Guide to Network Security
First Edition

Chapter Two
Introduction to Networking

Objectives

- Describe the basic elements of computer-based data communication

- Discuss the key entities and organizations behind current networking standards, as well as the purpose of and intent behind the more widely used standards

- Explain the nature and intent of the OSI reference model as well as list and describe each of the model's seven layers

Objectives (cont'd.)

- Describe the nature of the Internet and the relationship between the TCP/IP protocol and the Internet

Introduction

- Network
  - Transparent entity to computer users
  - Provides blood flow for the computing environment
  - Designed to allow information to flow efficiently
  - Maintained by network administrators

Networking Fundamentals

- Sender communicates message to receiver
  - Over some medium
- Communication occurs when:
  - Recipient receives, processes, and comprehends the message
- Channel
  - One-way flow of information from sender to receiver
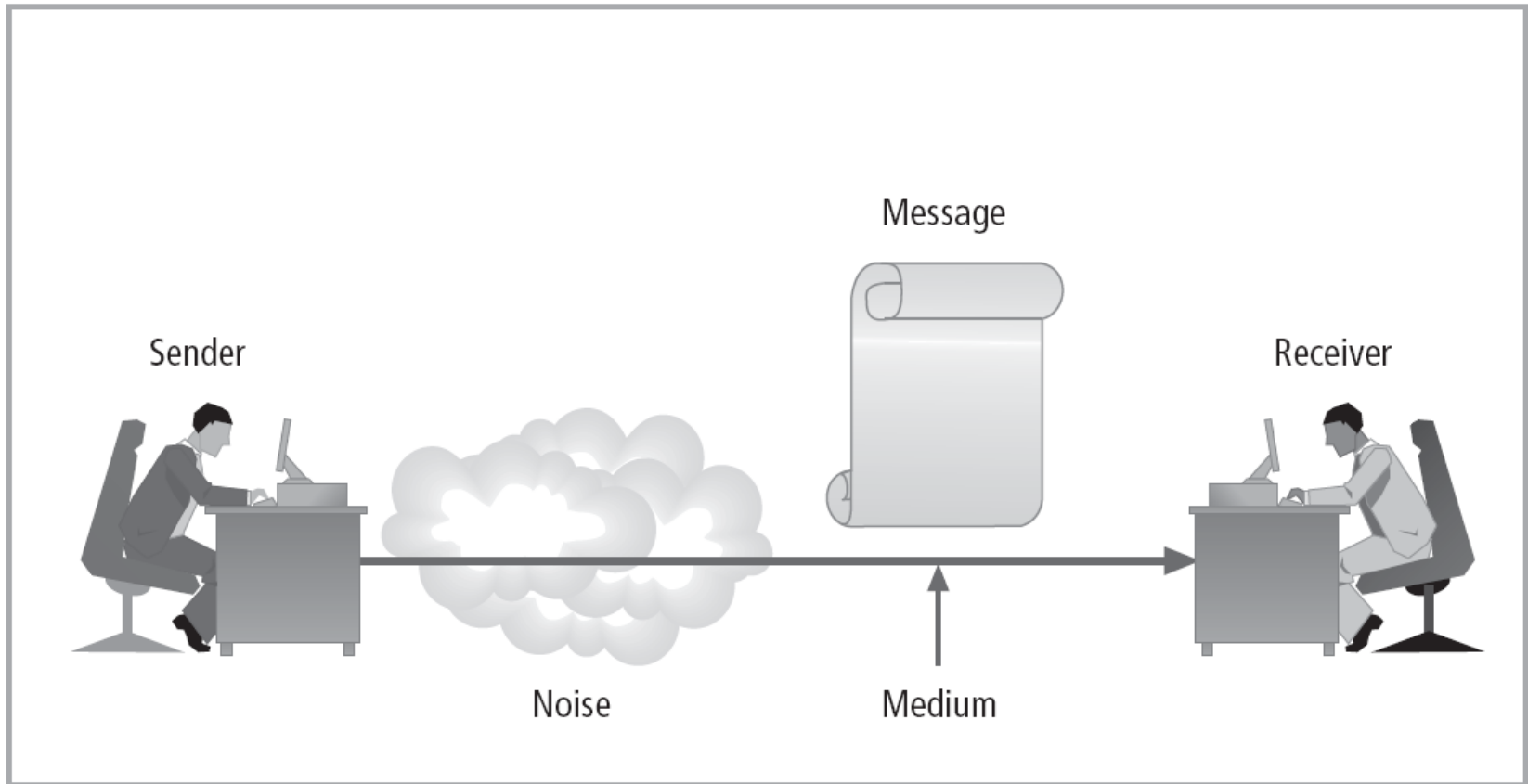- Circuit
  - Two-way flow of information

Figure 2-1 Basic communications model
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Reasons to Network

- Data communications
  - Exchange of digital messages across a medium
- Networking
  - Interconnecting groups or systems for information exchange
- Reasons to build a network
  - Exchanging information
  - Sharing resources
  - Allowing distributed organizations to act as if they are centrally located

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Getting the Message Across

- Modulation
  - Modification of a medium to carry the message
- Methods of embedding a message vary depending on type of message and signal
- Analog information on an analog medium
  - Public telephone network
  - Commercial radio stations
  - Signal characteristics used:
    - Amplitude, frequency, and phase

Figure 2-2 Data-to-signal modulation
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ANALOG SIGNALS

90°

Amplitude

0°   180°   360°
t →
1/4 cycle

270°

Period
(One cycle)

(a)
Amplitude

Frequency

(b)
Amplitude

Frequency

DIGITAL SIGNALS

1 (High)
0 (Low)

Time

Amplitude (in volts)

+15
+10
+5
0
−5
−10
−15

1   1   1   1

1

0   0

0

Time
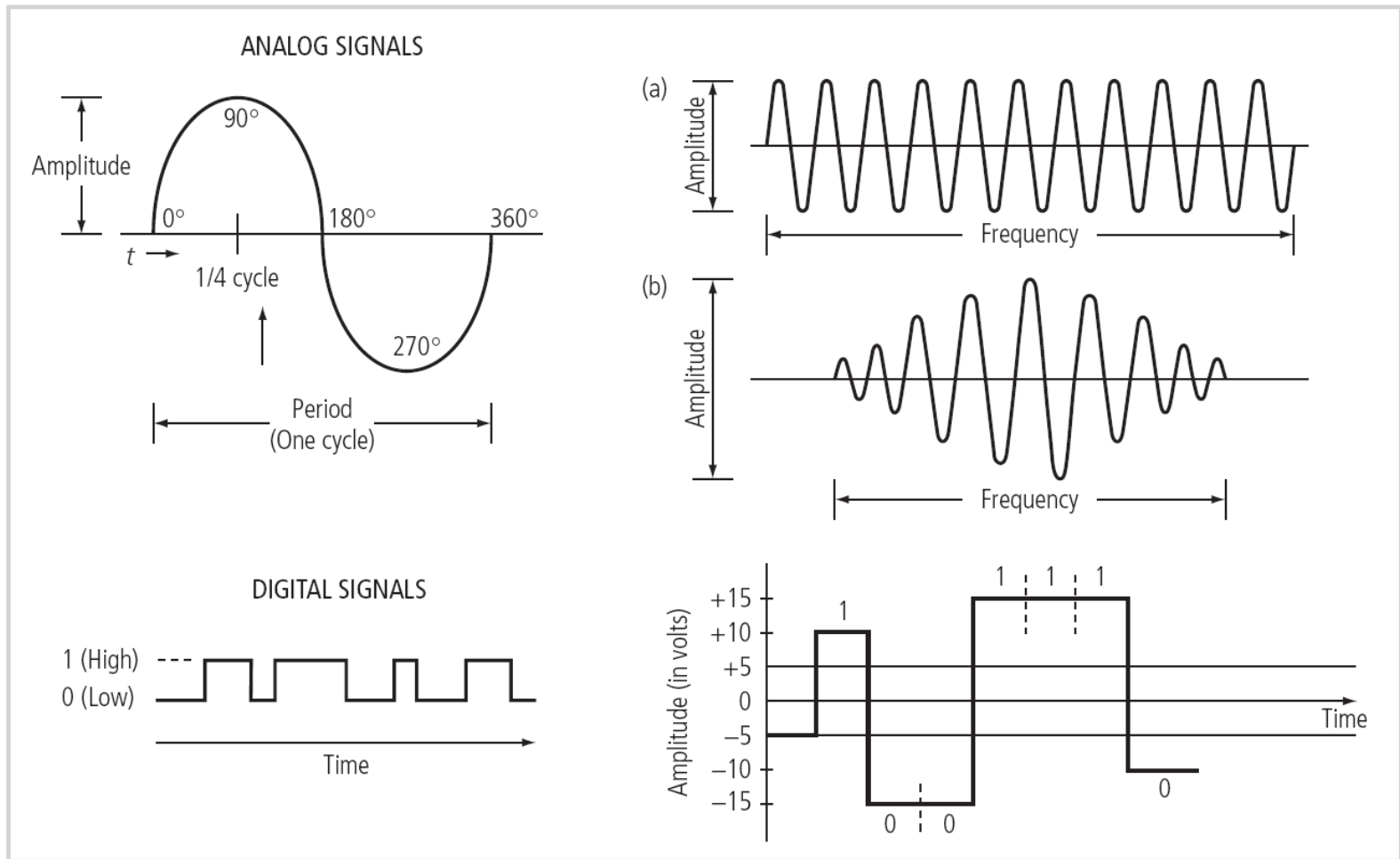
Figure 2-3 Analog and digital signals
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Getting the Message Across (cont'd.)

- Analog information on a digital medium
    - Pulse amplitude modulation is used
- Digital to analog
    - Amplitude shift keying
    - Frequency shift keying
    - Phase shift keying
- Digital to digital
    - Network interface card connects computer to its network
        - Modulates current into discrete voltage levels to encode binary data
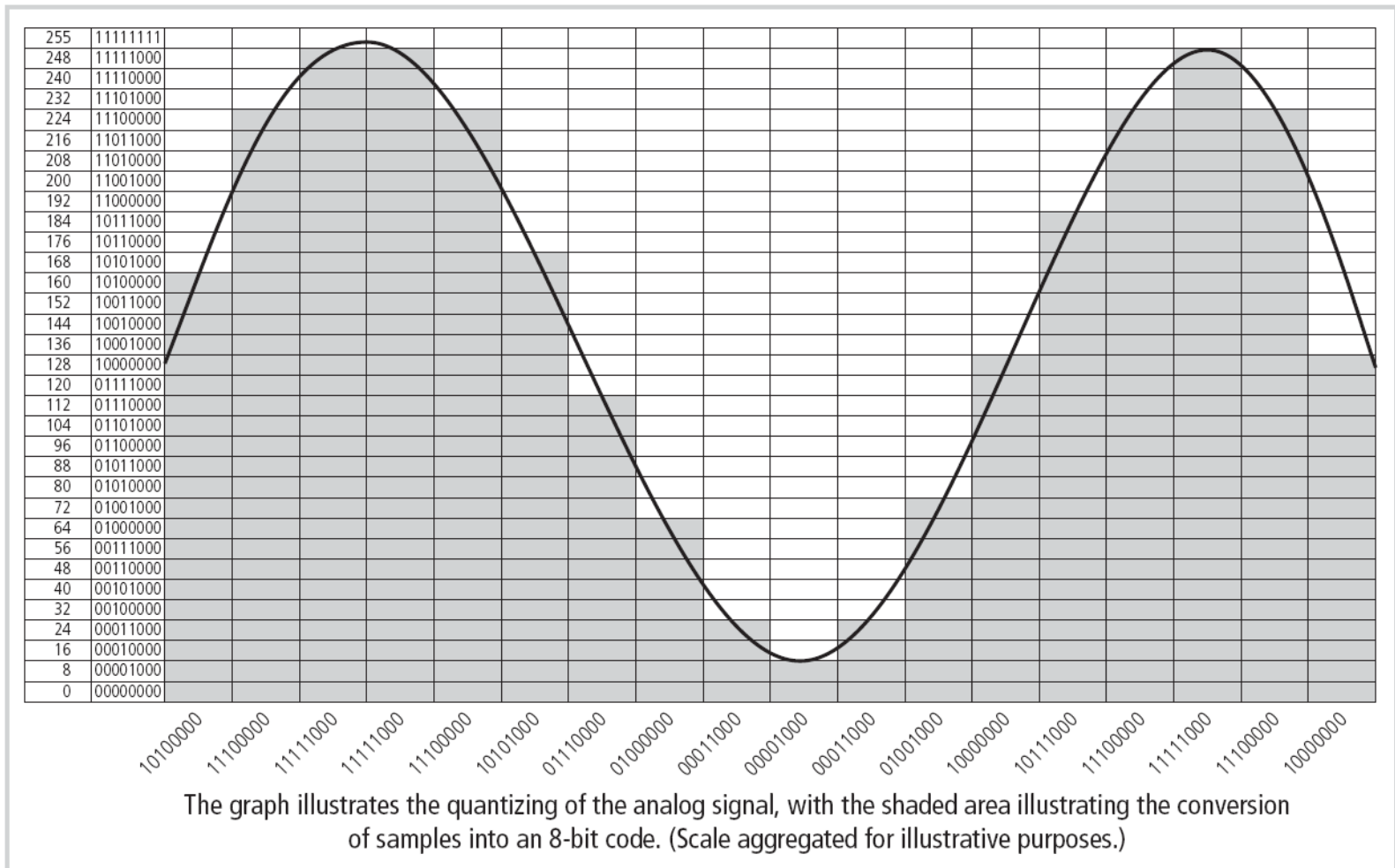
Figure 2-4 Digitization of voice signals by using PCM
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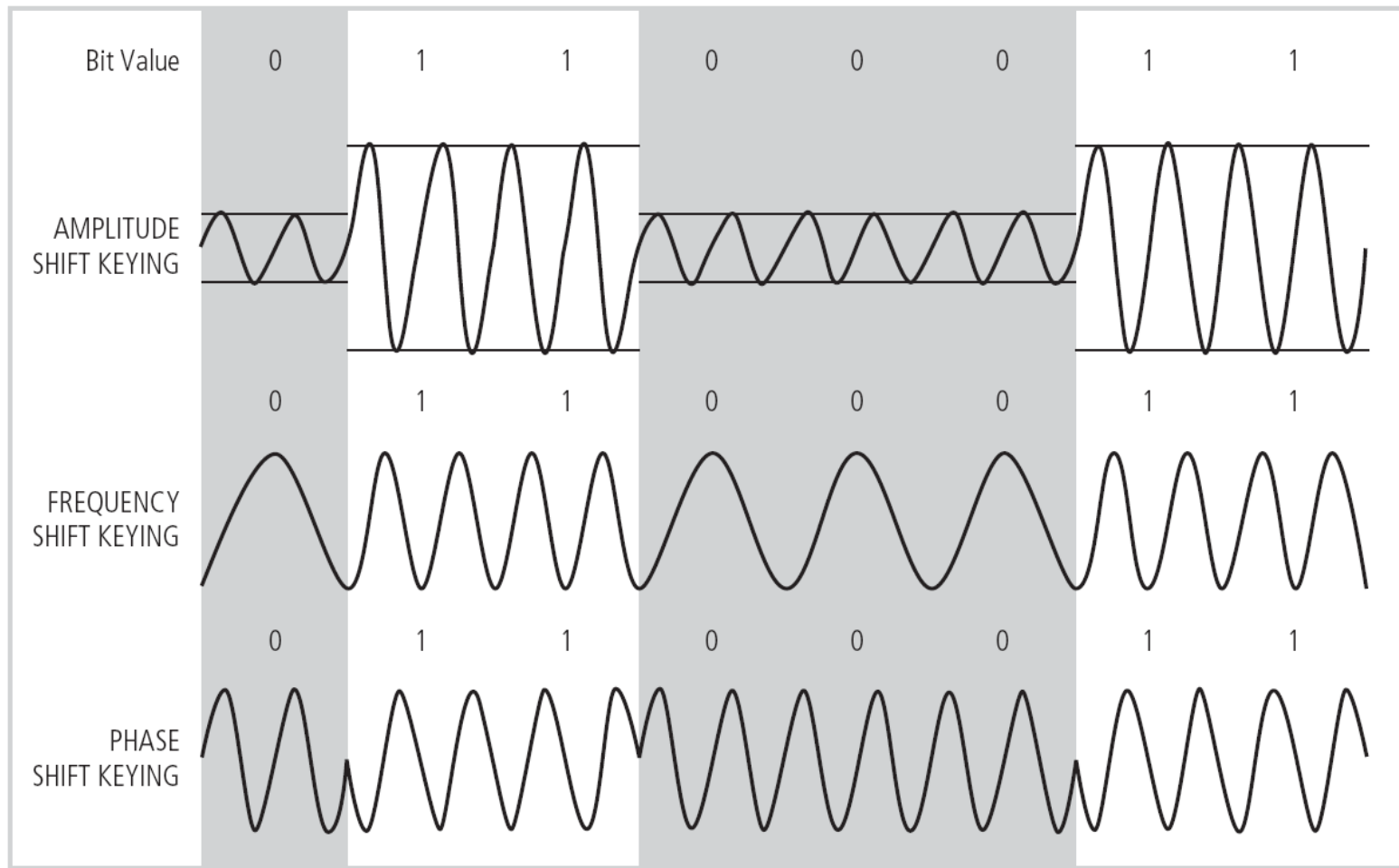
Figure 2-5 Shift keying
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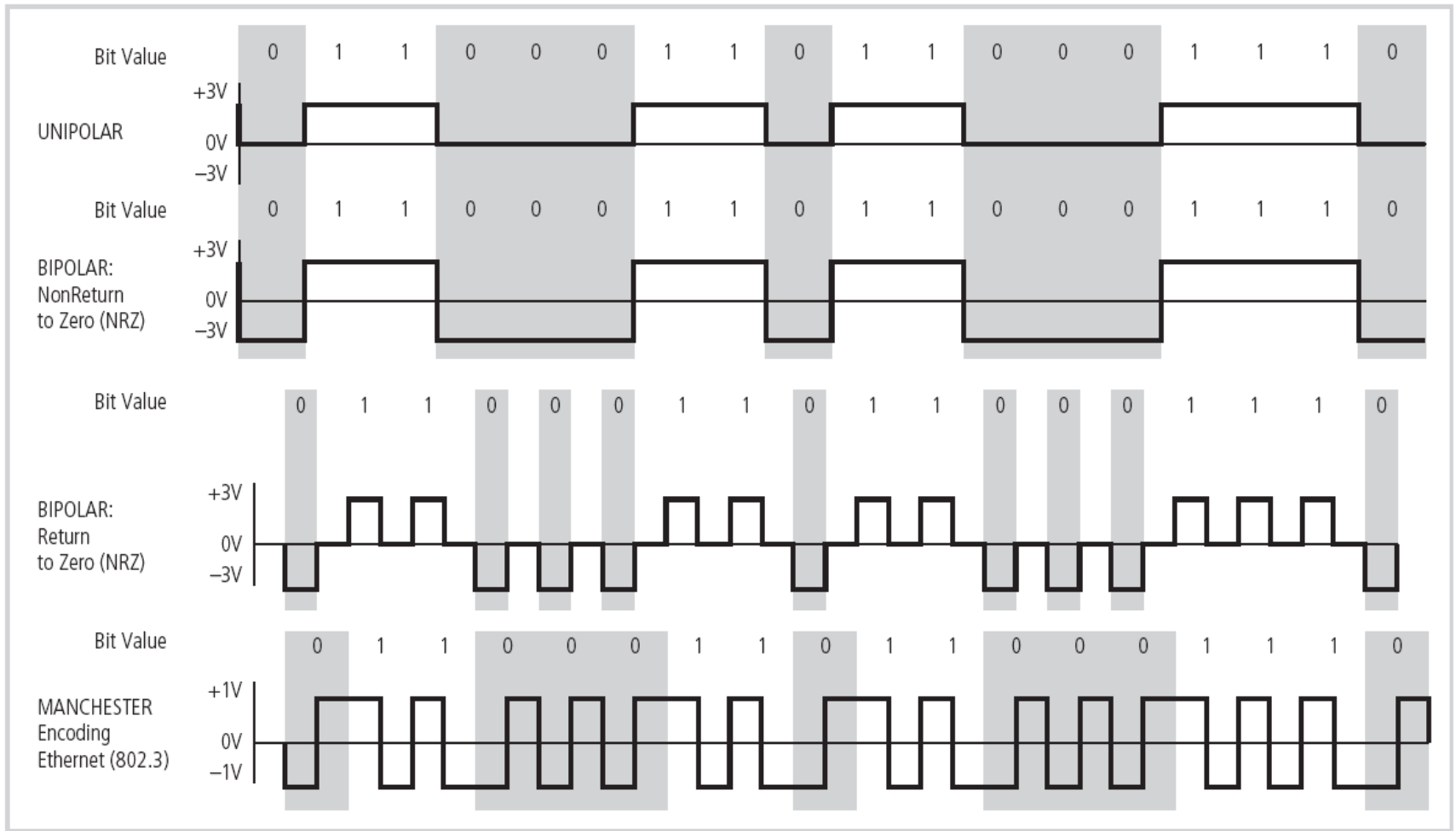
Figure 2-6 Digital communications
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Combining Multiple Signals

- Techniques to carry additional data over same media
  - Multi-bit encoding
  - Multiplexing
- Frequency division multiplexing
  - Used in analog communications to combine voice channels
- Time division multiplexing
  - Used in digital communications

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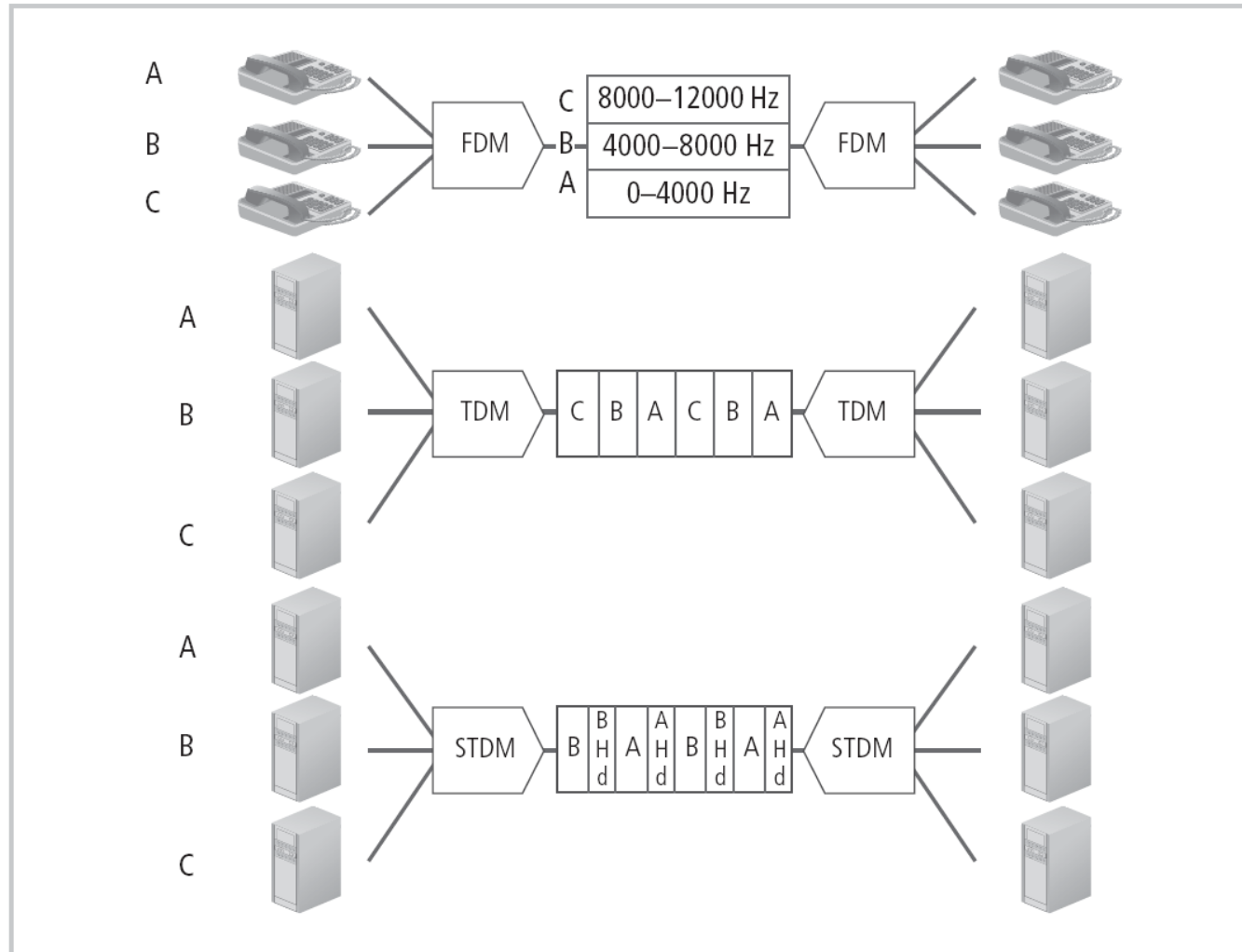
Figure 2-7 Multiplexing
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Combining Multiple Signals (cont'd.)

- Wave division multiplexing
  - Used in fiber-optic communications
  - Uses different colors of light to allow multiple signals to travel on same channel

Impedance to Communications

- Forms of interference (noise)
  - Attenuation
  - Crosstalk
  - Distortion
  - Echo
  - Impulse noise
  - Jitter
  - White noise

Types of Networks

- Network categorization
    - Components
    - Size
    - Layout (topology)
    - Media

Networks Categorized by Components

- Peer-to-peer (P2P) networks
  - Users may share hard drives, directories, or printers
  - Servant model
    - Music-sharing services
- Server-based networks
  - Uses dedicated system to provide specific services
- Distributed multi-server networks

Networks Categorized by Size

- Local area network (LAN)
  - Less than three miles of total cabling
- Metropolitan area network (MAN)
  - Covers region the size of a municipality, county, or district
- Wide area network (WAN)
  - Very large network
  - Covers large geographic region
    - State, country, and even the planet
  - Examples: public telephone network, and the Internet

Networks Categorized by Topology

- Topology
  - Pattern of association among network components
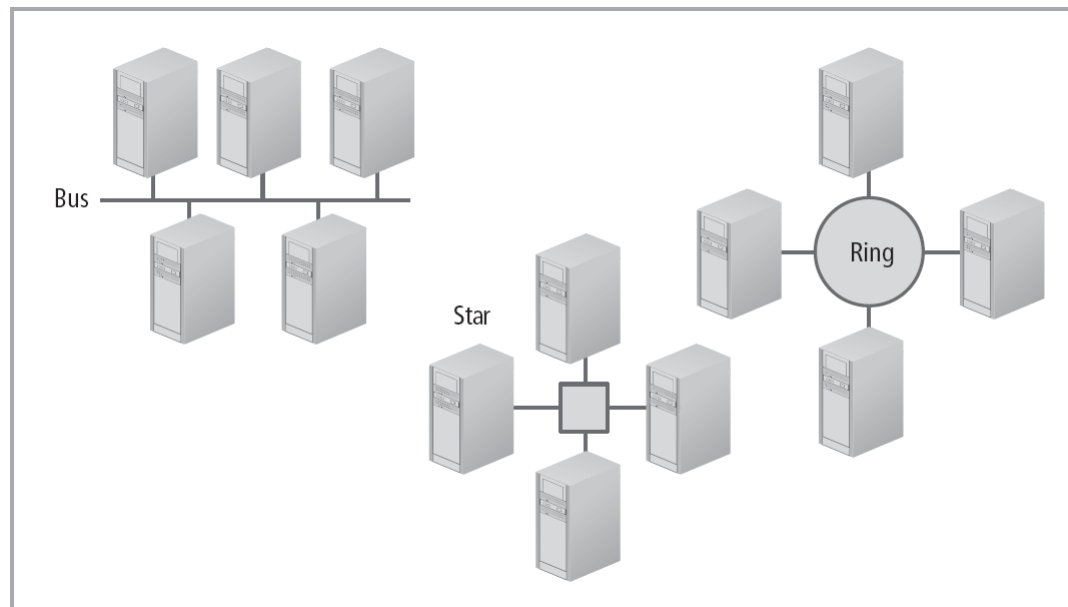
Figure 2-8 Physical network topologies
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Networks Categorized by Media

- Guided (wired)
  - Use electricity or light waves over cables
- Unguided (wireless)
  - Use radio or infrared electromagnetic energy

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Standards Organizations

- Protocols
  - Rules for communications
  - If widely accepted, they become standards
- Formal standards
  - De jure
  - Reviewed by a group of experts
  - Endorsed by a standards body
- Informal standards
  - De facto
  - Widely adopted without formal review

The Internet Society (ISOC)

- Formed in 1992

- Umbrella organization over:
  - Internet Engineering Task Force (IETF)
  - Internet Research Task Force (IRTF)
  - Internet Engineering Steering Group (IESG)
  - Internet Architecture Board (IAB)

Internet Assigned Numbers Authority (IANA)

- Originally part of the ISOC

- Coordinates domain names, IP addresses, protocols, and port assignments

- Transferred in recent years to ICANN (Internet Corporation for Assigned Names and Numbers)

American National Standards Institute (ANSI)

- Supervises creation and use of thousands of standards

- Standards affect companies and government agencies

  - Almost every sector of the economy

International Telecommunications Union (ITU)

- Principal agency of the United Nations for communication and information technologies

- Based in Geneva, Switzerland

- Focus for government interests and the private sector

- Facilitates communication in:
  - Radio communication
  - Calibration
  - Development

Institute of Electrical and Electronics Engineers (IEEE)

- Principal trade organization for technology advancement
- Active in many sectors
  - Computers and telecommunications
  - Electric power
  - Electronics
- Active among university students

Telecommunications Industry Association (TIA)

- Partnership among information, communications, and entertainment companies

- Role in policy development

- Standards published as dual standards with Electronics Industry Association (EIA)

  – Example: EIA/TIA T568A

International Organization for Standardization (ISO)

- Global leader in international standards
- Network of national standards bodies
  - 157 member countries
- Bridges gap between private and public sectors

OSI Reference Model

- Developed in 1978

- Dominant model for illustrating network functions

- Breaks down complex communication process
  - Seven distinct layers
  - Each layer has specific functions and protocols

OSI Model			
	Data Unit	**Layer**	**Function**
Host layers	Data	7. Application	Network process to application
		6. Presentation	Data representation and encryption
		5. Session	Interhost communication
	Segments	4. Transport	End-to-end connections and reliability (TCP)
Media layers	Packets	3. Network	Path determination and logical addressing (IP)
	Frames	2. Data Link	Physical addressing (MAC & LLC)
	Bits	1. Physical	Media, signal, and binary transmission

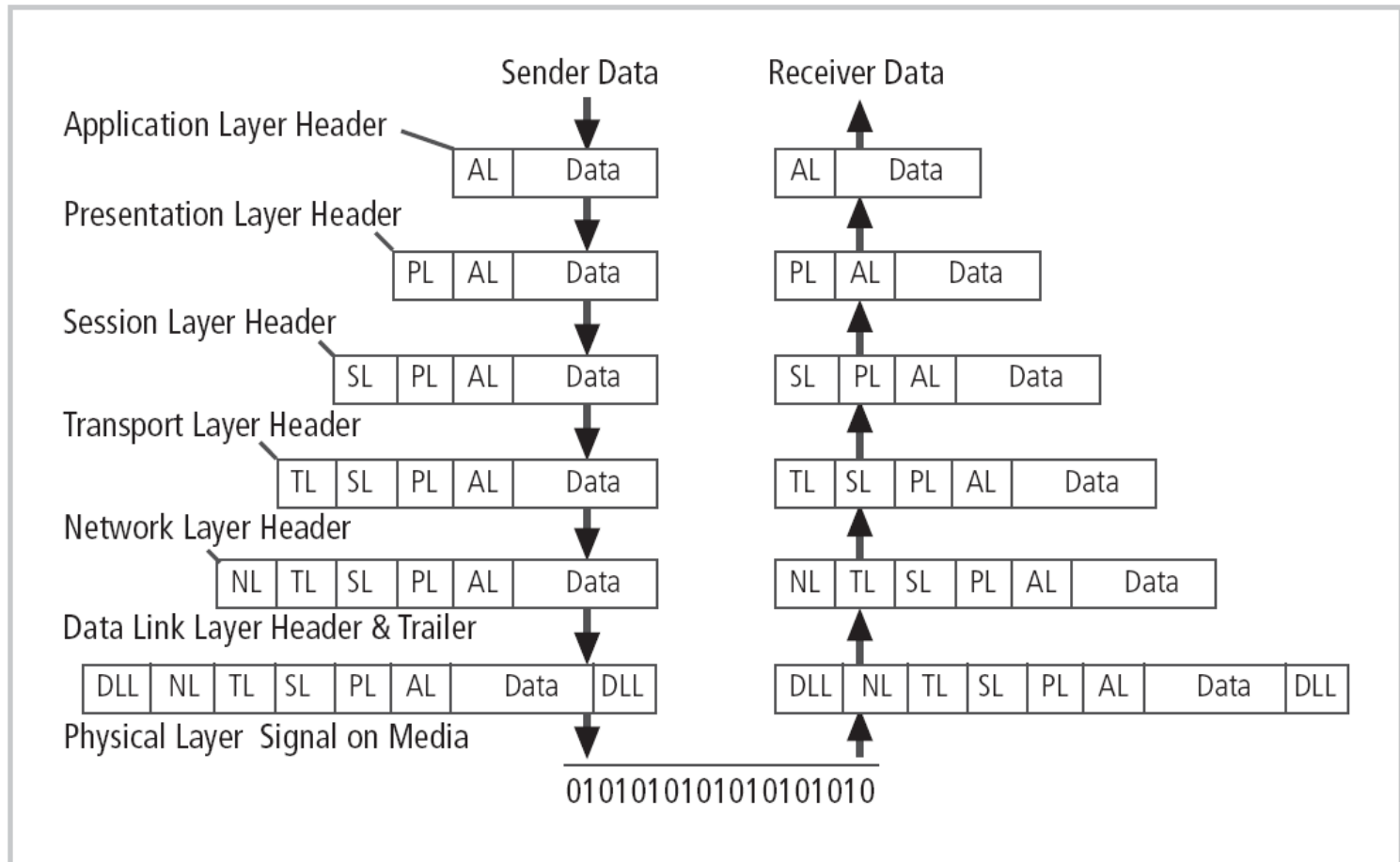Figure 2-9 ISO OSI reference model
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Figure 2-10 OSI reference model in action
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Physical Layer

- Function: to place transmission signal onto media
- Primary functions and services
  - Establish and terminate the physical and logical media connections
- Dominant media types
  - Twisted pair wire
  - Coaxial cable
  - Fiber-optic cable
  - Wireless LAN

Physical Layer (cont'd.)

- Dominant media types (cont'd.)
  - Bluetooth
  - Infrared
- Physical layer networking devices
  - Hub (simplest connection)
- Physical layer security
  - Protect media from unauthorized interception

Data Link Layer

- Primary layer for networking support
- Called the first subnet layer
- Provides addressing, packetizing, media access control, error control, some flow control
- DLL layers
  - Logic link control sublayer
  - Media access control sublayer

Data Link Layer (cont'd.)

- DLL protocols
  - Ethernet
  - Wireless Ethernet
  - Token ring
  - Fiber distributed data interface
  - Asynchronous transfer mode
  - Frame relay
  - PPP, PPTP, L2TP

Data Link Layer (cont'd.)

- Packet framing
  - DLL converts network layer packet into DLL frame
  - DLL adds header and trailer components

Figure 2-15 Ethernet II frame
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Data Link Layer (cont'd.)

- Addressing
  - Accomplished by a number embedded in the NIC
    - Known as MAC address or hardware address
    - Uniquely identifies the client system
    - Allows packets to be delivered to an endpoint
- Media access control
  - Control of traffic flow
  - Two approaches:
    - Deterministic and contention

Network Layer

- Key functions
  - Packetizing
    - Organizes segments from Transport layer into packets
    - Packets consist of header and data
  - Addressing
    - Dotted decimal notation commonly used
  - Routing
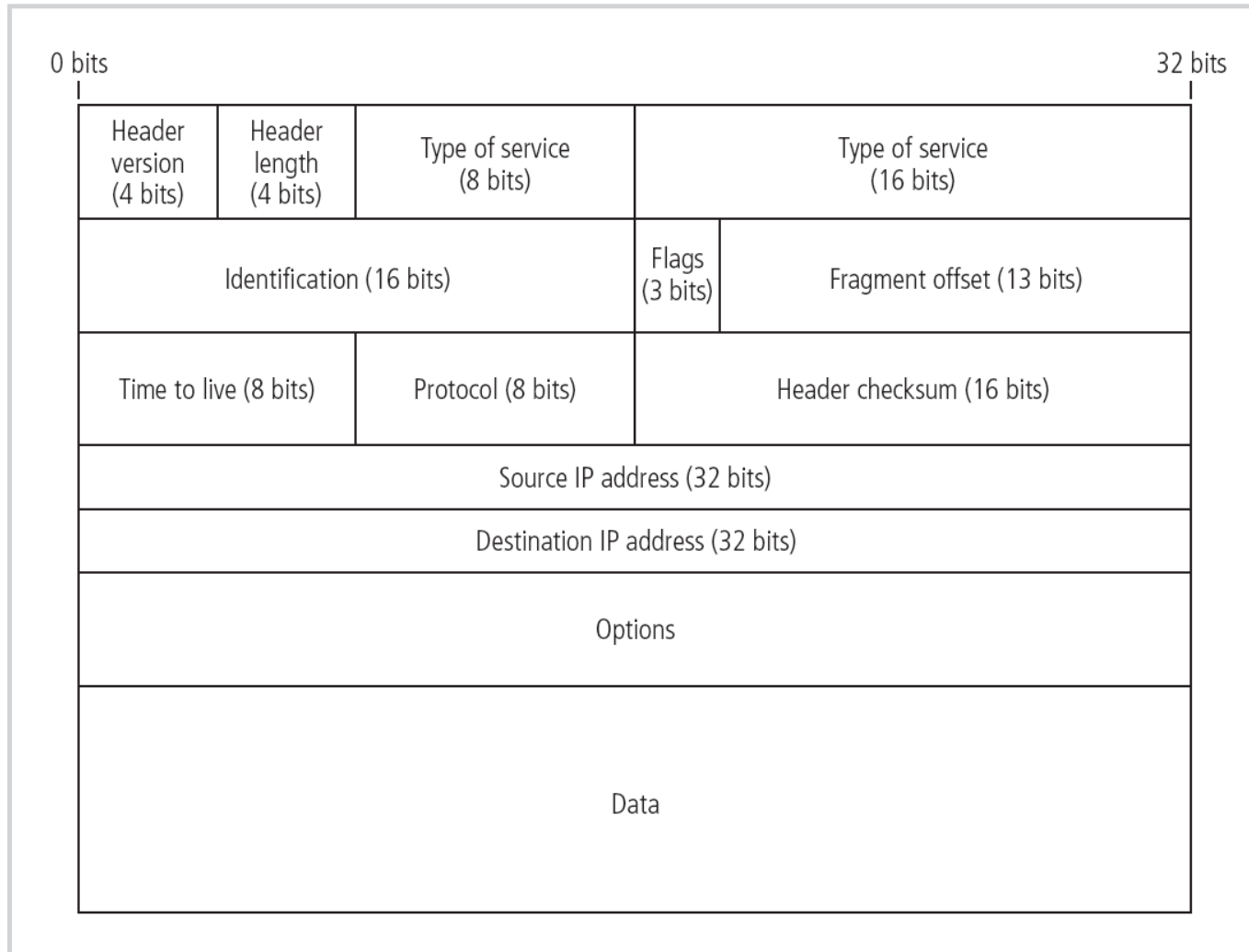   - Process of moving a network layer packet across multiple networks

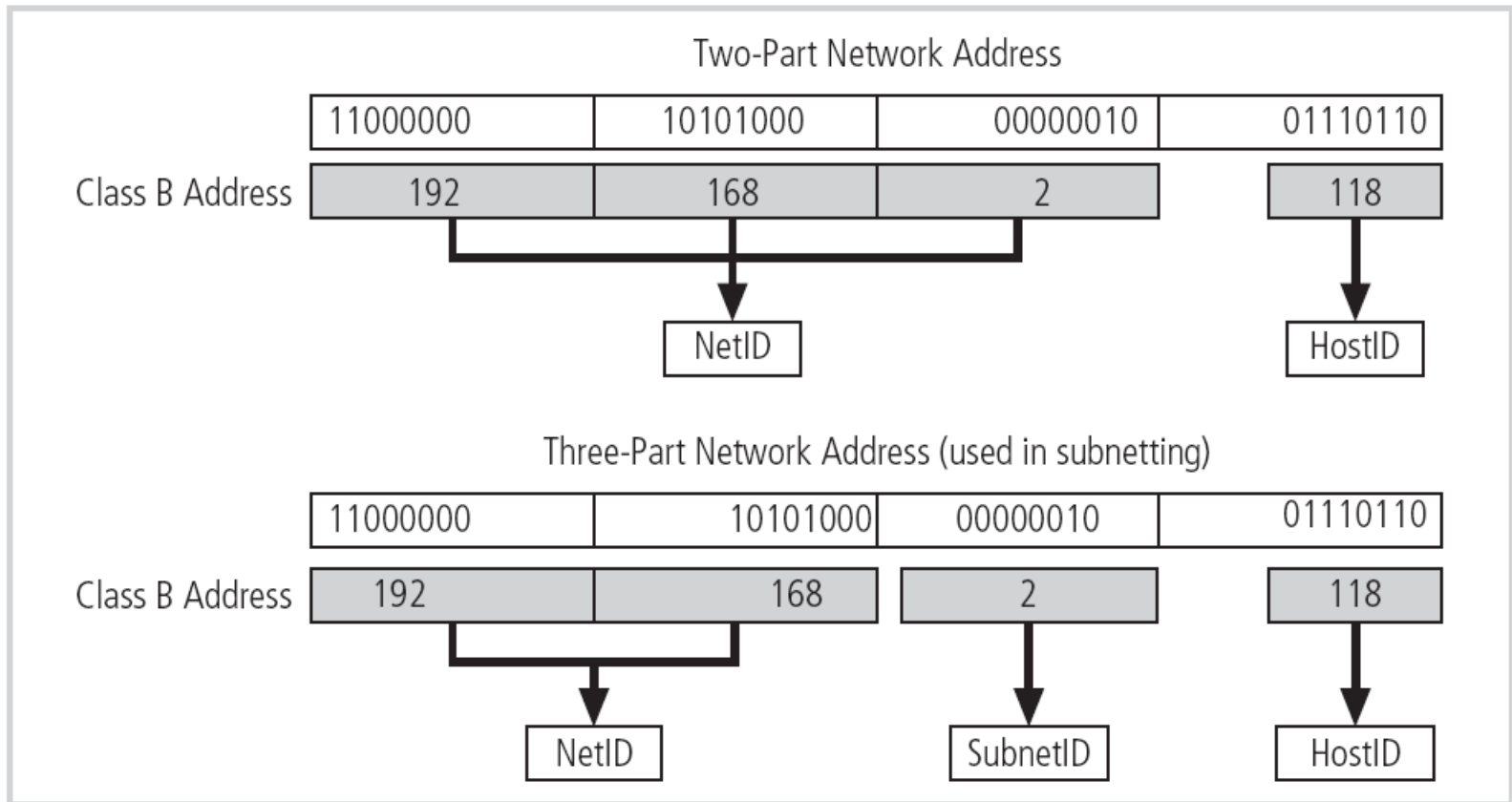Figure 2-16 IP packet
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Two-Part Network Address

11000000	10101000	00000010	01110110

Class B Address

192	168	2	118

NetID

HostID

Three-Part Network Address (used in subnetting)

11000000	10101000	00000010	01110110

Class B Address

192	168	2	118

NetID

SubnetID

HostID

Figure 2-17 IP addresses
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Transport Layer

- Provides reliable transfer of data between user applications

- Error control

  - Process of handling problems with the transfer process

- Error correction

  - Commonly done through retransmission of damaged segment

- Flow control

  - Prevents receiver from being overwhelmed with segments

Session Layer

- Establishes, maintains, terminates communication sessions between systems
  - Simplex
  - Half-duplex
  - Full-duplex
- Session layer security
  - TCP/IP does not have an explicit session layer
  - DNS has inherent weaknesses

Presentation Layer

- Responsible for data translation and encryption
- Presentation layer security
  - No direct counterpart in the TCP/IP protocol
  - Virtual private networks work at this layer
  - Encryption-oriented attacks affect this layer

Application Layer

- Provides users with services to exchange information

  – TCP/IP protocol suite

    - Applications include e-mail (SMTP and POP), the World Wide Web (HTTP, HTTPS) and file transfer (FTP, SFTP)

- Computer program still needed to access features of protocols

The Internet, WWW, and TCP/IP

- The Internet
  - Used by over 2 billion people as of March, 2011
- The World Wide Web
  - Set of applications that runs on top of the Internet
  - Uniform resource locators (URLs) allow creation and retrieval of information
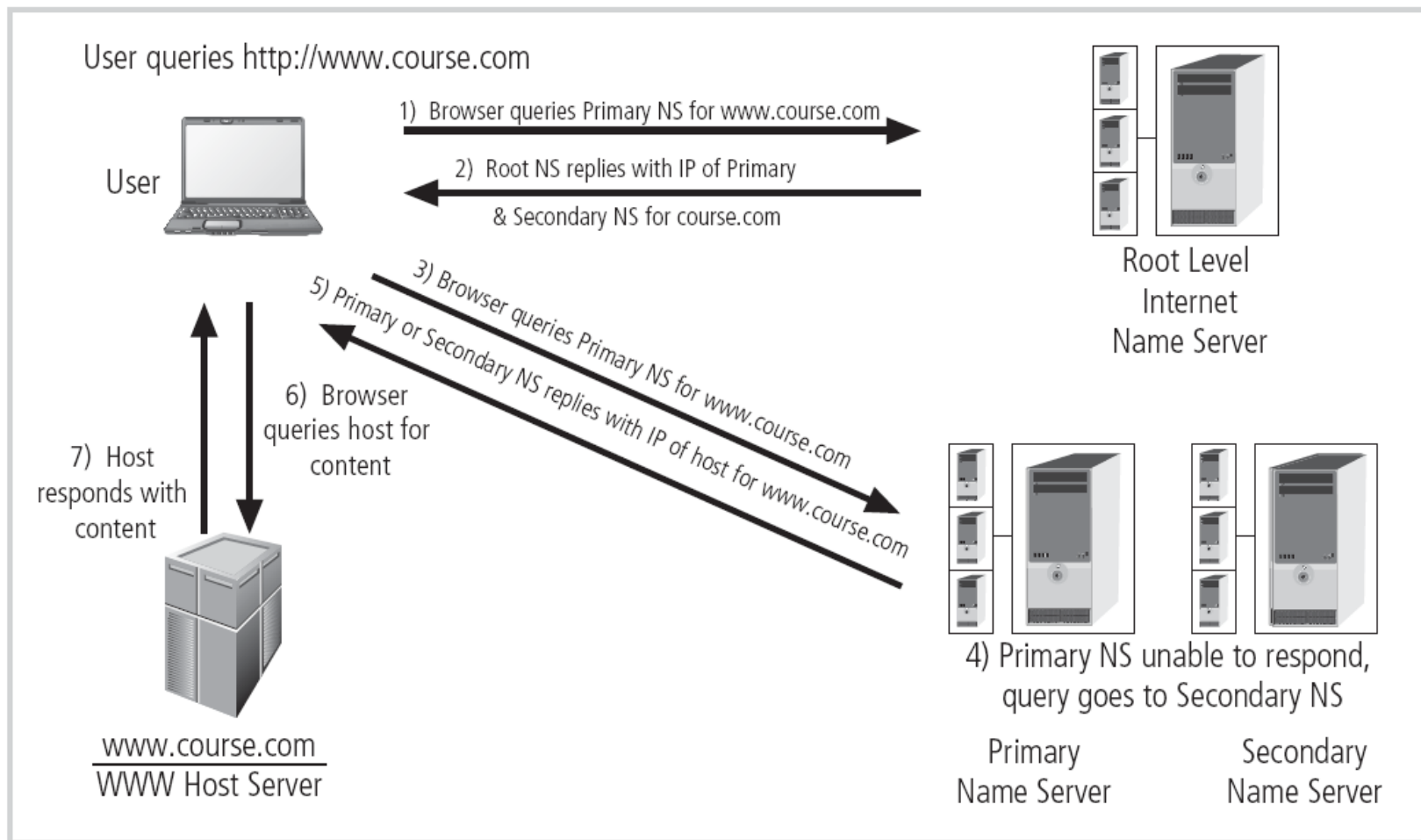 - Works through Web browsers

Figure 2-24 How DNS works
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TCP/IP

- Suite of protocols used to facilitate Internet communication

- Developed prior to the OSI reference model
  - Less formal

- Four layers
  - Application layer
  - Transport or host-to-host layer
  - Internet layer
  - Link or network interface layer

Summary

- Communication occurs when the recipient can receive, process, and comprehend a message
- Data communications is the exchange of messages across a medium
- Networking is the interconnection of various groups or systems
  - Purpose: exchange information
- Several standards organizations exist
  - Examples of data communication standards agencies: ISOC, ANSI, ITU, IEEE, TIA, and ISO