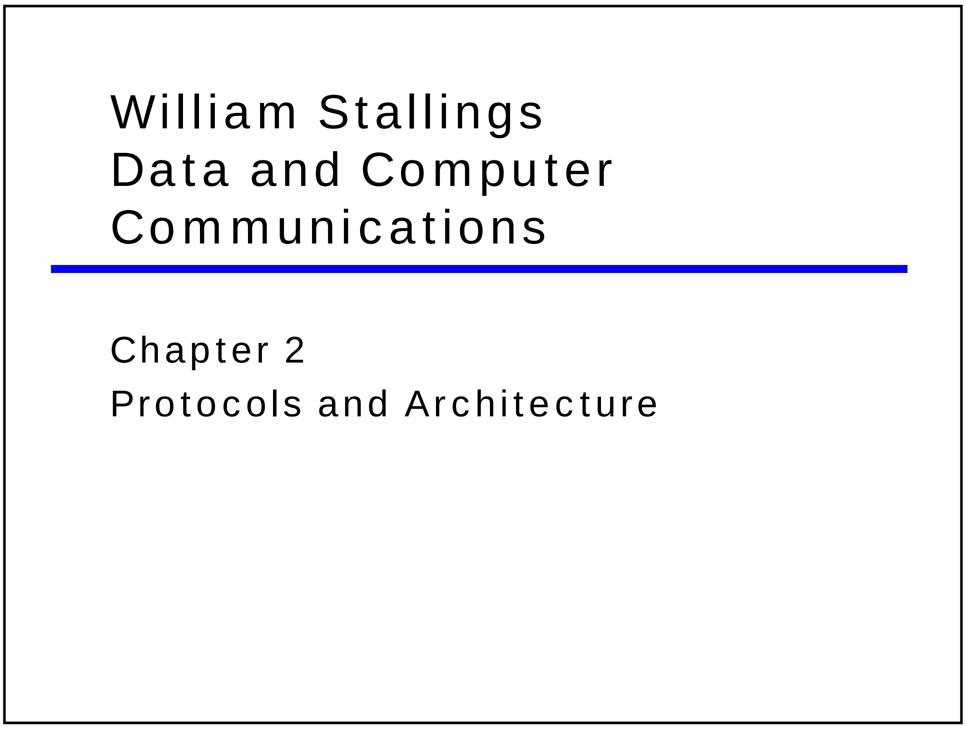
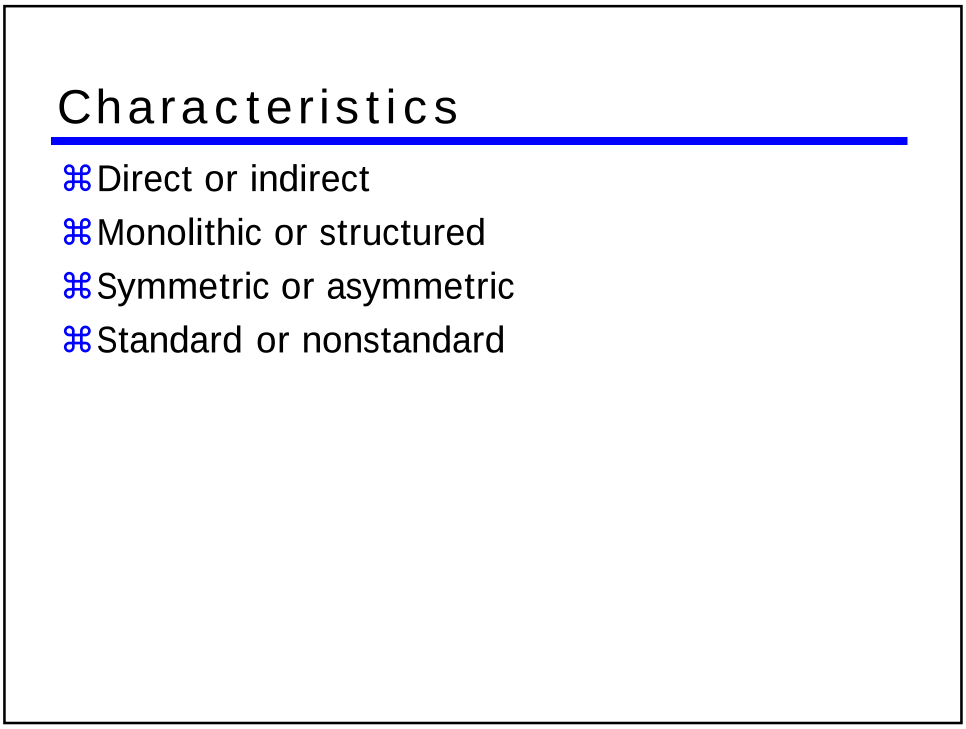


William Stallings Data and Computer Communications

Chapter 2

Protocols and Architecture



Characteristics

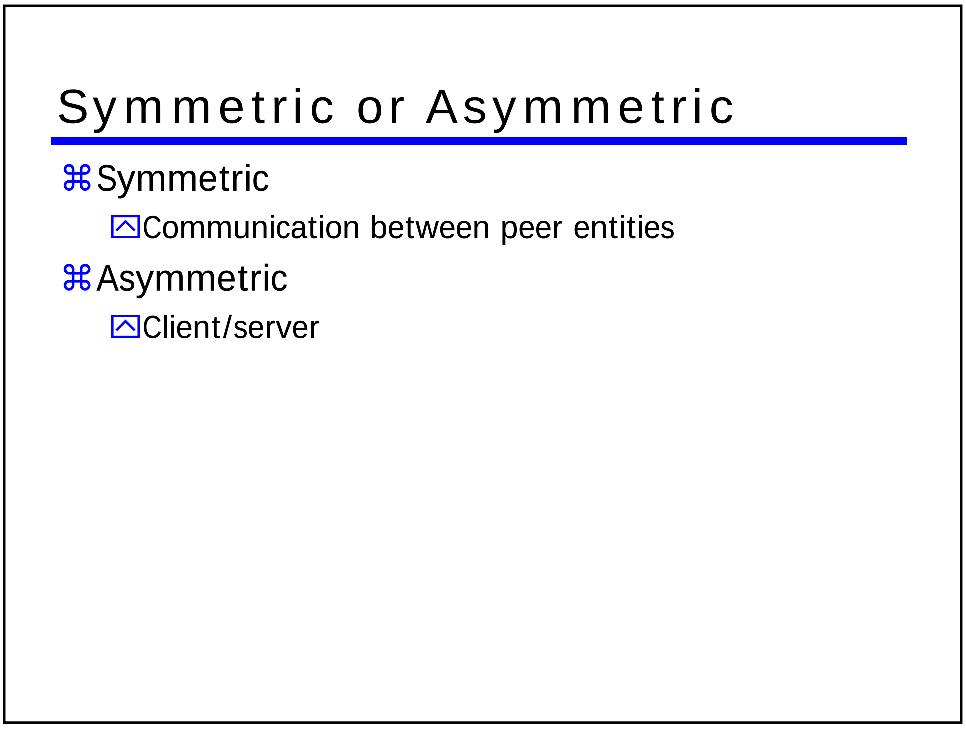
- Direct or indirect
- Monolithic or structured
- Symmetric or asymmetric
- Standard or nonstandard

Direct or Indirect

- Direct
  - Systems share a point to point link or
  - Systems share a multi-point link
  - Data can pass without intervening active agent
- Indirect
  - Switched networks or
  - Internetworks or internets
  - Data transfer depend on other entities

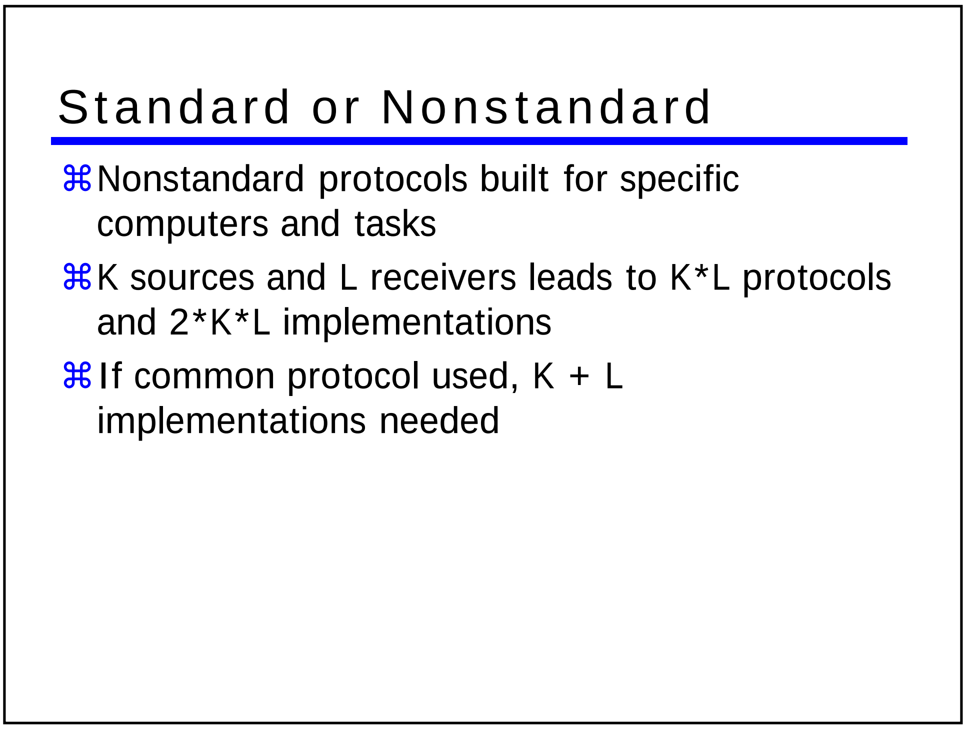
Monolithic or Structured

- Communications is a complex task
- To complex for single unit
- Structured design breaks down problem into smaller units
- Layered structure



Symmetric or Asymmetric

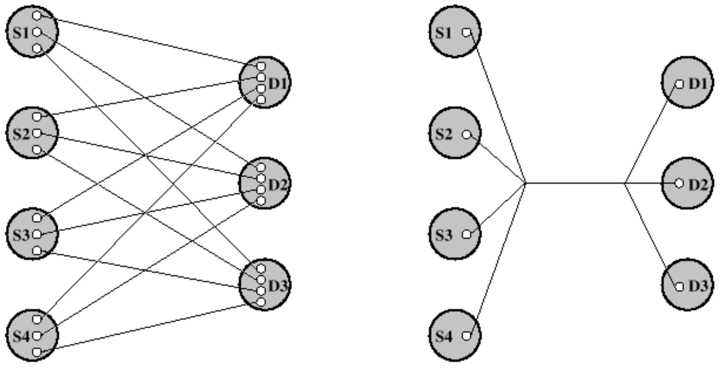
- Symmetric
  - Communication between peer entities
- Asymmetric
  - Client/server



Standard or Nonstandard

- Nonstandard protocols built for specific computers and tasks
- K sources and L receivers leads to K*L protocols and 2*K*L implementations
- If common protocol used, K + L implementations needed

Use of Standard Protocols



(a) Without standards: 12 different protocols;
24 protocol implementations

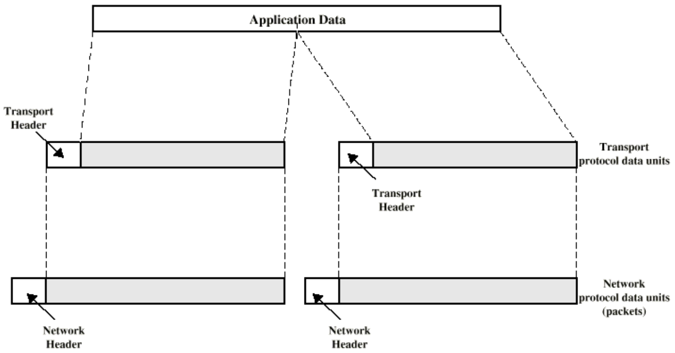
(a) With standards: 1 protocol;
7 implementations

Functions

- Encapsulation
- Segmentation and reassmebly
- Connection control
- Ordered delivery
- Flow control
- Error control
- Addressing
- Multiplexing
- Transmission services

Encapsulation

- Addition of control information to data
  - Address information
  - Error-detecting code
  - Protocol control



Segmentation (Fragmentation)

- Data blocks are of bounded size
- Application layer messages may be large
- Network packets may be smaller
- Splitting larger blocks into smaller ones is segmentation (or fragmentation in TCP/IP)
  - ATM blocks (cells) are 53 octets long
  - Ethernet blocks (frames) are up to 1526 octets long
- Checkpoints and restart/recovery

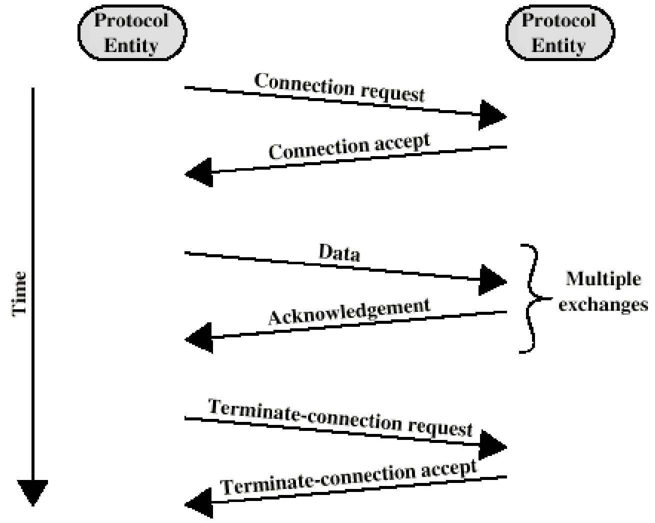
Why Fragment?

- Advantages
  - More efficient error control
  - More equitable access to network facilities
  - Shorter delays
  - Smaller buffers needed
- Disadvantages
  - Overheads
  - Increased interrupts at receiver
  - More processing time

Connection Control

- Connection Establishment
- Data transfer
- Connection termination
- May be connection interruption and recovery
- Sequence numbers used for
  - Ordered delivery
  - Flow control
  - Error control

Connection Oriented Data Transfer



Ordered Delivery

⌘PDUs may traverse different paths through network

⌘PDUs may arrive out of order

⌘Sequentially number PDUs to allow for ordering

Flow Control

- Done by receiving entity
- Limit amount or rate of data
- Stop and wait
- Credit systems
  - Sliding window
- Needed at application as well as network layers

Error Control

- Guard against loss or damage
- Error detection
  - Sender inserts error detecting bits
  - Receiver checks these bits
  - If OK, acknowledge
  - If error, discard packet
- Retransmission
  - If no acknowledge in given time, re-transmit
- Performed at various levels

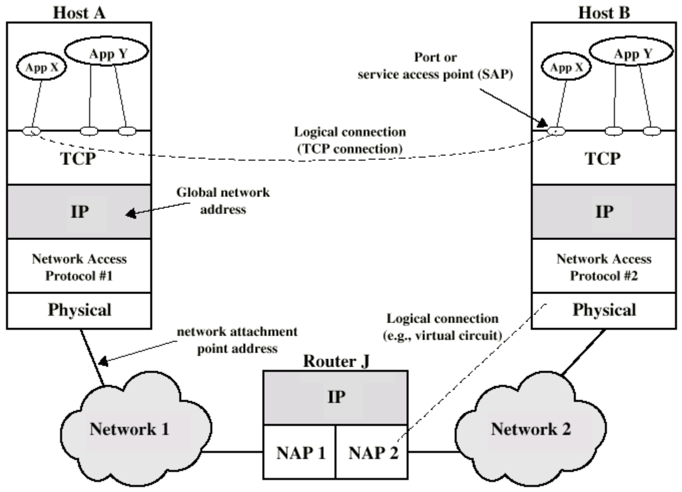
Addressing

- Addressing level
- Addressing scope
- Connection identifiers
- Addressing mode

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)

Address Concepts


Host A
App X
App Y
TCP
IP
Network Access Protocol #1
Physical
Host B
App X
App Y
TCP
IP
Network Access Protocol #2
Physical
Port or service access point (SAP)
Logical connection (TCP connection)
Global network address
network attachment point address
Logical connection (e.g., virtual circuit)
Router J
IP
NAP 1
NAP 2
Network 1
Network 2

Addressing Scope

- Global nonambiguity
  - Global address identifies unique system
  - There is only one system with address X
- Global applicability
  - It is possible at any system (any address) to identify any other system (address) by the global address of the other system
  - Address X identifies that system from anywhere on the network
- e.g. MAC address on IEEE 802 networks

Connection Identifiers

- Connection oriented data transfer (virtual circuits)
- Allocate a connection name during the transfer phase
  - Reduced overhead as connection identifiers are shorter than global addresses
  - Routing may be fixed and identified by connection name
  - Entities may want multiple connections - multiplexing
  - State information

Addressing Mode

- Usually an address refers to a single system
  - Unicast address
  - Sent to one machine or person
- May address all entities within a domain
  - Broadcast
  - Sent to all machines or users
- May address a subset of the entities in a domain
  - Multicast
  - Sent to some machines or a group of users

Multiplexing

- Supporting multiple connections on one machine
- Mapping of multiple connections at one level to a single connection at another
    - Carrying a number of connections on one fiber optic cable
    - Aggregating or bonding ISDN lines to gain bandwidth

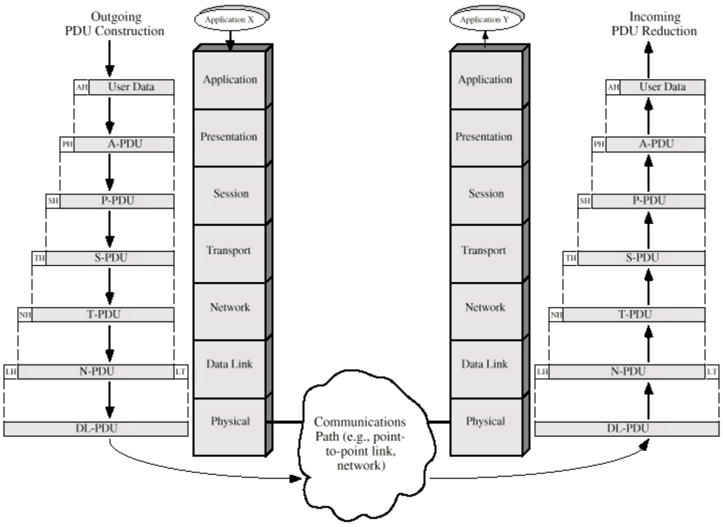
Transmission Services

- Priority
    - e.g. control messages
- Quality of service
    - Minimum acceptable throughput
    - Maximum acceptable delay
- Security
    - Access restrictions

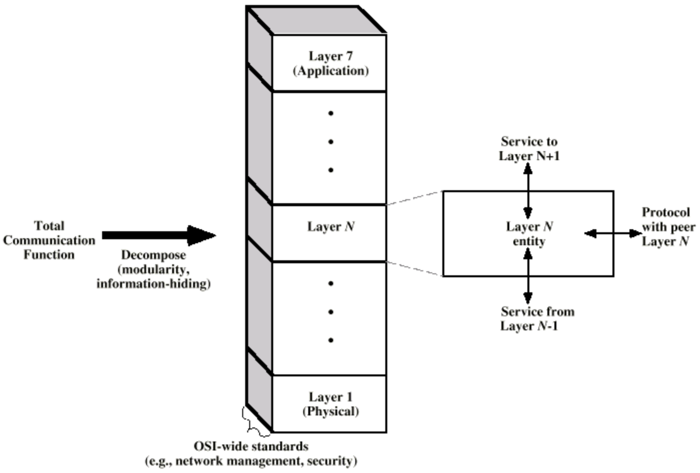
OSI - The Model

- A layer 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

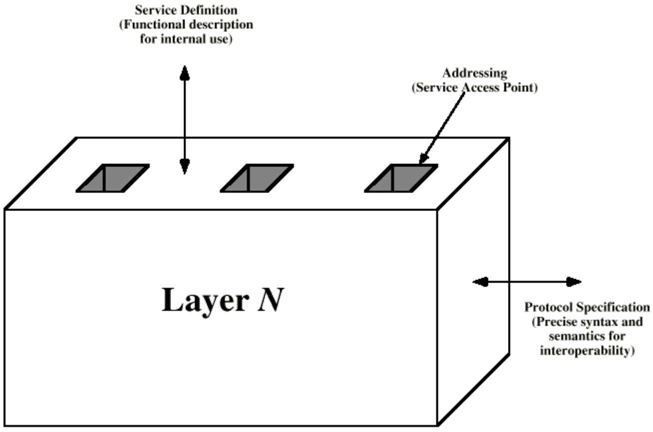
The OSI Environment



OSI as Framework for Standardization



Layer Specific Standards

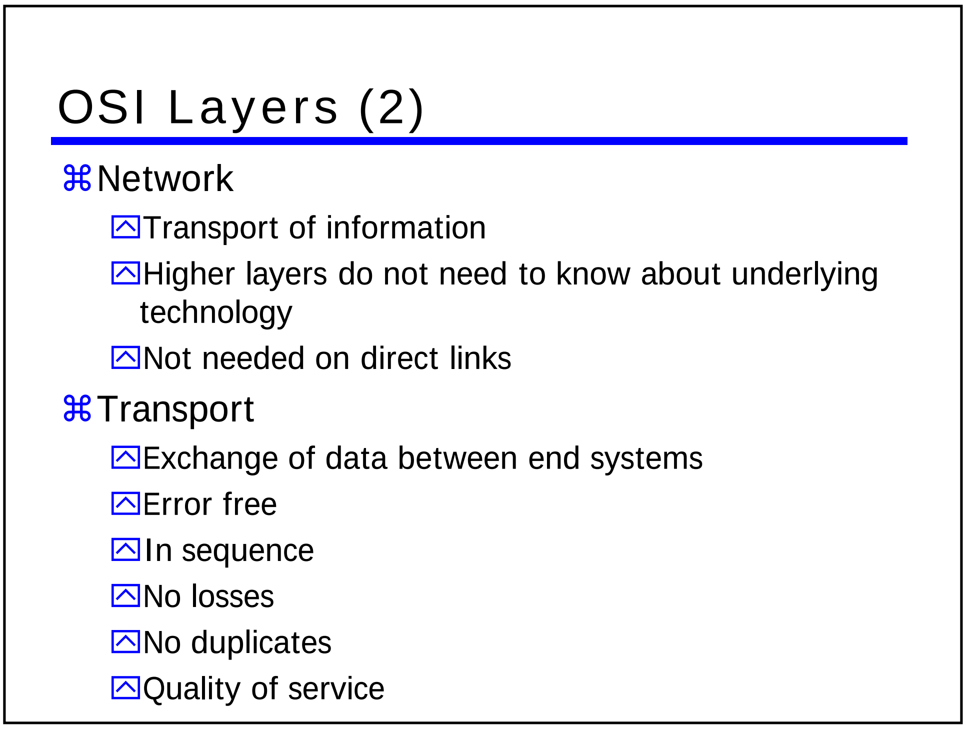


Elements of Standardization

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

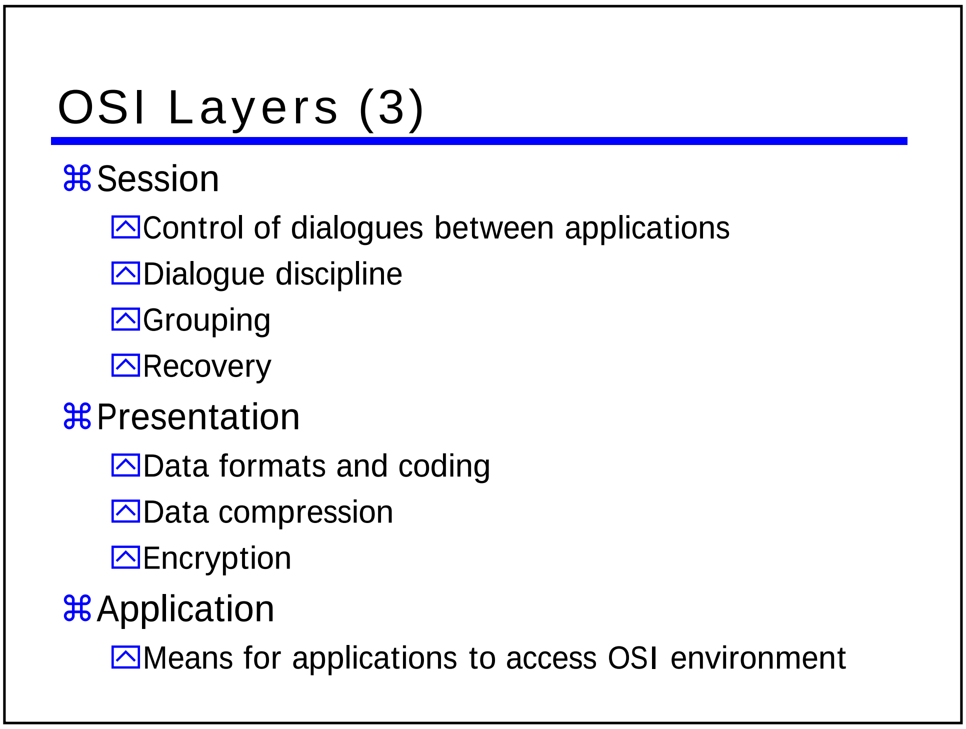
OSI Layers (1)

- 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)

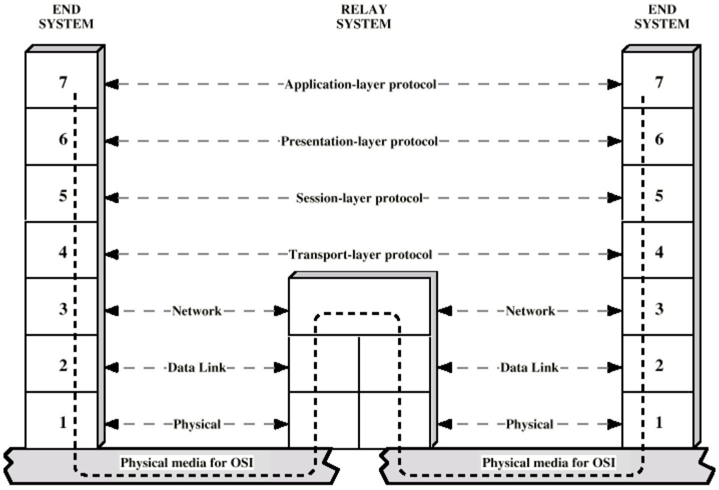
- Network
  - Transport of information
  - Higher layers do not need to know about underlying technology
  - Not needed on direct links
- Transport
  - Exchange of data between end systems
  - Error free
  - In sequence
  - No losses
  - No duplicates
  - Quality of service



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

Use of a Relay



TCP/IP Protocol Suite

- ⌘Dominant commercial protocol architecture
- ⌘Specified and extensively used before OSI
- ⌘Developed by research funded US Department of Defense
- ⌘Used by the Internet

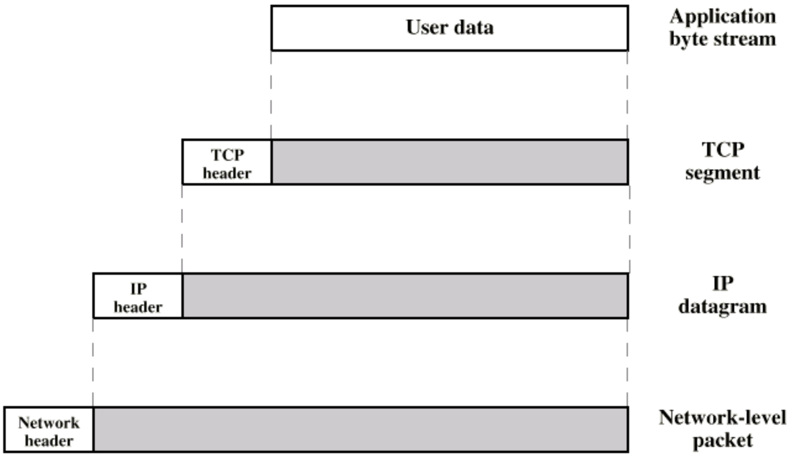
TCP/IP Protocol Architecture(1)

- Application Layer
  - Communication between processes or applications
- End to end or transport layer (TCP/UDP/...)
  - End to end transfer of data
  - May include reliability mechanism (TCP)
  - Hides detail of underlying network
- Internet Layer (IP)
  - Routing of data

TCP/IP Protocol Architecture(2)

- Network Layer
  - Logical interface between end system and network
- Physical Layer
  - Transmission medium
  - Signal rate and encoding

PDUs in TCP/IP



User data

Application byte stream

TCP header

TCP segment

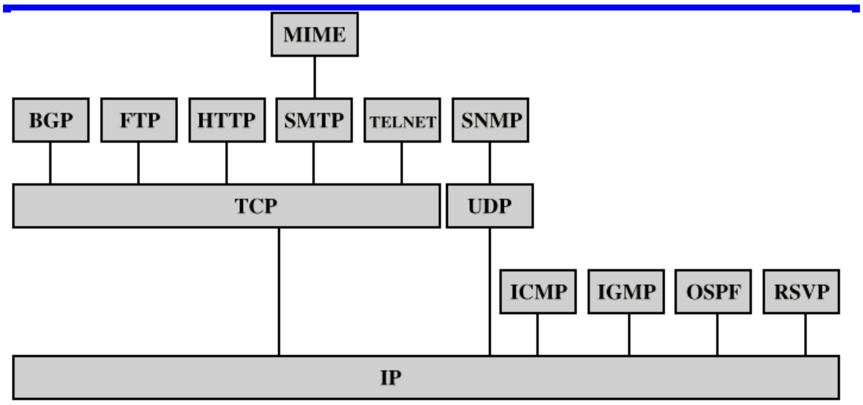
IP header

IP datagram

Network header

Network-level packet

Some Protocols in TCP/IP Suite



MIME

BGP

FTP

HTTP

SMTP

TELNET

SNMP

TCP

UDP

ICMP

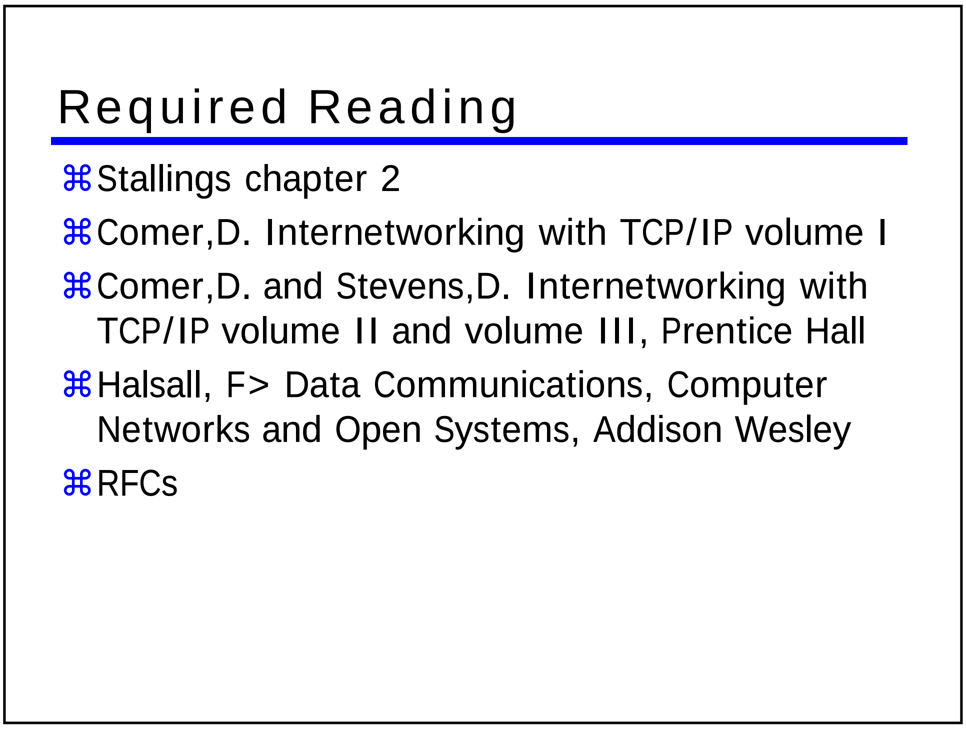
IGMP

OSPF

RSVP

IP

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	=	Multi-Purpose Internet Mail Extension			



Required Reading

- Stallings chapter 2
- Comer,D. Internetworking with TCP/IP volume I
- Comer,D. and Stevens,D. Internetworking with TCP/IP volume II and volume III, Prentice Hall
- Halsall, F> Data Communications, Computer Networks and Open Systems, Addison Wesley
- RFCs