Chapter 2

The OSI Model and TCP/IP Protocol Suite
Outline

- THE OSI MODEL
- LAYERS IN THE OSI MODEL
- TCP/IP PROTOCOL SUITE
- ADDRESSING
- TCP/IP VERSIONS
2.1 THE OSI MODEL

Figure 2-1

OSI Model

1. Physical
2. Data link
3. Network
4. Transport
5. Session
6. Presentation
7. Application
Layered Architecture

- Within a single machine
  - Each layer calls upon the services of the layer just below it
  - For example, layer 3 uses the services provided by layer 2 and provides services for layer 4
Layered Architecture (Cont.)

- Between machines
  - Layer x on one machine communicates with layer x on another machine
  - This communication is governed by a series of rules and conventions called protocols
Layered Architecture (Cont.)

- As the message travels from A to B, it may pass through intermediate nodes
  - These intermediate nodes usually involve only the first three layers of the OSI model

- As shown in the next slide
Peer-to-Peer Processes

- The processes on each machine that communicate at a given layer are called *peer-to-peer processes*
- Each layer in the sending device added its own information to the message it receives from the layer just above it
- At the receiving machine, the message is unwrapped layer by layer
Note

Headers are added to the data at layers 6, 5, 4, 3, and 2. Trailers are usually added only at layer 2.
Figure 2-3

An Exchange Using the OSI Model

Transmission medium

2.2 LAYERS IN THE OSI MODEL
Physical Layer

- From data link layer
  - L2 data
  - 10101000000010

- To data link layer
  - L2 data
  - 10101000000010

Transmission medium
Physical Layer

- Physical characteristics of interface and media
  - Interface between the devices and transmission media
  - The type of transmission media
- Representation of bits
  - Define the type of *encoding* (how 0s and 1s are changed to signals)
Physical Layer (Cont.)

- **Data rate**
  - The number of bits sent each second

- **Synchronization of bits**
  - The sender and receiver must not only use the same bit rate but must also be synchronized at the bit level
Physical Layer (Cont.)

- **Line configuration**
  - Be concerned with the connection of devices to the media
  - **Point-to-point configuration**
    - Two devices are connected through a dedicated link
  - **Multipoint configuration**
    - A link is shared between several devices

- **Physical topology**
  - Define how devices are connected to make a network
  - For example, mesh, star, ring, or bus topology
Physical Layer (Cont.)

- Transmission mode
  - Define the direction of transmission between two devices
  - Simple mode
    - only one device can send
  - Half-duplex mode
    - two devices can send and receive but not at the same time
  - Full-duplex mode
    - Two devices can send and receive at the same time
Data Link Layer

- Transform the physical layer to a reliable link

- Make the physical layer appear error free to the upper layer
Data Link Layer

From network layer

L3 data

Data link layer

T2

H2

Frame

L2 data

To physical layer

To network layer

L3 data

Frame

T2

H2

Data link layer

L2 data

From physical layer
Data Link Layer

- **Framing**
  - Divide the stream of bits into frames
- **Physical addressing**
  - only one hop
- **Flow control**
- **Error control**
  - Detect and retransmit damaged or lost frames
  - Prevent duplication of frames
Data Link Layer (Cont.)

- Access control
  - Determine which device has control over the link at any given time
Node-to-Node (Hop-to-Hop) Delivery
Network Layer

- Be responsible for the source-to-destination delivery of a packet possibly across multiple networks (links)
  - Data link layer take care of the delivery of the packet between two systems on the same network (links)
  - Network layer ensures the delivery of a packet from its point of origin to its final destination
Network Layer

From transport layer

Network layer

L4 data

H3

Packet

L3 data

To data link layer

To transport layer

Network layer

L4 data

Packet

H3

L3 data

From data link layer
Network Layer

- Logical addressing
  - Physical addressing in the data link layer handles the addressing problem locally
  - If a packet pass the network boundary
    - We need another addressing system to distinguish the source and destination systems

- Routing
Figure 2-8

End-to-End Delivery by the Network Layer
Transport Layer

- Be responsible for source-to-destination (end-to-end) delivery of the entire message
  - Network layer only oversees the end-to-end delivery of individual packets
- Oversee both error control and flow control at the source-to-destination level
Figure 2-9

Transport Layer

From session layer

L5 data

Transport layer

H4

H4

H4

L4 data

To network layer

From network layer

L4 data

L4 data

L4 data

To session layer

L5 data

Transport layer

H4

H4

H4

L4 data

L4 data

L4 data
Transport Layer

- Service-point addressing
  - Service-point address: port address
  - 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
Transport Layer (Cont.)

- Connection control
  - Connectionless
  - Connection-oriented

- Flow control
  - End to end flow control
  - The flow control, however, at the data link layer is across a single link
Transport Layer (Cont.)

- Error control
  - End to end error control that makes sure that the entire message arrives without error (damage, loss, or duplication)
  - Error correction is usually achieved through retransmission
  - The error control, however, at the data link layer is across a single link and applies to a single frame
Reliable End-to-End Delivery of a Message

end-to-end delivery by the transport layer

Session Layer

- Session layer is the network dialog controller
  - It establishes, maintains, and synchronizes the interaction between communication systems
Session Layer

Figure 2-11

From presentation layer

L6 data

Session layer

syn

H5

L5 data

To transport layer

To presentation layer

L6 data

Session layer

syn

H5

L5 data

From transport layer

Session Layer

- Dialog control
  - Allow two systems to enter a dialog
  - Allow the communication between two processes in
    - Half-duplex
    - Full-duplex

- Synchronization
  - Allow a process to add checkpoints (synchronization points) into a stream of data
Presentation Layer

- Be concerned with the syntax and semantics of the information exchanged between two systems
Presentation Layer

From application layer

Presentation layer

Encoded, encrypted, and compressed data

H6

L6 data

To session layer

To application layer

Presentation layer

Decoded, decrypted, and decompressed data

H6

L6 data

From session layer

L7 data

Presentation Layer

- Translation
  - Different computers use different encoding systems
  - The presentation layer is responsible for interoperability between these different encoding methods
- Encryption
- Compression
Application Layer

- The application layer enables the user, whether human or software, to access the network
Figure 2-13

Application Layer

User

Application layer

X.500  FTAM  X.400

L7 data

To presentation layer

Application layer

X.500  FTAM  X.400

L7 data

From presentation layer

Application Layer

- Specific services provided by the application layer
  - Network virtual terminal
  - File transfer, access, and management (FTAM)
  - Mail services
  - Directory services
Summary of Layers

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

- TCP/IP protocol suite was developed prior to the OSI model and is made of five layers:
  - Physical, data link, network, transport, and application layers
- The first four layers correspond to the first four layer of the OSI model
TCP/IP Protocol Suite

- The three topmost layers in OSI model are represented in TCP by a single layer called the application layer
TCP/IP and OSI Model
Physical and Data Link Layers

- TCP/IP does not define any specific protocol
- TCP/IP supports all of the standard and proprietary protocols
Network Layer

- Internetworking Protocols (IP)
- Four supporting protocols
  - ARP
  - RARP
  - ICMP
  - IGMP
Internetworking Protocol (IP)

- The packets in IP are called *datagrams*
- Unreliable and connectionless datagram protocol
- Best-effort delivery services
  - Provide no error checking or tracking
Address Resolution Protocol (ARP)

- Associate an IP address with the physical address
  - Data in LAN are transmitted by the physical address
Reverse Address Resolution Protocol (RARP)

- Discover a host’s internet address via its physical address
- Used when
  - A computer is first connected to the network
  - When a diskless computer is booted
Internet Control Message Protocol (ICMP)

- A mechanism used to send notification of datagram problems back to the sender
- ICMP sends query and error reporting messages
Internet Group Message Protocol (IGMP)

- Facilitate the simultaneous transmission of a message to a group of recipients
Transport Layer

- TCP/UDP
  - A process-to-process protocol
- IP
  - A host-to-host protocol
User Datagram Protocol (UDP)

- Add only
  - Port numbers
  - Checksum error control
  - length
Transmission Control Protocol (TCP)

- Reliable connection-oriented protocol
ADDRESSING

2.4
Addresses in TCP/IP

- Physical address
- IP address
- Port address
Relationship of Layers and Addresses in TCP/IP

- Application layer
- Transport layer
- Network layer
- Data link layer
- Physical layer

Processes
TCP
UDP
IP and other protocols
Underlying physical networks

Port address
IP address
Physical address
Physical Address

- Also called link address, the address of a node as defined by its LAN or WAN
  - Ethernet: 6 byte
  - LocalTalk: 1 byte

- Physical address can be either
  - Unicast address
  - Multicast address
  - Broadcast address
Figure 2.18 shows an example of physical addresses.
Physical Addresses
Most local area networks use a 48-bit (6 bytes) physical address written as 12 hexadecimal digits, with every 2 digits separated by a hyphen as shown below:

07-01-02-01-2C-4B
A 6-byte (12 hexadecimal digits) physical address
Internet Address

- Provide universal communication services that are independent of underlying physical network
  - Different networks can have different address format
  - A universal addressing system is thus needed
- Internet address can also be either in unicast, multicast and broadcast
- 4 bytes long in IPv4
Next slide shows an example of Internet addresses.

- Network address A and physical address 10 => send data to => Network address P and physical address 95
- IP address does not change along the trip
- However, physical address changes from network to network
IP Addresses
As we will see in Chapter 4, an Internet address (in IPv4) is 32 bits in length, normally written as four decimal numbers, with each number representing 1 byte. The numbers are separated by a dot. Below is an example of such an address.

132.24.75.9
Port Address

- A label assigns to a process
- 16 bits long
Next slide shows an example of transport layer communication.

- Process with port address $j$ send data to another process with port address $k$
Port Addresses

Figure 2-20

As we will see in Chapters 11 and 12, a port address is a 16-bit address represented by one decimal number as shown below.

753 A 16-bit port address
TCP/IP VERSIONS
Version

- Version 4
  - What we currently used

- Version 5
  - Only a proposal
  - Based on the OSI model

- Version 6
  - Also called IPng (IP next generation)