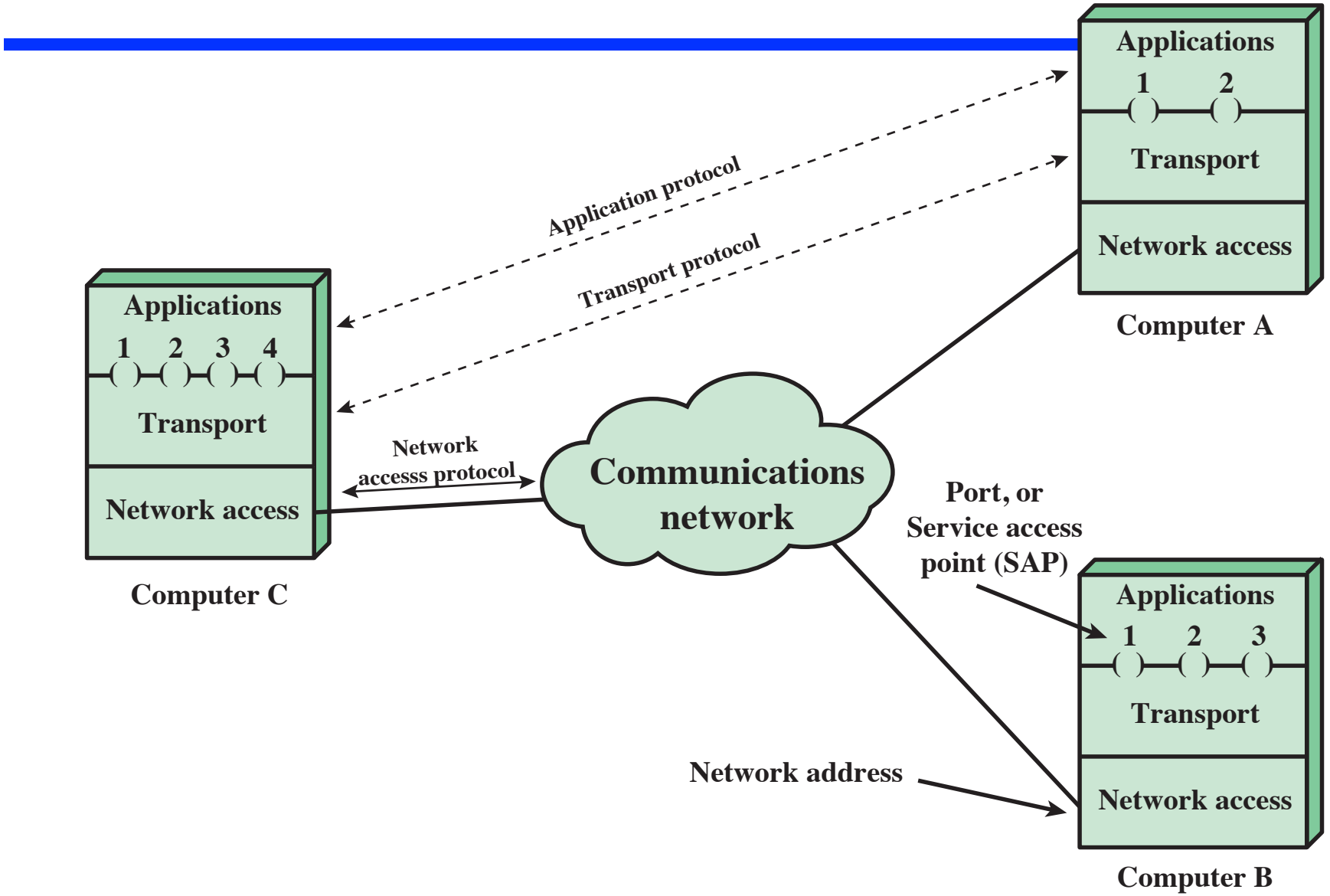
Chapter 2

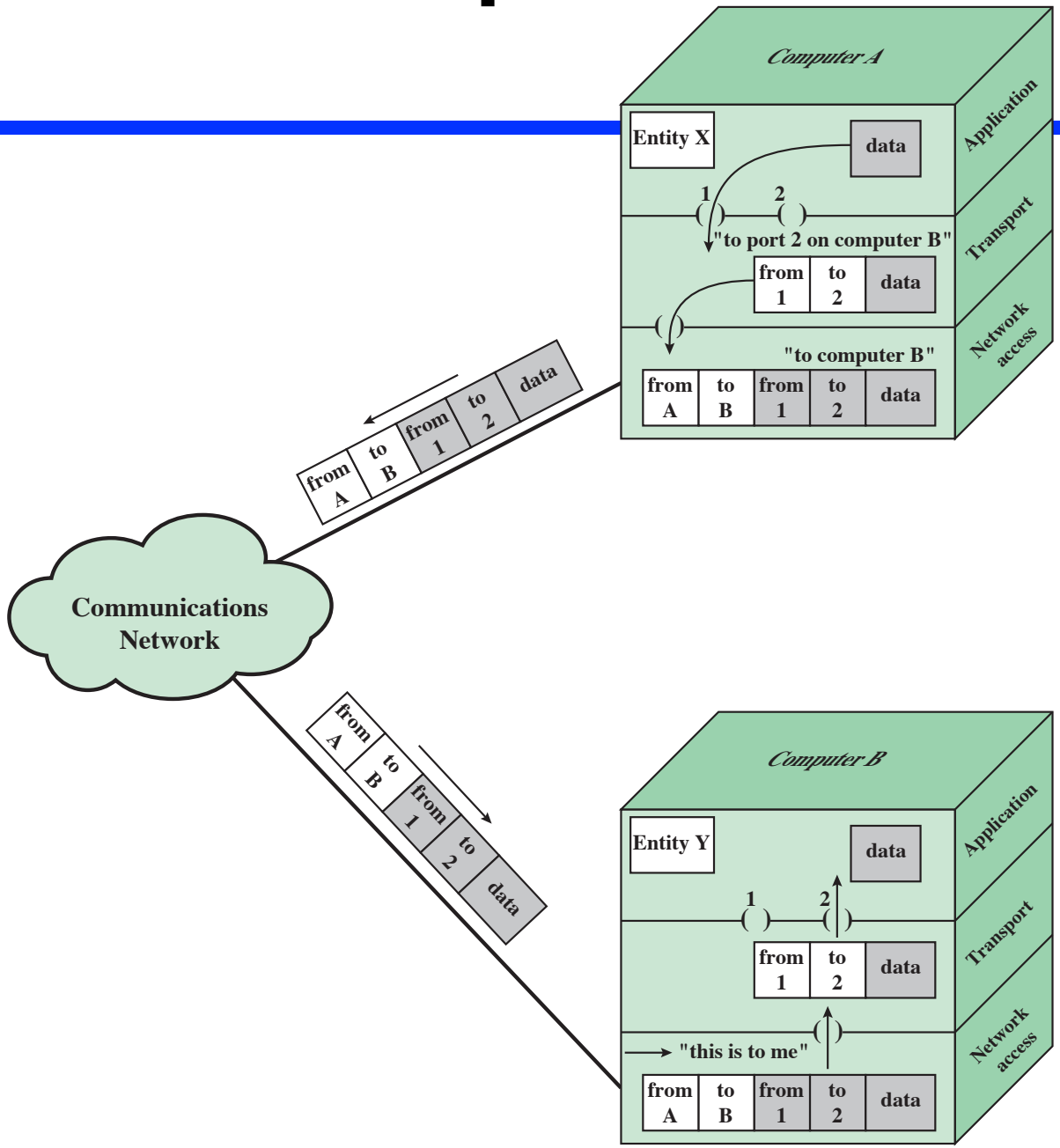
Need For Protocol Architecture

- E.g. File transfer
  - —Source must activate communications path or inform network of destination
  - —Source must check destination is prepared to receive
  - —File transfer application on source must check destination file management system will accept and store file for his user
  - —May need file format translation
- Task broken into subtasks
- Implemented separately in layers in stack
- Functions needed in both systems
- Peer layers communicate

Protocol Architecture and Networks



Protocols in a Simplified Architecture



Key Elements of a Protocol

- Syntax
  - —Data formats
  - —Signal levels
- Semantics
  - —Control information
  - —Error handling
- Timing
  - —Speed matching
  - —Sequencing

Standardized Protocol Architectures

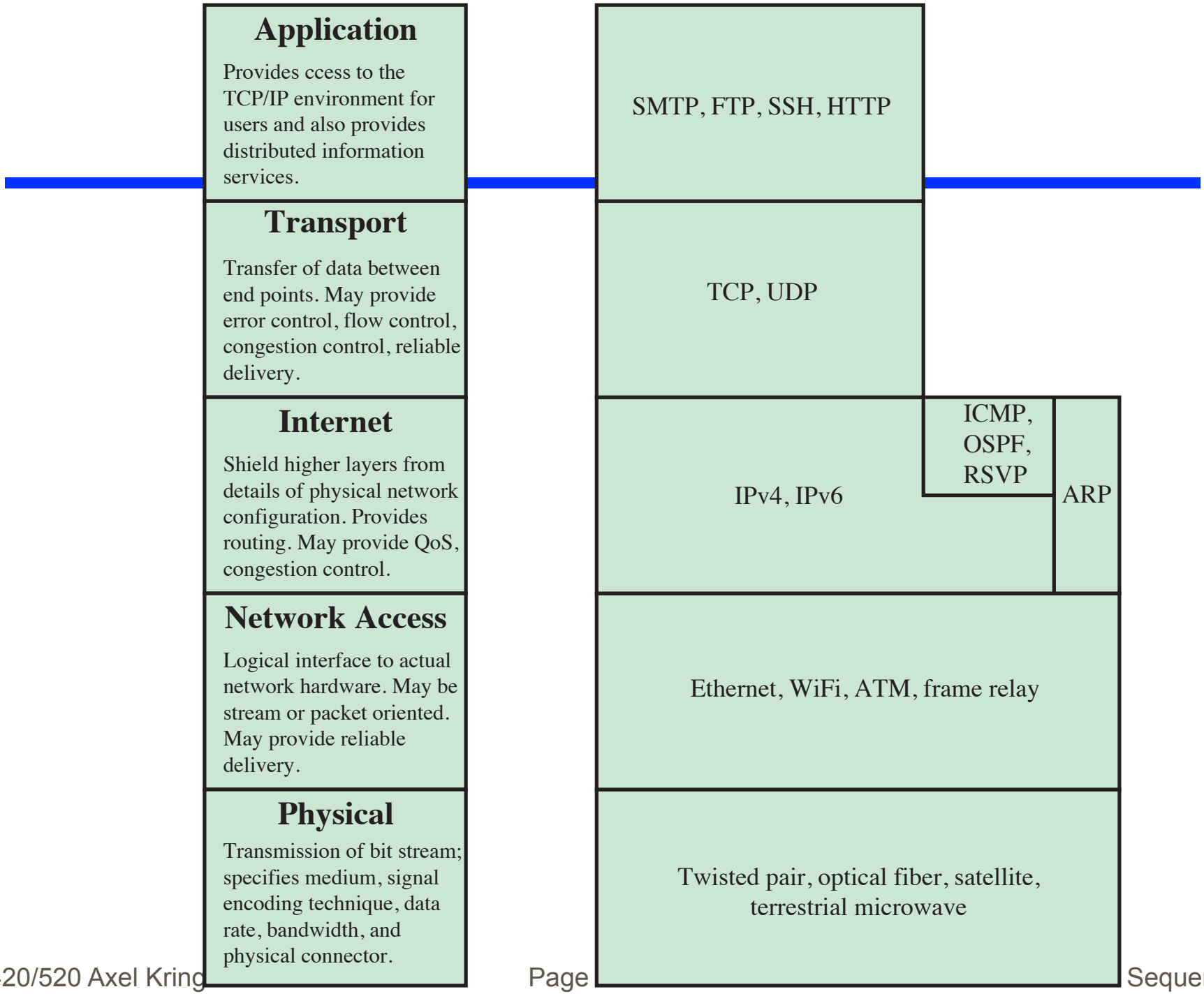
- Required for devices to communicate
- Vendors have more marketable products
- Customers can insist on standards based equipment
- Two standards:
  - —OSI Reference model
    - Never lived up to early promises
  - —TCP/IP protocol suite
    - Most widely used
- Also: IBM Systems Network Architecture (SNA)

TCP/IP Protocol Architecture

- developed by US Defense Advanced Research Project Agency (DARPA)
- for ARPANET packet switched network
- used by the global Internet
- protocol suite comprises a large collection of standardized protocols

TCP/IP Layers

- this is not an official model but a working one
  - —Application layer
  - —Host-to-host, or transport layer
  - —Internet layer
  - —Network access layer
  - —Physical layer


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.
Internet
Shield higher layers from details of physical network configuration. Provides routing. May provide QoS, congestion control.
Network Access
Logical interface to actual network hardware. May be stream or packet oriented. May provide reliable delivery.
Physical
Transmission of bit stream; specifies medium, signal encoding technique, data rate, bandwidth, and physical connector.
SMTP, FTP, SSH, HTTP
TCP, UDP
IPv4, IPv6
ICMP, OSPF, RSVP
ARP
Ethernet, WiFi, ATM, frame relay
Twisted pair, optical fiber, satellite, terrestrial microwave

Physical Layer

- concerned with physical interface between computer and network
- concerned with issues like:
  - characteristics of transmission medium
  - signal levels
  - data rates
  - other related matters

Network Access Layer

- exchange of data between an end system and attached network
- concerned with issues like :
  - —destination address provision
  - —invoking specific services like priority
  - —access to & routing data across a network link between two attached systems
- allows layers above to ignore link specifics

Internet Layer

- routing functions across multiple networks
- for systems attached to different networks
- using IP protocol
- implemented in end systems and routers
- routers connect two networks and relays data between them

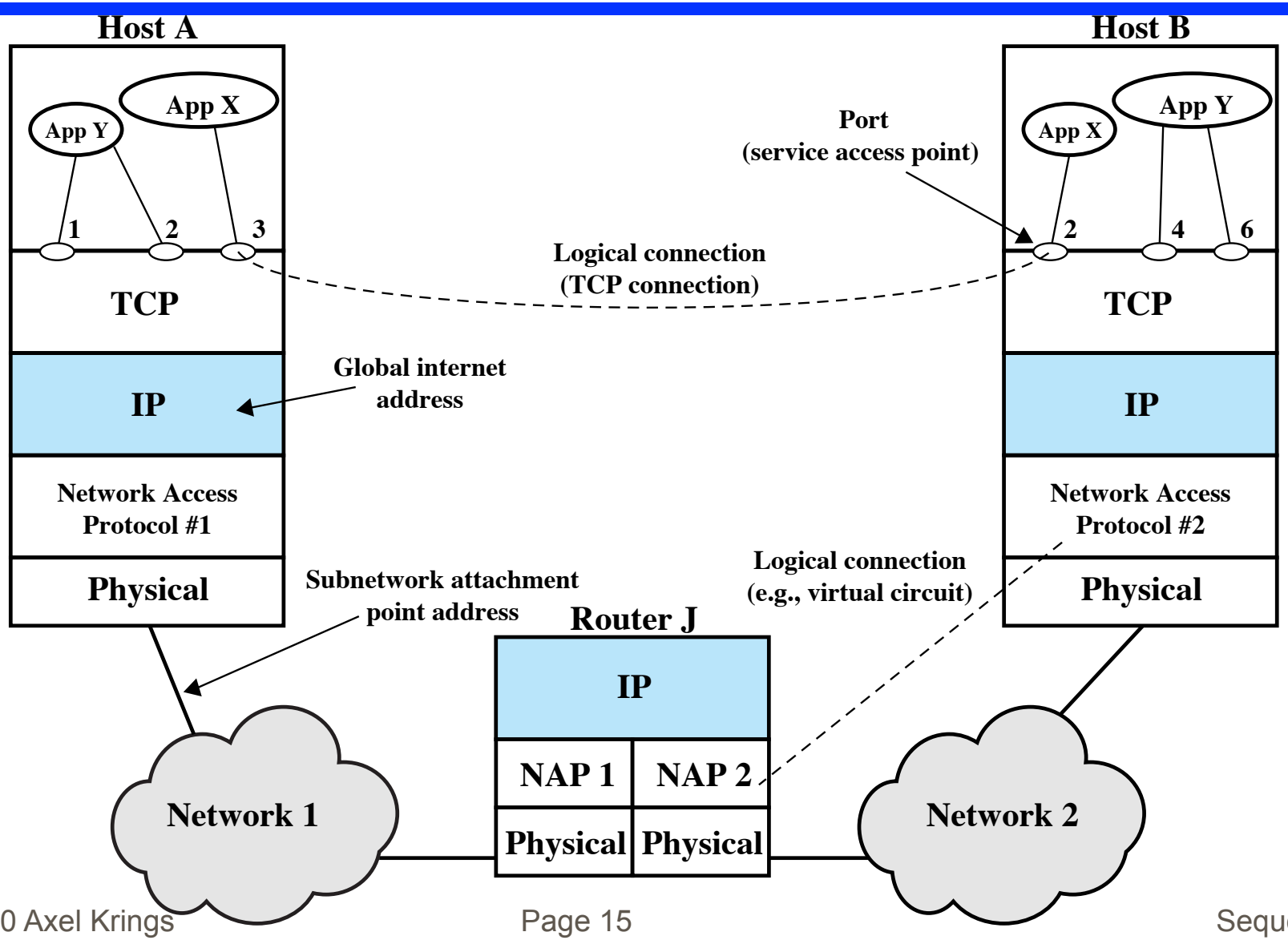
Transport Layer

- common layer shared by all applications
- provides reliable delivery of data
- in same order as sent
- commonly uses TCP

Application Layer

- provide support for user applications, e.g., ftp, email
- need a separate module for each type of application

Operation of TCP and IP



Addressing Requirements

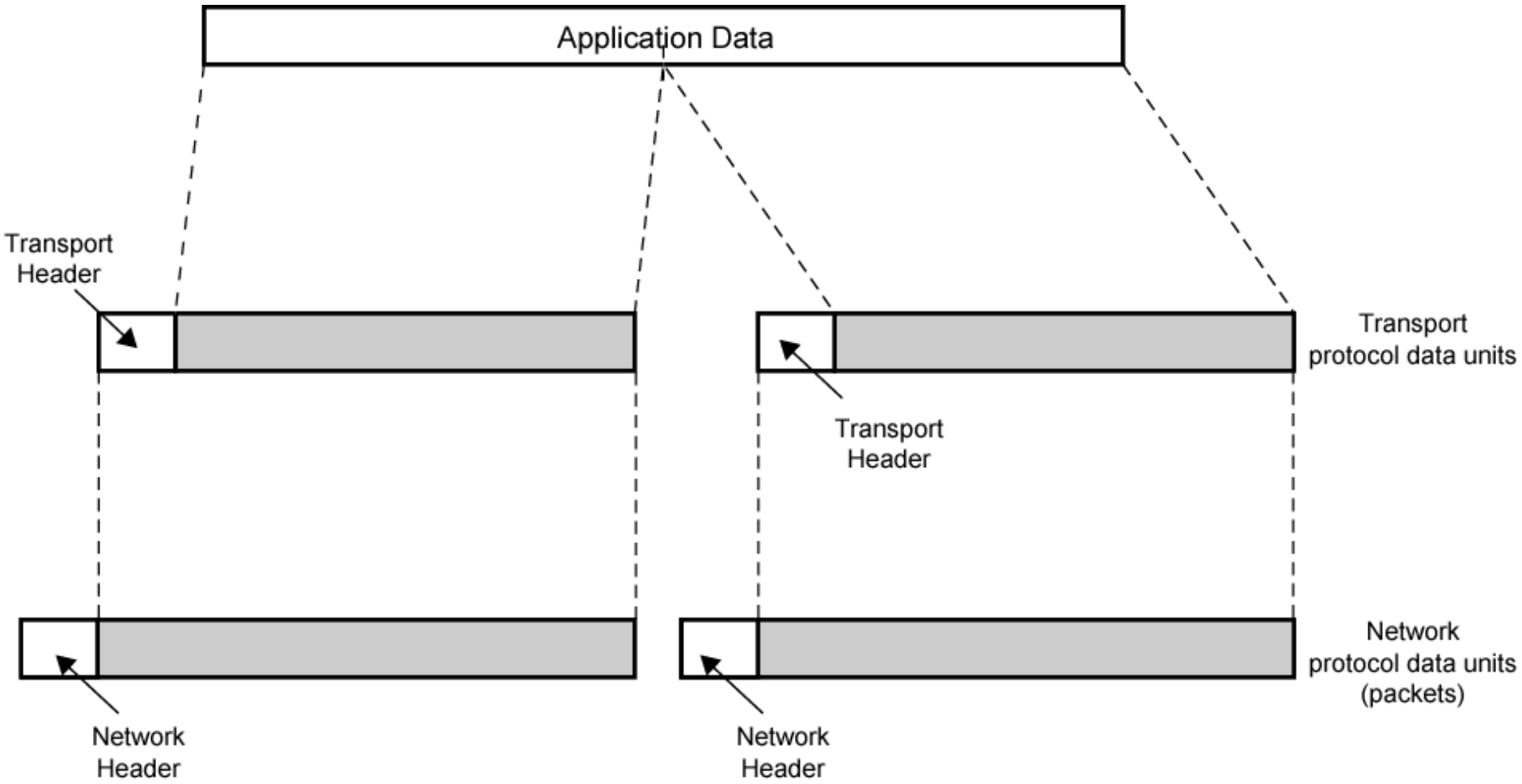
- two levels of addressing required
- each host on a subnet needs a unique global network address
  - —its IP address
- each application on a (multi-tasking) host needs a unique address within the host
  - —known as a port

Protocol Data Units (PDU)

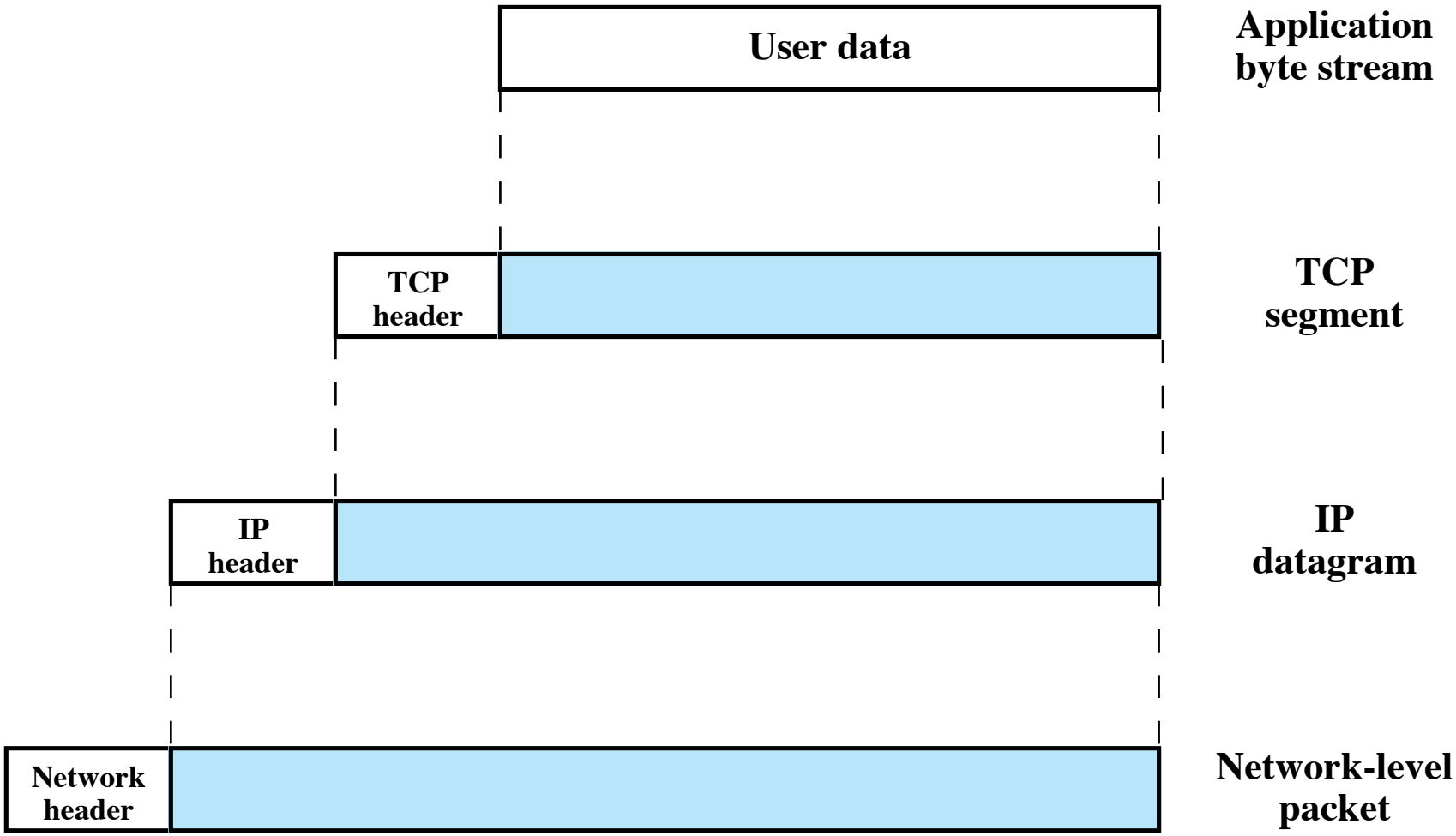
- At each layer
  - protocols are used to communicate
  - control information is added to user data

- Transport layer may fragment user data
  - Each fragment has a transport header added
    - Destination SAP (service access point)
    - Sequence number
    - Error detection code
  - This gives a transport protocol data unit

Protocol Data Units



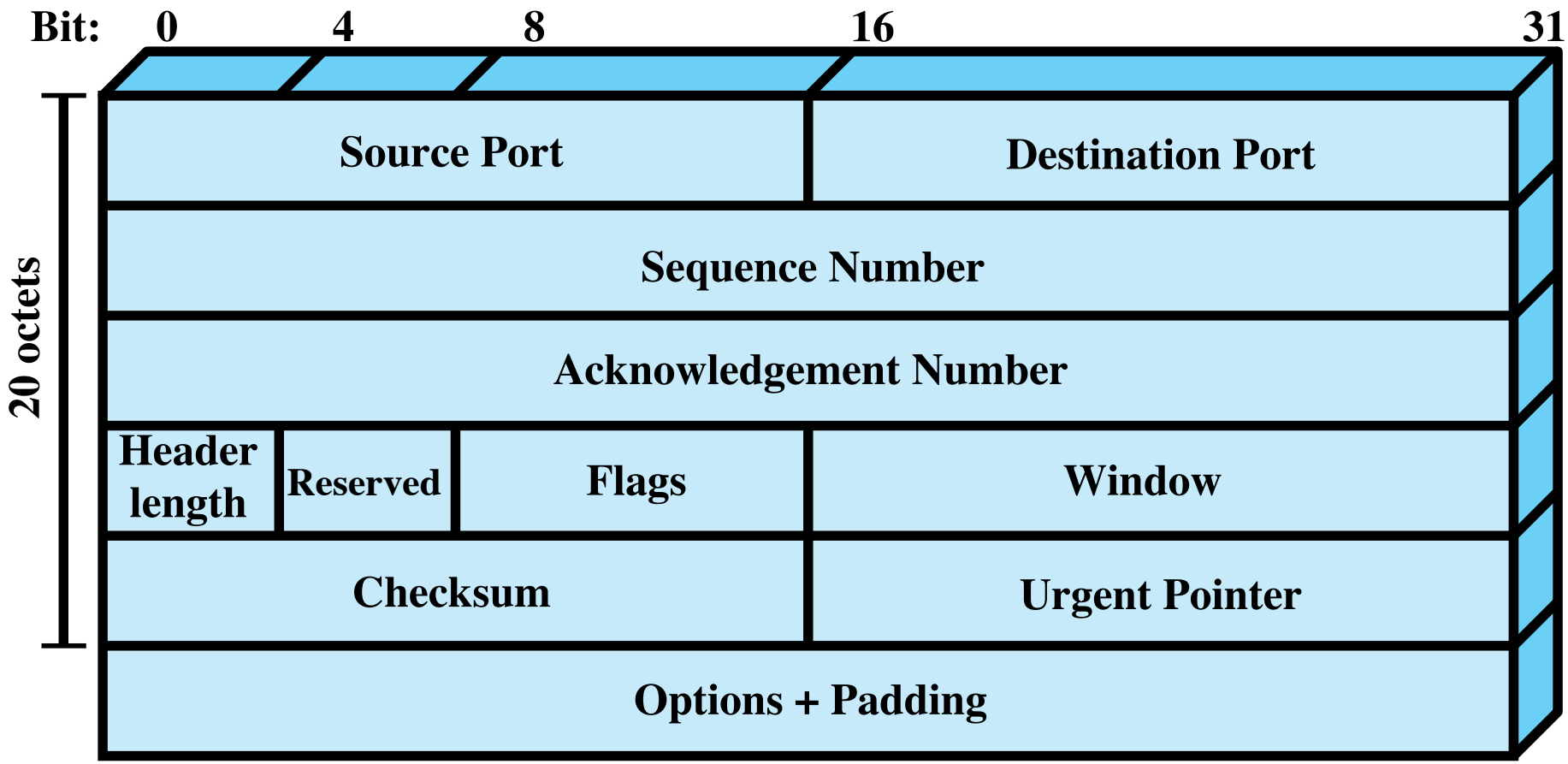
Operation of TCP/IP



TCP

- Usual transport layer is **T**ransmission **C**ontrol **P**rotocol
  - Reliable connection
  - RFC 793 from 1981
- Connection
  - Temporary logical association between entities in different systems
- TCP PDU
  - Called TCP segment
  - Includes source and destination port (c.f. SAP)
    - Identify respective users (applications)
    - Connection refers to pair of ports
- TCP tracks segments between entities on each connection

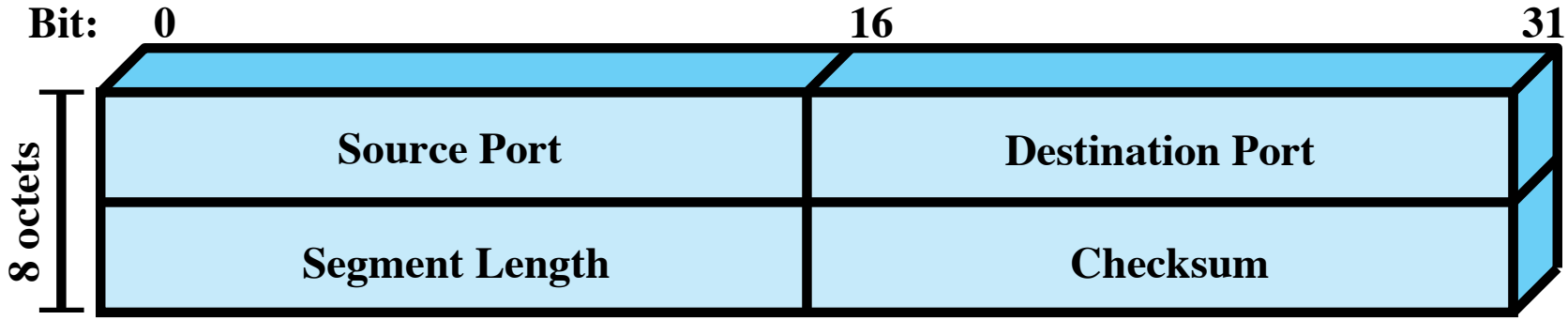
TCP Header


Bit:
0
4
8
16
31
20 octets
Source Port
Destination Port
Sequence Number
Acknowledgement Number
Header length
Reserved
Flags
Window
Checksum
Urgent Pointer
Options + Padding

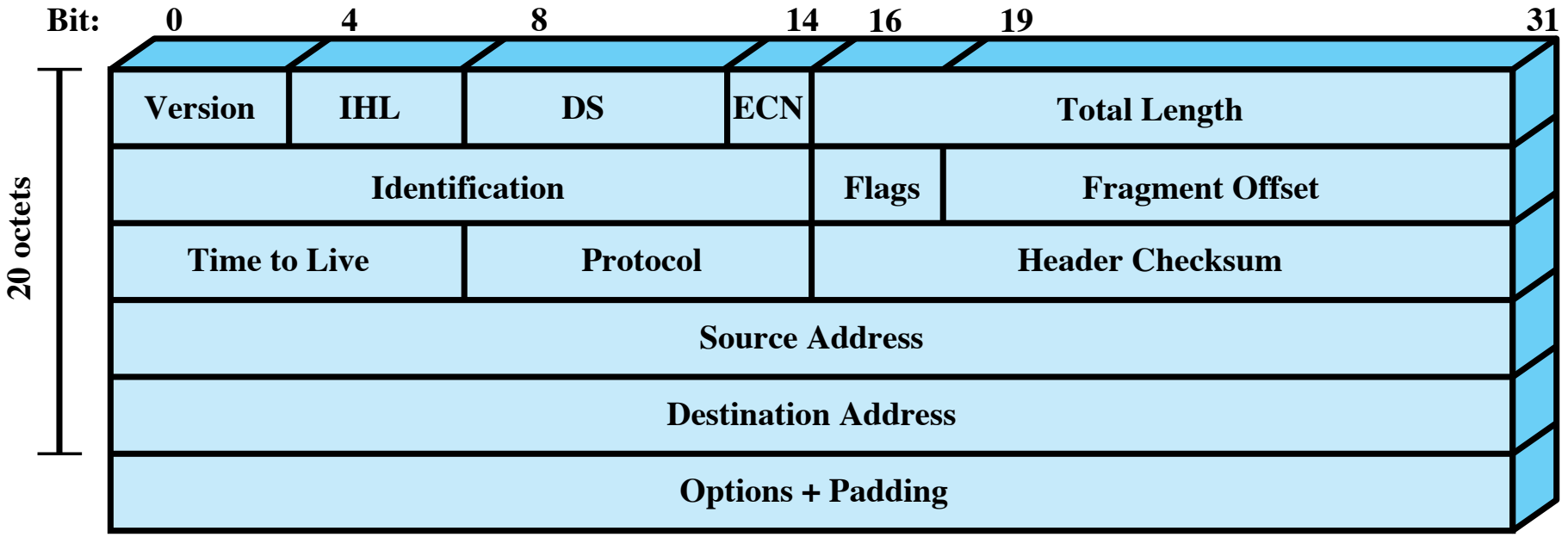
User Datagram Protocol (UDP)

- an alternative to TCP
- no guaranteed delivery (...it is a datagram)
- no preservation of sequence
- no protection against duplication
- minimum overhead
- adds port addressing to IP

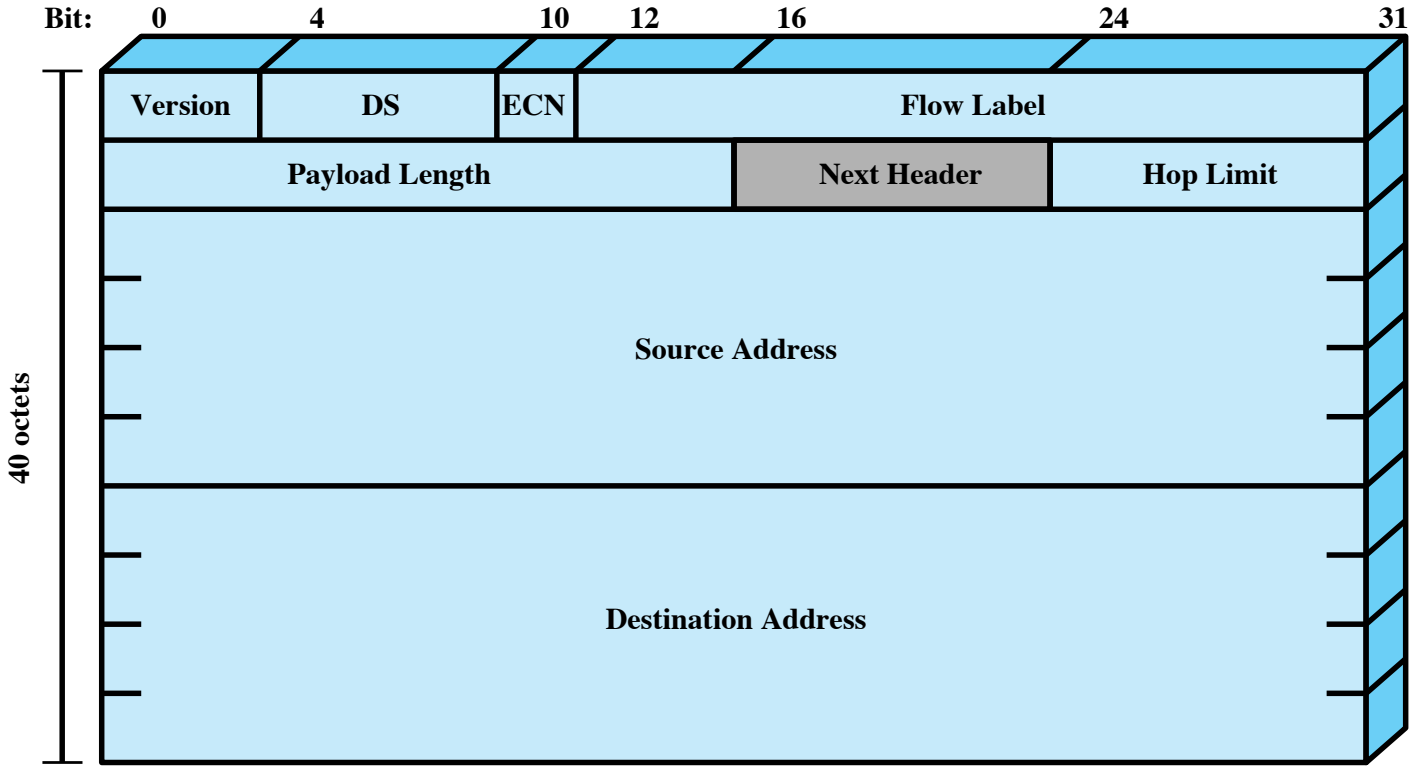
UDP Header


Bit:
0
16
31
8 octets
Source Port
Destination Port
Segment Length
Checksum

IP Header


Bit:
0
4
8
14
16
19
31
20 octets
Version
IHL
DS
ECN
Total Length
Identification
Flags
Fragment Offset
Time to Live
Protocol
Header Checksum
Source Address
Destination Address
Options + Padding

IPv6 Header



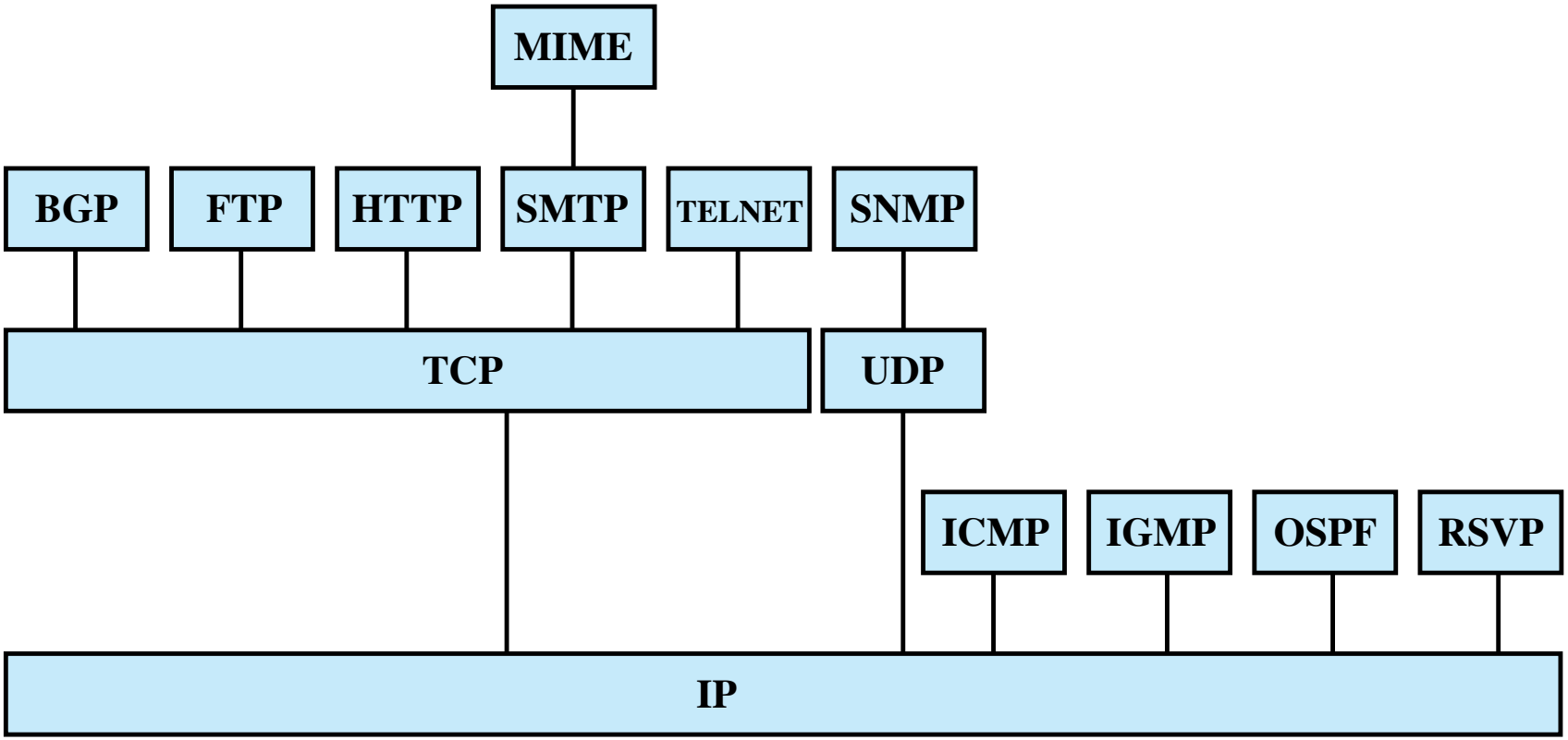
DS = Differentiated services field
ECN = Explicit congestion notification field

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.

TCP/IP Applications

- have a number of standard TCP/IP applications such as
  - —Simple Mail Transfer Protocol (SMTP)
  - —File Transfer Protocol (FTP)
  - —Telnet

Some TCP/IP Protocols

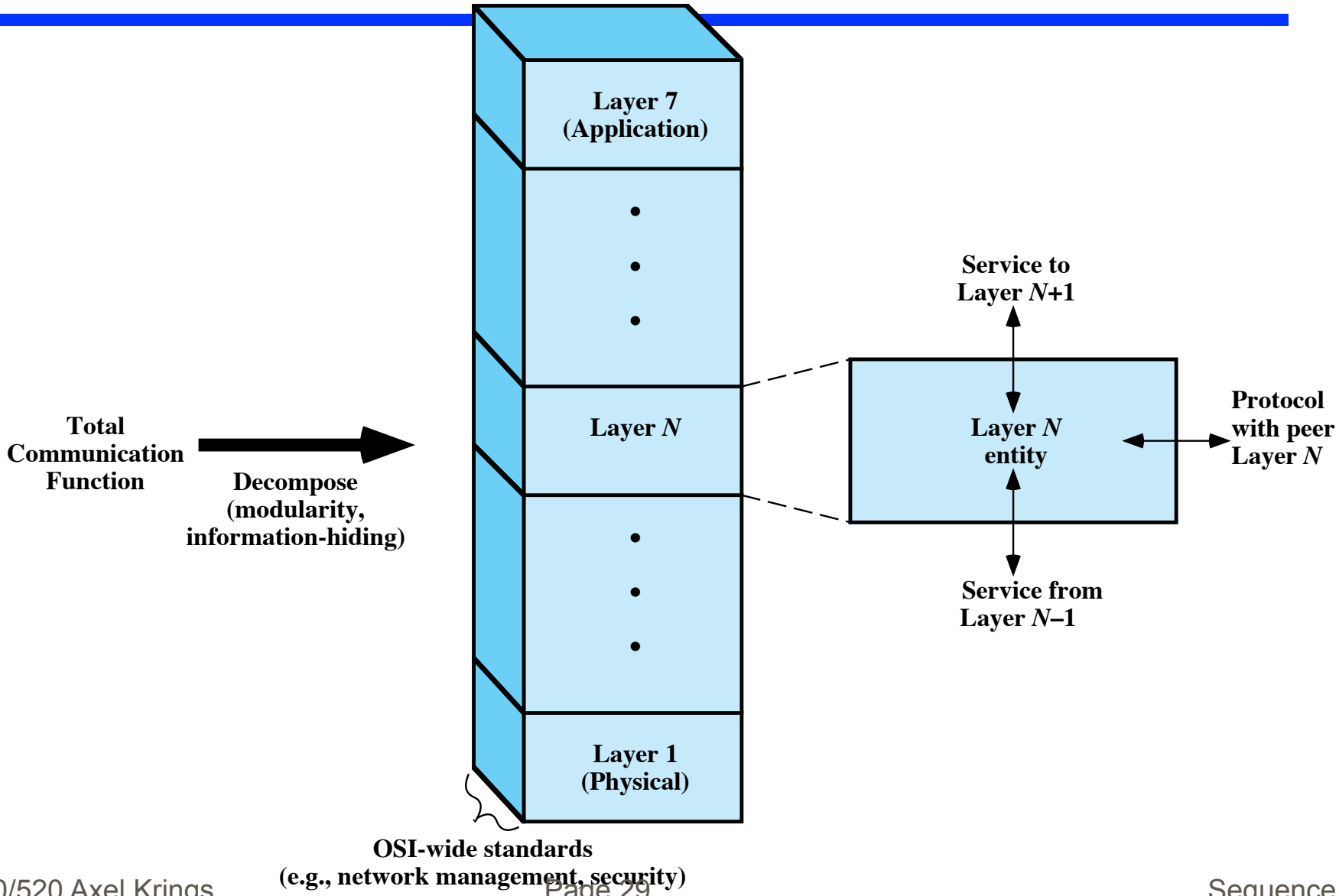


BGP	=	Border Gateway Protocol	OSPF	=	Open Shortest Path First
FTP	=	File Transfer Protocol	RSVP	=	Resource ReSerVation Protocol
HTTP	=	Hypertext Transfer Protocol	SMTP	=	Simple Mail Transfer Protocol
ICMP	=	Internet Control Message Protocol	SNMP	=	Simple Network Management Protocol
IGMP	=	Internet Group Management Protocol	TCP	=	Transmission Control Protocol
IP	=	Internet Protocol	UDP	=	User Datagram Protocol
MIME	=	Multipurpose Internet Mail Extension			

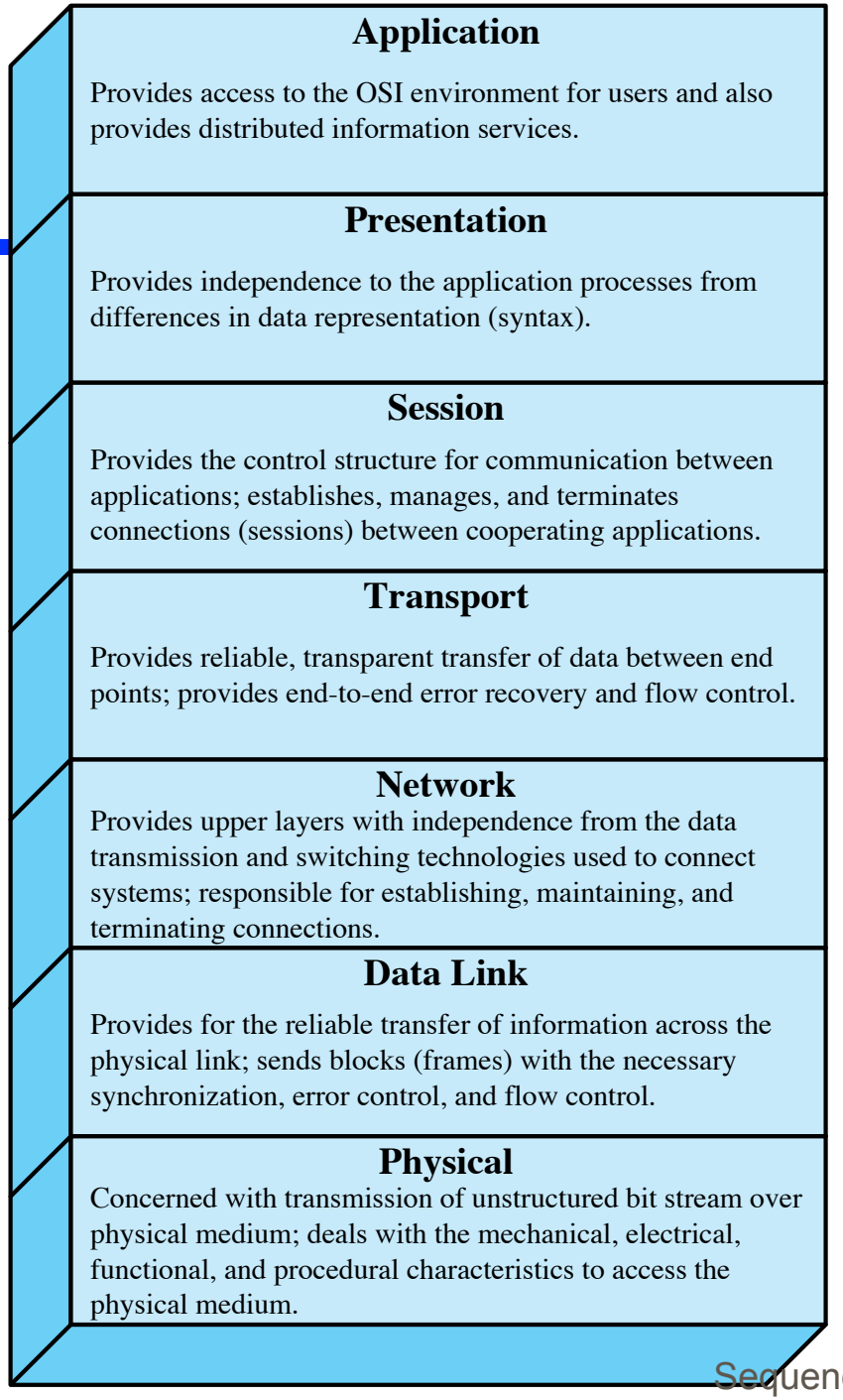
OSI

- Open Systems Interconnection
- developed by the International Organization for Standardization (ISO)
- has seven layers
- is a theoretical system delivered too late!
- TCP/IP is the de facto standard

Standardized Protocol Architectures



OSI Layers


Application
Provides access to the OSI environment for users and also provides distributed information services.
Presentation
Provides independence to the application processes from differences in data representation (syntax).
Session
Provides the control structure for communication between applications; establishes, manages, and terminates connections (sessions) between cooperating applications.
Transport
Provides reliable, transparent transfer of data between end points; provides end-to-end error recovery and flow control.
Network
Provides upper layers with independence from the data transmission and switching technologies used to connect systems; responsible for establishing, maintaining, and terminating connections.
Data Link
Provides for the reliable transfer of information across the physical link; sends blocks (frames) with the necessary synchronization, error control, and flow control.
Physical
Concerned with transmission of unstructured bit stream over physical medium; deals with the mechanical, electrical, functional, and procedural characteristics to access the physical medium.

OSI Layers (1)

- Physical
  - —Physical interface between devices
    - Mechanical
    - Electrical
    - Functional
    - Procedural
- Data Link
  - —Means of activating, maintaining and deactivating a reliable link
  - —Error detection and control
  - —Higher layers may assume error free transmission

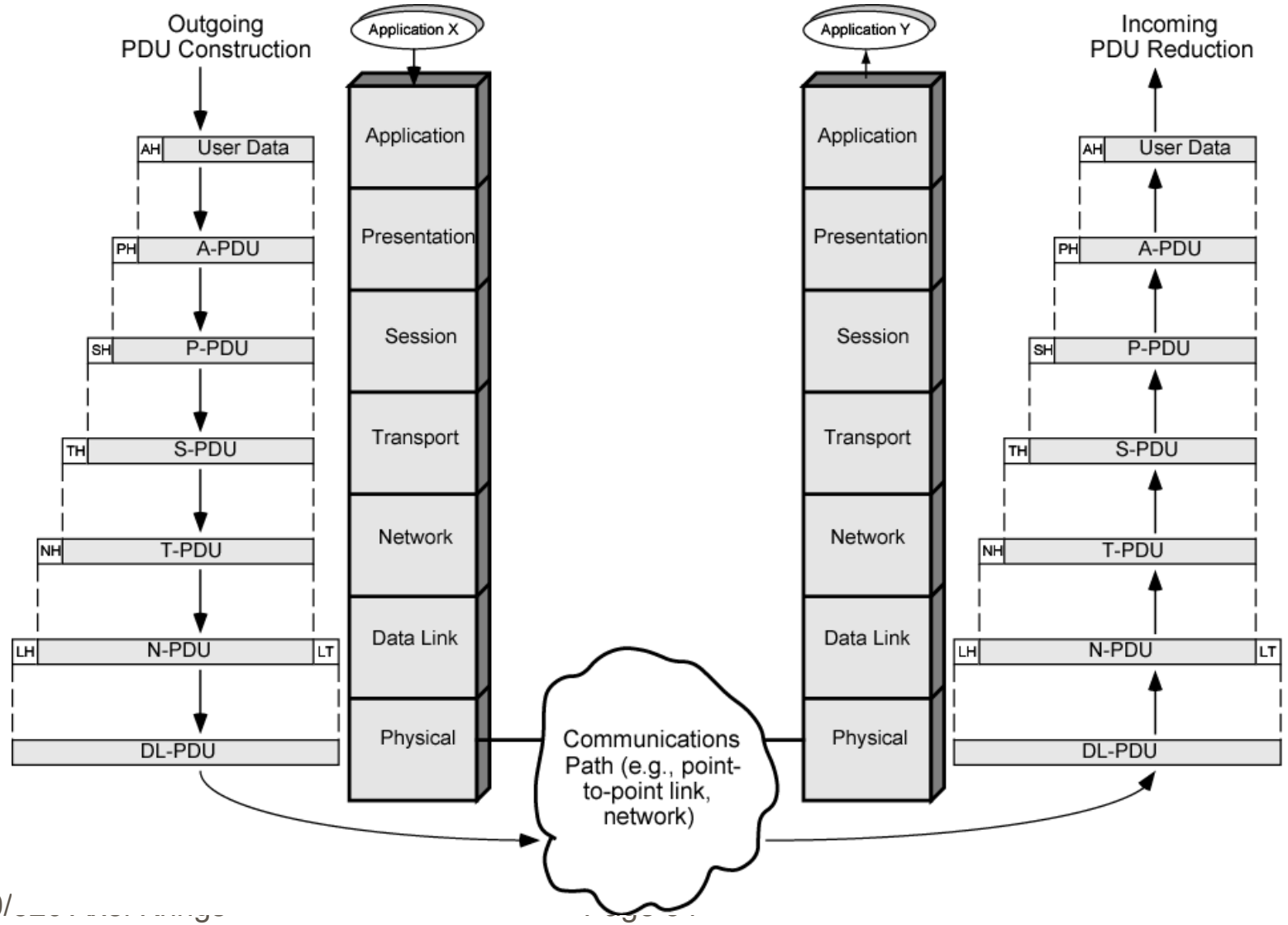
OSI Layers (2)

- Network
  - Transport of information
  - Higher layers do not need to know about underlying technology
  - Not needed on direct links
- Transport
  - Exchange of data between end systems
  - Error free
  - In sequence
  - No losses
  - No duplicates
  - Quality of service

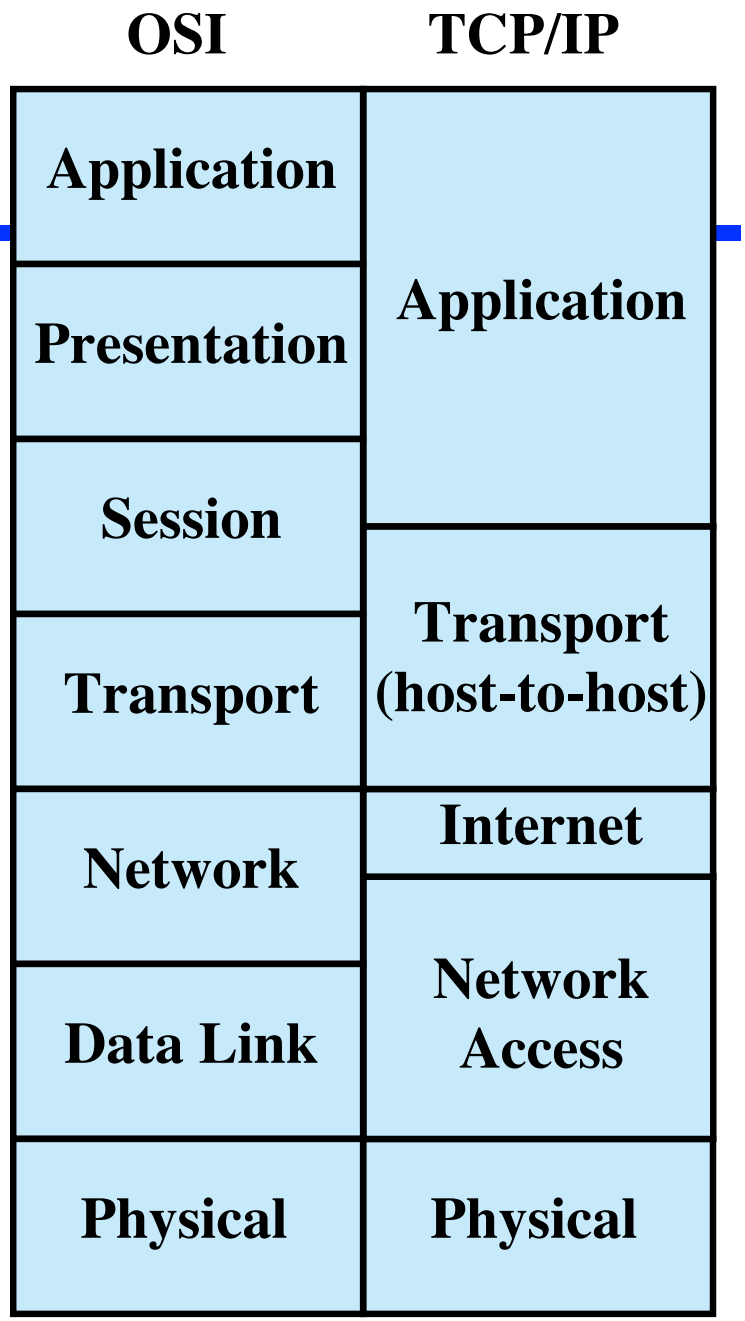
OSI Layers (3)

- Session
  - —Control of dialogues between applications
  - —Dialogue discipline
  - —Grouping
  - —Recovery
- Presentation
  - —Data formats and coding
  - —Data compression
  - —Encryption
- Application
  - —Means for applications to access OSI environment

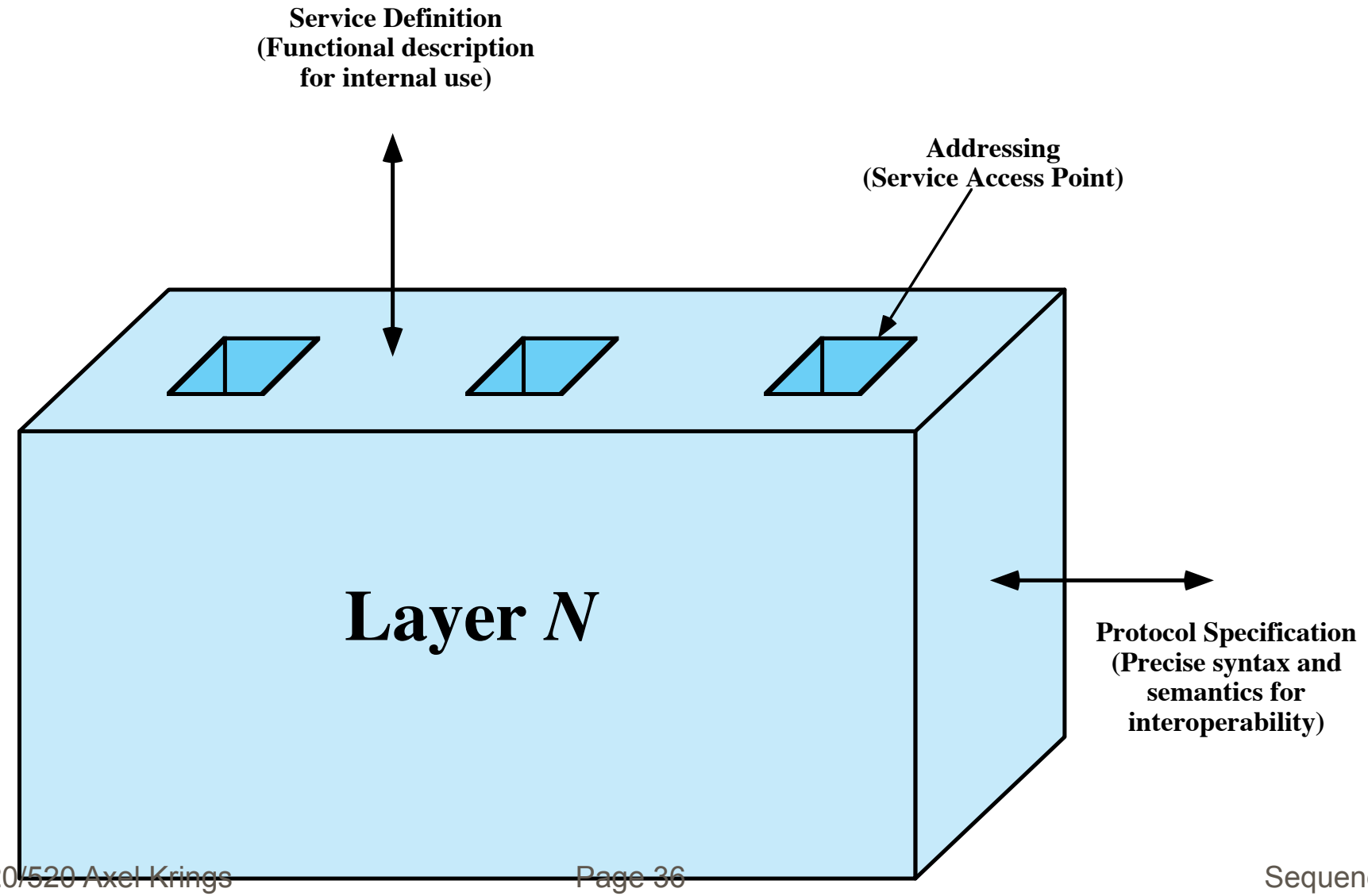
The OSI Environment



OSI vs TCP/IP

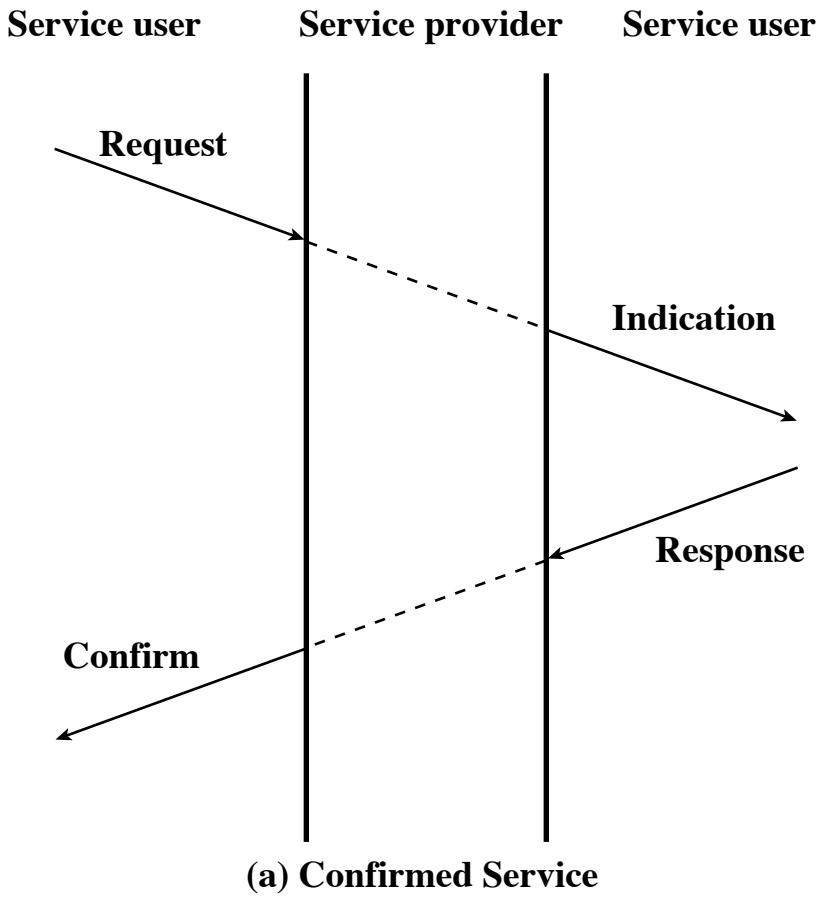

OSI
TCP/IP
Application
Presentation
Session
Transport
Network
Data Link
Physical
Application
Transport (host-to-host)
Internet
Network Access
Physical

Layer Specific Standards



Service Primitives and Parameters

- define services between adjacent layers using:
- primitives to specify function performed
- parameters to pass data and control info



(a) Confirmed 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

Traditional vs Multimedia Applications

- traditionally Internet dominated by info retrieval applications
  - —typically using text and image transfer
  - —eg. email, file transfer, web
- see increasing growth in multimedia applications
  - —involving massive amounts of data
  - —such as streaming audio and video

Elastic and Inelastic Traffic

- elastic traffic
  - —can adjust to delay & throughput changes over a wide range
  - —eg. traditional “data” style TCP/IP traffic
  - —some applications more sensitive though
- inelastic traffic
  - —does not adapt to such changes
  - —eg. “real-time” voice & video traffic
  - —need minimum requirements on net arch

Multimedia Technologies