Chapter 2
The OSI Model

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What Is A Protocol?

• For computers to be able to communicate, a language must be defined among them that they understand.
• A protocol defines almost every aspect of the language that is used for computers to communicate.

Protocol Stacks

• Computers use protocols to talk to each other when information travels between computers, it moves from device to device, or layer to layer as defined by the OSI model.
• Each layer of the model has different protocols that define how information travels.
• The layered functionality of the different protocols in the OSI model is called a protocol stack.

What Is the OSI Model?

• In 1984 the International Standards Organization (ISO) released a model—Open Systems Interconnection model.
• The OSI model depicts the stream of information down the seven layers of the model on the source device, across intermediate devices, and up through the seven layers on the destination device.
### OSI Model (Continued)

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<th>Function</th>
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<td>Interface between the user’s applications and the network</td>
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<td>Presentation</td>
<td>Negotiates data exchange formats</td>
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<td>Session</td>
<td>Allows users to establish connections using easily remembered names.</td>
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<td>Transport</td>
<td>Provides end-to-end, reliable connections</td>
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<td>Network</td>
<td>Routes data through a large internetwork</td>
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<td>Data Link</td>
<td>Determines access to the network media</td>
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<td>Physical</td>
<td>Transforms data into bits that are sent across the physical media</td>
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### Data Names at Different Layers

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<th>Data Name</th>
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<td>Bits</td>
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### Physical Layer

- **Characteristics:**
  - Transmits bits
    - The function of this layer is the transmission of bits over the network media.
  - Specifies requirements for how transmission occurs
  - Ensures compatible data transmission with other devices

### Physical Layer Transmission

![Physical Layer Diagram]

### Data Link Layer

- **Characteristics:**
  - Packages data into frames
    - The main purpose of this layer is to provide a reliable method of transmitting data across the physical media.
  - Transmits data sequentially
  - Processes acknowledged frames sent from the receiver
  - Data Link layer has two sublayers
    - Media Access Control (MAC) sublayer
    - Logical Link Control (LLC) sublayer.

### Data Link Layer Transmission

![Data Link Layer Diagram]
Media Access Control

- This sublayer is responsible for physical addressing and access to the network media.
- The three ways to control access to media are as follows:
  - Identification of devices
    - Addressing
  - Usage of transmission media
    - Contention
    - Deterministic

Addressing

- Every device on a network has a hard-coded address.
- For example, an Ethernet card would have an address 00-AA-00-59-65-71 (MAC address).

Contention

- The advantages of this system are that it allows equal access to the network media, but at the expense of possible collisions.
- On modern contention-based networks, devices listen for other signals on the media before transmitting.
  - CSMA/CD
  - CSMA/CA

Contention (Continued)

- Advantages:
  - Low overhead
  - High speed on networks with less than roughly forty percent utilization
- Disadvantages:
  - Degradation of performance due to collisions under moderate-to-high network loads
  - Inability to assign priorities to special devices
  - Channel access is not always predictable

CSMA/CD

- Ethernet uses the CSMA/CD method.
- Transmission sequence:
  - The device “listens” to the media for any other transmissions.
  - If the network media is quiet, then the device proceeds to start transmitting its data.
  - After the device transmits its data, it listens to the network media to detect any collisions.

CSMA/CD (Continued)

- If the device detects a collision, it will send out a signal for all other devices to receive. This signal tells the other devices to keep from sending data for a small period to clear all signals from the media.
- The transmitting stations will then wait a random amount of time before sending their data.
- If a second collision occurs with the same devices, they repeat the above steps, but double the random timeout before they transmit again. Once the devices have transmitted successfully, other devices are allowed to transmit again.
CSMA/CA

- CSMA/CA is most often used by Apple’s LocalTalk network.
- Transmission sequence:
  - The device wanting to send checks the media for any active transmissions.
  - If the media is clear, the device sends a Request to Send message.

CSMA/CA (Continued)

- If it is okay to transmit, the network server responds with a Clear to Send signal.
- When the device receives the Clear to Send signal, it transmits its data.
- After the transmission is completed, the device sends out an abort sequence to signal that it is finished.

Deterministic

- Deterministic network has a system that determines transmitting order.
- The two types of deterministic networks are:
  - token passing
  - polling

Token passing

- In a token-passing system, a small data frame is passed from device to device across the network in a predetermined order.
- The device that has control of the token frame has the ability to transmit data across the network.

Token passing (Continued)

- Advantages
  - Special devices can have higher priorities than normal devices.
  - Token passing is much more efficient under high network loads than contention-based networks.
  - Network access is predictable due to the predetermined transmitting order.
- Disadvantages
  - Contention-based systems on networks with low utilization are faster.
  - Network devices and interface cards are more expensive due to their increased intelligence.

Polling systems

- In a polling system a master device checks the other secondary devices on the network to see if they need to transmit.
- Most networks that use this configuration operate in a multipoint configuration, where each secondary device is directly connected to the primary.
Polling systems (Continued)

- Advantages
  - The priority and amount of data allowed to be transmitted at a time can be predetermined.
  - Little bandwidth is lost when the network reaches high utilization.
- Disadvantages
  - The process of polling each secondary device uses more bandwidth than the other methods.
  - Transmissions can be delayed from secondary devices while they wait to be polled by the primary device.

Logical Link Control

- The Logical Link Control (LLC) sublayer of the Data Link layer establishes and maintains data link connections between network devices.
- It is responsible for any flow control and error correction found in this layer.

Logical Link Control (Continued)

- Connection services:
  - Unacknowledged connectionless service:
    • It is unreliable, it is commonly used because the upper layer protocols handle their own error checking.
  - Connection-oriented service:
    • Uses a sliding-window flow control and acknowledgments for error checking.

Logical Link Control (Continued)

- Flow control ways:
  - Sliding window:
    • Allows the two communicating devices to negotiate the number of allowable outstanding frames.
    • It can send one acknowledgment for a group of frames.
  - Stop and wait:
    • When the receiving device has no memory left to store incoming data, it suspends transmission.

Stop and Wait

- source transmits one data unit and wait acknowledgement from the destination
- while receiving the acknowledgement, source transmits the next data unit

Logical Link Control (Continued)

- Error control
  - cyclic redundancy checks (CRCs)
    • Before data is sent, a CRC number is calculated by running the data through an algorithm and producing a unique number.
  - Checksums
    • The unique value generated from the algorithm is called a checksum.
Network Layer

- This layer is responsible for routing information from one network device to another.
- Data passes through the network by devices called intermediate devices.

Network Layer (Continued)

- The responsibilities of the Network layer
  - Routes information from sender to receiver
  - Converts data into packets
  - Uses connectionless transmissions
- Some data is sent directly to the device; some may be sent through many intermediate devices and stored there for a length of time. These types of data transfer are referred to as datagram switching.

Datagram Switching

- Three main methods:
  - Circuit switching
  - Message switching
  - Packet switching

Circuit Switching

- Advantages:
  - no congestion
  - almost no channel-access delay
- Disadvantages:
  - inefficient use of the media and a possible long wait to establish a connection.

Circuit Switching (Continued)
Message switching

• With message switching the data is sent from device to device in whole across the network.
• Store and forward.

Packet switching

• A combination of circuit switching and message switching.
• Data is broken into small pieces and routed from device to device.
• There are two methods of packet switching:
  – Datagram packet switching
  – Virtual circuit

Datagram Packet Switching

• Datagram packet switching is a connectionless method.
• Each piece of information is tagged with the destination address so, no dedicated connection is needed.
• At the destination device, the data is pieced back together by using a Packet Assembler/Disassembler (PAD).

Virtual Circuit

• Similar to dedicated circuit switching, except the connections are virtual.
• More than one communication can go over the physical media.
• This is considered connection oriented.
Virtual Circuit (Continued)

Routing

- For packets to be correctly routed, there needs to be a table set up to show the shortest routes between two networks.
- These tables can either be
  - dynamic
    - Set up manually by administrators
  - Static
    - All configuration settings can be detected by the network routers.

Dynamic routing

- Two methods to define the shortest route:
  - Distance vector
  - Link state
    - Link state takes more into account than just hop count—it usually considers link speed, latency, and congestion.

Addressing

- A device on a network has not only a device address, but also a network address that tells other computers where to locate that device.
- The fact that a device is local or remote may dictate certain sending parameters such as protocol and time-out values.

Transport Layer

- A transport service between the Session layer and the Network layer.
- A true source-to-destination layer.
- Using message headers and control messages

Transport Layer (Continued)

- The responsibilities of the Transport Layer:
  - Breaks up and restores data
  - Provides end-to-end reliability
  - Uses connection-oriented transmission of data
Transport Layer (Continued)

- Connection Services
  - Sequence control
    - Transport layer re-sequences (the packets out of order) information before passing it to the Session layer.
  - Error control
    - Using Checksums
  - Flow control
    - Managed by the use of acknowledgments.

Session Layer

- This layer lets users establish a connection — called a session — between devices.
- Sessions can be set up so that they are:
  - Half-duplex
  - Simplex
  - Full-duplex

Communication between the Session layers on two devices

Session Layer (Continued)

- The characteristics of the Session layer
  - Allows users to establish connections between devices
  - Manages dialogue
  - Uses remote address to establish connections

Half-duplex

- Advantages:
  - Costs less than full-duplex
  - Enables for two-way communications
- Disadvantages:
  - Costs more than simplex
  - Only one device can transmit at a time

Simplex

- Advantages:
  - Cheapest communications method
- Disadvantages:
  - Only allows for communications in one direction
Full-duplex

- Advantages:
  - Enables two-way communications simultaneously

- Disadvantages:
  - The most expensive method in terms of equipment because two bandwidth channels are needed

Presentation Layer

- Responsibilities of the Presentation layer
  - Establishes format for data exchange
  - Handles character set and numeric translations
  - Performs data compression preparation pointer

Communication between the Presentation layers of two devices

Character codes

- **EBCDIC** (Extended Binary Coded Decimal Interchange Code):
  - Uses 8 bits to represent up to 256 different characters.

- **ASCII**:
  - Uses 7 bits to allow for up to 128 characters.
  - The eighth bit is normally used for parity checking.

Application Layer

- Characteristics:
  - Serves as the interface between user applications and the network
  - Enables user applications to interact with the network

Revisit OSI Model
The IEEE 802 Standards

- **802.2:**
  - The two parts of the Data Link Layer are the LLC sublayer and the MAC sublayer. 802.2 defines the standards for the LLC layer of the Data Link layer.
- **802.3:**
  - CSMA/CD, for example, Ethernet, is defined by the 802.3 standard.

The IEEE 802 Standards (Continued)

- **802.5:**
  - The 802.5 standard is based on IBM’s Token Ring network standard. This standard uses a logical ring topology running at 4 or 16 megabits.

IEEE 802 Architecture

TCP/IP Reference Model