Principles of Data Communications

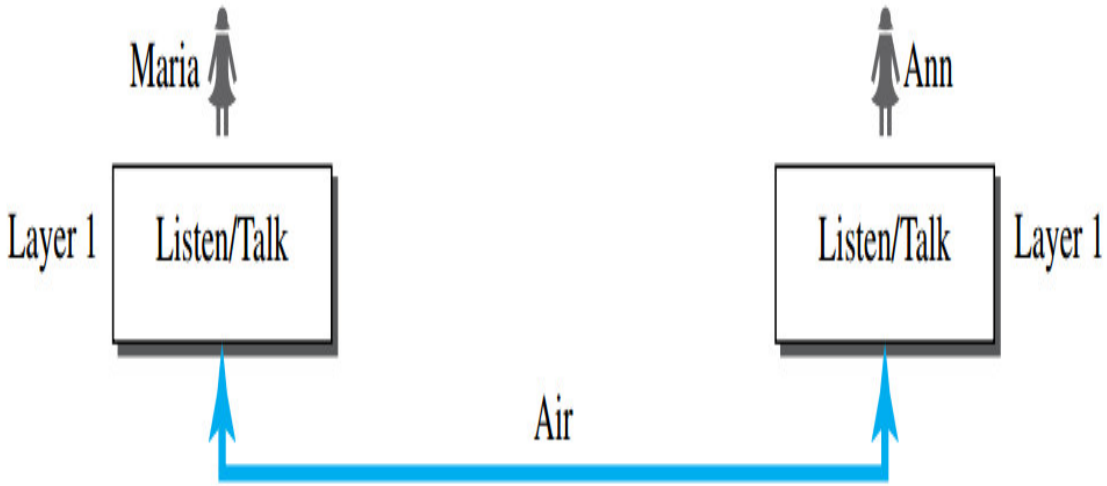
Reference Book: Data Communications and Networking by Behrouz A. Forouzan

Protocol Layering

- 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.

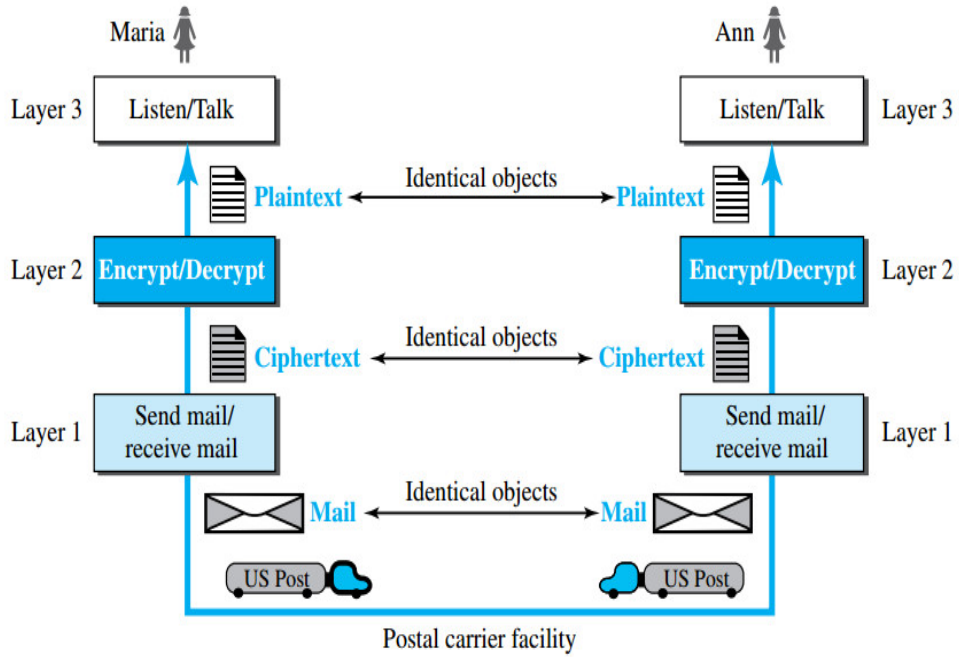
2 simple scenarios to better understand the need for protocol layering

- First Scenario
  - Communication is so simple that it can occur in only one layer
  - Face to Face, in the same language



- Rules
  - Greet each other when they meet
  - Confine their vocabulary to the level of their friendship
  - Refrain from speaking when the other party is speaking
  - Both should have the opportunity to talk
  - Exchange some nice words when they leave
- The protocol used by two friends is different from the communication between a professor and the students in a lecture hall.

- Second Scenario
  - They are at different offices in far away locations
  - They still want to communicate and exchange ideas
  - They do not want the ideas to be revealed to anyone else
  - Regular mail through post
  - Agree on encryption/decryption technique



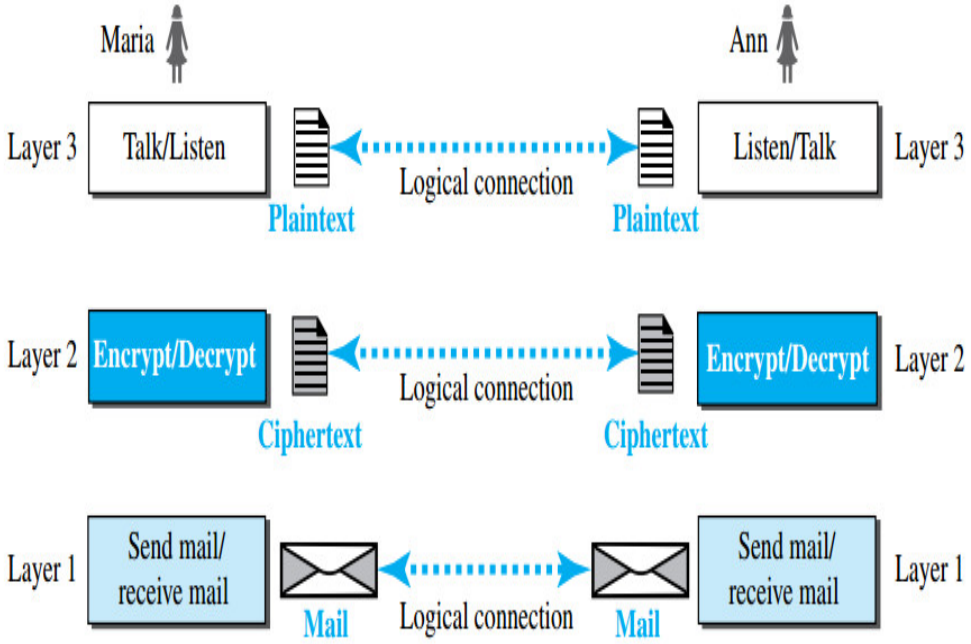
- Protocol layering enables us to divide a complex task into several smaller and simpler tasks.
- Modularity: Each layer is a black box with inputs and outputs, without concern about how inputs are changed to outputs
- Communication does not always use only two end systems; there are intermediate systems that need only some layers, but not all layers.
- If we did not use protocol layering, we would have to make each intermediate system as complex as the end systems, which makes the whole system more expensive.
- If one day the code is broken, they have to replace the entire system if all the layers are combined.

Principles of Protocol Layering

- First Principle
  - 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
  - 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.

Logical Connections

- Layer-to-Layer communication.
- Maria and Ann can think that there is a logical (imaginary) connection at each layer through which they can send the object created from that layer.

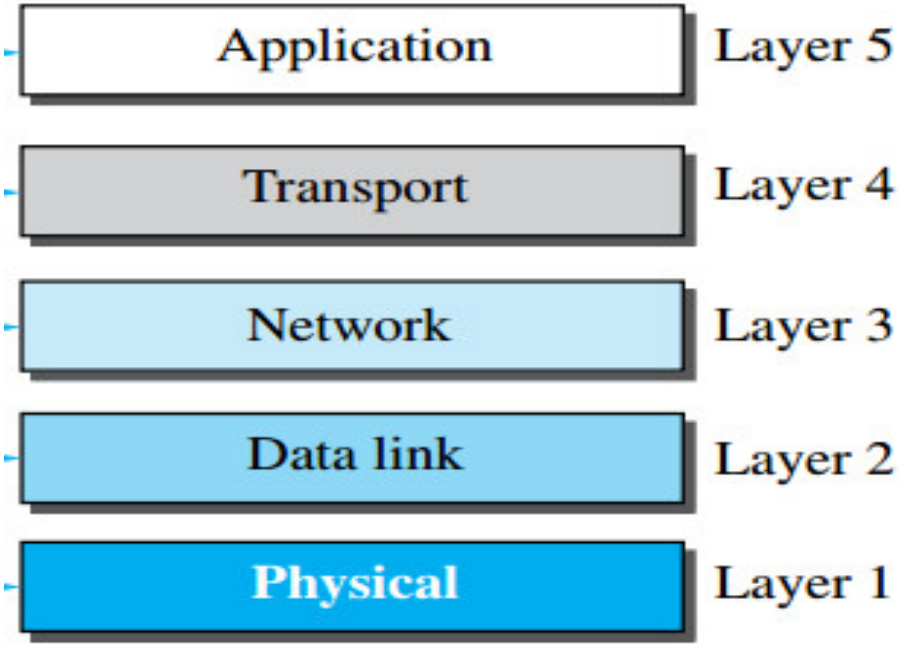


Network Models

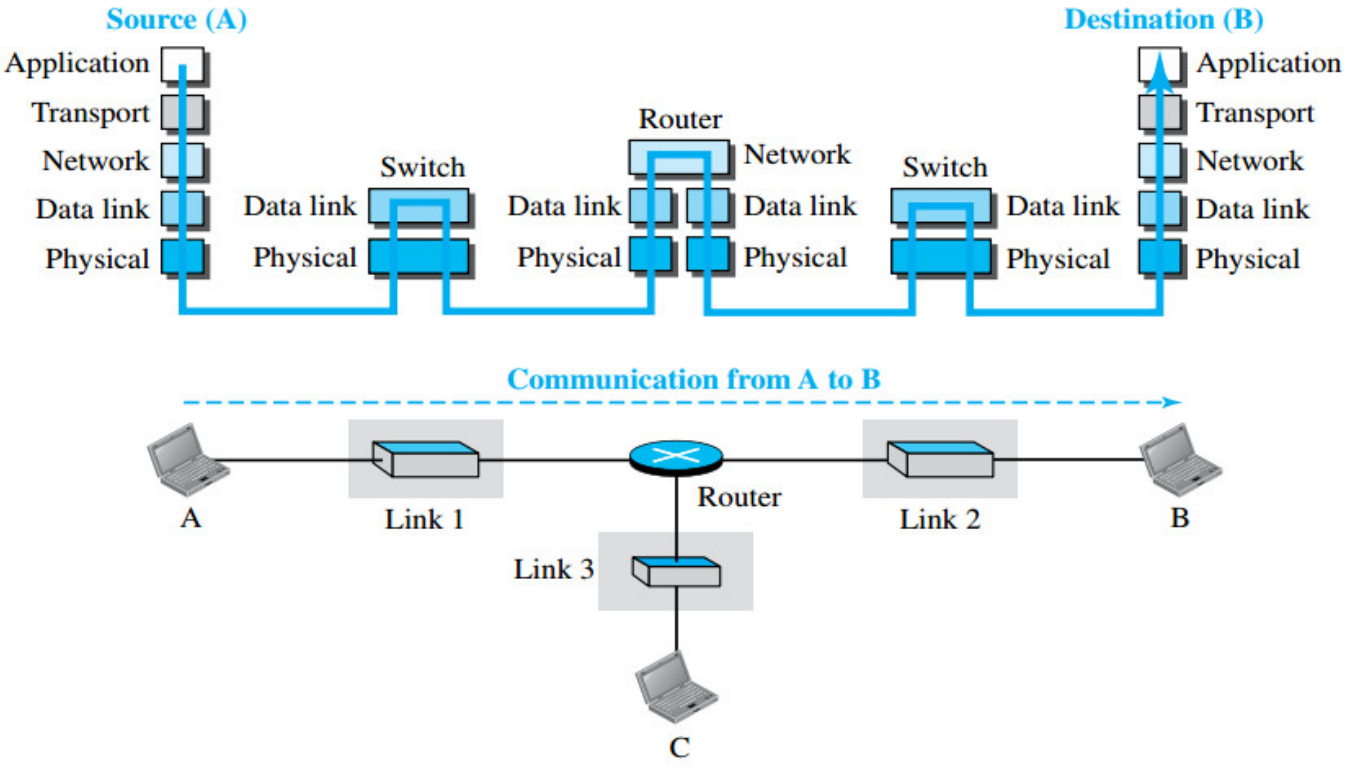
- TCP/IP Protocol Suite
- OSI Model

TCP/IP Protocol Suite

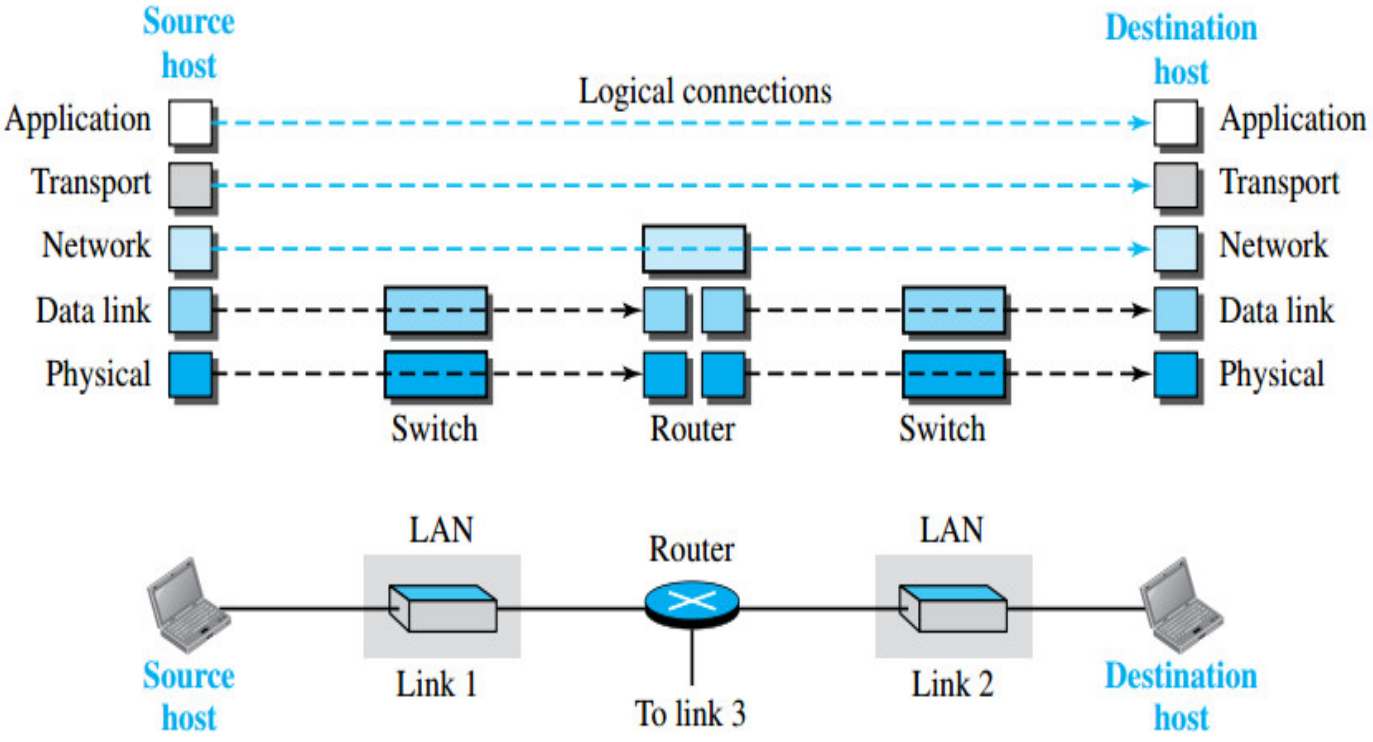
- TCP/IP is a protocol suite (a set of protocols organized in different layers) used in the Internet.
- The original TCP/IP protocol suite was defined as four software layers built upon the hardware. Today, however, TCP/IP is thought of as a five-layer model.



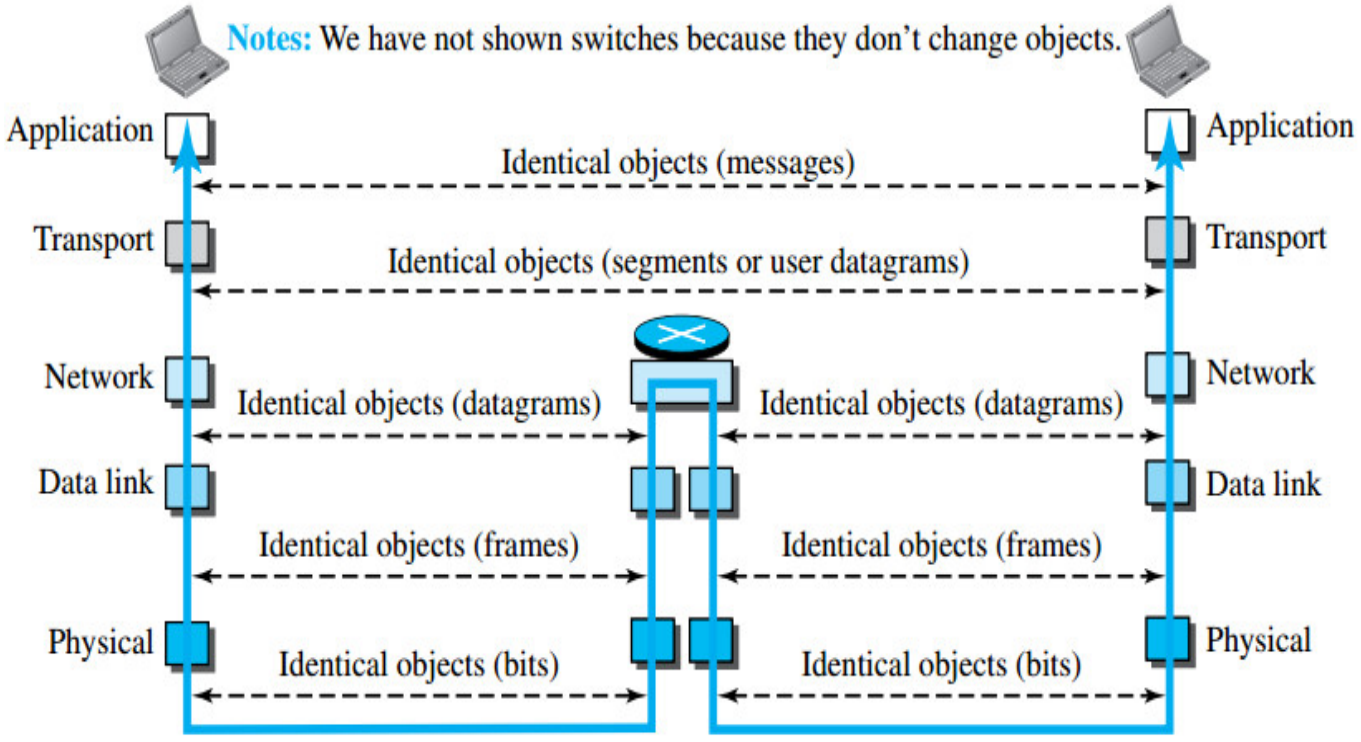
Communication through Internet



Logical Connections



Identical Objects



Physical Layer

- Physical layer is responsible for carrying individual bits in a frame across the link.
- There is another, hidden layer, the transmission media, under the physical layer. Two devices are connected by a transmission medium (cable or air).
- Transmission medium does not carry bits; it carries electrical or optical signals. So the bits received in a frame from the data-link layer are transformed and sent through the transmission media, but we can think that the logical unit between two physical layers in two devices is a bit. There are several protocols that transform a bit to a signal.

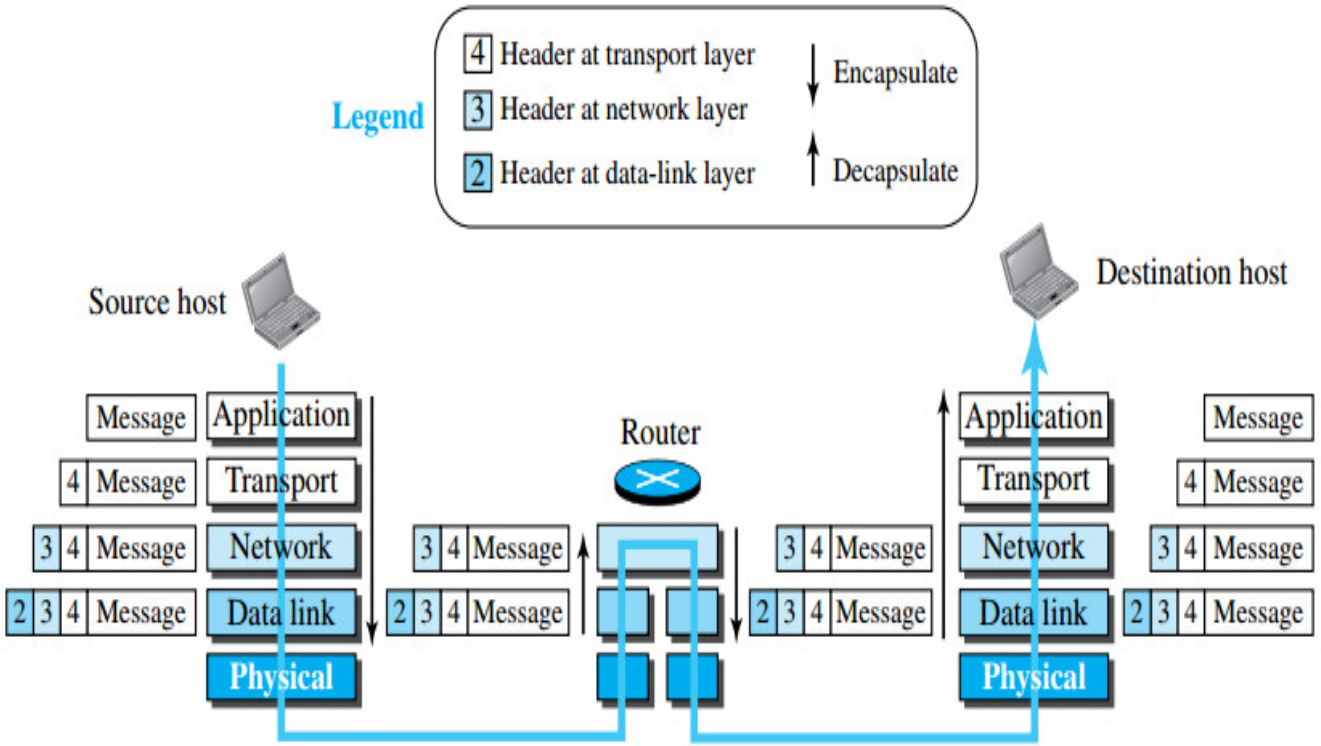
- Data Link Layer
  - The data-link layer takes a datagram and encapsulates it in a packet called a frame.
- Network Layer
  - Responsible for creating a connection between the source computer and the destination computer.
  - Routers in the path are responsible for choosing the best route for each packet.
  - We can say that the network layer is responsible for host-to-host communication and routing the packet through possible routes.
  - The network layer in the Internet includes the main protocol, Internet Protocol (IP), that defines the format of the packet, called a datagram at the network layer.

- Transport Layer
  - Transmission Control Protocol (TCP), is a connection-oriented protocol that first establishes a logical connection between transport layers at two hosts before transferring data.
  - TCP provides flow control, error control, and congestion control.
  - User Datagram Protocol (UDP), is a connectionless protocol that transmits user datagrams without first creating a logical connection. In UDP, each user datagram is an independent entity without being related to the previous or the next one (the meaning of the term connectionless).

Application Layer

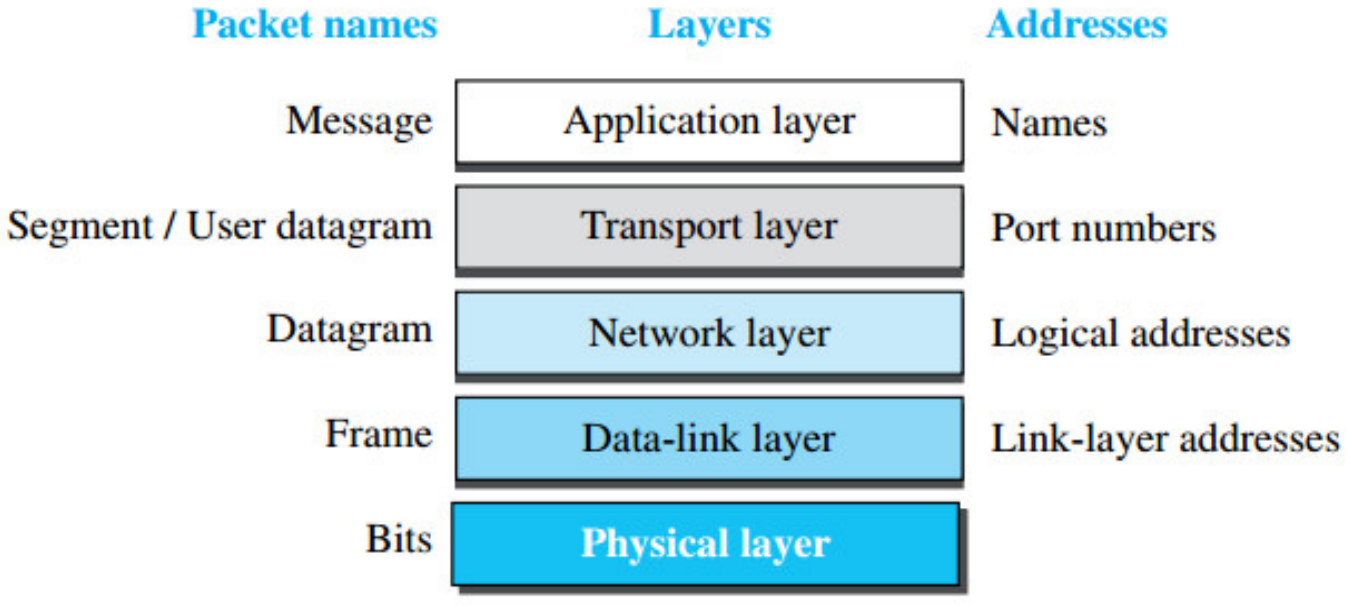
- Communication at the application layer is between two processes (two programs running at this layer).
- To communicate, a process sends a request to the other process and receives a response.
- Process-to-process communication is the duty of the application layer.
- Hypertext Transfer Protocol (HTTP), Simple Mail Transfer Protocol (SMTP), File Transfer Protocol (FTP) etc.

Encapsulation and Decapsulation

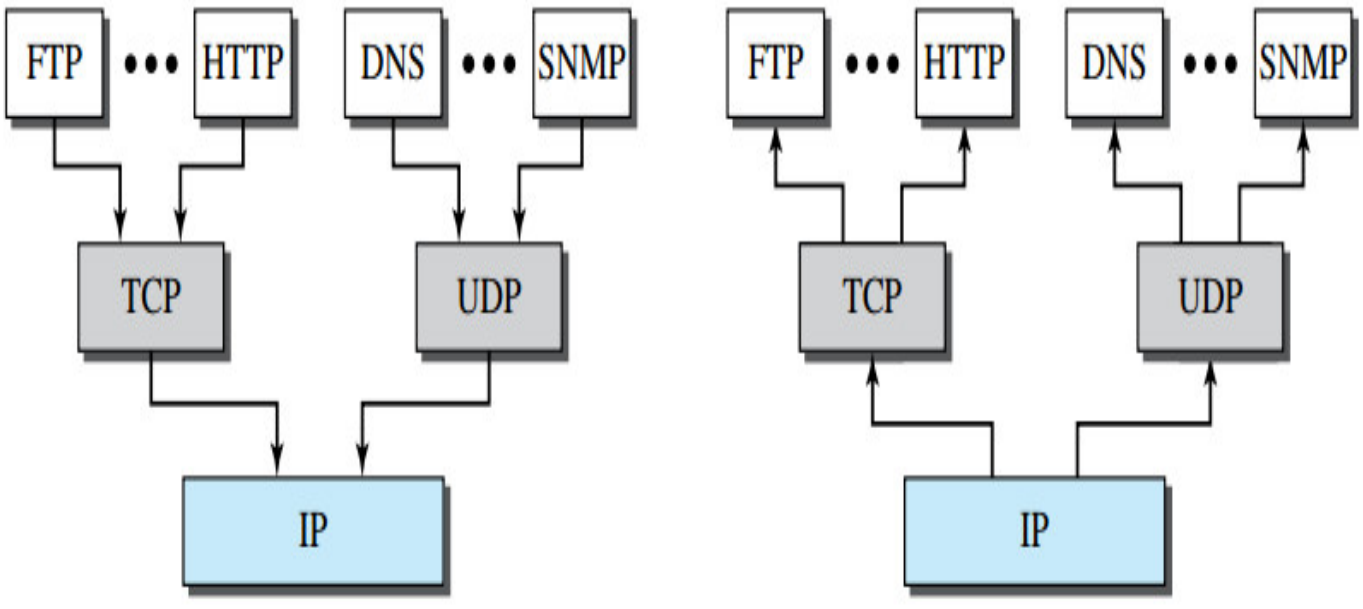


Addressing

Addressing in the TCP/IP protocol suite



Multiplexing and Demultiplexing



a. Multiplexing at source

b. Demultiplexing at destination

Multiplexing and Demultiplexing

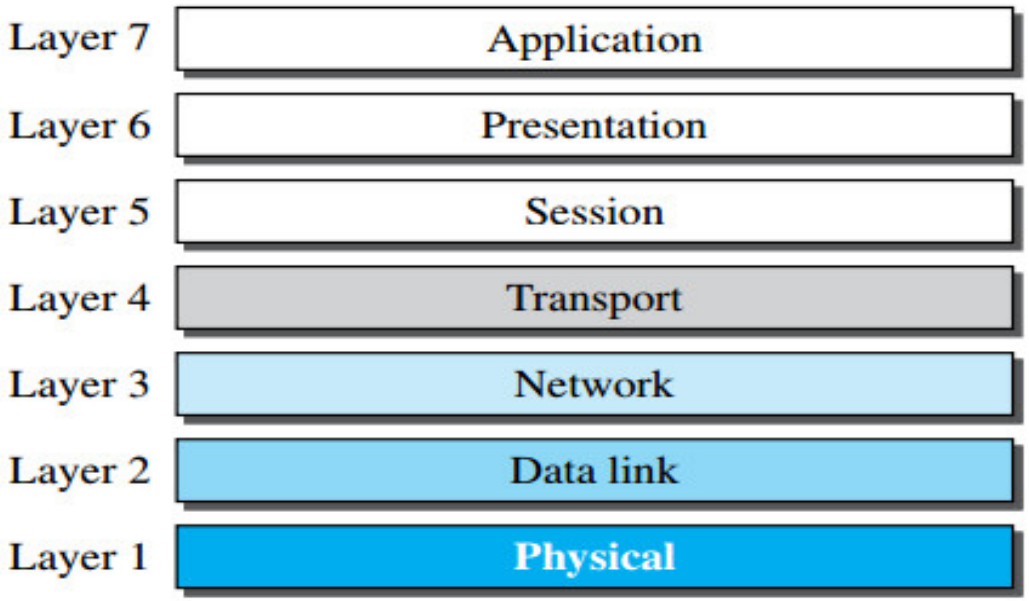
- Multiplexing at the source and demultiplexing at the destination.
- Multiplexing in this case means that a protocol at a layer can encapsulate a packet from several next-higher layer protocols (one at a time).
- Demultiplexing means that a protocol can decapsulate and deliver a packet to several next-higher layer protocols (one at a time).

OSI MODEL

- The International Organization for Standardization (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.
- 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

OSI MODEL

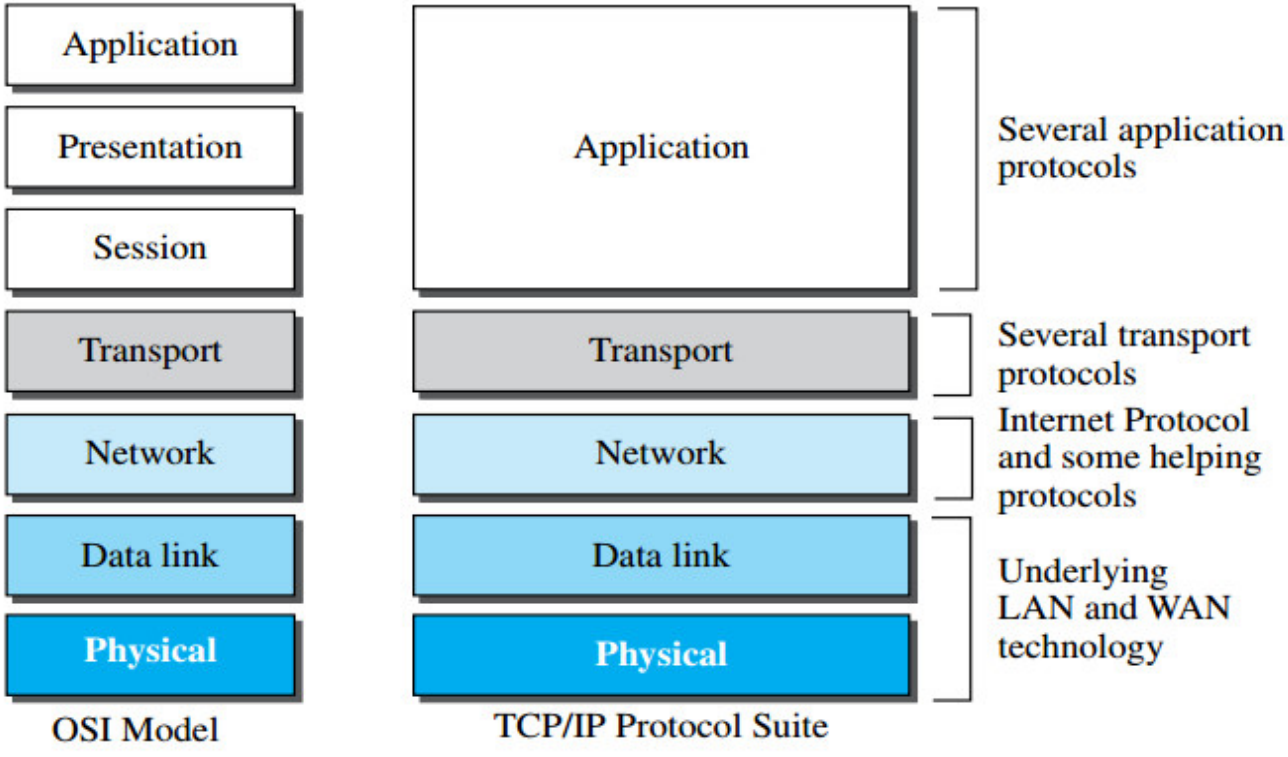
The OSI model



Easy way to remember

- **P**lease **D**o **N**ot **T**hrow **S**pinach **P**izza **A**way
- **P**lease **D**o **N**ot **T**ell **S**ecret **P**asswords **A**nytime
- **P**lease **D**o **N**ot **T**ouch **SPA**

OSI versus TCP/IP



Lack of OSI Models 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.
- 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.

Summary

- TCP/IP Protocol Suite
- OSI Model

THANK YOU