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Network Models

Introduction to Computing and Web Technologies

Aims and Objectives

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- In this section we will look at Network Models in detail focussing on:
  - Layered architecture
  - Encapsulation
  - Peer-to-Peer Processes
  - TCP/IP protocol suite

Layer based Communication

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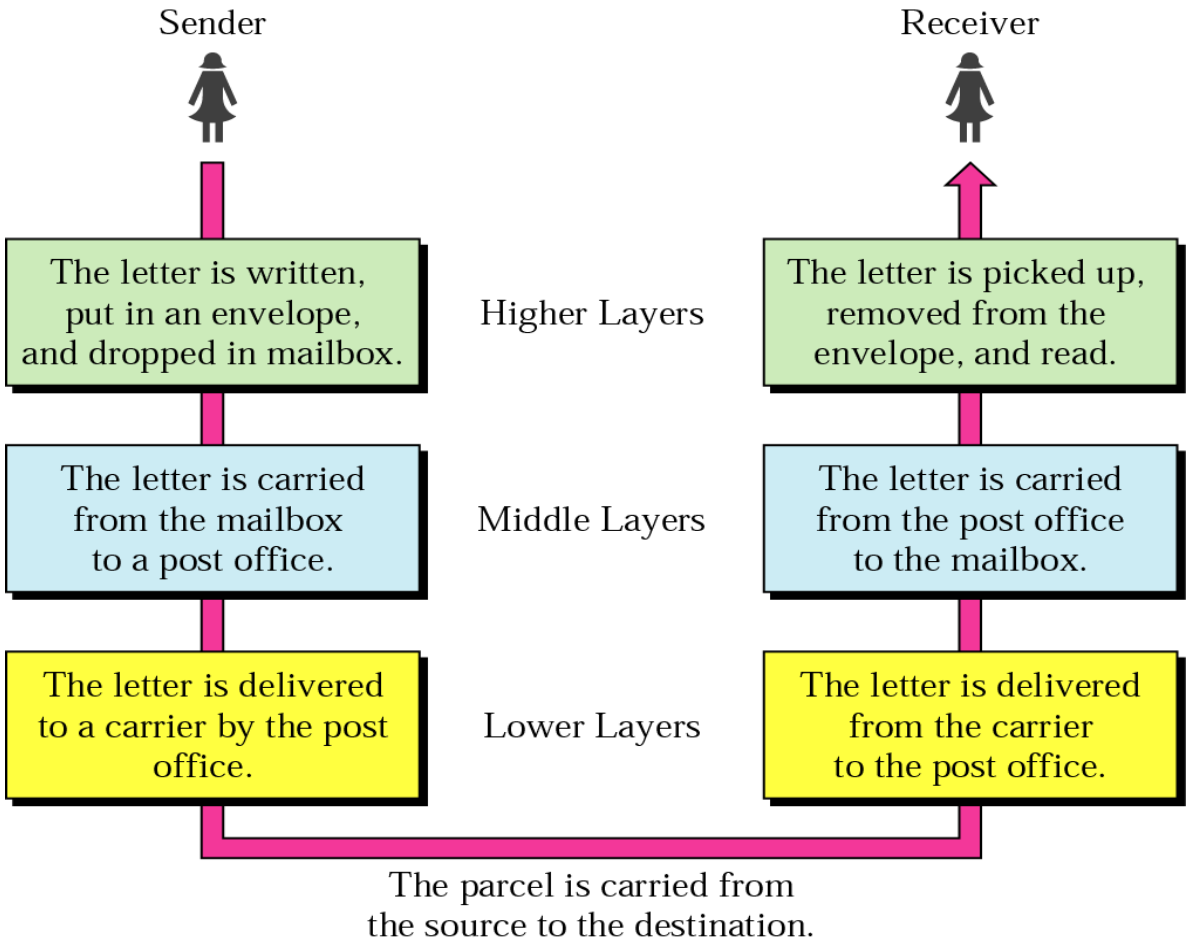
- How two people communicate using a letter ?



Layer-based Communication

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- The process of sending a letter is divided in smaller actions/services
- Each service corresponds to a layer
- Each layer at the sending/receiving site uses the service of the layer immediately below it.
- The lowest layer uses the services of the carrier.
- There is also a relationship between corresponding processes on the sender and receiver. One is the opposite of the other and they communicate using a protocol.

Layer-based Communication

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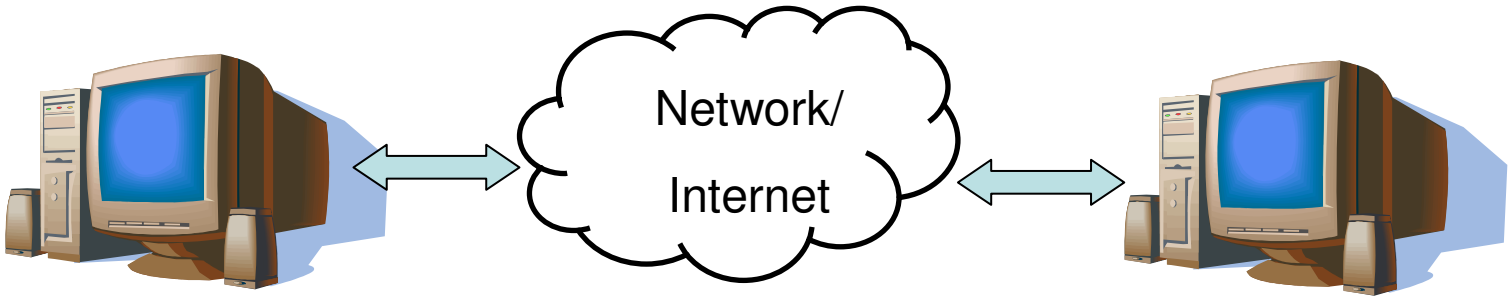
- How computers communicate?
- Computers exchange data though packets that consist of bits (e.g. 0110011…)



Layer-based Communication

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- The Layered Architecture involves dividing the network into layers
- Advantages:
  - It breaks network communication into smaller, simpler parts and easier to understand
  - It standardises network components to allow multiple-vendor development and support.
  - It allows different types of network hardware and software to communicate with each other.
  - It prevents changes in one layer from affecting the other layers, so that they can develop more quickly.
- We will discuss two layered architectures:
  - Internet Model
  - OSI Model

Internet Model

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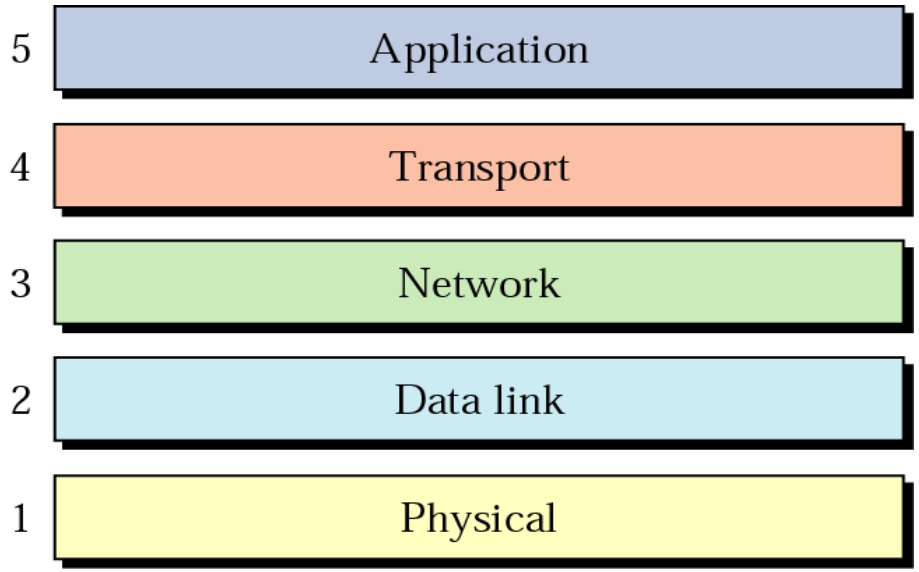

- 5 Layers are used for communication
- Layer 3: also known as the Internet Protocol (IP) layer

Internet Model

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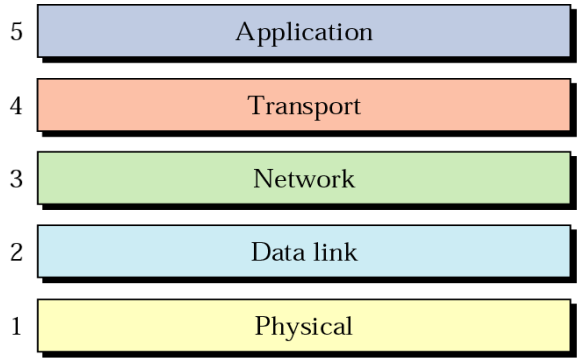
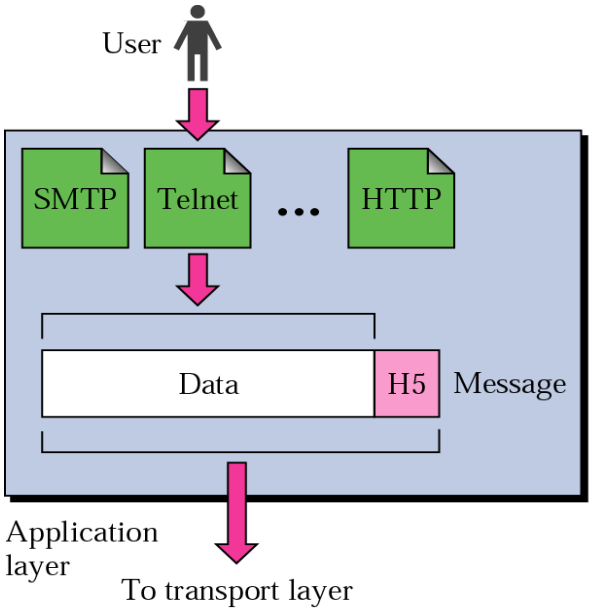
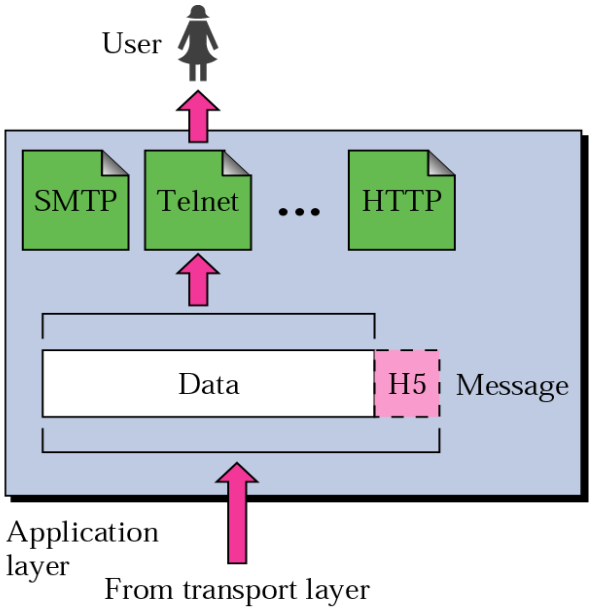
- Application Layer
  - enables the user to access the network provides user interfaces and support for services such as
    - e-mail
    - remote file access and transfer
    - shared database management
    - access to the World Wide Web







Internet Model

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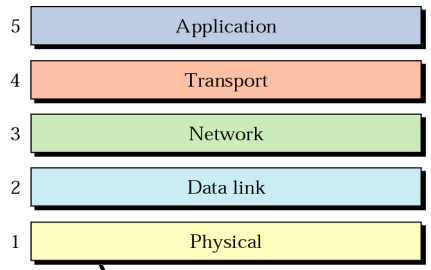
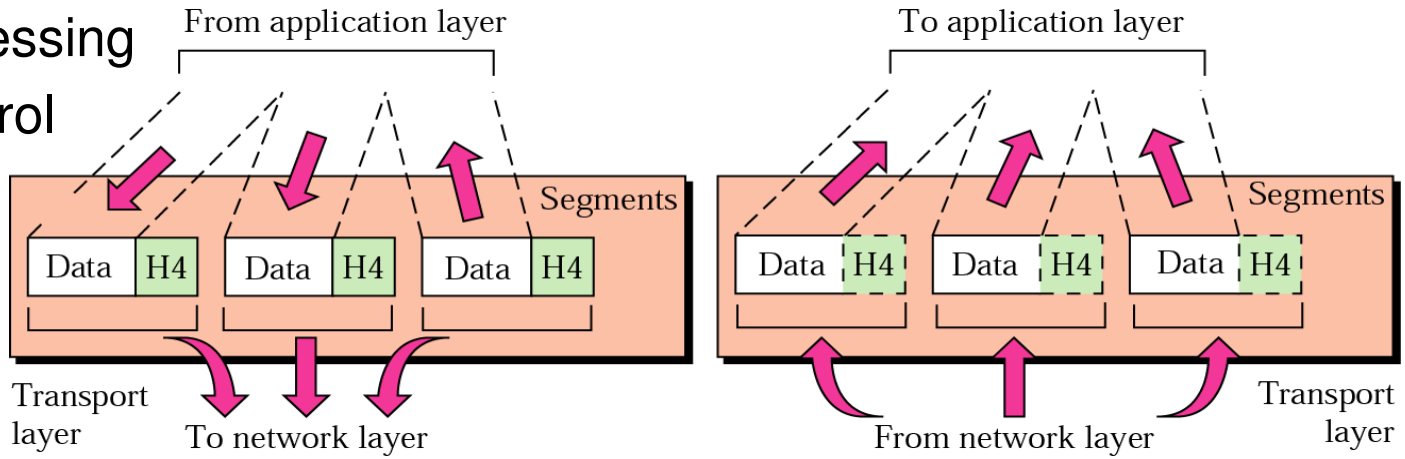


- Transport Layer
  - provides the flow of data for the application layer between two computers
  - responsible for process-to-process (apps- to-apps) delivery of the entire message
  - Specific responsibilities include:
    - Connection control
    - Segmentation and reassembly
    - Port addressing
    - Error control



Internet Model

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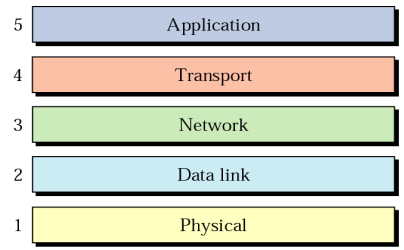
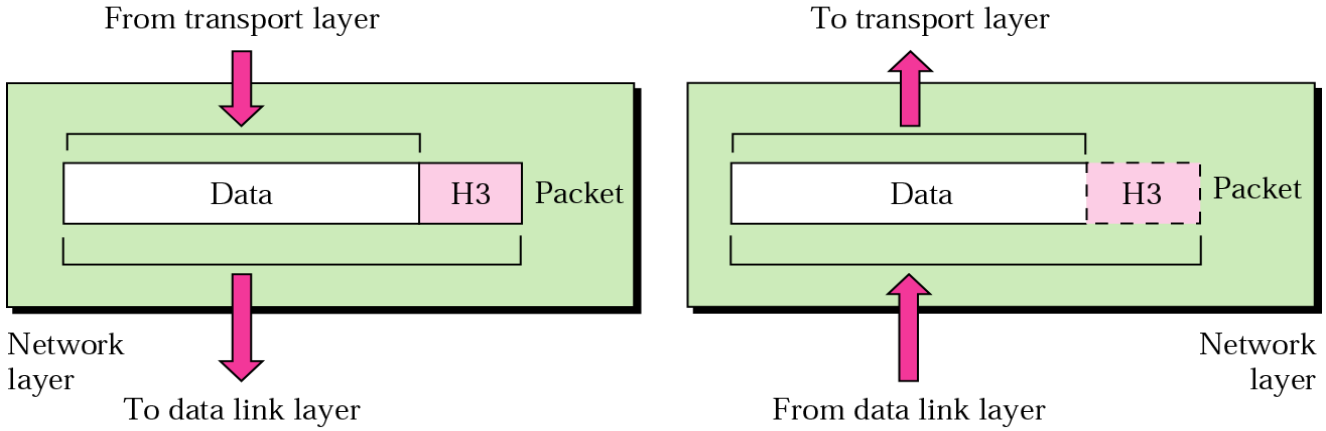
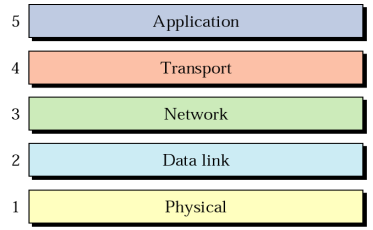
- Network Layer
  - Handles the movement of packets (source-to-destination) across the network.



  - Specific responsibilities of the network layer include the following:
    - Source-to-destination delivery
    - Addressing
    - Routing



Internet Model



- Data Link Layer
  - handles all the hardware details of physically interfacing with the cable (or whatever type of media is being used, e.g. optical fiber, radio link).
  - accepts a data unit from the third layer and adds meaningful bits (e.g. information control, addresses). A data unit with this additional information is a called frame.
  - Specific responsibility of the data link layer include the following:
    - Framing (bits are put into units called frames)
    - Physical addressing
    - Node to node delivery
    - Flow control

Internet Model

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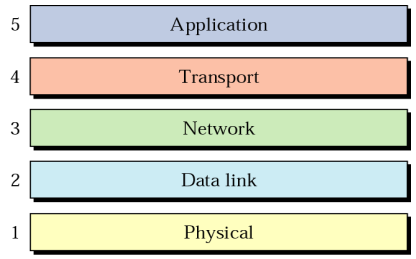

- Physical Layer:
  - Coordinates the functions required to transmit the bits over a physical medium (e.g. cable)
  - Requires a number of considerations:
    - Type of connections (e.g. wired. wireless
    - Direction of data flow (e.g. uni-directional, bi-directional)
    - Medium (co-axial cable, fibre-optic cable))
    - Encoding (How the bits are to be represented)

Internet Model

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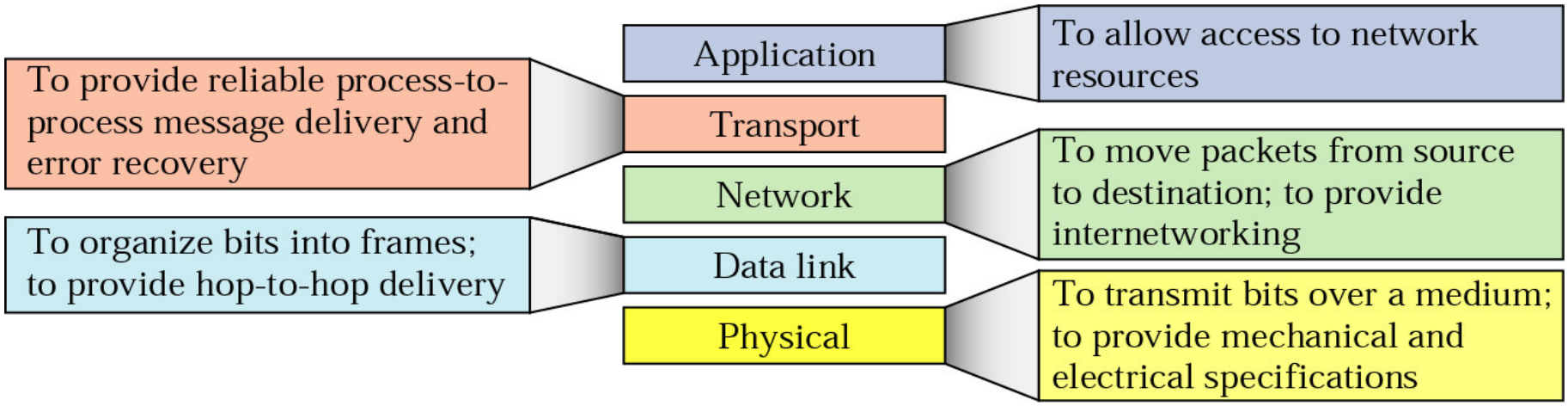
Summary



Peer-to-Peer Communication

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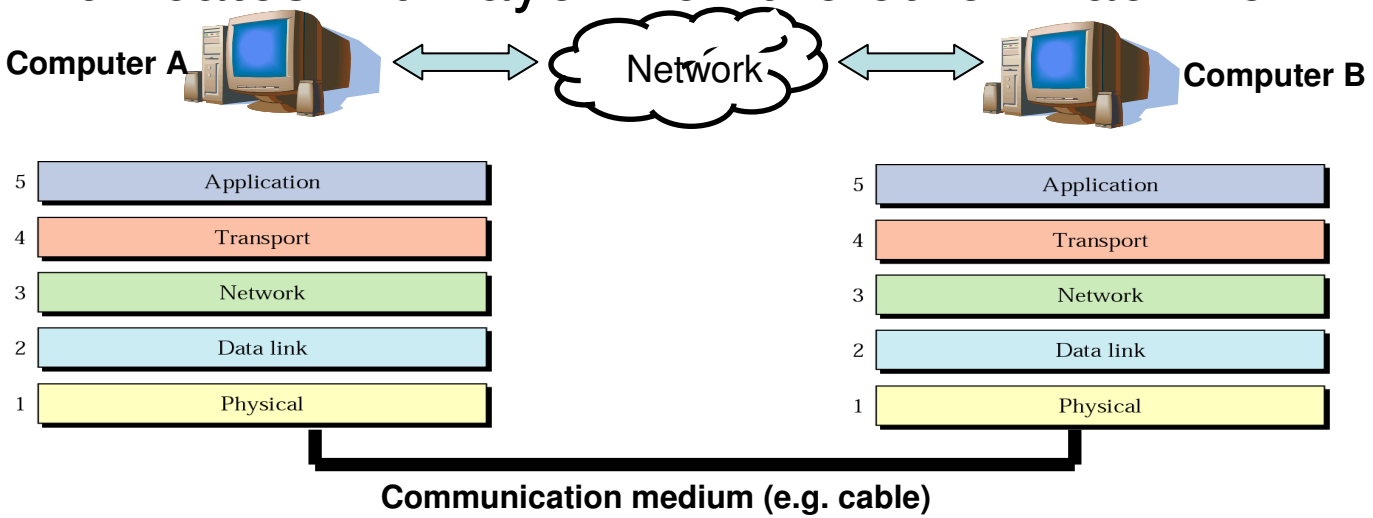
- Application programs on different machines cannot communicate directly.
- Therefore they must communicate indirectly by using the below layers
- Within a single device each layer calls on the services of the layer below it.
- Between computers, layer *x* on one machine communicates with layer *x* on the other machine



Peer-to-Peer Communication

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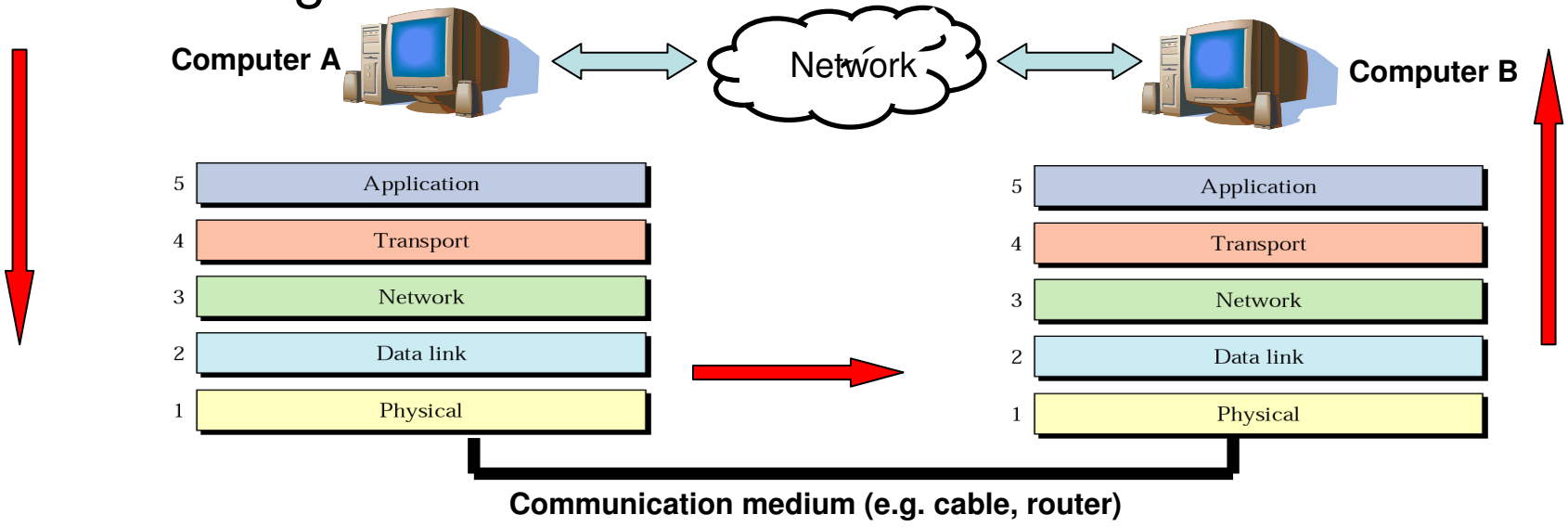
- Communication between computers is a peer-to-peer process using the protocols appropriate to a given layer.
- At the higher layers communication must move down through the layers at computer A and up through the layers at computer B
- Each layer in Computer A adds *control information* to the message in the form of a headers and trailers.



Peer-to-Peer Communication

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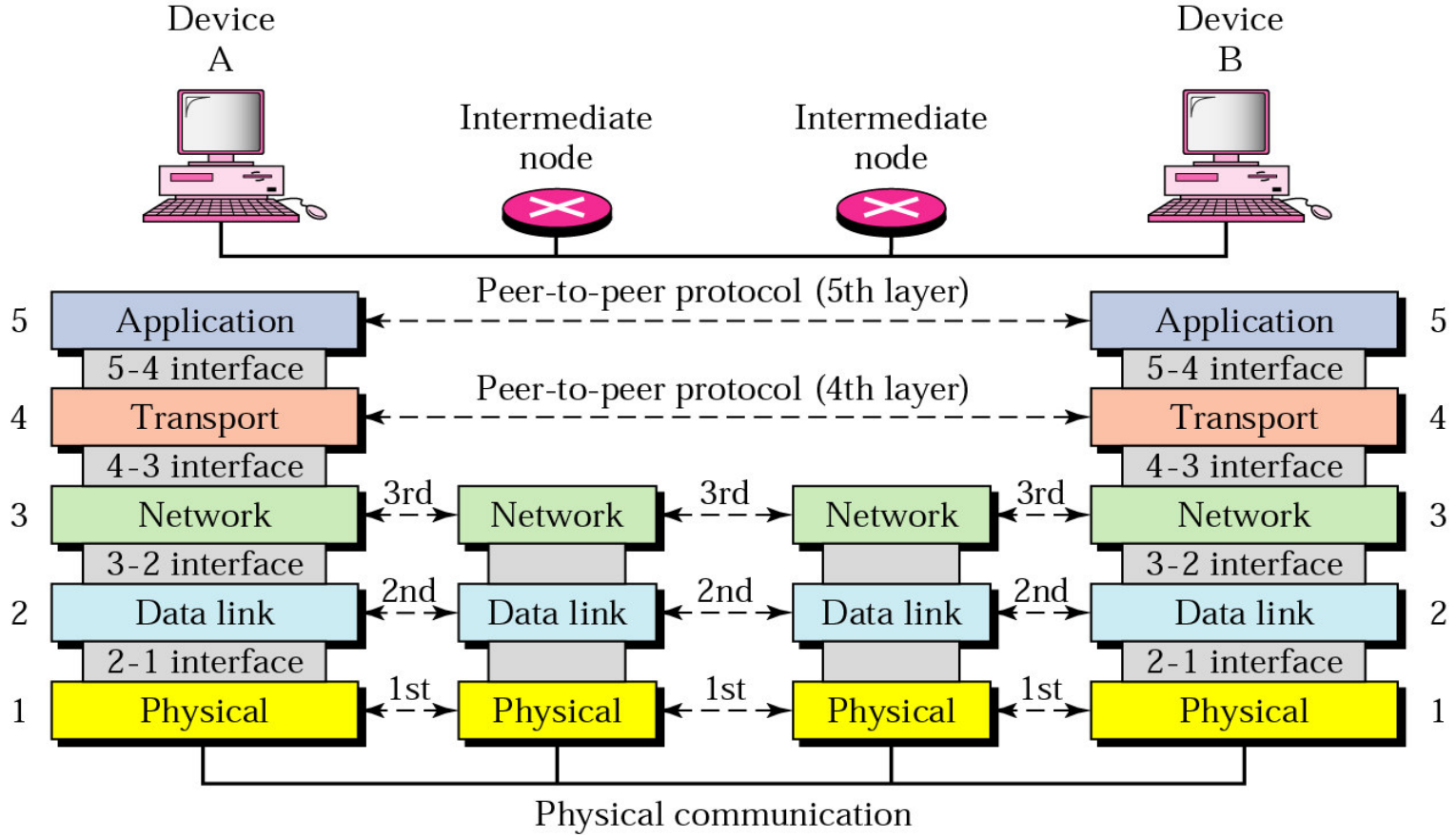
- Example - how a message is sent from over the Internet
- Data may pass through intermediate nodes (e.g. router) that have only the bottom three layers



Peer-to-Peer Communication

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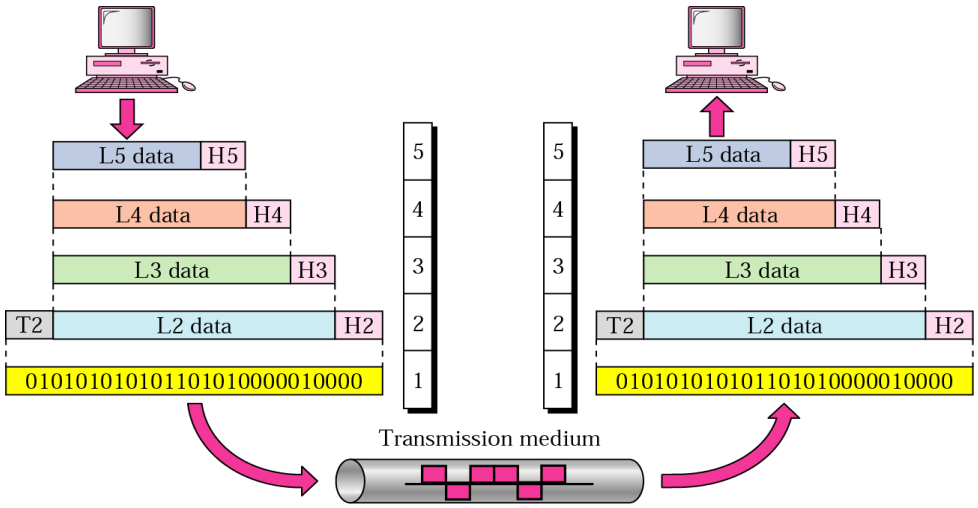
- Control information such as headers and trailers are added to the beginning and end of a message respectively.
  - Headers are added to the message layers at 5,4,3 and 2.
  - A trailer is added at layer 2.
- At the physical layer no header or trailer is added and communication is direct.
- Computer B receives the message and unwraps it layer by layer.

•Each layer receives the message and removes the header and/or footer meant for it.



Layer-based Communication

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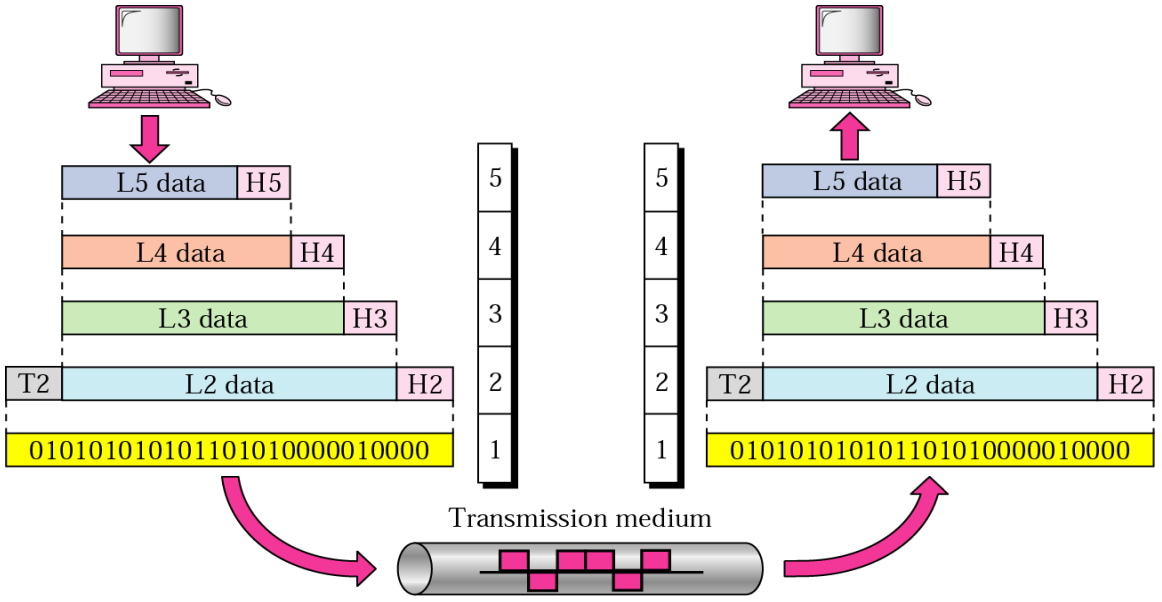
Encapsulation

- When an application sends data, the data is sent down through each layer, until it is sent as a stream of bits across the network.
- Each layer adds extra data by adding 'headers' (and sometimes 'trailers') to the data it receives. This process is called *encapsulation*



Layer-based Communication

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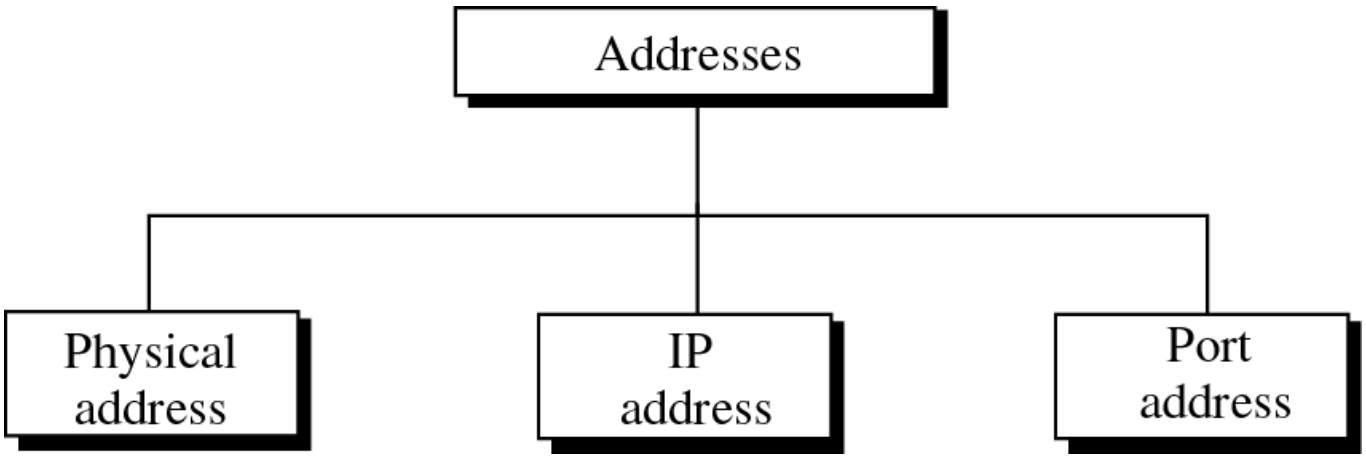
Addressing

- Three different levels of addresses are used in the Internet model:
  - Physical (datalink) addresses (a.k.a. MAC addresses)
  - Logical (network) addresses (a.k.a. IP addresses)
  - Port addresses for inter-process communication



Exercise

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- Open a command prompt (Start-> Run and type in “cmd”)
- Type in *ipconfig* and see do you understand what gets returned.
- Do the same with *ipconfig -all*

Exercise - *ipconfig*

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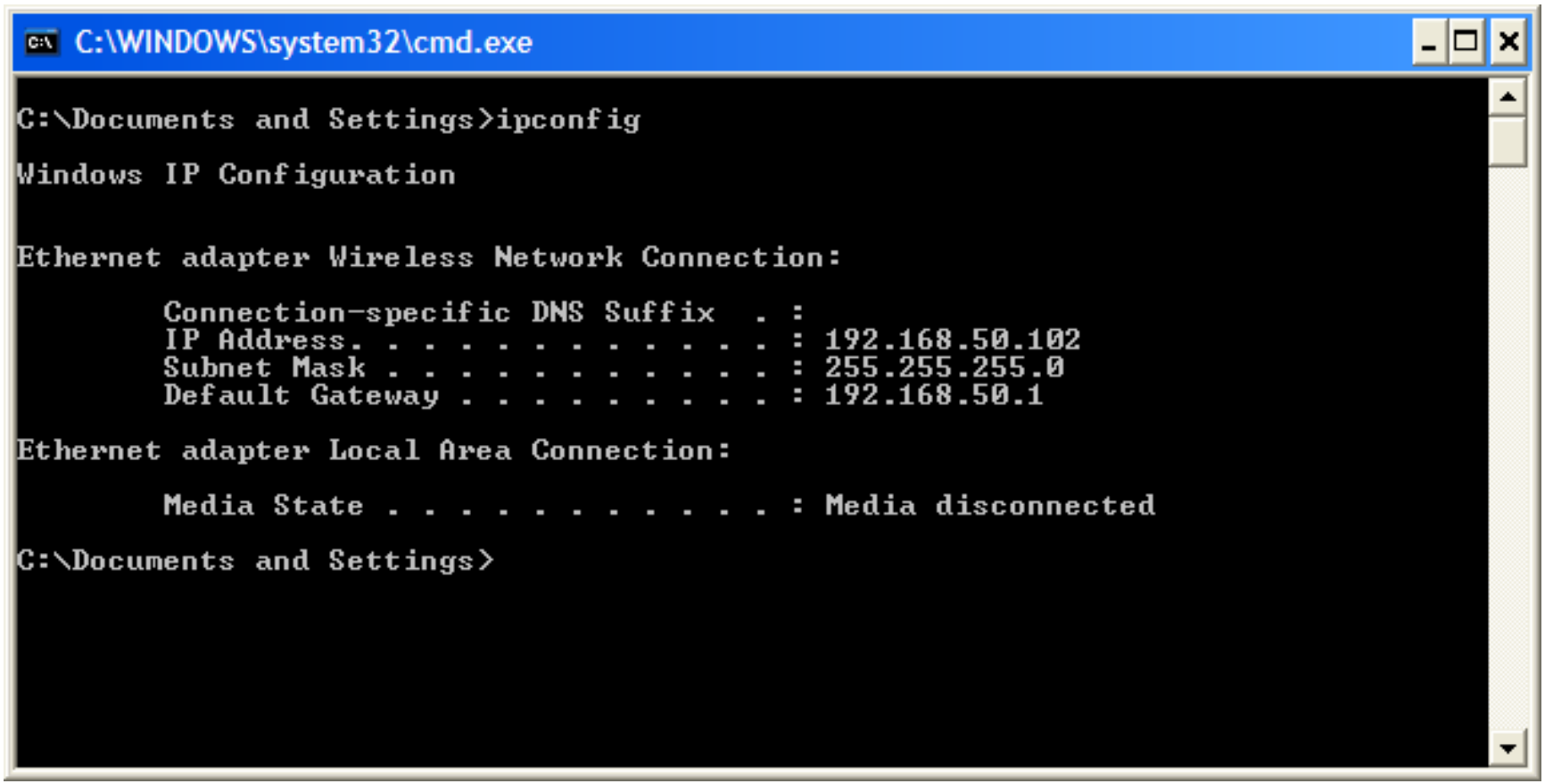

Exercise – *ipconfig -all*

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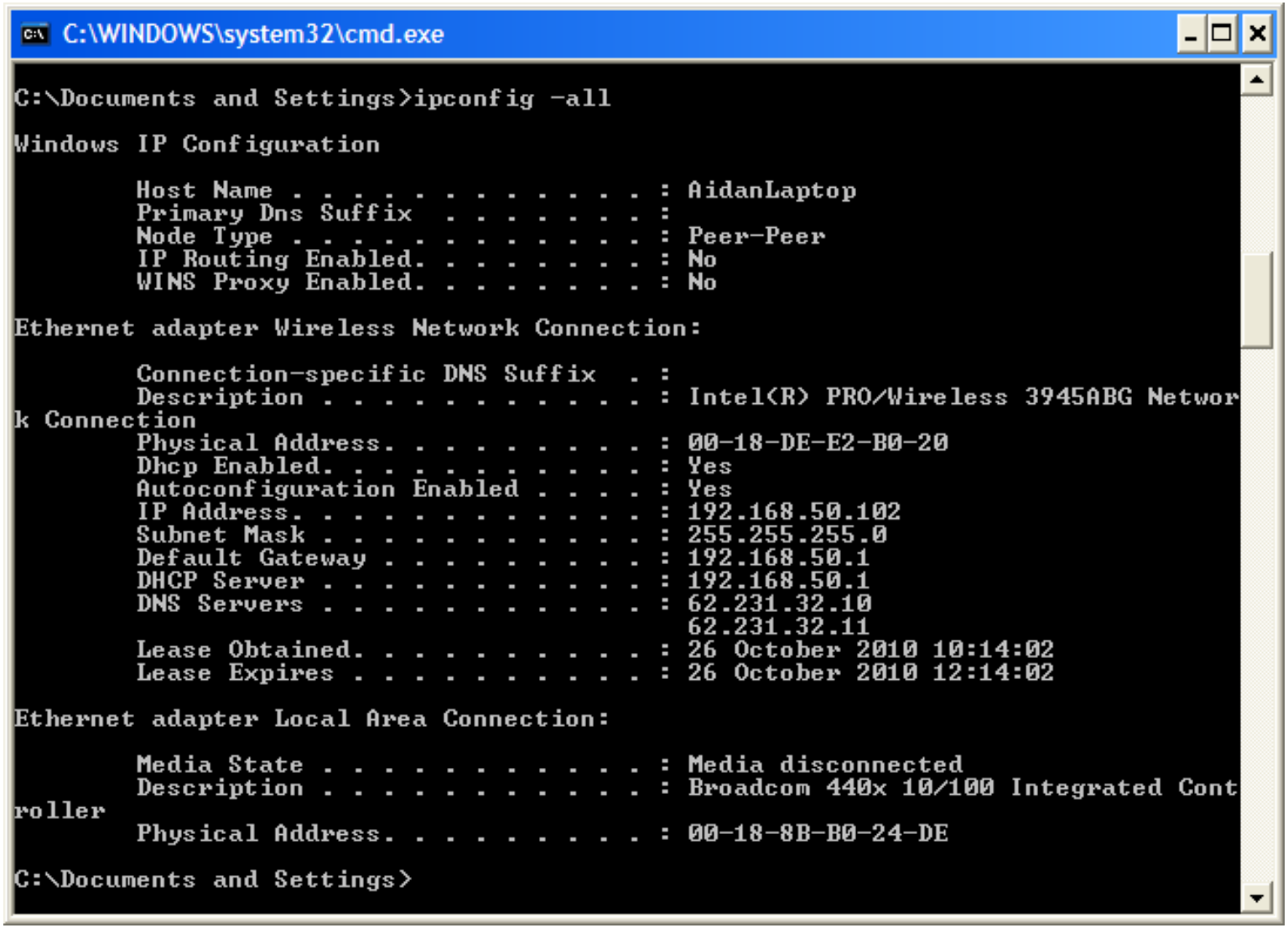

Layer-based Communication

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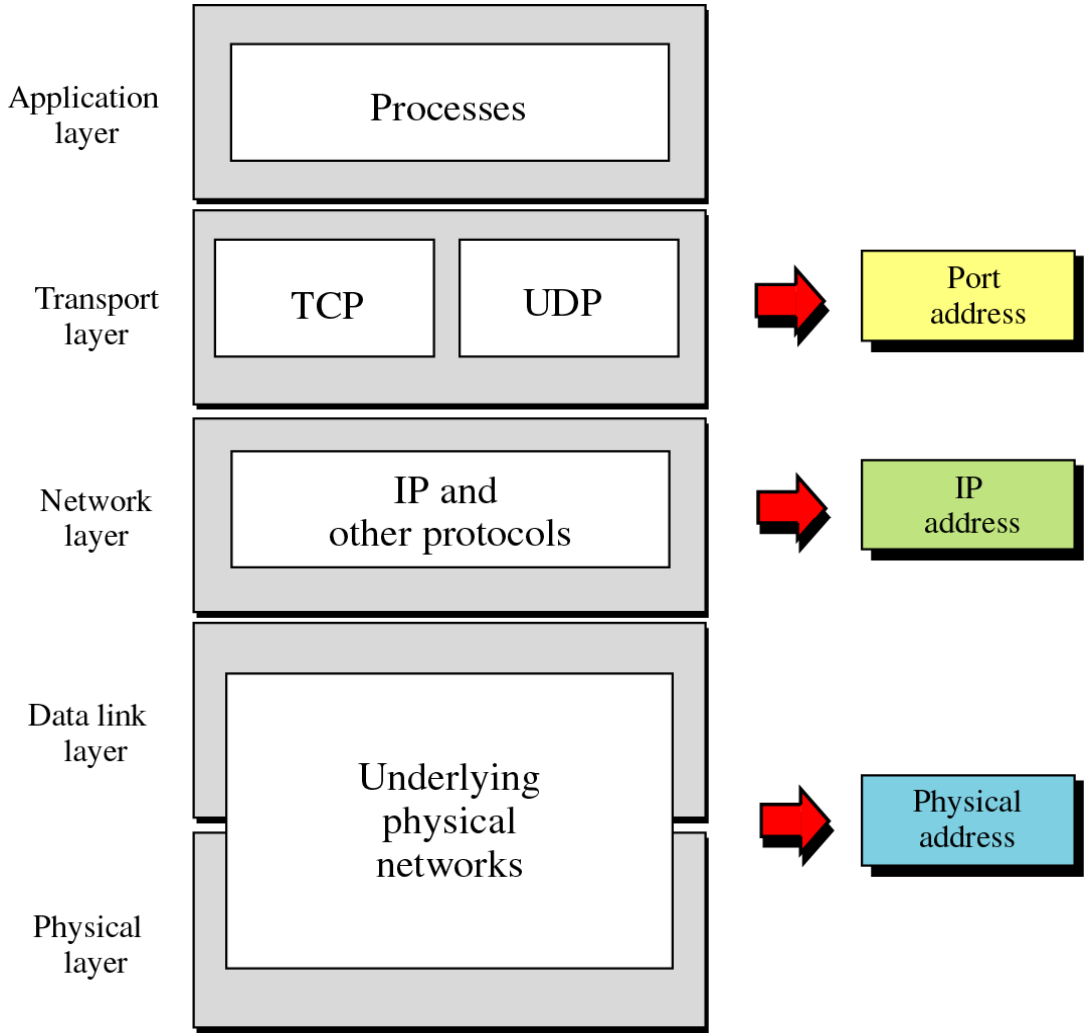
Addressing



OSI Model

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- The layered model that dominated data communications and networking until recently was the Open Systems Interconnection (OSI) model.
- Everyone believed OSI would become the ultimate standard for data communication
- The 5-layered Internet protocol suite has become the dominant commercial architecture because it was used and tested extensively in the Internet.
- It was developed prior to OSI

OSI Model

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ISO

- Established in 1947, the International Standards Organisation (**ISO**) is a multinational body dedicated to worldwide agreement on international standards.

- Open Standards Interconnection (**OSI**) model is an ISO standard that covers all aspects of network communication

The OSI Layered Architecture

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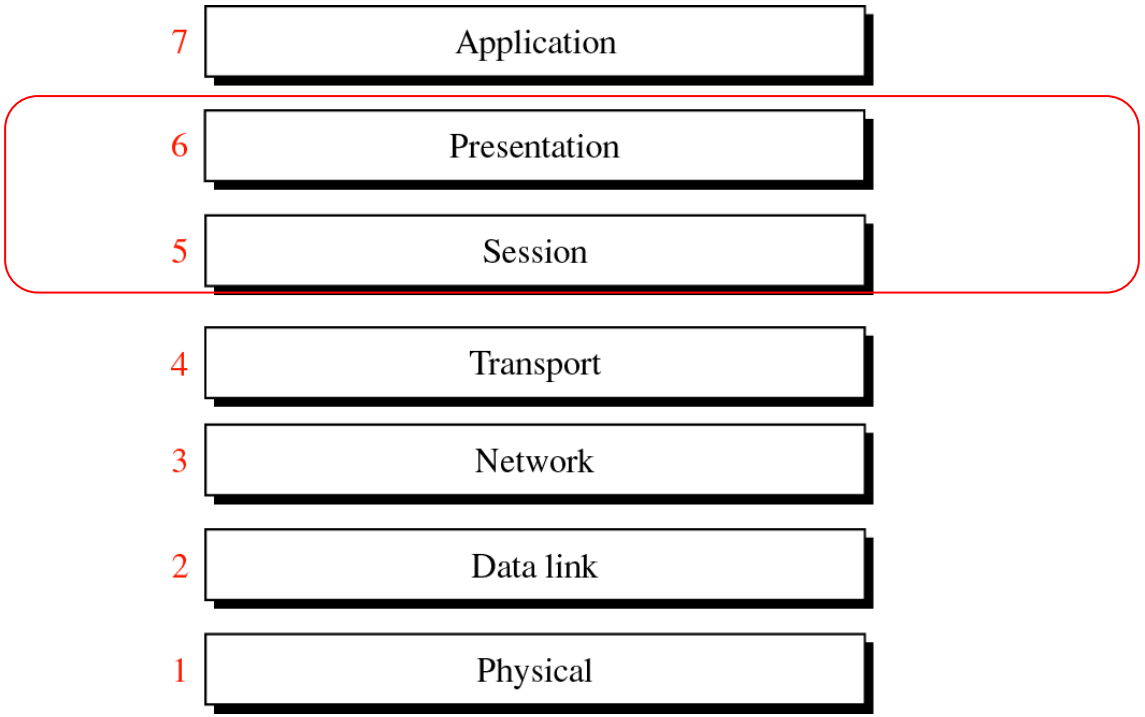

These mnemonics help you to remember the order of the OSI Model layers

Please Do Not Touch Sarah's Pet Alligator

Please Do Not Throw Sausage Pizza Away

The OSI Layered Architecture

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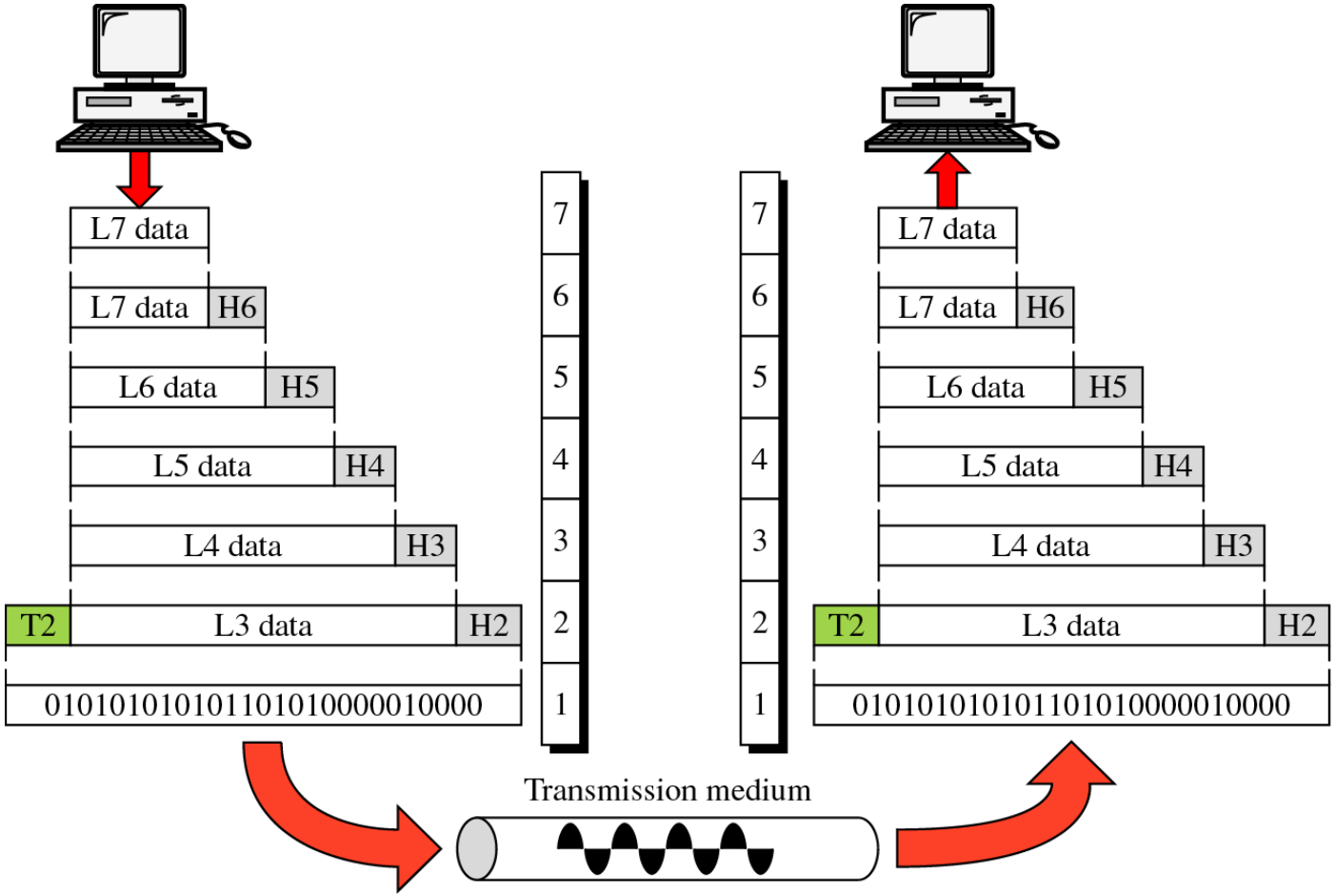
Peer-to-Peer Communications



The OSI Layered Architecture

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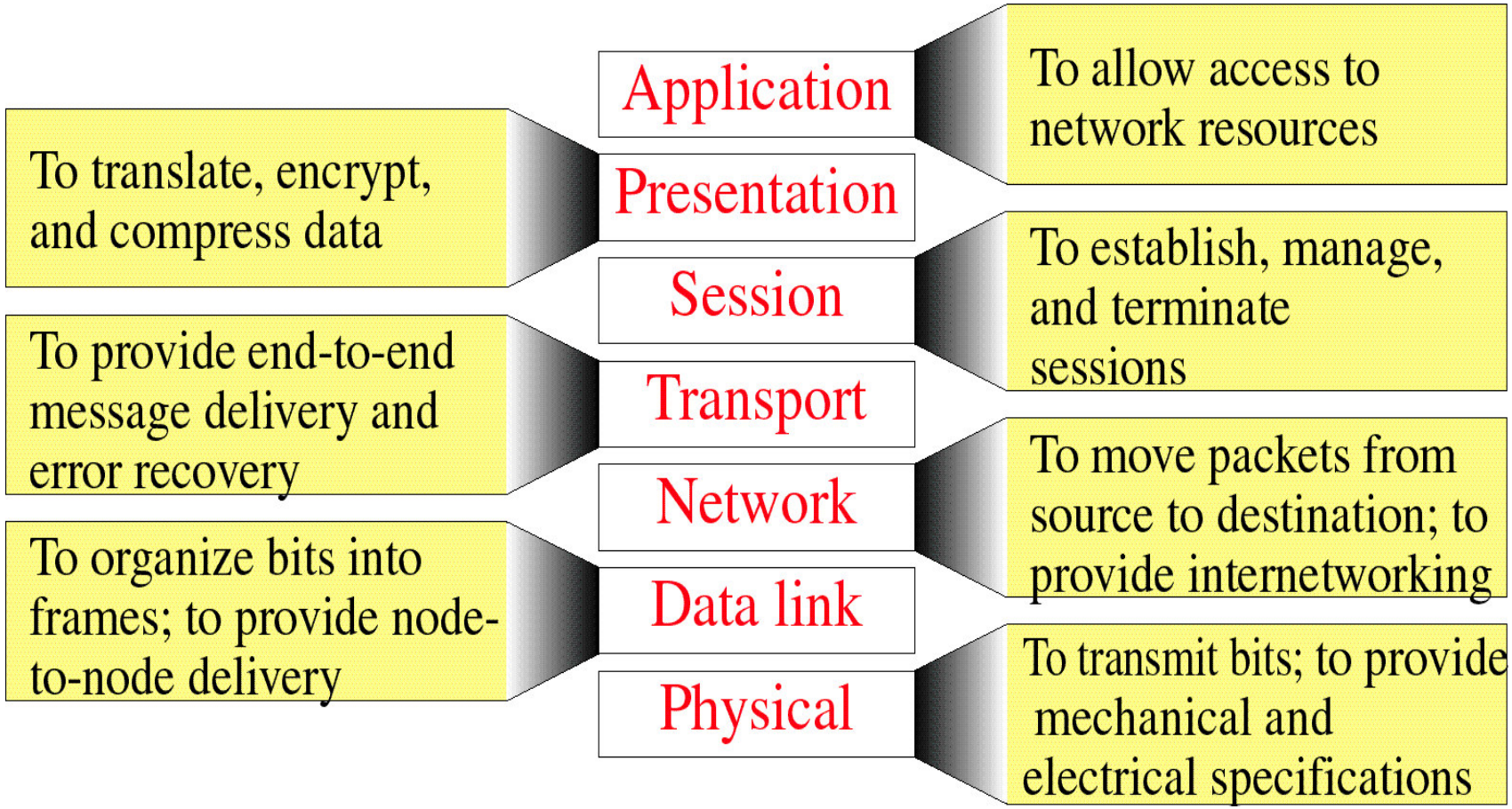
Summary of the OSI Layer Functions



The OSI Layered Architecture

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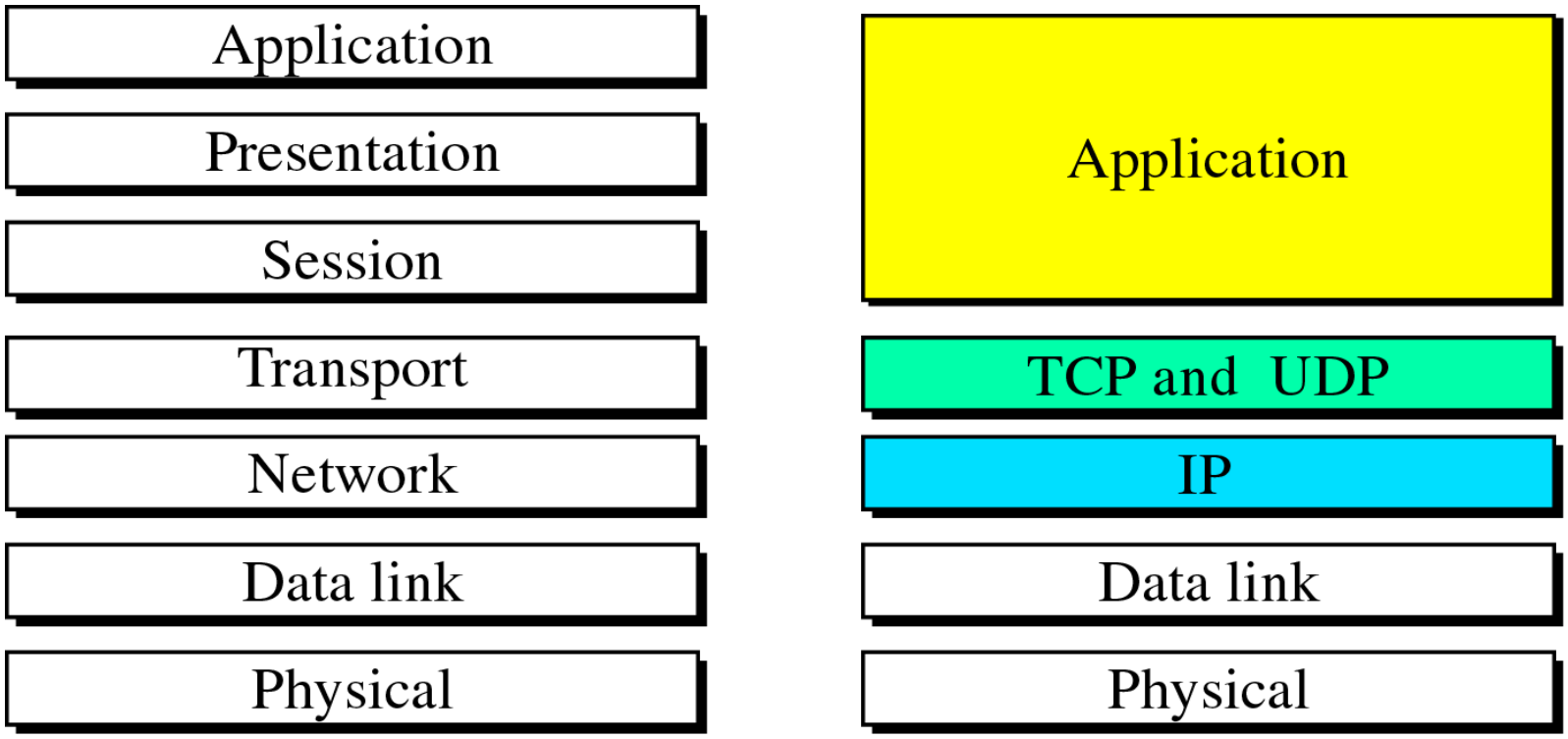
OSI Model vs. Internet Model



Exercises

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- As the data packet moves from the lower layers to the upper layers, headers are _____ Choose your answer.
  - added
  - subtracted
  - rearranged
  - Modified
- The _____ layer changes bits into electrical signals.

- What are some of the advantages to using a layered model to describe networking? Choose all that apply
- During the encapsulation process, what happens to data at layer 1? Choose your answer.
  - It stays in the form of data with some protocol info added to it
  - it is encoded into bits and made ready for transmission
  - it is "put into a packet" and a header is appended containing logical addresses
  - a header is placed on it with source and destination address

- During the encapsulation process, what happens to data at layer 2?

Introduction to TCP/IP

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- Transmission Control Protocol/Internet Protocol (TCP/IP) is a set of protocols, or a protocol suite, that defines how all transmissions are exchanged across the Internet

- TCP/IP is named after its two most popular standards
  - TCP (used on transport layer)
  - IP (used on network layer)

- An internet using TCP/IP acts like a single network connecting many computers of any size or type.
- Internally, the Internet is an interconnection of independent physical networks (such as LANs) linked together by internetworking devices.

Introduction to TCP/IP

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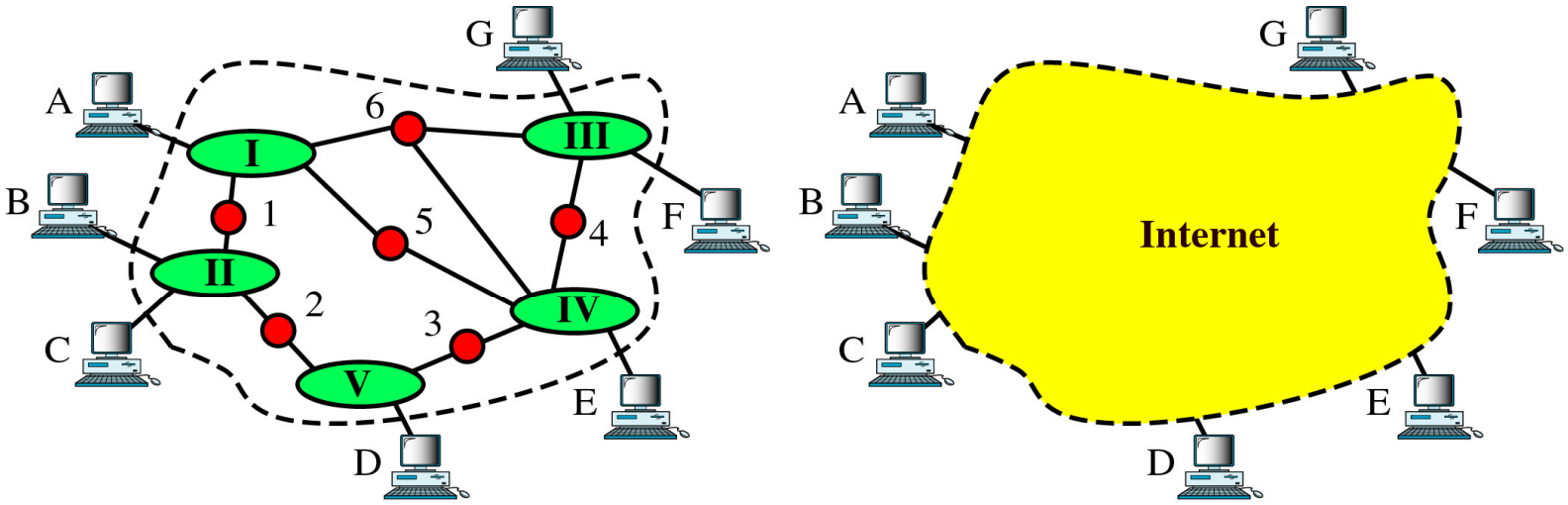

a. An actual internet

b. An internet seen by TCP/IP

TCP/IP protocol suite vs. OSI / Internet Models

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- TCP/IP is a set of protocols, or a protocol suite made up of 4 layers
- Whereas Internet or OSI models specifies which functions belong to each layer TCP/IP contains relatively independent protocols which can be mixed and matched depending on the needs of the system.
- OSI is a theoretical model designed to show how hosts should communicate
- Internet model is more widely used even though it is an older model
- The reason is because of the success of the Internet which uses TCP/IP protocol suite => Internet model = TCP/IP

Comparison of OSI and TCP/IP

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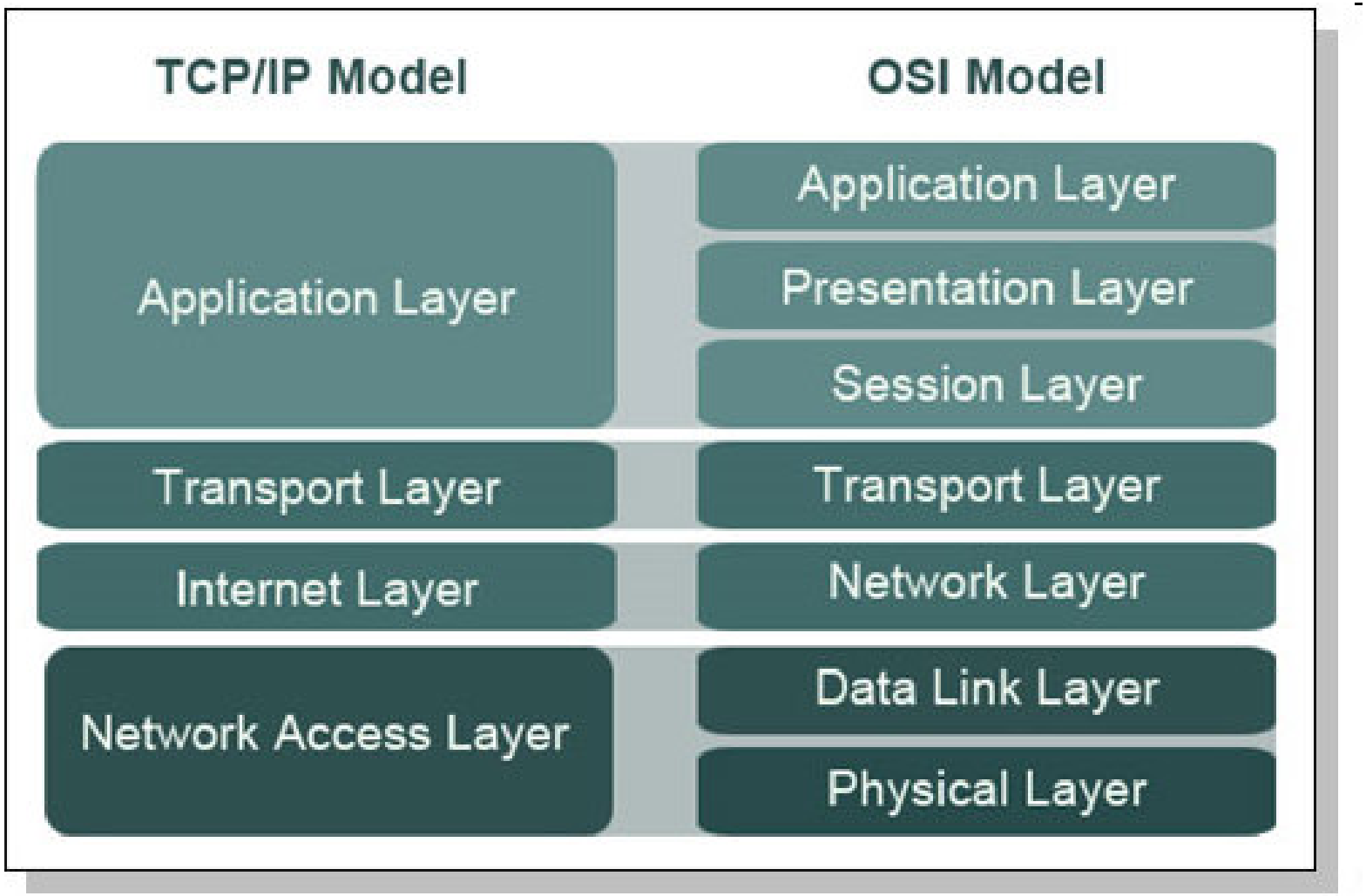

Comparison of OSI and TCP/IP

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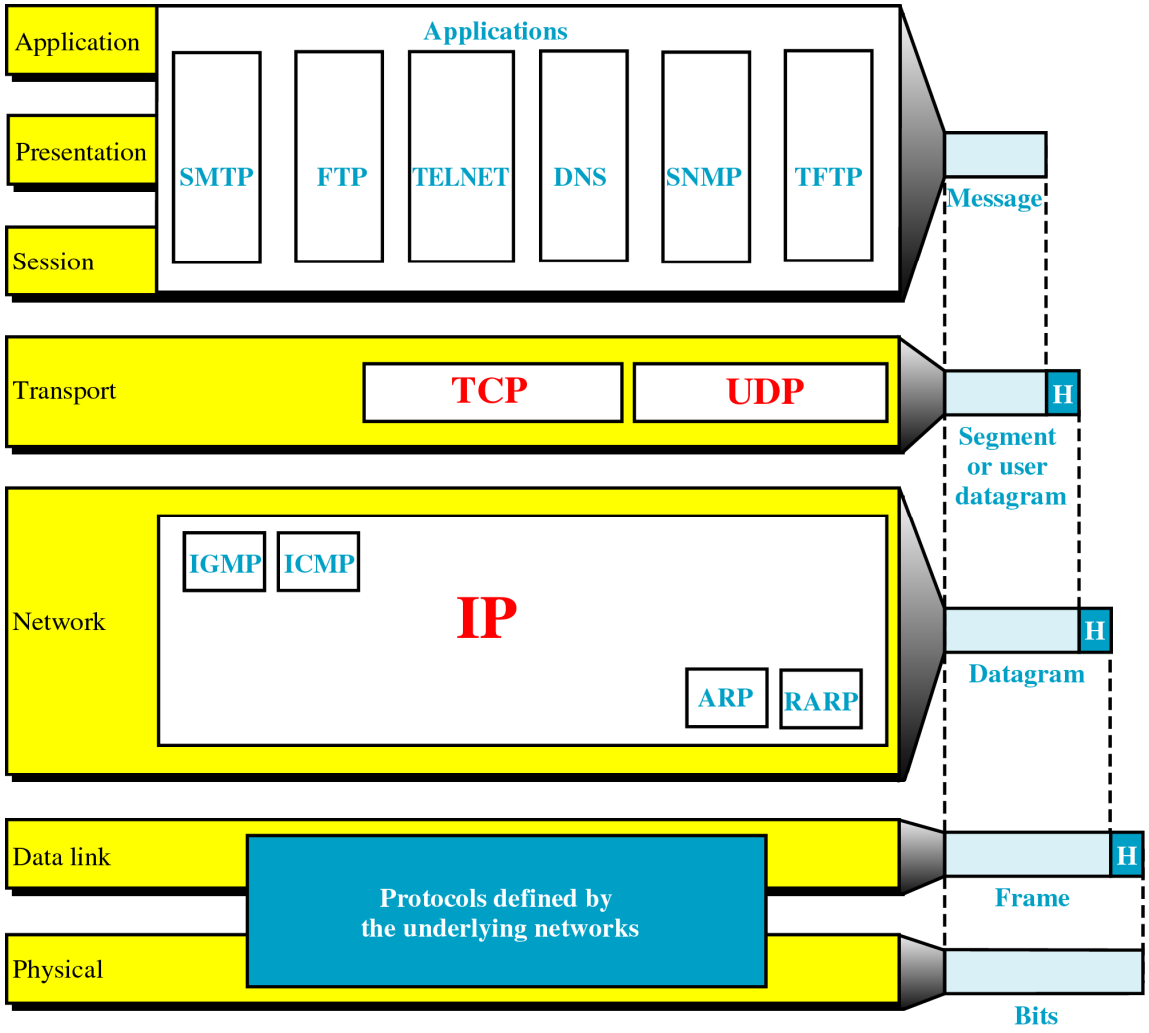

TCP/IP Protocol Suite

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- At the transport layer TCP/IP defines two protocols:
  - TCP
  - User Datagram Protocol (UDP).
- At the network layer (also called Internet layer) the main protocol is
  - Internet Protocol (IP)
  - there are other protocols that support data movement in this layer.
- At the data link and physical layers
  - no specific protocols are defined.
  - Depends on the type of network used eg. Ethernet

Addressing

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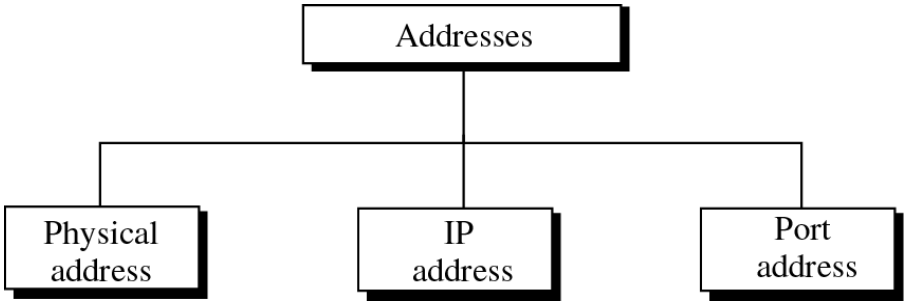
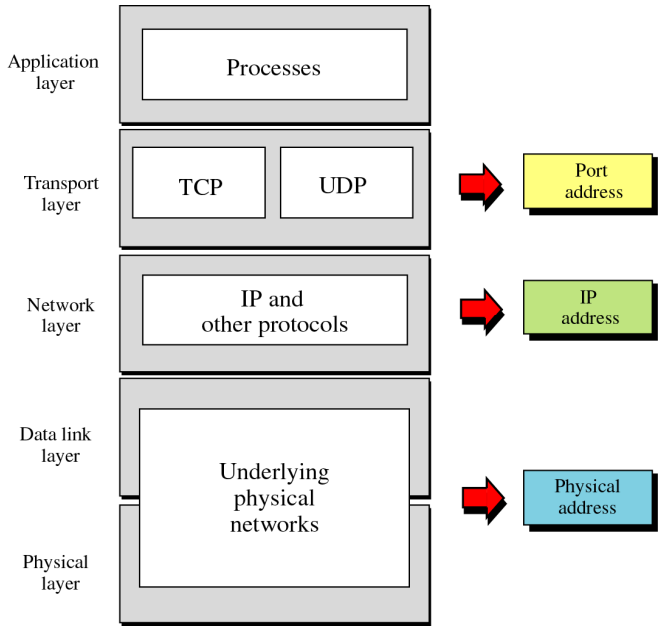
- Three different levels of addresses are used in an internet using the TCP/IP protocols:
  - Physical (link) addresses (MAC addresses)
  - Logical Internetwork addresses (IP addresses)
  - Port addresses for inter-process communication





Addressing

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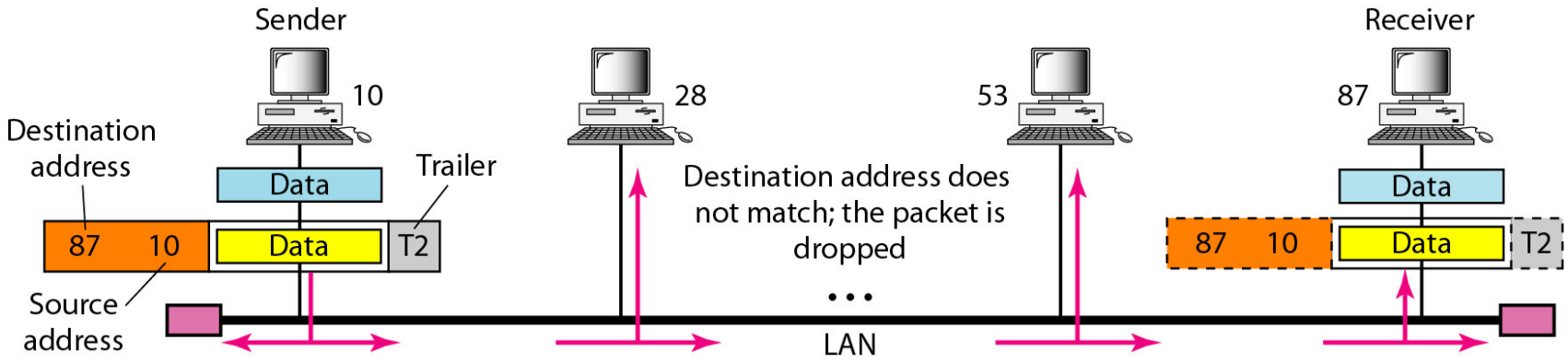
- Physical (MAC) Addressing:
  - Size and format of the address depends on the network type
  - Ethernet uses 6 byte (48 bits) physical address imprinted on the Network Interface card (NIC). E.g.: 07:01:02:01:2C:4B.
  - LocalTalk (Applet) network uses 1-byte dynamic address that changes each time the station comes up



Addressing

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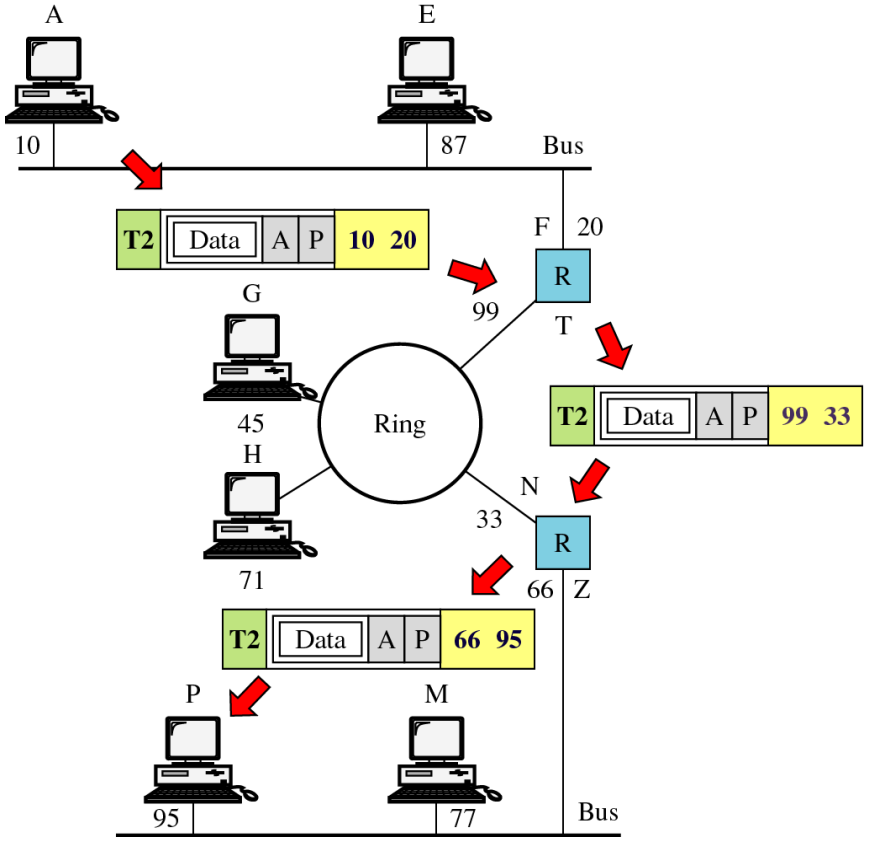
- IP Addressing (logical Address):
  - Independent of the underlying physical network
  - A 32bit address that can uniquely define a host connected to the internet



Addressing

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- Port Addressing:
  - Computers can run multiple processes (applications) at the same time
  - Each process has a label assigned named port address (16 bits in length)
  - Example:
    - **Computer A communicate with Computer B using TELNET application**
    - **In the same time, computer A communicates with Computer B using FTP (File Transfer Protocol) application**

Internet Layer: IP Protocol

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- At the internet layer the IP protocol is used.
- IP, in turn, contains four supporting protocols:
  - ARP, RARP, ICMP and IGMP
- IP is an unreliable and connection-less protocol - a best-effort delivery system.
- IP provides no error checking or tracking.
- If reliability is important then IP must be paired with a reliable protocol such as TCP (on the transport layer)

The Internet Layer: IP Protocol

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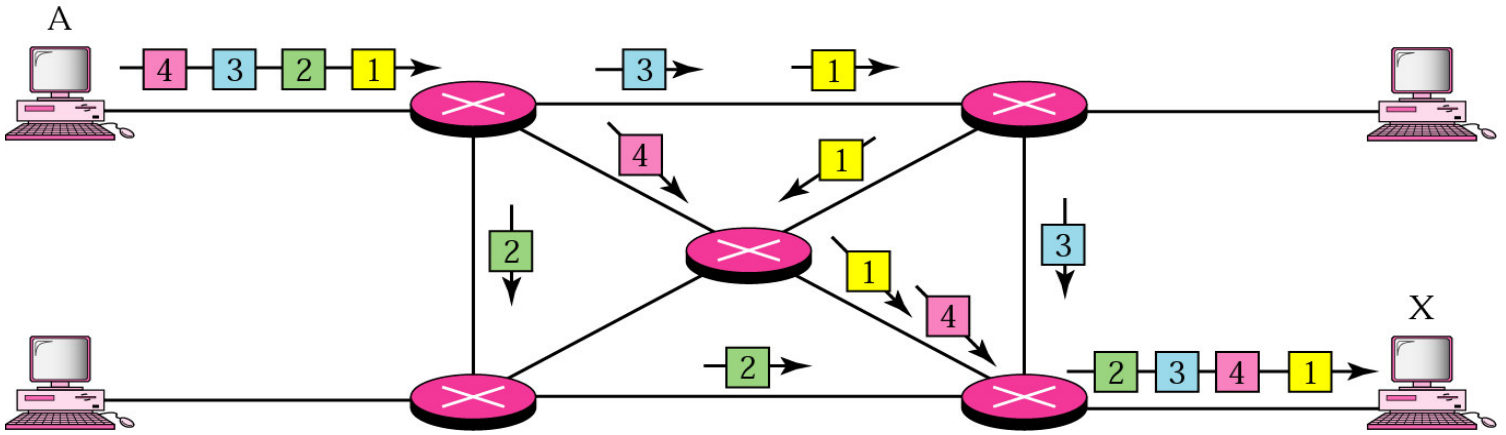
- IP transports data in packets called datagrams, each of which is transported separately.
- Datagrams may travel along different routes and may arrive out of sequence or duplicated.
- IP does not keep track of the routes and has no facility for re-ordering datagrams on arrival
- IP provides bare-bones functionality that frees the user to add only those facilities necessary for a given application and thereby allows for maximum efficiency.



The Internet Layer: IP Protocol

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- A datagram is a variable-length packet (up to 65,536 bytes) consisting of two parts: header and data
- The header part of the datagram
  - can be from 20 to 60 bytes and contains information essential to routing and delivery.
  - identifies the sender of the datagram (source ip address) and the intended recipient of the datagram (destination ip address)

The Internet Layer: IP Protocol

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- IP Datagram