Chapter 2

Reference Models

2.1 The ISO/OSI Reference Model

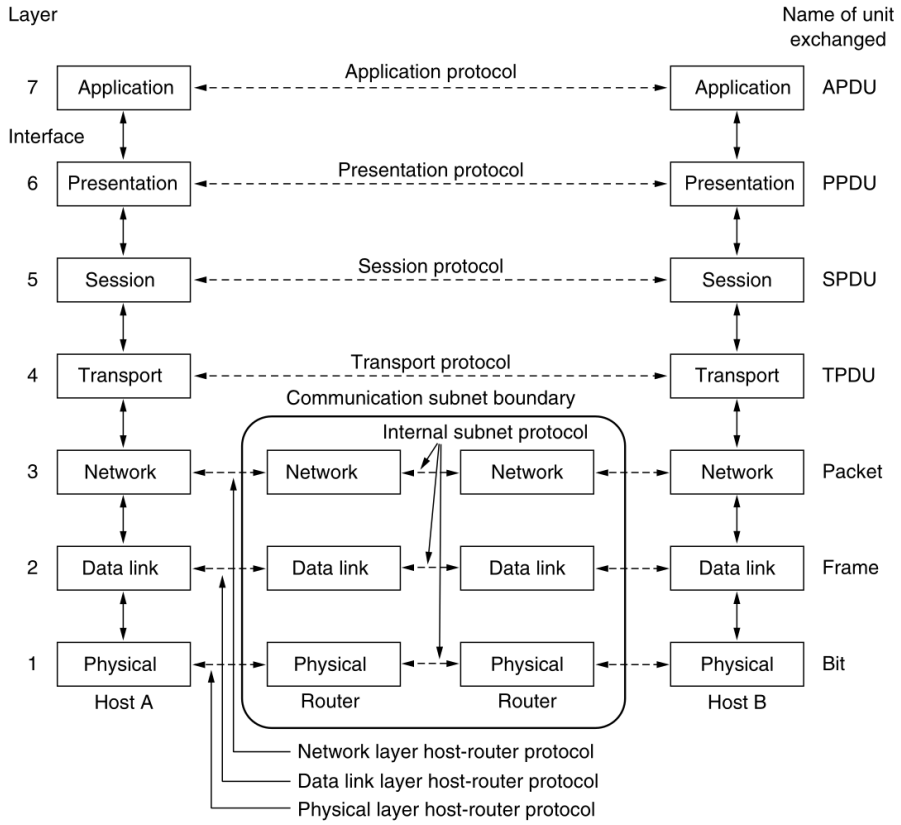

Figure 2.1: The ISO/OSI Reference Model (Courtesy: Computer Networks by Tanenbaum, 5$^{\text{th}}$ Ed.)

The ISO[1]/OSI[2] reference model (OSI model, for short) is a conceptual model, which uses a generic way of describing the communication requirements of a telecommunication or computing system. Though there is no direct implementation of this model, this model is by far the most popular and standard way of discussing, teaching, and learning the bits and pieces of computer networks.

The model is shown in figure 2.1. As shown in the figure, this model has *seven abstract layers*. Each layer has its own well-defined functions, and each layer provides some services to the layers above and beneath it. For this, a well-defined interface is used between the layers.

[1]International Organization for Standardization (Wikipedia)/International Standards Organization (Tanenbaum)
[2]Open Systems Interconnection

Though the physical flow of data and control information happens either from an upper layer to a lower layer or from a lower layer to an upper layer (shown in the figure with solid arrows), the logical communication actually happens between the same layers situated at different hosts (shown in the figure with the dashed arrows). Moreover, while the majority of the functionalities provided by the third layer and below are implemented in hardware, from the fourth layer and up most of them are software based.

2.2 Summary of the Various ISO/OSI Layers

A summary of the various functionalities and services provided by each layers in the IOS/OSI reference model, along with the related protocols and devices used in those layers are mentioned below.

2.2.1 The Physical Layer

- Concerned with transmitting raw bits over a communication channel
- Defines electrical, physical, timing specifications for devices
- Deals with pins, voltages, cable specification, NIC (Network Interface Card) etc.
- Establish/Terminate a connection to a communication media
- Modulation/Demodulation
- **Protocols:** Ethernet
- **Devices:** Hub, Repeater, Modem, DSL, RJ45, CAT5/6

2.2.2 The Data Link Layer

- Provides reliable, efficient communication between *adjacent* machines connected by a *single communication channel*
- Group physical layer bit streams into units called *frames*
- Flow control
- Error control (Error detection / Error correction)
- Physical Addressing
- Controlling access to the shared channel, in a broadcast network
- **Protocols:** Ethernet, ATM, ARP, PPP
- **Devices:** Switch

2.2.3 The Network Layer

- Responsible for routing packets from source to destination
  - For *connectionless service*, routing decision is taken for each datagram
  - In case of *connection-oriented service* — the decision is made once — at circuit setup time
- Routes can be *static* or *dynamic*
- Congestion control
- Report delivery errors (optional)
- Quality of Service (QoS) (eg. handling delay, transmission time, jitter etc.)
- Logical addressing

- Internetworking (eg. handling packet fragmentation and re-assembly)
- **Protocols:** IP(v4, v6), ICMP, OSPF, ARP
- **Devices:** Router, L3 Switch

Note: In broadcast networks, the routing problem is simple, so the network layer is often thin or even non-existent.

2.2.4 The Transport Layer

- Provides end-to-end communication between *processes* executing on different machines
- Provides efficient, reliable, cost effective data transfer services to the upper layers
- *Types of Service:*
  - Error-free point-to-point channel, that delivers messages or bytes in the order in which they were sent
  - Transporting isolated messages, with no guarantee about the order of delivery, and
  - Broadcasting of messages to multiple destinations
- Connection Establishment/Release
- Flow control & Buffering
- Multiplexing
- Crash recovery
- **Protocols:** TCP, UDP, RPC, BGP

2.2.5 The Session Layer

- Establishes sessions between various users
- Dialog control (keeping track of whose turn it is to transmit)
- Token management (preventing two parties from attempting the same critical operation at the same time)
- Synchronization (check-pointing long transmissions to allow them to continue from where they were, after a crash)
- **Protocols:** SOCKS, NetBIOS

2.2.6 The Presentation Layer

- Concerned with the syntax and semantics of the information transmitted
- Encoding data in a standard agreed upon way
- Manages the abstract data structures and converts from representation used inside the computer to network standard representation and back
- **Protocols:** TLS, SSL

2.2.7 The Application Layer

- Provides applications with access to network services
- Contains a variety of protocols that are commonly needed by the users
- **Protocols:** HTTP, FTP, SMTP, SSH, Telnet etc.

2.3 The TCP/IP Reference Model

Unlike the ISO/OSI reference model, the TCP/IP reference model is less popular from the theory point of view. However, the TCP/IP protocol suit (also known as the *Internet Protocol Suit*) is a concrete implementation of various methods and protocols, and is one of the most popular protocol suit in practical use today in computer networks. Moreover, the TCP/IP protocol suit is the basis of the Internet.

Various authors have interpreted this model in different ways. As a result, some authors put the number of layers in this model to five, while some others describe it as having four layers. Moreover, name of the lower layers are also not consistent among the various authors. One more point to note here is that, some of the protocols present in the TCP/IP model may not fit cleanly in the OSI model, due to the absence of some layers in the TCP/IP model. One of the representation of this model is shown in figure 2.2, as given by Tanenbaum.

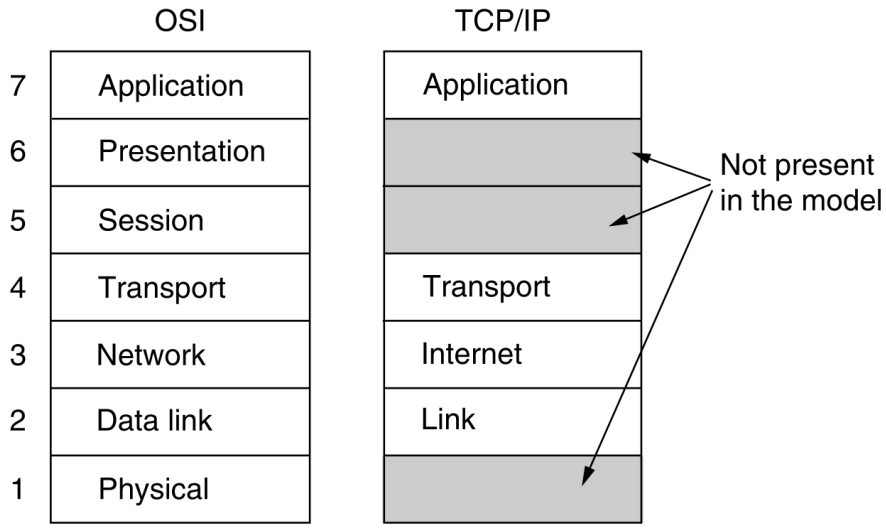

Figure 2.2: The TCP/IP Reference Model (Courtesy: Computer Networks by Tanenbaum, 5^{th} Ed.)

2.3.1 Design Goals of the TCP/IP model

For the initial design of the TCP/IP model, following requirements were emphasised:

- Ability to connect multiple networks in a seamless way.
- Redundancy i.e. tolerate path failures.

2.4 Summary of the various TCP/IP Layers

Some of the functionalities and services provided by the layers of the TCP/PI model are mentioned below.

2.4.1 The Internet Layer

- Packet switching network.
- Connection-less.
- Defines a packet format and a protocol called the *Internet Protocol (IP)*.
- The main job of this layer is to deliver IP packets where they are supposed to go i.e. *Routing*.
- Congestion control.

2.4.2 The Transport Layer

- Similar to the OSI Transport layer.
- Two major end-to-end transport protocols are defined here:
  (i) *Transmission Control Protocol (TCP):*
    - It is a reliable, connection-oriented protocol.
    - Provides error-free delivery of byte-streams between two machines.
    - Does Fragmentation/Reassembly.
    - Flow Control.
  (ii) *User Datagram Protocol (UDP):*
    - It is an unreliable, connection-less protocol.

2.4.3 The Application Layer

- Contains all the higher-level protocols.

2.4.4 The Link Layer

- Some earlier version of the model also refer to this layer as *The Host-to-Network Layer*.
- Not clearly defined.
- The host has to connect to the network using some protocol so that it can send IP packets to it.