

# 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

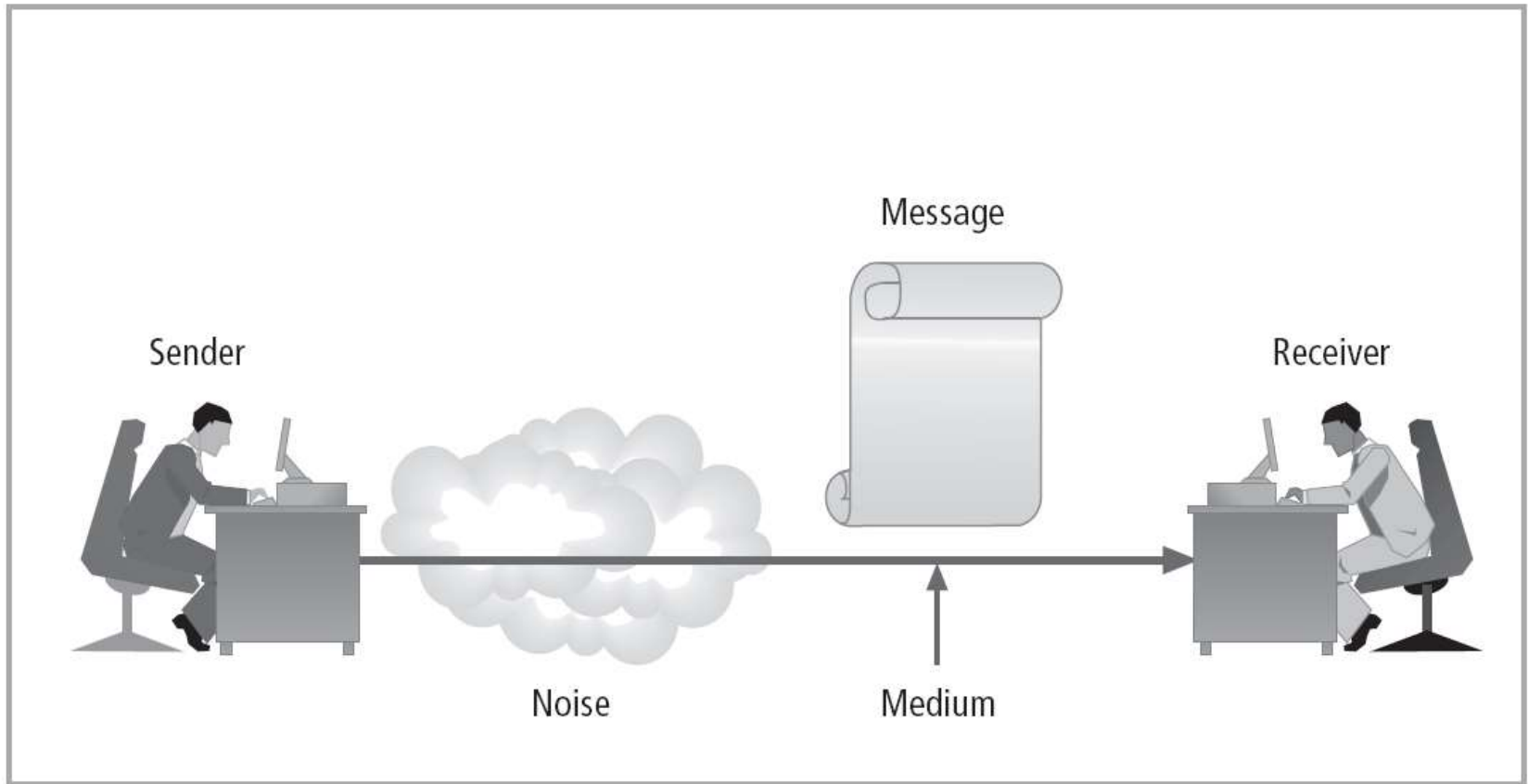


Figure 2-1 Basic communications model  
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# Reasons to Network

- 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

# 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







Signal Type Data Type	    Analog                      Digital	
Analog (i.e., Voice)	Analog to Analog AM FM PM	Analog to Digital PAM PCM ADPCM
01010101	Digital to Analog ASK FSK PSK	Digital to Digital RZL NRZL Bipolar/Unipolar Manchester Differential Manchester
Digital (i.e., Computer)		

Figure 2-2 Data-to-signal modulation  
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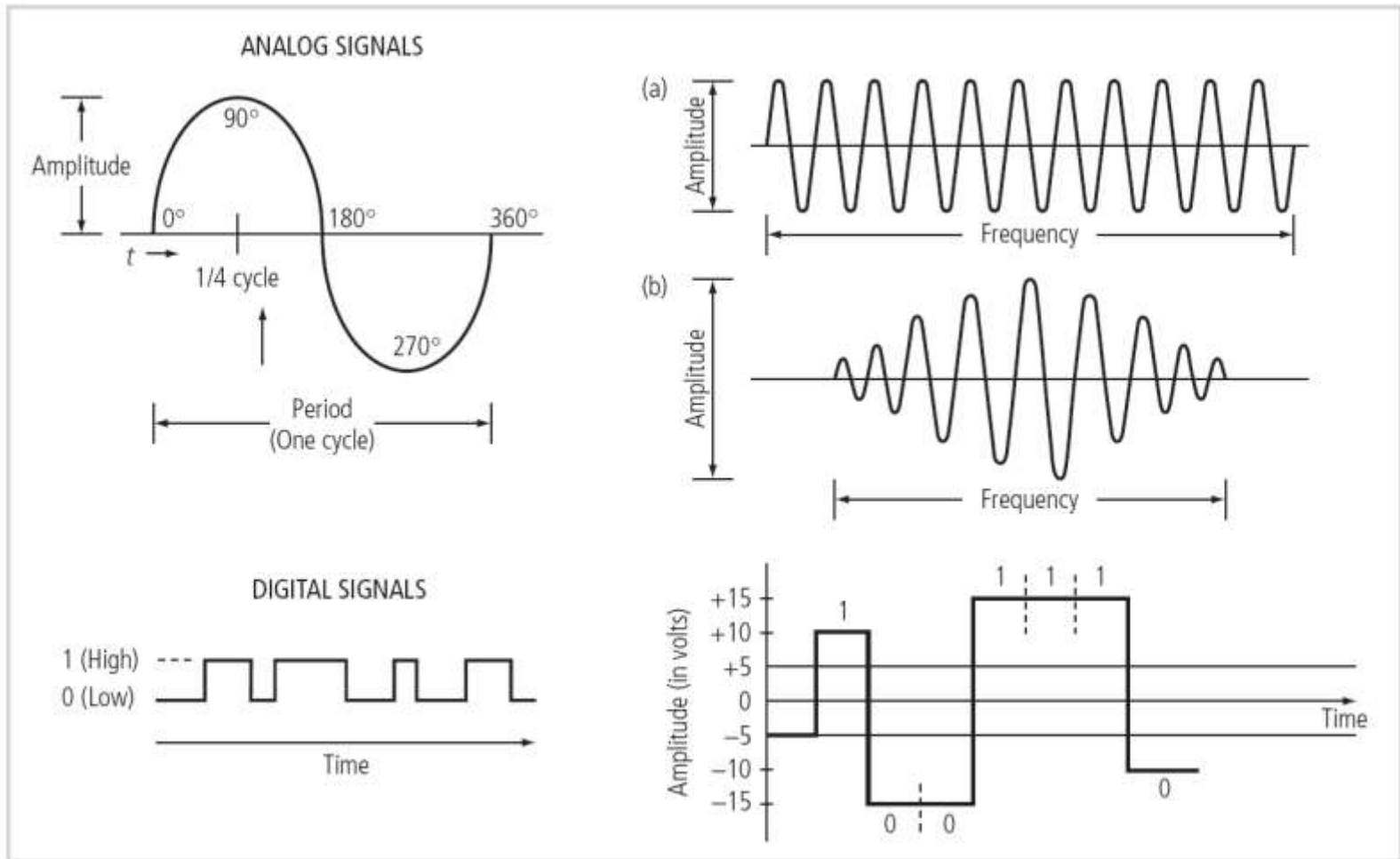


Figure 2-3 Analog and digital signals  
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# Getting the Message Across (cont'd.)

- 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

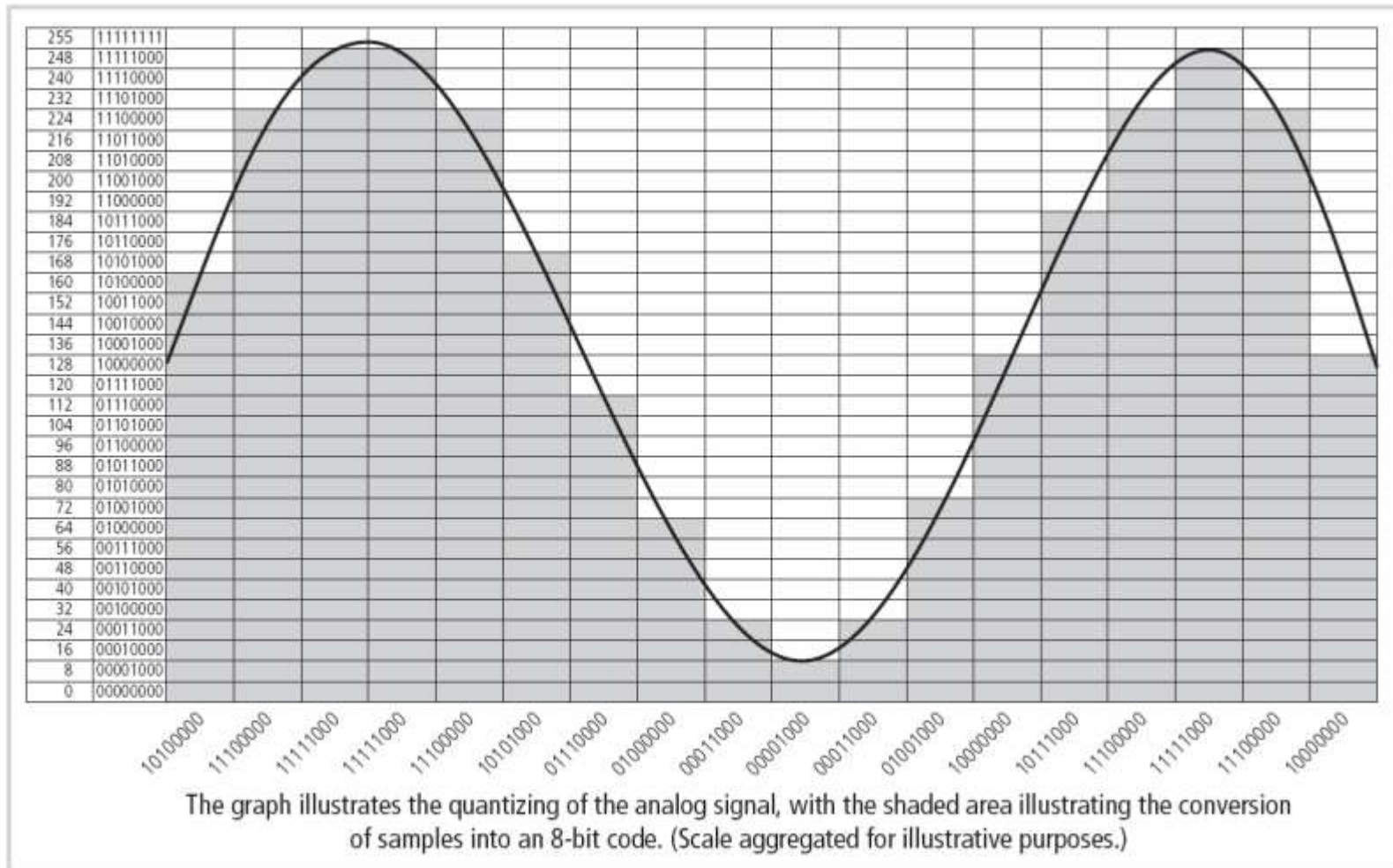


Figure 2-4 Digitization of voice signals by using PCM  
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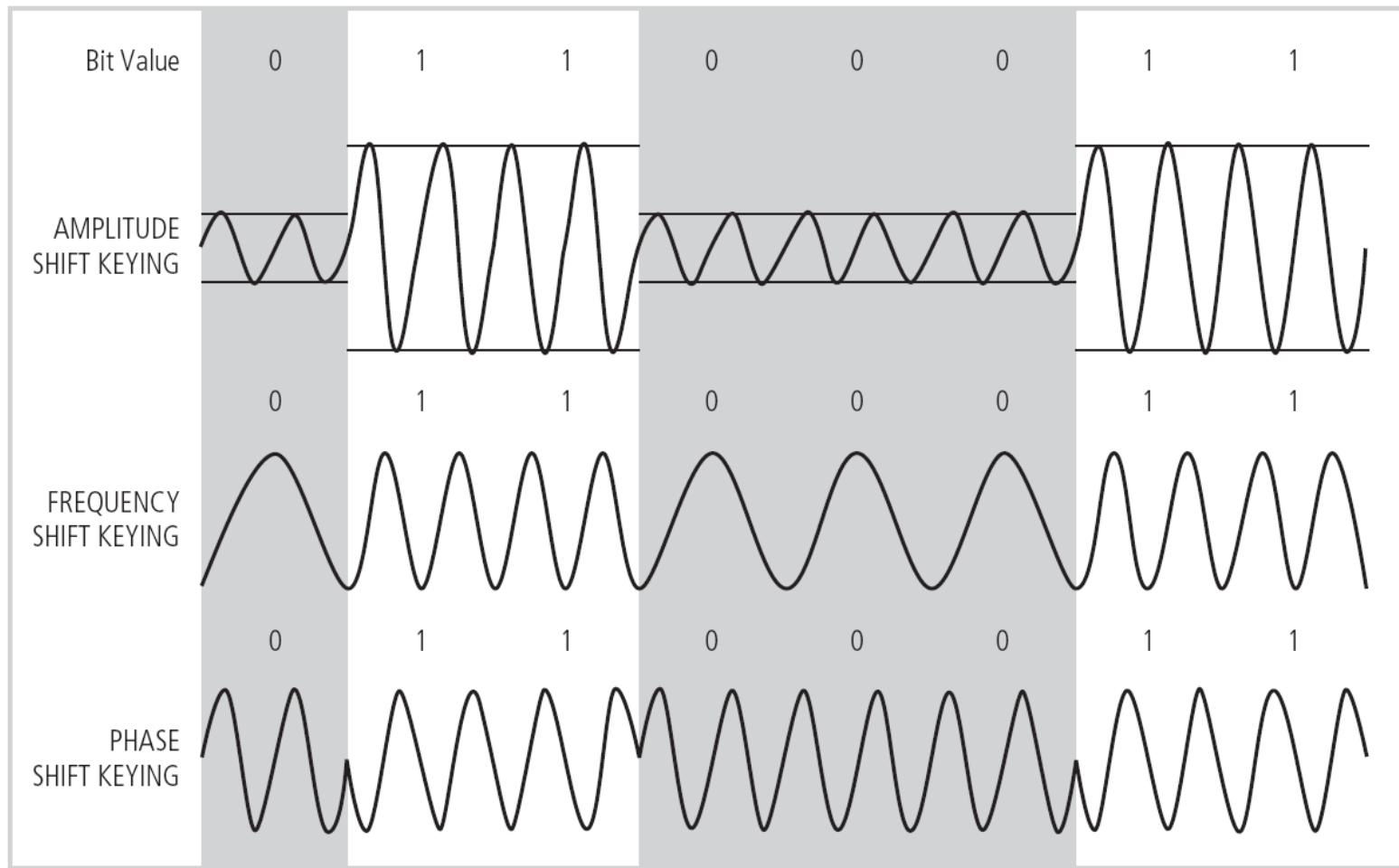


Figure 2-5 Shift keying  
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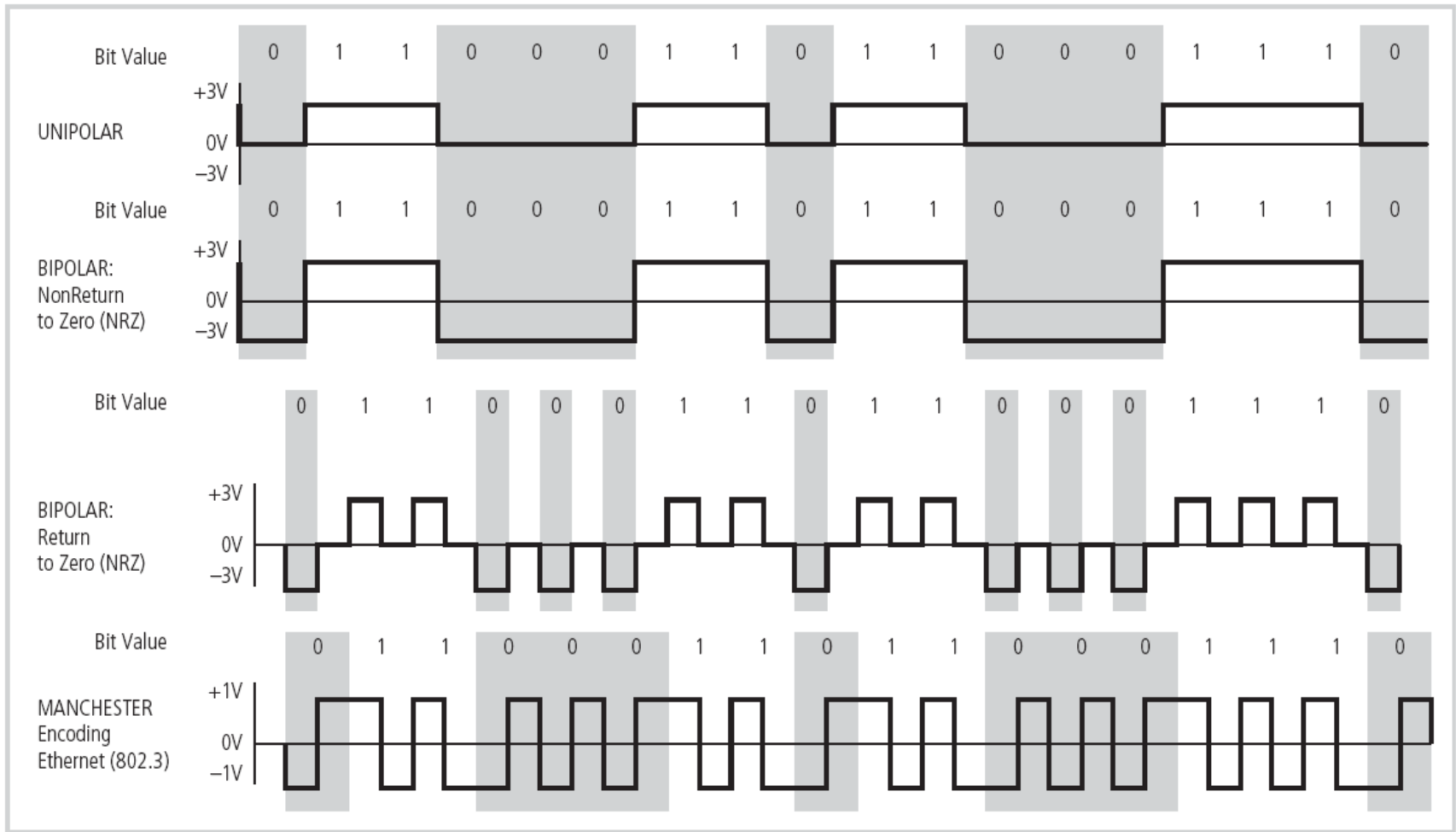


Figure 2-6 Digital communications  
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# Combining Multiple Signals

- 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

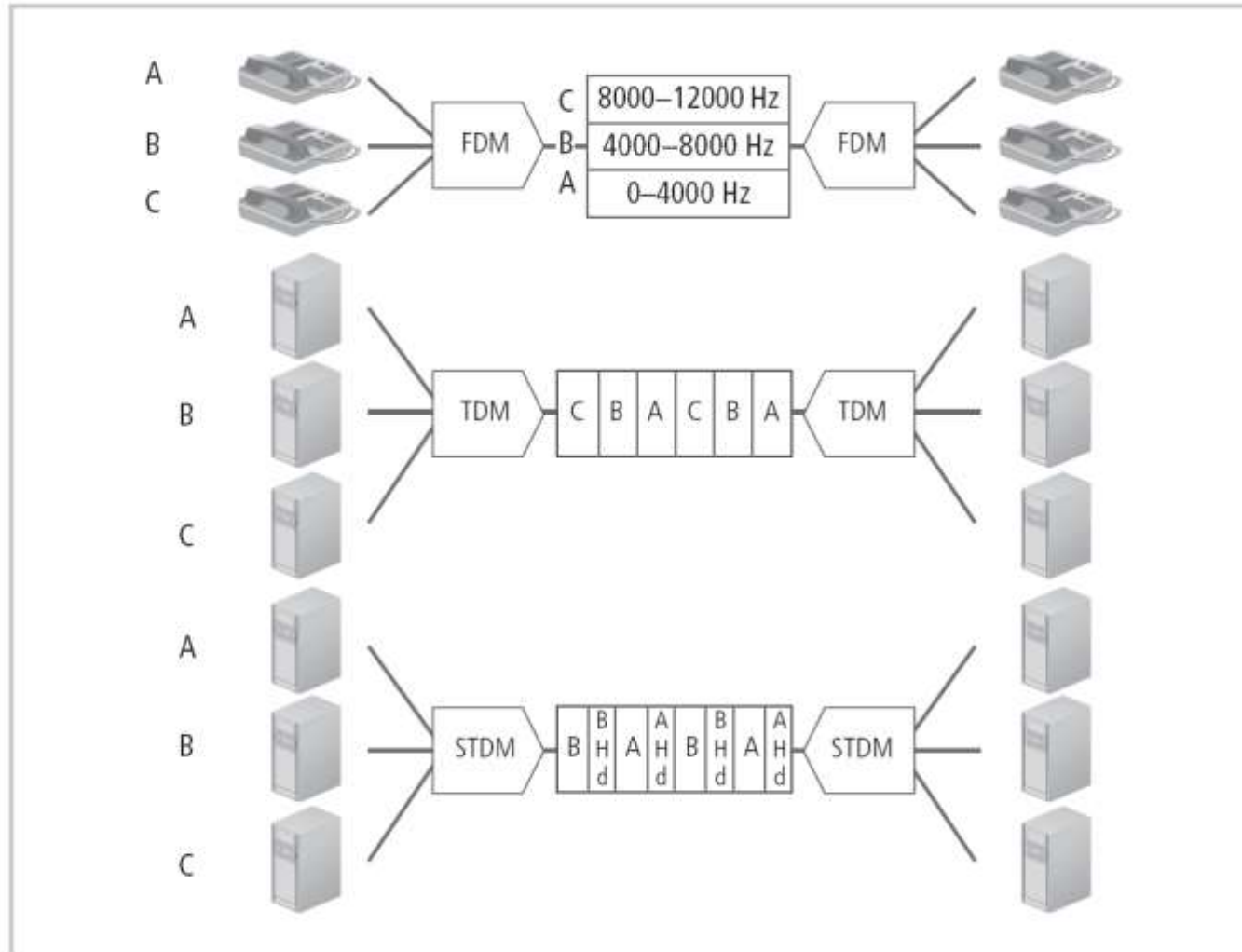


Figure 2-7 Multiplexing  
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# Combining Multiple Signals (cont'd.)

- 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

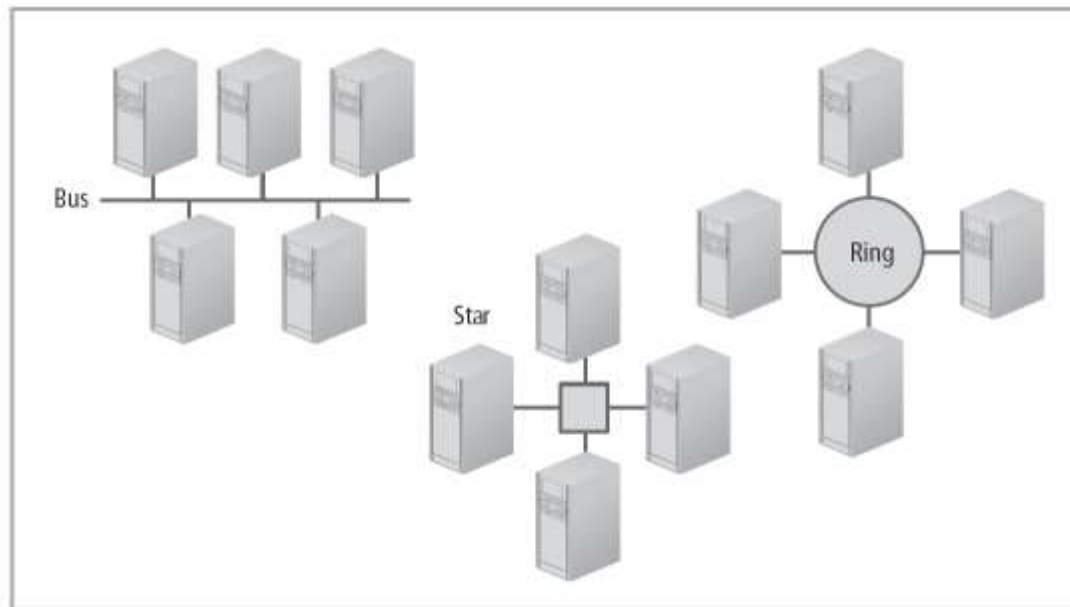


Figure 2-8 Physical network topologies  
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# Networks Categorized by Media

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

# 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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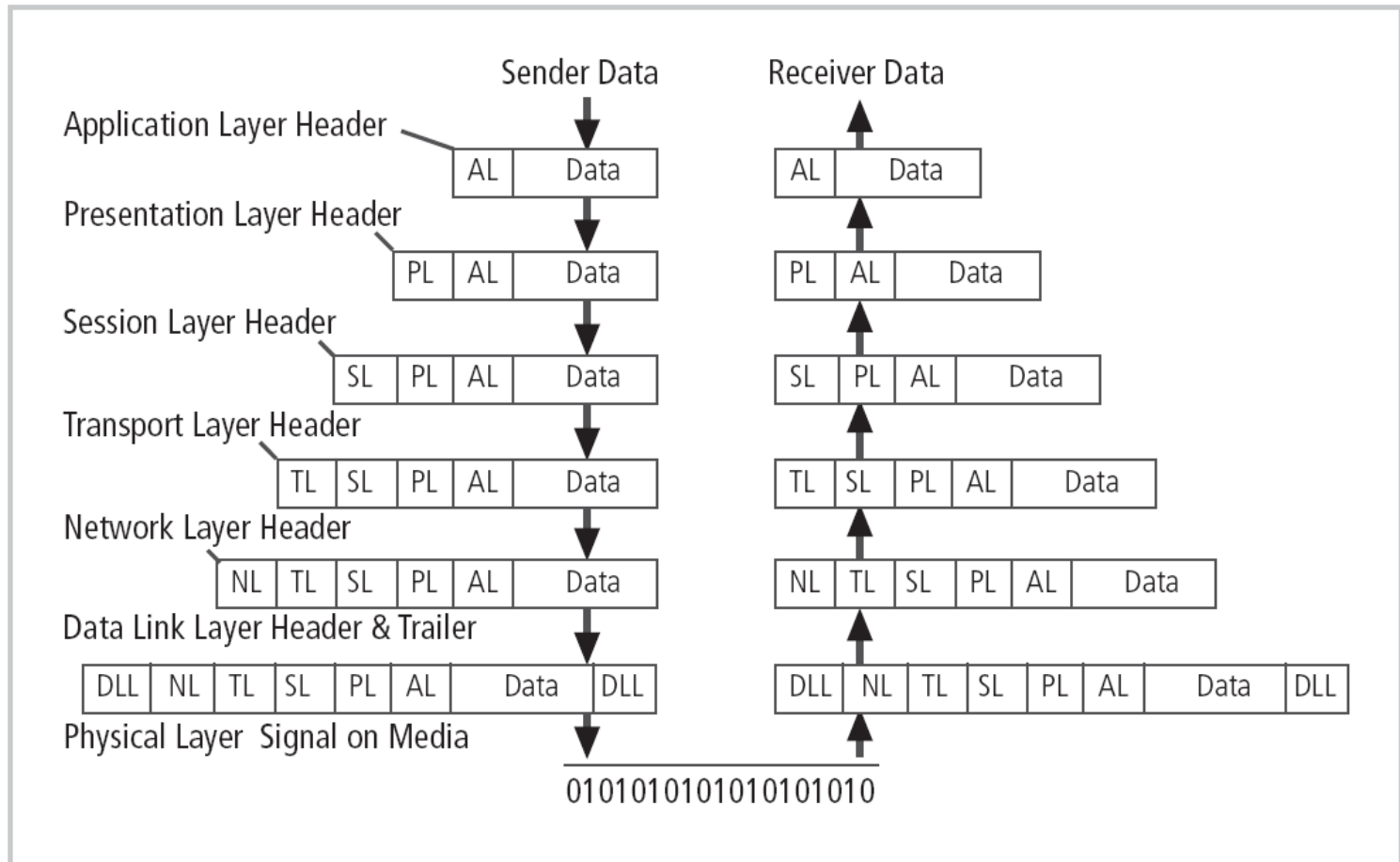


Figure 2-10 OSI reference model in action  
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# Physical Layer

- 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

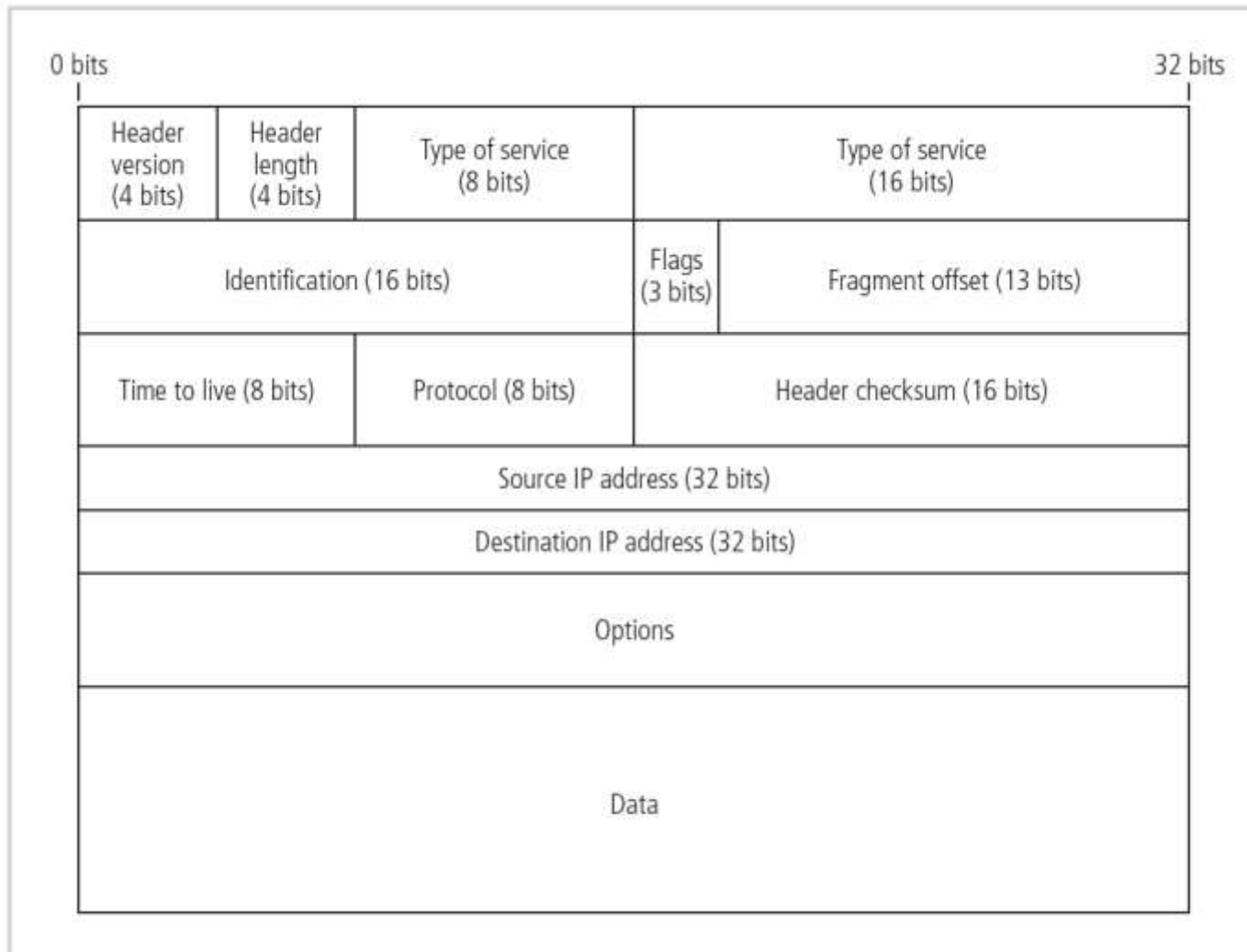


Figure 2-16 IP packet  
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# Transport Layer

- 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



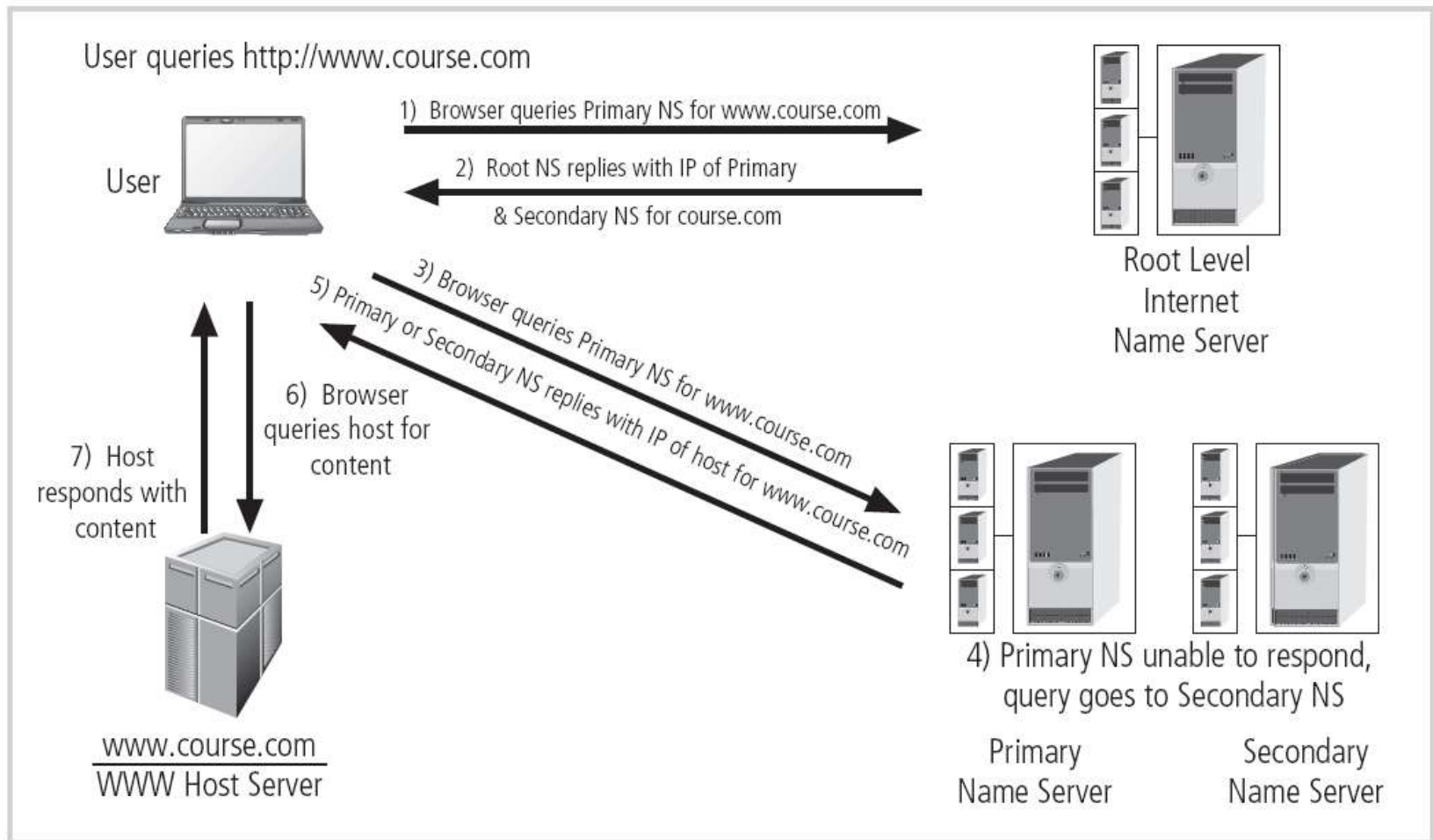


Figure 2-24 How DNS works  
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# TCP/IP

- 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