Chapter 3: Network Protocols and Communications

Introduction to Networks
Chapter 3: Objectives

After completing this chapter, you will be able to:

- Explain how rules are used to facilitate communication.
- Explain the role of protocols and standards organizations in facilitating interoperability in network communications.
- Explain how devices on a LAN access resources in a small to medium-sized business network.
Chapter 3

3.1 Rules of Communication
3.2 Network Protocols and Standards
3.3 Moving Data in the Network
3.4 Summary
3.1 Rules of Communication
The Rules

What is Communication?
The Rules

Establishing the Rules

- An identified sender and receiver
- Agreed upon method of communicating (face-to-face, telephone, letter, photograph)
- Common language and grammar
- Speed and timing of delivery
- Confirmation or acknowledgment requirements
The Rules

Message Encoding

Message Source → Encoder → Transmitter → Transmission Medium "The Channel" → Receiver → Decoder → Message Destination

Source Encoded

Destination Decoded
The Rules
Message Formatting and Encapsulation

Example: Personal letter contains the following elements:

- Identifier of the recipient’s location
- Identifier of the sender’s location
- Salutation or greeting
- Recipient identifier
- The message content
- Source identifier
- End of message indicator
The Rules
Message Size

An overview of the segmenting process:

▪ The size restrictions of frames require the source host to break a long message into individual pieces (or segments) that meet both the minimum and maximum size requirements.

▪ Each segment is encapsulated in a separate frame with the address information, and is sent over the network.

▪ At the receiving host, the messages are de-encapsulated and put back together to be processed and interpreted.
The Rules

Message Timing

- Access Method
- Flow Control
- Response Timeout
The Rules

Message Delivery Options

Unicast  Multicast  Broadcast

Unicast  Multicast  Broadcast

Unicast  Multicast  Broadcast

Unicast  Multicast  Broadcast

Source

Source

Source

Source
3.2 Network Protocols and Standards
Protocols

Rules that Govern Communications

Protocols: Rules that Govern Communications

Content Layer

Where is the café?

Rules Layer

Conversation protocol suite
1. Use a common language
2. Wait your turn
3. Signal when finished

Physical Layer

Protocol suites are sets of rules that work together to help solve a problem.
Protocols

Network Protocols

- How the message is formatted or structured
- The process by which networking devices share information about pathways with other networks
- How and when error and system messages are passed between devices
- The setup and termination of data transfer sessions
Protocols

Interaction of Protocols

- Application Protocol – Hypertext Transfer Protocol (HTTP)
- Transport Protocol – Transmission Control Protocol (TCP)
- Internet Protocol – Internet Protocol (IP)
- Network Access Protocols – Data link & physical layers
**Protocol Suites**

**Protocol Suites and Industry Standards**

<table>
<thead>
<tr>
<th>TCP/IP</th>
<th>ISO</th>
<th>AppleTalk</th>
<th>Novell Netware</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTTP, DNS, DHCP, FTP</td>
<td>ACSE, ROSE, TRSE, SESE</td>
<td>AFP</td>
<td>NDS</td>
</tr>
<tr>
<td>TCP, UDP</td>
<td>TP0, TP1, TP2, TP3, TP4</td>
<td>ATP, AEP, NBP, RTMP</td>
<td>SPX</td>
</tr>
<tr>
<td>IPv4, IPv6, ICMPv4, ICMPv6</td>
<td>CONP/CMNS, CLNP/CLNS</td>
<td>AARP</td>
<td>IPX</td>
</tr>
<tr>
<td>Ethernet, PPP, Frame Relay, ATM, WLAN</td>
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<td></td>
</tr>
</tbody>
</table>
Protocol Suites

Creation of Internet, Development of TCP/IP

- The first packet switching network and predecessor to today’s Internet was the Advanced Research Projects Agency Network (ARPANET), which came to life in 1969 by connecting mainframe computers at four locations.

- ARPANET was funded by the U.S. Department of Defense for use by universities and research laboratories. Bolt, Beranek and Newman (BBN) was the contractor that did much of the initial development of the ARPANET, including creating the first router known as an Interface Message Processor (IMP).

- In 1973, Robert Kahn and Vinton Cerf began work on TCP to develop the next generation of the ARPANET. TCP was designed to replace ARPANET’s current Network Control Program (NCP).

- In 1978, TCP was divided into two protocols: TCP and IP. Later, other protocols were added to the TCP/IP suite of protocols including Telnet, FTP, DNS, and many others.
Protocol Suites

TCP/IP Protocol Suite and Communication
Standards Organizations

Open Standards

- The Internet Society (ISOC)
- The Internet Architecture Board (IAB)
- The Internet Engineering Task Force (IETF)
- Institute of Electrical and Electronics Engineers (IEEE)
- The International Organization for Standards (ISO)
Standards Organizations

ISOC, IAB, and IETF
Standards Organizations

IEEE

- 38 societies
- 130 journals
- 1,300 conferences each year
- 1,300 standards and projects
- 400,000 members
- 160 countries
- IEEE 802.3
- IEEE 802.11

IEEE 802 Working Groups and Study Groups

- 802.1 Higher Layer LAN Protocols Working Group
- 802.3 Ethernet Working Group
- 802.11 Wireless LAN Working Group
- 802.15 Wireless Personal Area Network (WPAN) Working Group
- 802.16 Broadband Wireless Access Working Group
- 802.18 Radio Regulatory TAG
- 802.19 Wireless Coexistence Working Group
- 802.21 Media Independent Handover Services Working Group
- 802.22 Wireless Regional Area Networks
- 802.24 Smart Grid TAG
Standards Organizations

ISO

OSI Model

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

Other Standards Organization

- The Electronic Industries Alliance (EIA)
- The Telecommunications Industry Association (TIA)
- The International Telecommunications Union – Telecommunications Standardization Sector (ITU-T)
- The Internet Corporation for Assigned Names and Numbers (ICANN)
- The Internet Assigned Numbers Authority (IANA)
Reference Models

Benefits of Using a Layered Model

A networking model is only a representation of a network operation. The model is not the actual network.

<table>
<thead>
<tr>
<th>OSI Model</th>
<th>TCP/IP Protocol Suite</th>
<th>TCP/IP Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
<td>HTTP, DNS, DHCP, FTP</td>
<td>Application</td>
</tr>
<tr>
<td>Presentation</td>
<td>TCP, UDP</td>
<td>Transport</td>
</tr>
<tr>
<td>Session</td>
<td>IPv4, IPv6, ICMPv4, ICMPv6</td>
<td>Internet</td>
</tr>
<tr>
<td>Transport</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network</td>
<td>IPv4, IPv6, ICMPv4, ICMPv6</td>
<td></td>
</tr>
<tr>
<td>Data Link</td>
<td>PPP, Frame Relay, Ethernet</td>
<td></td>
</tr>
<tr>
<td>Physical</td>
<td></td>
<td>Network Access</td>
</tr>
</tbody>
</table>
Reference Models

The OSI Reference Model

1. Physical
2. Data Link
3. Network
4. Transport
5. Session
6. Presentation
7. Application
Reference Models

The TCP/IP Reference Model

TCP/IP Model

- **Application**: Represents data to the user, plus encoding and dialog control.
- **Transport**: Supports communication between diverse devices across diverse networks.
- **Internet**: Determines the best path through the network.
- **Network Access**: Controls the hardware devices and media that make up the network.
## Reference Models

### Comparing the OSI and TCP/IP Models

<table>
<thead>
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<th>OSI Model</th>
<th>TCP/IP Model</th>
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<tr>
<td>7. Application</td>
<td>Application</td>
</tr>
<tr>
<td>6. Presentation</td>
<td>Transport</td>
</tr>
<tr>
<td>5. Session</td>
<td>Internet</td>
</tr>
<tr>
<td>4. Transport</td>
<td>Network Access</td>
</tr>
<tr>
<td>3. Network</td>
<td></td>
</tr>
<tr>
<td>2. Data Link</td>
<td></td>
</tr>
<tr>
<td>1. Physical</td>
<td></td>
</tr>
</tbody>
</table>
3.3 Moving Data in the Network
Data Encapsulation

Communicating the Messages

- Segmenting message benefits
  - Different conversations can be interleaved
  - Increased reliability of network communications

- Segmenting message disadvantage
  - Increased level of complexity

Communicating the Message

Multiple pieces are labeled for easy direction and re-assembly.

Labeling provides for ordering and assembling the pieces when they arrive.
Data Encapsulation

Protocol Data Units (PDUs)

- Data
- Segment
- Packet
- Frame
- Bits
Data Encapsulation

Protocol Encapsulation
Data Encapsulation

Protocol De-encapsulation
Moving Data in the Network
Accessing Local Resources

Network Addresses and Data Link Addresses

- **Physical**: Timing and synchronization bits
- **Data Link**: Destination and source physical addresses
- **Network**: Destination and source logical network addresses
- **Transport**: Destination and source process number (ports)
- **Upper Layers**: Encoded application data
Accessing Local Resources

Communicating with Device / Same Network

Data Link
Ethernet Frame Header

<table>
<thead>
<tr>
<th>Destination</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC-CC-CC-CC-CC-CC</td>
<td>AA-AA-AA-AA-AA-AA</td>
</tr>
</tbody>
</table>

Network Layer
IP Packet Header

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network 192.168.1.</td>
<td>Host 110</td>
</tr>
<tr>
<td>Network 192.168.1.</td>
<td>Host 9</td>
</tr>
</tbody>
</table>

Data

PC1
192.168.1.110
AA-AA-AA-AA-AA-AA

FTP Server
192.168.1.9
CC-CC-CC-CC-CC-CC-CC
Accessing Local Resources
MAC and IP Addresses

PC1
192.168.1.110
AA-AA-AA-AA-AA-AA

PC2
192.168.1.111
BB-BB-BB-BB-BB-BB

FTP Server
192.168.1.9
CC-CC-CC-CC-CC-CC

R1
192.168.1.1
11-11-11-11-11-11

ARP Request
Accessing Remote Resources

Default Gateway

Getting the Pieces to the Correct Network

<table>
<thead>
<tr>
<th>Source</th>
<th>Destination</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network 192.168.1</td>
<td>Device 110</td>
<td></td>
</tr>
<tr>
<td>Network 172.16.1</td>
<td>Device 99</td>
<td></td>
</tr>
</tbody>
</table>

My default gateway is 192.168.1.1.

I am the default gateway for this LAN.

My default gateway is 192.168.1.1.

My default gateway is 192.168.1.1.

PC1
192.168.1.110
AA-AA-AA-AA-AA-AA

PC2
192.168.1.111
BB-BB-BB-BB-BB-BB

R1
192.168.1.1
11-11-11-11-11-11

FTP Server
192.168.1.9
CC-CC-CC-CC-CC-CC

Web Server
172.16.1.99
### Accessing Remote Resources

**Communicating Device / Remote Network**

<table>
<thead>
<tr>
<th>Data Link</th>
<th>Network Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethernet Frame Header</td>
<td>IP Packet Header</td>
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</table>

<table>
<thead>
<tr>
<th>Destination</th>
<th>Source</th>
<th>Source</th>
<th>Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Device 172.16.1.99</td>
<td>Device 99</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PC1</th>
<th>R1</th>
<th>R2</th>
<th>Web Server</th>
</tr>
</thead>
</table>
In this chapter, you learned:

- Data networks are systems of end devices, intermediary devices, and the media connecting the devices. For communication to occur, these devices must know how to communicate.

- These devices must comply with communication rules and protocols. TCP/IP is an example of a protocol suite.

- Most protocols are created by a standards organization such as the IETF or IEEE.

- The most widely-used networking models are the OSI and TCP/IP models.

- Data that passes down the stack of the OSI model is segmented into pieces and encapsulated with addresses and other labels. The process is reversed as the pieces are de-encapsulated and passed up the destination protocol stack.
In this chapter, you learned:

- The OSI model describes the processes of encoding, formatting, segmenting, and encapsulating data for transmission over the network.

- The TCP/IP protocol suite is an open standard protocol that has been endorsed by the networking industry and ratified, or approved, by a standards organization.

- The Internet Protocol Suite is a suite of protocols required for transmitting and receiving information using the Internet.

- Protocol Data Units (PDUs) are named according to the protocols of the TCP/IP suite: data, segment, packet, frame, and bits.

- Applying models allows individuals, companies, and trade associations to analyze current networks and plan the networks of the future.