Overview

- Last Lecture
  - Data security 2
- This Lecture
  - Introduction to networks
  - Source: Sections 2
- Next Lecture
  - Media Access Control (MAC)
  - Source: Sections 12

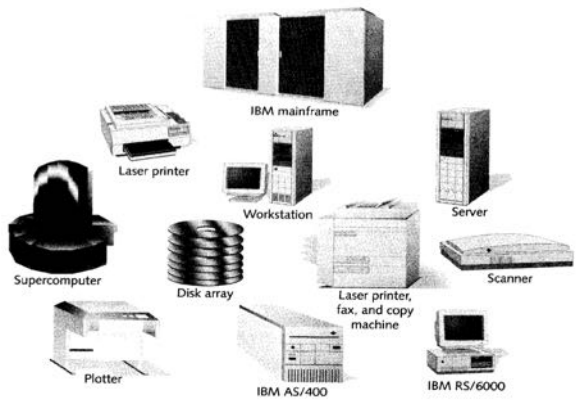
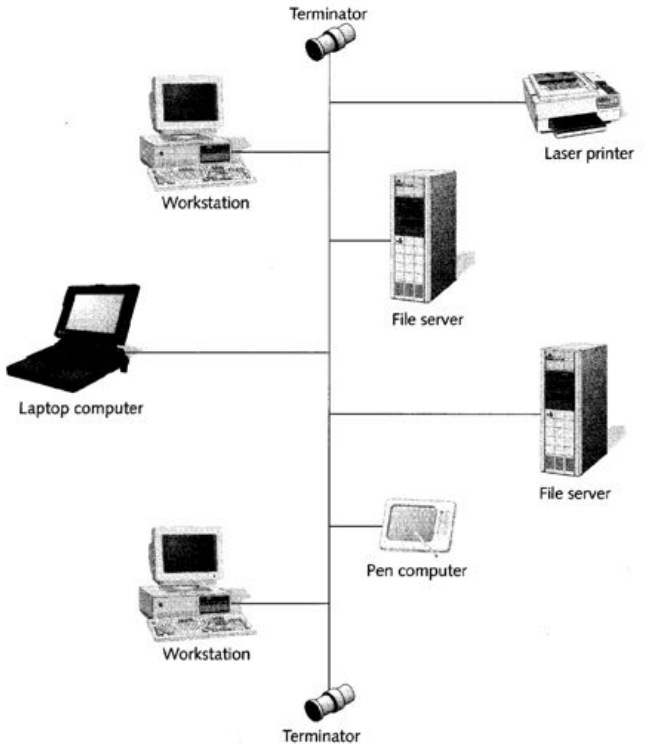


Figure 1-5 Elements in an enterprise network

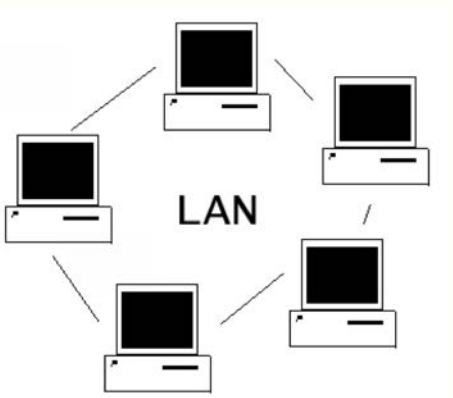
Computer Networks

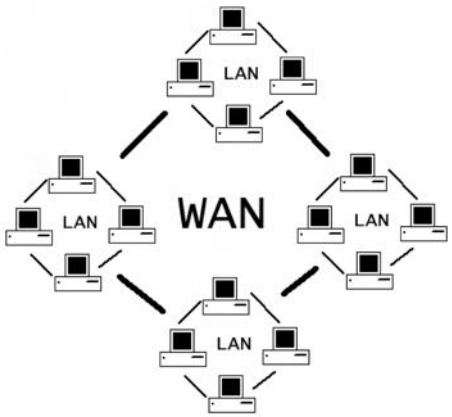
- What is a computer network
  - A computer network is an interconnected collection of autonomous computers which are able to exchange information online.
  - It may include devices such as printers, faxes, copy machines, etc.

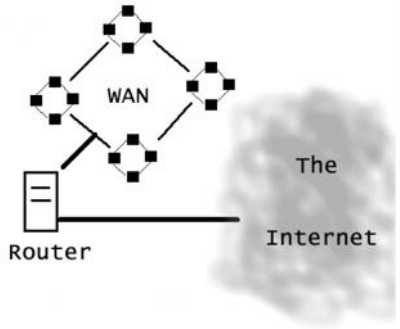


Computer Networks (cont.)

- LAN - local area network
  - Covers a small geographic area and connects devices in a single building or group of buildings
- WAN - wide area network
  - Covers a larger area such as a city /municipal region, country, or the world

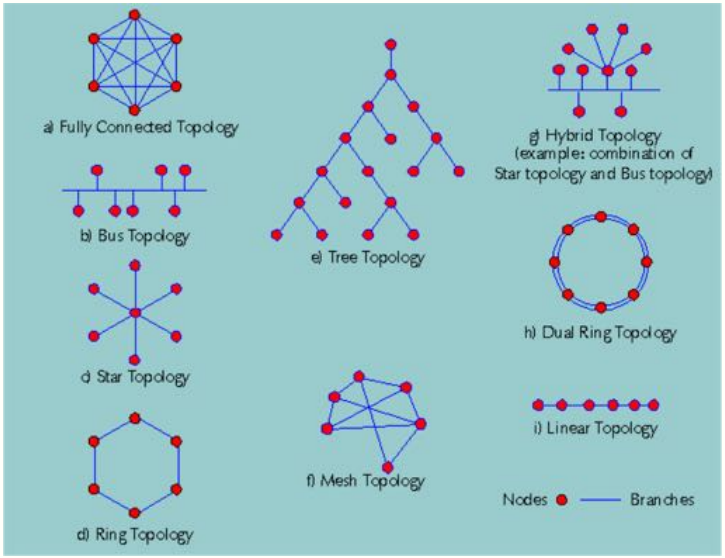






Network Topologies

- A way of organising the physical connections
  - Star, Ring, Bus etc.



Star Topology

- Control is centralised.
- If a device wants to communicate, it does so only through the central computer.
- Advantage - focal point for responsibility
- Disadvantage - failure of the central computer brings down the entire network

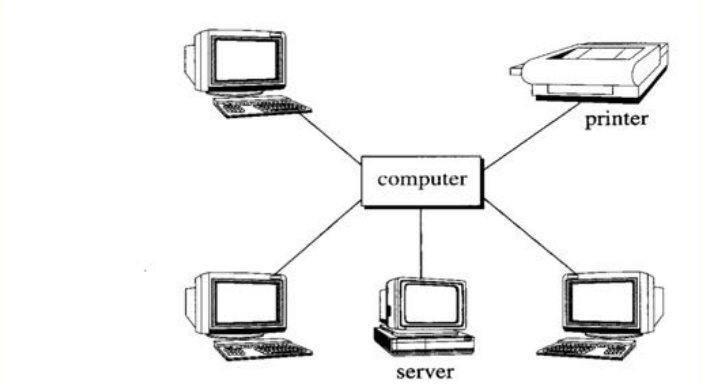


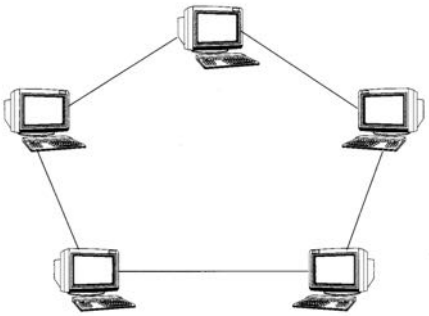
Figure 1.7 Star Topology

Ring Topology

http://www.netbook.cs.purdue.edu/animations/token%20ring.html

- Devices connected circularly, unidirectional or bi-directional communication
- Advantage - no central coordination
- Disadvantages
  - All stations in between sender and receiver are involved when passing a message.
  - Failure of one station causes a break.
  - More time on relaying messages.

Figure 1.8 Ring Topology



Bus Topology

- Devices communicate through a single bus.
- Only communicating devices are involved when passing messages
- Advantage: easy to add/remove devices to/from the network
- Disadvantages:
  - Collision detection
  - High collision rate may reduce the data rate

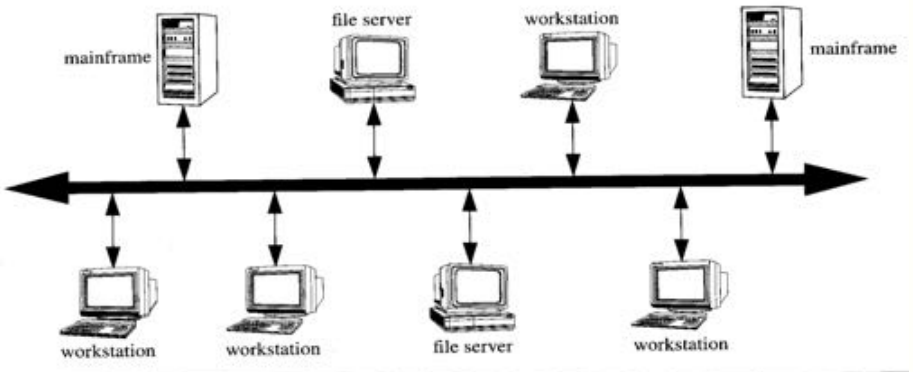
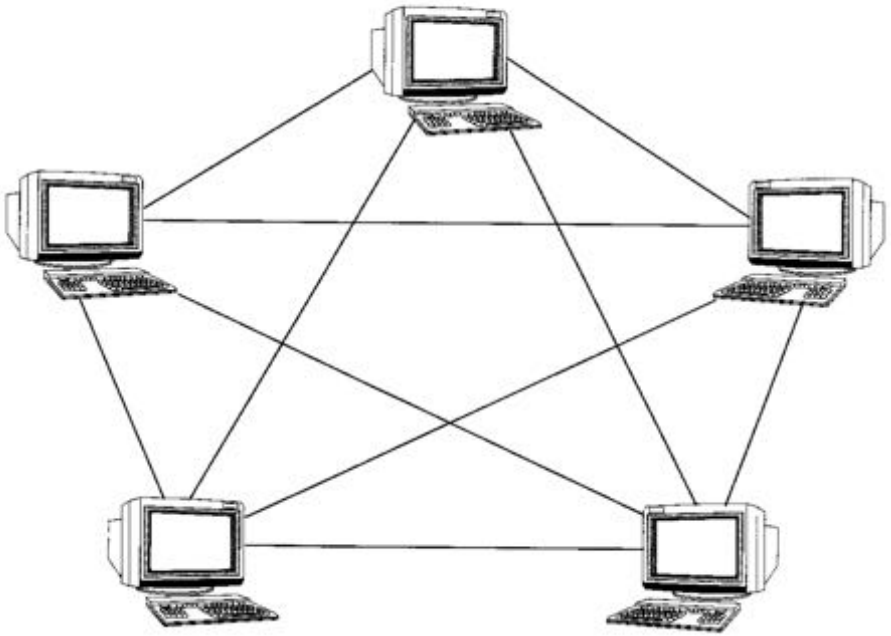


Figure 1.6 Common Bus Topology

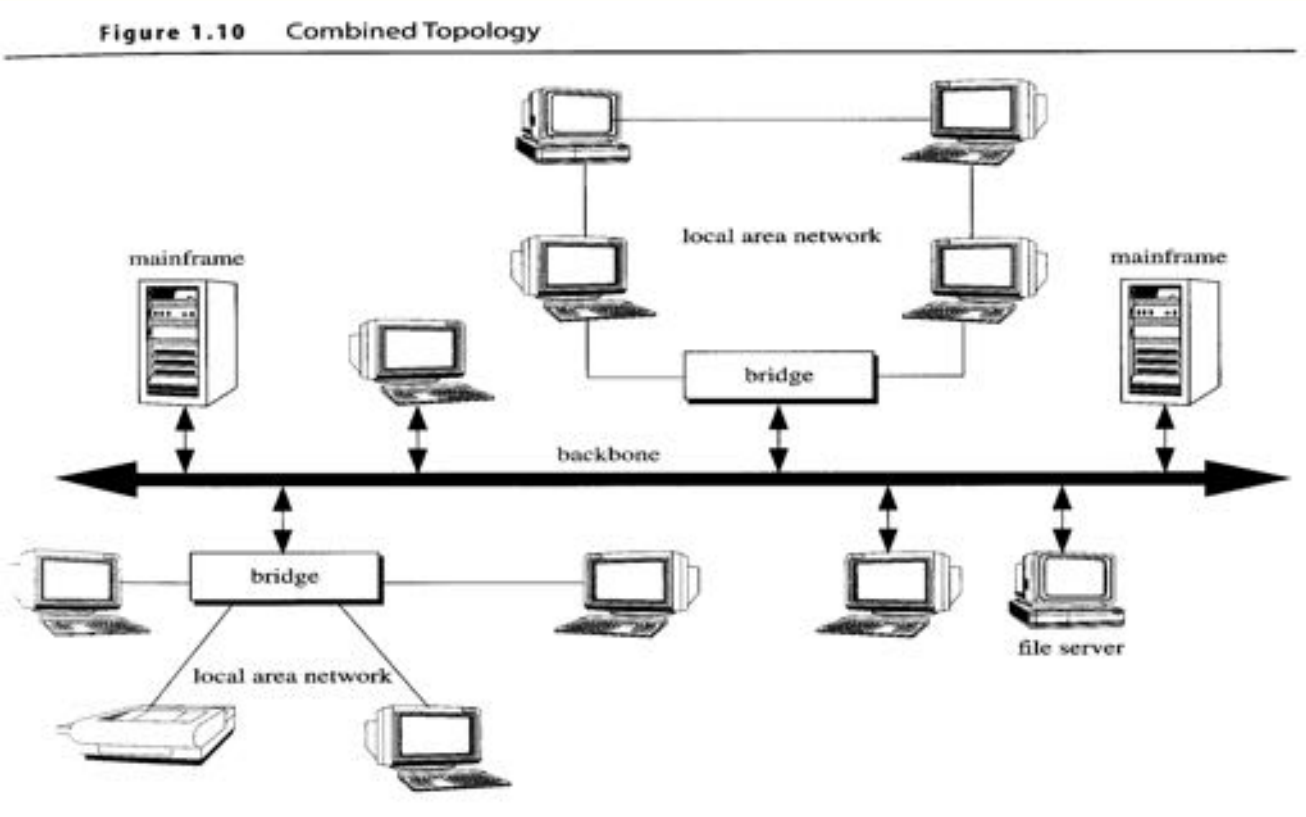
Fully Connected Topology

e 1.9 Fully Connected Topology



Combined Topology

- The de facto situation



What is a protocol?

- Protocol – An agreement about how to do something
  - A set of rules governing the exchange or transmission of data electronically between devices.
  - This enables computers and software built by different people to be able to communicate in the same language
- How does it work to send an email to a friend in UK?

  I just write it in Gmail, and never care about how the data is transmitted through the internet.
- How does it work to post a mail to a friend in UK?

  I just put my letter in the envelope, put it in the mailbox, and never care about how it is post through the mail system.

They have similar management concepts!

Example: Letter Sending Protocol

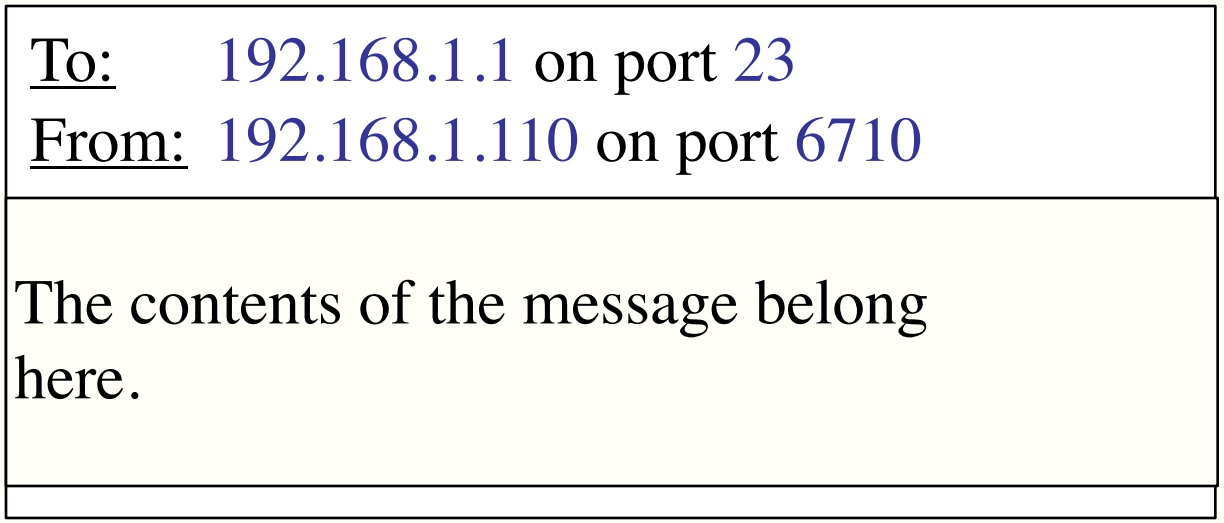
- Sending a letter via the postal service

Shayne Evans
5501 Sennott Sq.
Pittsburgh, PA. 15260

Kim Morrison
123 Somewhere St.
Someplace, PA. 15555

Example: Letter Sending Protocol

- Sending a packet via the network



Example: Letter Writing Protocol

- A common protocol that is followed when writing a letter is:

04/01/2008

Dear Kim,

Hey there! What's up? I'm good. Thanks.

Sincerely,
Shayne Evans
Shayne Evans

Example: Letter Writing Protocol

- A common protocol that is followed when writing a letter is:

[Date]

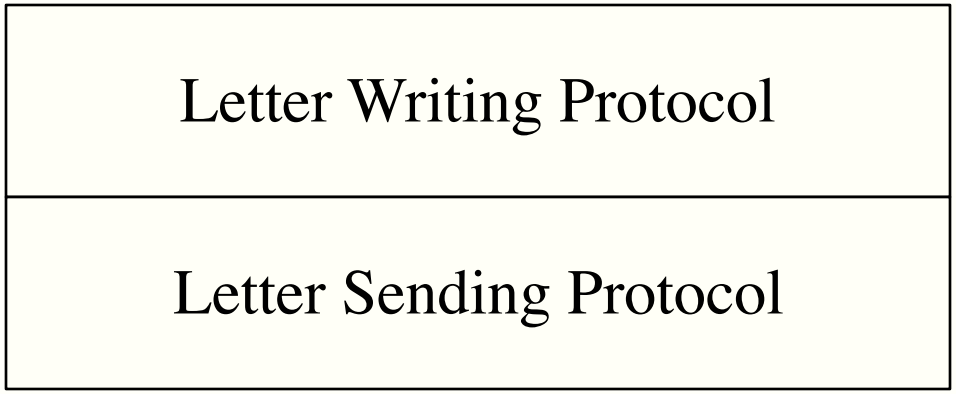
Dear [Recipient],

[Body of message goes here]

[Closing]
[Sender signature]
[Sender name]

Example: Letter Protocol

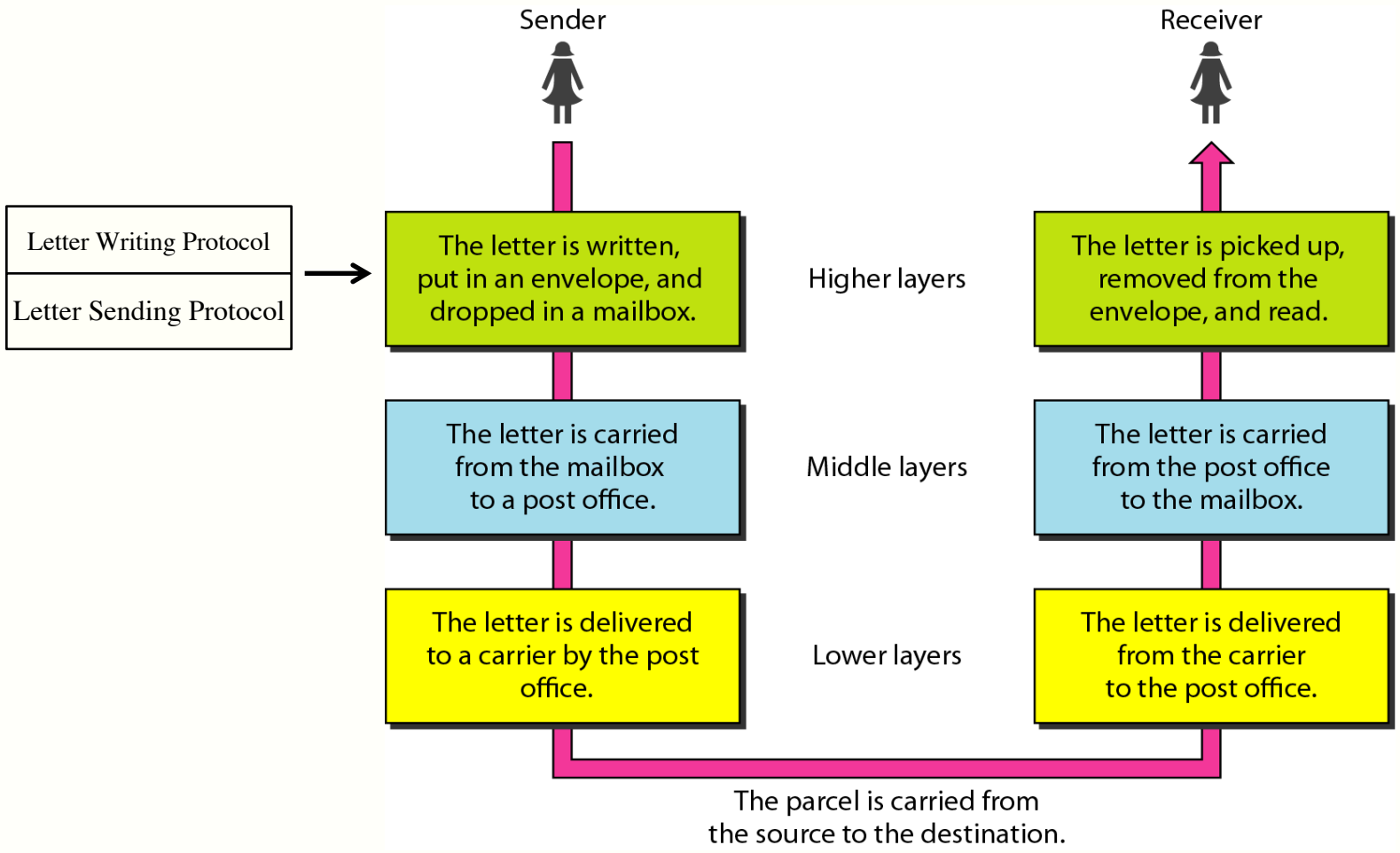
- Thus, I have layered two protocols on top of each other.



- The lower protocol provides a service used by the higher protocols.

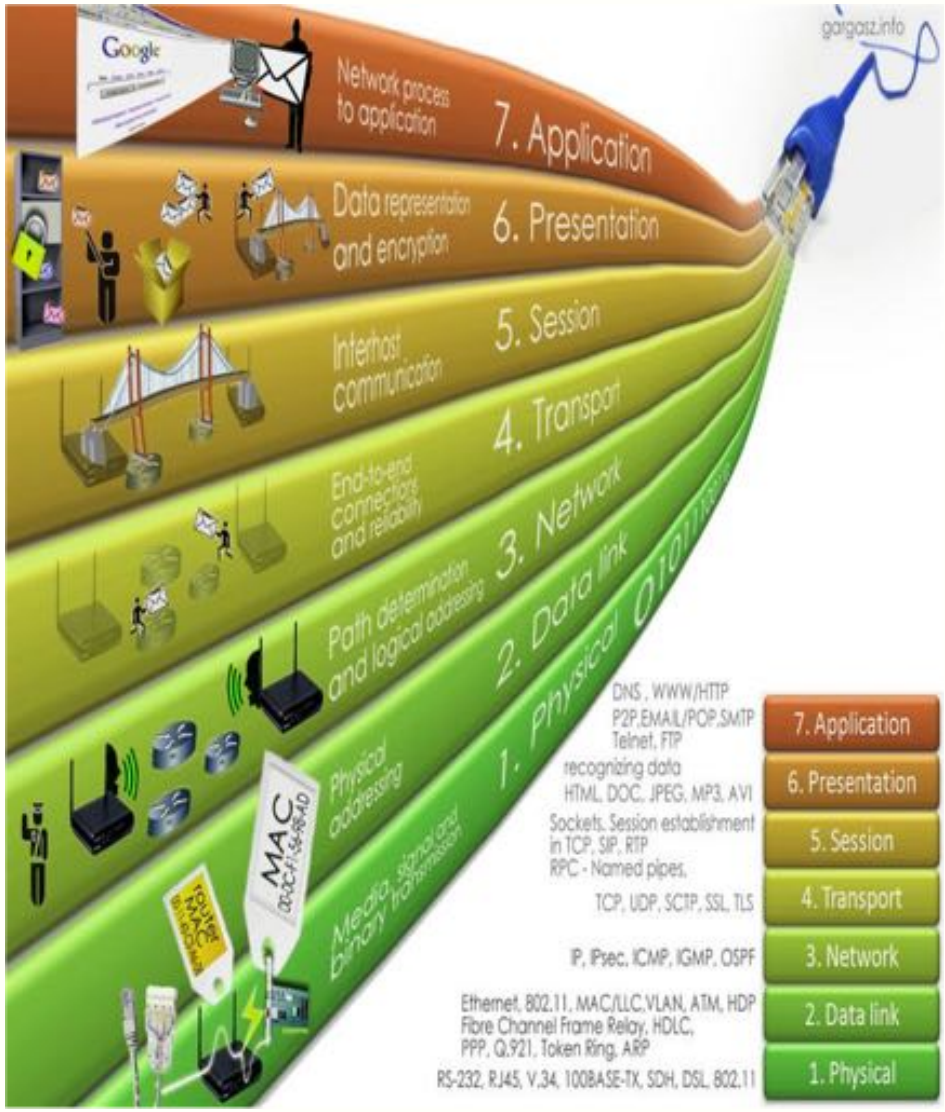
Example: Letter Protocol

- Layered Tasks



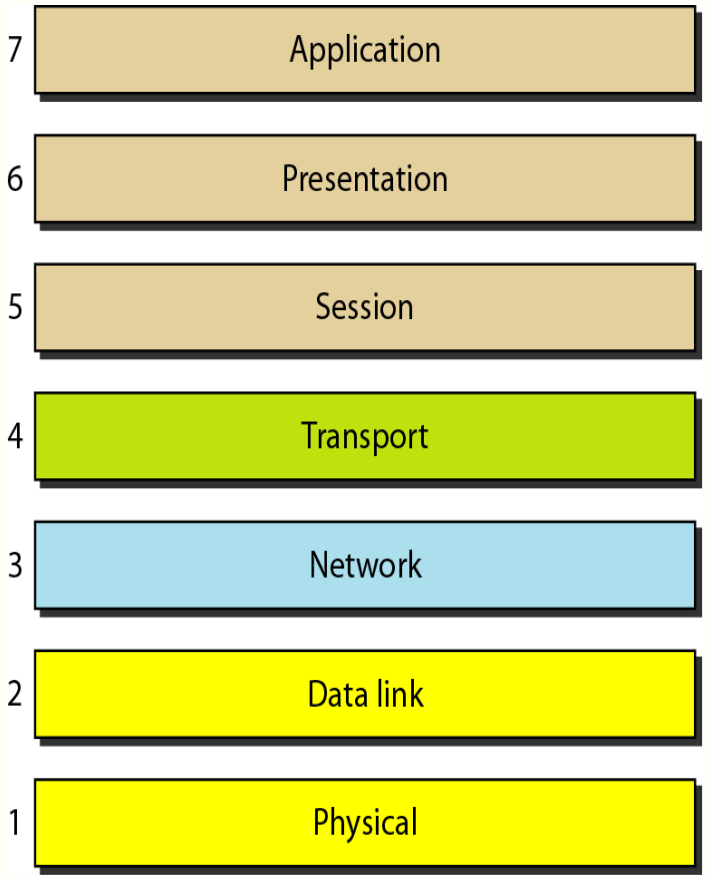
Network protocols

- Similarly, Network protocols are layered
  - Modular requirement
  - Change of lower layer protocols does not affect higher layer protocols.
  - Each layer has its own independent protocol.
  - There are defined interfaces between two adjacent layers



ISO's OSI Model

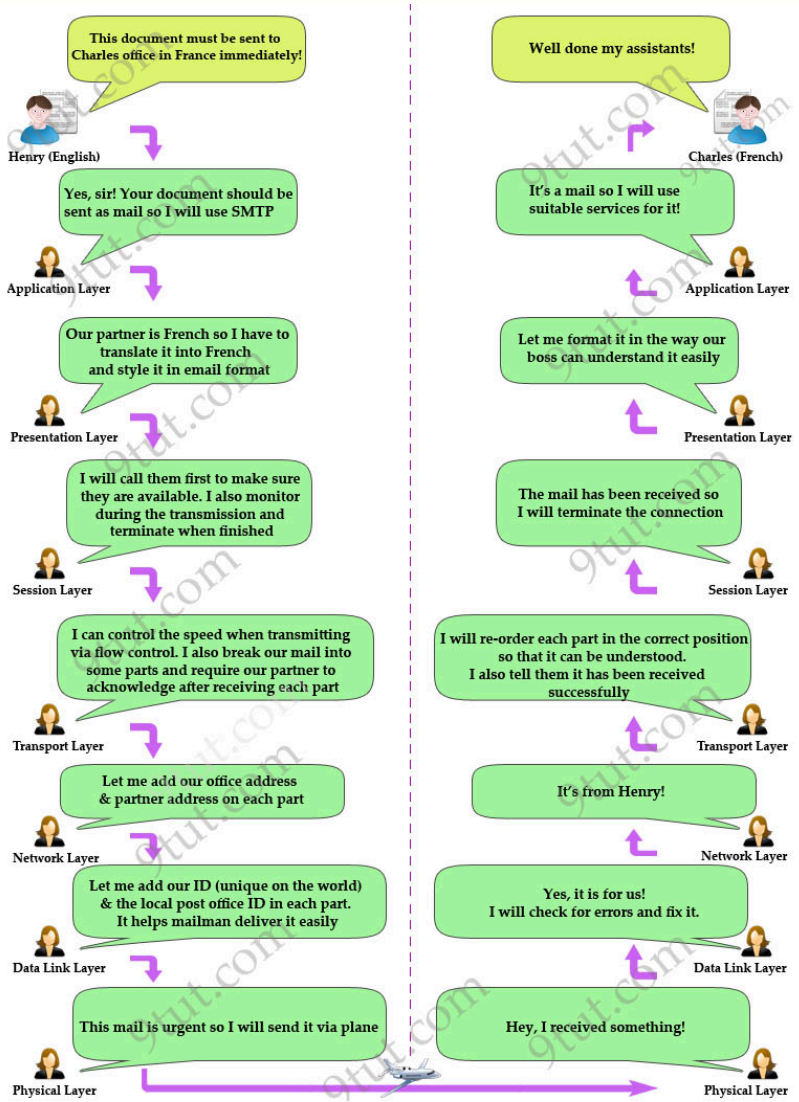
- ISO: the International Standards Organization
- OSI: Open Systems Interconnection Model (1984)
- Layered protocol model (composed of seven layers)
- Each layer performs specific functions and communicates with the layers directly above and below it.



"Please **D**o **N**ot **T**hrow **S**ausage **P**izza **A**way"

Components of Each OSI Layer

- *Service* - defines what the layer does
- *Interface* - defines how the layers above and below interact with it. What parameters exist and what results to expect
- *Protocol* - Layer *n* on one machine carries on a logical conversation with layer *n* on another machine. The rules used in this conversation are known as the layer *n* protocol



Why a Layered Protocol?

- Each layer performs a separate function. Makes changes and modifications easier. Change of lower layers does not affect higher layers as long as their interfaces are the same.
- Higher layers (5, 6, 7) deal with end-to-end communications, user services and applications. Lowest three layers (1, 2, 3) deal primarily with the details of data transmission in networks.
- Each layer offers certain services to the higher layers, shielding those layers from the details of how the offered services are actually implemented.
- Reduces complexity/Provides compatibility/Accelerates evolution of technology/Simplifies learning

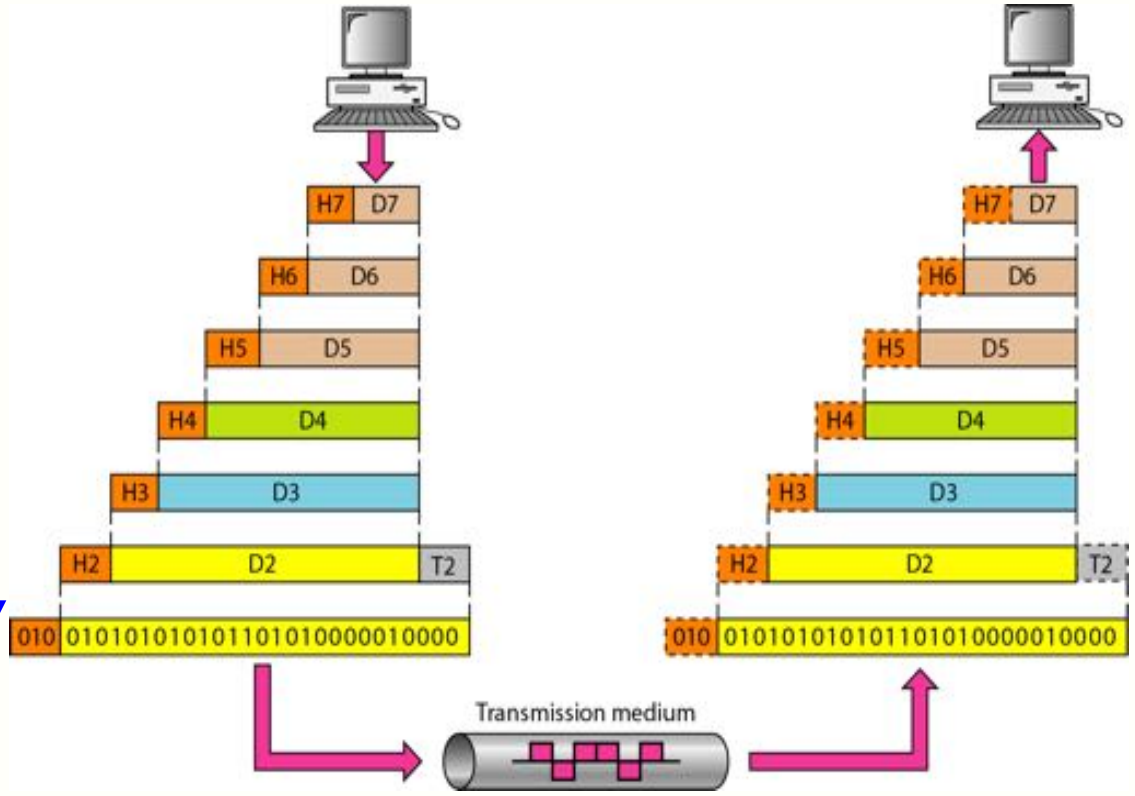
OSI Model (cont.)

demo: http://www.bpsharma.in/eLearning/Networking/images/osilayer.gif

- The data portion of a packet at level N-1 carries the whole packet from level N – The concept is called encapsulation.

A receiving layer wraps incoming message with an envelope

• Adds layer related information

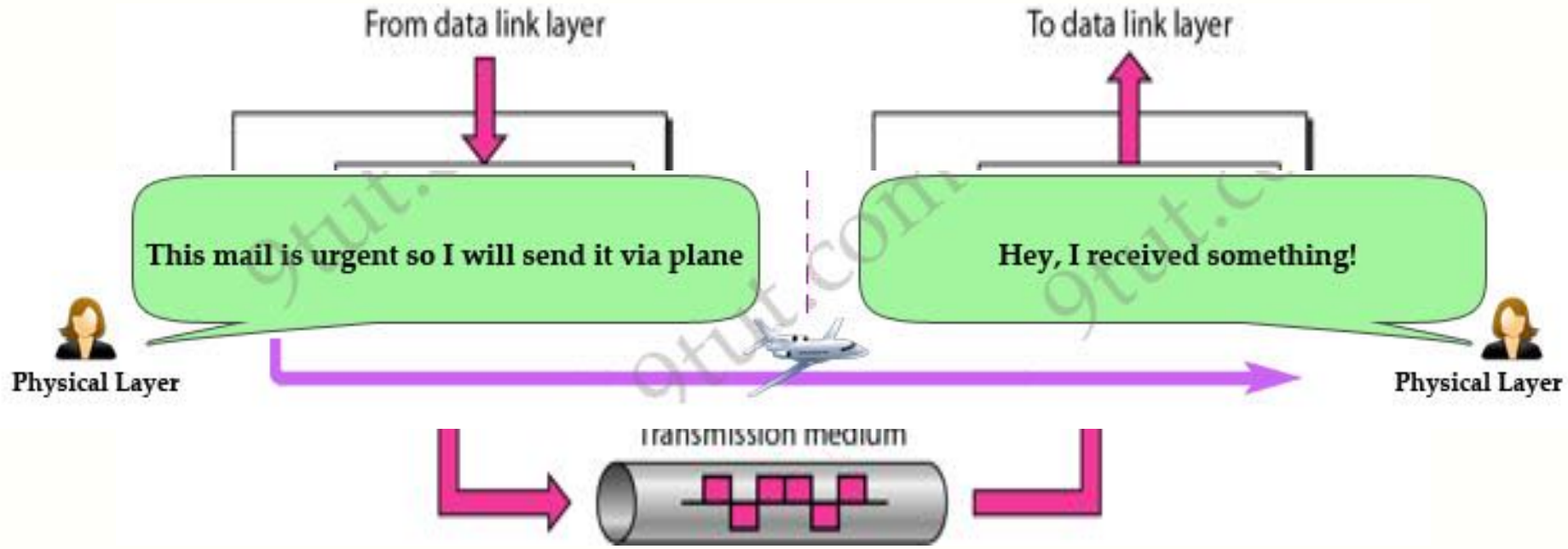


A receiving layer removes the layer related envelope and forwards the message up

Email demo:http://www.pucomp.org/2010/12/osi-model-how-email-passes-through-each.html

Physical Layer

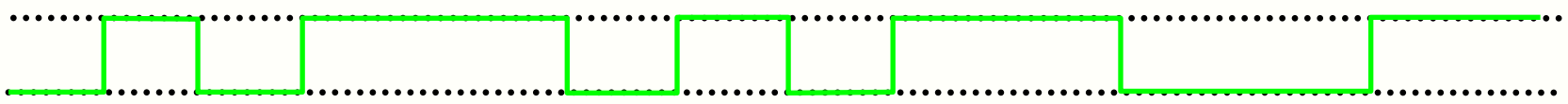
- The physical layer is responsible for movements of individual bits from one hop (node) to the next.



Analogy from: http://www.9tut.com/osi-model-tutorial

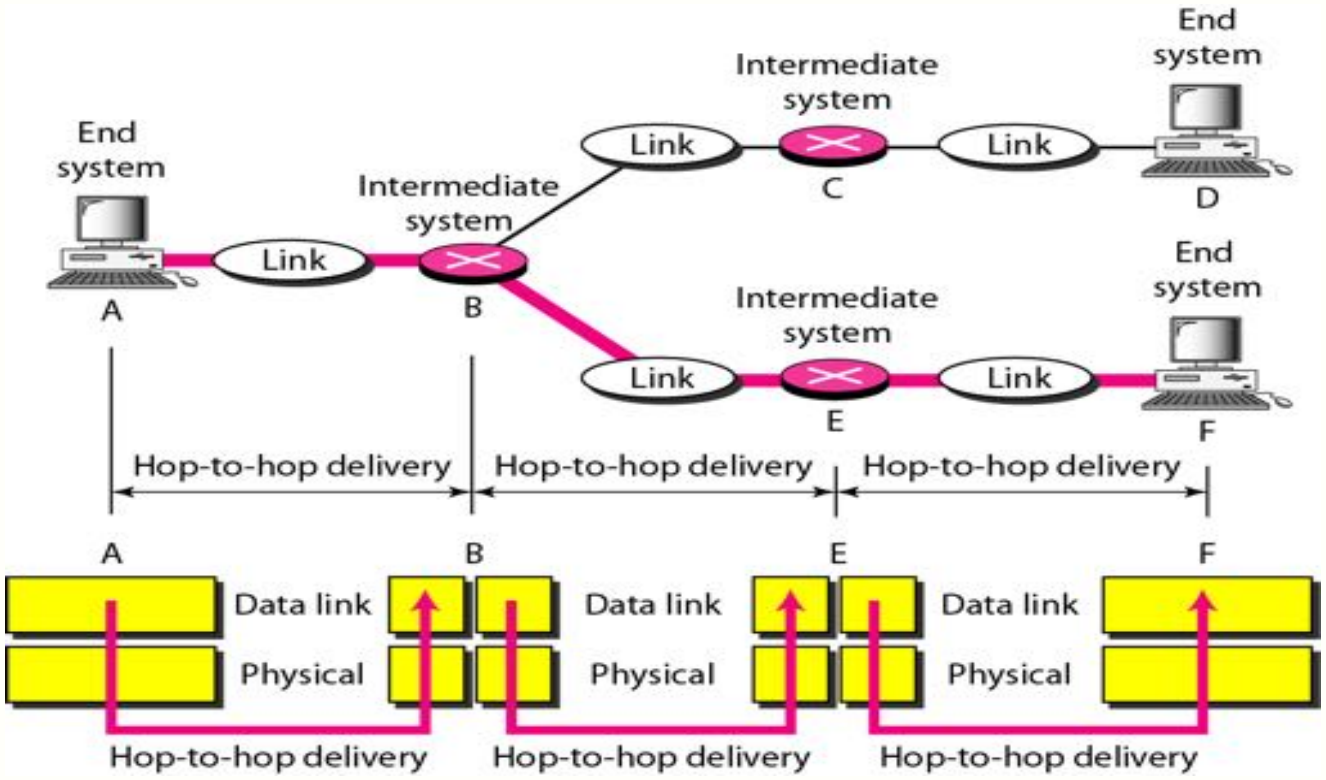
Physical Layer

- Defines how signals are sent by a media
- Transmits physical bits over the network
- Concerned with the physical and electrical aspects:
  - physical or electrical interfaces between the user equipment and the network equipment
  - signal and encoding
- Protocols/standards include: RS-232, RS-449, RJ-45
- Sometimes called the “bit pipe”



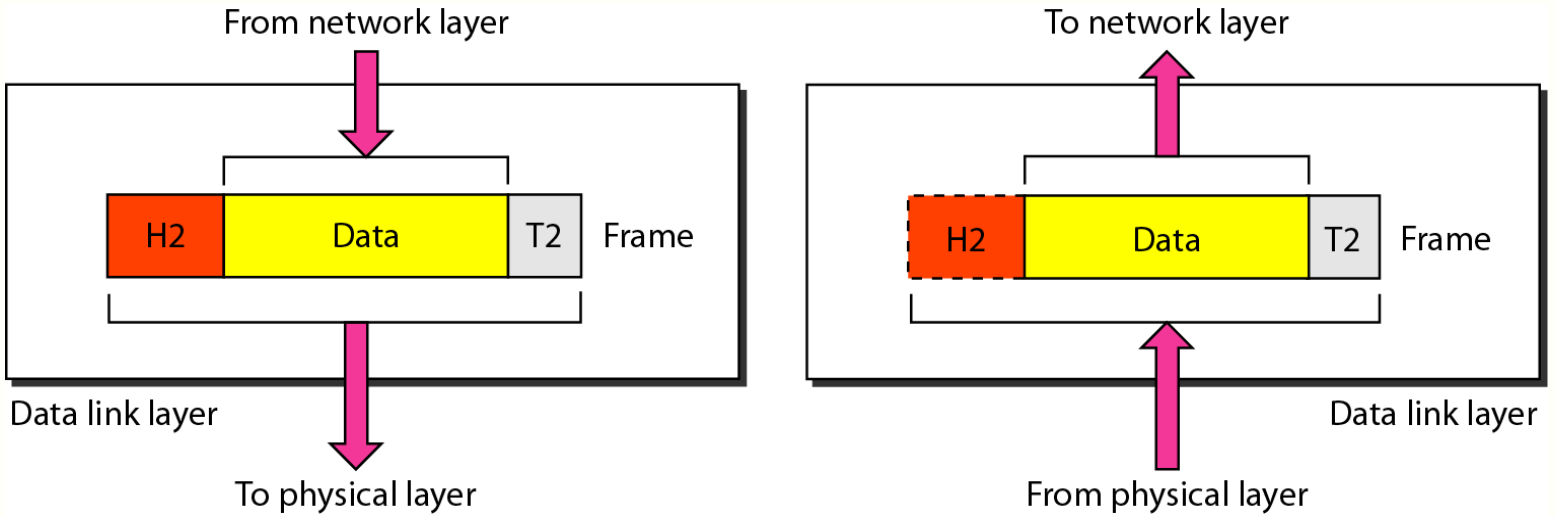
Data Link Layer

- The data link layer is responsible for moving frames from one hop (node) to the next. (hop-to-hop delivery)



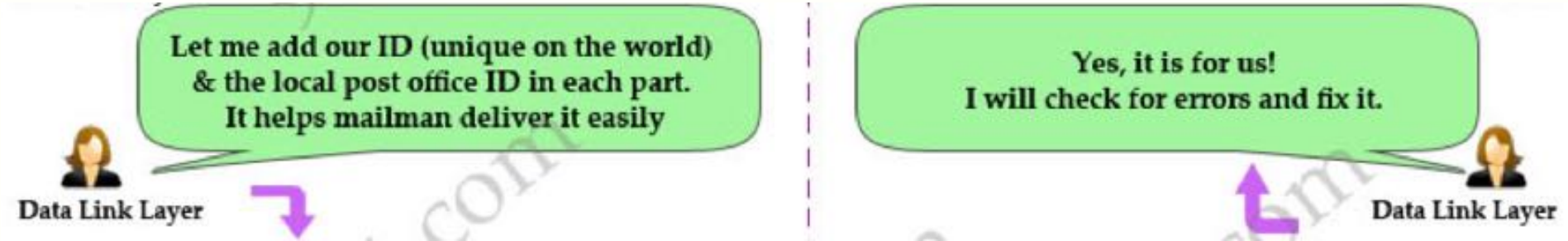
Data Link Layer

- Defines frames: Sends and receives frames
- Sender: Accepts messages from the higher layer; Breaks them into frames; Hands these frames to the physical layer
- Receiver: Receives frames from the physical layer; Assembles them into messages; Hands the messages to the next higher layer



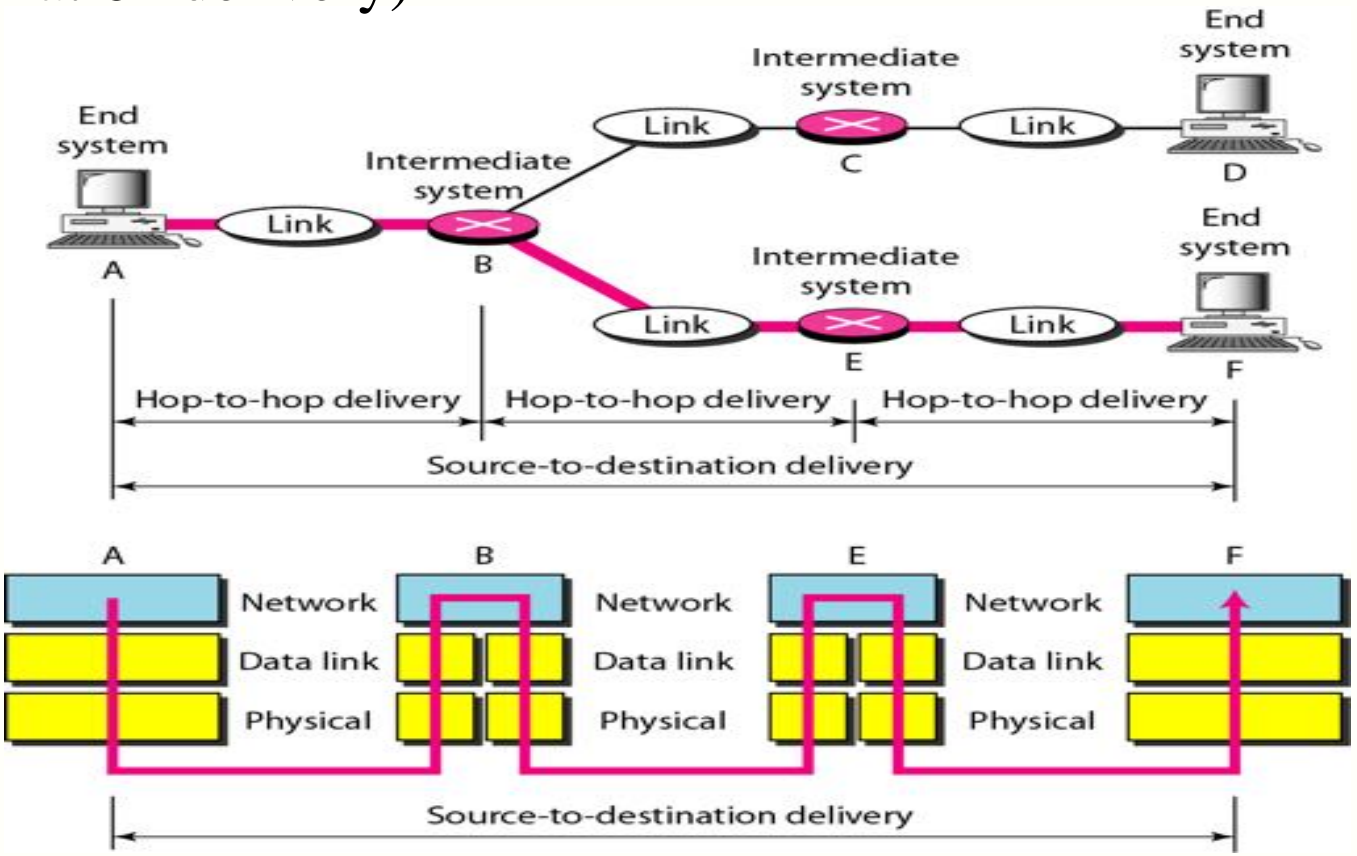
Data Link Layer (cont.)

- Detects or corrects errors to ensure error-free messages
  - CRC, Hamming codes
- Flow control between two adjacent network nodes.
- Error control - deals with damaged, lost, and duplicate frames
- Sub layers:
  - Medium Access Control (MAC)
  - Logical Link Control (LLC)



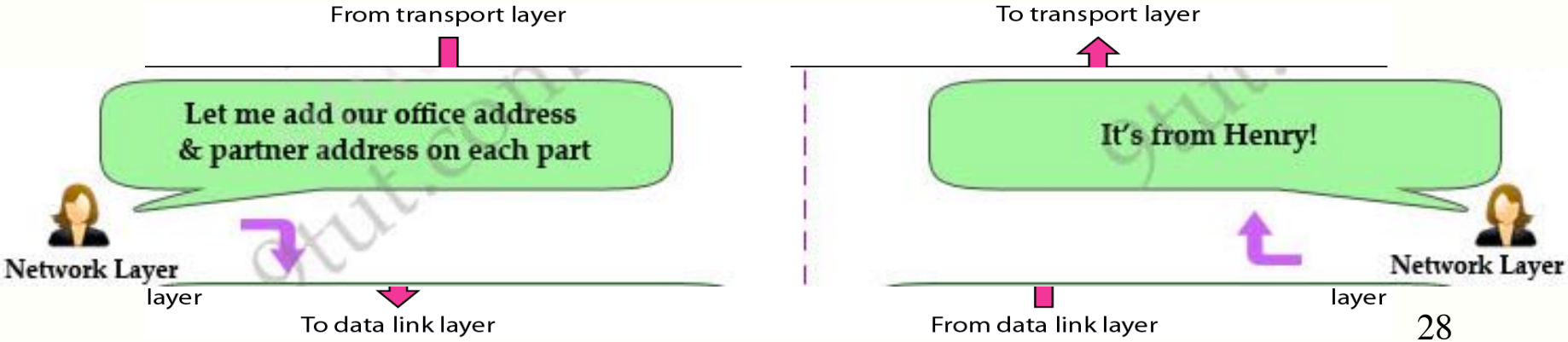
Network Layer

- The network layer is responsible for the delivery of individual packets from the source host to the destination host. (source-to-destination delivery)



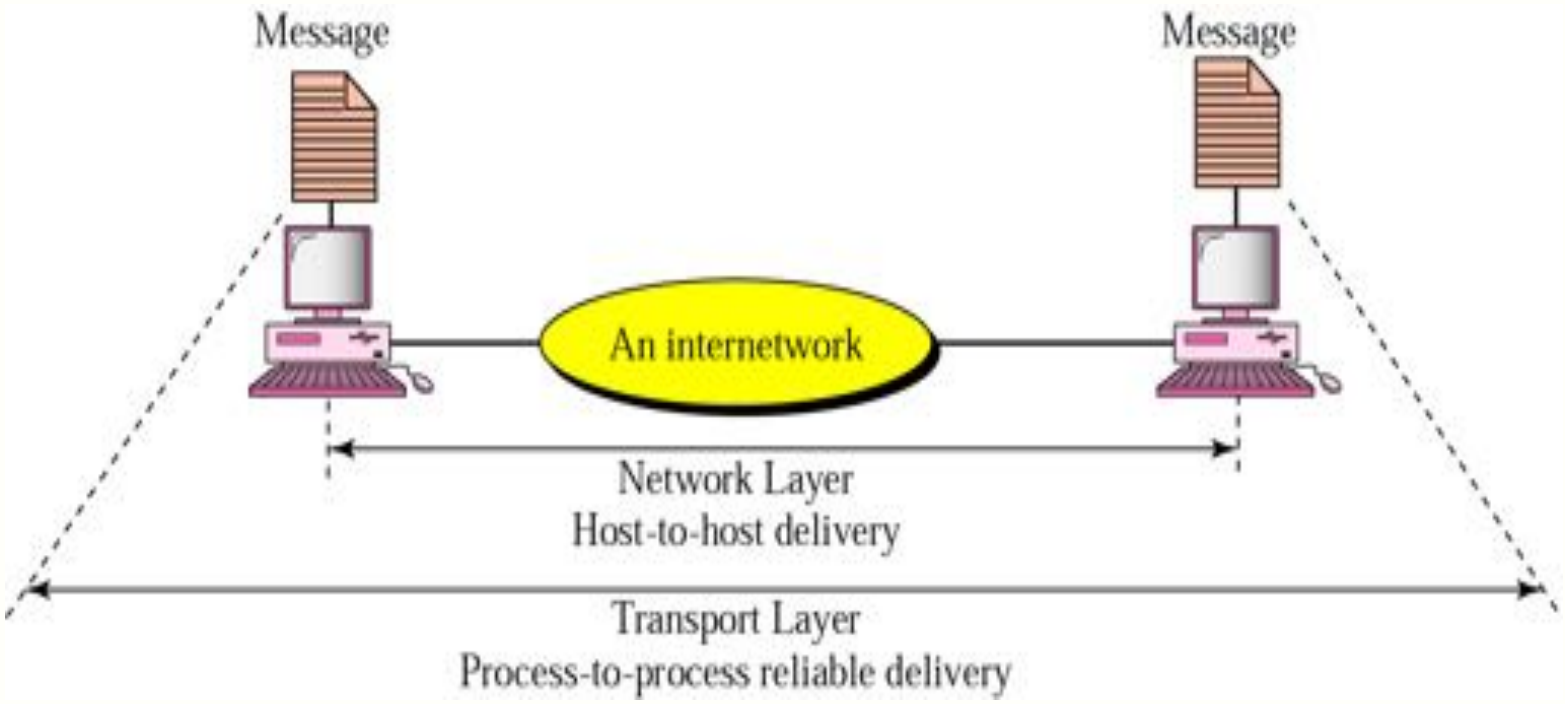
Network Layer

- Determines routes from source to destination.
- Send messages hop by hop to the destination.
- Control of congestion
- Address mapping
- Interconnection of heterogeneous networks
  - Hides differences of various networks such as length of packets
- Examples: IP/ARP/ICMP



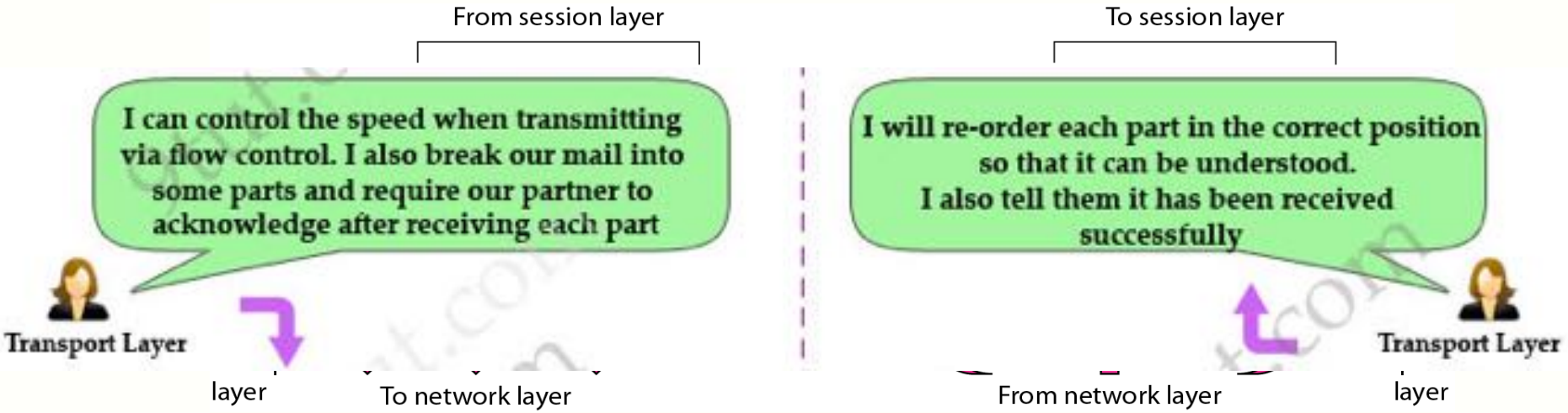
Transport Layer

- The transport layer is responsible for the delivery of a message from one process to another. (process-to-process delivery, a process is an application program running on a host)



Transport Layer

- Accepts data from session layer, splits it into smaller units, and passes information to network layer.
- Ensures pieces all arrive correctly at receiver and reassembles them into the original order.
- Flow control between source and destination.

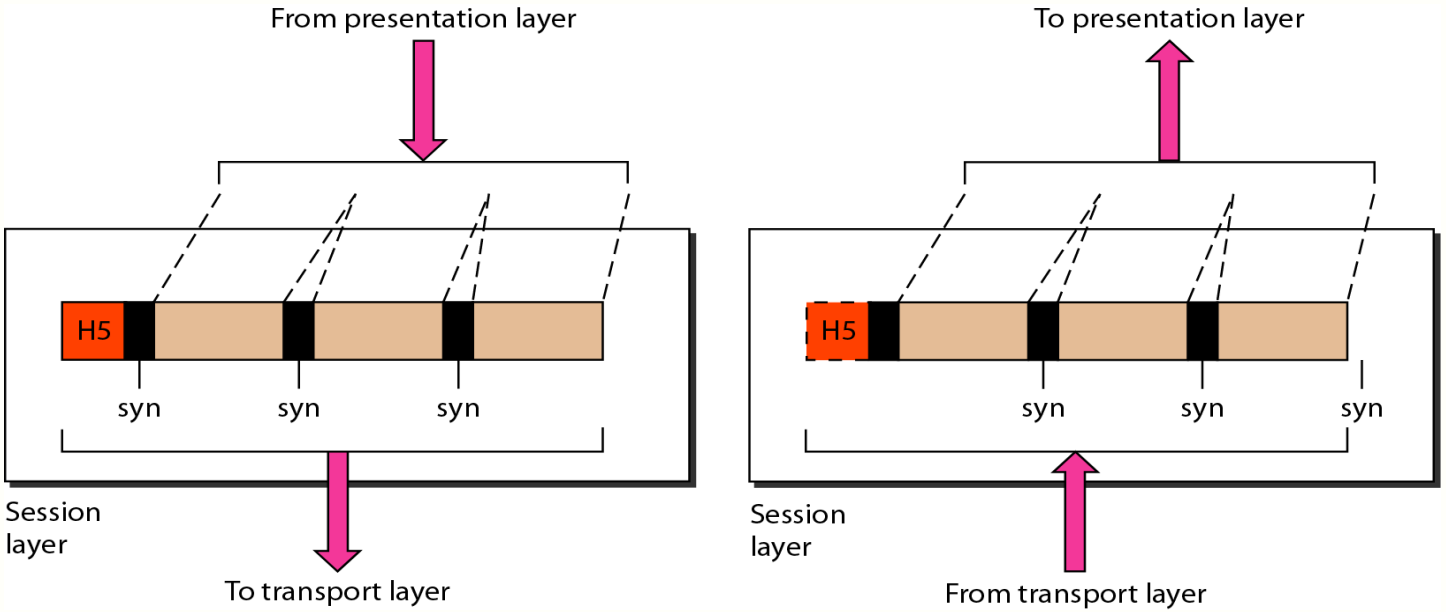


Transport Layer (cont.)

- Connection management
  - Establish and delete connections.
  - Might establish multiple connections for a high throughput application.
  - May multiplex several transport connections onto the same network connection.
- True end-to-end layer.
  - At this layer, the program on the source machine carries on a conversation with a similar program on the destination machine.
  - Examples: TCP and UDP

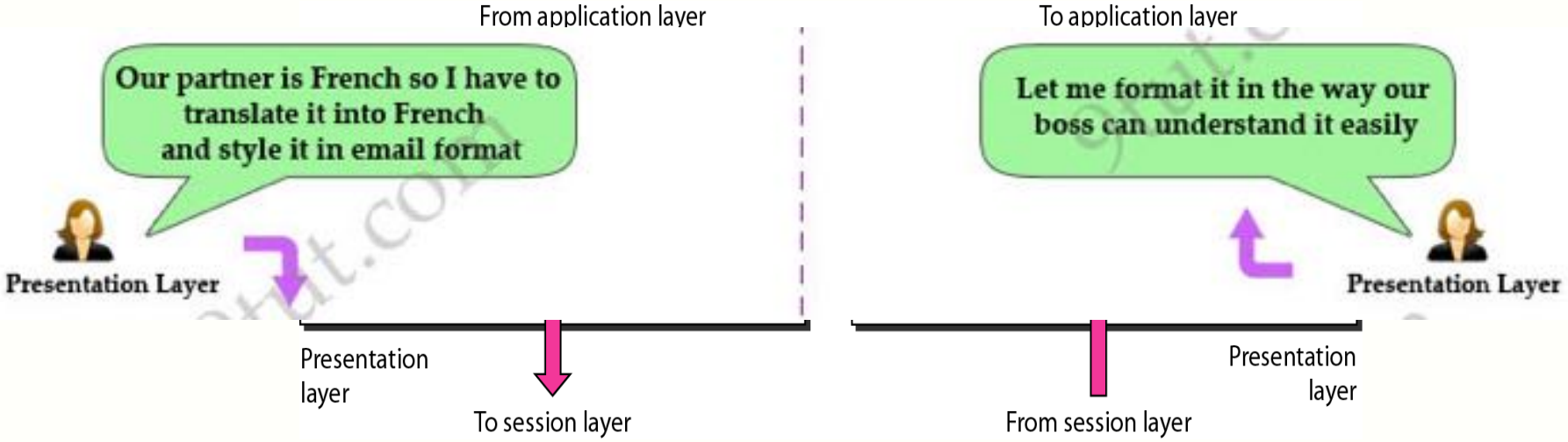
Session Layer

- Session layer is responsible for dialog control and synchronization.
  - Allows applications on two different computers to establish a session or logical connection.
  - May coordinate the process by determining when each is to send or listen (synchronisation).
  - Used in some applications, such as remote login, remote file transfer



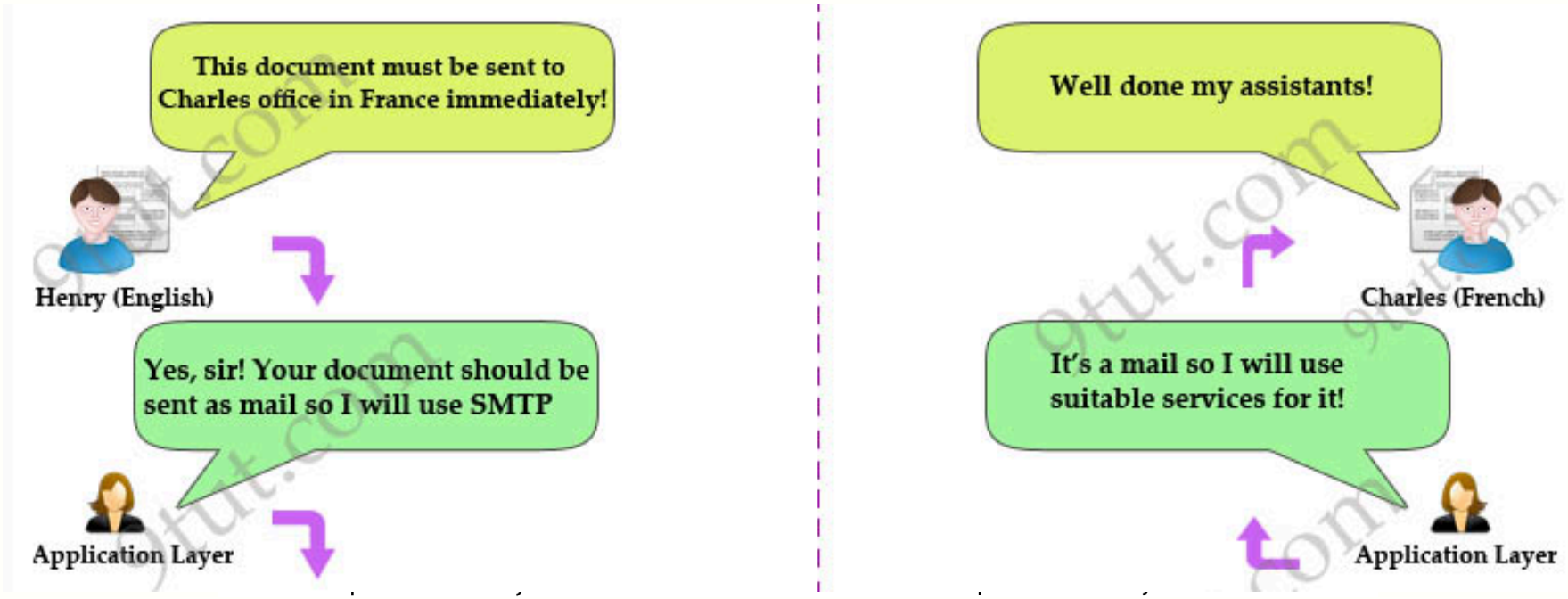
Presentation Layer

- The presentation layer is responsible for translation, compression, and encryption
  - Responsible for presenting data in a format its user can understand. (Hides character encoding differences, Translates data formats, such as EBCDIC and ASCII)
  - Concerned with the syntax and semantics of the information transmitted.

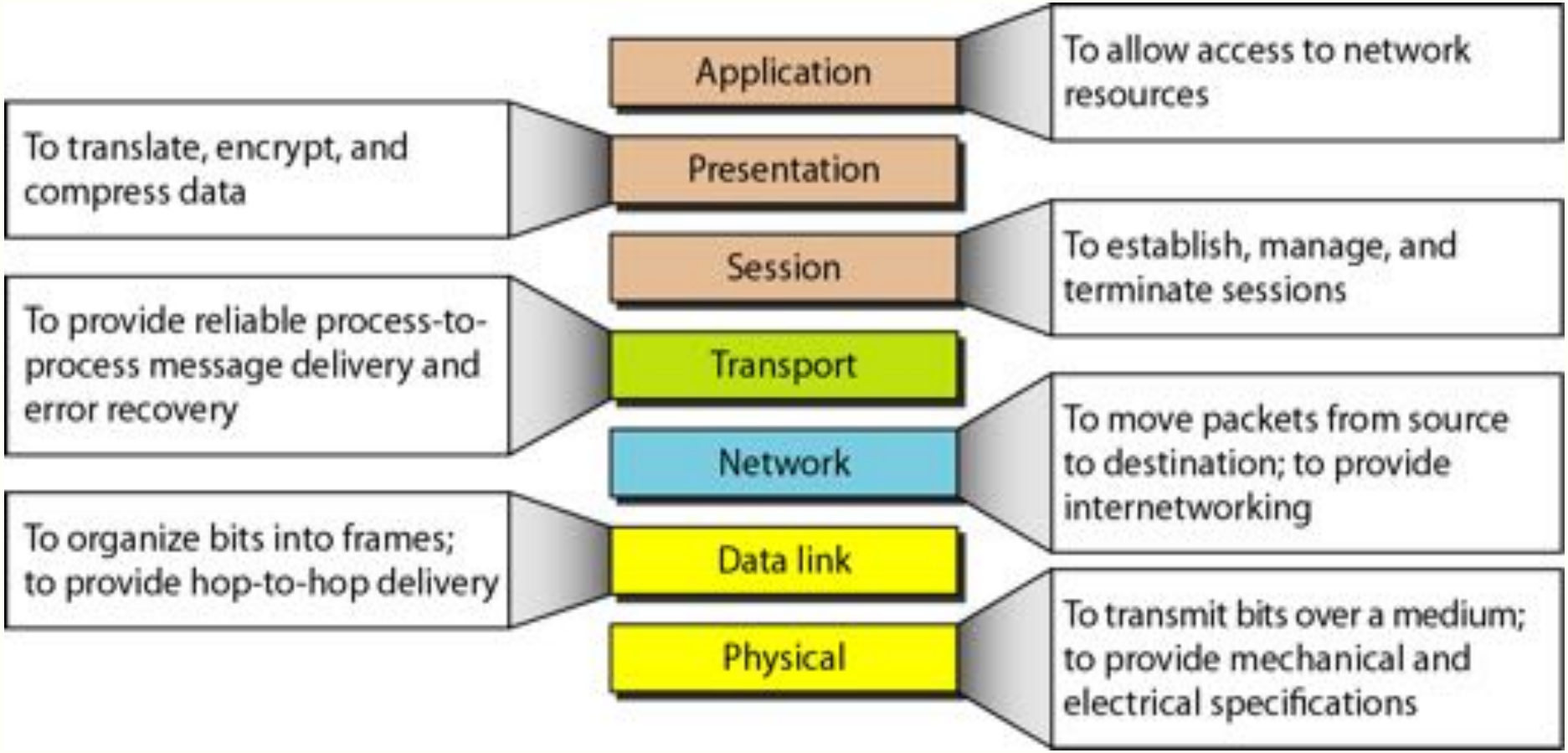


Application Layer

- Application layer is responsible for providing services to the user.
  - Communicates with the user or application programs.
  - Provides services and protocols for electronic mail, file transfers, virtual terminal. E.g. FTP, HTTP, SMTP/POP3/IMAP (email)



Summary of Layers

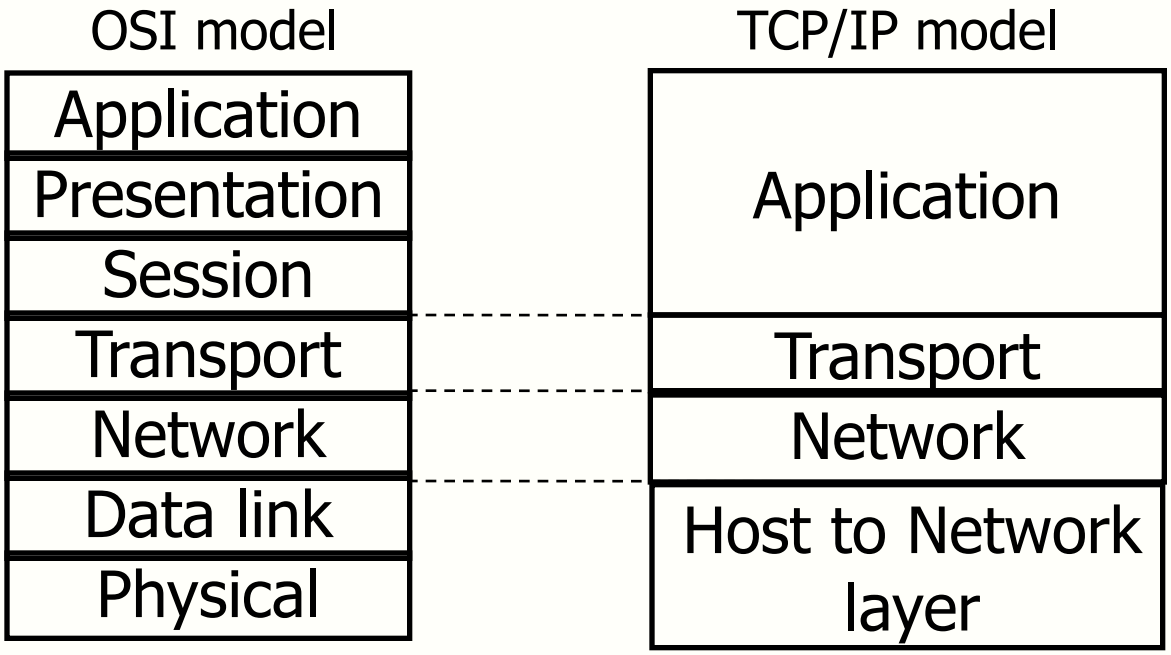


Summary of Layers

Data	7	**Application Layer** Type of communication: E-mail, file transfer, client/server.
Data	6	**Presentation Layer** Encryption, data conversion: ASCII to EBCDIC, BCD to binary, etc.
Data	5	**Session Layer** Starts, stops session. Maintains order.
Segment	4	**Transport Layer** Ensures delivery of entire file or message.
Packet	3	**Network Layer** Routes data to different LANs and WANs based on network address.
Frame	2	**Data Link (MAC) Layer** Transmits packets from node to node based on station address.
Bits	1	**Physical Layer** Electrical signals and cabling.

OSI Model (cont.)

- OSI model is just a guideline for protocol design, not the actual protocols
- Not all layers are always used: Internet uses only four layers
- Some layers may be combined together
  - Top three layers are normally combined into one layer



Standards Organisations

- ANSI: American National Standards Institute
  - FDDI: Fiber Distributed Data Interface
  - ASCII
- ITU: International Telecommunications Union, formerly called CCITT
  - X.25, protocol in ATM
- EIA: Electronic Industries Association
  - RS-232, RS-449
- IEEE: Institute of Electrical and Electronic Engineers
  - LAN standards, such as Ethernet

Standards Organisations (cont.)

- ISO: International Organization for Standization
  - OSI model
- IETF: Internet Engineering Task Force
  - Internet protocols, IP, IPv6
- IBM: International Business Machines
  - System Network Architecture
- IEC: International Electrotechnical Commission
  - JPEG
- Others

Summary

- Computer network
  - LAN, WAN
- Network topologies
  - Star, ring, bus, fully connected, combined
- Layered protocols
  - Components - service, interface, protocol
- OSI model concepts
  - Physical layer, Data link layer, Network layer, Transport layer, Session layer, Presentation layer, Application layer