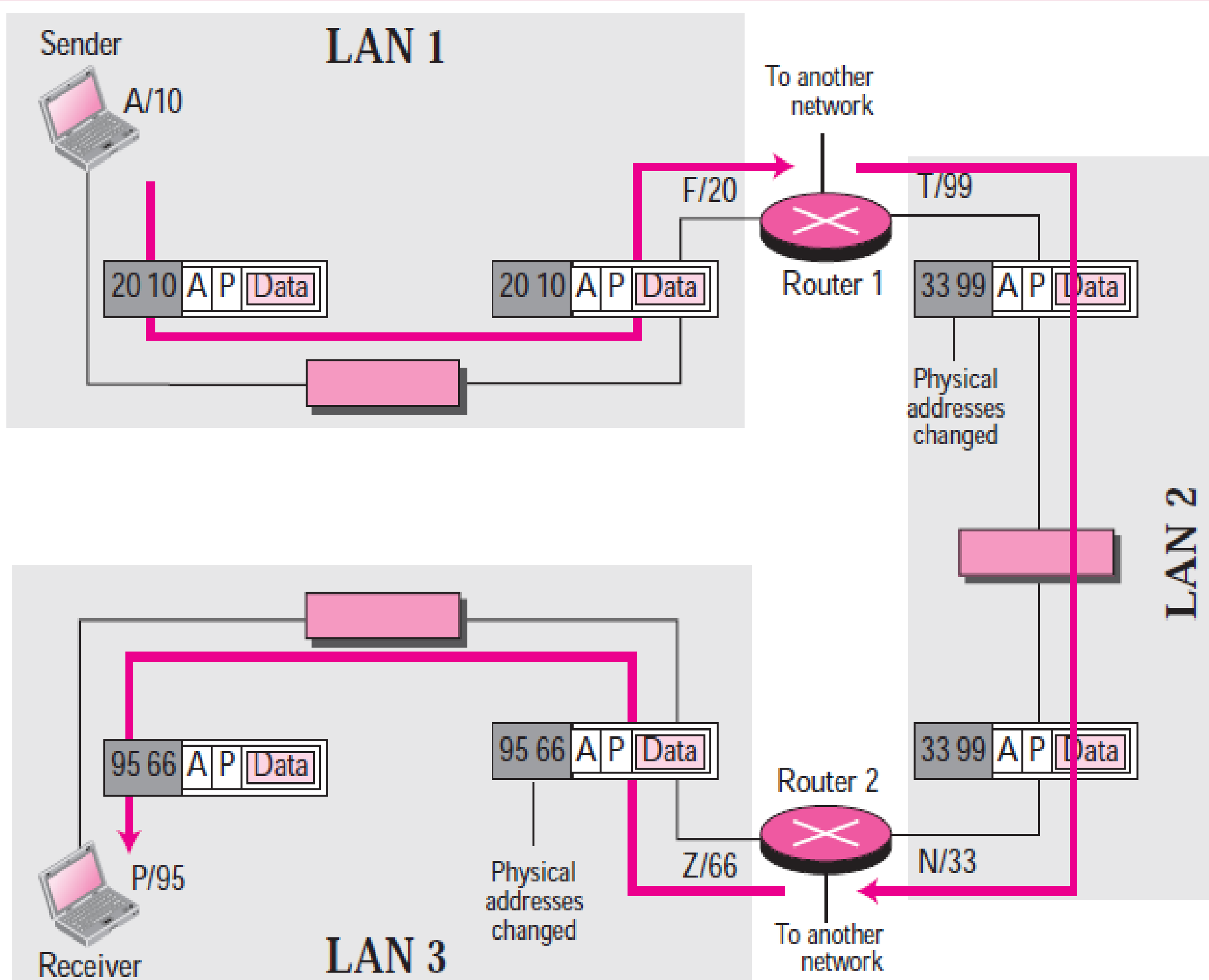
- Some networks support all three addresses. Ethernet supports the **unicast** physical addresses (6 bytes), the **multicast** addresses, and the **broadcast** addresses.

- Some networks do **not support** the **multicast** or **broadcast** physical addresses.

Logical Addresses

- **Logical addresses** are necessary for universal communications that are independent of underlying physical networks.
- **Physical addresses** are not adequate in an internetwork environment where different networks can have different address formats.
- A universal addressing system is needed in which each host can be identified uniquely, regardless of the underlying physical network. The logical addresses are designed for this purpose.
- A **logical address** in the Internet is currently a **32-bit address** that can **uniquely define a host connected to the Internet**. No two publicly addressed and visible hosts on the Internet can have the same IP address.

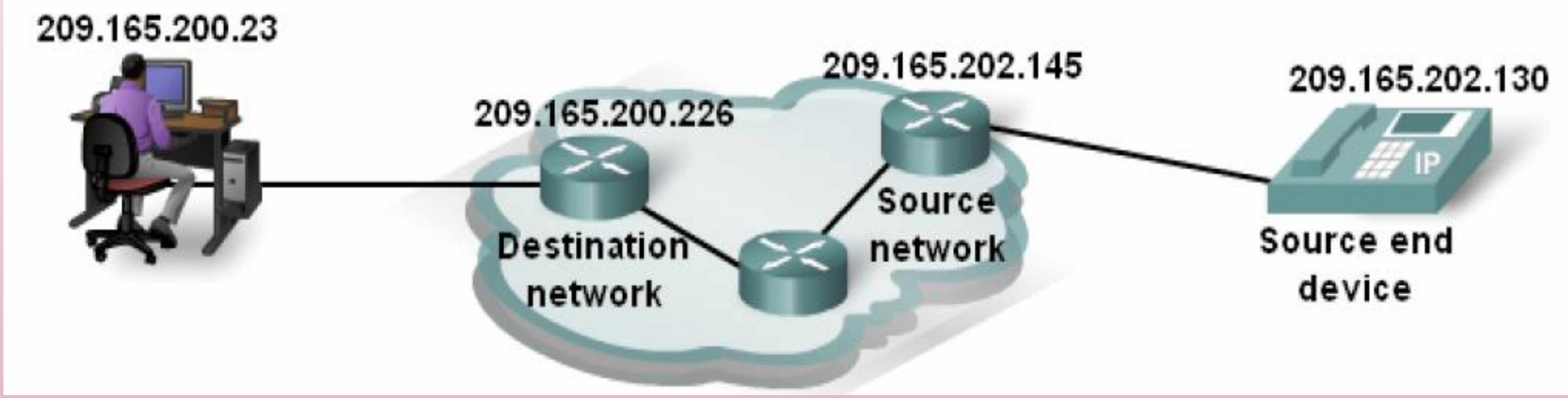
Logical Addresses



The physical addresses will change from hop to hop, but the logical addresses remain the same.

- The network layer, however, needs to find the physical address of the next hop before the packet can be delivered. The network Layer consults its **routing table** and finds the logical address of the next hop to be F.
- Another protocol, **Address Resolution Protocol (ARP),** finds the physical address of router 1 that corresponds to its logical address (20).

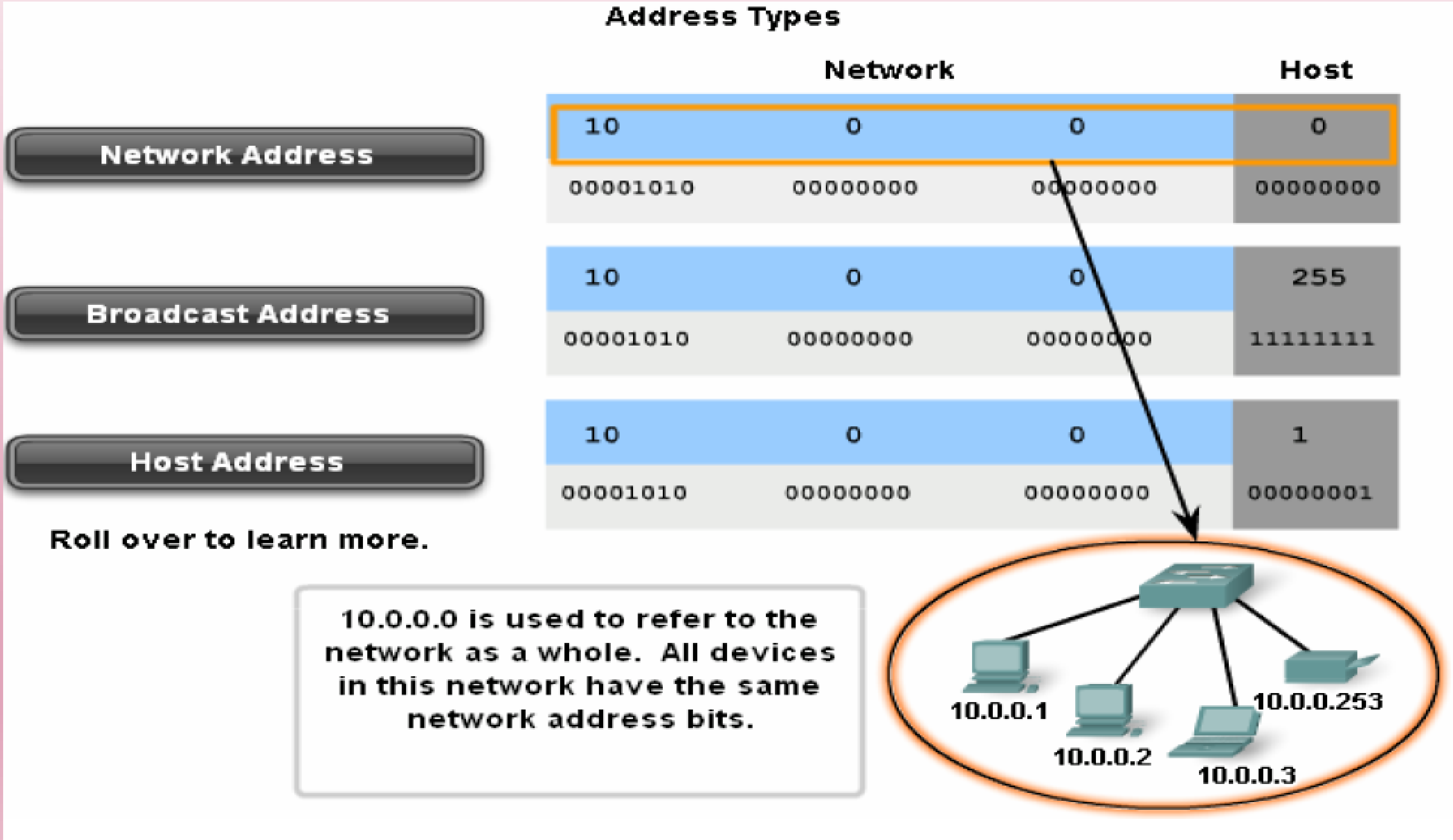
Logical Addresses



Unicast, Multicast, and Broadcast Addresses

- The logical addresses can be either unicast (one single recipient), multicast (a group of recipients), or broadcast (all systems in the network). There are limitations on broadcast addresses.

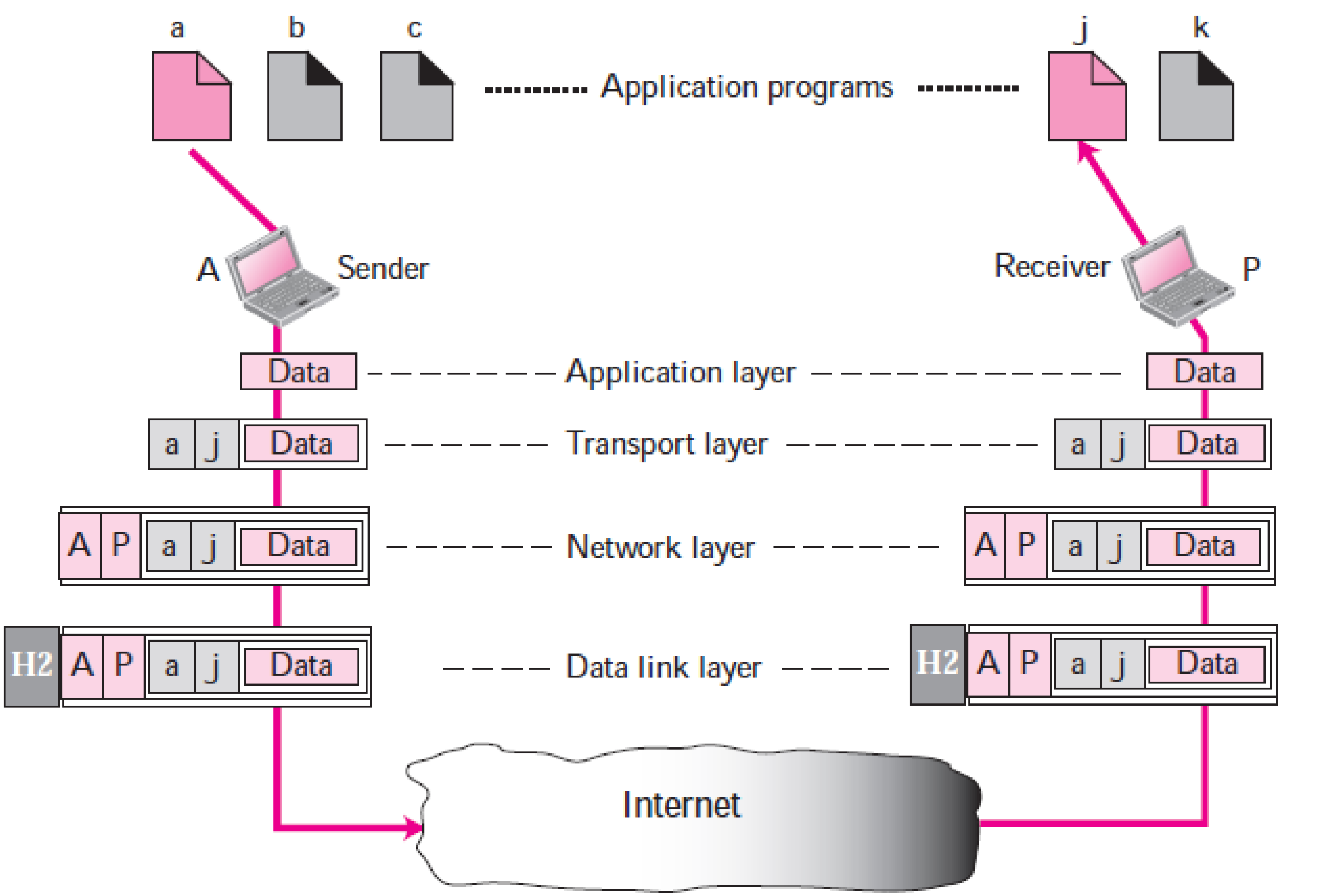
Logical Addresses



Port Addresses

- Computers are devices that can run multiple processes at the same time. The end objective of Internet communication is a **process communicating with another process**.
- For example, **computer A** can communicate with **computer C** by using TELNET. At the same time, **computer A** communicates with **computer B** by using the File Transfer Protocol (FTP).
- For these processes to receive data simultaneously, we need a method to **label the different processes**. In the TCP/IP architecture, the label assigned to a process is called a **port address**. A port address in TCP/IP is **16 bits in length**.

Port Addresses



- Port address is a **16-bit** address represented by one decimal number as shown.
- 753 A 16-bit port address represented as one single number

The physical addresses change from hop to hop,
but the logical and port addresses usually remain the same.

Port Addresses

- **Some of these Addresses are:**
  - **Domain Name System (DNS) - TCP/UDP Port 53**
  - **Hypertext Transfer Protocol (HTTP) - TCP Port 80**
  - **Simple Mail Transfer Protocol (SMTP) - TCP Port 25**
  - **Post Office Protocol (POP) - UDP Port 110 Telnet - TCP Port 23**
  - **Dynamic Host Configuration Protocol - UDP Port 67**
  - **File Transfer Protocol (FTP) - TCP Ports 20 and 21**

For more:

CCNA Exploration 4.0 Network Fundamentals, Chapter Three Application Layer functionality & Protocols (P. 24).

Application-Specific Addresses

- Some applications have user-friendly addresses that are designed for that specific application.
- Examples include the **e-mail address** (for example, forouzan@fhda.edu) and the Universal Resource Locator (URL) (for example, www.mhhe.com). The first defines the recipient of an e-mail; the second is used to find a document on the World Wide Web.
- These addresses, however, get changed to the corresponding port and logical addresses by the sending computer.

Internetworking Protocol (IP)

Transmission mechanism by the TCP/IP
An unreliable and connectionless datagram protocol – best-effort delivery service; IP provides no error checking or tracking

UDP and TCP

User Datagram Protocol (UDP)

A process-to-process protocol that add only port addresses, checksum error control, length information.

Transmission Control Protocol (TCP)

Reliable stream (connection-oriented) transport protocol

Dividing a stream of data into smaller units called segments.

IP Addresses (example 4)

As we will see in Chapter 4, an Internet address (in IPv4) is 32 bits in length, normally written as four decimal numbers, with each number representing 1 byte. The numbers are separated by a dot. Below is an example of such an address

132.24.75.9

Port Addresses (example 6)

As we will see in Chapters 11 and 12, a port address is a 16-bit address represented by one decimal number as shown below.

753 : A 16-bit port address

TCP/IP Versions

Version 4 (IPv4)

32 bits address length

Version 6 (IPv6 or IPng)

128 bits address length