Computer Communication & Network

Chapter 2: Network Models

❖ Protocol Layering

In data communication and networking, a protocol defines the rules that both the sender and receiver and all intermediate devices need to follow to be able to communicate effectively. When communication is simple, we may need only one simple protocol; when the communication is complex, we may need to divide the task between different layers, in which case we need a protocol at each layer, or protocol layering.

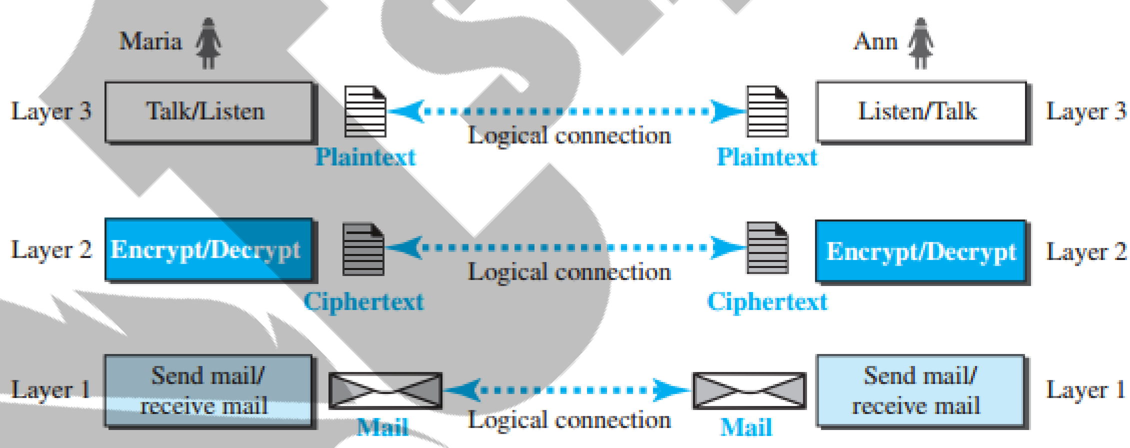
❖ Principles of Layering

First Principle

The first principle dictates that if we want bidirectional communication, we need to make each layer so that it is able to perform two opposite tasks, one in each direction. For example, the third layer task is to listen (in one direction) and talk (in the other direction). The second layer needs to be able to encrypt and decrypt. The first layer needs to send and receive mail.

Second Principle

The second principle that we need to follow in protocol layering is that the two objects under each layer at both sites should be identical. For example, the object under layer 3 at both sites should be a plaintext letter. The object under layer 2 at both sites should be a cipher text letter. The object under layer 1 at both sites should be a piece of mail.



Logical Connections

❖ History of TCP/IP Protocol Suite

The first layered protocol model for internet work 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.

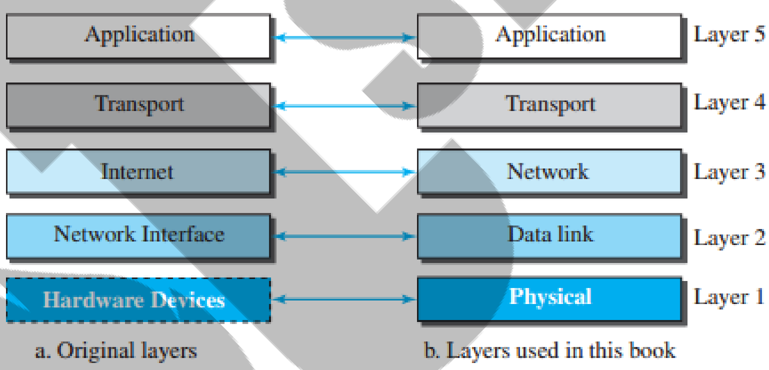
TCP/IP is a result of protocol research and development conducted on the experimental packet-switched network, ARPANET, funded by the Defense Advanced Research Projects Agency (DARPA), and is generally referred to as the TCP/IP protocol suite. This protocol suite consists of a large collection of protocols that have been issued as Internet standards by the Internet Activities Board (IAB).

❖ TCP/IP Protocol Suite

- The TCP/IP protocol suite, also referred to as the Internet protocol suite, is the set of communications protocols that implements the protocol stack on which the Internet and most commercial networks run. It is named after the two most important protocols in the suite: the Transmission Control Protocol (TCP) and the Internet Protocol (IP). The TCP/IP protocol suite—like the OSI reference model—is defined as a set of layers. Upper layers are logically closer to the user and deal with more abstract data, relying on lower layer protocols to translate data into forms that are transmitted physically over the network.
- TCP/IP (Transmission Control Protocol/Internet Protocol) is a protocol suite (a set of protocols organized in different layers) used in the Internet today. It is a hierarchical protocol made up of interactive modules, each of which provides a specific functionality. The term hierarchical means that each upper level protocol is supported by the services provided by one or more lower level protocols. To reduce their design complexity, most networks are organized as a stack of layers or levels, each one built upon the one below it. The purpose of each layer is to offer certain services to the higher layers while shielding those layers from the details of how the offered services are actually implemented.

❖ Layered Architecture

- Interfaces between Layers: Each interface defines what information and services a layer must provide for the layer above it.
- The upper OSI layers are almost always implemented in software; lower layers are a combination of hardware and software, except for the physical layer, which is mostly hardware.



1. Physical Layer

The physical layer covers the physical interface between a data transmission device (e.g., workstation, computer) and a transmission medium or network. This layer is concerned with specifying the characteristics of the transmission medium, the nature of the signals, the data rate, and related matters. TCP/IP does not define any specific protocol for the physical layer. It supports all of the standard and proprietary protocols. 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).

2. Data Link Layer

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

3. Network Layer

The network layer is responsible for creating a connection between the source computer and the destination computer. The communication at the network layer is host-to-host. However, since there can be several routers from the source to the destination, the routers in the path are responsible for choosing the best route for each packet. We can say that the network layer is responsible for host-to-host communication and routing the packet through possible routes. Protocols of Network Layers are as follows:

- **IP**

  Internet Protocol (IP), that defines the format of the packet, called a datagram at the network layer. IP also defines the format and the structure of addresses used in this layer. IP is also responsible for routing a packet from its source to its destination, which is achieved by each router forwarding the datagram to the next router in its path. There two versions of IP, Ipv4 and IPv6. **IP is a connectionless protocol that provides no flow control, no error control, and no congestion control services.** The network layer also has some auxiliary protocols that help IP in its delivery and routing tasks.

- **ICMP**

  ICMP is Internet Control Message Protocol. The Internet Control Message Protocol (ICMP) helps IP to report some problems when routing a packet.

- **IGMP**

  IGMP is Internet Group Management Protocol. The Internet Group Management Protocol (IGMP) is another protocol that helps IP in multitasking.

- **DHCP**

  DHCP means Dynamic Host Configuration Protocol. It is used to get IP Address for a host in network layer.

- **ARP**

  It is Address Resolution Protocol. The Address Resolution Protocol (ARP) is a protocol that helps IP to find the link-layer address of a host or a router when its network-layer address is given.

4. 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.
Since the Internet defines a different route for each datagram, the datagrams may arrive out of order and maybe 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.

5. Application Layer

The application layer 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, shared database management, and other types of distributed information services.

❖ The OSI Model

Although, when speaking of the Internet, everyone talks about the TCP/IP protocol suite, this suite is not the only suite of protocols defined. Established in 1947, the International Organization for Standardization (ISO) is a multinational body dedicated to worldwide agreement on international standards. Almost three-fourths of the countries in the world are represented in the ISO. 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 was intended to be the basis for the creation of the protocols in the OSI stack. 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.

{ISO is the organization; OSI is the model}

❖ OSI Versus TCP/IP

When we compare the two models, we find that 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.

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 layers are needed for a particular application, they can be included in the development of that piece of software.

❖ Lack of OSI's Model Success

The OSI model appeared after the TCP/IP protocol suite. Most experts were at first excited and thought that the TCP/IP protocol would be fully replaced by the OSI model. This did not happen for several reasons, but we describe only three, which are agreed upon by all experts in the field. First, OSI was completed when TCP/IP was fully in place and a lot of time and money had been spent on the suite; changing it would cost a lot. Second, some layers in the OSI model were never fully defined. For example, although the services provided by the presentation and the session layers were listed in the document, actual protocols for these two layers were not fully defined, nor were they fully described, and the corresponding software was not fully developed. Third, when OSI was implemented by an organization in a different application, it did not show a high enough level of performance to entice the Internet authority to switch from the TCP/IP protocol suite to the OSI model.

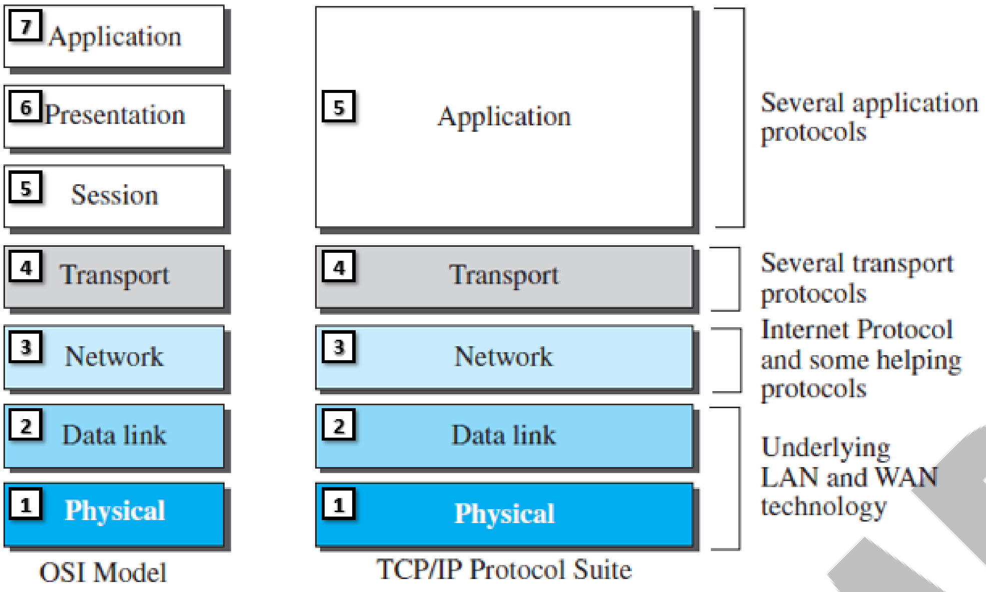
The first layers are defined above in TCP/IP protocol suite. Physical layer, Data link layer, Network layer and Transport Layer are same. Session layer and Presentation layer are as follows and then comes Application layer.

5. Session Layer

The session layer is the network dialog controller. It establishes, maintains, and synchronizes the interaction between communicating systems. The session layer allows two systems to enter into a dialog. It allows the communication between two processes to take place in either half-duplex or full-duplex mode. The session layer allows a process to add checkpoints (synchronization points) into a stream of data. For example, if a system is sending a file of 2,000 pages, it is advisable to insert checkpoints after every 100 pages to ensure that each 100- page unit is received and acknowledged independently. In this case, if a crash happens during the transmission of page 523, the only pages that need to be resent after system recovery are pages 501 to 523. Pages previous to 501 need not be resent.

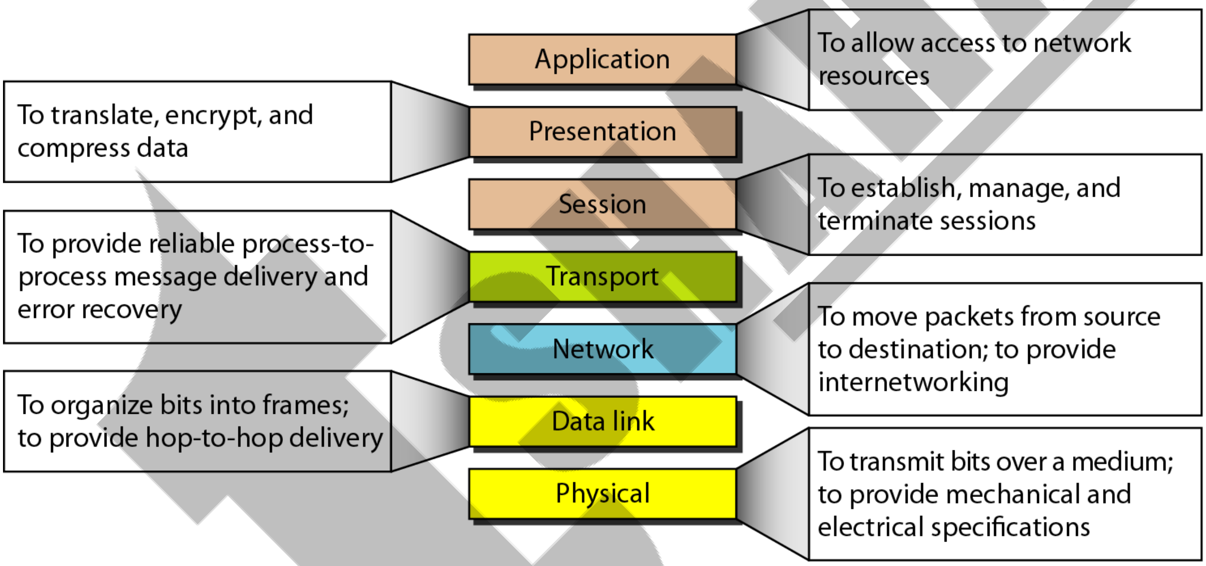
6. Presentation Layer

The presentation layer is concerned with the syntax and semantics of the information exchanged between two systems. The presentation layer is responsible for interoperability between these different encoding methods. The presentation layer at the sender changes the information from its sender-dependent format into a common format. The presentation layer at the receiving machine changes the common format into its receiver dependent format.



7 Application
6 Presentation
5 Session
4 Transport
3 Network
2 Data link
1 Physical
OSI Model
5 Application
4 Transport
3 Network
2 Data link
1 Physical
TCP/IP Protocol Suite
Several application protocols
Several transport protocols
Internet Protocol and some helping protocols
Underlying LAN and WAN technology

SUMMARY



Application
To allow access to network resources
Presentation
To translate, encrypt, and compress data
Session
To establish, manage, and terminate sessions
Transport
To provide reliable process-to-process message delivery and error recovery
Network
To move packets from source to destination; to provide internetworking
Data link
To organize bits into frames; to provide hop-to-hop delivery
Physical
To transmit bits over a medium; to provide mechanical and electrical specifications