Chapter 2
Data Communication Models

Layered Architecture

- A network needs to provide communication between one application program on one end system and another application program on another end system.
- There is a need for harmony between:
  - Application programs
  - End systems (e.g. computer stations)
  - Intermediate systems (e.g. routers)
  - Transmission media (e.g. Ethernet, Token Ring)

Layered Architecture

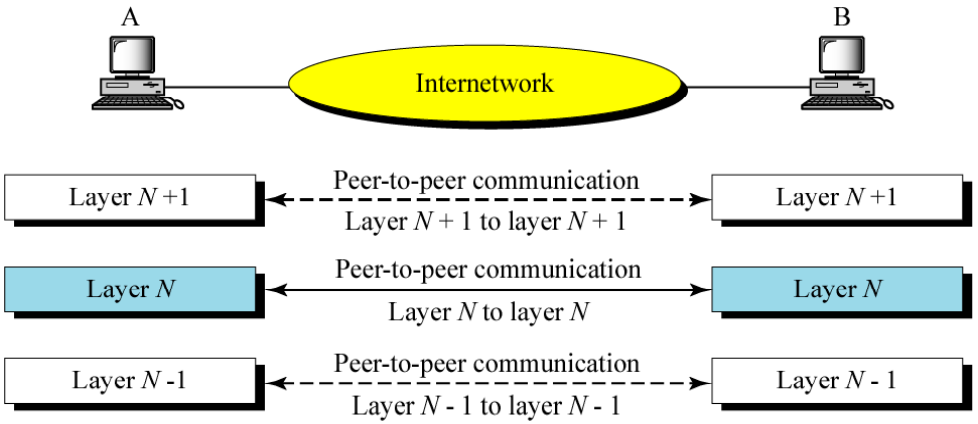
- The task of networking is very complex due to the fact that some part of the systems should handle a subset of the task and others another subset (e.g. media, routers).
- In a layered architecture the complex task of communication between two applications is broken into **layers**.
- Different protocols use different numbers of layers with the duty of each layer being different from protocol to protocol.

Peer-to-Peer Communication

- In a layered architecture, each given layer in one system logically communicates with its corresponding layer at the other system.
- The communication between two corresponding layers requires a common unit of data (packet) called a **protocol data unit** (**PDU**) be defined – the PDU used at layer *N* is called *N*-PDU.

Figure 2-1

Peer-to-Peer Communication

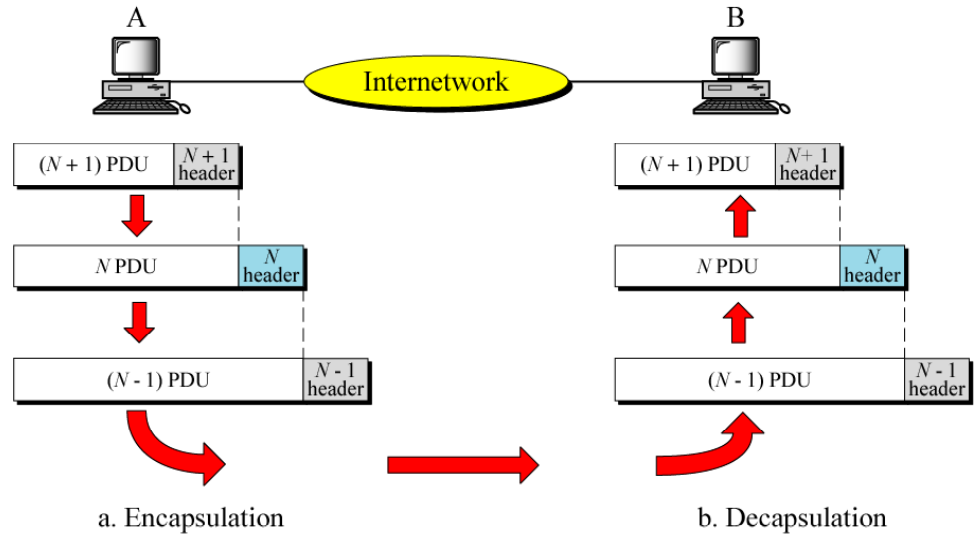


Encapsulation / Decapsulation

- Unlike logical communication, the actual communication happens through the layers.
- At the source the data flows downward while at the destination the data flows upward.
- Headers or trailers are added to or removed from the PDU delivered by upper or lower layers – a process called encapsulation or decapsulation.
- In a multilayer protocol, layer N receives services from layer N-1 and gives services to layer N+1.

Figure 2-2

Encapsulation/Decapsulation

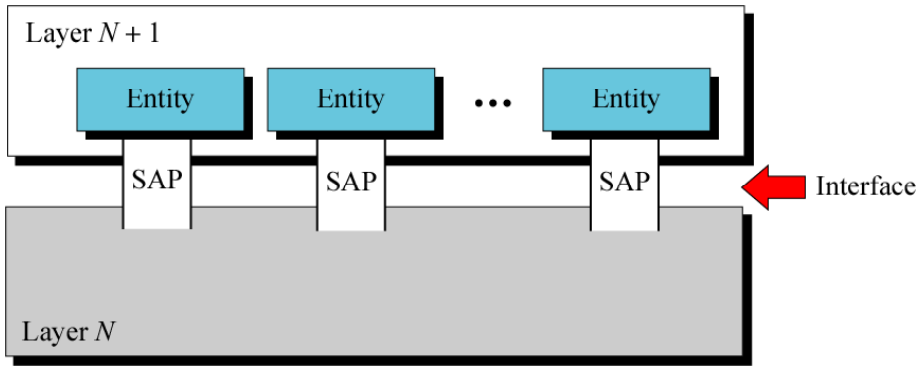


Layered Architecture

- An entity in layer N may provide service to more than one entity in layer N+1. The entity at layer N uses the **service access point (SAP)** address to define the entity at layer N+1.
- The passing of data between each adjacent layer is made possible by an **interface**, which defines what information and services a layer must provide for the layer above it.
- Well-defined interfaces and layer functions provide modularity to the network – changes in one layer do not affect other layers.

Figure 2-3

Service Access Points

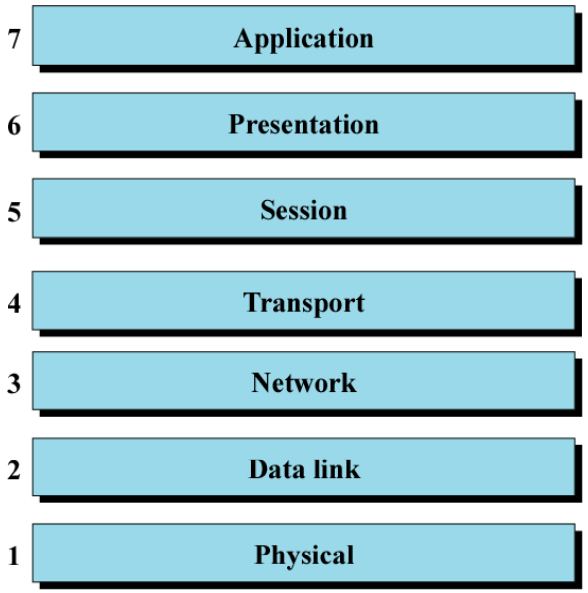


OSI Model

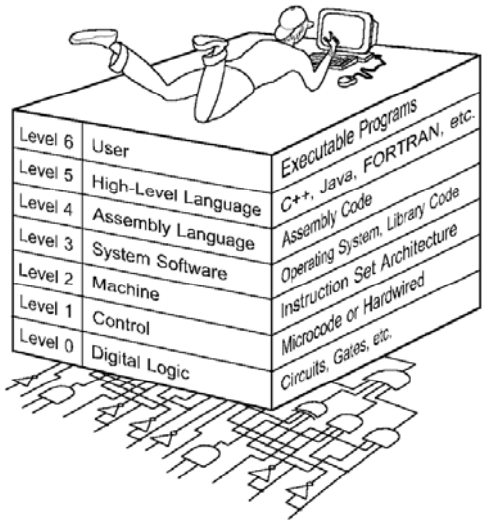
- The Open Systems Interconnection (OSI) model, designed by ISO, is a standardized layered architecture that is often used to describe the network communication functions.
- But OSI is now rarely implemented.
- It is a layered framework with seven separate but related layers, each layer performs a defined function for moving information across the network.

Figure 2-4

OSI Model



The Computer Level Hierarchy

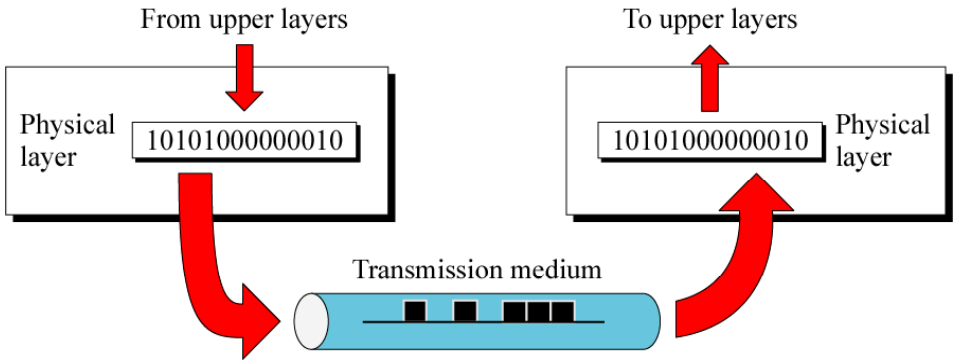


Physical Layer

- The **physical layer** coordinates the functions required to create a bit link (i.e. a physical connection) between the sender and receiver.
- It is concerned with the following:
  - Representation of bits: analog, digital …
  - Data rate: # of bits sent per second (bps)
  - Bit synchronization: self-synchronizing encoding …
  - Characteristics of interfaces: system to media connection
  - Transmission medium: cable, fiber optic, air …
  - Transmission mode: simplex, half-duplex, full-duplex

Figure 2-5

Physical Layer



Data Link Layer

- The **data link layer** is responsible for hop-to-hop delivery. It combines the bits into manageable units called frames and delivers the frames to the next hop (a computer or a connecting device).
- In some protocol it makes the physical layer appear error-free to the upper network layer through error control.
- Some protocol divide it into two sublayers: media access control (MAC) and logical link control (LLC) sublayer.

Functions of Data Link Layer

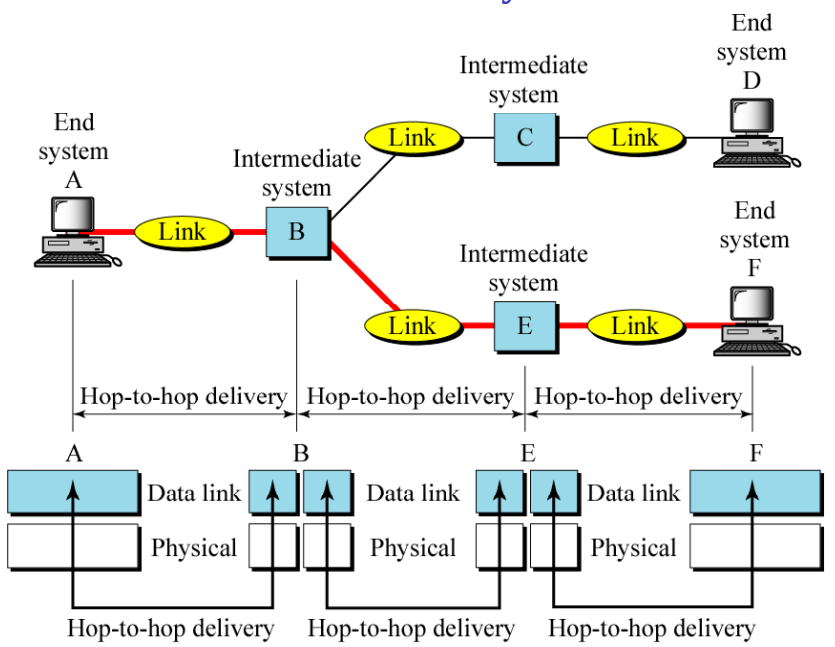
- **Framing** – adding sequence of bits to the packet received from the upper layer to inform the receiver that a packet is coming.
- **Addressing** – each frame contains a source and a destination addresses (also called the physical or MAC address) to identify the sending and receiving stations.
- **Medium access control (MAC)** – try to resolve conflict when more than one station tries to send data to the medium at the same time.

Functions of Data Link Layer

- **Flow control** – controls the frame rate and ensures that the next station is not overwhelmed with data; acknowledgement system can be used; flow control is hop-to-hop, not end-to-end.
- **Error control** – can add mechanisms to detect and retransmit damaged or lost frames.

Figure 2-6

Data Link Layer



Network Layer

- It is responsible for the source-to-destination (end-to-end) delivery of a packet possibly across multiple networks (links).
- Data link layer is only concerned with the delivery of the packet between two systems on the same network (link).

Functions of Network Layer

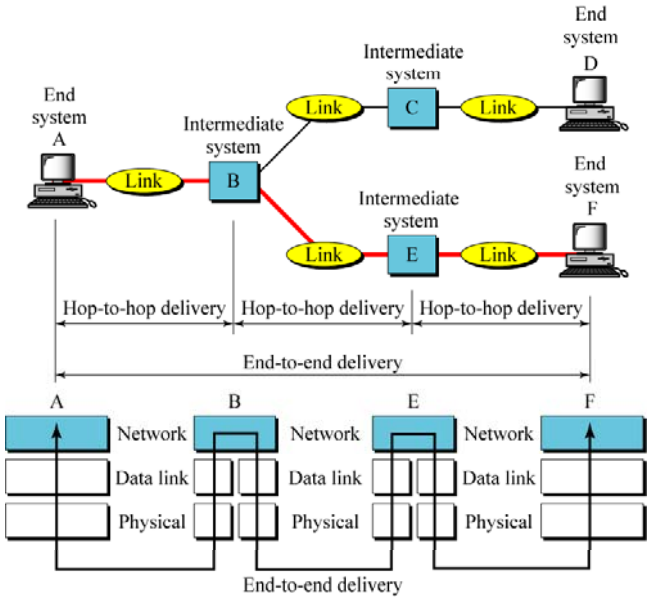
- Creating a logical end-to-end connection – the two end systems should see a logical connection without worrying about links and their connecting devices.
- Hiding the details of the lower layer – if the physical connection or the data link layer is changed, the upper transport layer should not be aware of it.

Functions of Network Layer

- Addressing – while the data link layer handles the addressing problem locally, the network layer makes addressing possible across the network boundary by specifying the addresses of the source and destination systems.
- Routing – it provides routing mechanism for routers or gateways which find the optimum path for the packets to their final destination.

Figure 2-7

Network Layer



Transport Layer

- While the network layer oversees host-to-host delivery of individual packets, the transport layer is responsible for end-to-end error-free delivery of the entire message.
- When a packet is received by the end system, the transport layer is responsible for delivering it to the session layer.

Functions of Transport Layer

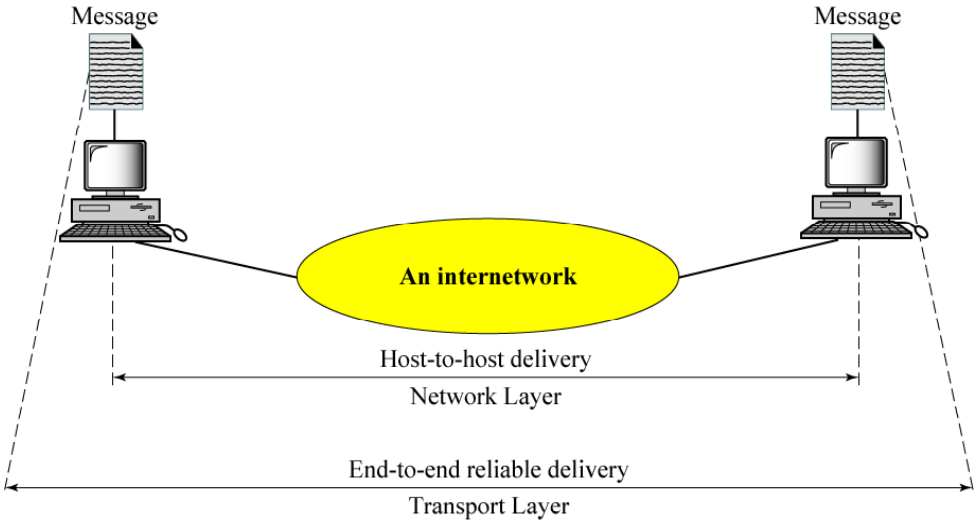
- **Service-point addressing** – use **service-point address** (or **port address**) to identify each process; the network layer gets each packet to the correct computer; the transport layer gets the entire message to the correct process on that computer.
- **Segmentation and reassembly** – a message is divided into transmittable segments, each containing a sequence number allowing the segments to be reassembled upon arriving at the destination.

Functions of Transport Layer

- **Connection control**
  - Connectionless: each segment is an independent packet and is delivered to the transport layer at the destination separately
  - Connection-oriented: a connection must be established between the source and destination transport layers before delivering the packets
- **Flow & Error control** – similar to data link layer, but is performed end to end rather across a single link.

Figure 2-8

Transport Layer



Session Layer

- It provides the control structure for communication between applications, and establishes, manages and terminates connections (sessions) between cooperating applications.
- A session is a persistent logical linking of two software application processes, to allow them to exchange data over a prolonged period of time.
- The three upper layers are concerned mainly with software application issues and not with the details of network and internet implementation.

Presentation Layer

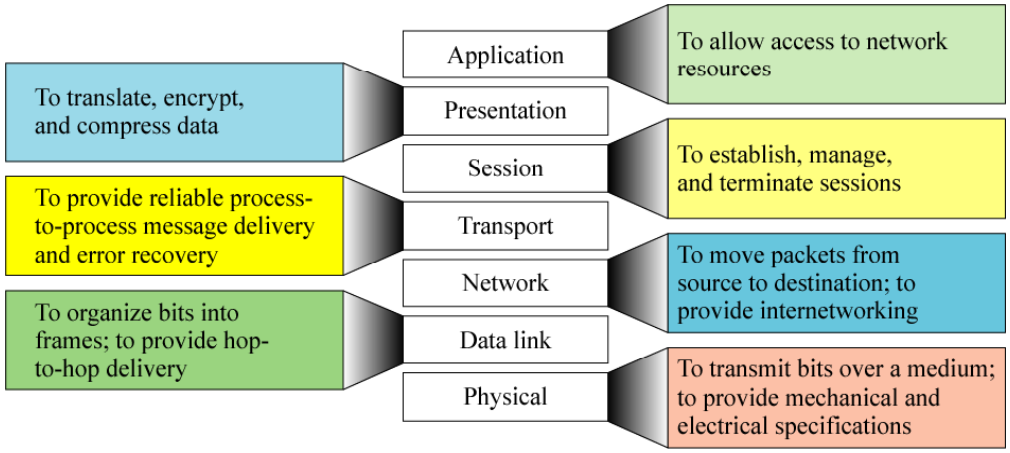
- It allows the two corresponding application layers to use their own data formats.
- Functions of presentation layer include:
  - Translation: the sender changes the data from sender's format into a common format; the receiver changes the data from common format into its own format
  - Encryption
  - Compression

Application Layer

- It enables the software and you to access the network. It provides user interfaces and support for various network services.
- Some examples of application layer protocols include HTTP, FTP, SMTP, DHCP (dynamic IP address), NFS (network file access), Telnet, SNMP (network management), POP3, NNTP (read/post Usenet articles) and IRC (online chat).

Figure 2-9

Summary of Layer Functions

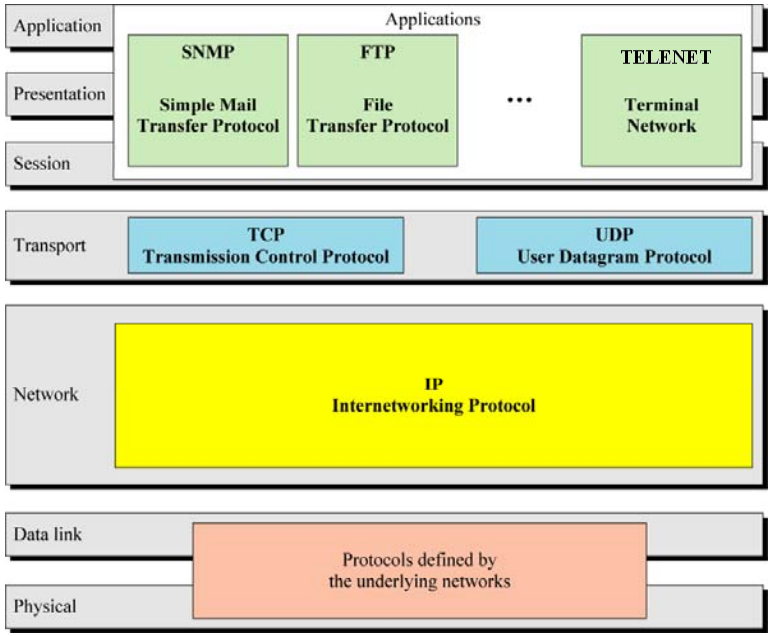


TCP/IP Model

- It was developed prior to the OSI model and was used in the Internet.
- It does not match exactly with those in the OSI model.
- It consists of three layers: network, transport, and application layers.
- It is a hierarchical protocol made of interactive modules each of which provides a specific functionality but are not necessarily interdependent.

Figure 2-10

TCP/IP and the OSI Model



TCP/IP Model

- Physical and Data Link Layers
  - Not defined within TCP/IP protocol suite
  - They are the concern of LANs and WANs
- Network Layer
  - It contains the Internetworking Protocol (IP)
  - IP creates packets called datagrams and sends them to destination
  - The routers routes the packets through the most appropriate paths

TCP/IP Model

- Transport Layer
  - It contains two protocols: TCP, UDP (unreliable)
  - TCP is responsible for segmenting data stream at source and restoring the data at destination
  - TCP performs some tasks of OSI session layer, e.g. creating full-duplex connection between two application layers
  - UDP is used for fast delivery of single shot packets without flow and error control.

TCP/IP Model

- Session and Presentation Layers
  - They are not implemented. Their functions are moved to either the transport layer or the application layer.
- Application Layer
  - It contains several protocols used by users and programs to access Internet resources in remote systems

IEEE 802 Standards

- IEEE 802 is a standard that specifies the functions of the physical and data link layers of major LAN and MAN protocols.
- Data link layer is divided into two sublayers:
  - **Logical link control (LLC)**: same for all IEEE LANs
  - **Media access control (MAC)**: different for different types of LANs
- Physical Sublayers
  - Totally depend on the implementation and type of the physical media used

Figure 2-11

LAN Compared with OSI Model

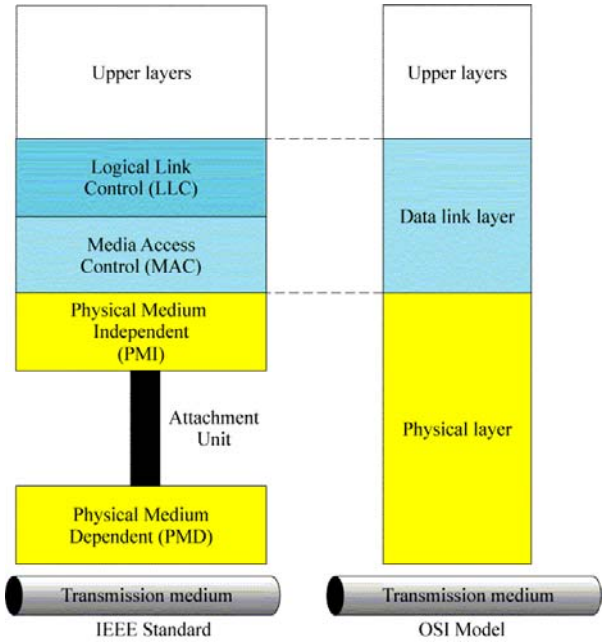
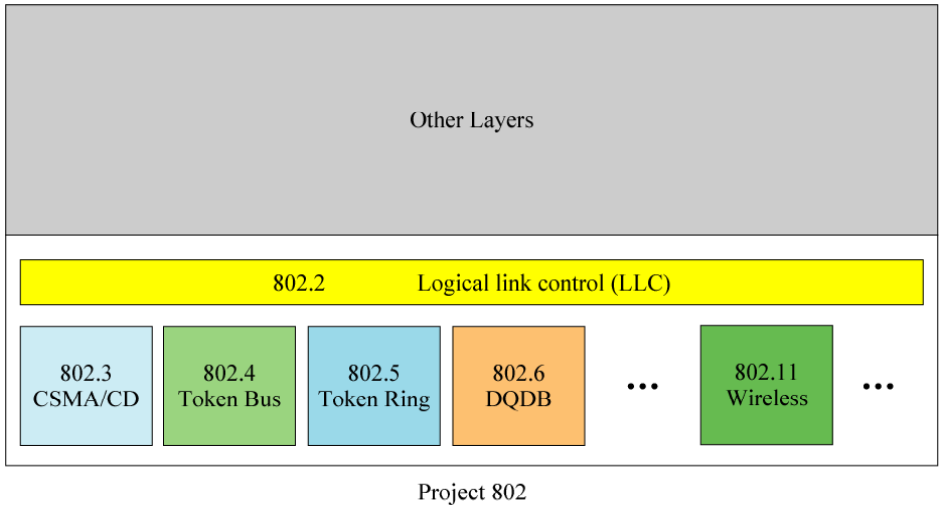


Figure 2-12

IEEE Standards for LANs



Project 802

Summary

- In a layered architecture, each layer at the source logically communicates with the corresponding layer at the destination.
- In a layered architecture, the communication between two corresponding layers requires a protocol data unit (PDU).
- As a PDU travels down through the layers, it is encapsulated by each succeeding layer.

Summary

- A service access point (SAP) identifies the entities in one specific layer.
- The interface defines the information and services a layer must provide for its immediate upper layer.
- The Open Systems Interconnection (OSI) model allows diverse systems to communicate.
- The seven-layer OSI model provides guidelines for the development of universally compatible architecture, hardware, and software.

Summary

- The physical, data link, and network layers are the network support layers.
- The session, presentation, and application layers are the user support layers.
- The transport layer links the network support layers and the user support layers.
- TCP/IP, a three-layer hierarchical protocol suite developed before OSI model, is the protocol suite used in the Internet.