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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
- ⌘ Too 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

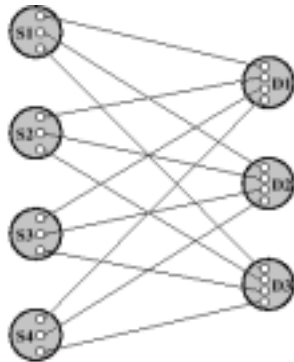
Standard or Nonstandard

⌘ Nonstandard protocols built for specific computers and tasks

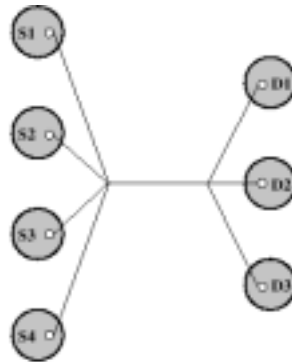
⌘ K sources and L receivers leads to $K \cdot L$ protocols and $2 \cdot K \cdot L$ implementations

⌘ 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

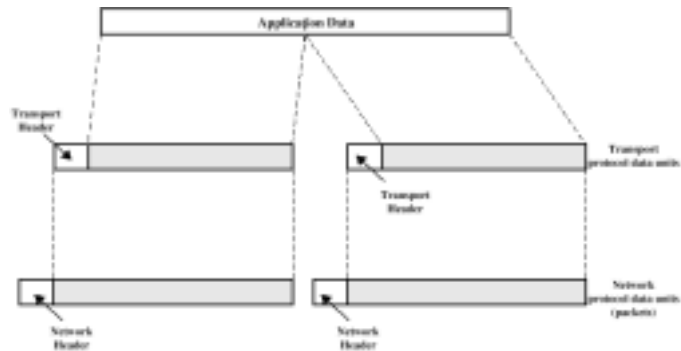
Functions

- ⌘ Encapsulation
- ⌘ Segmentation and reassembly
- ⌘ 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

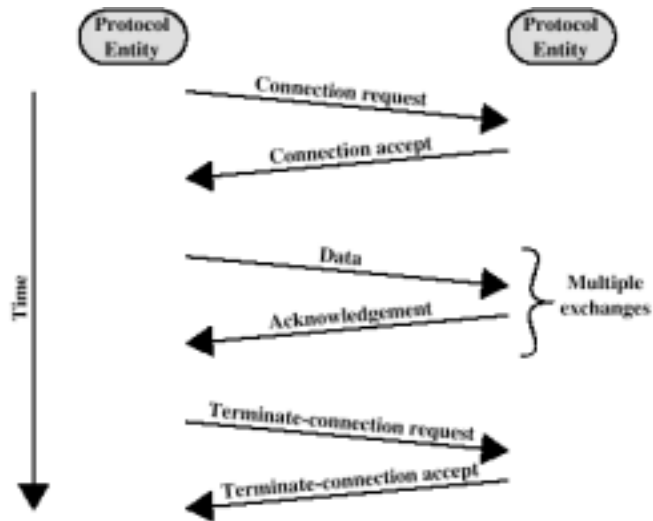
⌘ Connection termination

⌘ 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

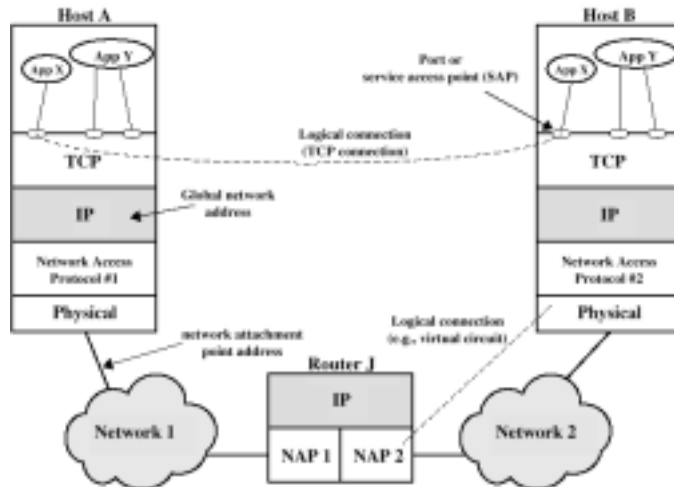
Addressing

- ⌘ 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



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

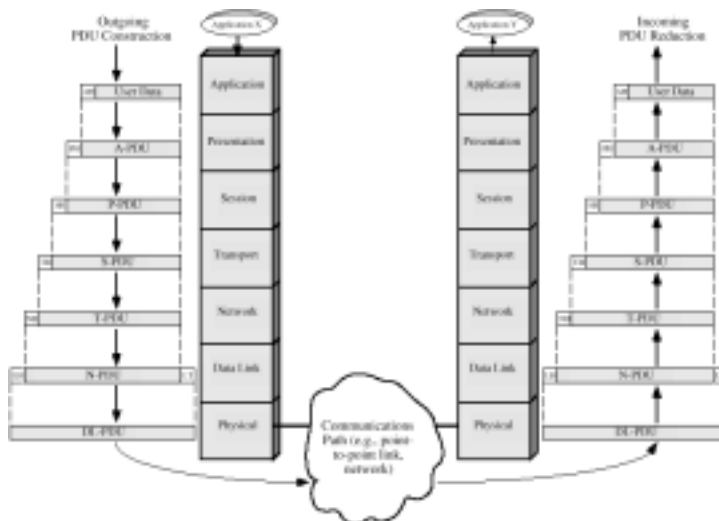
Transmission Services

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

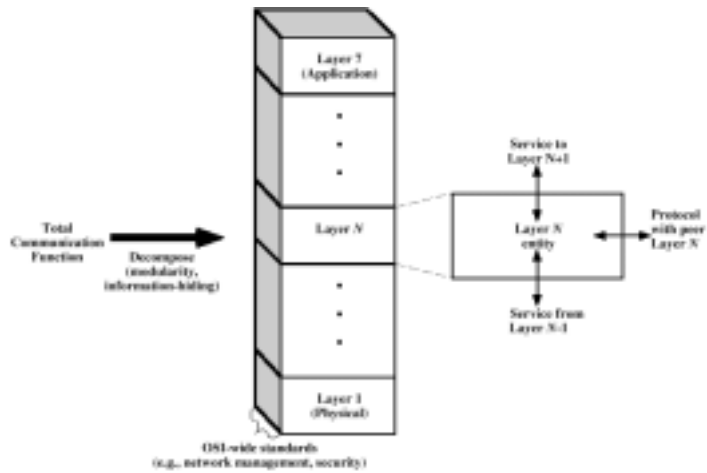
OSI - The Model

- ⌘ 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

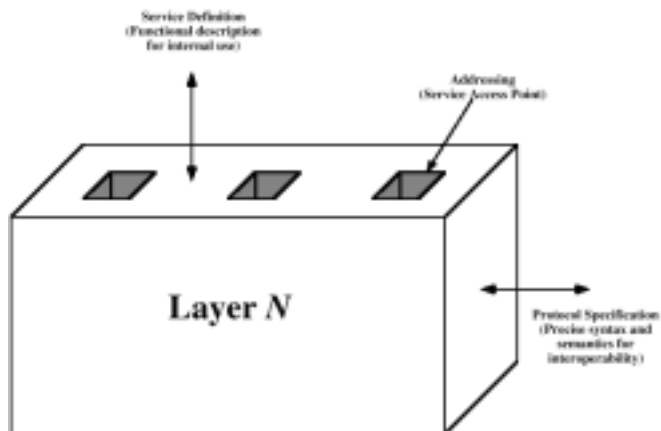
The OSI Environment



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

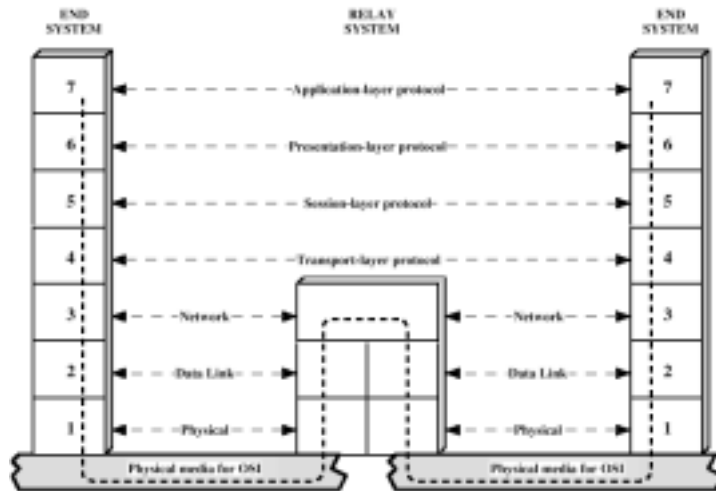
⌘ Presentation

- ☒ 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)

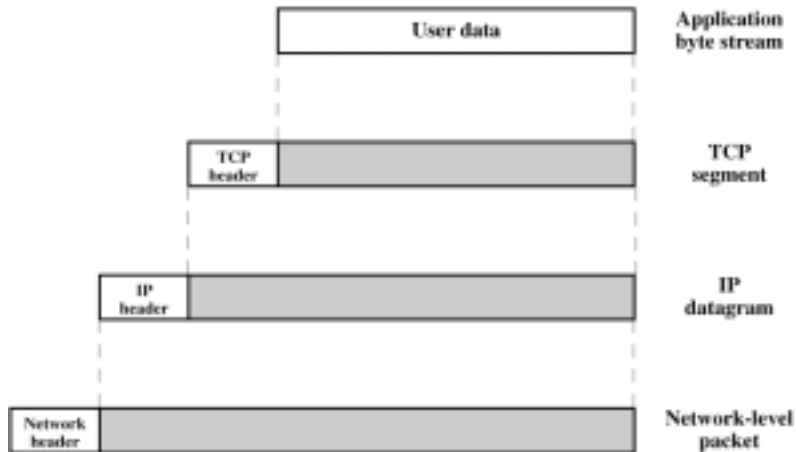
⌘ Network Layer

- ☒ Logical interface between end system and network

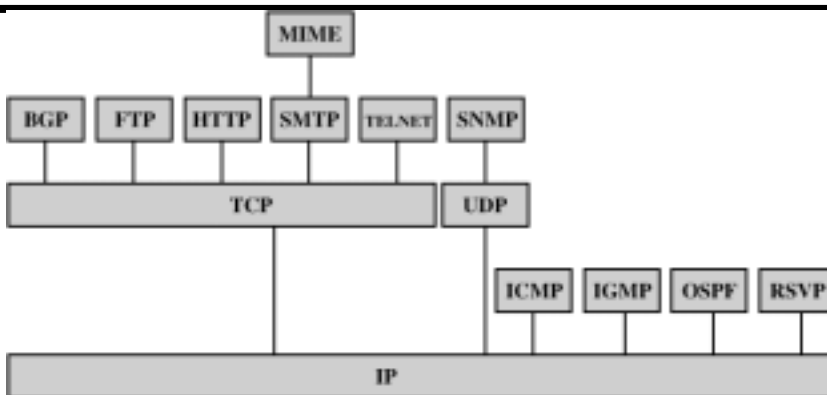
⌘ Physical Layer

- ☒ Transmission medium
- ☒ Signal rate and encoding

PDU in TCP/IP



Some Protocols in TCP/IP Suite



- | | |
|--|---|
| 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