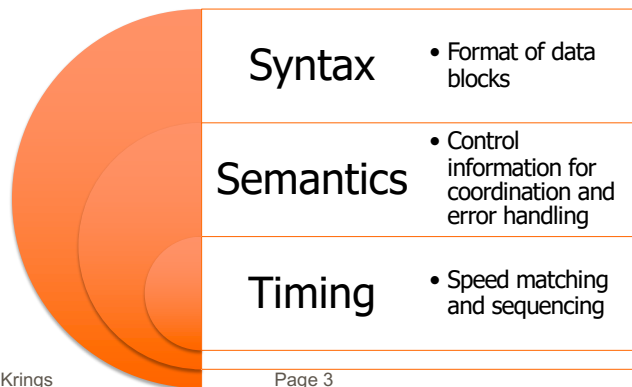# Chapter 2

1

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
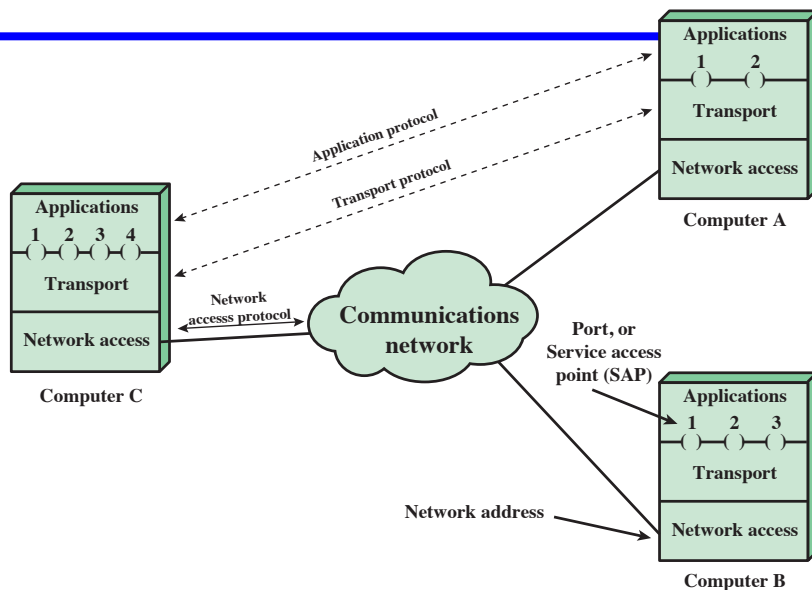
2

1

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

3

Protocol Architecture and Networks

Applications 1 2
Transport
Network access
Computer A

Application protocol

Transport protocol

Applications 1 2 3 4
Transport
Network access
Computer C

Network accesss protocol

Communications network

Port, or Service access point (SAP)

Applications 1 2 3
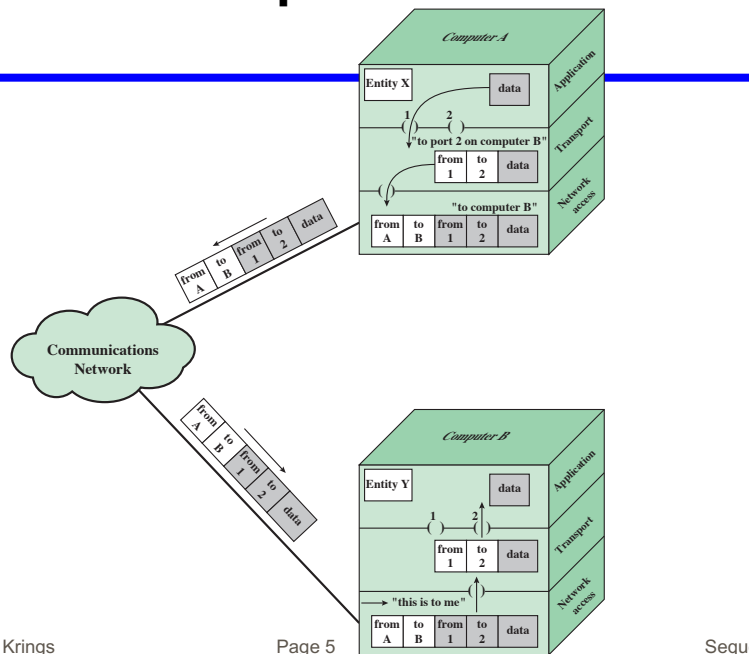**Transport**
Network access
Computer B

Network address

4

2

Protocols in a Simplified Architecture

5

Key Elements of a Protocol

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

6

3

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)

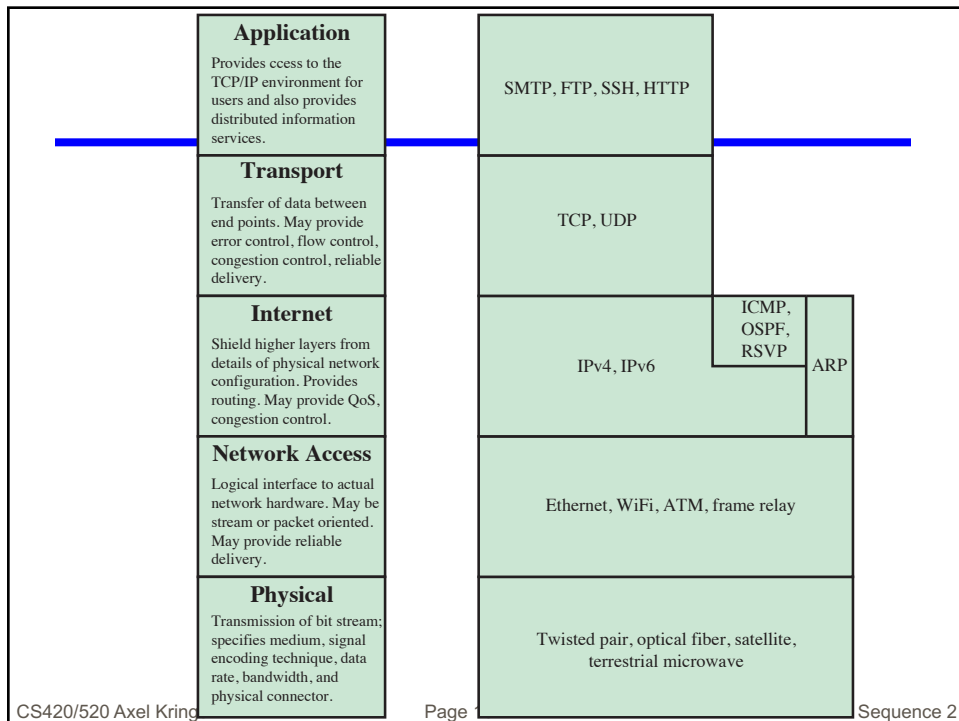7

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

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4

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

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Application Provides ccess to the TCP/IP environment for users and also provides distributed information services.	SMTP, FTP, SSH, HTTP	
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 Logical interface to actual 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	

10

5

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

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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

12

6

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

13

Transport Layer

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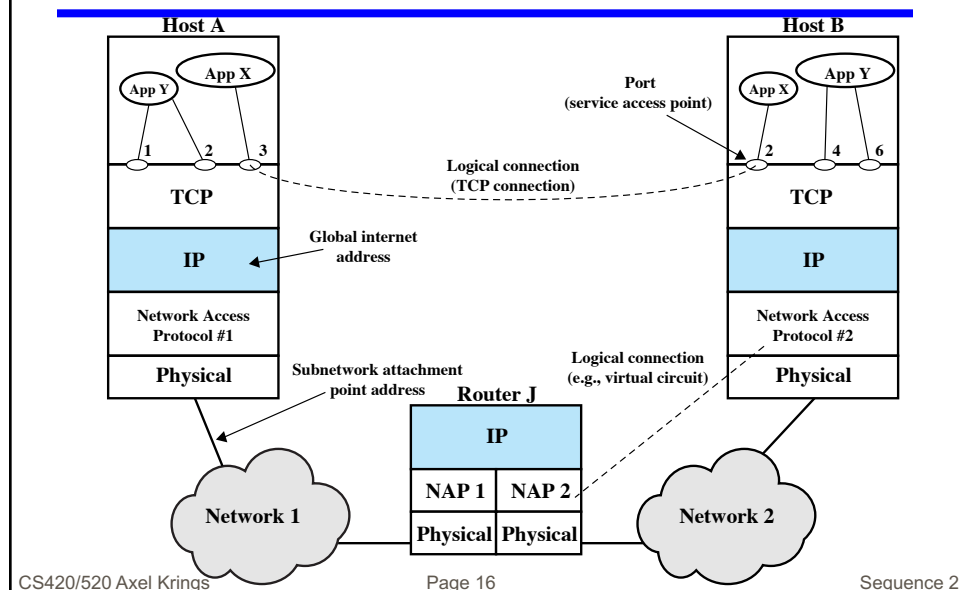- in same order as sent
- commonly uses TCP

14

Application Layer

- provide support for user applications, e.g., ftp, email
- need a separate module for each type of application
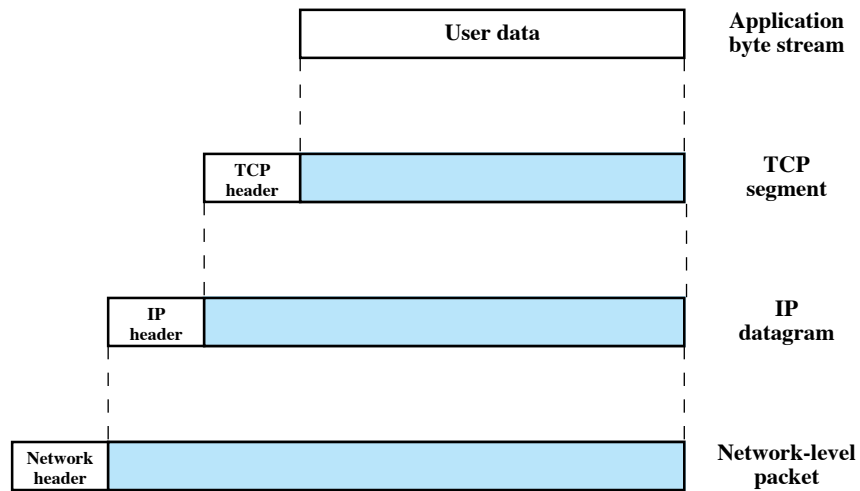
15

Operation of TCP and IP

16

8

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

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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 IXP (Internet Exchange Point). The book still calls it SAP (service access point)
    - Sequence number
    - Error detection code
  - —This gives a transport protocol data unit

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Operation of TCP/IP

User data	**Application byte stream**
TCP header ░░░░	**TCP segment**
IP header ░░░░	**IP datagram**
Network header ░░░░	**Network-level packet**

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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

20

10

TCP Header

Source Port	Destination Port
Sequence Number	
Acknowledgement Number	

Header length	Reserved	Flags	Window

Checksum	Urgent Pointer
Options + Padding	

20 octets
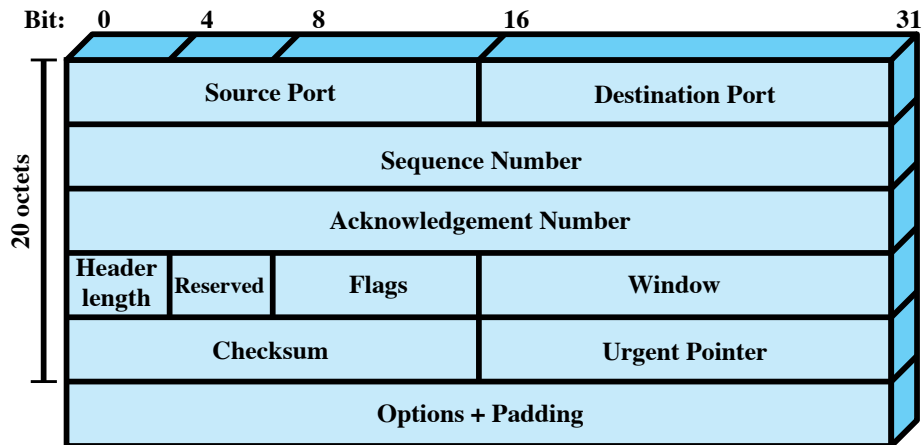
21
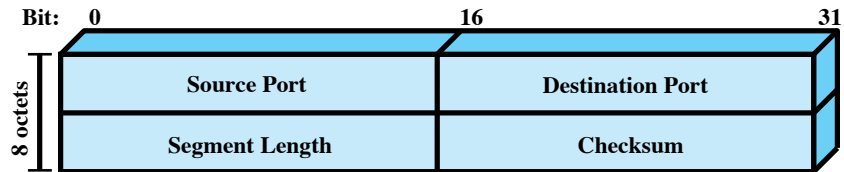
User Datagram Protocol (UDP)

- 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

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UDP Header

Bit: 0   16   31

| 8 octets | Source Port | Destination Port |
| | Segment Length | Checksum |

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IP Header

Bit: 0   4   8   14   16   19   31

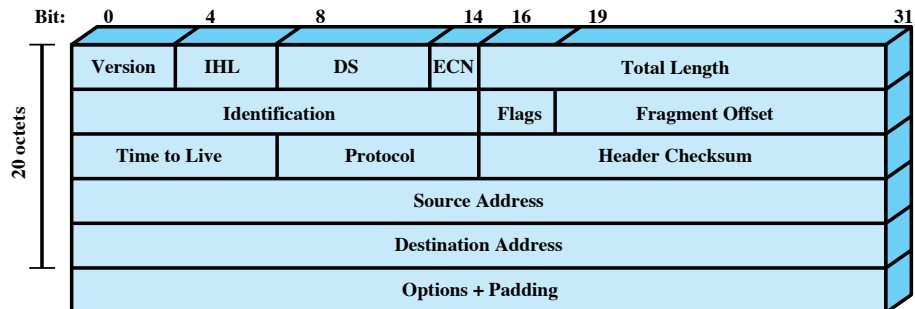| 20 octets | Version | IHL | DS | ECN | Total Length | | |
	Identification			Flags	Fragment Offset	
	Time to Live		Protocol	Header Checksum		
	Source Address					
	Destination Address					
	Options + Padding					

24

12
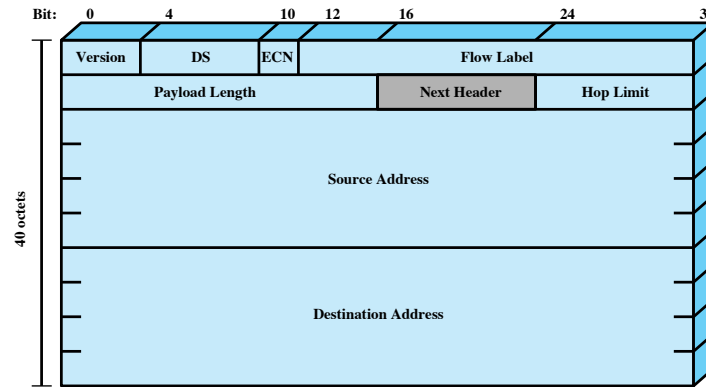
IPv6 Header

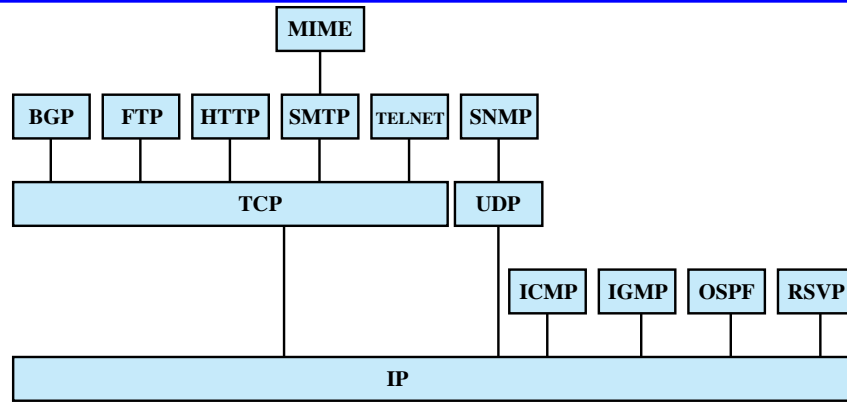**DS = Differentiated services field**
ECN = Explicit congestion notification field

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.

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TCP/IP Applications

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

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Some TCP/IP Protocols

```
                        ┌──────┐
                        │ MIME │
                        └──┬───┘
 ┌─────┐  ┌─────┐  ┌──────┐ │ ┌──────┐ ┌────────┐ ┌──────┐
 │ BGP │  │ FTP │  │ HTTP │ │ │ SMTP │ │ TELNET │ │ SNMP │
 └──┬──┘  └──┬──┘  └──┬───┘   └──┬───┘ └───┬────┘ └──┬───┘
    └────────┴────────┴──────────┴─────────┘         │
 ┌──────────────────────────────────────────┐ ┌──────────┐
 │                   TCP                      │ │   UDP    │
 └────────────────────┬───────────────────────┘ └────┬─────┘
                      │         ┌──────┐┌──────┐┌──────┐┌──────┐
                      │         │ ICMP ││ IGMP ││ OSPF ││ RSVP │
                      │         └──┬───┘└──┬───┘└──┬───┘└──┬───┘
 ┌──────────────────────────────────────────────────────────┐
 │                          IP                                │
 └──────────────────────────────────────────────────────────┘
```

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**
TCP	**=**	**Transmission Control Protocol**
UDP	**=**	**User Datagram Protocol**

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OSI

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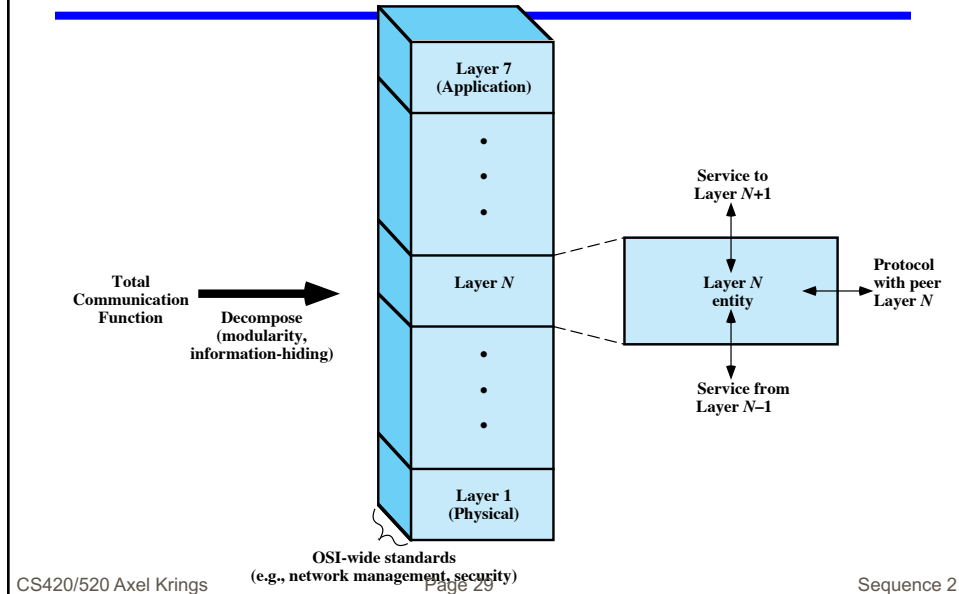- is a theoretical system delivered too late!
- TCP/IP is the de facto standard

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Standardized Protocol Architectures

Layer 7 (Application)

•
•
•

Layer N

Total Communication Function

Decompose (modularity, information-hiding)

Service to Layer N+1

Layer N entity

Protocol with peer Layer N

Service from Layer N–1

•
•
•

Layer 1 (Physical)

OSI-wide standards (e.g., network management, security)

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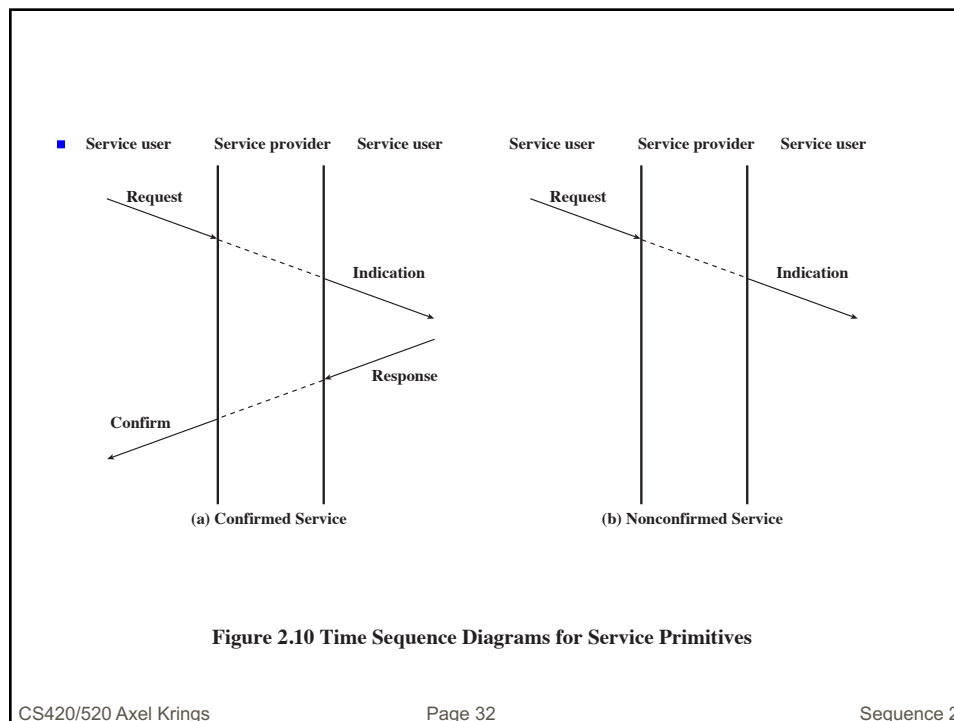# Service Primitives and Parameters

- Services between adjacent layers
- Expressed as:

  - Primitives
    - Specify the function to be performed

  - Parameters
    - Used to pass data and control information
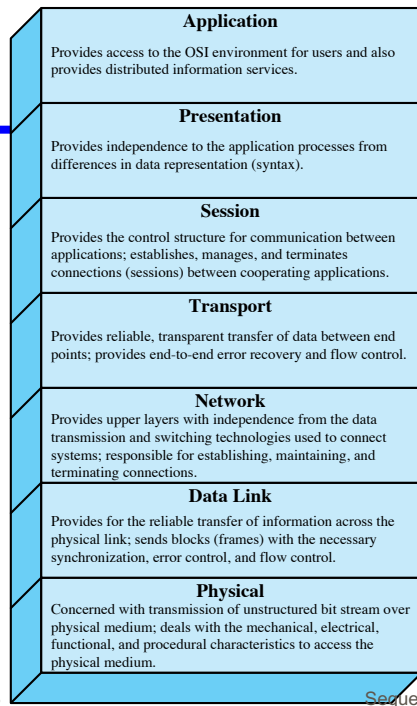
30

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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

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Figure 2.10 Time Sequence Diagrams for Service Primitives

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OSI Layers

Layer	Description
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.

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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

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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

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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

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The OSI Environment
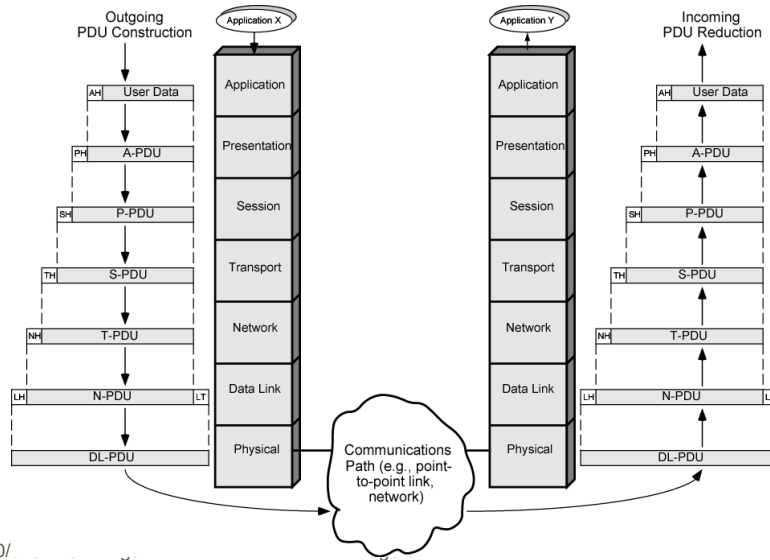
37

OSI vs TCP/IP

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

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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

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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

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Multimedia Technologies

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

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