ADVANCED COMPUTER NETWORKS

Prof. Dr. Hasan Hüseyin BALIK

(2nd Week)

Outline

- 1. Overview
  - 1.1. Data Communications, Data Networks, and the Internet
  - 1.2. Protocol Architecture, TCP/IP, and Internet-Based Applications

1.2. Protocol Architecture, TCP/IP, and Internet-Based Applications

1.2.Outline

- The Need for a Protocol Architecture
- A Simple Protocol Architecture
- TCP/IP Protocol Architecture
- Standardization within a Protocol Architecture
- Traditional Internet-Based Applications
- Multimedia

The Need for a Protocol Architecture

1.) The source must either activate the direct communications path or inform the network of the identity of the desired destination system

2.) The source system must ascertain that the destination system is prepared to receive data

To transfer data several tasks must be performed:

3.) The file transfer application on the source system must ascertain that the file management program on the destination system is prepared to accept and store the file for this particular user

4.) A format translation function may need to be performed by one or the other system if the file formats used on the two systems are different
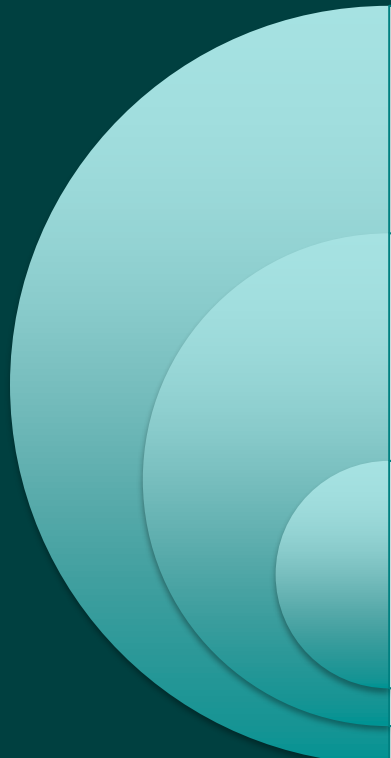
Functions of Protocol Architecture

➤ Breaks logic into subtask modules which are implemented separately

➤ Modules are arranged in a vertical stack

- Each layer in the stack performs a subset of functions

- Relies on next lower layer for primitive functions

- Provides services to the next higher layer

- Changes in one layer should not require changes in other layers

Key Features of a Protocol

A protocol is a set of rules or conventions that allow peer layers to communicate

The key features of a protocol are:

Syntax	• Format of data blocks
Semantics	• Control information for coordination and error handling
Timing	• Speed matching and sequencing

A Simple Protocol Architecture

Agents involved:
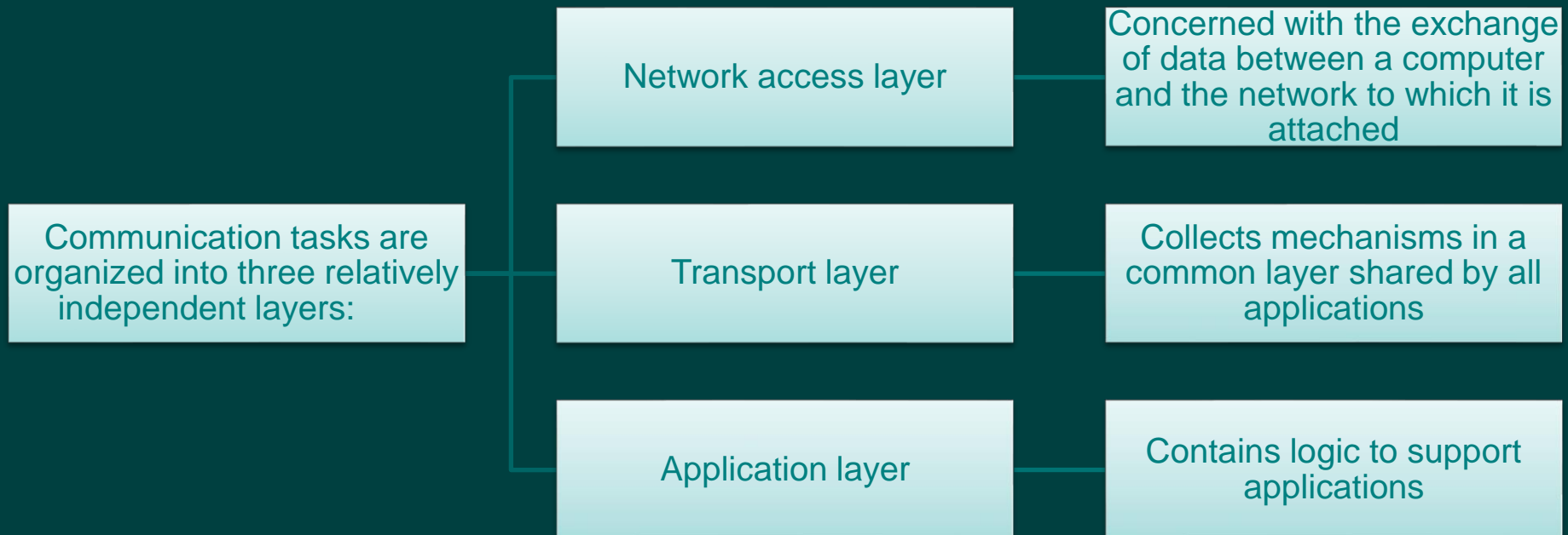- **Applications**
- **Computers**
- **Networks**

Examples of applications include file transfer and electronic mail

These execute on computers that support multiple simultaneous applications

Communication Layers

Communication tasks are organized into three relatively independent layers:

Network access layer — Concerned with the exchange of data between a computer and the network to which it is attached

Transport layer — Collects mechanisms in a common layer shared by all applications

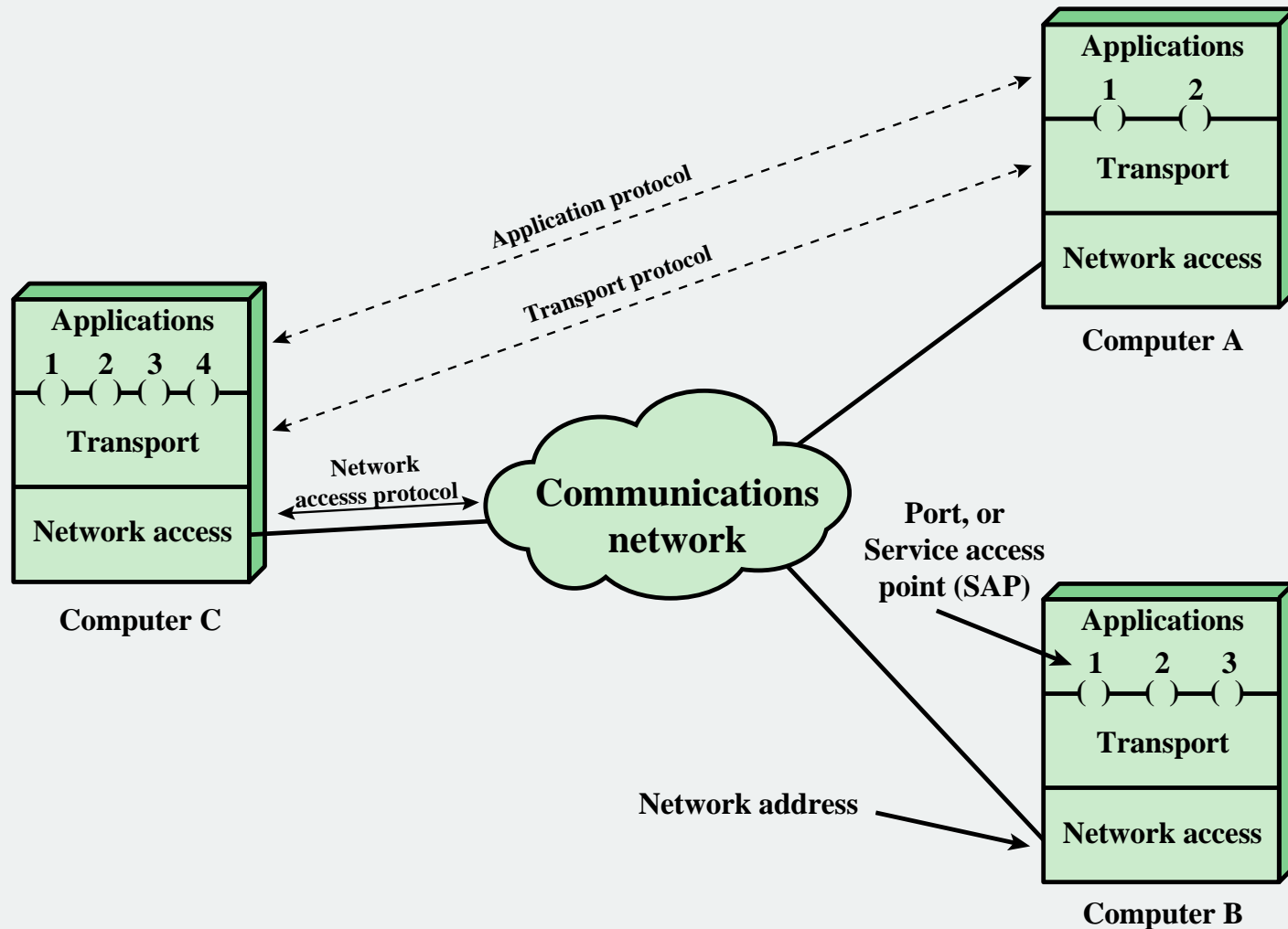Application layer — Contains logic to support applications

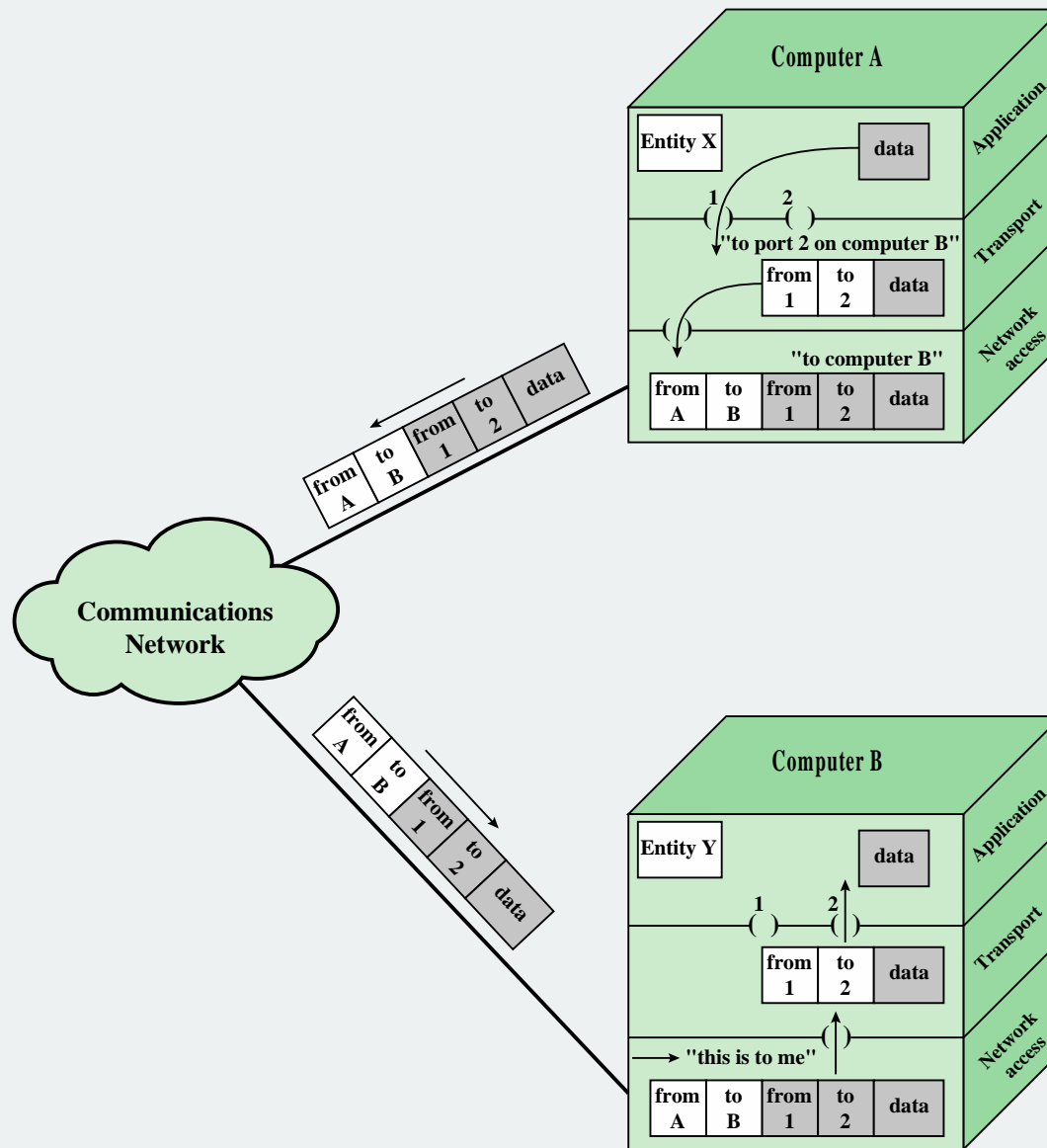**Figure 2.1 Protocol Architectures and Networks**

Figure 2.2   Protocols in a Simplified Architecture

TCP/IP Protocol Architecture

TCP/IP Protocol Architecture

- Result of protocol research and development conducted on ARPANET
- Referred to as TCP/IP protocol suite
- TCP/IP comprises a large collection of protocols that are Internet standards
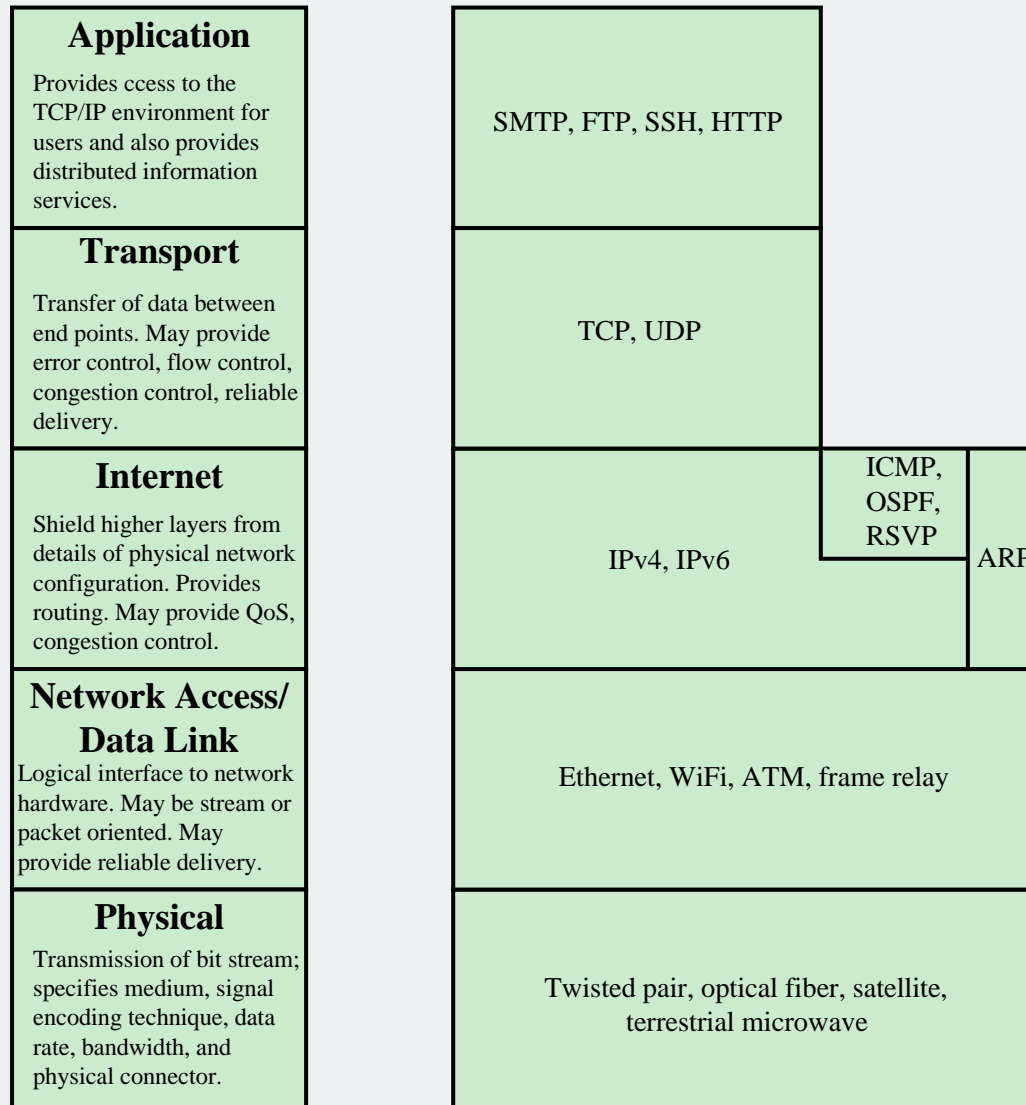
Application	SMTP, FTP, SSH, HTTP	
Application Provides ccess to the TCP/IP environment for users and also provides distributed information services.		
Transport Transfer of data between end points. May provide error control, flow control, congestion control, reliable delivery.	TCP, UDP	
Internet Shield higher layers from details of physical network configuration. Provides routing. May provide QoS, congestion control.	IPv4, IPv6	ICMP, OSPF, RSVP / ARP
Network Access/ Data Link Logical interface to network hardware. May be stream or packet oriented. May provide reliable delivery.	Ethernet, WiFi, ATM, frame relay	
Physical Transmission of bit stream; specifies medium, signal encoding technique, data rate, bandwidth, and physical connector.	Twisted pair, optical fiber, satellite, terrestrial microwave	

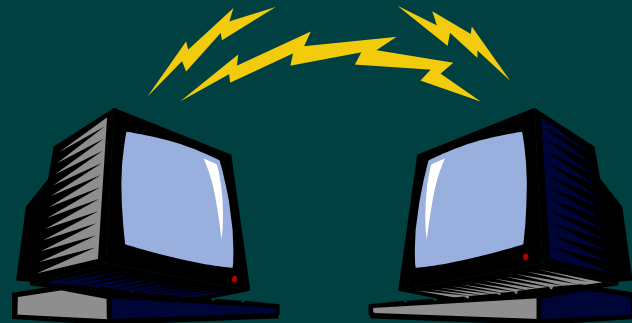**Figure 2.3 The TCP/IP Layers and Example Protocols**

Physical Layer

- Covers the physical interface between computer and network
- Concerned with issues like:
  - Characteristics of transmission medium
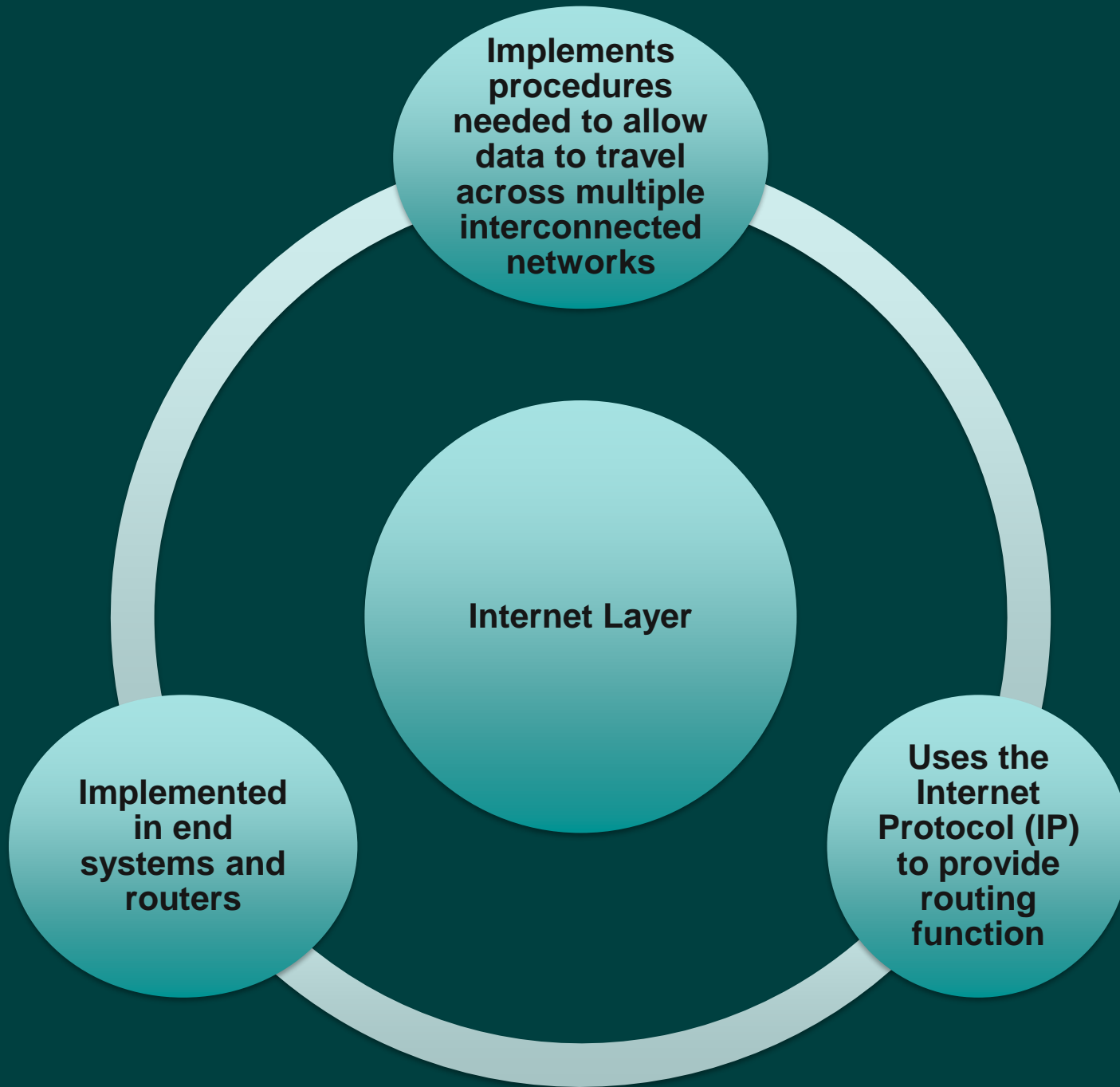 - Nature of the signals
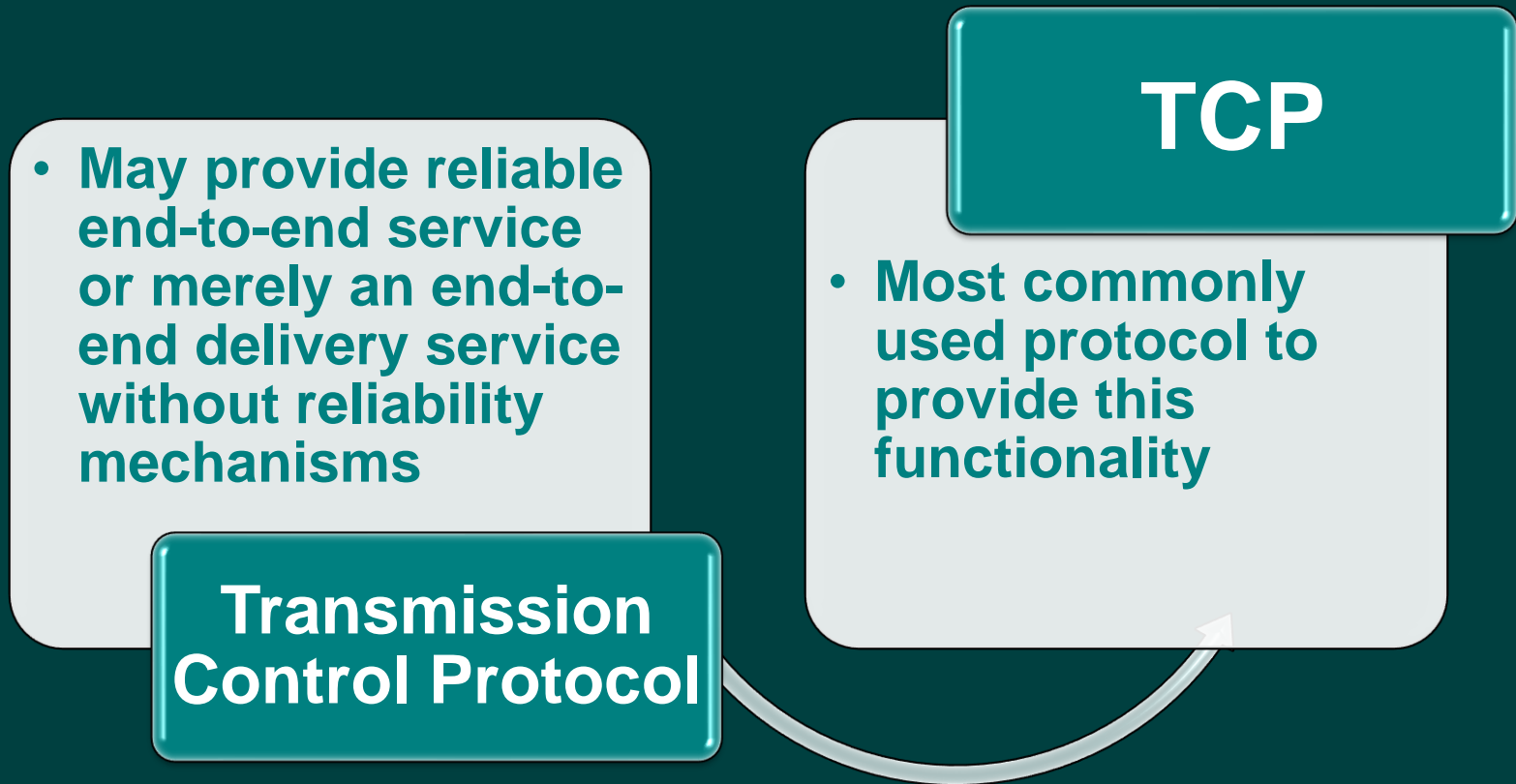 - Data rates

Network Access/Data Link Layer

➢ Covers the exchange of data between an end system and the network that it is attached to

➢ Concerned with:

- Access to and routing data across a network for two end systems attached to the same network

Internet Layer

- Implements procedures needed to allow data to travel across multiple interconnected networks
- Internet Layer
- Implemented in end systems and routers
- Uses the Internet Protocol (IP) to provide routing function

Host-to-Host (Transport) Layer

- May provide reliable end-to-end service or merely an end-to-end delivery service without reliability mechanisms

Transmission Control Protocol

TCP

- Most commonly used protocol to provide this functionality

Application Layer

➢ Contains the logic needed to support the various user applications

➢ A separate module is needed for each different type of application that is peculiar to that application
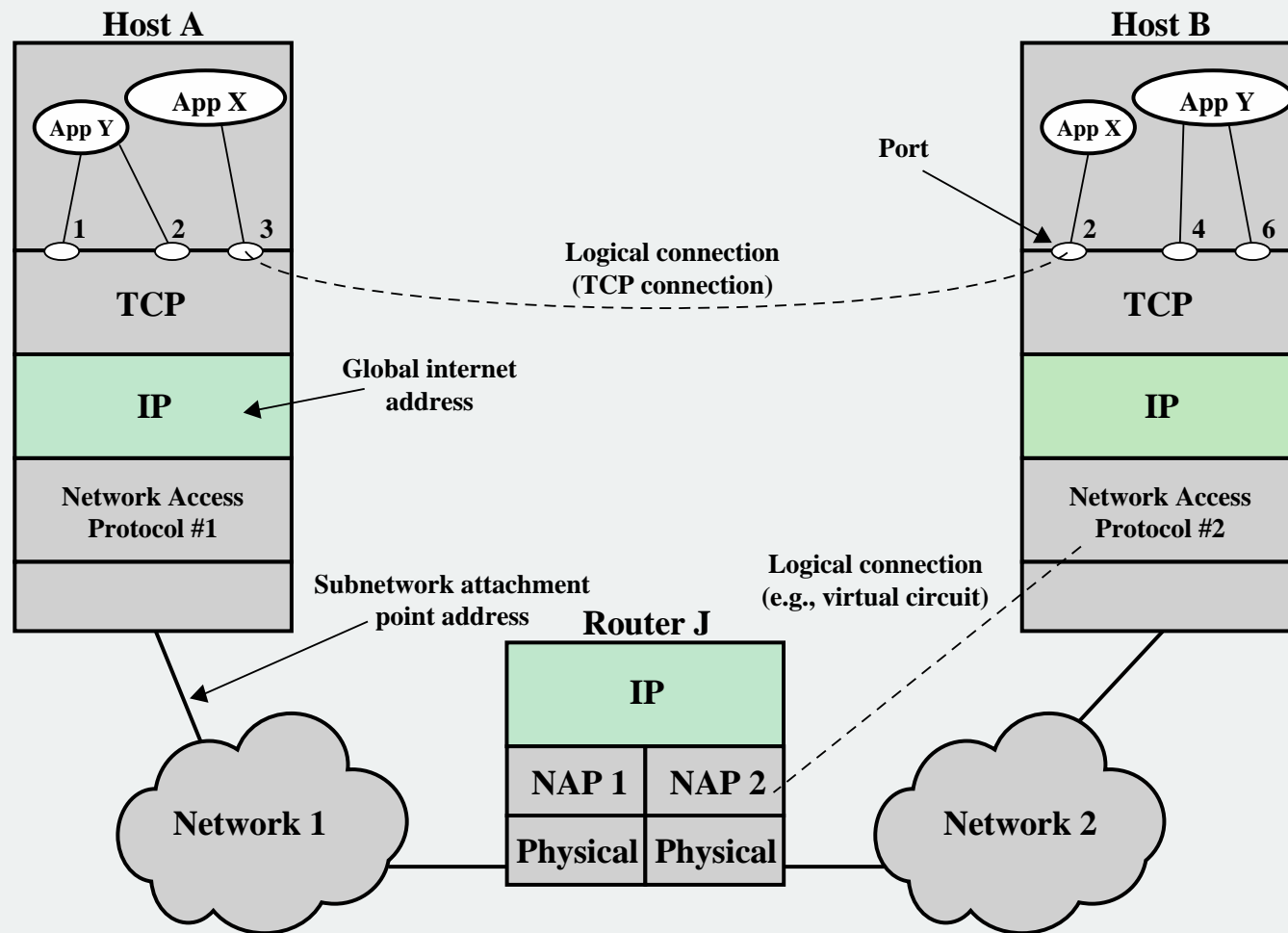
Figure 2.4 TCP/IP Concepts

TCP/IP Address Requirements

Two levels of addressing are needed:

Each host on a subnetwork must have a unique global internet address

Each process with a host must have an address (known as a port) that is unique within the host
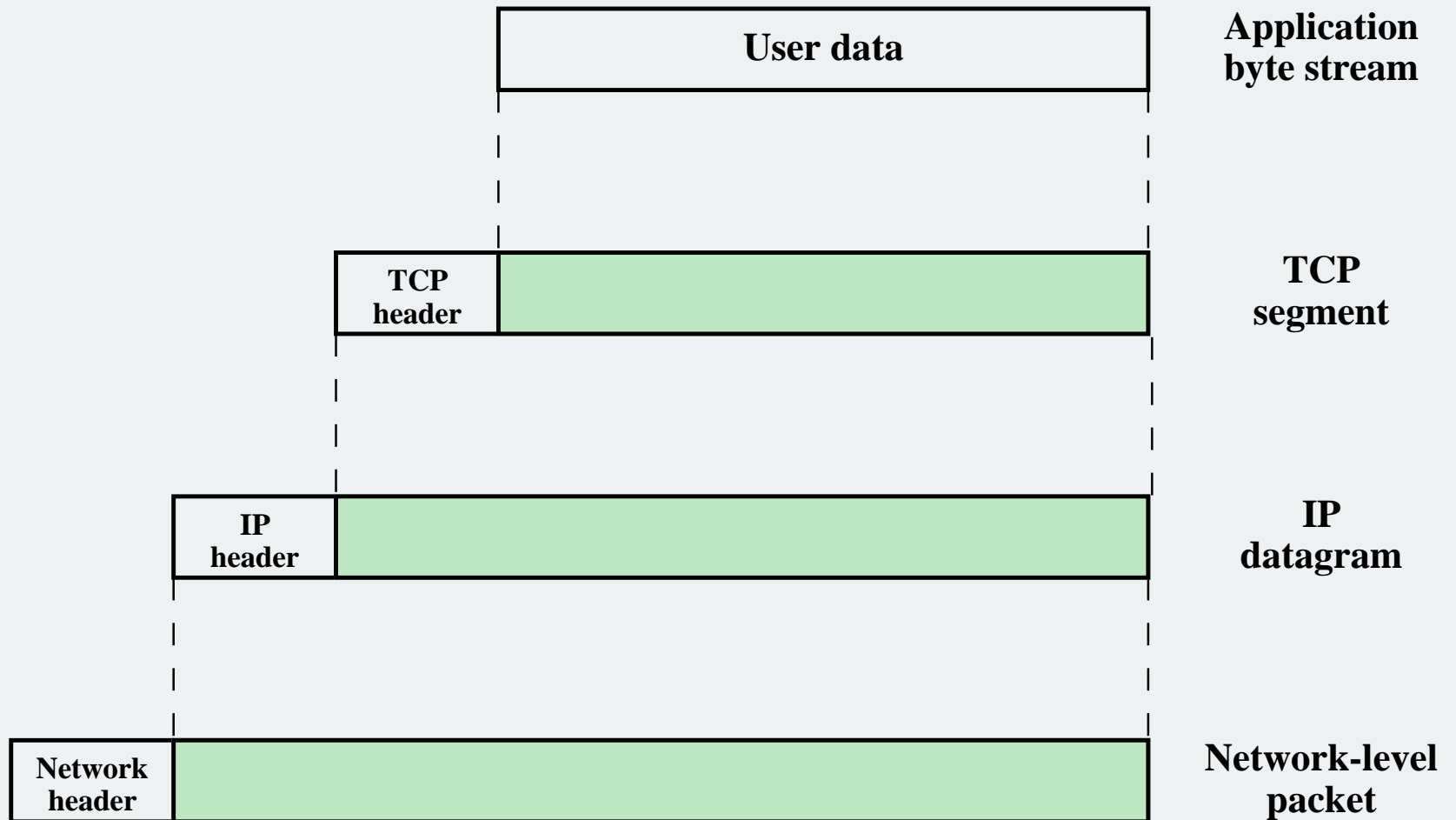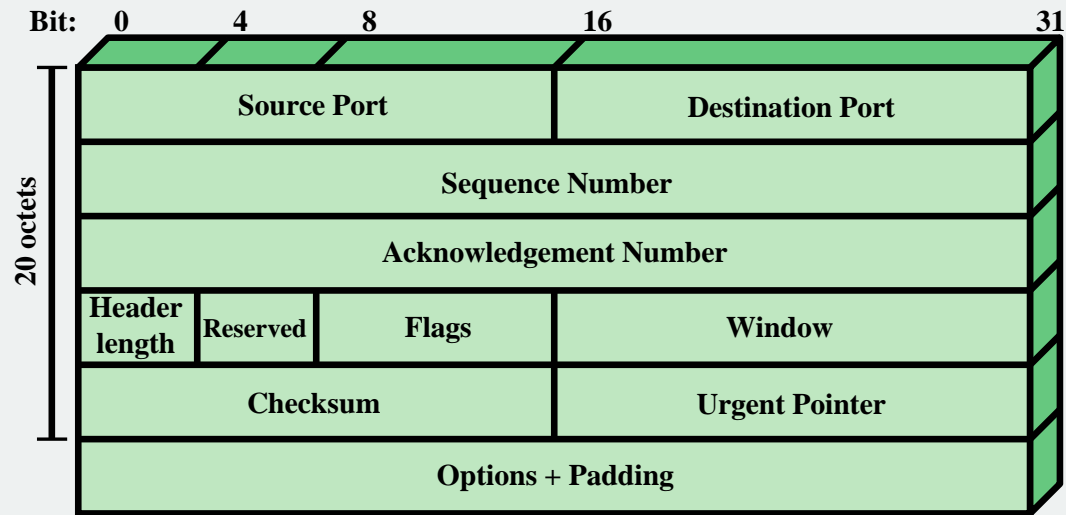
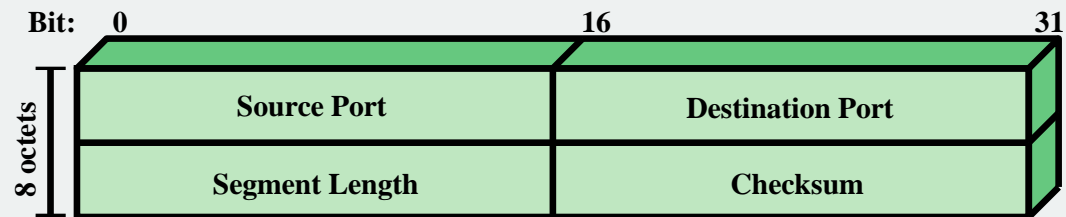**Figure 2.5 Protocol Data Units (PDUs) in the TCP/IP Architecture**

Transmission Control Protocol (TCP)

➢ TCP is the transport layer protocol for most applications

➢ TCP provides a reliable connection for transfer of data between applications

➢ A TCP segment is the basic protocol unit

➢ TCP tracks segments between entities for duration of each connection

Bit: 0 4 8 16 31

Source Port	Destination Port
Sequence Number	
Acknowledgement Number	
Header length	Reserved	Flags	Window
Checksum	Urgent Pointer
Options + Padding	

20 octets

(a) TCP Header

Bit: 0 16 31

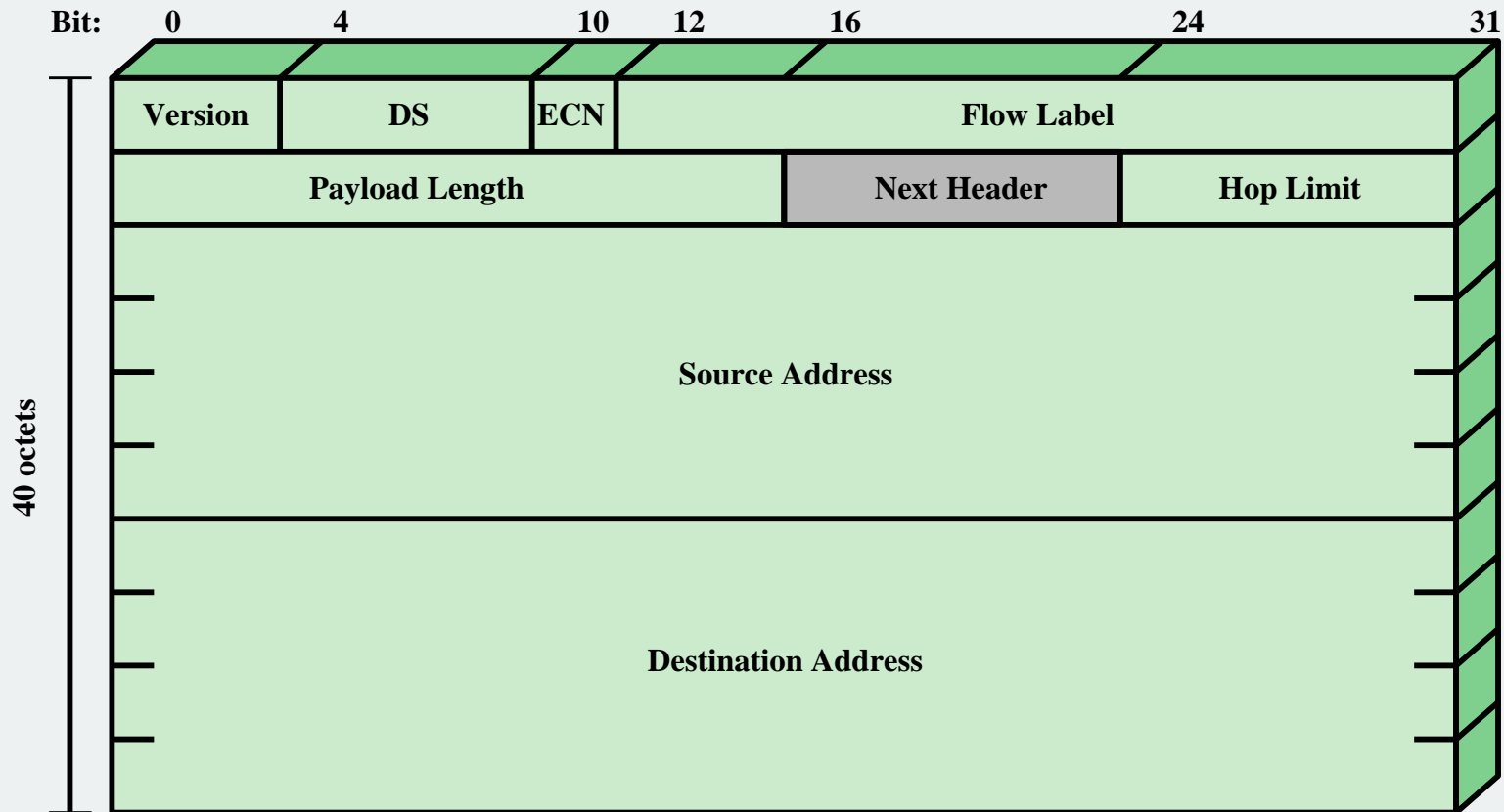| Source Port | Destination Port |
| Segment Length | Checksum |

8 octets

(b) UDP Header

Figure 2.6 TCP and UDP Headers

User Datagram Protocol (UDP)

- Alternative to TCP
- Does not guarantee delivery, preservation of sequence, or protection against duplication
- Enables a procedure to send messages to other procedures with a minimum of protocol mechanism
- Adds port addressing capability to IP
- Used with Simple Network Management Protocol (SNMP)
- Includes a checksum to verify that no error occurs in the data

Bits	0 3	4 7	9 15	16 31
	Version	Header length	Type of service	Total length
	Identification			Flags / Fragment offset
	Time to live		Protocol	Header checksum
	32-bit source address			
	32-bit destination address			
	Options			Padding

Bit:	0	4	10	12	16	24	31

Version	DS	ECN	Flow Label
Payload Length		Next Header	Hop Limit

Source Address

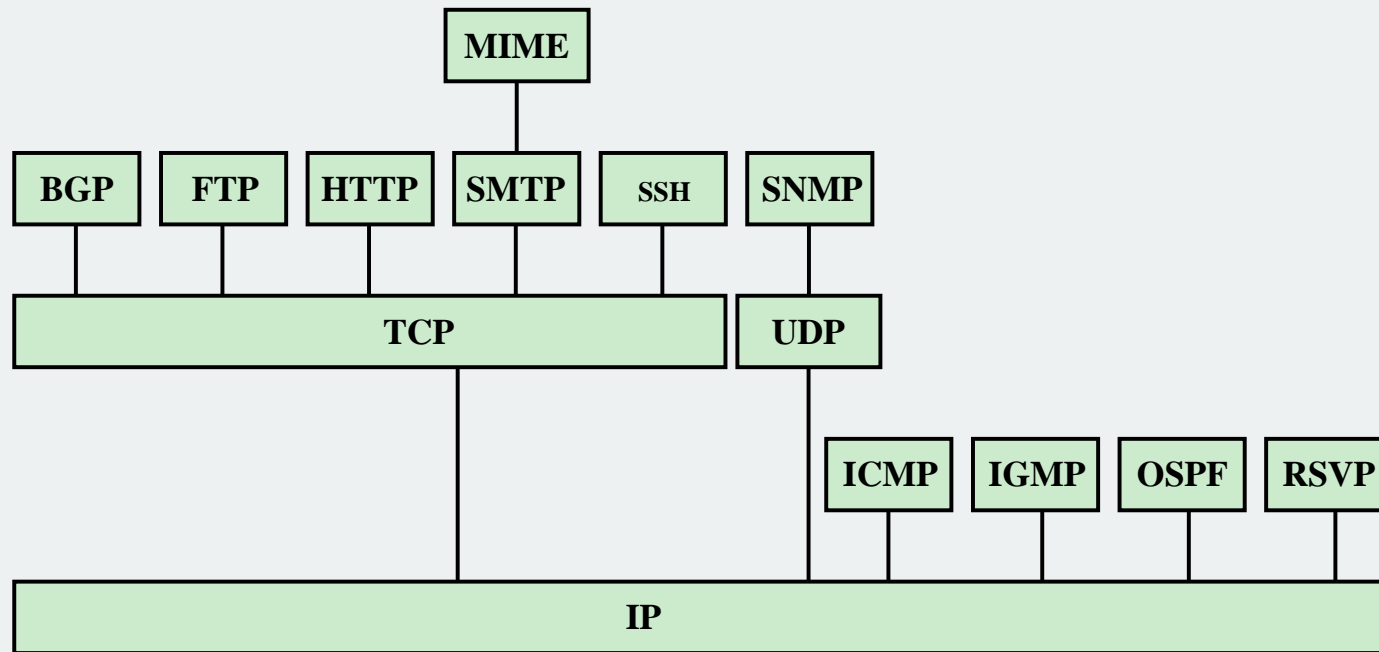**Destination Address**

40 octets

(b) IPv6 Header

DS = Differentiated services field
ECN = Explicit congestion notification field

Note: The 8-bit DS/ECN fields were formerly known as the Type of Service field in the IPv4 header and the Traffic Class field in the IPv6 header.

Figure 2.7 IP Headers

Figure 2.8 Some Protocols in the TCP/IP Protocol Suite

BGP   = Border Gateway Protocol
FTP   = File Transfer Protocol
HTTP = Hypertext Transfer Protocol
ICMP = Internet Control Message Protocol
IGMP = Internet Group Management Protocol
IP   = Internet Protocol
MIME = Multipurpose Internet Mail Extension

OSPF = Open Shortest Path First
RSVP = Resource ReSerVation Protocol
SMTP = Simple Mail Transfer Protocol
SNMP = Simple Network Management Protocol
SSH   = Secure Shell
TCP   = Transmission Control Protocol
UDP   = User Datagram Protocol

Service Primitives and Parameters

➤ Services between adjacent layers

➤ Expressed as:

- **Primitive**s

  - Specify the function to be performed

- **Parameters**

  - Used to pass data and control information

Service Primitive Types

REQUEST	A primitive issued by a service user to invoke some service and to pass the parameters needed to specify fully the requested service

INDICATION	A primitive issued by a service provider either to
	    1. indicate that a procedure has been invoked by the peer service user on the connection and to provide the associated parameters, or
	    2. notify the service user of a provider-initiated action

RESPONSE	A primitive issued by a service user to acknowledge or complete some procedure previously invoked by an indication to that user
CONFIRM	A primitive issued by a service provider to acknowledge or complete some procedure previously invoked by a request by the service user
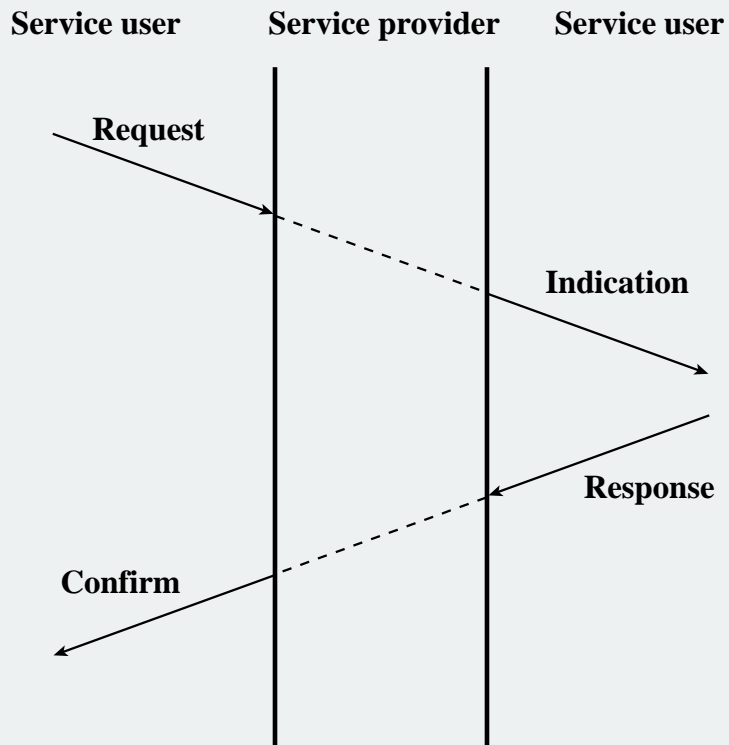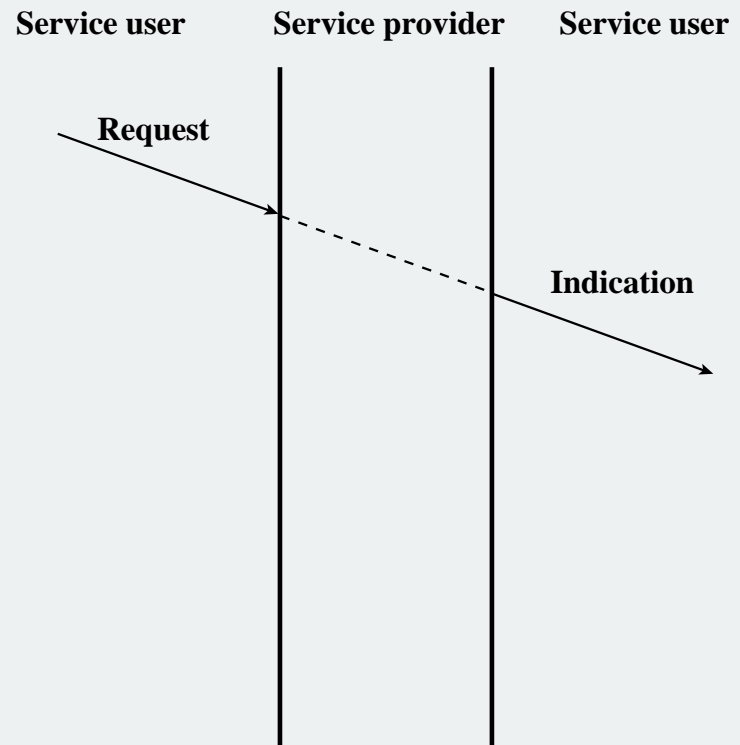
Figure 2.10 Time Sequence Diagrams for Service Primitives

Traditional Internet-Based Applications

➢ Three common applications that have been standardized to operate on top of TCP are:

Simple Mail Transfer Protocol (SMTP)

- Provides a mechanism for transferring messages among separate hosts

File Transfer Protocol (FTP)

- Used to send files from one system to another under user command
- Both text and binary files are accommodated

Secure Shell (SSH)

- Provides a secure remote logon capability

Multimedia Terminology

Media

    Refers to the form of information and includes text, still images, audio, and video.

Multimedia

    Human-computer interaction involving text, graphics, voice and video. Multimedia also refers to storage devices that are used to store multimedia content.

Streaming media

    Refers to multimedia files, such as video clips and audio, that begin playing immediately or within seconds after it is received by a computer from the Internet or Web. Thus, the media content is consumed as it is delivered from the server rather than waiting until an entire file is downloaded.
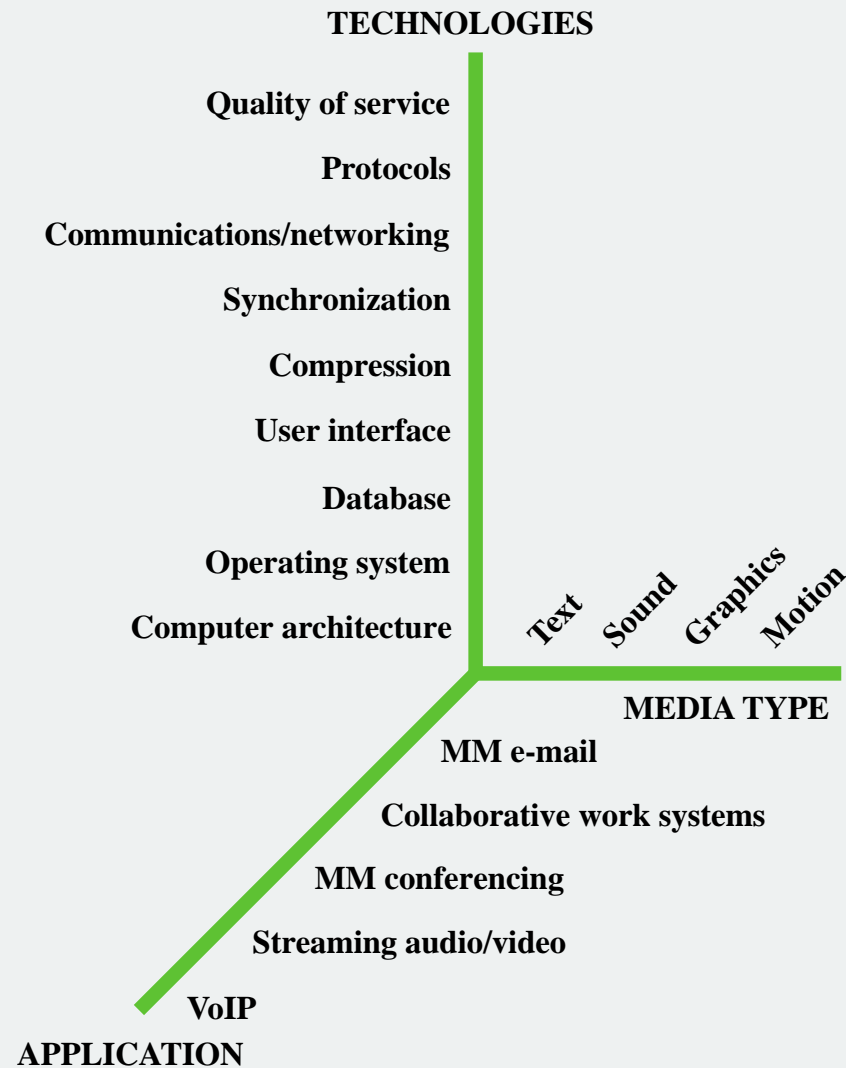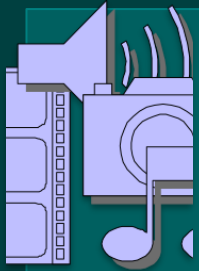
TECHNOLOGIES

Quality of service

Protocols

Communications/networking

Synchronization

Compression

User interface

Database

Operating system

Computer architecture

Text Sound Graphics Motion

MEDIA TYPE

MM e-mail

Collaborative work systems

MM conferencing

Streaming audio/video

VoIP

APPLICATION

Figure 2.11 A Multimedia Taxonomy

Media Types

audio generally encompasses sounds that are produced by the human speech mechanism

image supports the communication of individual pictures, charts, or drawings

video service carries sequences of pictures in time

text is information that can be entered via a keyboard and is directly readable and printable

Multimedia Applications

Information systems

- Information kiosks, electronic books that include audio and video, and multimedia expert systems

Communication systems

- Support collaborative work, such as videoconferencing

Entertainment systems

- Computer and network games and other forms of audiovisual entertainment

Business systems

- Business-oriented multimedia presentations, video brochures, and online shopping

Educational systems

- Electronic books with a multimedia component, simulation and modeling applets, and other teaching support systems

Multimedia Technologies

➢ Some technologies that are relevant to the support of multimedia applications are:

Compression	Communications/networking	Protocols	Quality of service (QoS)
JPG for still images	Refers to the transmission and networking technologies that can support high-volume multimedia traffic	RTP	Can deal with priority, delay constraints, delay variability constraints, and other similar requirements
MPG for video		SIP	