CSC465 – Computer Networks
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These slides are based on material from "TCP/IP Protocol Suite (2nd Edition)" by Fourouzan

The OSI Model and TCP/IP Protocol Suite

CONTENTS

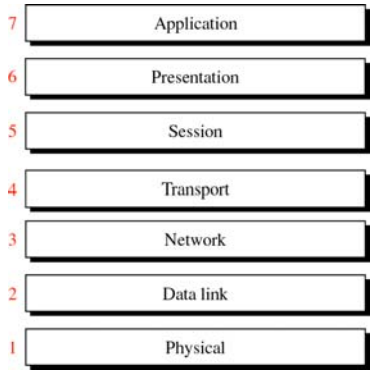
OSI ISO Model

ISO is the organization.
OSI is the model.

International Standards Organization

Open System Interconnection

OSI Model



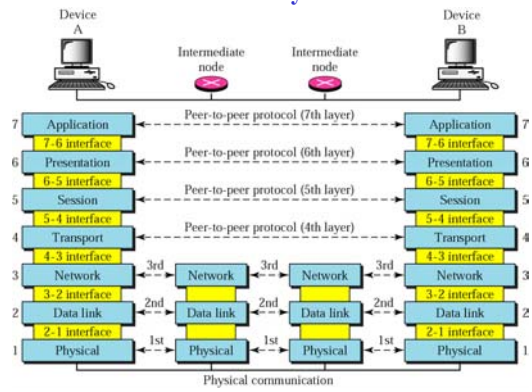
Peer-to-Peer Processes

- Processes on each machine that communicates at a given layer are called peer-to-peer processes
- Communication between machines is a peer-to-peer process using the protocols appropriate to a given layer

Organization of the Layers

- Physical, Link & Network→ *network support*
  - Address physical aspects of moving data from one device to another
  - Electrical specifications, physical connections, physical addressing, transport timing, reliability
- Session, Presentation & Application → *user support*
  - Allow interoperability among unrelated software systems
- Transport layer: links two subgroups

OSI layers



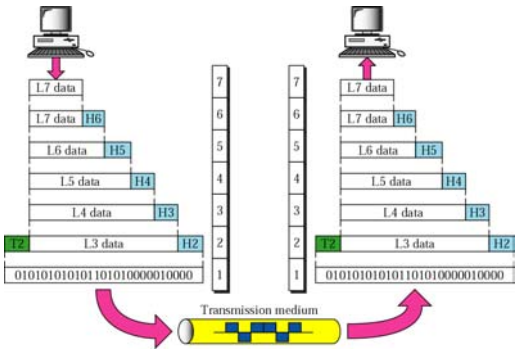
Implementation of the Layers

- Well-defined interfaces and layer functions provide modularity to a network (encapsulation)
- Lower OSI layers:
  - implemented using combination of hardware and software
  - Physical layer implemented mostly in hardware
- Upper OSI layers
  - implemented using software

Note

Headers are added to the data at layers 6, 5, 4, 3, and 2. Trailers are usually added only at layer 2.

An exchange using the OSI model



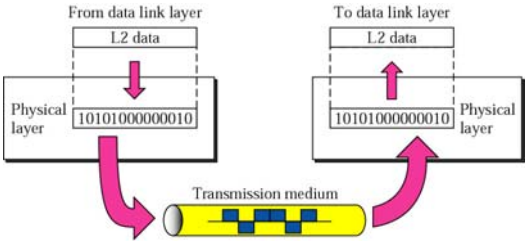
2.2

LAYERS IN THE OSI MODEL

Physical Layer

- Coordinates the functions required to transmit a bit stream over a physical medium
- Addresses mechanical and electrical specifications of the interface and transmission media
- Defines procedures and functions that physical devices and interfaces have to perform for transmission to occur

Physical Layer



Physical Layer Topics

- Defines *characteristics of the interface* between the devices *and the transmission media* (also defines type of media)
- Representation of bits without interpretation. Bits encoded electromagnetically or optically (defines *encoding*: how 0's and 1's are changed to signals)
- Defines data transmission rate: duration of bit
- Transmission synchronization

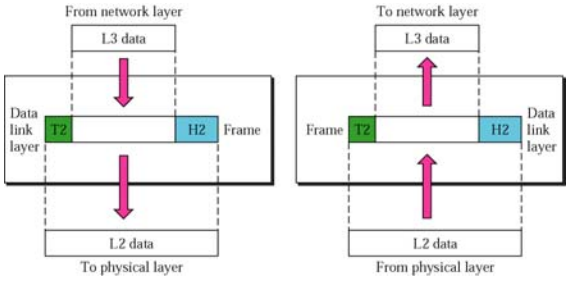
Physical Layer Topics

- Line configuration
  - Point-to-Point: dedicated link
  - Multipoint: several devices share a link
- Physical topology
  - how devices connect to form a network
  - Examples: Ring, Star, Mesh, Bus
- Transmission mode
  - simplex, half-duplex, full-duplex

Data Link Layer

- Transforms the physical layer, a raw transmission facility, to a reliable link
- DLL makes physical layer seem error free to upper layers

Data Link Layer



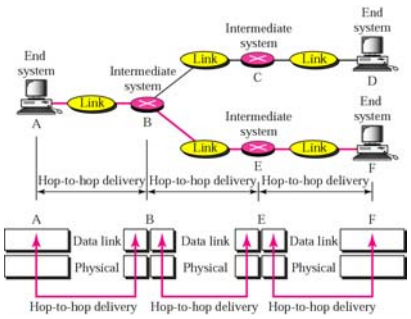
Data Link Layer Tasks

- **Framing:** converts streams of bits into manageable data units (frames)
- **Physical addressing:** If frames are to distributed to different systems on the network, DLL adds a header to specify sender and/or receiver (if outside network, frames goes to connecting device)
- **Flow control:** If receiver is slower than sender, flow control mechanism is applied

Data Link Layer Tasks (con't)

- **Error Control:** includes mechanisms to detect and retransmit damaged or lost frames
  - Also prevents duplication of frames
- **Access Control**
  - If a multipoint configuration (2 or more devices share link), mechanism is needed to determine which device has control of the link at any given time

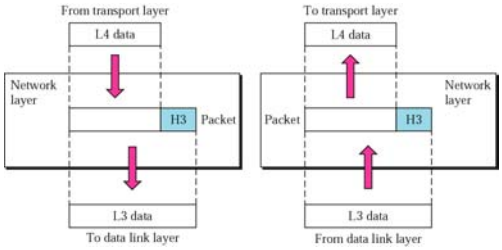
Node-to-node delivery



Network Layer

- Responsible for source-to-destination delivery of data (packet) across multiple network links
- Ensures packet gets from point of origin to final destination
- If two systems are connected to the same link, network layer not usually necessary
- If two systems are attached to different links (networks), there is often a need for the network layer to accomplish source to destination delivery

Network Layer



Network Layer Tasks

Logical Addressing

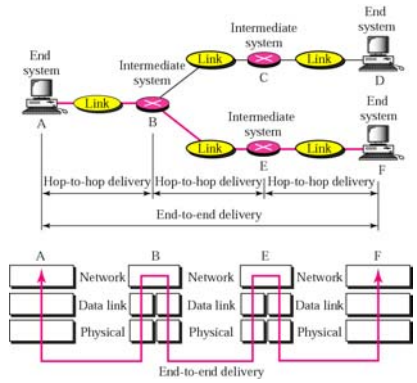
- Physical addressing performed by DLL handles addressing "locally"
- If destination is on a different network, i.e., passes a network boundary, another addressing system is necessary
- Network layer header adds logical addresses of sender and receiver

Network Layer Tasks (con't)

Routing

- Networks and links are combined to form networks of networks (called "internetworks")
- The connecting devices direct packets to final destination
- A function of the network layer is to provide this mechanism

End-to-end delivery



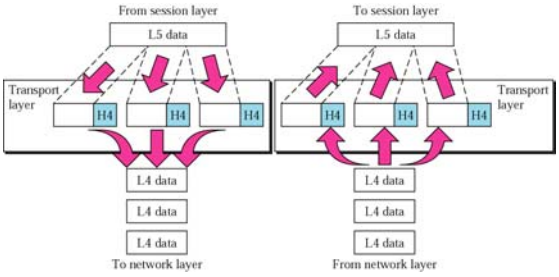
Transport Layer

- Responsible for source-to-destination (end-to-end) delivery of the entire message.
- Whereas the network layer overseas end-to-end delivery of individual packets, it does not recognize any relationship between those packets
- Network layer treats each packet as if belonging to a separate message, regardless of whether or not it actually does

Transport Layer (con't)

- Transport layer ensures that the whole message (set of packets) arrives completely and in order
- Oversees error control and flow control at the source-to-destination level

Transport Layer



Transport Layer Tasks

Service Port Addressing

- device-to-device is restrictive because devices (computers) support multiple processes that may wish to communicate to processes on other devices
- Transport layer (TL) must include a service-point address
- The network layer ensures a packet reaches its final destination
- The TL gets the **entire message** to the **correct process** on that computer

Transport Layer Tasks (con't)

Segmentation and Reassembly

- Message is divided into transmittable segments, each with a sequence number
- TL reassembles message and identifies and replaces any packets lost in transmission

Transport Layer Tasks (con't)

Connection Control

- TL can be either connectionless or connection-oriented
- With a connection-oriented TL, the source and destination devices work in a more tightly-coupled manner (virtual circuit).
- A connection is requested by the sender before packets are sent.
- When all packets are sent, connection closes

Transport Layer Tasks (con't)

Flow Control

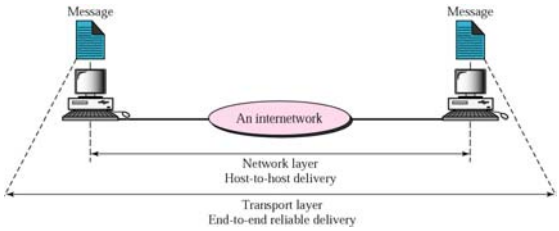
- Like the DLL, the TL is responsible for flow control
- TL flow control is performed end-to-end rather than across a single link

Transport Layer Tasks (con't)

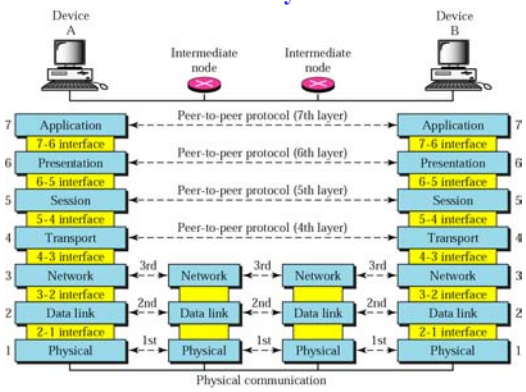
Error Control

- Like the DLL, the TL is responsible for error control
- TL error control is performed end-to-end rather than across a single link
- TL layer ensure that the entire message arrives at the receiving TL without damage, loss or duplication
- Correction is usually achieved through retransmission

Reliable end-to-end delivery of a message



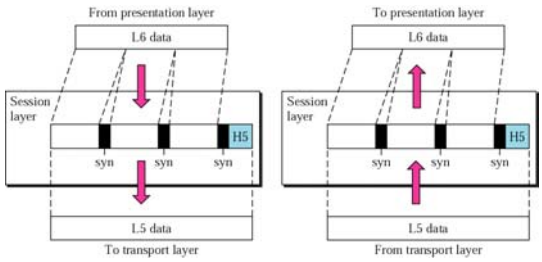
OSI layers



Session Layer

- *Network Dialog Controller*
- Allows two systems to enter into a dialog; controls the mode (half/full duplex)
- Allows a process to add checkpoints (synchronization points) into a data stream
- A failure during message transmission can be recovered without complete retransmission of message

Session Layer



Presentation Layer

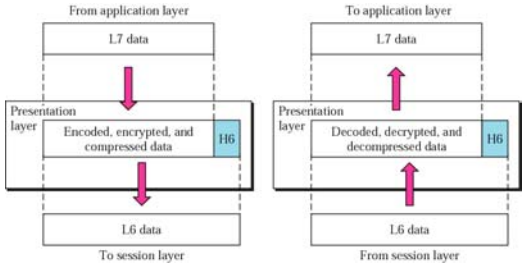
Concerned with the syntax and semantics of the information exchanged between two systems

Tasks:

- Translation
  - Resolves differences in character and numeric representation via common transmitted format
- Encryption
- Compression
  - important for audio, image and video

Note: encryption is available at lower OSI levels

Presentation Layer

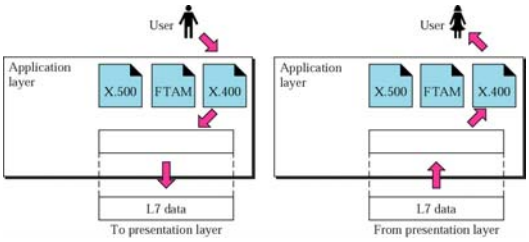


Application Layer

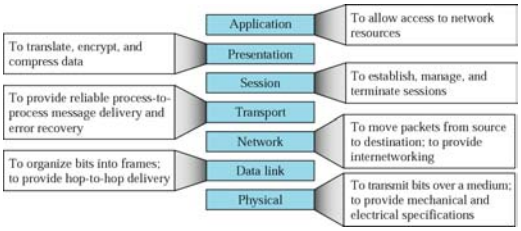
- *Enables the user, either directly or via application software, to access the network*
- Provides user interfaces and support for services such:
  - Mail Services (E-mail, IRC, IM
  - Remote file access and transfer (FTP, HTTP)
  - Directory services, e.g., DNS, Distributed DBs
  - Network Virtual Terminal (Telnet)
  - Malicious Software!

Figure 2-13

Application Layer



Summary of layers

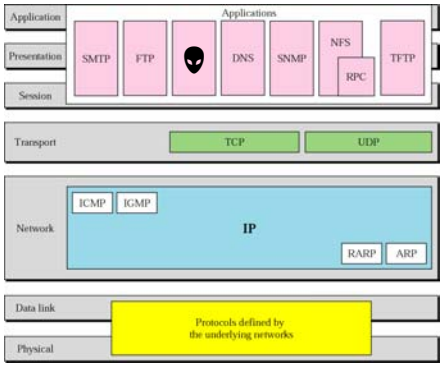


2.3 TCP/IP PROTOCOL SUITE

TCP/IP Protocol Suite

- Developed prior to OSI model
- 5 layers instead of 7 (only defines protocols for 3)
- TCP "Application layer" subsumes OSI's "Presentation and Session layers"
- Transport Layer comprised of two protocols
  - Transmission Control Protocol (TCP)
  - User Datagram Protocol (UDP)
- Network Layer → Internetworking Protocol (IP)
  - Internet Control/Group Message Protocol
  - (Reverse) Address Resolution Protocol

TCP/IP and OSI model



(Inter)Network Layer

Internetworking Protocol (IP)

- Unreliable and connection less
- "Best effort"→ no error checking or tracking
- IP packets called *datagrams*
- Sent separately and can travel different routes
- Can arrive out of sequence or be duplicated
- IP does not keep track of routes and cannot reorder datagrams
- Allows additional functionality to be added only if necessary

(Inter)Network Layer

Address Resolution Protocol (ARP)

- *ARP(IP_Address) → Physical_Address*
- *RARP(Physical_Address) → IP_Address*

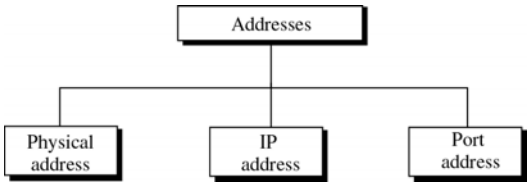
Internet Control Message Protocol (ICMP)

- Used for query and error reporting

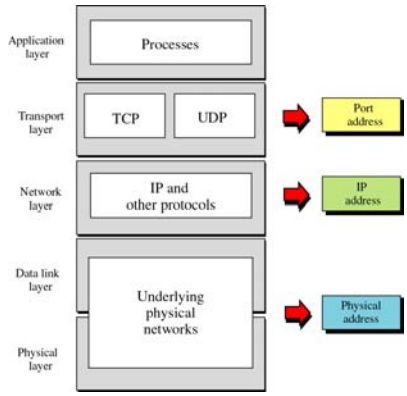
Internet Group Message Protocol (IGMP)

- Assists with the management of multicasting

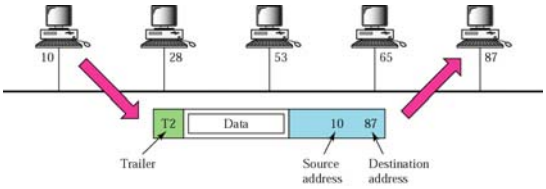
Addresses in TCP/IP



Relation-ship of layers and addresses in TCP/IP



Concept of Physical Addressing



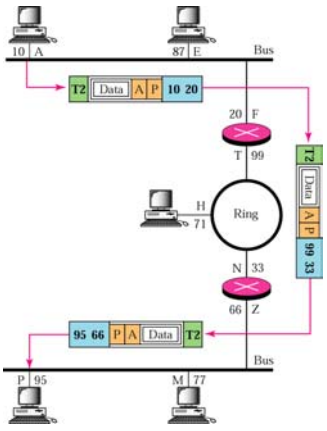
Example Physical Address

Most local area networks use a 48-bit (6 bytes) physical address written as 12 hexadecimal digits, with every 2 bytes separated by a hyphen as shown below:

07-01-02-01-2C-4B

A 6-byte (12 hexadecimal digits) physical address

Concept of IP Addressing

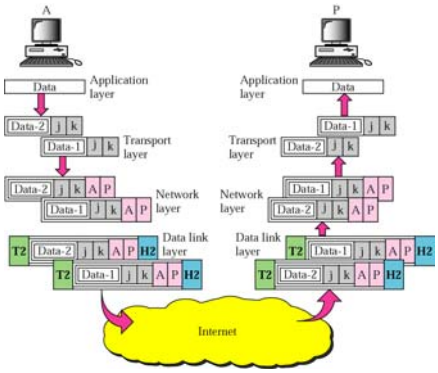


Example IP Address

An Internet address (in IPv4) is 32 bits in length, normally written as four decimal numbers, with each number representing 1 byte. The numbers are separated by a dot. Below is an example of such an address.

132.24.75.9

Port addresses



TCP/IP Versions

Version 4 – current

Version 5 – superceded by IPv6

Version 6
- Starting to be deployed in US
- Already deployed in other countries