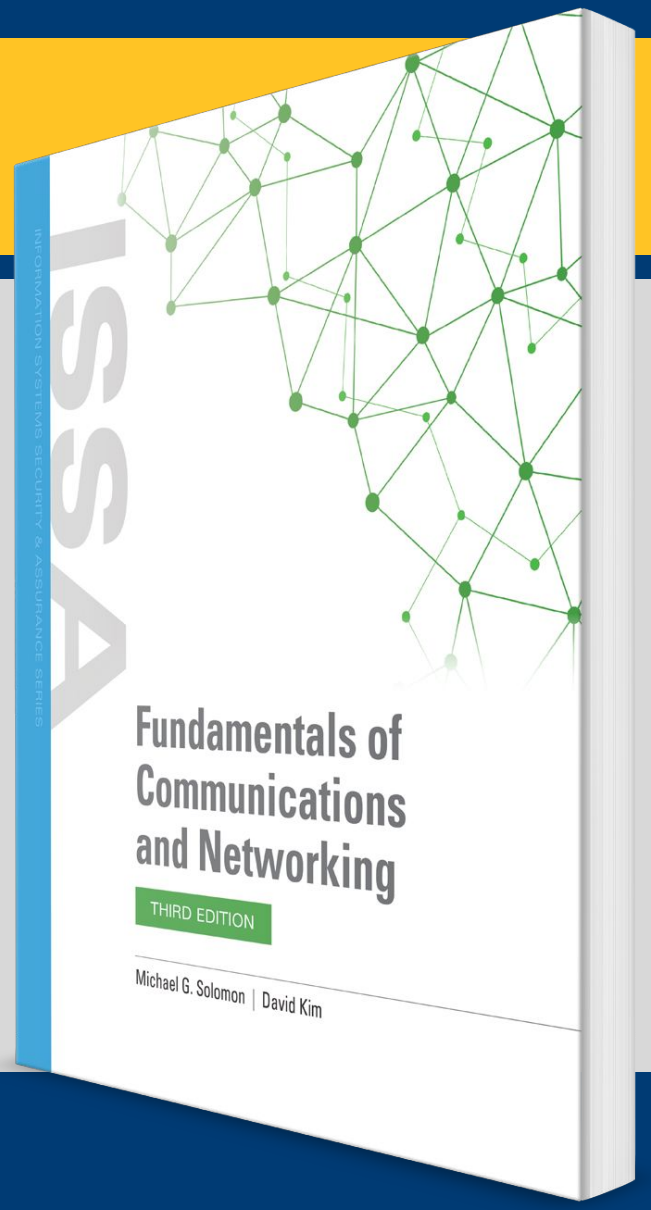
CHAPTER 4

The Physical and Data Link Layers



Learning Objective(s) and Key Concepts

Learning Objective(s)

- Differentiate between the standards, specifications, technologies, and infrastructure that drive current LAN connectivity.

Key Concepts

- The IEEE 802.3 standard and specifications
- The Physical Layer and Data Link Layer
- Structured wiring and internetworking Ethernet LANs
- Designing Ethernet networks for workgroups, buildings, campuses, and metropolitan area networks
- GigE and 10 GigE specifications, and backbone trunking

Physical Layer and Data Link Layer

Physical Layer

- Where the signaling of 1's and 0's occurs
- Where cabling and other transmission media is needed to transit them

Data Link Layer

- Defines the frame format that the 1's and 0's are to follow

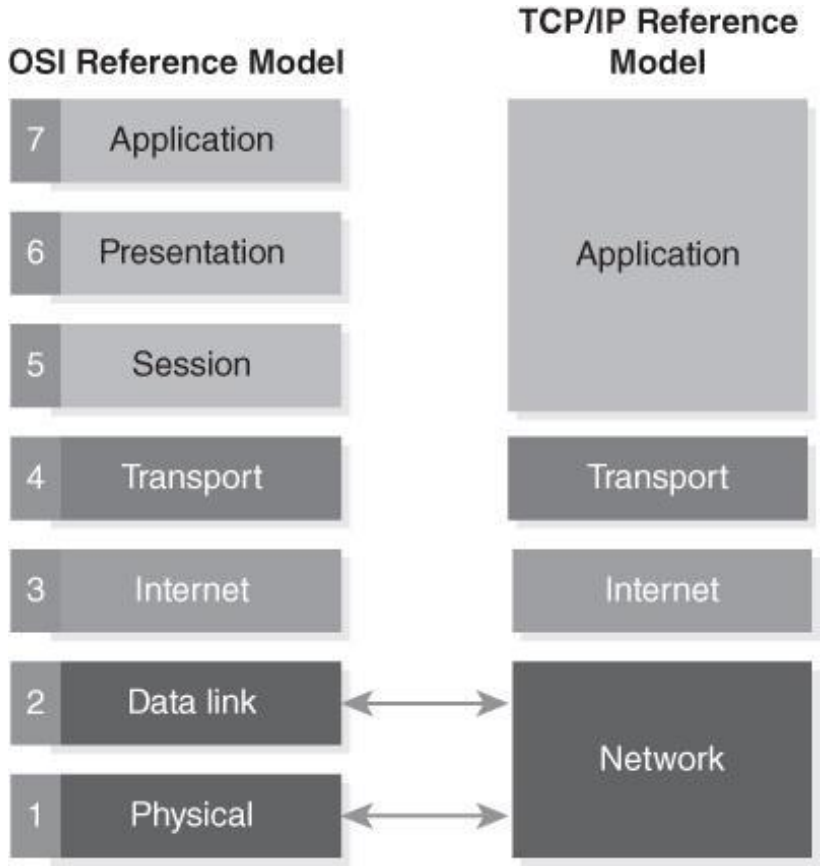


FIGURE 4-1 OSI model compared to TCP/IP model.

OSI Model Compared to TCP/ IP Model

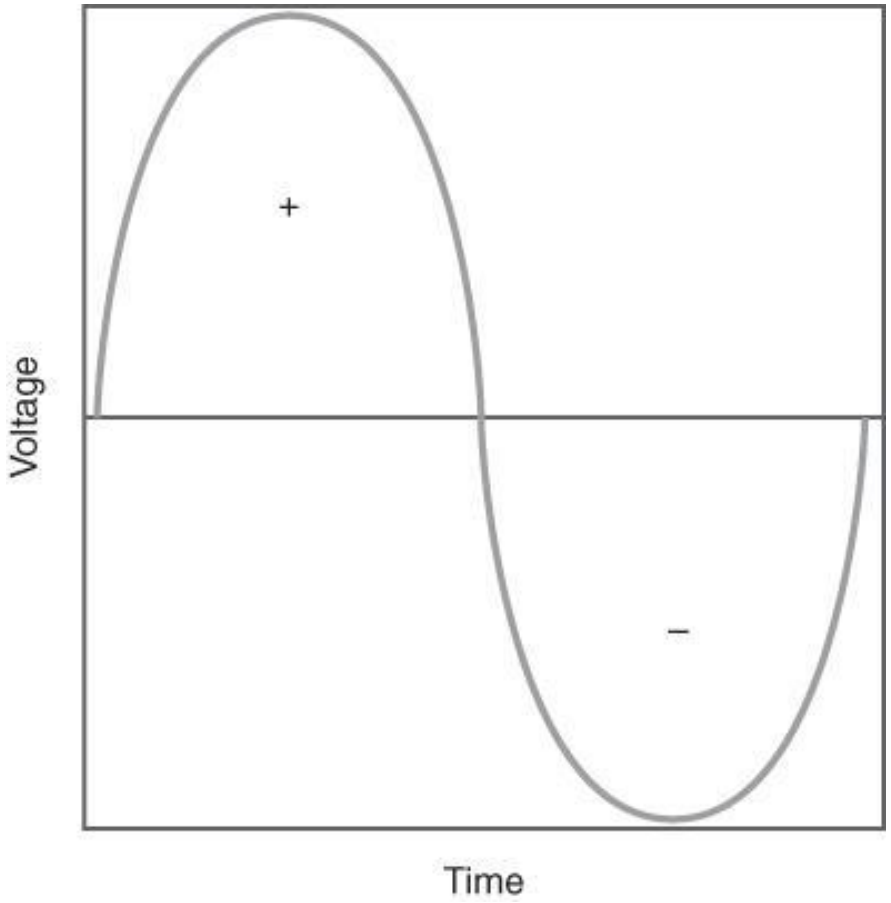


FIGURE 4-2 A sine wave.

Physical Layer: OSI Layer 1

- Operates at the bottom layer (Layer 1) of the Open Systems Interconnection (OSI) Reference Model
- **Reliability** is the availability and integrity of the data transmission
- **Availability** refers to uptime—whether there is physical link access to the communication line
- **Integrity** refers to whether the data (the 1's and 0's) made it to the destination intact and accurate
- Transmission medium can be air (radio frequency), metal (copper unshielded twisted-pair, shielded twisted-pair, or coaxial cable), or glass (optical fiber)

Transmission Media

Copper

- Used in unshielded twisted-pair (UTP) and shielded twisted-pair (STP) cable
- UTP is most common in office buildings and wired network environments

Coaxial

- Rugged indoor or outdoor cable
- Cable TV infrastructure is supported by coaxial cable to the residence

Glass/fiber

- Fiber cables have a glass core surrounded by a glass cladding; light travels through glass core
- Fiber optics can support large amounts of data transmissions over very far distances; often used for long-haul data transmissions

Structured Wiring System

- Is a modular cabling solution that is flexible
- Includes both outside cabling and indoor cabling
- Has the following parts:
  - Workstation outlet and RJ-45 connections
  - Intermediate distribution frame (IDF) or wiring closet
  - Intrabuilding distribution
  - Main distribution frame (MDF) or data center
  - Campus or building backbone distribution

Example of a Structured Wiring System

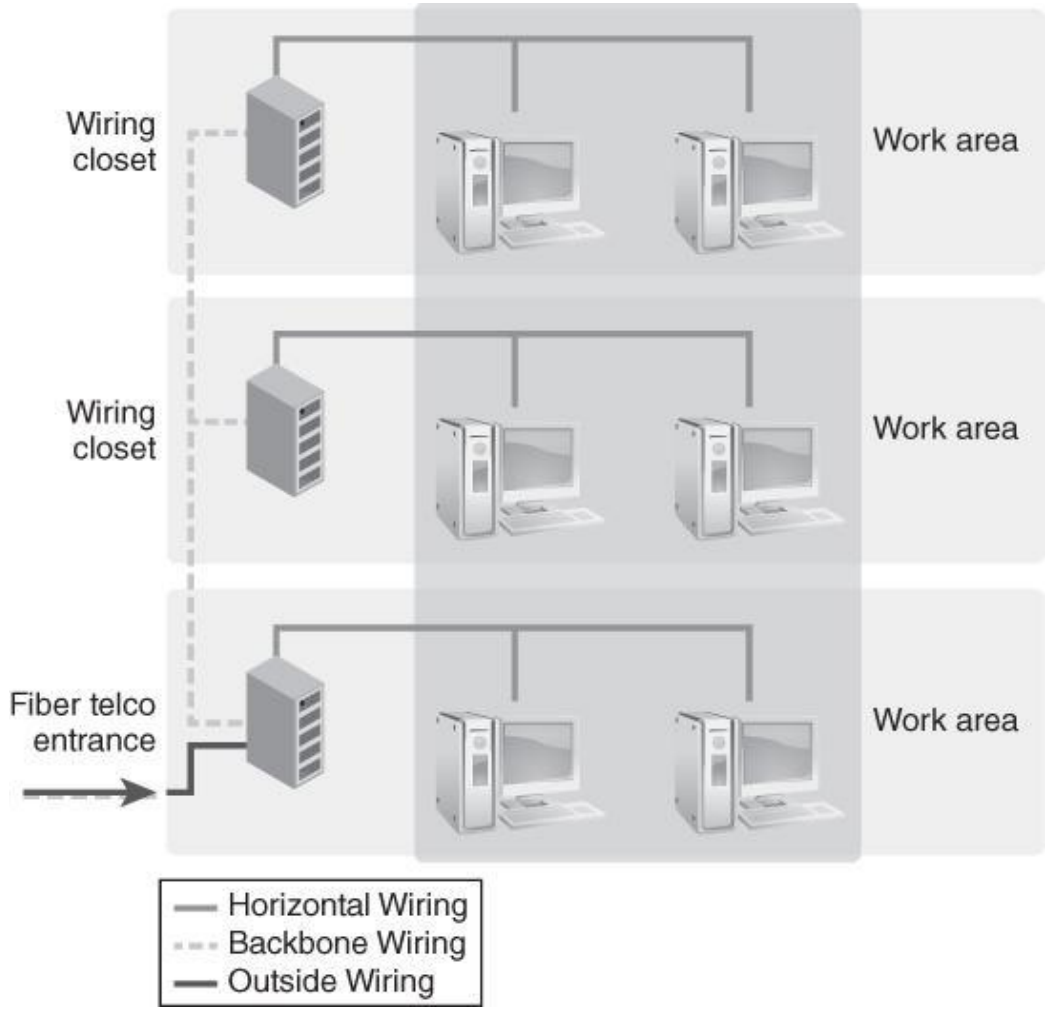


FIGURE 4-9 An example of a structured wiring system.

Data Link Layer: OSI Layer 2

- Think of Data Link Layer as the physical envelope (frame format) that you put the letter in, where the letter is composed of a series of 1's and 0's
- Frame format
  - Is based on 8 bits or 1 octet, also known as a byte
  - Is what defines the structure of the 1's and 0's being transmitted
- Data Link Layer prepares data to be placed onto the physical link

Sublayers

Media Access Control (MAC)

Logical Link Control (LLC)

The Data Link Layer and its Sublayers

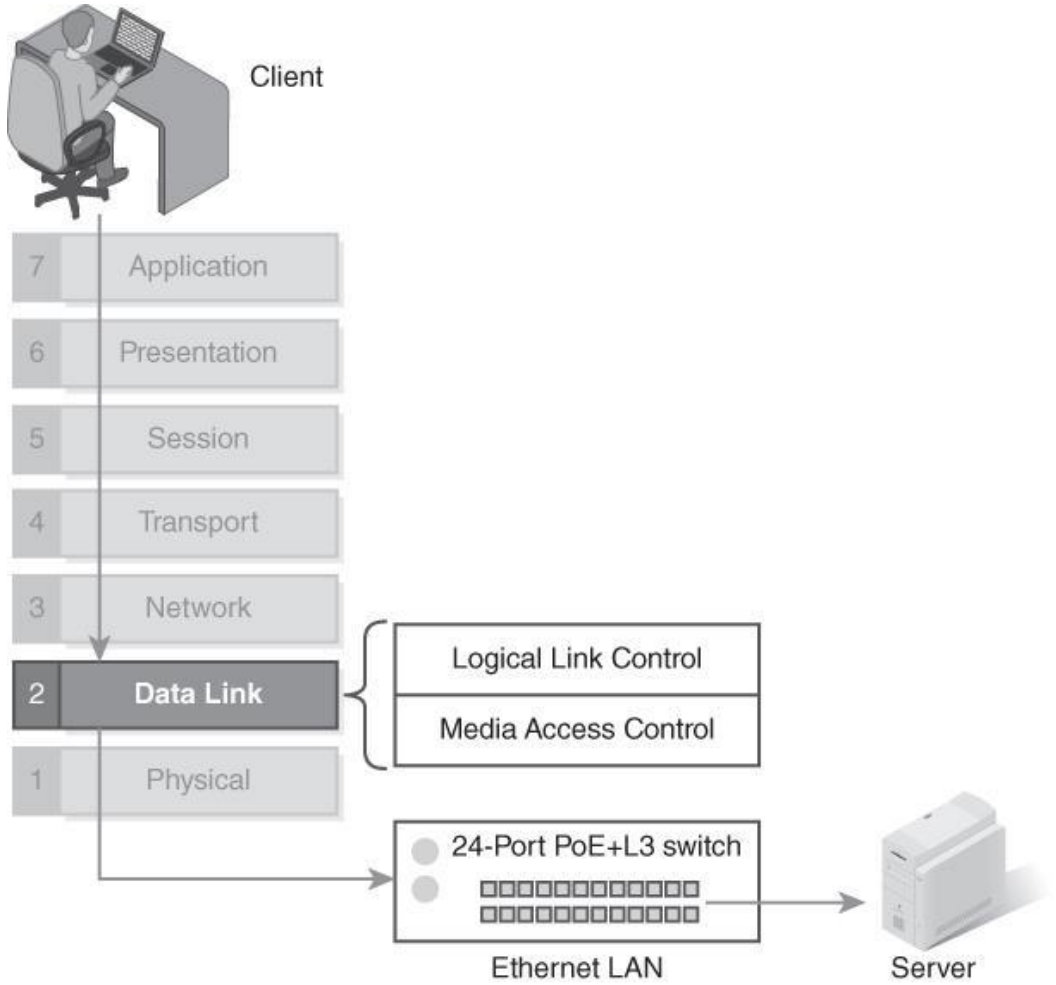


FIGURE 4-11 The Data Link Layer and its sublayers.

Ethernet and IEEE 802.3 Frame Formats

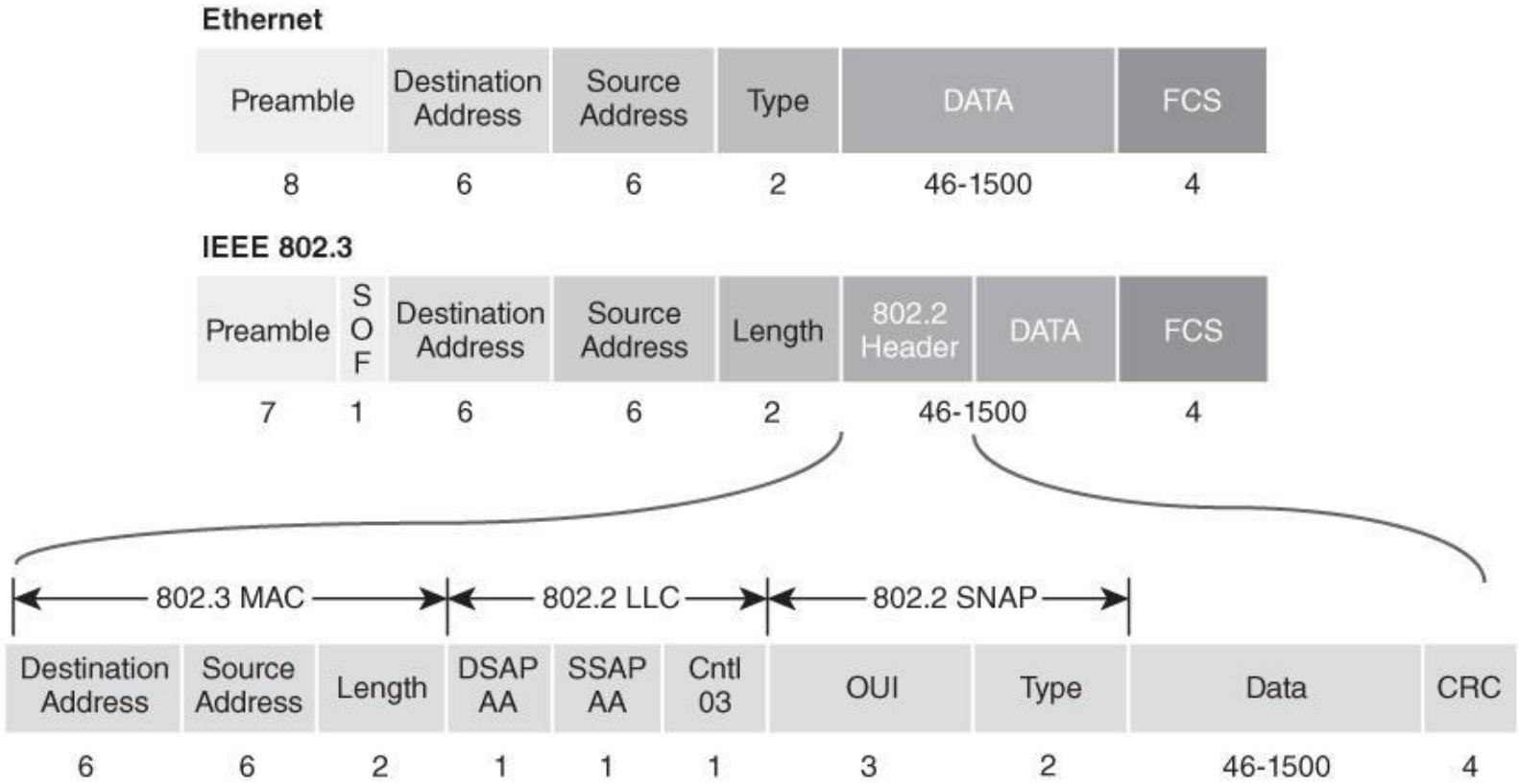


FIGURE 4-12 Ethernet II and IEEE 802.3 frame formats.

Ethernet Evolution

10Base5 “Thicknet” evolved into 10Base2 “Thinnet”

Transition to structured wiring systems drove:

- 10Base-T, 100Base-TX, and 1000Base-T (GigE) **to the desktop**

Transition to structured wiring systems drove:

- 10GBase-T (10 GigE), 25GBase-T (25 GigE), 40GBase-T (40 GigE), and 100GBase-T (100 GigE) **for server farm connectivity**

IEEE 802.3 Standards and Specifications: Solving Business Challenges (1 of 2)

Business Challenge	Business Solution	Technical Solution
Need to connect PCs, workstations, and servers	Interconnect the PCs, workstations, and servers on the same physical and logical network	Ethernet switch connectivity via star-wired, unshielded twisted-pair cabling
Need to share and access applications with other workers	Install shared applications on servers for all users to access	Implement LAN servers with enterprise-wide access controls
Need to share files between workers	Implement user and shared permission rights for access to drives, folders, and data	Implement standardized access controls and permission rights as per policy definition
Need to share printers and other devices among multiple users	Allow users to access shared servers and printers	Integrate office automation functionality within departments and workgroups

IEEE 802.3 Standards and Specifications: Solving Business Challenges (2 of 2)

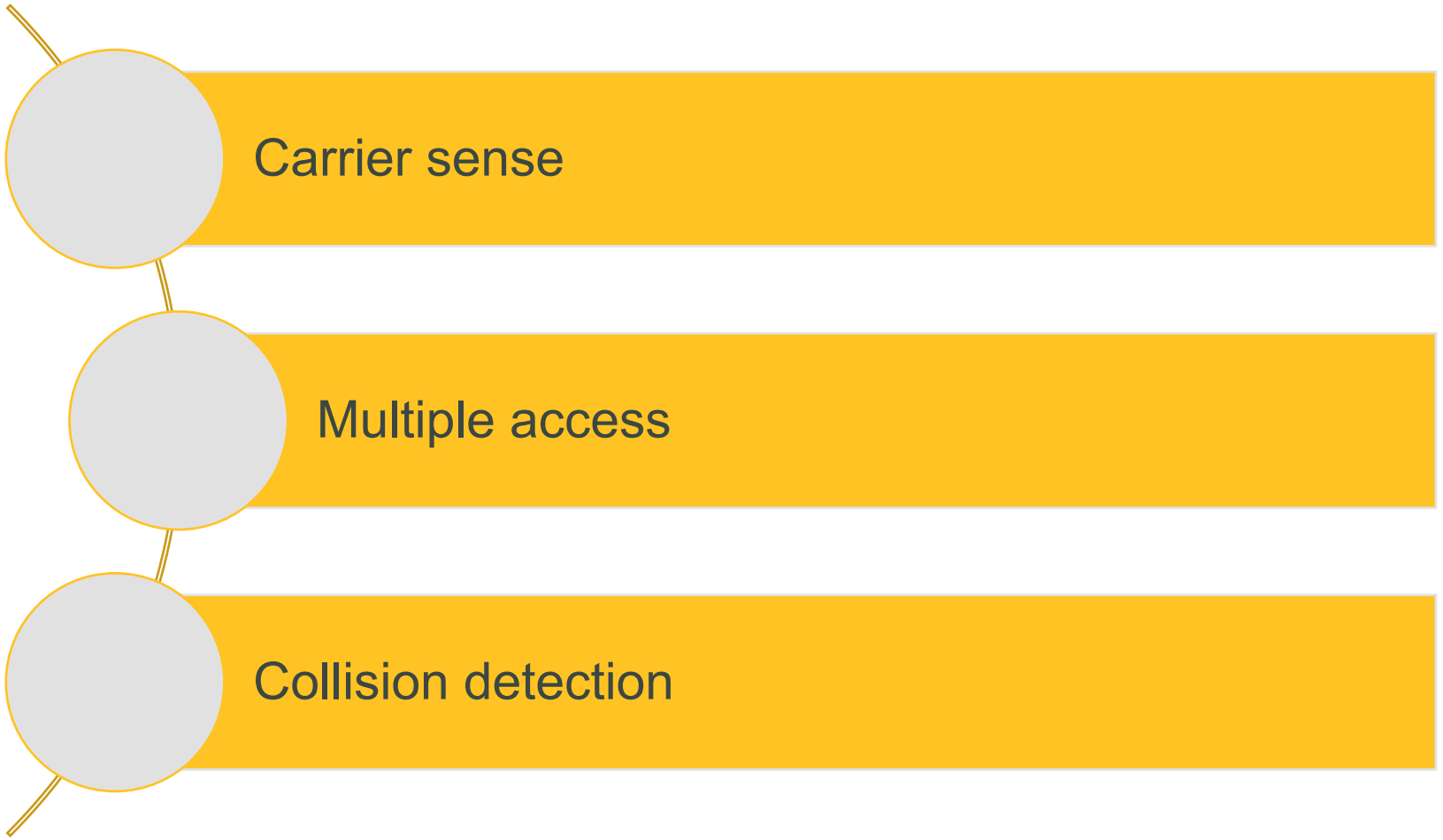
Business Challenge	Business Solution	Technical Solution
Need to communicate with other workers throughout the company	Support multiple methods of communicating between users—VoIP, email, IM chat, conferencing, and collaboration	Enable VoIP, SIP, and unified communication solutions for user desktops and mobile devices
Need for faster network speeds and increased connectivity to allow distributed applications and worldwide collaboration	Support applications such as multimedia (a combination of voice, data, imaging, and video)	Enable applications, including desktop video conferencing, video on demand, and transmission of video images, such as for medical diagnosis
Need for faster backbone networking speeds for MANs and data center backbone connections	Support high-speed LAN connections in the MAN and data center	Enable data backup and recovery solutions and disaster recovery backup network connections, and extend the LAN within a MAN

Some IEEE 802.3 CSMA/CD Standards

Ethernet Standard	Release Date	Description
802.3	1983	(10Base5) 10 Mbps using thick coaxial cable
802.3ab	1999	(1000Base-T) 1 Gbps using twisted-pair cable
802.3an	2006	(10GBase-T) 10 Gbps using twisted-pair cable
802.3ba	2010	40 Gbps and 100 Gbps to support both endpoint and link aggregation over single-mode fiber
802.3cg	2019	10Base-T equivalent 10 Mbps network to support transmit and receive signaling over a single pair of unshielded twisted-pair cabling

How Multiple Nodes Share Network Media

CSMA/CD



Ethernet Carrier Sense Multiple Access

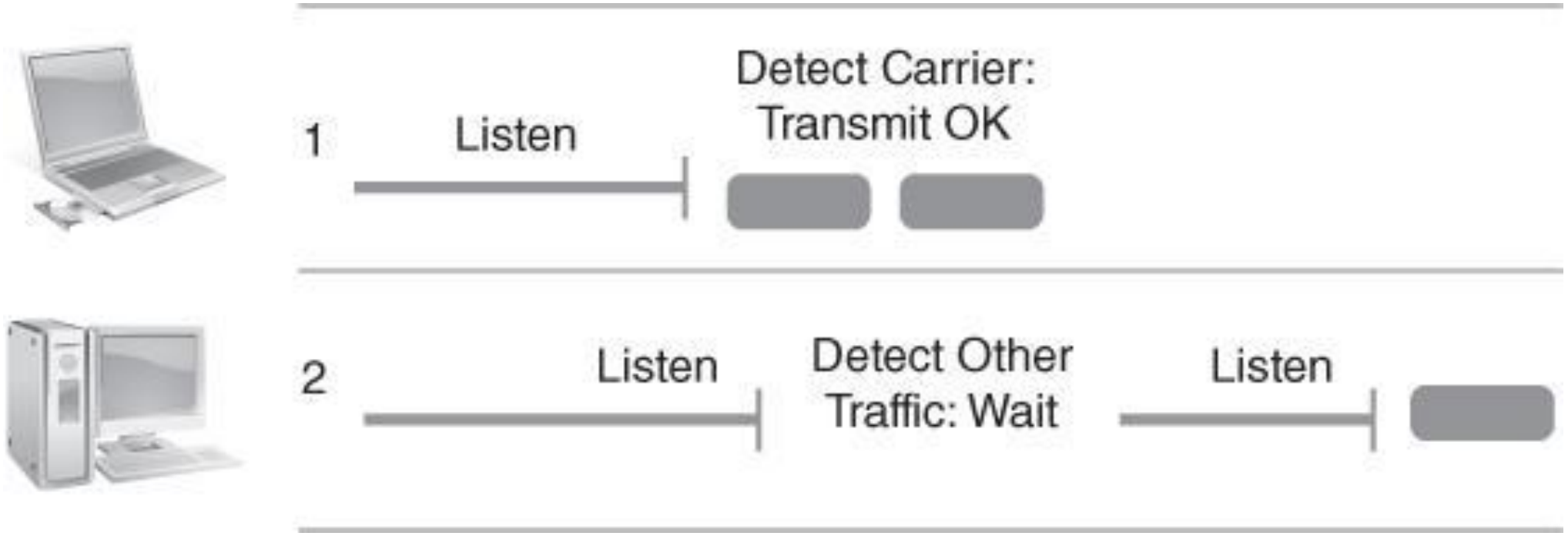


FIGURE 4-15 Ethernet carrier sense multiple access.

Ethernet Collision Detection

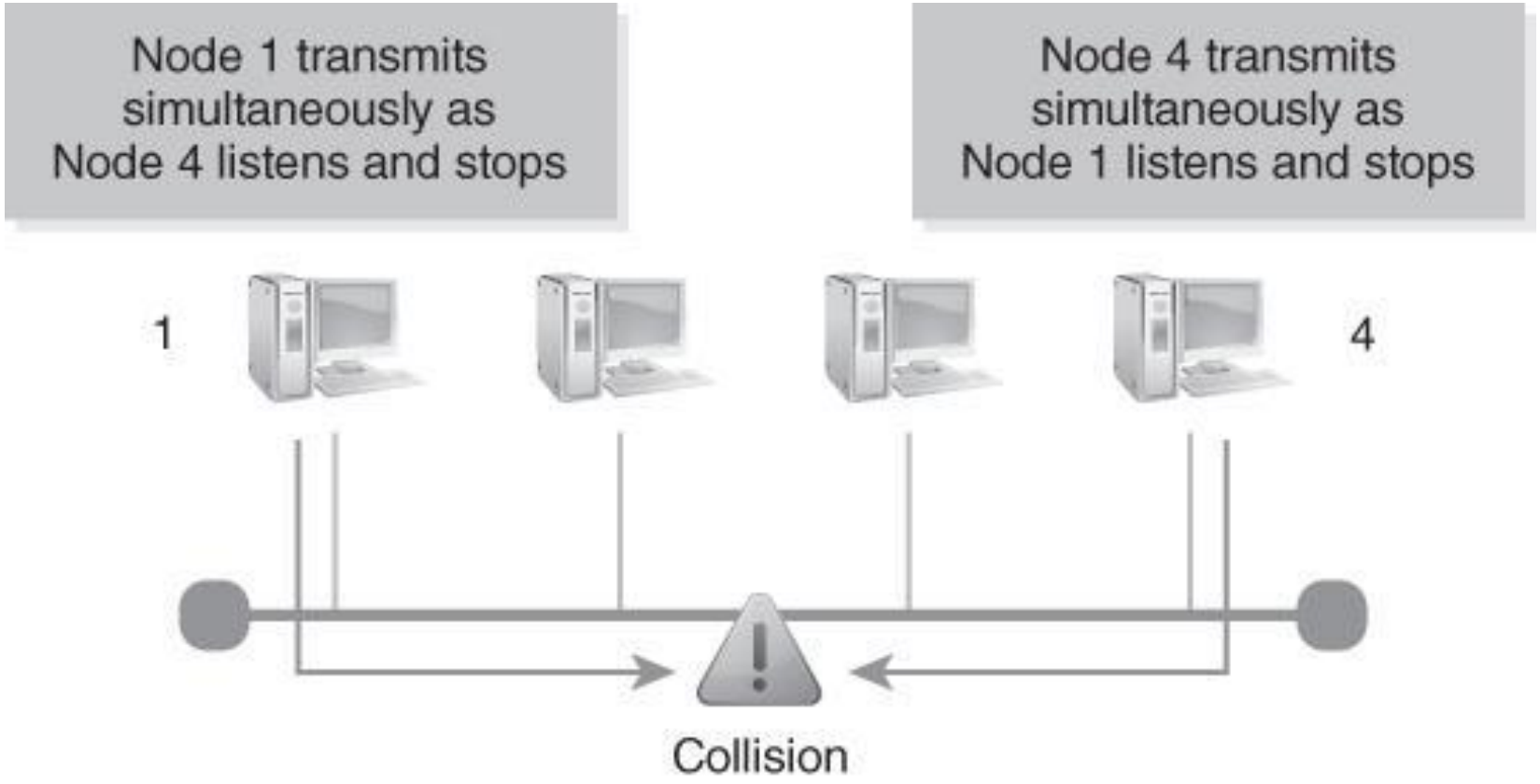


FIGURE 4-16 Ethernet collision detection.

Ethernet Technology Bandwidth Speed Evolution

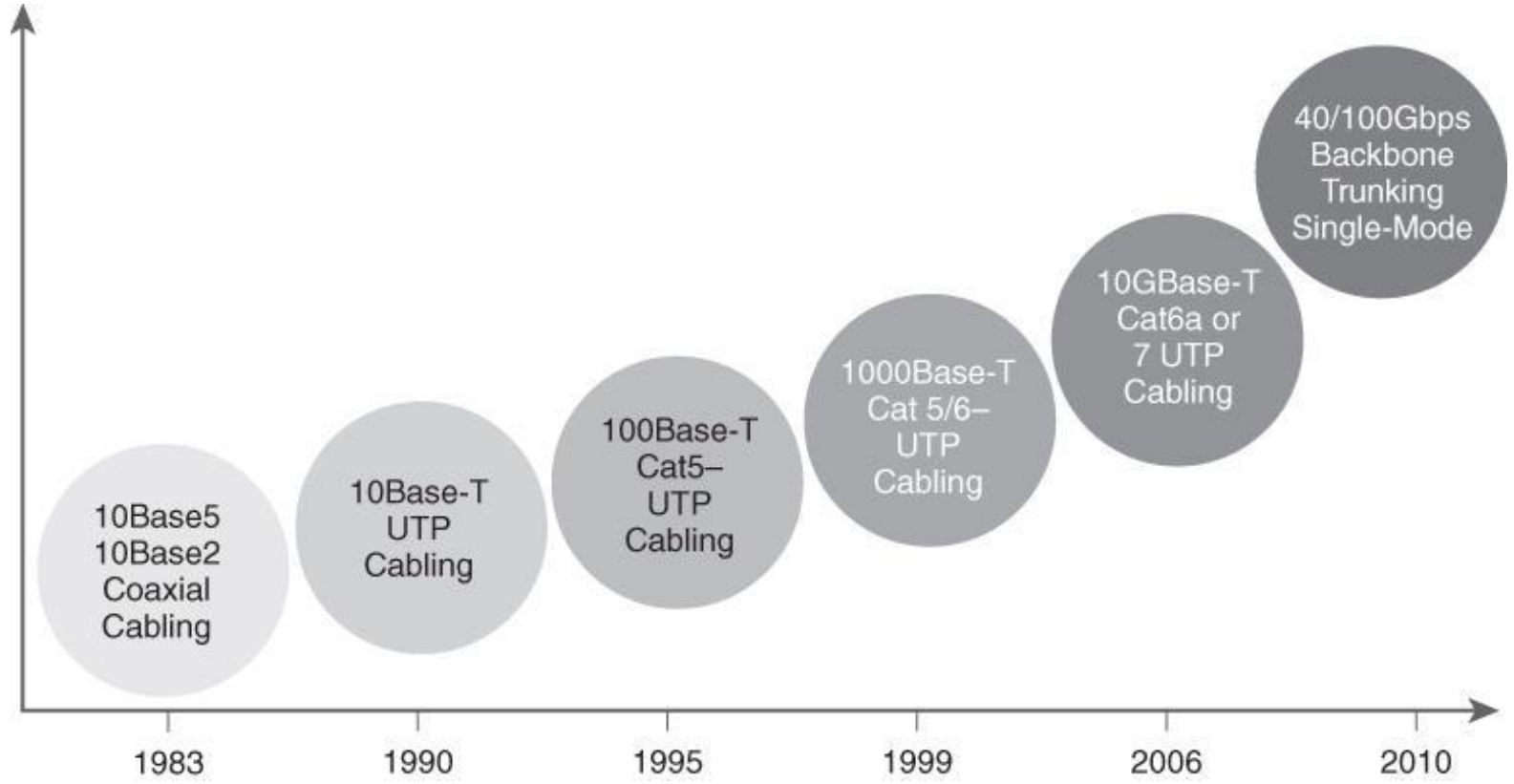
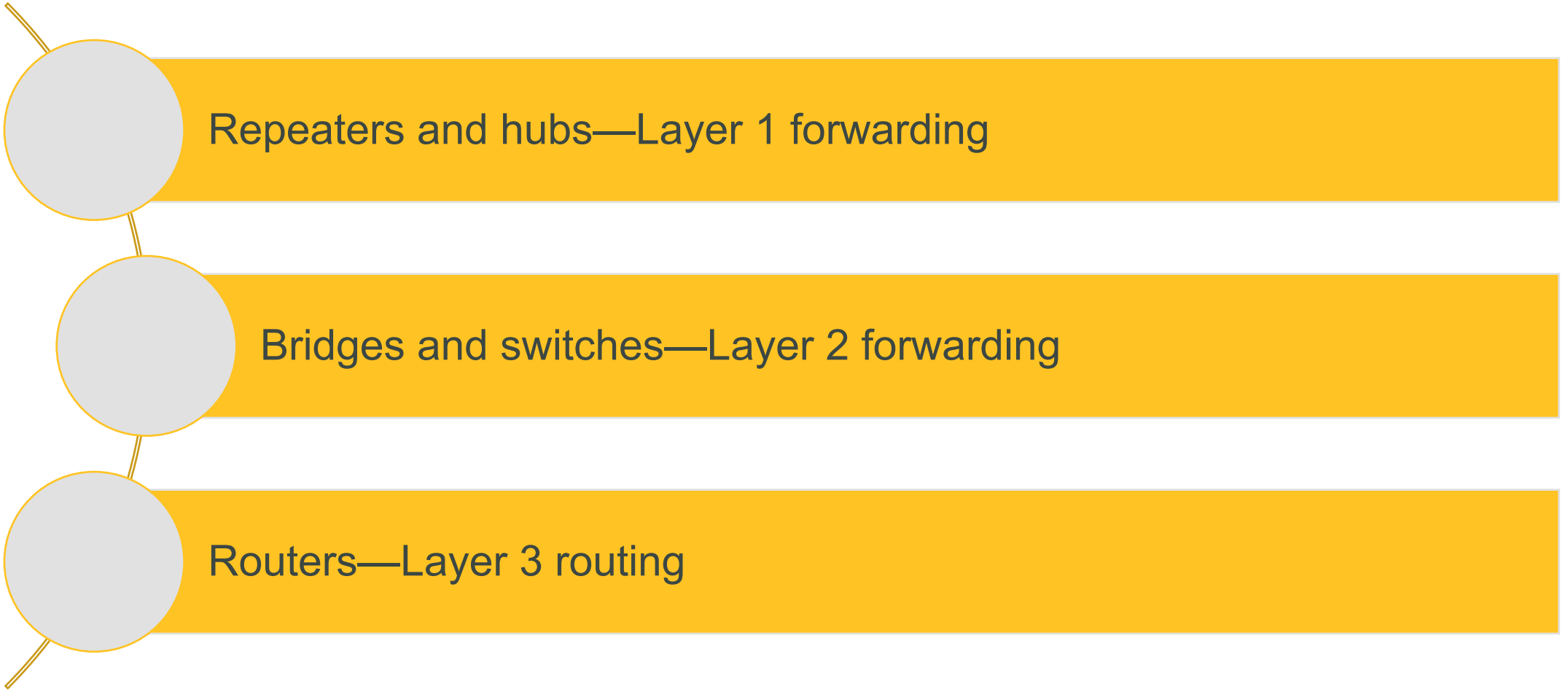


FIGURE 4-17 Ethernet technology bandwidth speed evolution.

Internetworking LANs: Bridging Versus Routing (1 of 2)

- Reasons to separate and internetwork LANs: Security, traffic segmentation, and ease of network management
- Server access and maximizing performance are key considerations when designing LANs
- Where you put servers can impact how you design network
- Need for high-speed backbone connectivity from data center to desktop location is paramount
- How Layer 2 and Layer 3 networking can achieve that is main objective of internetworking

Internetworking LANs: Bridging Versus Routing (2 of 2)



LAN Hub Single Broadcast Domain

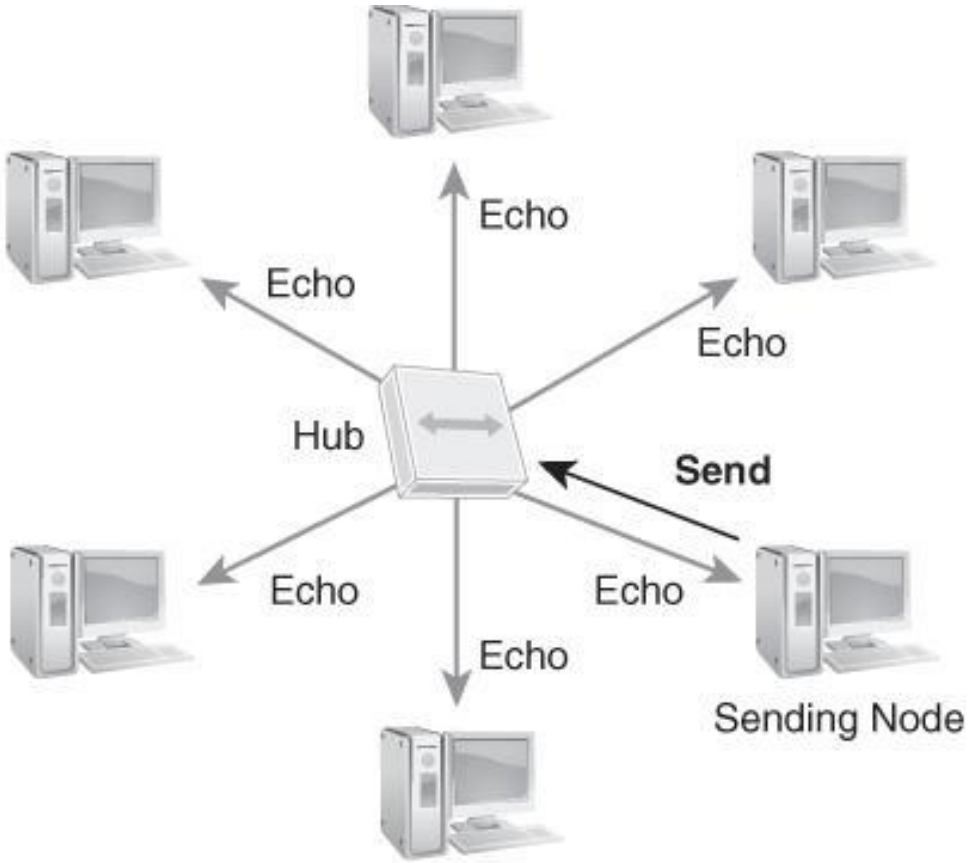
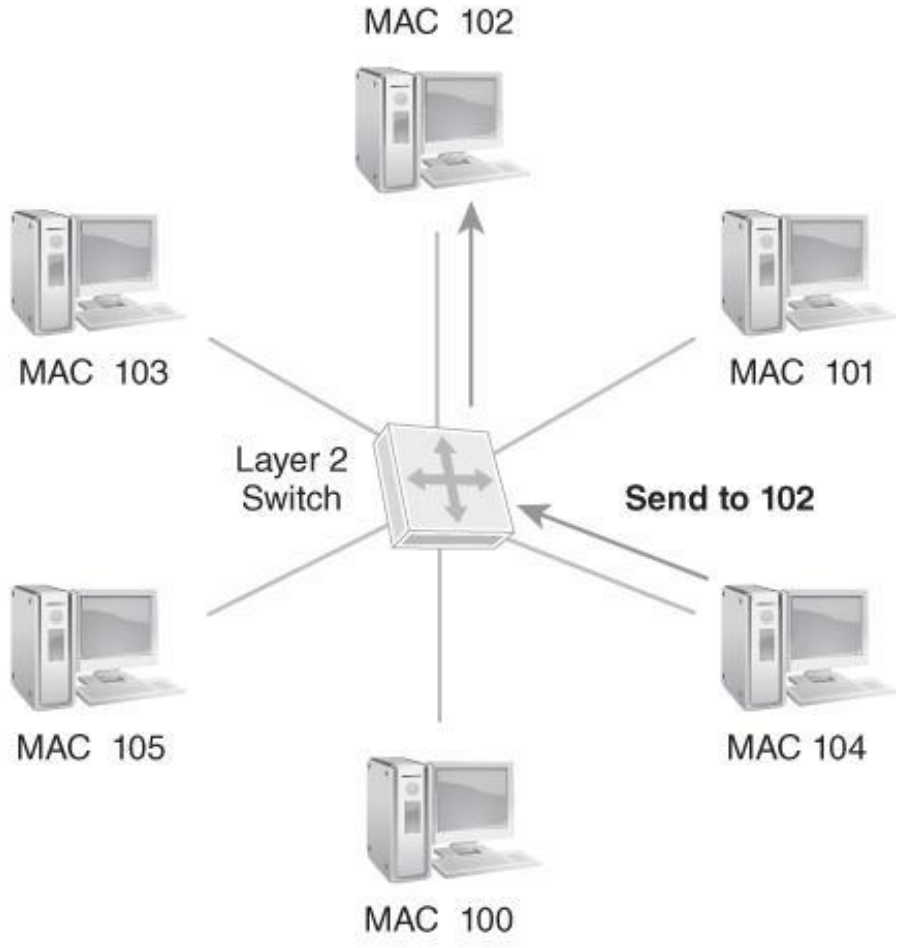


FIGURE 4-18 LAN hub single broadcast domain.

Multiple Collision Domains with a Layer 2 Switch



Multiple Collision Domains

FIGURE 4-19 Multiple collision domains with a Layer 2 switch.

Ethernet Network Design Fundamentals (1 of 2)

- **Edge networks**—The desktop workstation LAN connection
- **Building backbone networks**—Aggregations of edge network switches into a collapsed backbone within that building
- **Campus backbone networks**—Campus backbone networks are aggregations of multiple buildings on the same physical campus
- **Metropolitan area networks (MANs)**—Aggregations of remote buildings, but within a regional MAN service area (usually provided by a metro Ethernet service provider)
- **Wide area backbone networks**—Cloud-based wide area network infrastructures such as Multiprotocol Label Switching (MPLS) for wide area IP network connectivity

Ethernet Network Design Fundamentals (2 of 2)

- Port density
- Power over Ethernet (PoE)
- Layer 2 versus Layer 3 edge switch
- Layer 2 and Layer 3 resiliency and redundancy
- Layer 2 and Layer 3 trunking
- Switch architecture
- Switch security

Edge Network: Workgroup LAN Connection to the Desktop

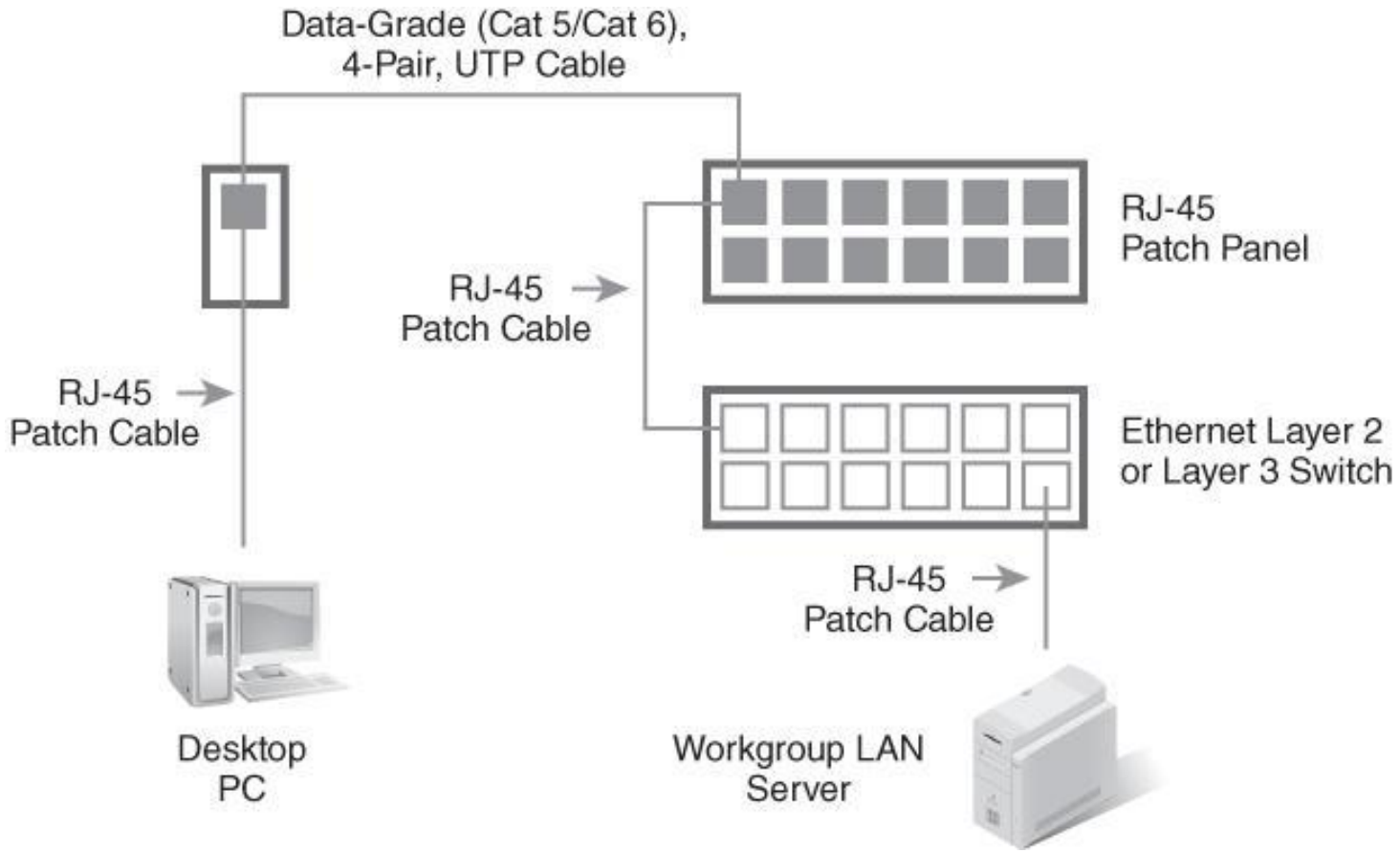


FIGURE 4-20 Workgroup LAN connection to the desktop.

Edge Network: Workgroup LAN

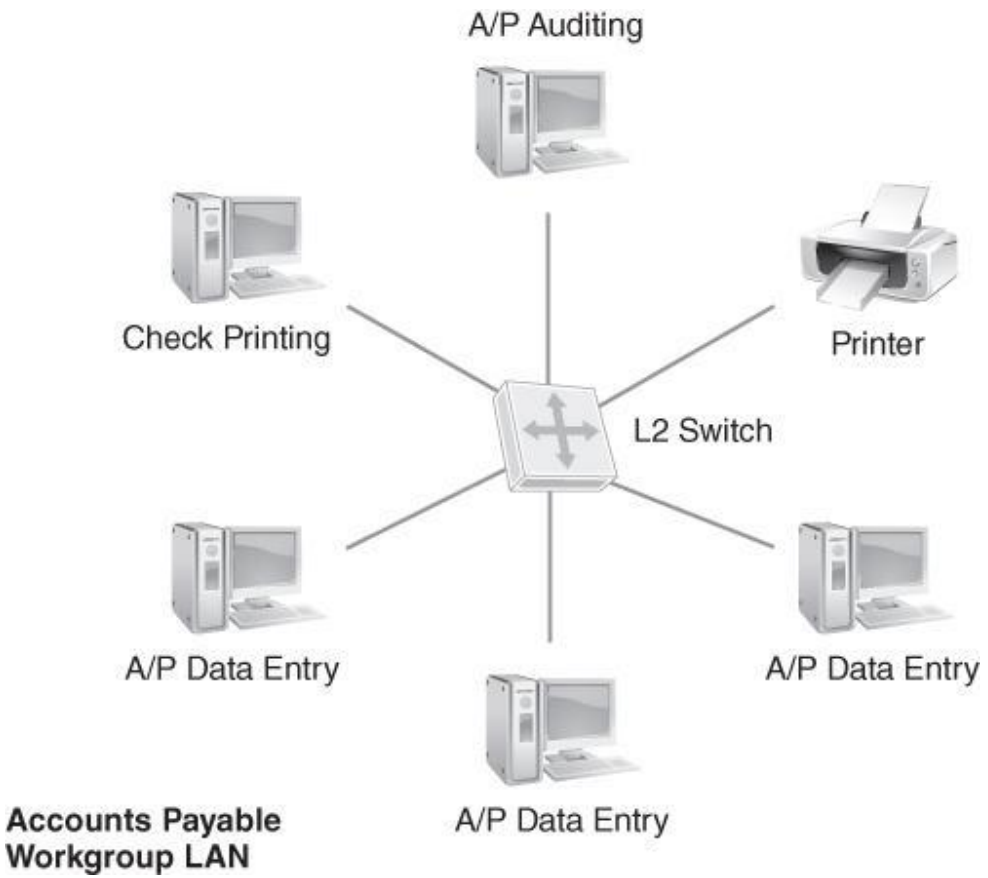


FIGURE 4-21 Workgroup LAN.

Edge Network: Use of PoE Switches

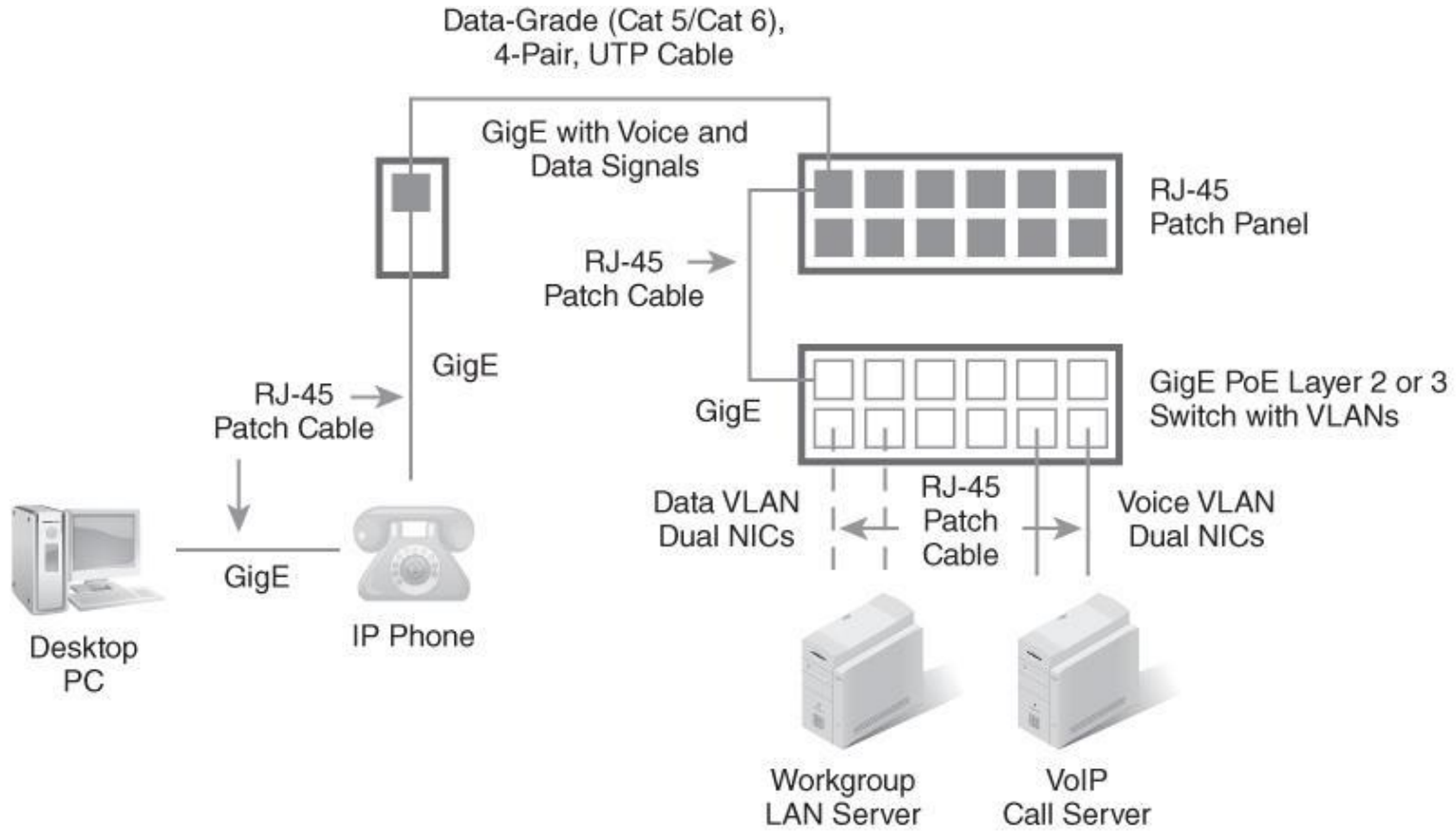


FIGURE 4-22 PoE LAN switches.
Data from National Institute of Standards and Technology.

Edge Network: Departmental LAN

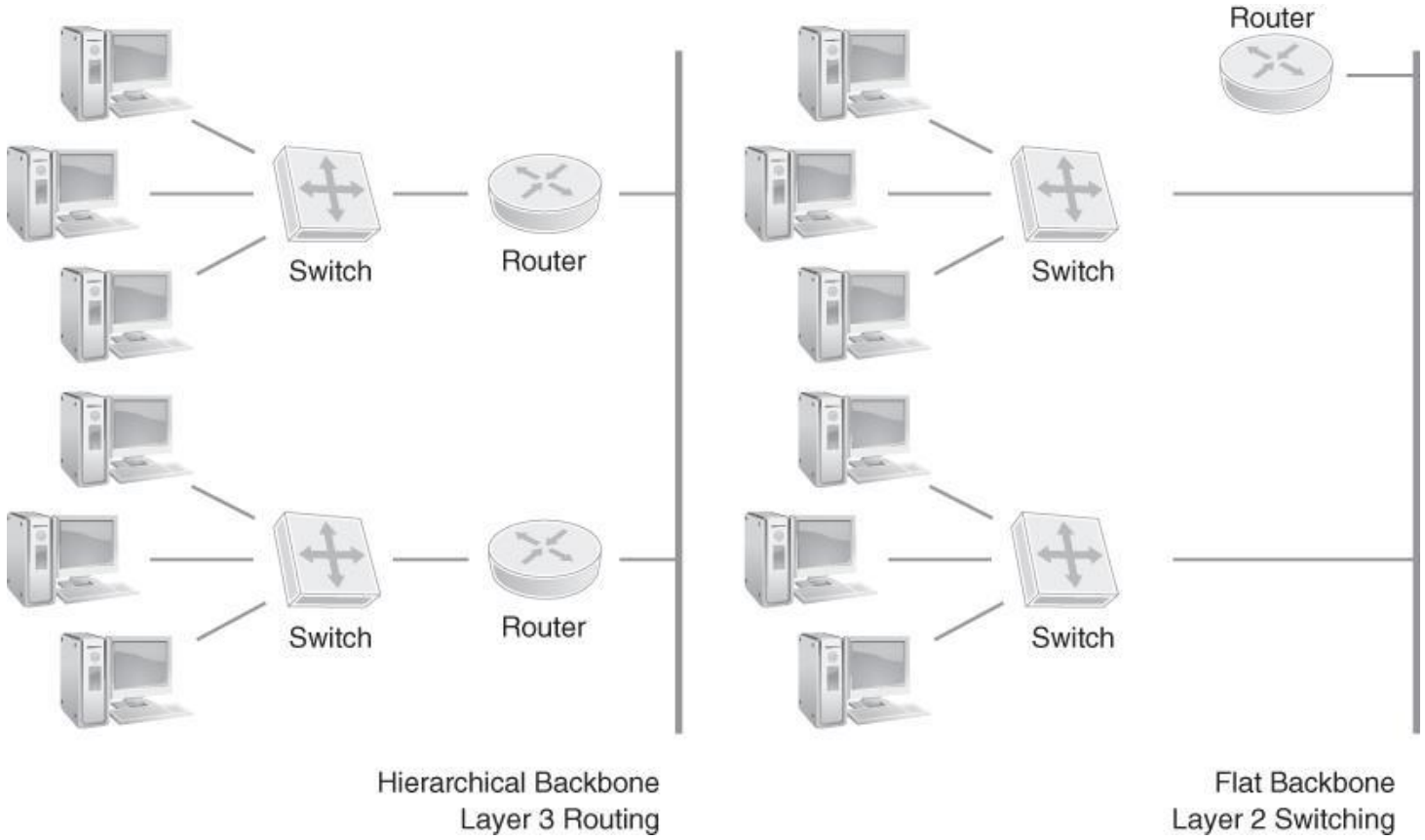


FIGURE 4-23 Departmental backbone LAN topologies.

Building Backbone: Collapsed Backbones

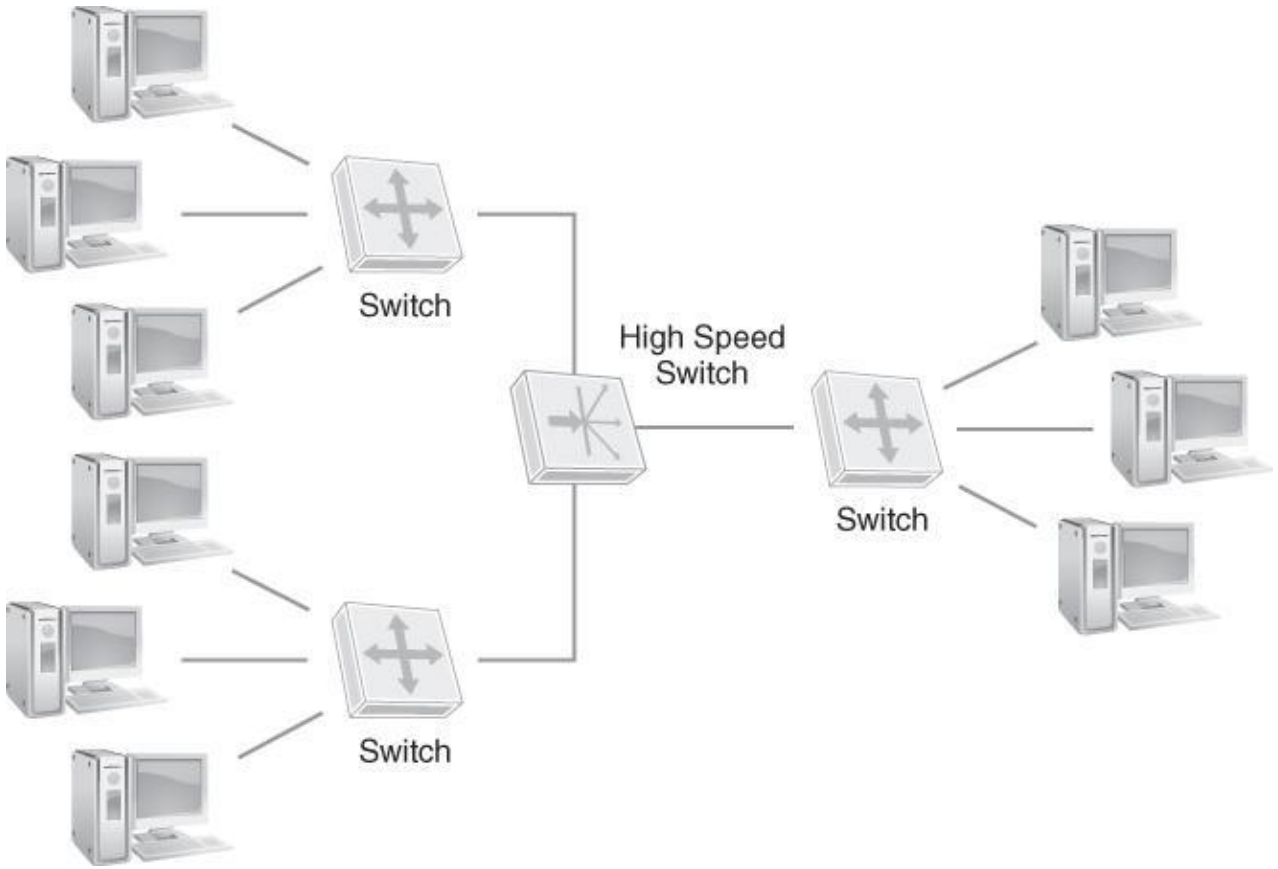


FIGURE 4-24 Collapsed building backbone network.

Campus Backbone: Collapsed Data Center Backbone

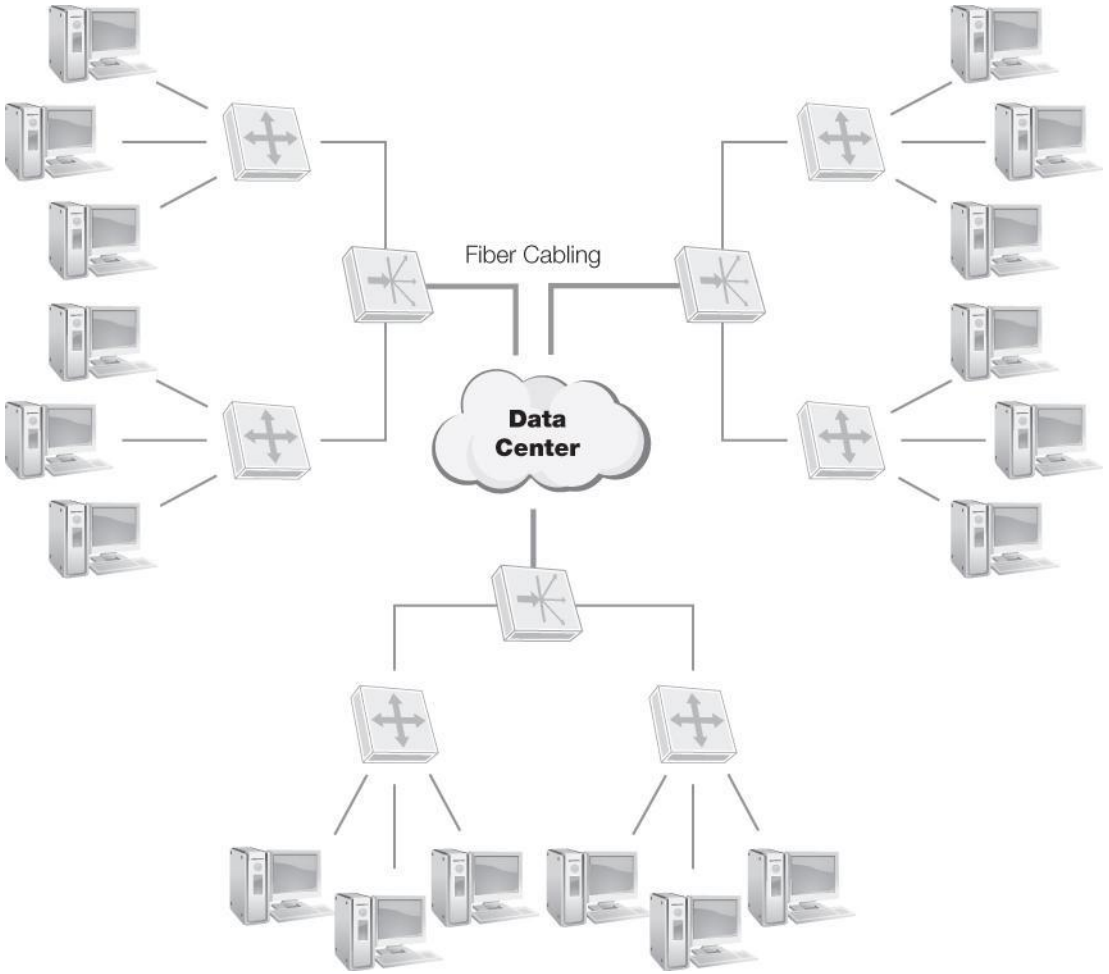


FIGURE 4-25 Collapsed campus backbone network.

Metropolitan Area Backbone: Metro Ethernet Backbone

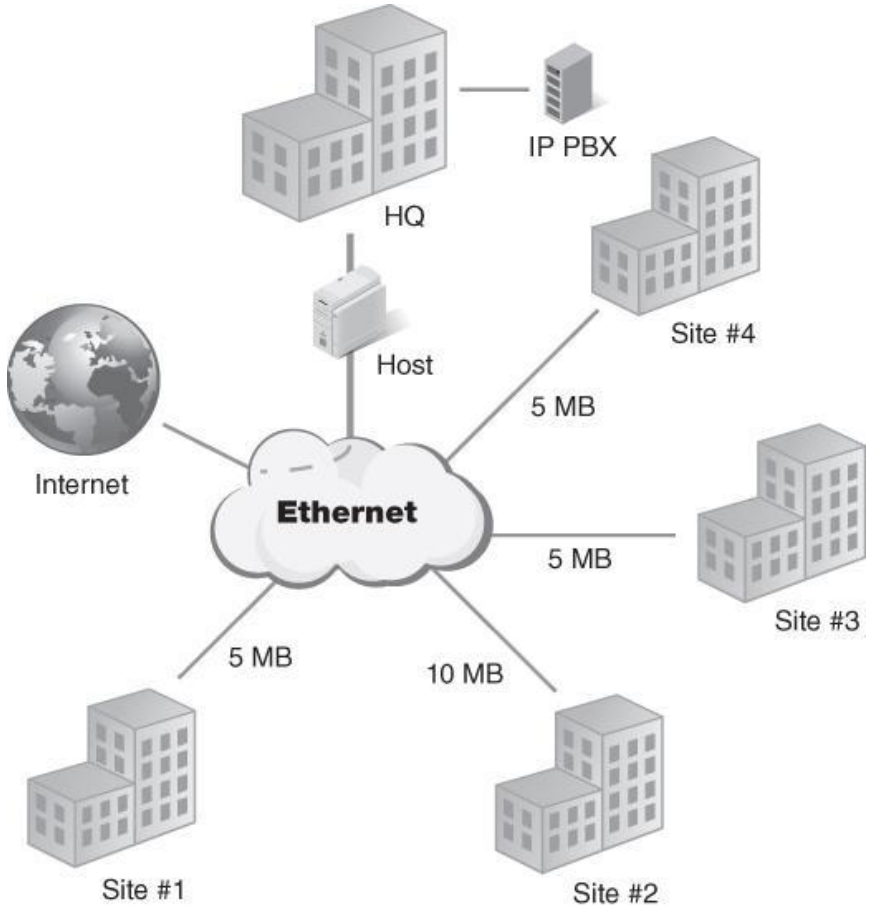


FIGURE 4-26 Metro Ethernet backbone network.
ForeScout.com

GigE and 10 GigE Specifications

- Ethernet running at 1 Gbps is also called GigE
- Ethernet running at 10 Gbps (10 times faster) is also called10 GigE
- Current, most common versions of Ethernet are 100 Mbps and GigE
- 10 GigE is becoming a standard for LANs

25, 40, and 100 GigE: Server Farms and Backbone Trunking

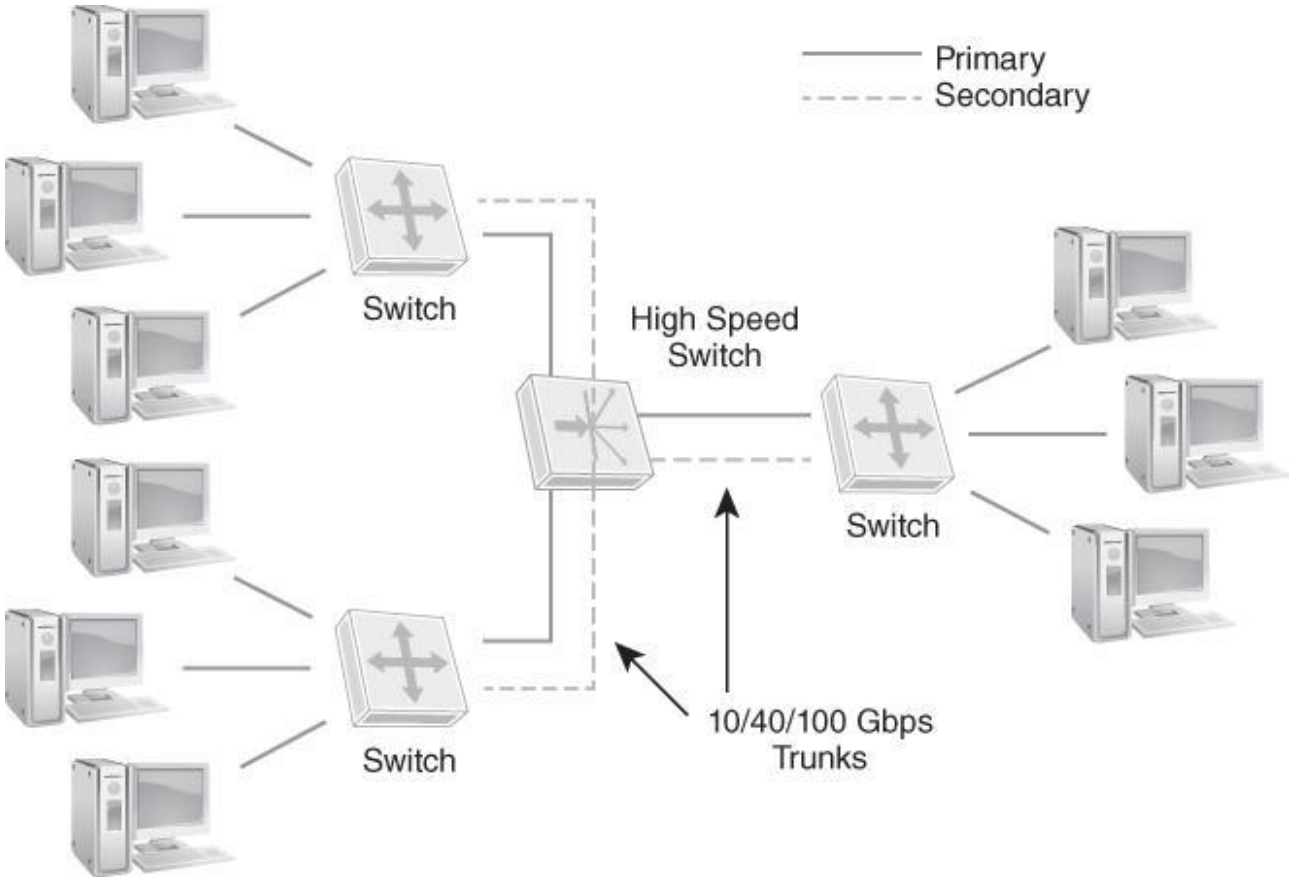


FIGURE 4-27 Server farm and backbone trunking.
ForeScout.com.

Summary

- The IEEE 802.3 standard and specifications
- The Physical Layer and Data Link Layer
- Structured wiring and internetworking Ethernet LANs
- Designing Ethernet networks for workgroups, buildings, campuses, and metropolitan area networks
- GigE and 10 GigE specifications, and backbone trunking