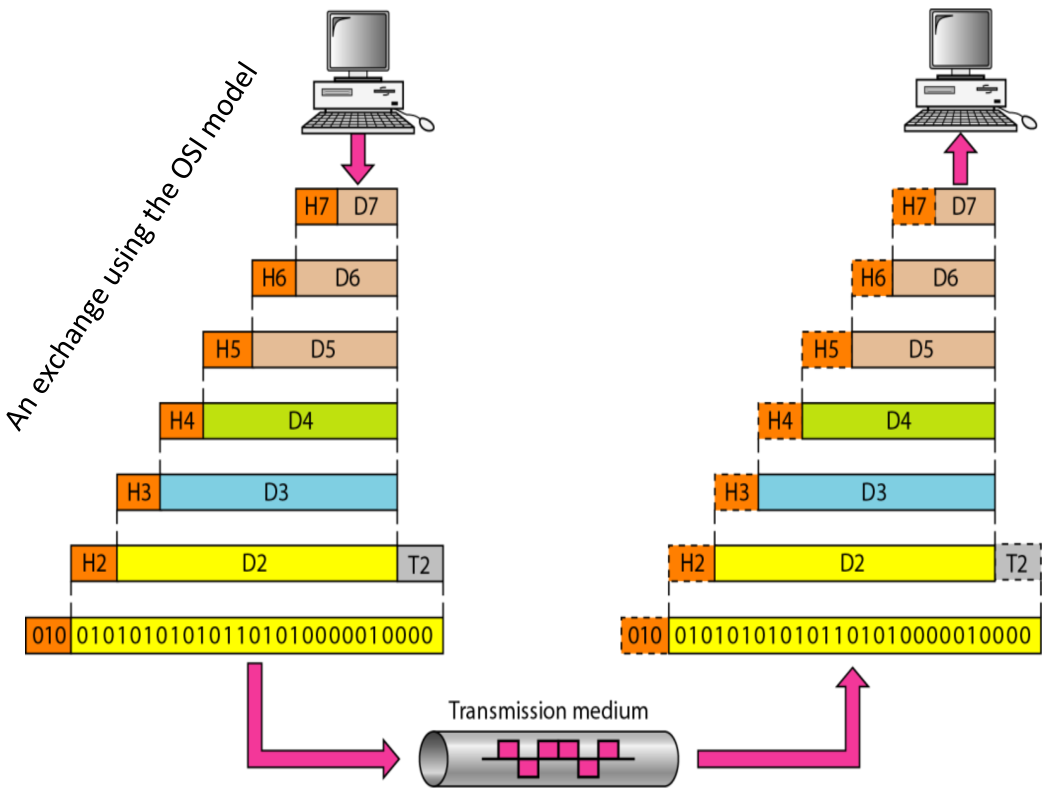
Data communication and Networks

Chapter 2: Network Standards and OSI Model



2.1 Network Criteria

A network must be able to meet a certain number of criteria. The most important of these are ***performance, reliability***, and ***security.***

Performance can be *measured* in many ways, including *transit time* and *response time*. **Transit time** is the amount of time required for a message to travel from one device to another. **Response time** is the elapsed time between an inquiry and a response. The performance of a network depends on a number of ***factors***, including the 1) number of users, 2) the type of transmission medium, 4) the capabilities of the connected hardware, and 5) the efficiency of the software.

Performance is often ***evaluated*** by two networking ***metrics***: *throughput* and *delay*. We often need more *throughput* and *less delay*. However, these two criteria are often contradictory. If we try to send more data to the network, we may increase throughput but we increase the delay because of *traffic congestion* in the network.

Reliability In addition to accuracy of delivery, network reliability is measured by the 1) frequency of failure, 2) the time it takes a link to recover from a failure, and 3) the network's robustness in a catastrophe.

Security Network security issues include 1) protecting data from *unauthorized access*, 2) protecting data from *damage and change*, and 3) implementing policies for recovery from data losses.

2.2. Protocols and Standards

A. Protocols In computer networks, communication occurs between entities in different systems. An entity is anything capable of sending or receiving information. For communication to occur, the entities must agree on a protocol. A protocol defines ***what*** is communicated, ***how*** it is communicated, and ***when*** it is communicated. The *key elements* of a protocol are syntax, semantics, and timing.

Syntax It refers to the structure or format of the data, meaning the order in which they are presented. For example, a simple protocol might expect the first 8 bits of data to be the address of the sender, the second 8 bits to be the address of the receiver, and the rest of the stream to be the message itself.

Semantics It refers to the meaning of each section of bits. How is a particular pattern to be interpreted, and what action is to be taken based on that interpretation? For example, does an address identify the route to be taken or the final destination of the message?

Timing It refers to two characteristics: *when* data should be sent and *how fast* they can be sent. For example, if a sender produces data at 100 Mbps but the receiver can process data at only 1 Mbps, the transmission will overload the receiver and some data will be lost.

B. **Standards** are essential in creating and maintaining an open and competitive market for equipment manufacturers and in guaranteeing national and international interoperability of data and telecommunications technology and processes.

Standards Creation Committees

Most data telecommunications rely primarily on the standards published by the following committees:

- *International Organization for Standardization* (**ISO**). The ISO is a multinational. It is active in the realms of scientific, technological, and economic activity.
- *American National Standards Institute* (**ANSI**). The ANSI is a completely private, not affiliated with the U.S. federal government. However, all ANSI activities are undertaken.
- *Institute of Electrical and Electronics Engineers* (**IEEE**). This institute is the largest professional engineering society in the world. It aims to advance theory, creativity, and product quality in the fields of electrical engineering, electronics, and radio. The IEEE oversees the development and adoption of international standards for computing and communications.
- *Electronic Industries Association* (**EIA**). In the field of *information technology* (IT), the EIA has made significant contributions by defining *physical connection interfaces* and *electronic signalling specifications* for data communication.

2.3 Network Models

The layered model that dominated data communications and networking literature before 1990 was the *Open Systems Interconnection* (**OSI**) model. Everyone believed that the OSI model would become the ultimate standard for data communications, but this did not happen. *The **TCP/IP** protocol suite became the dominant commercial architecture* **because** it was used and tested extensively in the Internet; the OSI model was never fully implemented. Figure 2.1 shows the layers included in the TCP/IP and OSI models and also the main protocols and services provided by each layer.

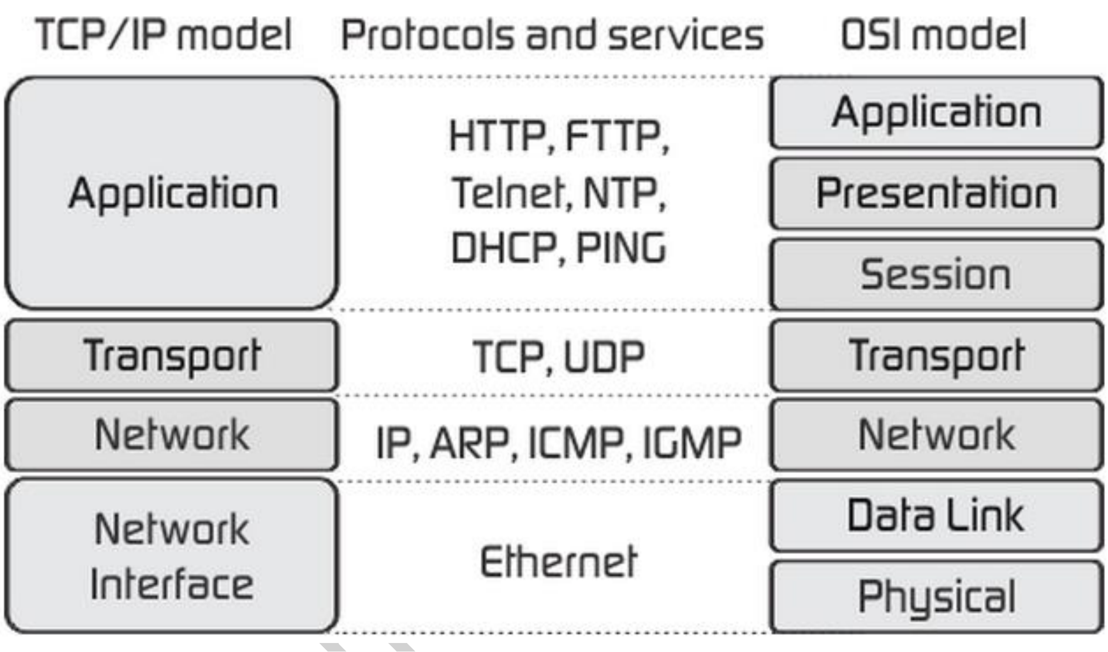


Figure 2.1 The TCP/IP and OSI models for data communications and networking

2.3.1 Layered Task

We use the concept of layers in our daily life. As an example, let us consider two friends who communicate through postal mail. The process of sending a letter to a friend would be complex if there were no services available from the post office. Figure 2.2 shows the steps in this task.

Each layer at the sending site uses the services of the layer immediately below it. The sender at the higher layer uses the services of the middle layer. The middle layer uses the services of the lower layer. The lower layer uses the services of the carrier.

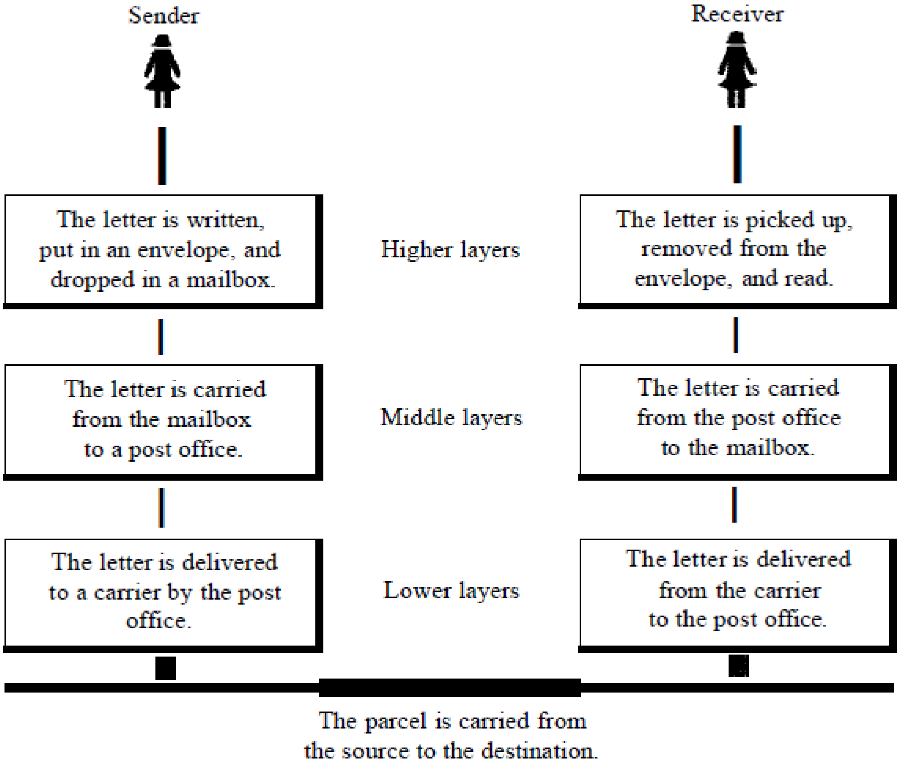


Figure 2.2 *Tasks involved in sending a letter*

2.3.2 The OSI Model

The ***Open Systems Interconnection*** (OSI) model is introduced in the late 1970s by the ***International Standards Organization*** (ISO). The **purpose** of the OSI model is to show how to facilitate communication between different systems without requiring changes to the logic of the underlying hardware and software. The *OSI model is not a protocol*; it is a model for understanding and designing a network architecture. (**Note:** ISO is the organization. OSI is the model.)

The OSI model is a layered framework for the design of network systems that allows communication between all types of computer systems. It consists of seven separate but related layers, each of which defines a part of the process of moving information across a network (*see the right side of Figure 2.1*).

Figure 2.3 shows the layers involved when a message is sent from device A to device B. As the message travels from A to B, it may pass through many intermediate nodes. These intermediate nodes usually involve only the first three layers of the OSI model.

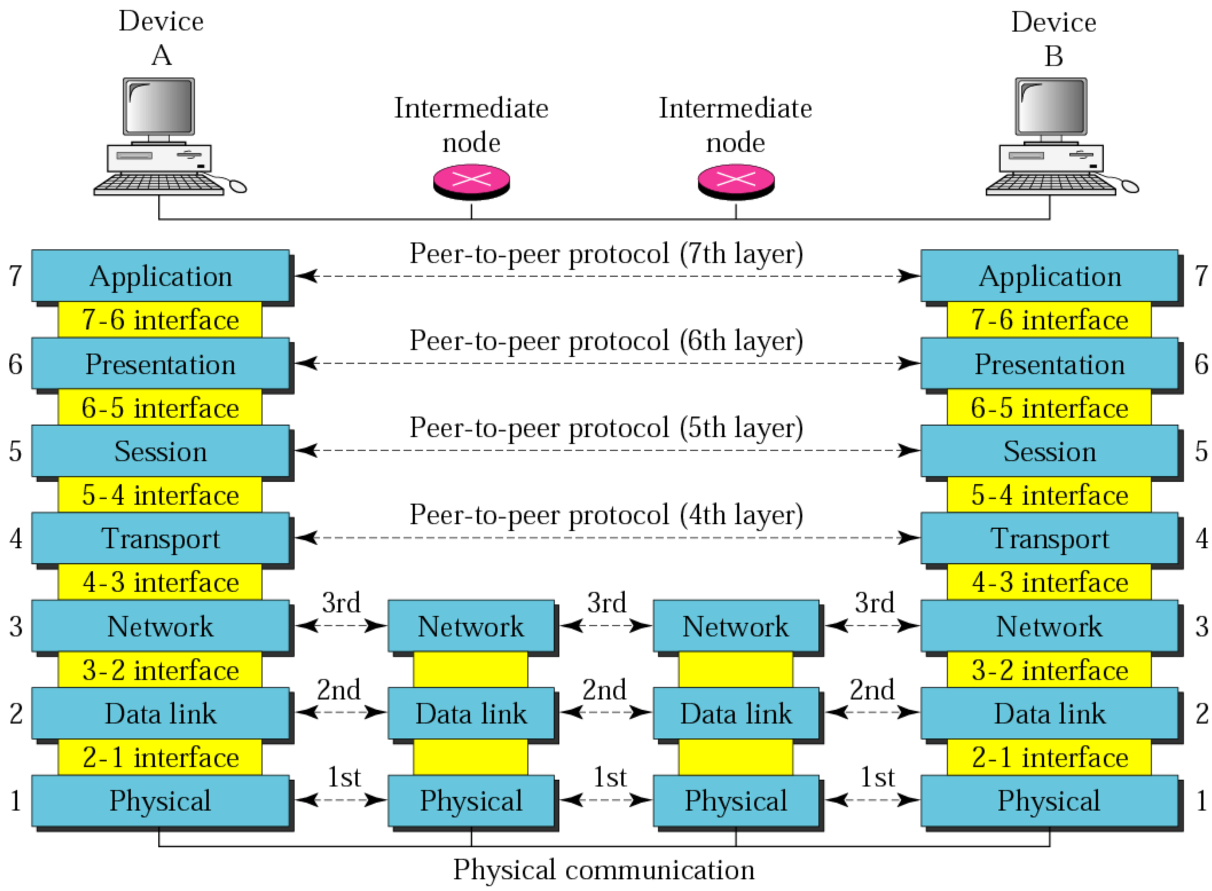


Figure 2.3 *The interaction between layers in the OSI model*

Each layer defines a family of functions distinct from those of the other layers. Within a single machine, each layer calls upon the services of the layer just below it. Layer 3, for example, uses the services provided by layer 2 and provides services for layer 4. Between machines, layer *x* on one machine communicates with layer *x* on another machine. *This communication* is governed by an agreed-upon series of rules and conventions called **protocols**.

The processes on each machine that communicate at a given layer are called ***peer-to-peer processes***. Communication between machines is therefore a peer-to-peer process using the protocols appropriate to a given layer.

The interfaces between layers are to define the information and services that each layer must provide for the layer above it. Well-defined ***interfaces*** and ***layer functions*** provide **modularity** to a network.

The seven layers are belonging to three subgroups. Layers 1, 2, and 3 are the network support layers; they deal with the physical aspects of moving data from one device to another (such as electrical specifications, physical connections, and physical addressing). Layers 5, 6, and 7 are the user support layers; they allow interoperability among unrelated software systems. Layer 4, the transport layer, links the two subgroups.

2.3.3 Layers in the OSI Model

In the following we describe the functions of each layer in the OSI model.

1. Physical Layer

The physical layer coordinates the functions required to carry a bit stream over a physical medium (see Figure 2.4).

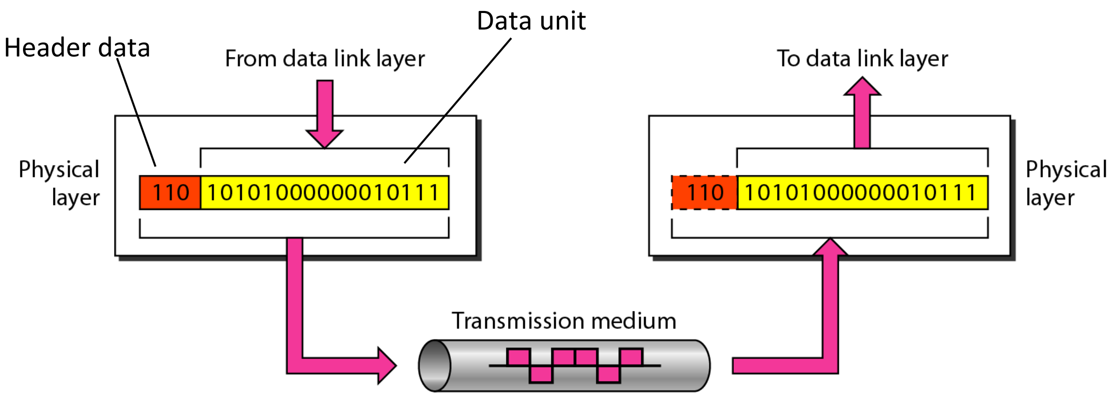


Figure 2.4 *Physical layer*

The physical layer is concerned with the following:

- Physical characteristics of interfaces and medium.
- Representation of bits (sequence of 0s or 1s) with defining the type of encoding (how 0s and 1s are changed to signals).
- Data rate or the transmission rate (the number of bits sent each second)
- Synchronization of bits. The sender and receiver not only must use the same bit rate but also must be synchronized at the bit level.
- Line configuration (point-to-point or multipoint configuration).
- Physical topology (mesh, star, bus, etc.).
- Transmission mode (simplex, half-duplex, or full-duplex).

2. Data Link Layer

The data link layer makes the physical layer appear error-free to the upper layer (network layer). Figure 2.5 shows the relationship of the data link layer to the network and physical layers.

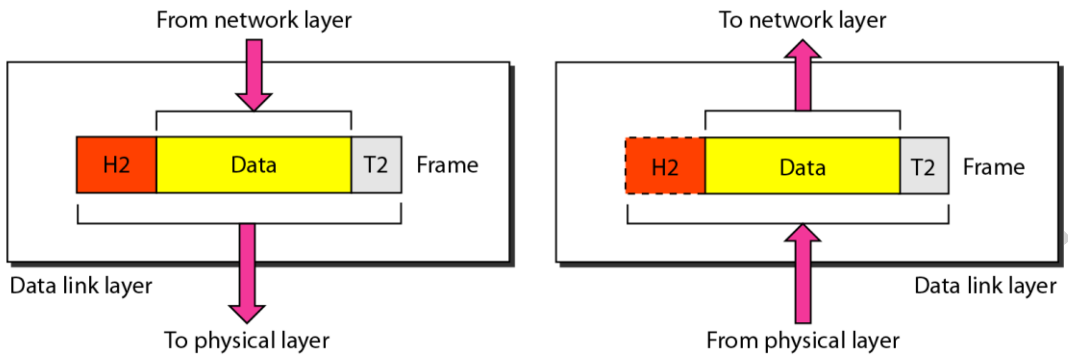


Figure 2.5 Data Link layer

The data link layer is responsible for moving frames from one hop (node) to the next. Other responsibilities of the data link layer include the following:

- Framing. The data link layer divides the stream of bits received from the network layer into manageable data units called **frames** (see Figure 2.5).
- Physical addressing. The data link layer adds a header to the frame to define the sender and/or receiver devices of the frame. The devises are defined by the physical address (or MAC address).
- Flow control. The data link layer ensures the rate at which data are produced in the sender and arrived in the receiver.
- Error control. The data link layer adds mechanisms to detect and retransmit damaged or lost frames. Error control is normally achieved through a **trailer** added to the end of the frame (see the **T2** in Figure 2.5).
- Access control. The data link layer controls the access to the link when two or more devices are connected to the same link.

3. Network Layer

The network layer is responsible for the **source-to-destination delivery** of a **packet** (see Figure 2.6), possibly across multiple networks (links). Whereas the data link layer oversees the delivery of the packet between two systems *on the same* network (links).

Other responsibilities of the network layer include the following:

- Logical addressing. The network layer adds a header to the packet coming from the upper layer that, among other things, includes the logical addresses (**IP address**) of the sender and receiver. We discuss logical addresses in a next lecture.
- Routing. When independent networks or links are connected to create internetworks, the connecting devices (called routers or switches) route or switch the packets to their final destination. One of the functions of the network layer is to provide this mechanism.

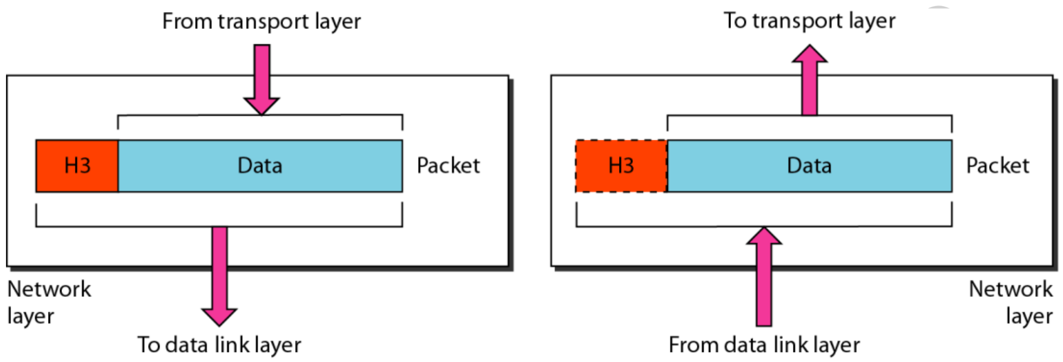


Figure 2.6 Network layer

4. Transport Layer

The transport layer is responsible for **process-to-process delivery** of the entire message. A process is an application program running on a host. Whereas the network layer oversees source-to-destination delivery of individual packets.

Other responsibilities of the transport layer include the following:

- Service-point addressing. Computers often run several programs at the same time. The transport layer header includes a type of address called a service-point address (or port address) in order to deliver the entire message to the correct process on that computer.
- Segmentation and reassembly. A message is divided into transmittable segments, with each segment containing a sequence number. These numbers enable the transport layer to reassemble the message correctly at the destination (see Figure 2.7).

- Flow control. Like the data link layer, the transport layer is responsible for flow control. However, flow control at this layer is performed end to end rather than across a single link.
- Error control. Like the data link layer, the transport layer is responsible for error control. However, error control at this layer is performed process-to-process rather than across a single link.

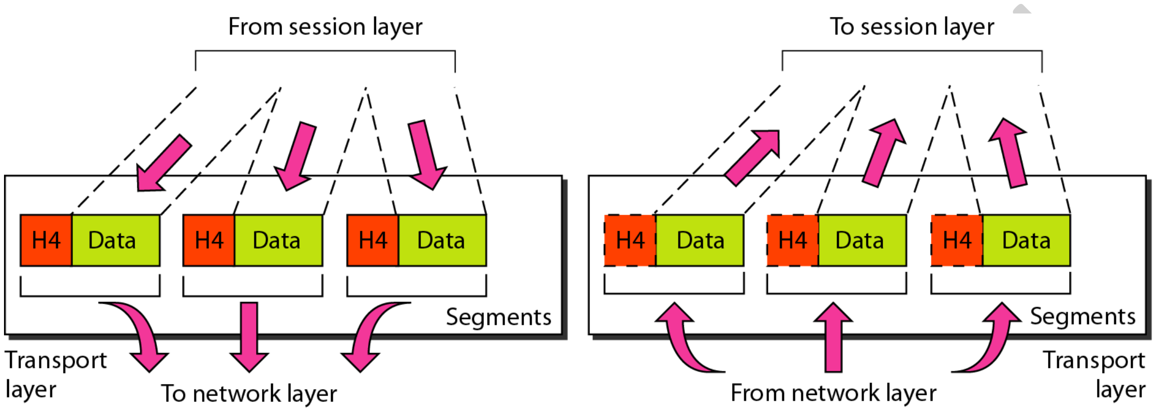


Figure 2.7 Transport layer

5. Session Layer

The services provided by the first three layers (physical, data link, and network) are not sufficient for some processes. The session layer is responsible for dialog control and synchronization.

Specific responsibilities of the session layer include the following:

- Dialog control. The session layer allows the communication between two processes to take place in either half-duplex (one way at a time) or full-duplex (two ways at a time) mode.
- Synchronization. The session layer allows a process to add checkpoints, or synchronization points, to a stream of data (see Figure 2.8). For example, if a system is sending a file of 2000 pages, it is advisable to insert checkpoints after every 100 pages.

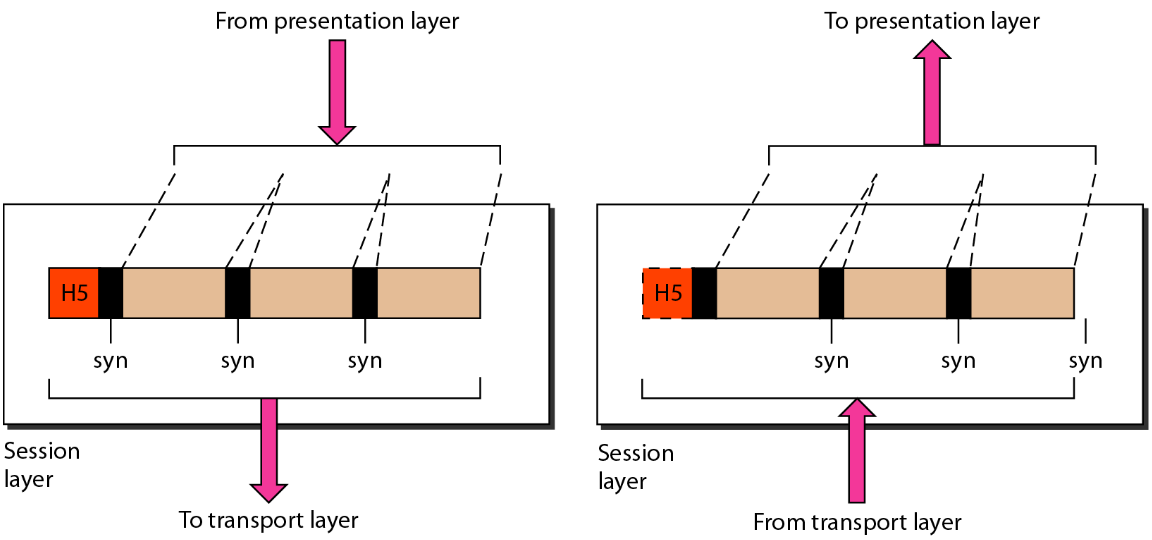


Figure 2.8 Session layer

6. Presentation Layer

The presentation layer is concerned with the syntax and semantics of the information exchanged between two systems (see Figure 2.9).

Specific responsibilities of the presentation layer include the following:

- Translation. Because different computers use different encoding systems, the presentation layer is responsible for interoperability between these different encoding methods.
- Encryption. To carry sensitive information, a system must be able to ensure privacy.
- Compression. Data compression **reduces** the number of bits contained in the information. Data compression becomes particularly important in the data transmission.

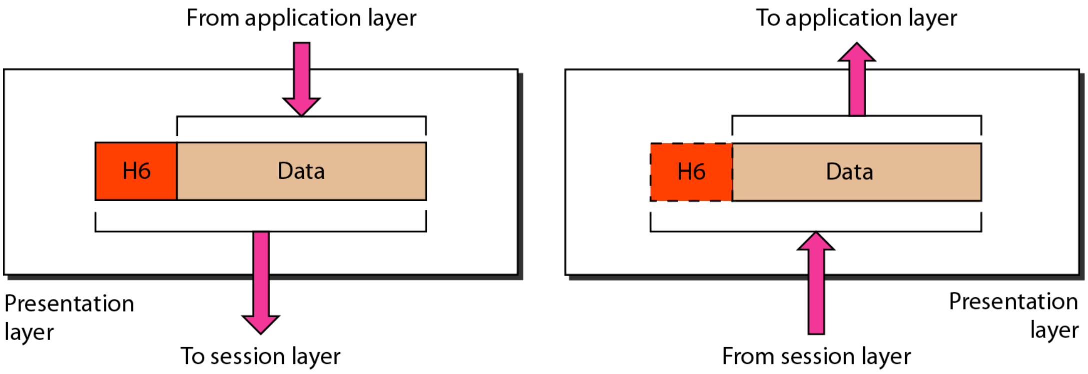


Figure 2.9 Presentation layer

7. Application Layer

The application layer is responsible for providing services to the user. It enables the user, whether human or software, to access the network. It provides user interfaces and support for services such as electronic mail, remote file access and transfer, and other types of distributed information services.

Figure 2.10 shows only three application services available on a user computer: *XAOO* (message-handling services), X.500 (directory services), and file transfer, access, and management (FTAM). The user in this example employs *XAOO* to send an e-mail message.

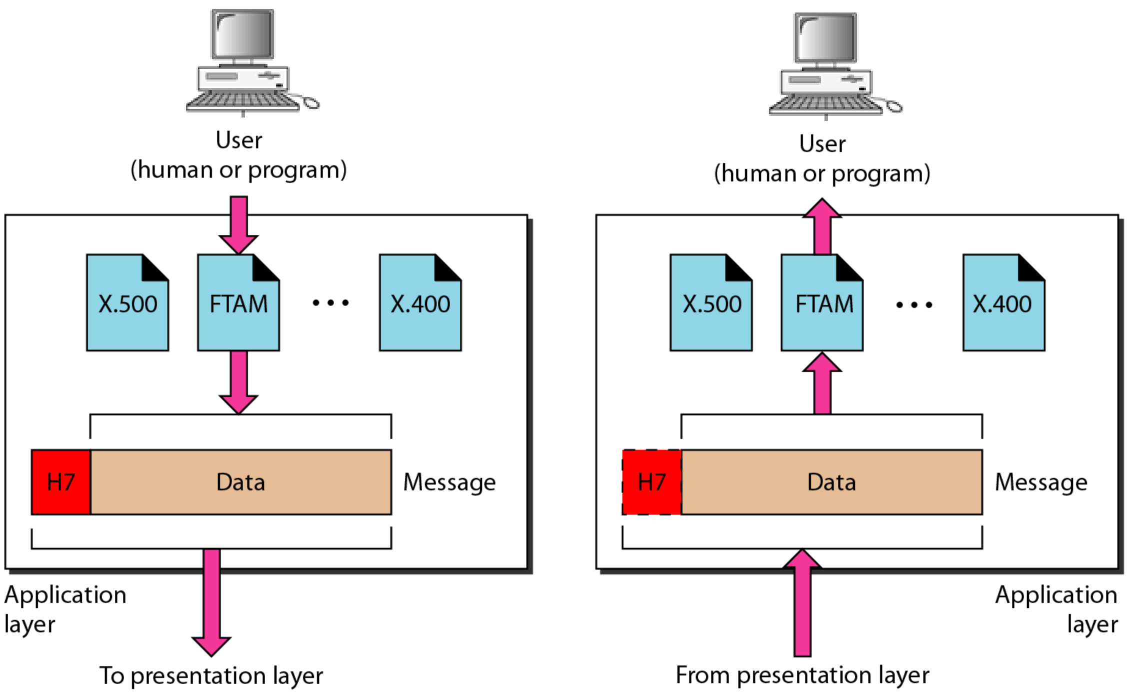


Figure 2.10 Application layer

Summary of OSI Layers

Figure 2.11 shows a summary of duties for each layer in the OSI model.

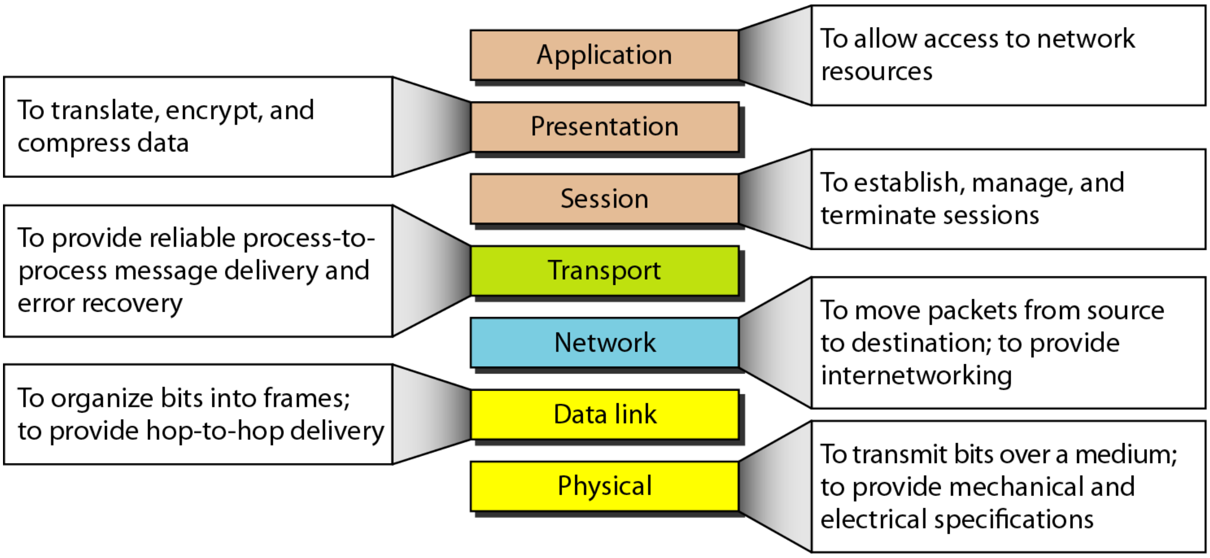


Figure 2.11 Summary of OSI layers