DATA COMMUNICATION AND NETWORKING

Software Department – Fourth Class

Network Models I

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Introduction

A network is a combination of hardware and software that sends data from one location to another. The hardware consists of the physical equipment that carries signals from one point of the network to another. The software consists of instruction sets that make possible the services that we expect from a network.

Layered Tasks

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 1 shows the steps in this task.

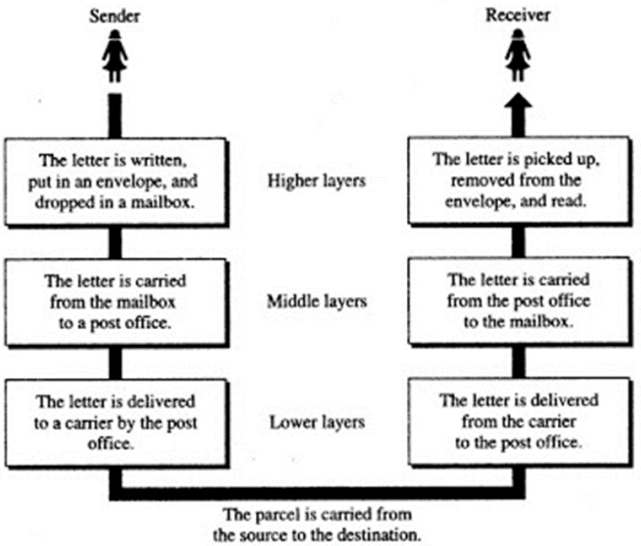

Figure 1. Tasks involved in sending a letter

At the Sender Site

Let us first describe, in order, the activities that take place at the sender site.

- **Higher layer**. The sender writes the letter, inserts the letter in an envelope, writes the sender and receiver addresses, and drops the letter in a mailbox.
- **Middle layer**. The letter is picked up by a letter carrier and delivered to the post office.
- **Lower layer**. The letter is sorted at the post office; a carrier transports the letter.

At the Receiver Site

- **Lower layer**. The carrier transports the letter to the post office.
- **Middle layer**. The letter is sorted and delivered to the recipient's mailbox.
- **Higher layer**. The receiver picks up the letter, opens the envelope, and reads it.

- **Hierarchy:** According to our analysis, there are three different activities at the sender site and another three activities at the receiver site. The task of transporting the letter between the sender and the receiver is done by the carrier. Something that is not obvious immediately is that the tasks must be done in the order given in the hierarchy. At the sender site, the letter must be written and dropped in the mailbox before being picked up by the letter carrier and delivered to the post office. At the receiver site, the letter must be dropped in the recipient mailbox before being picked up and read by the recipient.
- **Services**: 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.

The Open Systems Interconnection Model

Established in 1947, the ***International Standards Organization (ISO)*** is a multinational body dedicated to worldwide agreement on international standards. An ISO standard that covers all aspects of network communications is the ***Open Systems Interconnection (OSI***) model. It was first introduced in the late 1970s. An open system is a set of protocols that allows any two different systems to communicate regardless of their underlying architecture. 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 that is flexible, robust, and interoperable. 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 Figure 2).

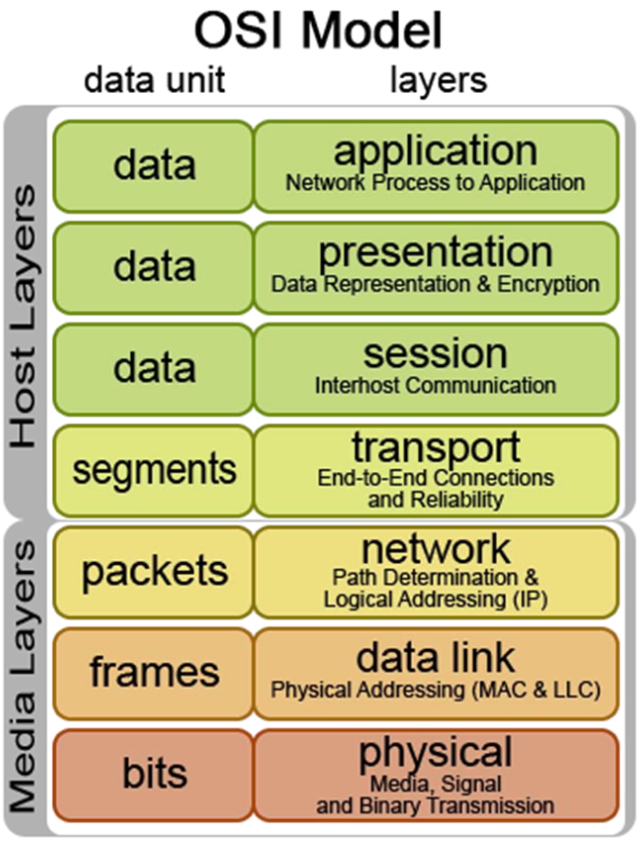

Figure 2. Seven layers of the OSI model

- ***Layered Architecture:*** The OSI model is composed of seven ordered layers: **physical** (layer 1), data link (layer 2), **network** (layer 3), **transport** (layer 4), session (layer 5), **presentation** (layer 6), and **application** (layer 7). *These intermediate nodes usually involve only the first three layers of the OSI model.*
- ***Peer-to-Peer Process***: At the physical layer, communication is direct: In Figure 3, device A sends a stream of bits to device B (through intermediate nodes). At the higher layers, however, communication must move down through the layers on device A, over to device B, and then back up through the layers. Each layer in the sending device adds its own information to the

message it receives from the layer just above it and passes the whole package to the layer just below it.

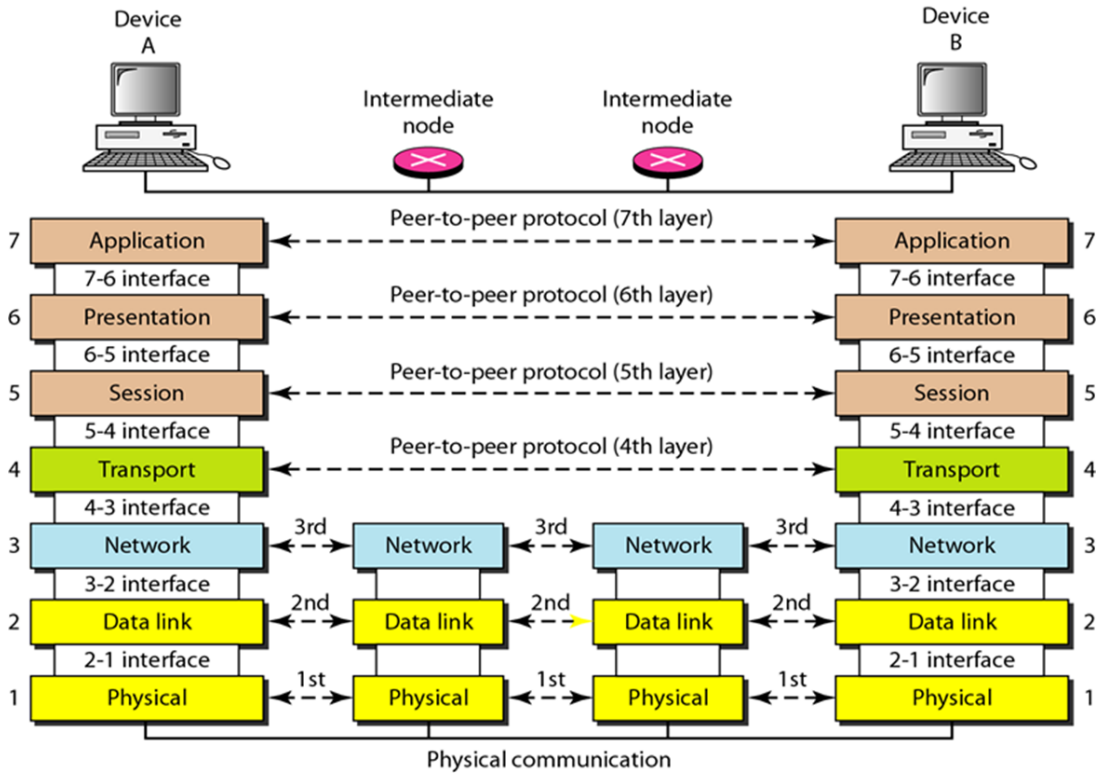

Figure 3. The interaction between layers in the OSI model

- ***Interfaces between Layers:*** The passing of the data and network model information down through the layers of the sending device and back up through the layers of the receiving device is made possible by an interface between each pair of adjacent layers. Each interface defines the information and services a layer must provide for the layer above it.
- ***Organization of the Layers***: The seven layers can be thought of as belonging to three subgroups. Layers 1, 2, and 3—physical, data link, and network model—are the network model support layers; they deal with the ***physical aspects*** of moving data from one device to another. Layers 5, 6, and 7—session, presentation, and application—can be thought of as the ***user support layers***; they allow interoperability among unrelated software systems. Layer 4, the transport layer, ***links the two subgroups*** and ensures that what the lower layers have transmitted is in a form that the upper layers can use.

❖ ***Encapsulation***: A packet (header and data) at level 7 is encapsulated in a packet at level 6. The whole packet at level 6 is encapsulated in a packet at level 5, and so on.

Layers in the OSI Model

1- Physical Layer:

The physical layer in a network model coordinates the functions required to carry a bit stream over a physical medium. It deals with the mechanical and electrical specifications of the interface and transmission medium. It also defines the procedures and functions that physical devices and interfaces have to perform for transmission to occur. Figure 4 shows the position of the physical layer in a network model with respect to the transmission medium and the data link layer of the network model.

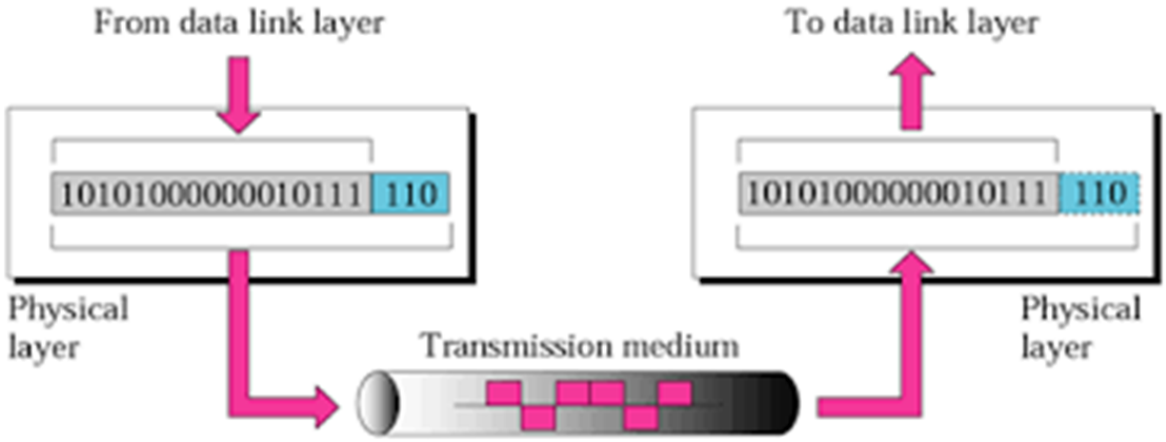

Figure 4. Physical layer in a network model

The physical layer is also concerned with the following:

- ✓ ***Physical characteristics of interfaces and medium.*** The physical layer defines the characteristics of the interface between the devices and the transmission medium. It also defines the type of transmission medium.
- ✓ ***Representation of bits.*** The physical layer data consists of a stream of bits (sequence of 0s or 1s) with no interpretation. To be transmitted, bits must be encoded into signals--electrical or optical. The physical layer defines the type of encoding (how 0s and 1s are changed to signals).
- ✓ ***Data rate.*** The transmission rate-the number of bits sent each second-is also defined by the physical layer. In other words, the physical layer defines the duration of a bit, which is how long it lasts.

- ✓ ***Synchronization of bits.*** The sender and receiver not only must use the same bit rate but also must be synchronized at the bit level. In other words, the sender and the receiver clocks must be synchronized.
- ✓ ***Line configuration.*** The physical layer is concerned with the connection of devices to the media. In a point-to-point configuration, two devices are connected through a dedicated link. In a multipoint configuration, a link is shared among several devices.
- ✓ ***Physical topology.*** The physical topology defines how devices are connected to make a network. Devices can be connected by using a tree topology, a star topology, a ring topology, and a bus topology, etc.
- ✓ ***Transmission mode.*** The physical layer also defines the direction of transmission between two devices: simplex, half-duplex, or full-duplex.

2- Data Link Layer:

The data link in a network model layer transforms the physical layer, a raw transmission facility, to a reliable link. It makes the physical layer appear error-free to the upper layer (network layer). Figure 5 shows the relationship of the data link layer to the network and physical layers of network model.

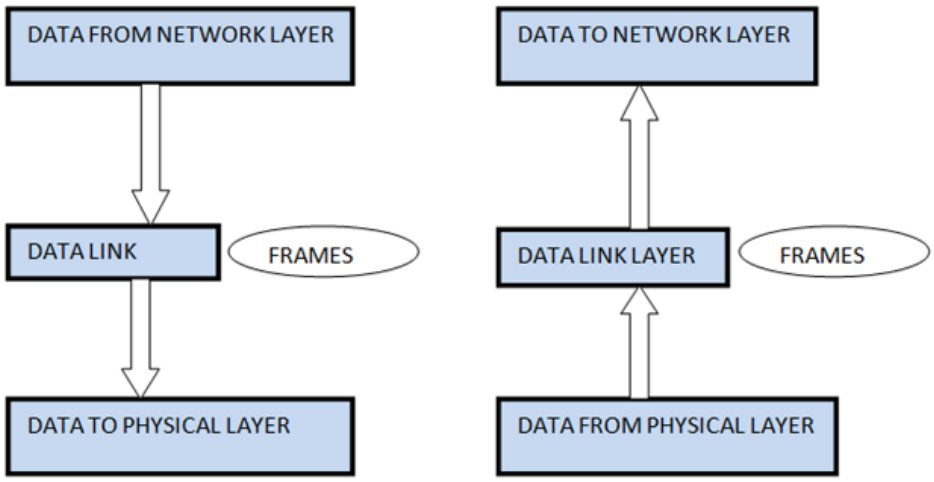

Figure 5. Data link layer in a network model

Other responsibilities of the data link layer include the following:

- ✓ ***Framing***. The data link layer a network model divides the stream of bits received from the network layer into manageable data units called frames.

- ✓ ***Physical addressing.*** *If frames are to be distributed to different systems* on the network model, the data link layer in network model adds a header to the frame to define the sender and/or receiver of the frame. *If the frame is intended for a system outside* the sender's network, the receiver address is the address of the device that connects the network to the next one.
- ✓ ***Flow control.*** If the rate at which the data are absorbed by the receiver is less than the rate at which data are produced in the sender, the data link layer in network model imposes a flow control mechanism to avoid overwhelming the receiver.
- ✓ ***Error control.*** The data link in network model layer adds reliability to the physical layer by adding mechanisms to detect and retransmit damaged or lost frames. It also uses a mechanism to recognize duplicate frames. Error control is normally achieved through a trailer added to the end of the frame.
- ✓ ***Access Control.*** When two or more devices are connected to the same data link layer protocols in network model are necessary to determine which device has control over the link at any given time.

3- Network Layer:

The network layer in a network model is responsible for the source-to-destination delivery of a packet, possibly across multiple network models (links). Whereas the data link layer oversees the delivery of the packet between two systems on the same network model (links), the network layer in a network model ensures that each packet gets from its point of origin to its final destination.

If two systems are connected to the same link, there is usually no need for a network layer in a network model. However, if the two systems are attached to different network models (links) with connecting devices between the network models (links), there is often a need for the network layer in network model to accomplish source-to-destination delivery. Figure 6 shows the relationship of the network layer to the data link and transport layers in a network model.

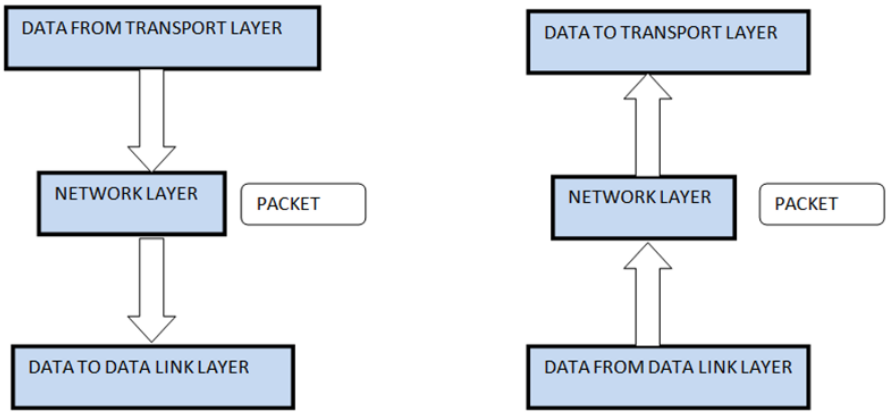

Figure 6. Network layer in a network model

Other responsibilities of the network layer include the following:

- ✓ ***Logical addressing.*** The physical addressing implemented by the data link layer handles the addressing problem locally. *If a packet passes the network boundary*, we need another addressing system to help distinguish the source and destination systems. The network layer in network model adds a header to the packet coming from the upper layer that, among other things, includes the logical addresses of the sender and receiver.
- ✓ ***Routing.*** When independent network models or links are connected to create internetworks (network of networks) or a large network model, the connecting devices (called routers or switches) route or switch the packets to their final destination.

4- Transport Layer:

The transport layer in a network model 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 in a network model oversees source-to-destination delivery of individual packets, it does not recognize any relationship between those packets. It treats each one independently, as though each piece belonged to a separate message, whether or not it does. The transport layer in a network model, on the other hand, ensures that the whole message arrives intact and in order, overseeing both error control and flow control at the source-to-destination level. Figure 7 shows the relationship of the transport layer to the network and session layers of a network model.

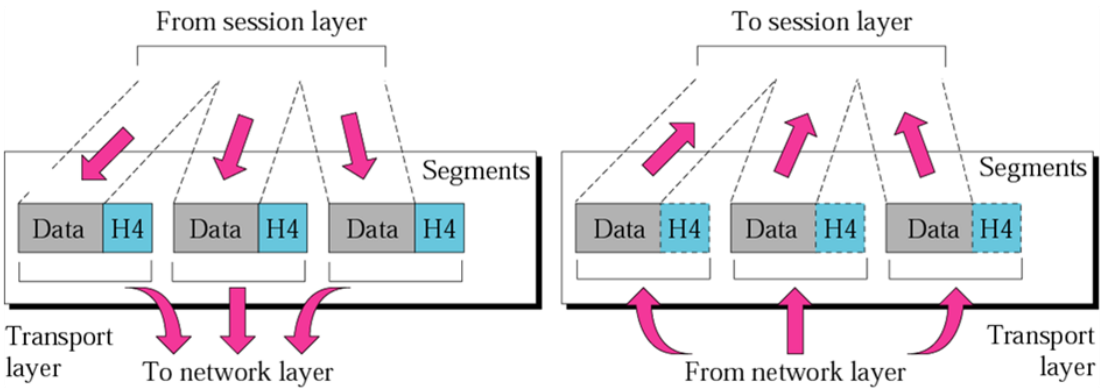

Figure 7. Transport layer in a network model

Other responsibilities of the transport layer include the following:

- ✓ ***Service-point addressing.*** Computers often run several programs at the same time. For this reason, source-to-destination delivery means delivery not only from one computer to the next but also from a specific process (running program) on one computer to a specific process (running program) on the other. The transport layer header in a network model must therefore include a type of address called a service-point address (or port address).
- ✓ ***Segmentation and reassembly.*** A message is divided into transmittable segments, with each segment containing a sequence number. These numbers enable the transport layer in a network model to reassemble the message correctly upon arriving at the destination and to identify and replace packets that were lost in transmission.
- ✓ ***Connection control.*** The transport layer in a network model can be either connectionless or connection-oriented. A ***connectionless*** transport layer in a network model treats each segment as an independent packet and delivers it to the transport layer at the destination machine. A ***connection-oriented*** transport layer makes a connection with the transport layer at the destination machine first before delivering the packets.
- ✓ ***Flow control.*** Like the data link layer, the transport layer in a network model 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 in a network model is responsible for error control. However, error control at this layer is performed process-to-process rather than across a single link. The sending transport layer in a network model makes sure that the entire message arrives at the receiving transport layer without error (damage, loss, or duplication).

5- Session Layer:

The services provided by the first three layers (physical, data link, and network layers in a network model) are not sufficient for some processes. The session layer in a network model is the network dialog controller. It establishes, maintains, and synchronizes the interaction among communicating systems.

Specific responsibilities of the session layer include the following:

- ✓ ***Dialog control.*** The session layer in a network model allows two systems to enter into a dialog. It 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 in a network model allows a process to add checkpoints, or synchronization points, to a stream of data. For example, if a system is sending a file of 2000 pages, it is advisable to insert checkpoints after every 100 pages to ensure that each 100-page unit is received and acknowledged independently.

6- Presentation Layer:

The presentation layer in a network model is concerned with the syntax and semantics of the information exchanged between two systems.

Specific responsibilities of the presentation layer include the following:

- ✓ ***Translation***. The processes (running programs) in two systems are usually exchanging information in the form of character strings, numbers, and so on. The information must be changed to bit streams before being transmitted. Because different computers use different encoding systems, the presentation layer in a network model is responsible for interoperability between these different encoding methods.
- ✓ ***Encryption***. To carry sensitive information, a system must be able to ensure privacy. Encryption means that the sender transforms the original information to another form and sends the resulting message out over the network. Decryption reverses the original process to transform the message back to its original form.
- ✓ ***Compression***. Data compression reduces the number of bits contained in the information. Data compression becomes particularly important in the transmission of multimedia such as text, audio, and video.

7- Application Layer:

The application layer in a network model enables the user, whether human or software, to access the network model. It provides user interfaces and support for services such as electronic mail, remote file access and transfer, shared database management, and other types of distributed information services.

Specific services provided by the application layer include the following:

- ✓ ***Network virtual terminal.*** A network virtual terminal is a software version of a physical terminal, and it allows a user to log on to a remote host.
- ✓ ***File transfer, access, and management.*** This application allows a user to access files in a remote host (to make changes or read data), to retrieve files from a remote computer for use in the local computer, and to manage or control files in a remote computer locally.
- ✓ ***Mail services.*** This application provides the basis for e-mail forwarding and storage.
- ✓ ***Directory services.*** This application provides distributed database sources and access for global information about various objects and services.

The summery of layers (see Figure 8)

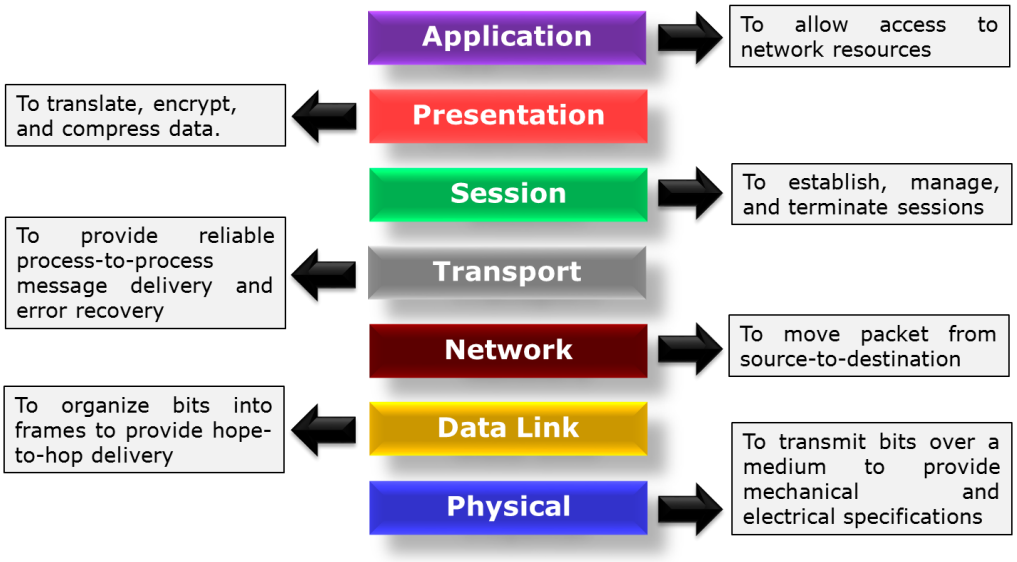

Figure 8. The summery of layer

Good Luck