Computer Communication Networks

Introduction, Communication link, Multiplexing

Dr. Raja Vara Prasad

Assistant Professor

IIIT Sri City

CDMA—Code Division Multiple Access

Figure 2-45. (a) Binary chip sequences for four stations. (b) Bipolar chip sequences. (c) Six examples of transmissions. (d) Recovery of station C's signal.

A: 0 0 0 1 1 0 1 1	A: (–1 –1 –1 +1 +1 –1 +1 +1)
B: 0 0 1 0 1 1 1 0	B: (–1 –1 +1 –1 +1 +1 +1 –1)
C: 0 1 0 1 1 1 0 0	C: (–1 +1 –1 +1 +1 +1 –1 –1)
D: 0 1 0 0 0 0 1 0	D: (–1 +1 –1 –1 –1 –1 +1 –1)
(a)	(b)

Six examples:

– – 1 –	$\mathbf{C}$	$S_1 = (-1 +1 -1 +1 +1 +1 -1 -1)$
– 1 1 –	$\mathbf{B} + \overline{\mathbf{C}}$	$S_2 = (-2 \ 0 \ 0 \ 0 +2 +2 \ 0 -2)$
1 0 – –	$\mathbf{A} + \overline{\mathbf{B}}$	$S_3 = (\ 0 \ 0 -2 +2 \ 0 -2 \ 0 +2)$
1 0 1 –	$\mathbf{A} + \overline{\mathbf{B}} + \mathbf{C}$	$S_4 = (-1 +1 -3 +3 +1 -1 -1 +1)$
1 1 1 1	$\mathbf{A} + \mathbf{B} + \mathbf{C} + \mathbf{D}$	$S_5 = (-4 \ 0 -2 \ 0 +2 \ 0 +2 -2)$
1 1 0 1	$\mathbf{A} + \mathbf{B} + \overline{\mathbf{C}} + \mathbf{D}$	$S_6 = (-2 -2 \ 0 -2 \ 0 -2 +4 \ 0)$

(c)

$S_1 \bullet C = (1 +1 +1 +1 +1 +1 +1 +1)/8 = 1$
$S_2 \bullet C = (2 +0 +0 +0 +2 +2 +0 +2)/8 = 1$
$S_3 \bullet C = (0 +0 +2 +2 +0 -2 +0 -2)/8 = 0$
$S_4 \bullet C = (1 +1 +3 +3 +1 -1 +1 -1)/8 = 1$
$S_5 \bullet C = (4 +0 +2 +0 +2 +0 -2 +2)/8 = 1$
$S_6 \bullet C = (2 -2 +0 -2 +0 -2 -4 +0)/8 = -1$

(d)

two stations, A and C, both transmit a 1 bit at the same time that B transmits a 0 bit.

If the received chip sequence is S and the receiver is trying to listen to a station whose chip sequence is

$$\mathbf{S} \bullet \mathbf{C} = (\mathbf{A} + \overline{\mathbf{B}} + \mathbf{C}) \bullet \mathbf{C} = \mathbf{A} \bullet \mathbf{C} + \overline{\mathbf{B}} \bullet \mathbf{C} + \mathbf{C} \bullet \mathbf{C} = 0 + 0 + 1 = 1$$

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If the received chip sequence is S and the receiver is trying to listen to a station whose chip sequence is C

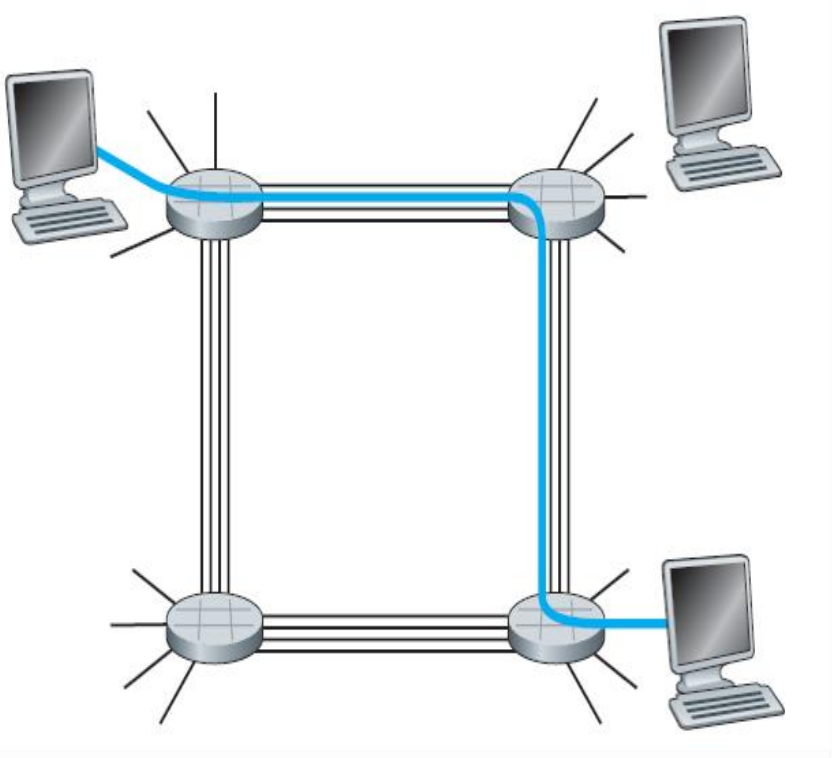
$$S \bullet C = (A + \overline{B} + C) \bullet C = A \bullet C + \overline{B} \bullet C + C \bullet C = 0 + 0 + 1 = 1$$

How are the end systems connected

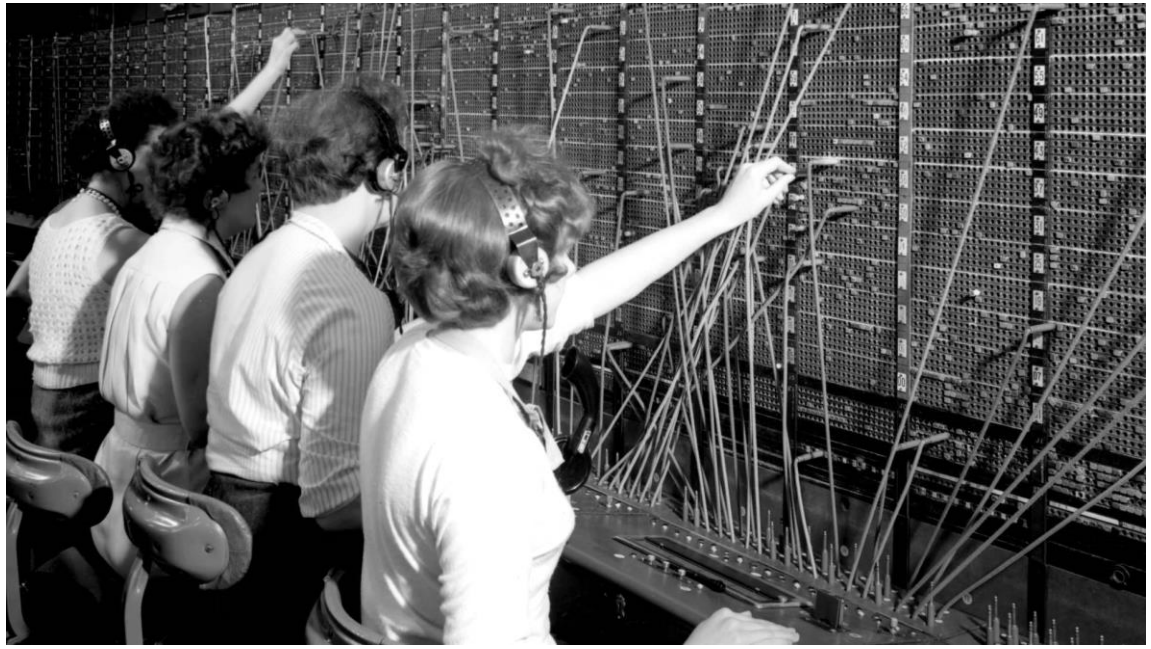
- Circuit switching
  - A dedicated path from source to destination
  - Resources on the path are reserved for the source-destination pair
- Packet switching
  - No dedicated path from source to destination
  - A switch/router forwards packets to another router / destination on the path.

Circuit switching

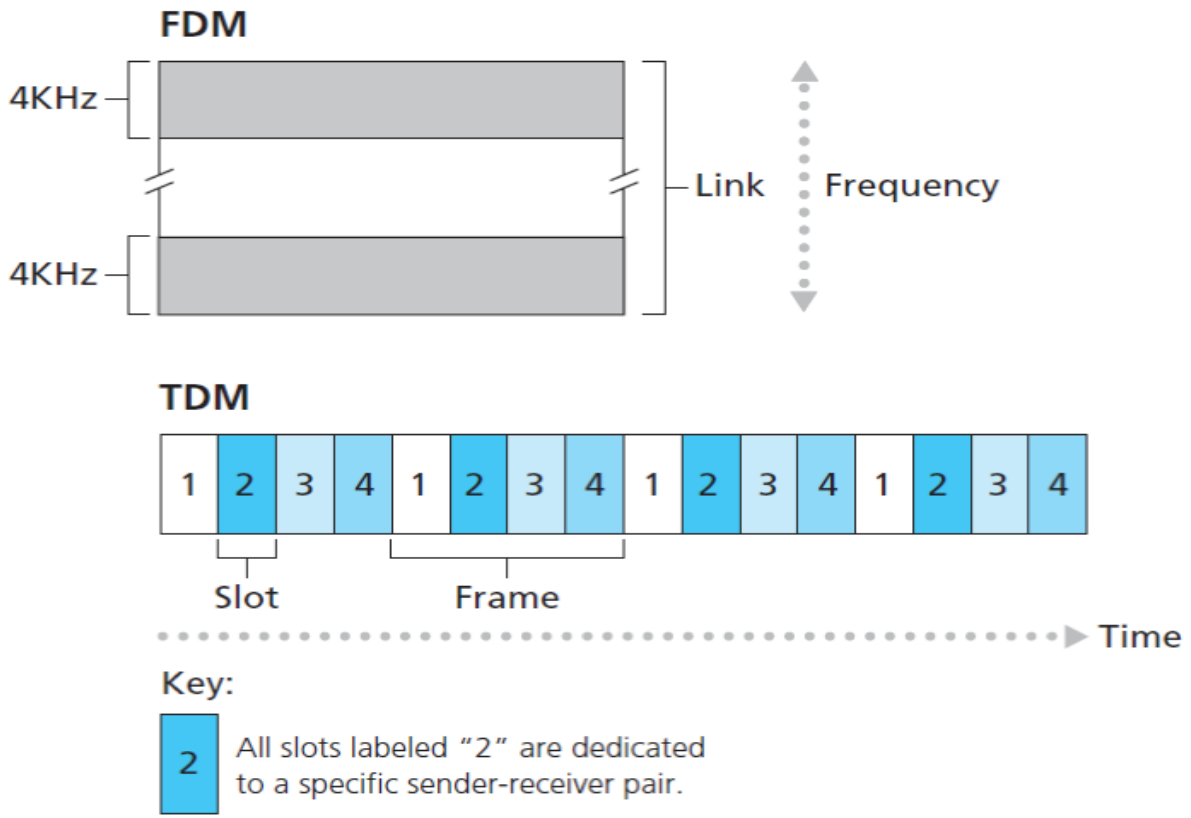
- The network establishes a connection from source to its destination. This connection is called circuit.
- Resources such as bandwidth, buffers on the circuit are blocked for the duration of communication.
- Telephone network is a circuit switching network.
- Links are finite, so very few users can be supported simultaneously.



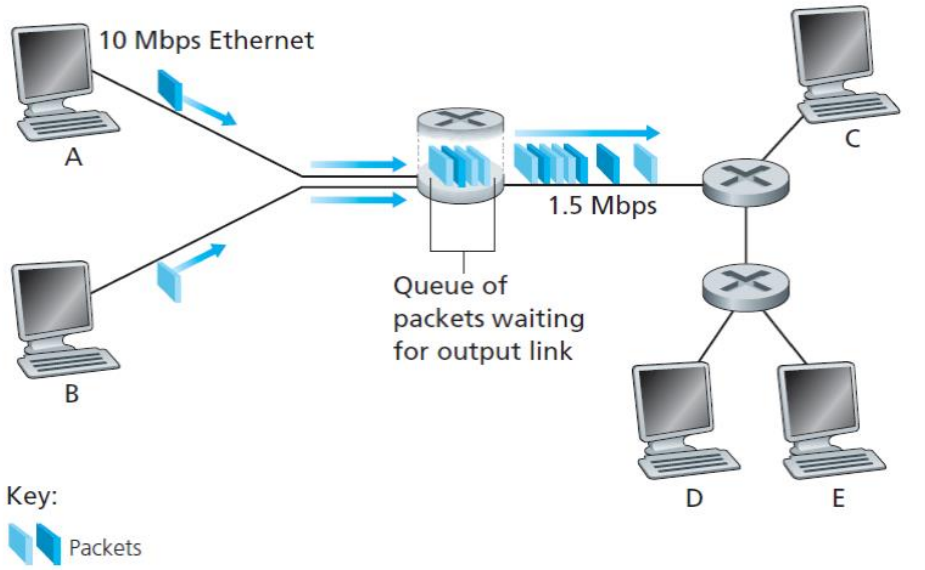
Circuit switching

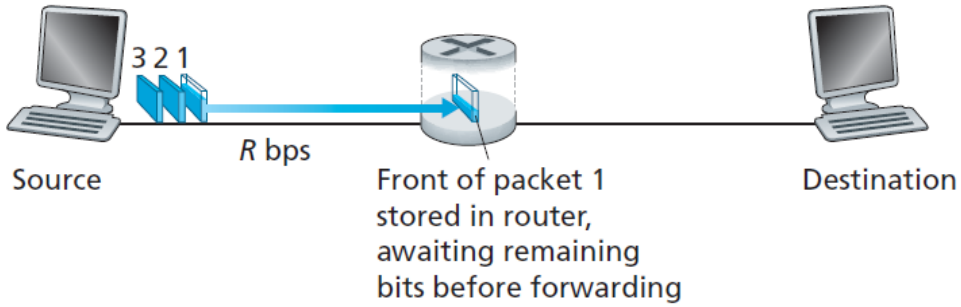


Multiplexing in circuit switching



Packet switching





Statistical multiplexing

- Suppose users share a 1Mbps link.
- A user can be active or inactive. User will generate 100Kbps when active and we assume that a user is active for 10% of the time.
- Circuit switching : 100Kbps must be reserved for each user all the time, can support 10 users simultaneously!
- Circuit switching with TDM:
  - Say, one-second frame is divided into 10 frames each of 100ms.
  - Only 10 simultaneous connections are supported!!!

Statistical multiplexing

- Packet switching: Let there be 35 users in the system. What is the probability that 11 or more users are active simultaneously?
  - Approximately 0.0004
- As the probability of more than 10 users being active simultaneously is small, Packet switching can support 35 users!
- Packet switching allocate links on demand
- On demand allocation of resources is referred to as Statistical multiplexing.

Circuit switching vs Packet switching

Circuit switching

- Waste of bandwidth in silent periods
- Expensive
- Supports less number of connections
- Suitable for real-time services (video conferencing, etc)

Packet switching

- Effective use of bandwidth
- Cheaper than circuit switched network
- Supports more simultaneous connections
- Queuing delays
- Packet loss
- Not suitable for delay constrained applications

Layered Network Architecture

Why Layered Architecture?

- Organizing a network is a big and complicated task.
- Divide and conquer
- Example: Organization of an institute
  - academic section
  - finance section
  - administration section
  - procurement section

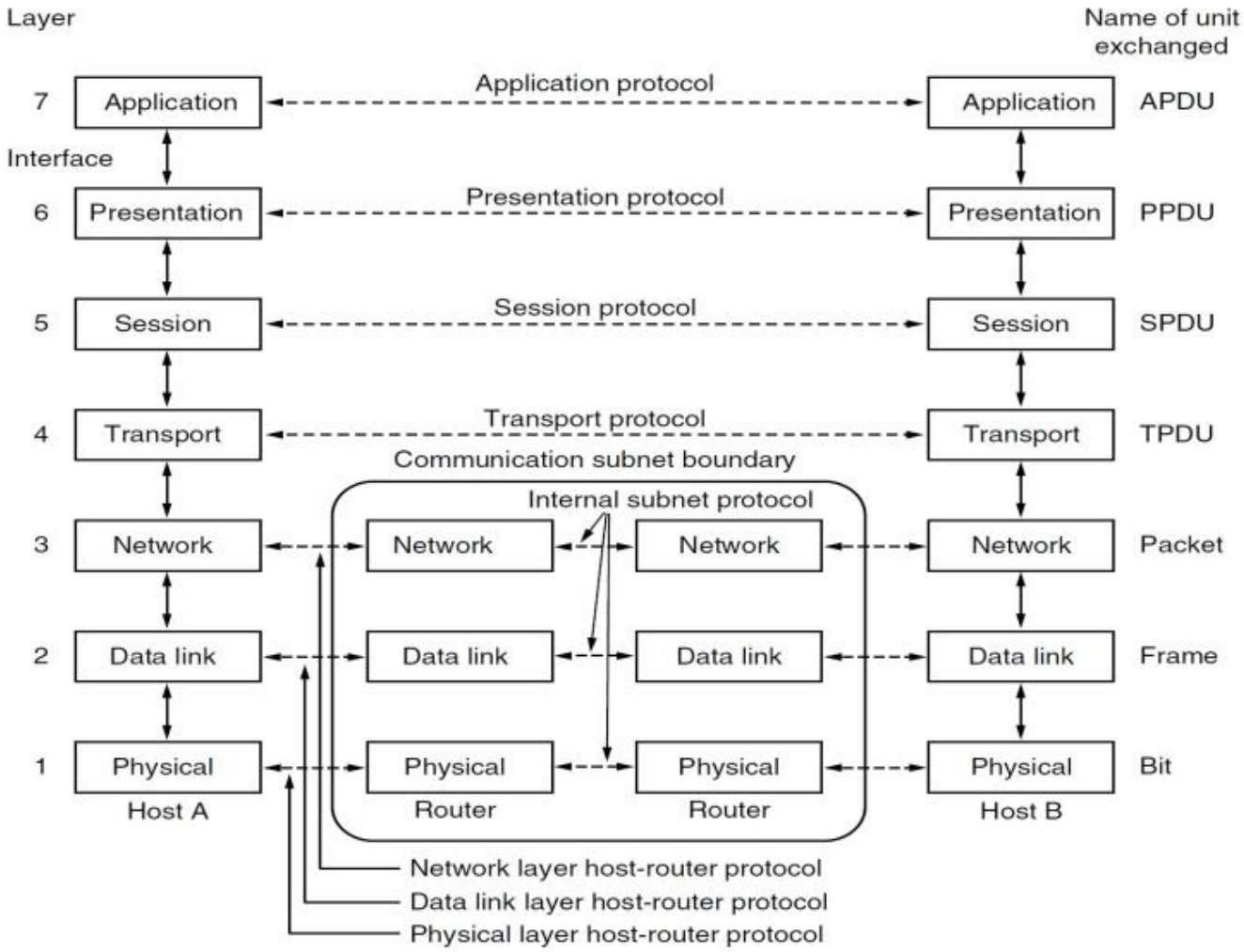
Advantages of Layered Architecture

- Divide the design issues into small pieces.
- A layer provides a service (set of actions) to the immediate higher layer.
- New technologies can be adopted in a layer without affecting other layers.
- Each layer can be analysed and tested independently.

Open System Interconnection (OSI) Reference Model

- Developed by International Organization for Standardization (ISO)
- 7-layer model:
  - Application layer
  - Presentation layer
  - Session layer
  - Transport layer
  - Network layer
  - Data-link layer
  - Physical layer

Layers


Layer
Name of unit exchanged
7
Application
Application protocol
Application
APDU
Interface
6
Presentation
Presentation protocol
Presentation
PPDU
5
Session
Session protocol
Session
SPDU
4
Transport
Transport protocol
Transport
TPDU
Communication subnet boundary
Internal subnet protocol
3
Network
Network
Network
Network
Packet
2
Data link
Data link
Data link
Data link
Frame
1
Physical
Physical
Physical
Physical
Bit
Host A
Router
Router
Host B
Network layer host-router protocol
Data link layer host-router protocol
Physical layer host-router protocol

Application Layer

- Consists of user programs, network applications that does work at hand
- Examples:
  - File transfer, Remote login, Mail, Web access
- Protocols: FTP, Telnet, Simple Mail Transfer Protocol(SMTP), HTTP.

Presentation Layer

- Concerned with syntax and semantics of information transmitted
- Translation
- Encoding data: Data compression/conversion, encryption and decryption

Session Layer

- Allows to establish a session between peers
- Dialogue control: Session can allow bidirectional traffic or only unidirectional traffic.
- Token management: In some protocols, it is required that both sides do not attempt same operation at same time. Session layer provides tokens to perform such actions
- Synchronization: Pausing and resuming a download.

Transport Layer

- Connection-oriented services to applications
  - flow control
  - guaranteed delivery of messages to destination
- Ensures data delivery is
  - error-free
  - in sequence
  - no loss, duplication and corruption of packets

Network Layer

- Interface between host and network
- Routing
- Congestion and deadlock
- Internetworking

Data-Link Layer and Physical Layer

- Data-link layer
  - Takes packet from network layer and moves it to the next router
  - error-free delivery: computes error detection information
- Physical layer
  - Controls transmission into the network cable.
  - Defines electrical signals.

Internet Protocol Stack

- Application layer
- Transport layer
- Network layer
- Data-link layer
- Physical layer

Encapsulation

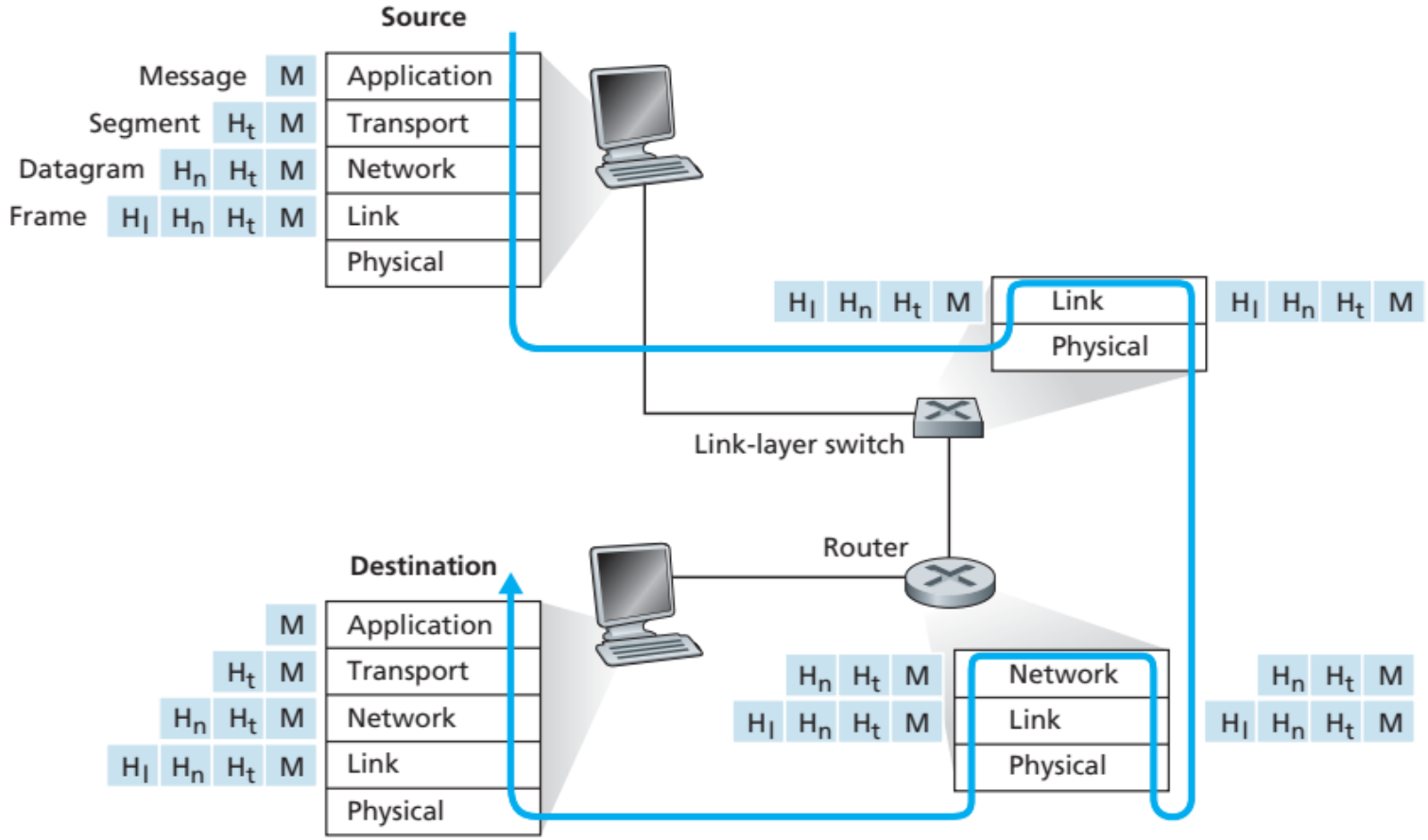


Figure 1.24 ♦ Hosts, routers, and link-layer switches; each contains a different set of layers, reflecting their differences in functionality