Chapter 2

Protocol Architecture

Reading Materials

- **Data and Computer Communications**, William Stallings

Need For Protocol Architecture

- Protocol: a set of technical rules about how information should be transmitted and received using computers.
- Task broken into subtasks
- Implemented separately in layers in stack
- Functions needed in both systems
- Peer layers communicate

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

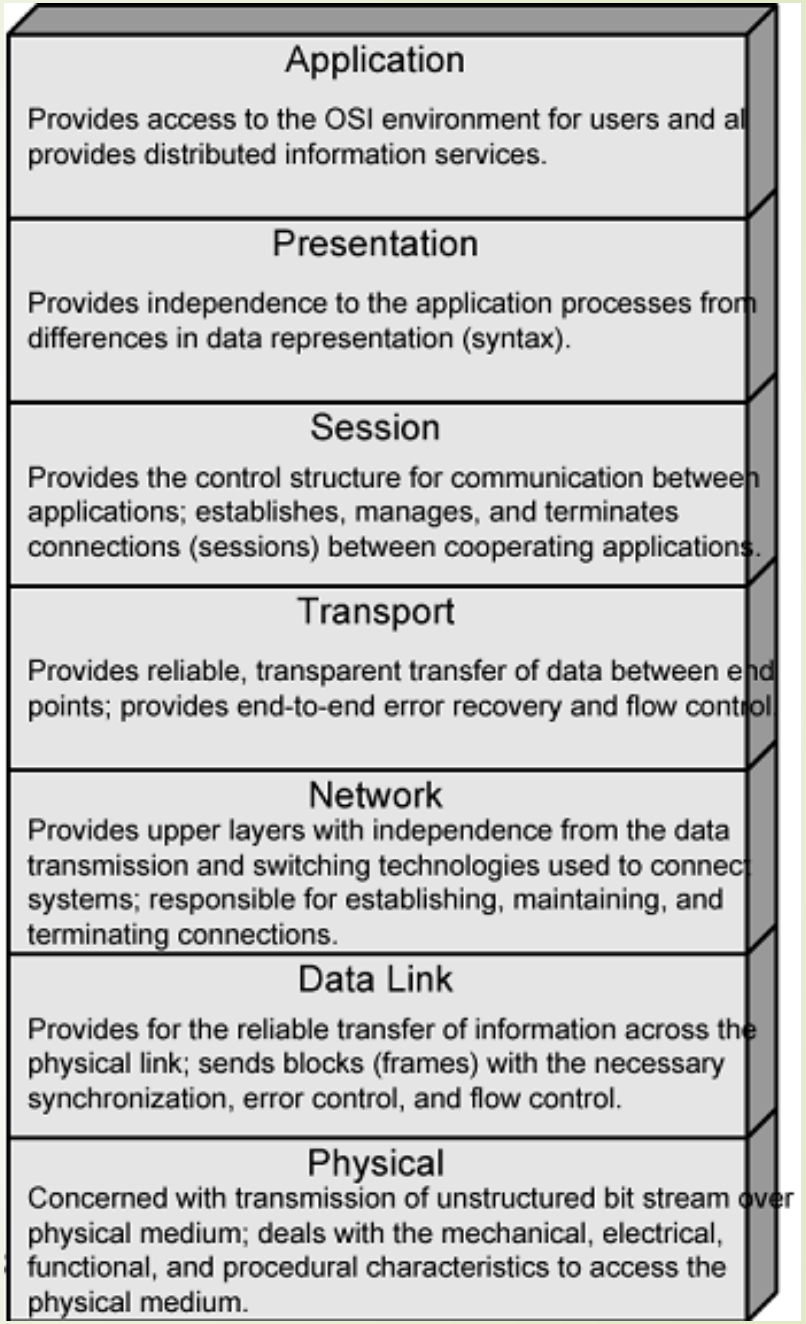
OSI

- **O**pen **S**ystems **I**nterconnection
  - Developed by the International Organization for Standardization (ISO)
  - Seven layers
  - A theoretical system delivered too late! (1984)
    - TCP/IP is the de facto standard

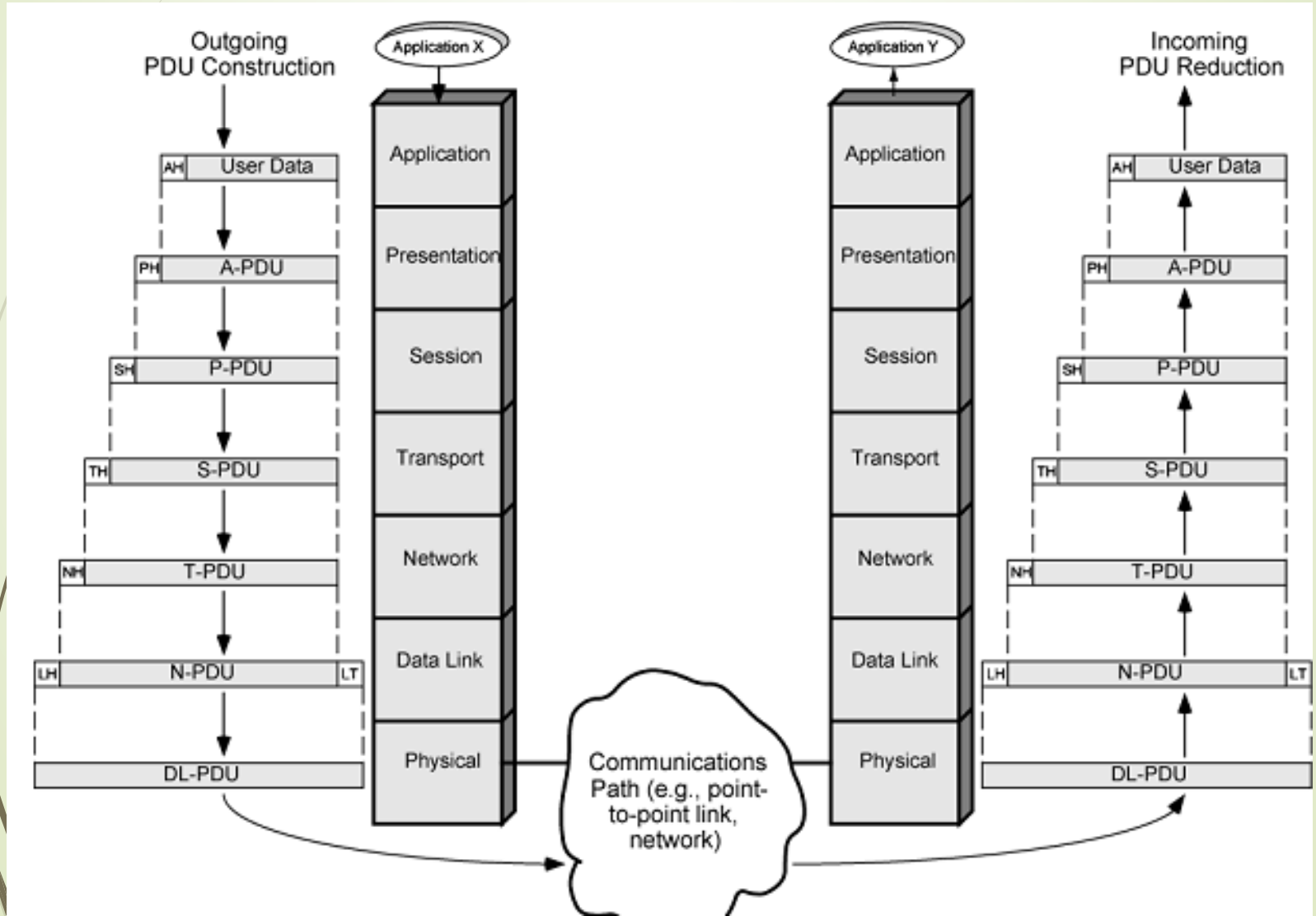
OSI - The Model

- A layered model
- Each layer performs a subset of the required communication functions
- Each layer relies on the next lower layer to perform more primitive functions
- Each layer provides services to the next higher layer
- Changes in one layer should not require changes in other layers

OSI Layers


Application
Provides access to the OSI environment for users and al
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.

The OSI Environment



Elements of Standardization

- Protocol specification
  - Operates between the same layer on two systems
  - May involve different operating systems
  - Protocol specification must be precise
- Format of data units
- Semantics of all fields
- Allowable sequence of PDUs
- Service definition
  - Functional description of what is provided
- Addressing
  - Referenced by SAPs

OSI Layers (I)

- 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

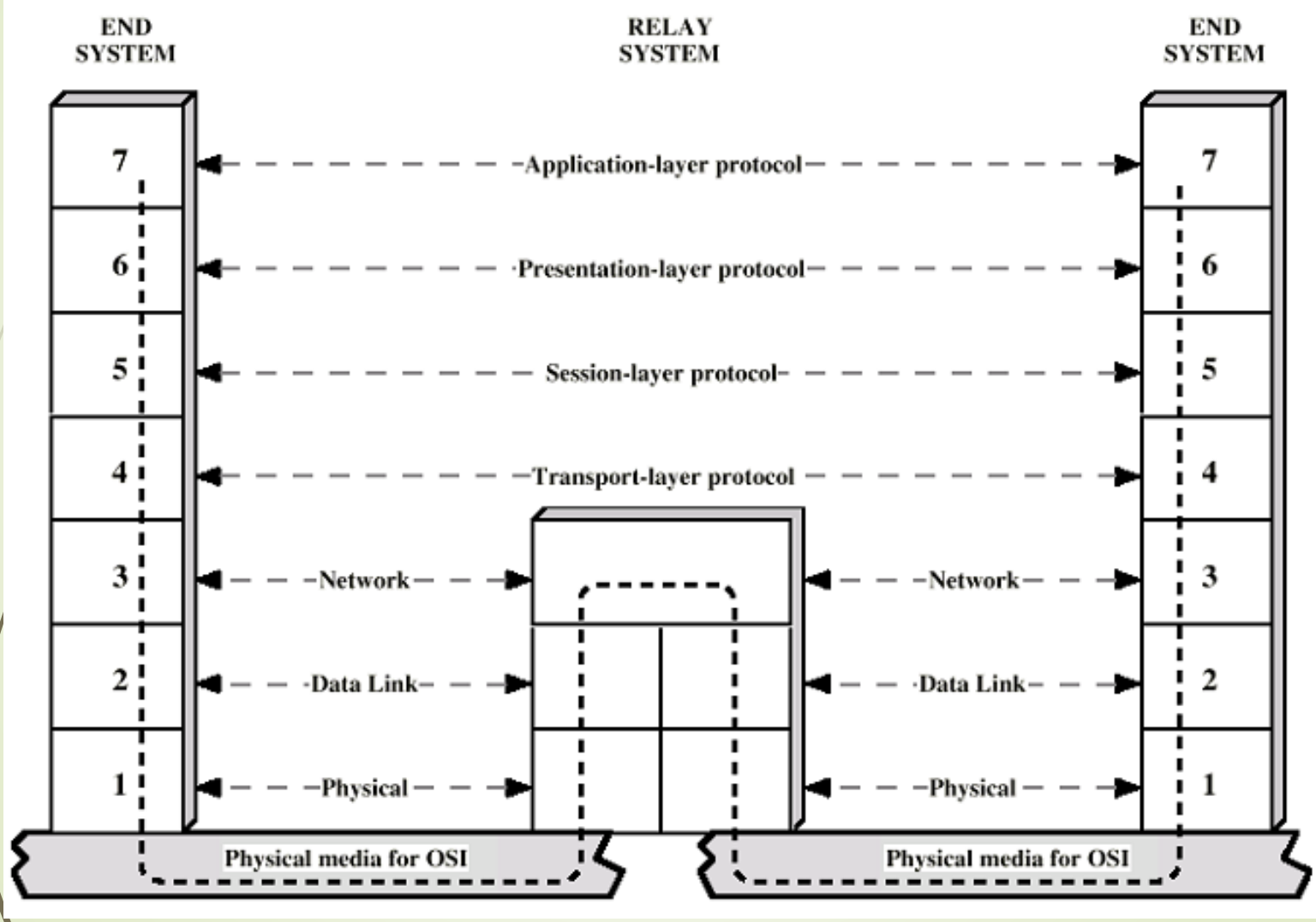
OSI Layers (II)

- Network
  – Transport of information (cross communication network)
  – Relieve higher layers of the 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 (III)

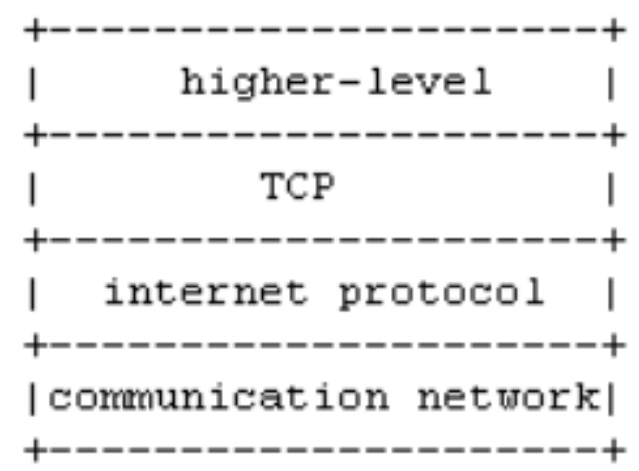
- Session
  - Control of dialogues between applications
  - Dialogue discipline
  - Recovery
- Presentation
  - Data formats and coding
  - Data compression
  - Encryption
- Application
  - Means for applications to access OSI environment

Use of a Relay



TCP/IP Protocol Architecture

- Developed by the US Defense Advanced Research Project Agency (DARPA) for its packet switched network (ARPANET)
- Used by the global Internet
- No official model but a working one.
  - Application layer
  - Host to host or transport layer
  - Internet layer
  - Network access layer
  - Physical layer



Physical Layer

- Physical interface between data transmission device (e.g. computer) and transmission medium or network
- Characteristics of transmission medium
- Signal levels
- Data rates
- etc.

Network Access Layer

- Exchange of data between end system in the same network
- Destination address provision
- Invoking services like priority

Internet Layer (IP)

- Systems may be attached to different networks
- Routing functions across multiple networks
- Implemented in end systems and routers

Transport Layer (TCP)

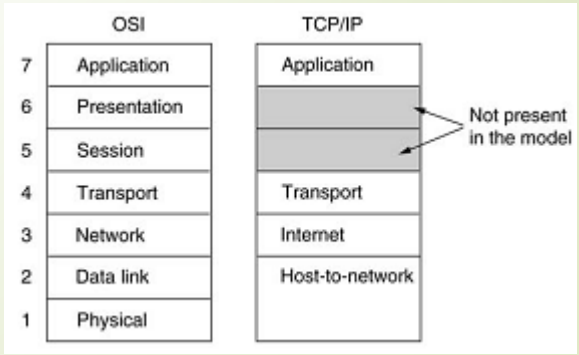
- Reliable delivery of data
- Ordering of delivery

Application Layer

- Support for user applications
- e.g. HTTP, SMTP

OSI vs TCP/IP

- OSI: reference model was devised before the corresponding protocols were invented.
- The OSI model has proven to be exceptionally useful for discussing computer networks.
- The OSI protocols have not become popular.
- TCP/IP: the protocols came first, and the model was just a description of the existing protocols.
- TCP/IP protocols are widely used.



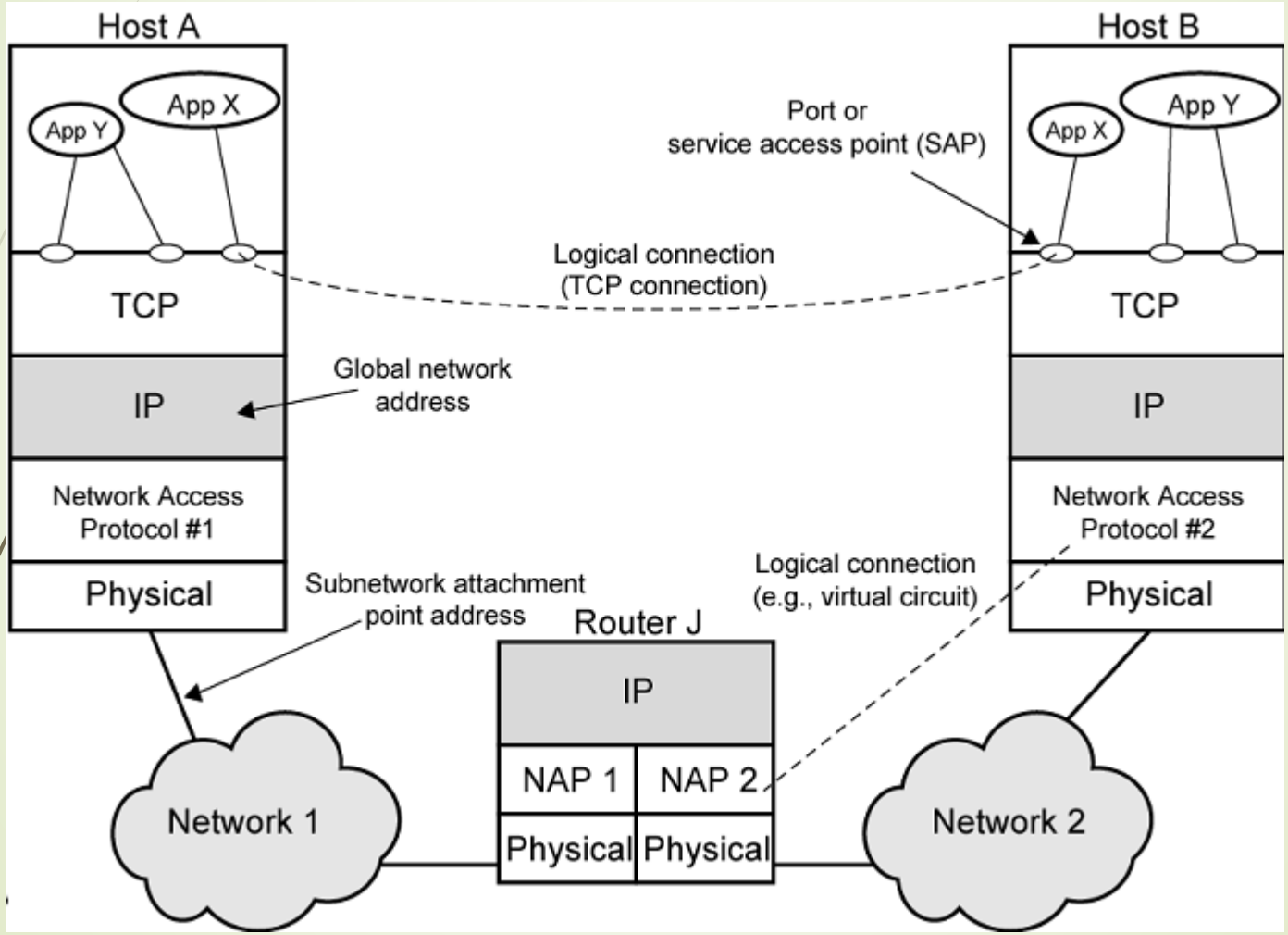
TCP

- Usual transport layer is **Transmission Control Protocol**
  – Reliable connection
- Connection
  – Temporary logical association between entities in different systems
- TCP PDU
  – Called TCP segment
  – Includes source and destination port
    - Identify respective users (applications)
    - Connection refers to pair of ports
- TCP tracks segments between entities on each connection

UDP

- Alternative to TCP is User Datagram Protocol
- Not guaranteed delivery
- No preservation of sequence
- No protection against duplication
- Minimum overhead
- Adds port addressing to IP

TCP/IP Concepts



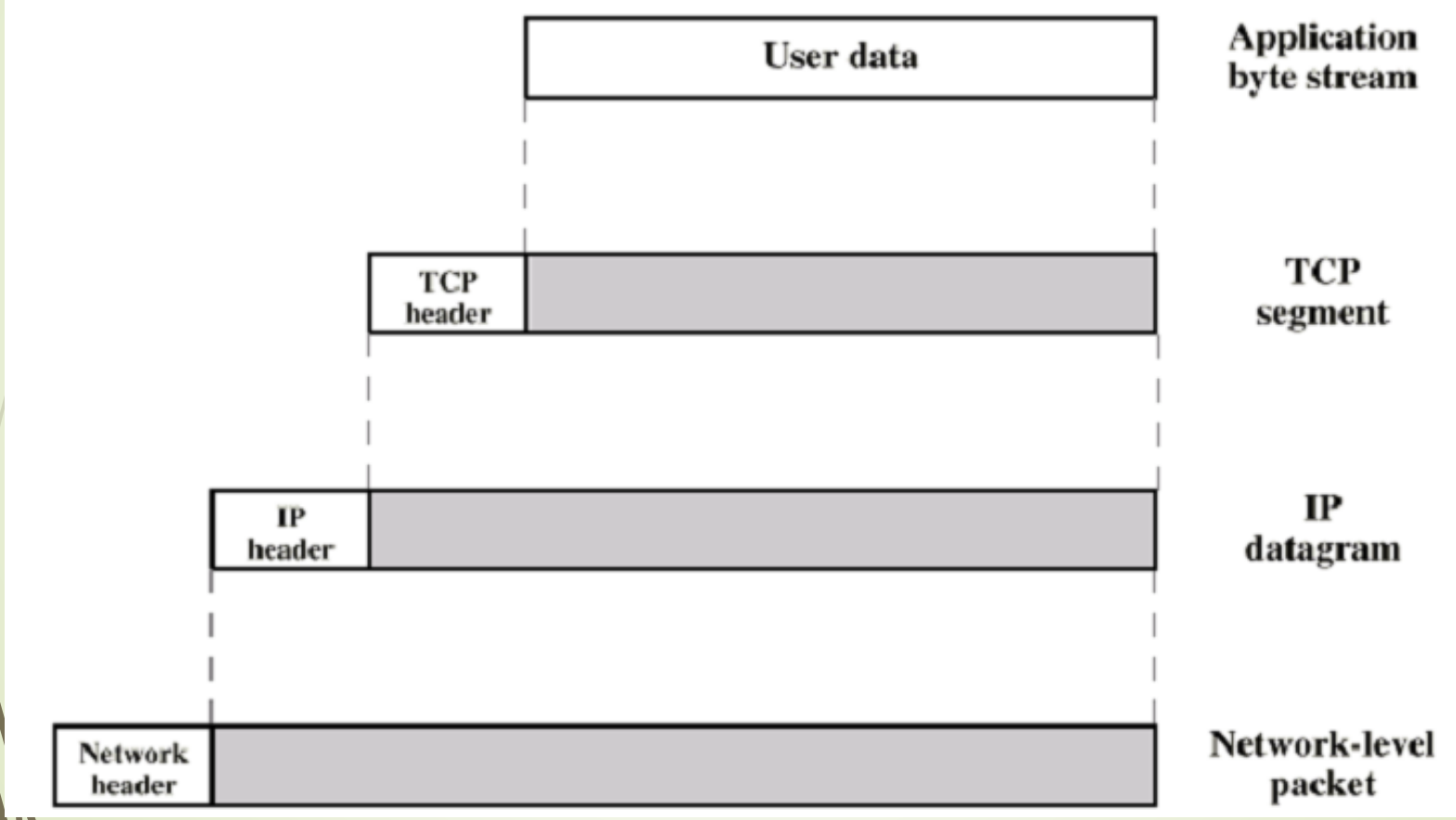
Addressing level

- Level in architecture at which entity is named
- Unique address for each end system (computer)
  and router
- Network level address
  – IP or internet address (TCP/IP)
  – Network service access point or NSAP (OSI)
- Process within the system
  – Port number (TCP/IP)
  – Service access point or SAP (OSI)

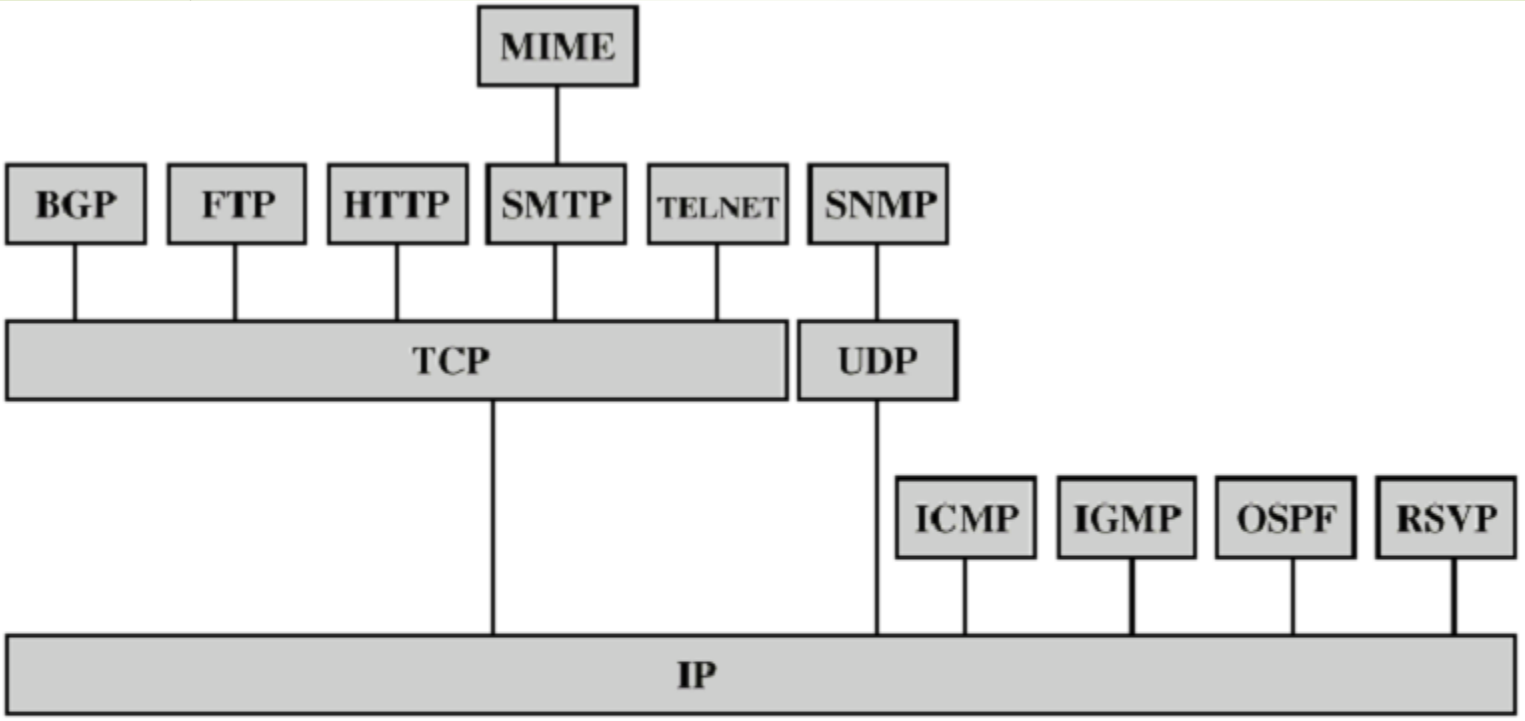
Trace of Simple Operation

- Process associated with port 1 in host A sends message to port 2 in host B
- Process at A hands down message to TCP to send to port 2
- TCP hands down to IP to send to host B
- IP hands down to network layer (e.g. Ethernet) to send to router J
- Generates a set of encapsulated PDUs

PDUs in TCP/IP

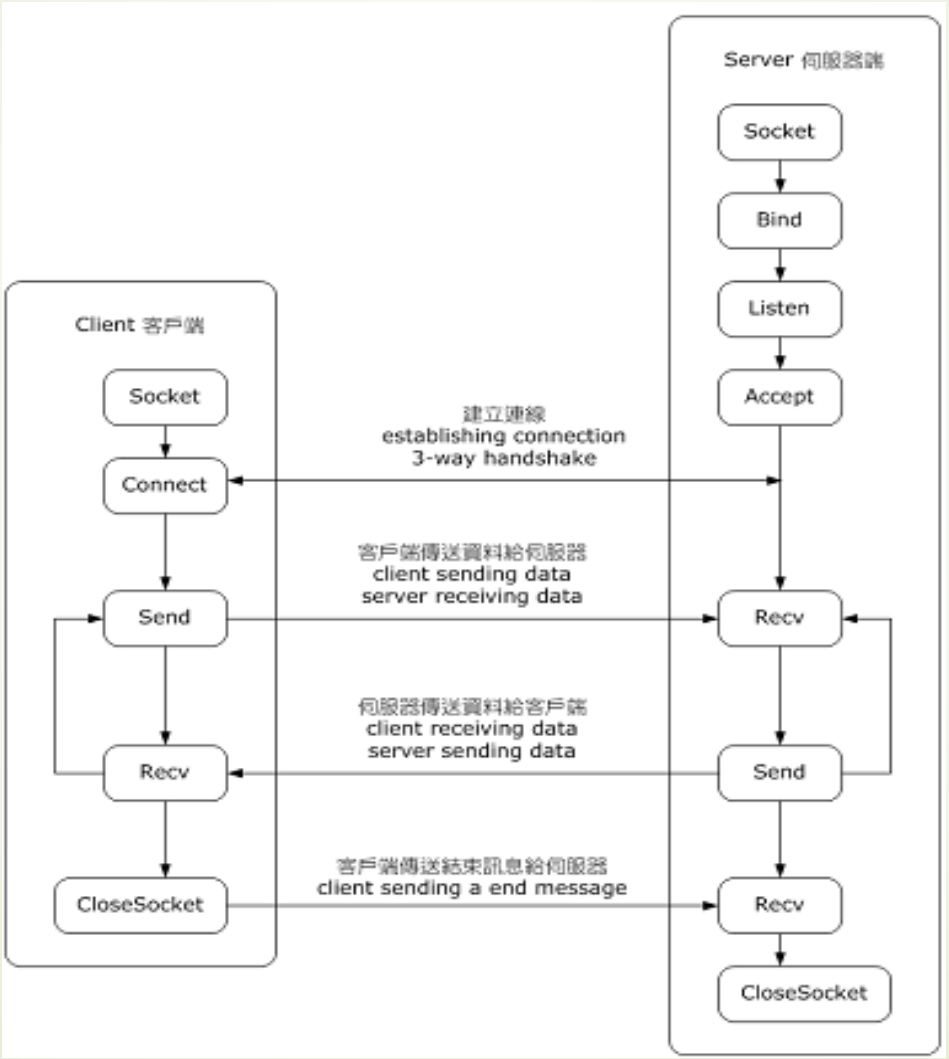


Some Protocols in TCP/IP Suite



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 = Multi-Purpose 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

Socket programming



Courtesy

- Professor Jiying Zhao, University of Ottawa