IT 4504
Section 4.0

Network Architectures

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Section 4.1

Introduction to Computer Networks

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Introduction to Computer Networks

- *A **computer network** is a system for communicating between two or more computers and associated devices*
- **A popular example of a computer network is the Internet, which allows millions of users to share information**
- **Computer networks can be classified according to their size:**
  - **Local area network (LAN)**
  - **Metropolitan area network (MAN)**
  - **Wide area network (WAN)**
  - **Personal Area Network (PAN)**

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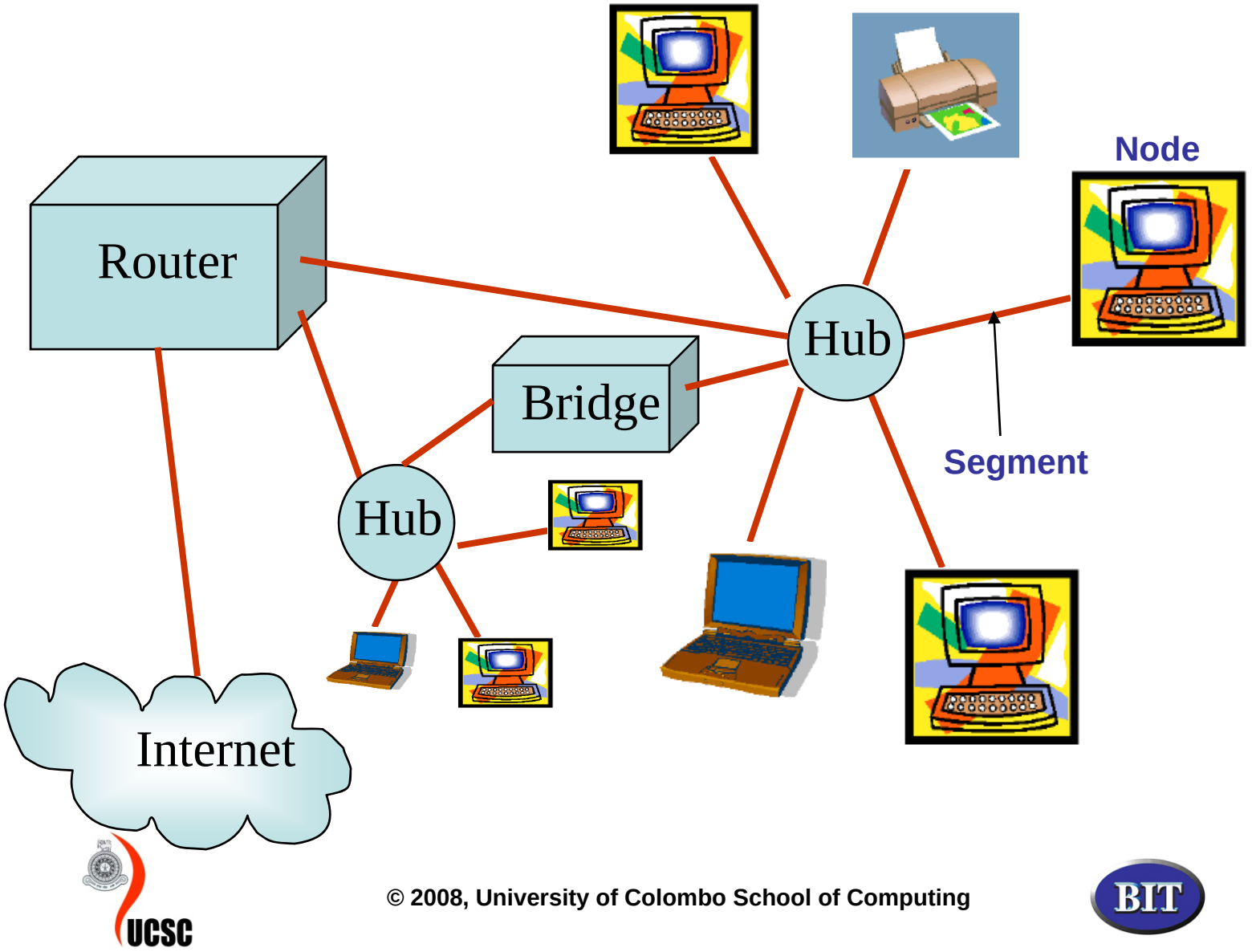
An example of a network



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Section 4.2

Network Topologies: Bus, Star, Ring

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Network Topologies

- A ***network topology*** is the structure or organization of communications that links between hosts or devices on a network.
- LAN topology

  •A LAN is a shared medium that serves many DTEs (data terminal equipment) located in close proximity such as in one building.

  •Three basis topologies associated with LANs: **bus**, **ring**, and **star**
- WAN topology

  • A WAN links networks that are geographically separated by long distance through switches, routers, and/or bridges.

  • Two topologies: **mesh** and **tree**

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Network Topologies (Contd.)

Why Multiple Topologies?

Each has advantages and disadvantages:

Ring – predictable network performance

Star – easier to manage and more robust, but requires more cables

Bus – requires fewer cables

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Network Topologies (Contd.)

- There are two types of LAN topologies:
  - **Logical**
  - **Physical**
- Logical topology is concerned with ***how messages are passed*** from node to node within the network. It corresponds to the media access control (MAC) protocol used in the LAN.
- Two logical LAN topologies exist:

  1) Sequential (or logical ring): data is passed from one node to another in a ring-like sequence

  Token passing in token ring and FDDI LANs are examples

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Network Topologies (Contd.)

2) **Broadcast**: nodes transmit frames/packets to all other nodes in the network; only the intended recipient processes the entire frame/packet

Ethernet LANs use a logical broadcast topology

- Physical LAN topology refers to the ***physical layout of the network***

- The way in which the communication is configured and how nodes attach to the network.

- Because the focus is on physical connections among hardware component, physical topologies correspond to the physical layer of the OSI reference model.

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Bus Topology

- In a classic bus topology, the medium consists of a ***single wire*** or cable (backbone) to which other nodes are ***attached via*** connectors and drop cables.
  - Disadvantages include the potential for loose connections or breaks in the bus to ***disrupt the entire network***
- Early Ethernet LAN implementations were typically physical bus architectures; today, most Ethernet implementations are physical stars. (However, an Ethernet ***shared media hub*** is sometimes called a “bus in a box”)
- Both IEEE 802.3 standard and IEEE 802.4 standards and their protocols address communication over LANs with bus topologies.

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Bus Topology (Contd.)

Advantages of bus topologies:

- Inexpensive to install (uses less cable)
- Easy to add new devices onto the bus or onto the network

Disadvantages of bus topologies:

- Can be expensive to maintain and troubleshoot
- A naive user can easily "bring down" the entire bus
- Overall maximum length of the bus is limited (10-Base-2)

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Ring Topology

- In a physical ring topology, the communication medium forms a ***closed loop*** (ring) and all stations are connected to the loop
  - Data is transmitted node-to-node in ***one direction*** on the ring
  - Similar to a physical bus, the entire network could be disrupted if one of the connectors or links in the ring is failed
- Physical ring topologies are ***less common*** than bus or star topologies
- ***Token ring*** and ***FDDI*** LANs have physical ring topologies
- The most widely used microcomputer ring network is the token passing ring. It conforms to the IEEE 802.5 standard. IEEE 802.6 addresses ***dual-ring*** metropolitan area network (MAN) architecture.

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Ring Topology (Contd.)

Token ring network:

- The nodes attach to multi-station access units (MAUs)
- MAUs can be described as “a ring in a box”, because nodes attach to the physical ring by connecting to the MAU
- MAUs can be interconnected to form larger rings

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Ring Topology (Contd.)

Advantages of ring topologies:

- Very predictable network performance
- May be slightly more secure than other topologies

Disadvantages of ring topologies:

- Expensive as compared to bus/star topologies
- Hardware for ring topologies is less available and therefore more expensive
- Many systems lack good support for networking in ring environments
- Unique wiring requirements
- More complex networking and operational protocol

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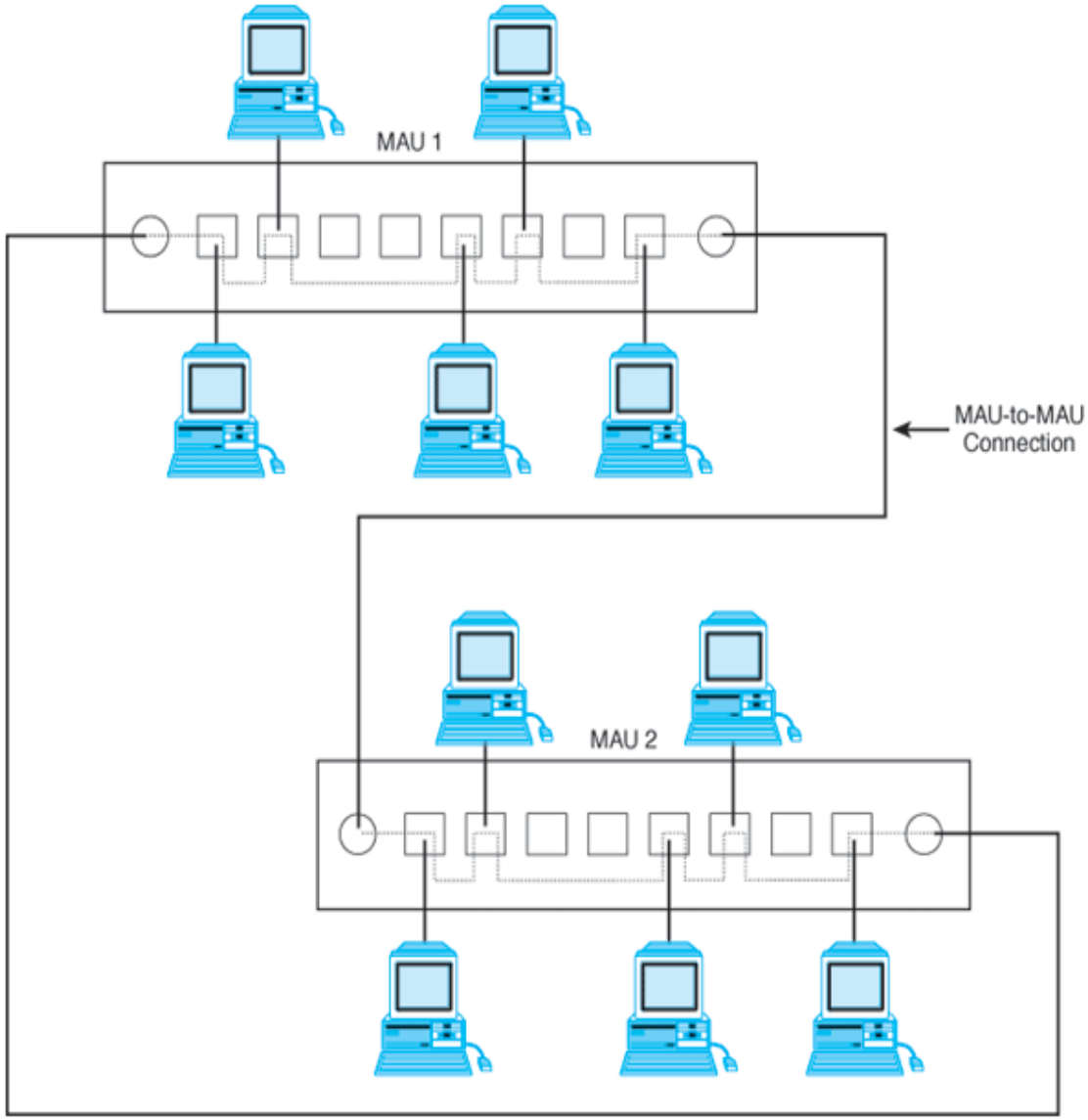
Ring Topology (Contd.)



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Star Topology

- In LANs with star topologies, all nodes are connected to some kind of wiring center such as a ***hub or switch***

- Each ***node is isolated*** on its own network segment in a physical star topology which minimizes the possibility of total network disruption by a malfunctioning connector, NIC, or link

  However, the network is vulnerable to wiring center failure

- The use of central connection points also facilitates network ***traffic monitoring*** and ***network management***, including network security management

- ARCnet (2.5Mbps) was one of the first (1970) LAN architectures with a star topology

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Star Topology (Contd.)

Advantages of star topologies:

- Each node has a dedicated connection to the network – disconnecting a single node does not bring down the rest of the nodes on the network
- Network and cable administration are centralized

Disadvantages of star topologies:

- More expensive to install – require more cable and the additional cost of a hub
- Maximum length of each spoke of the hub is limited to the allowed maximum length of the medium (for example, on a 10-Base-T network using UTP cable, the maximum distance from the hub to a host is 100m)
- Breakdown of the hub causes breakdown of the entire system (also the Hub can become the bottleneck)

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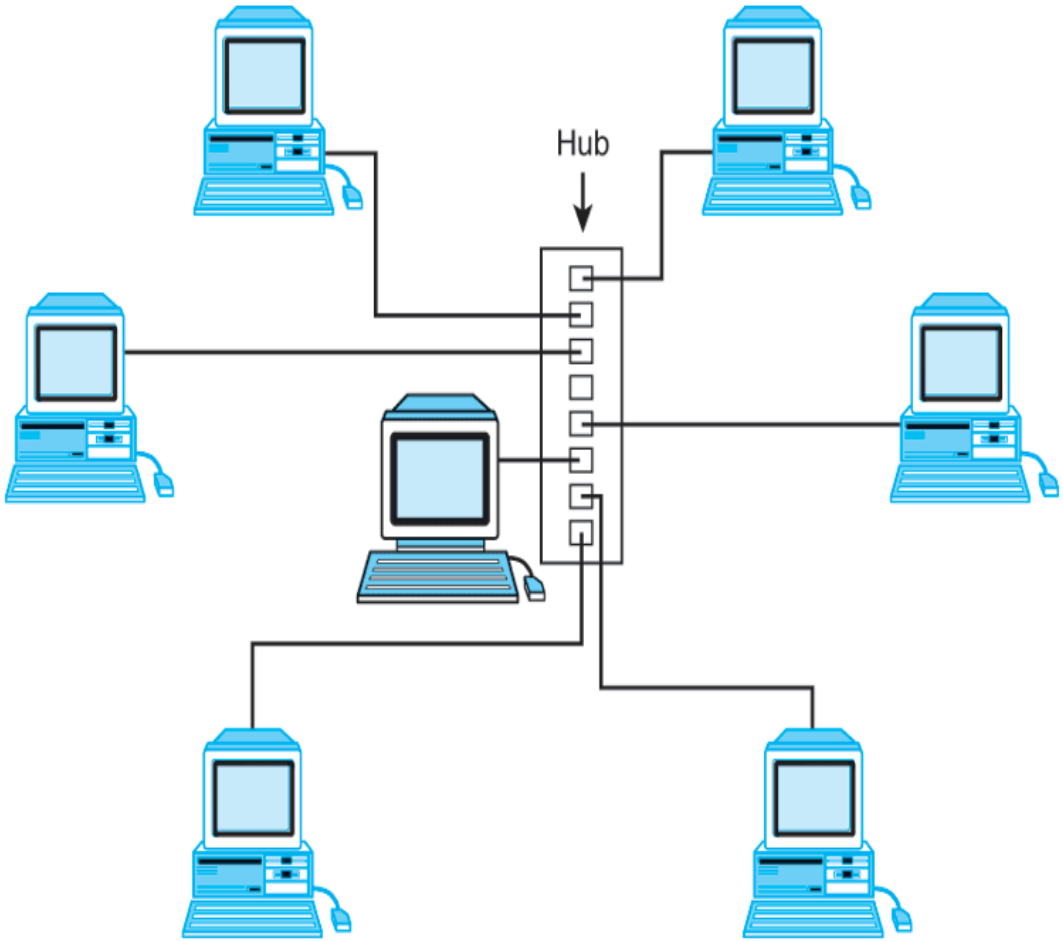
Star Topology (Contd.)



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Choice of Topology

- reliability
- expandability
- performance
- needs considering in context of:
  - medium
  - wiring layout
  - access control

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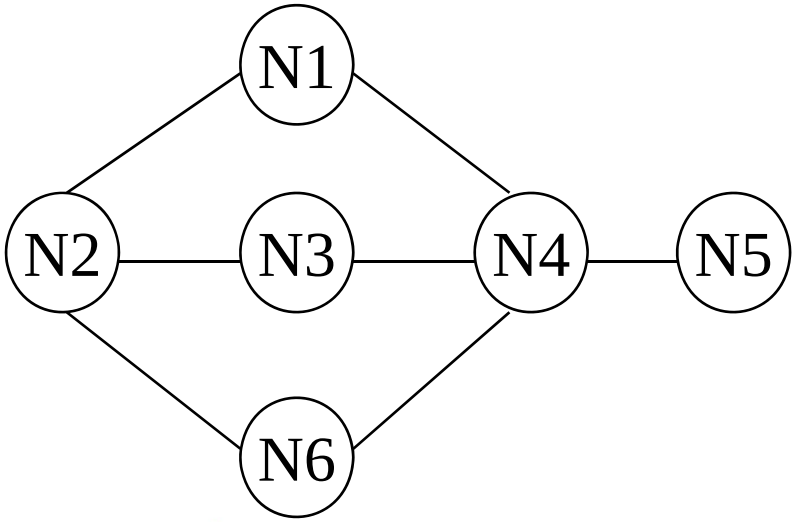
WAN Topologies

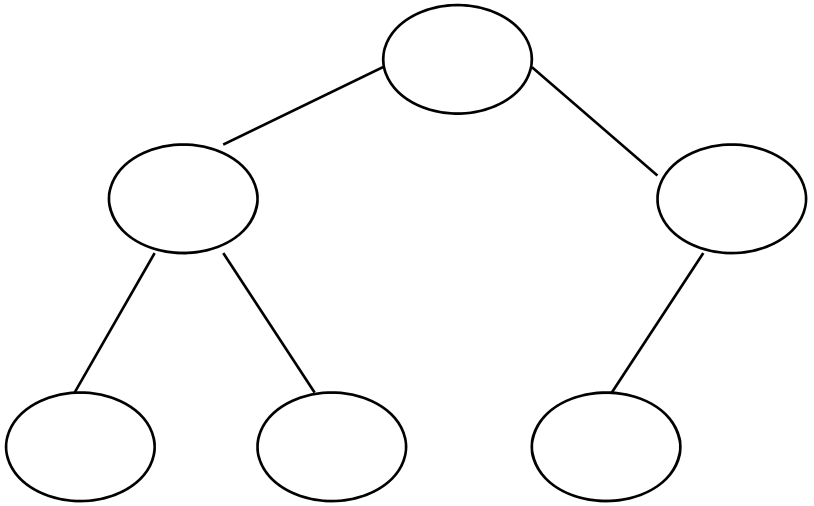
Mesh/Network Topology:

provides ***multiple*** paths between nodes or networks (N) usually implemented with switches and routers



Tree/Hub Topology:

A ***hierarchical architecture*** starts with ***header node*** and branches out to other nodes. Simpler to implement than mesh topology



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Section 4.3

Types of Networks

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Types of Networks

- Local Area Networks (LANs)
- Wide Area Networks (WANs)
- Personal Area Networks (PANs)

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Local Area Network

- A LAN is a network that is used for communicating among computer devices, usually within an office building or home
- LAN's enable the sharing of resources such as files or hardware devices that may be needed by multiple users
- Is limited in size, typically spanning a few hundred meters, and no more than a ....
- Is very fast, with speeds from 100 Mbps to 10 Gbps
- Requires very little wiring, typically a single cable connecting to each device
- Has lower cost compared to MAN's or WAN's

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LAN Basics

- LAN's can either be made wired or wireless.
  Twisted pair, coax or fiber optic cable can be used in wired LAN's.
- Nodes in a LAN are linked together with a certain *topology*.
  These topologies include:
  - Bus
  - Ring
  - Star
  - Branching tree
- A *node* is defined to be any device connected to the network.
  This could be a computer, a printer, router, ...
- A *Hub* is a networking device that connects multiple segments of the network together

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LAN basics.....cont.

- A *Network Interface Card* (NIC) is the circuit board that is used to connect computers to the network. In most cases, this is an *Ethernet* card plugged in a computer's motherboard.

- The *Network Operating System* (NOS) is the software that enables users to share files and hardware and communicate with other computers. Examples of NOS include: Windows XP, Windows NT, Sun Solaris, Linux, ...

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LAN basics.....cont.

- Resource sharing in a LAN is accomplished with different *access methods*.

Multiple Access Methods:

- Fixed assignment (Channel partitioning)
  - Partition channel so each node gets a slice of the bandwidth
  - Essentially circuit switching – thus inefficient

    Examples: TDMA, FDMA, CDMA (all used in cellular env.)
- Contention-based (Random Access)
  - Nodes contends equally for bandwidth and recover from collisions

    Examples: Aloha, Ethernet, CSMA/CD
- Token-based or reservation-based
  - Take turns using the channel

    Examples: Token ring

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Generations of LANs

- **First Generation** – Legacy LANs provide terminal-to-host connectivity and client-server architecture (802.3 & 802.5)
- **Second Generation** – Responded to need for backbone LANs and support of high performance workstations (FDDI)
- **Third Generation** - Designed for high throughput with delay control for multimedia applications (ATM LANs, Fast Ethernet, Gigabit Ethernet)
- **Fourth Generation** - Designed to support mobility and broadband wireless (802.11, Bluetooth, 802.15)

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Generations of LANs

Legacy LANs and IEEE Standards:

802.1 – Higher Level Interface Ad. Group

802.2 – Logical Link Control LAN Interface

802.3 – ***CSMA/CD Ethernet***

802.4 – Token Bus

802.5 – ***Token Ring***

802.6 – MAN Broadband Net.

802.7 – Broadband Tech. Advisory Gp.

802.8 – Fiber Optics Tech.

802.9 – Integrated Services

802.10 – Std. for Interoperable LAN Sec.

802.11 – ***Wireless LAN***

802.12 – Demand Priority

802.14 – Cable TV based

802.15 – Wireless Personal (WPAN)

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LAN Architecture?

- ***LAN architecture*** is the overall design of a LAN. It includes:
  - LAN hardware
  - LAN software
  - LAN topology
  - Media access control (MAC) protocol
- The LAN's network operating system is sometimes also considered to be part of LAN architecture

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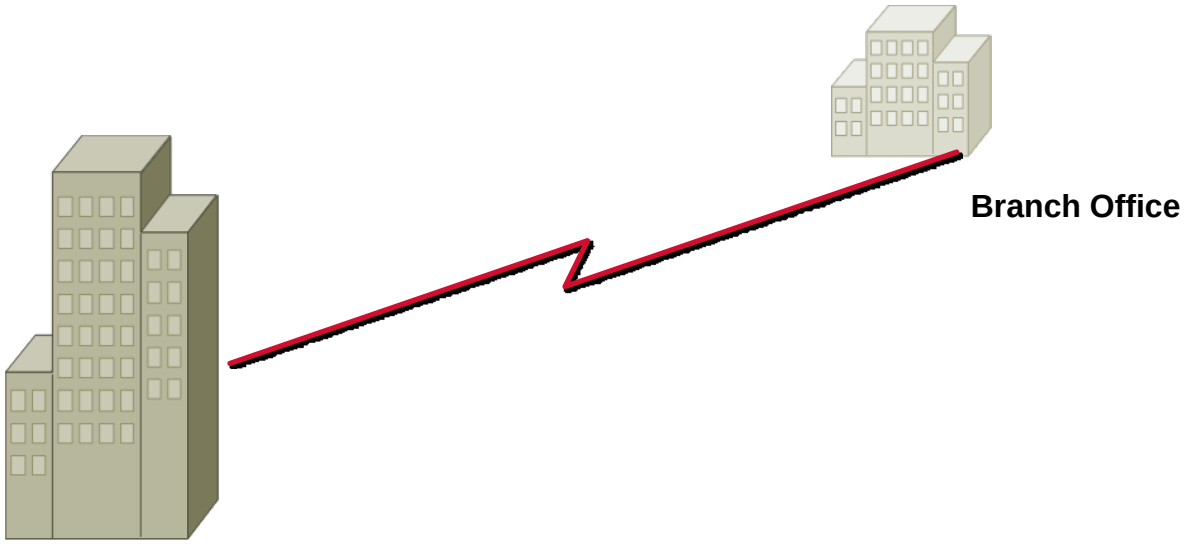
What is Wide Area Networking ?

- A network connecting two or more geographically separate locations
- Wide area network (WAN) involves a carrier or network service provider (NSP) to make the connectivity



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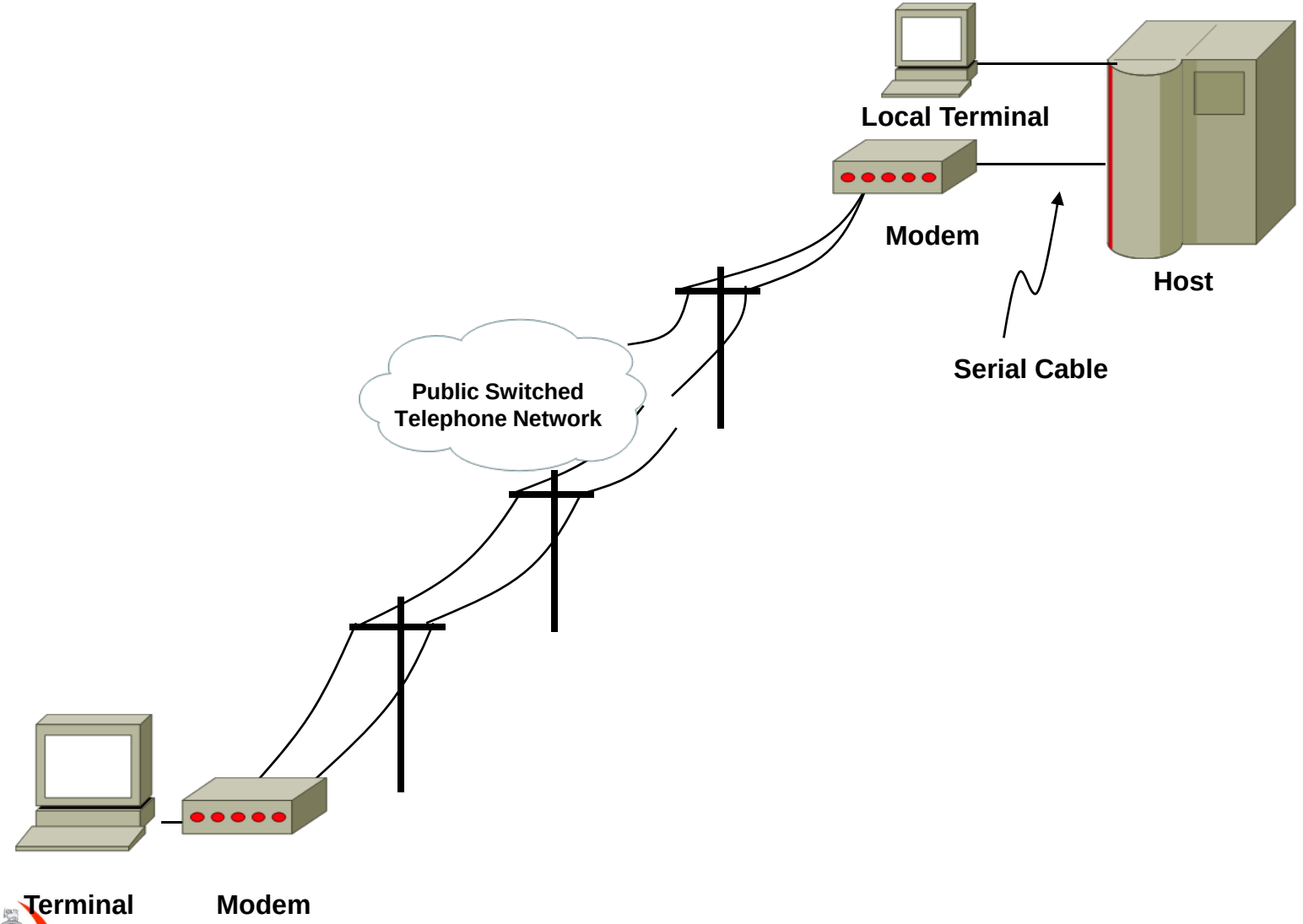
Simplest type of WAN link



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Personal Area Networks

- A **personal area network** (**PAN**) is a computer network used for communication among computer devices close to one person. The devices may or may not belong to the person in question. The reach of a PAN is typically a few meters. PANs can be used for communication among the personal devices themselves, or for connecting to a higher level network and the Internet.

- Personal area networks may be wired with computer buses such as USB and FireWire. A wireless personal area network (WPAN) can also be made possible with network technologies such as IrDA, Bluetooth, UWB, and ZigBee.

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Personal Area Networks

PAN Standards

802.15.1a: Bluetooth (2.4GHz at 1Mbps)

802.15.2: Coexistence of PANs with one another

802.15.3: High rate PAN (2.4GHz at 55 Mbps)

802.15.3a: Alternative high rate PAN for UWB (2.4GHz at 110 Mbps)

802.15.4: Low rate PAN - Zigbee

802.15.4a: Alternative low rate - low power UWB

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Section 4.4

Layered Network Model

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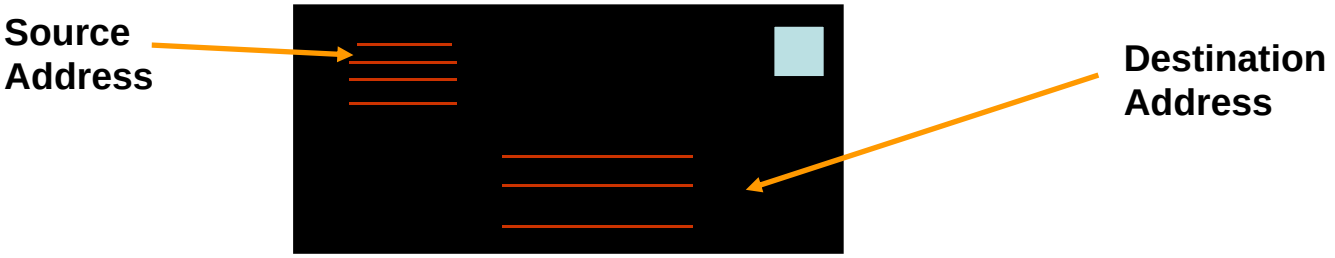
How Does Data Transmit?

- Information is placed in “packets”
- Packets are like envelopes that carry information to its destination
- What a packet looks like is defined by the network protocol



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Layered Network Models

What is Layering?

A technique to organize a network system into a succession of logically distinct entities, such that the service provided by one entity is solely based on the services provided by the previous (lower level) entity.

Why Layering?

Solving all the problems at once is difficult.

It's a good idea to divide problems or functions into several sets in such a way that:

- problems or functions in a same set are tightly coupled
- the inter-dependence between problems or functions in different sets is minimized

Address the problem sets separately.

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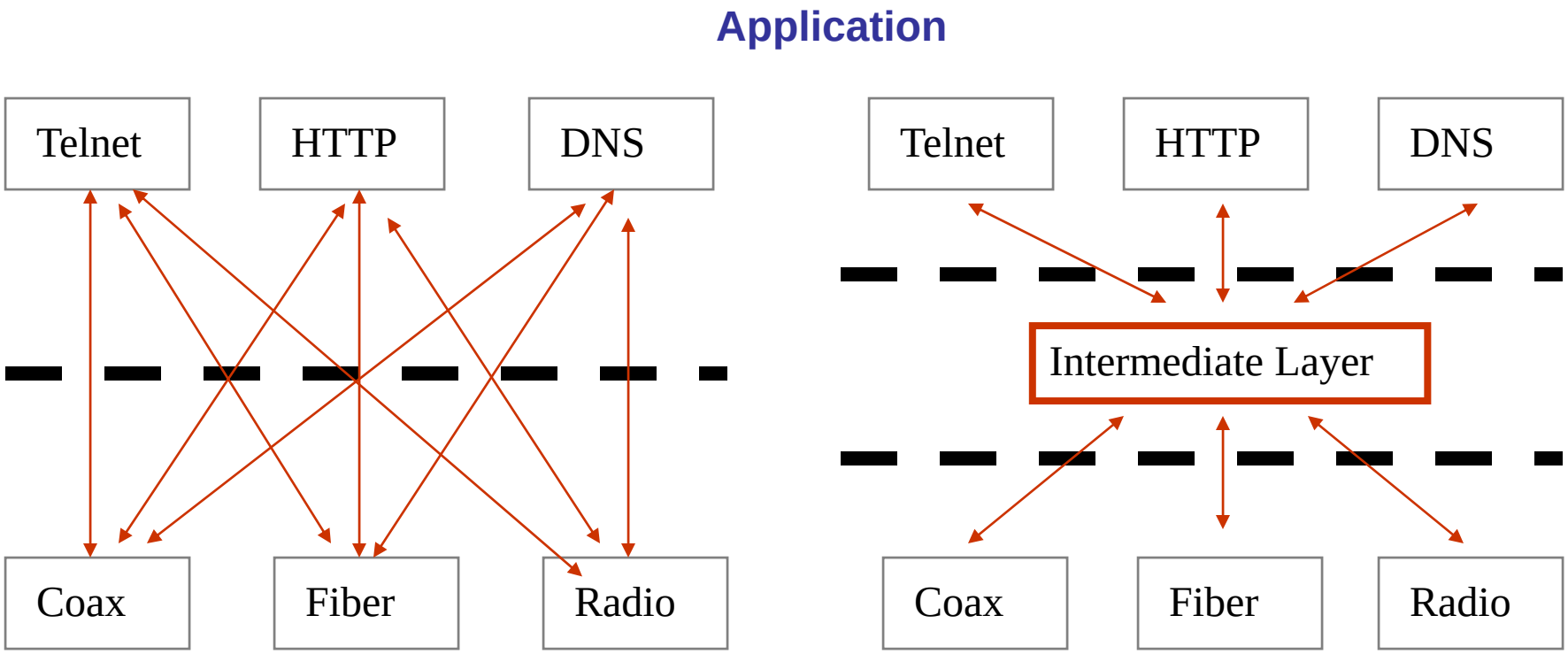
Layered Network Architecture

Why Layering?



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Advantages of Layering

- A smaller number of problems need to be addressed at a time
- Modularity – protocols easier to manage and maintain
- A solution to a problem set can be easily modified without affecting solutions to other sets. ***Abstract functionality*** – lower layers can change without affecting the upper layers.
- Facilitate standardization process
- Reuse – upper layers can reuse the functionality provided by lower layers
- ***Many different*** solutions for ***different*** problem sets can be combined in ***many different*** ways to form a complete solution.
- Good for teaching and learning

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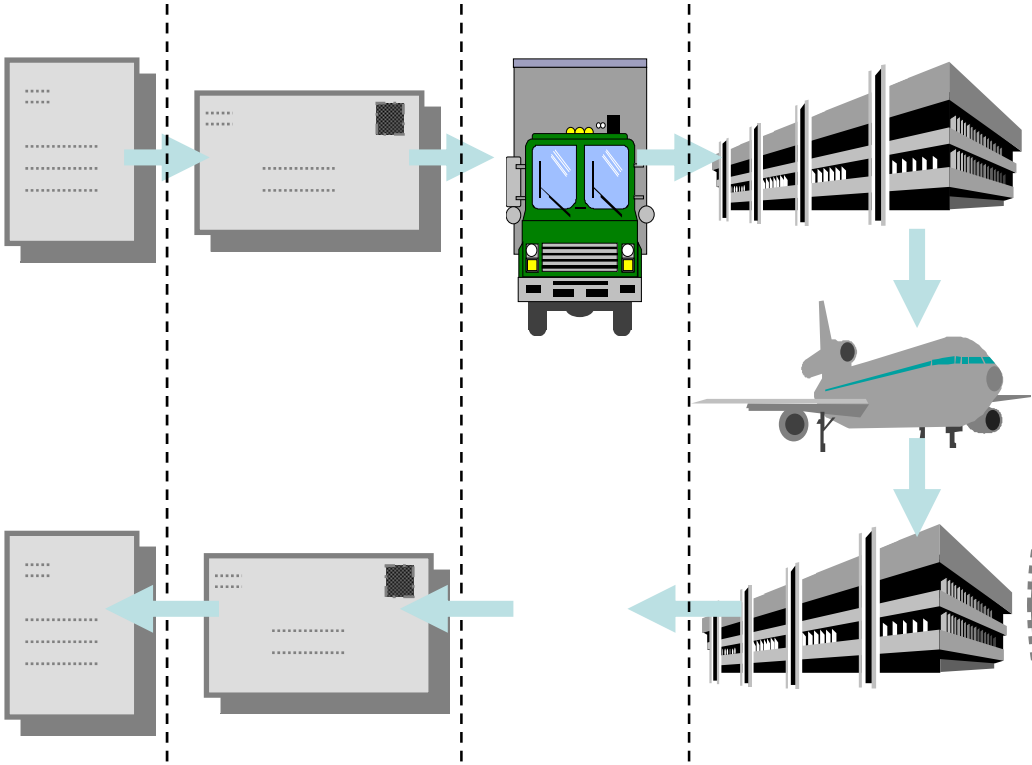
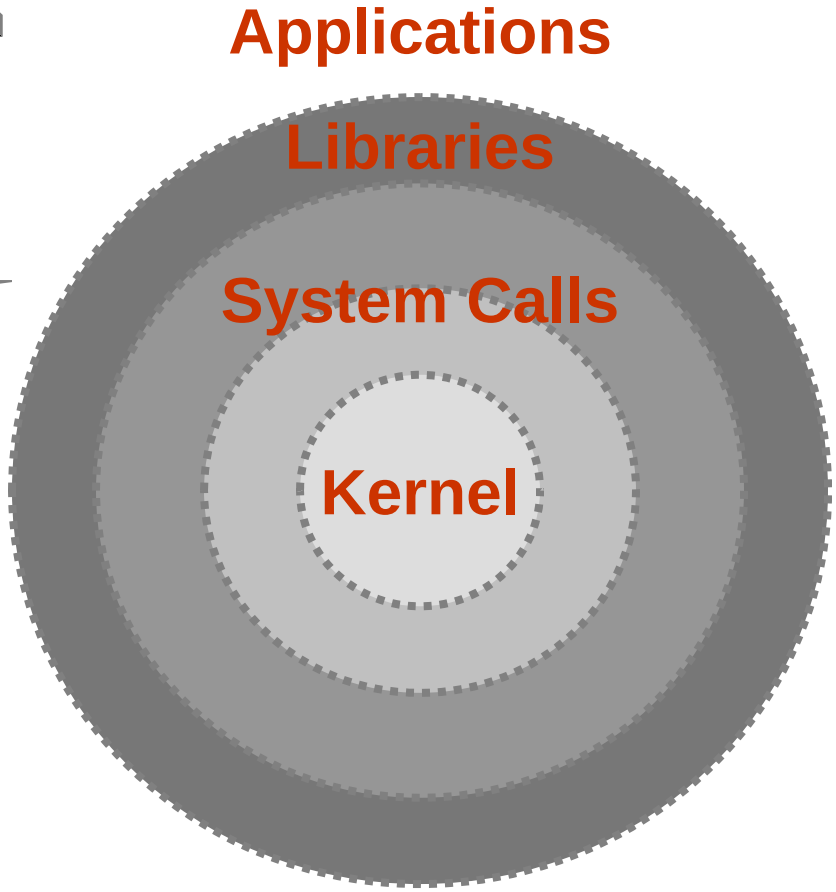
Examples of Layering





Network Software and Operating System Software are some examples that use layered architecture.

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OSI Reference Model

- The International Standards Organization (ISO) proposal for the ***standardization*** of the various protocols used in computer networks (specifically those networks used to connect ***open systems***) is called the ***Open Systems Interconnection Reference Model***, or simply the OSI model.
- In 1970's the ISO undertook to develop this standard and the ***first standard*** of the ***7 layer*** architecture came in 1974.
- Although the OSI model is a just a model (***not a specification***), it is generally regarded as the most complete model (***popular network protocol*** suites in use today were developed before the OSI model was defined – APANET 1969 & TCP/IP 1974).
- Detailed standards for the various layers were developed separately by ISO.
- Goal : A general open standard
  - allow vendors to enter the market by using their own implementation and protocols.

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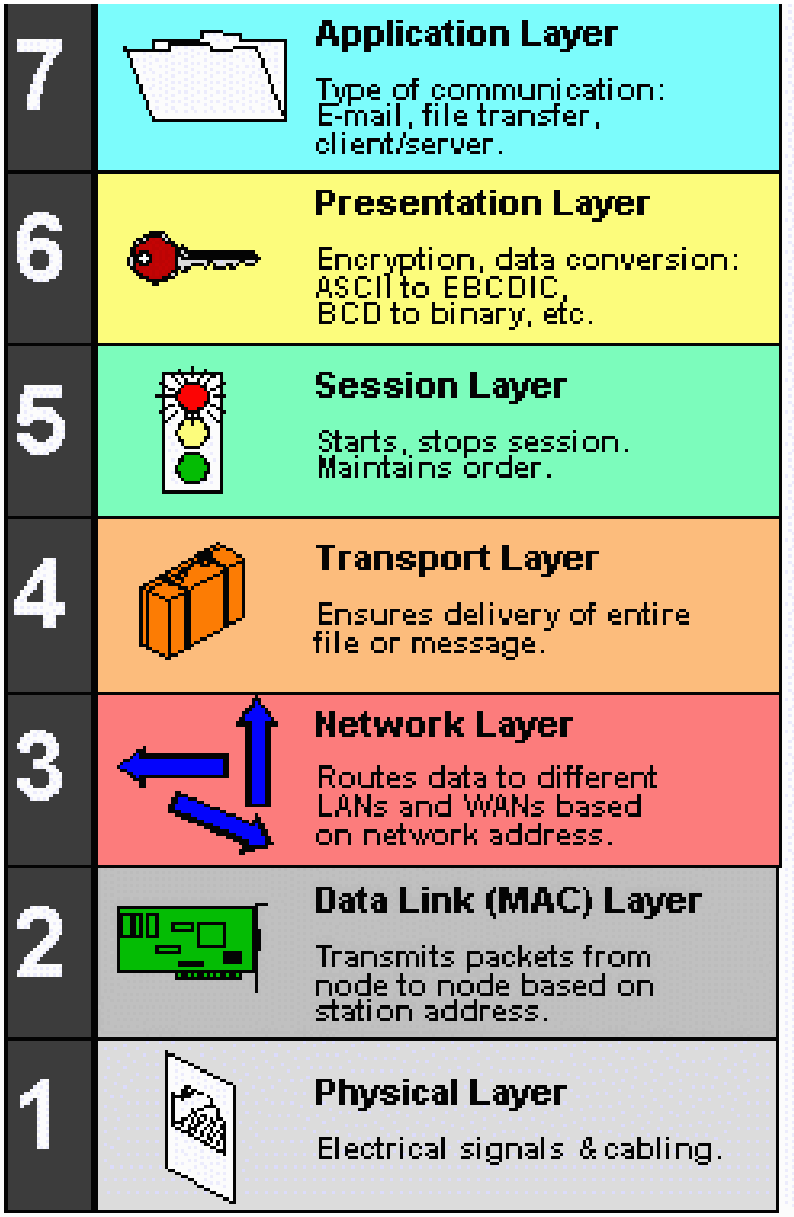
OSI Model

OSI:
Open Systems
Interconnection
Reference Model



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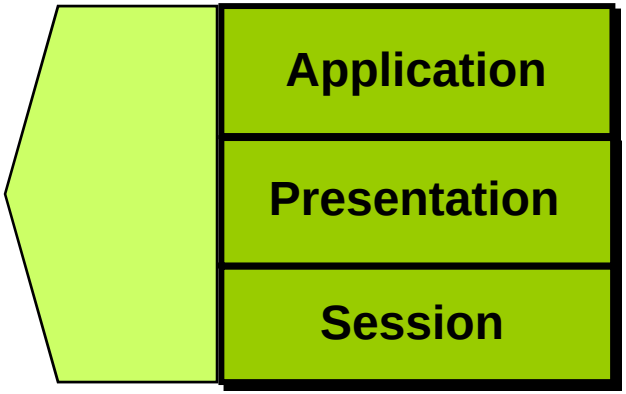
OSI Model Overview

Application (Upper Layers)



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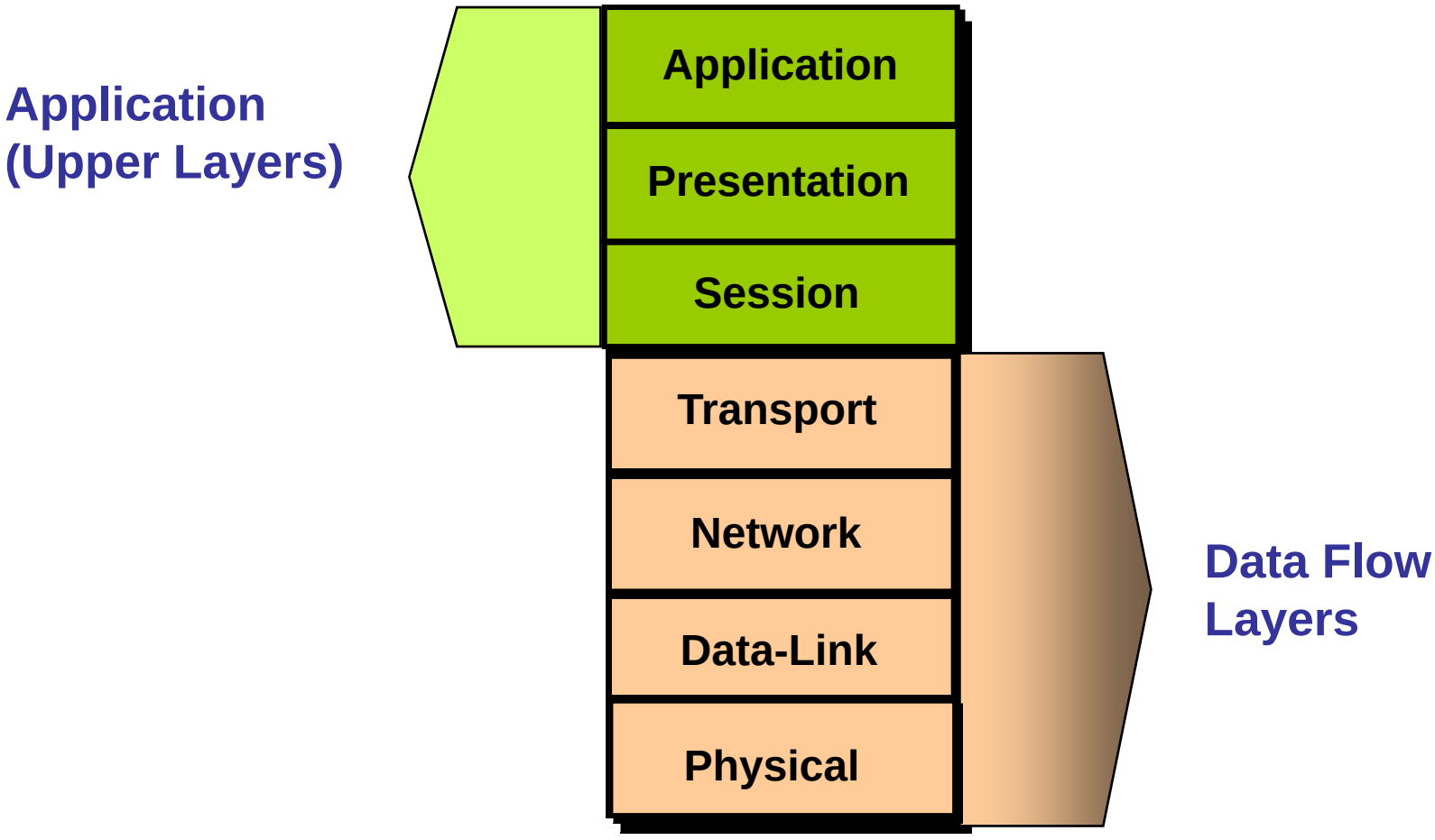
OSI Model Overview



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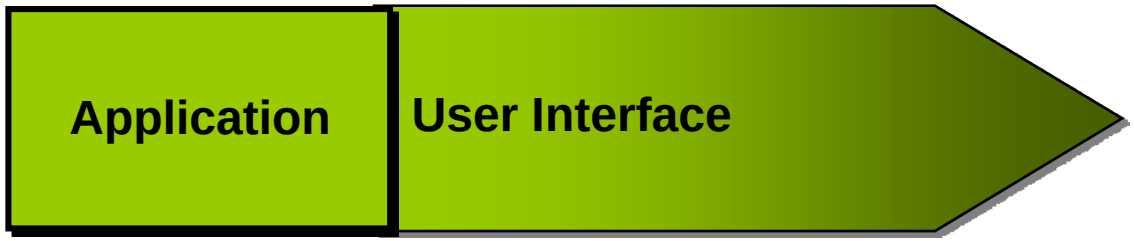
Role of Application Layers



Examples

Telnet
FTP

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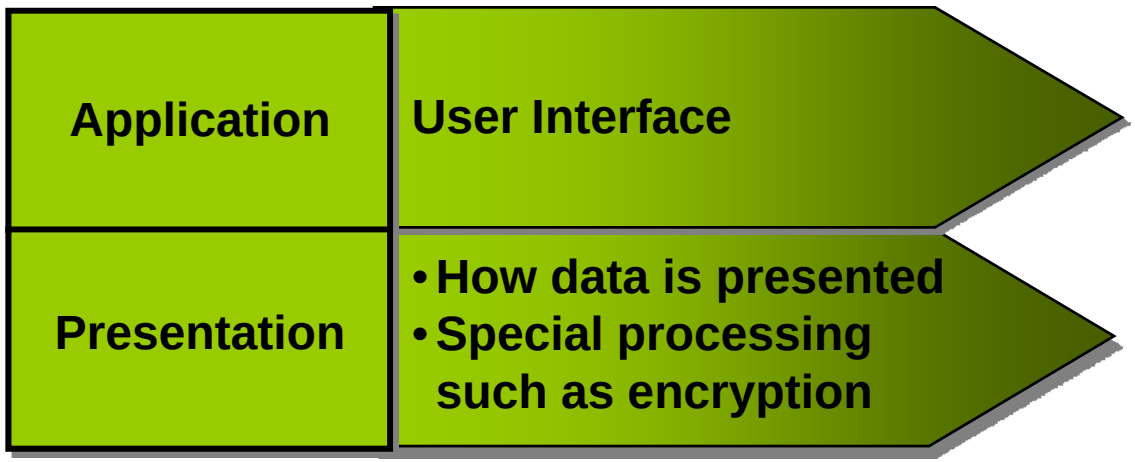
Role of Application Layers



Examples

Telnet
FTP

ASCII
EBCDIC
JPEG

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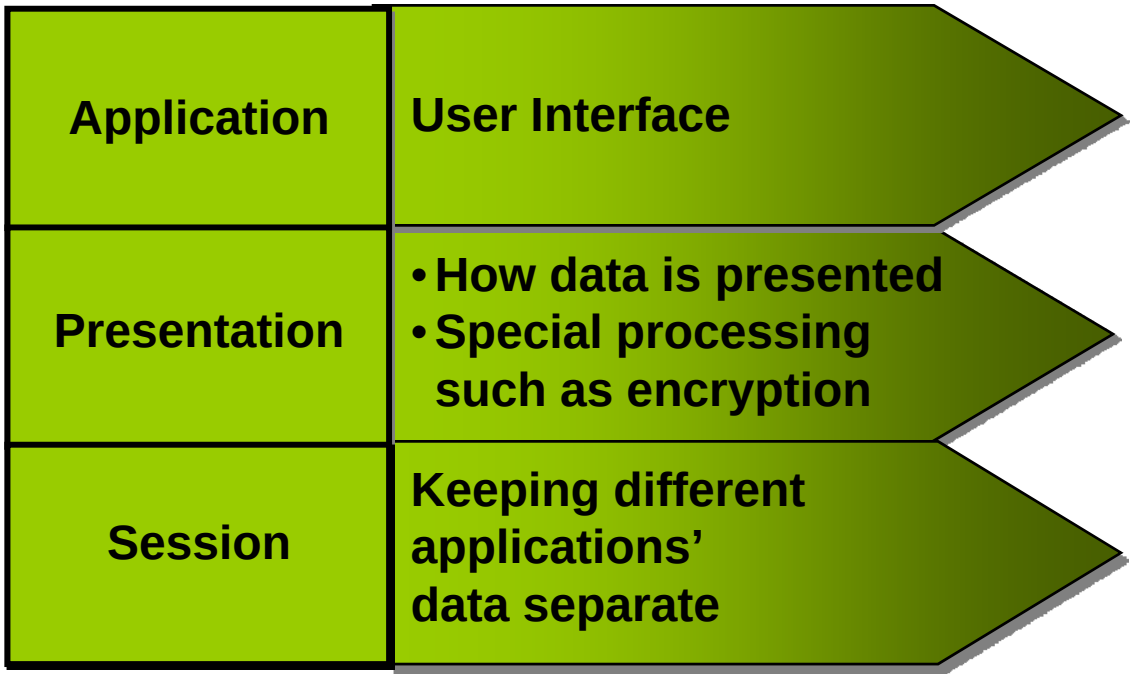
Role of Application Layers



Examples

Telnet
FTP

ASCII
EBCDIC
JPEG

Operating System/ Application Access Scheduling

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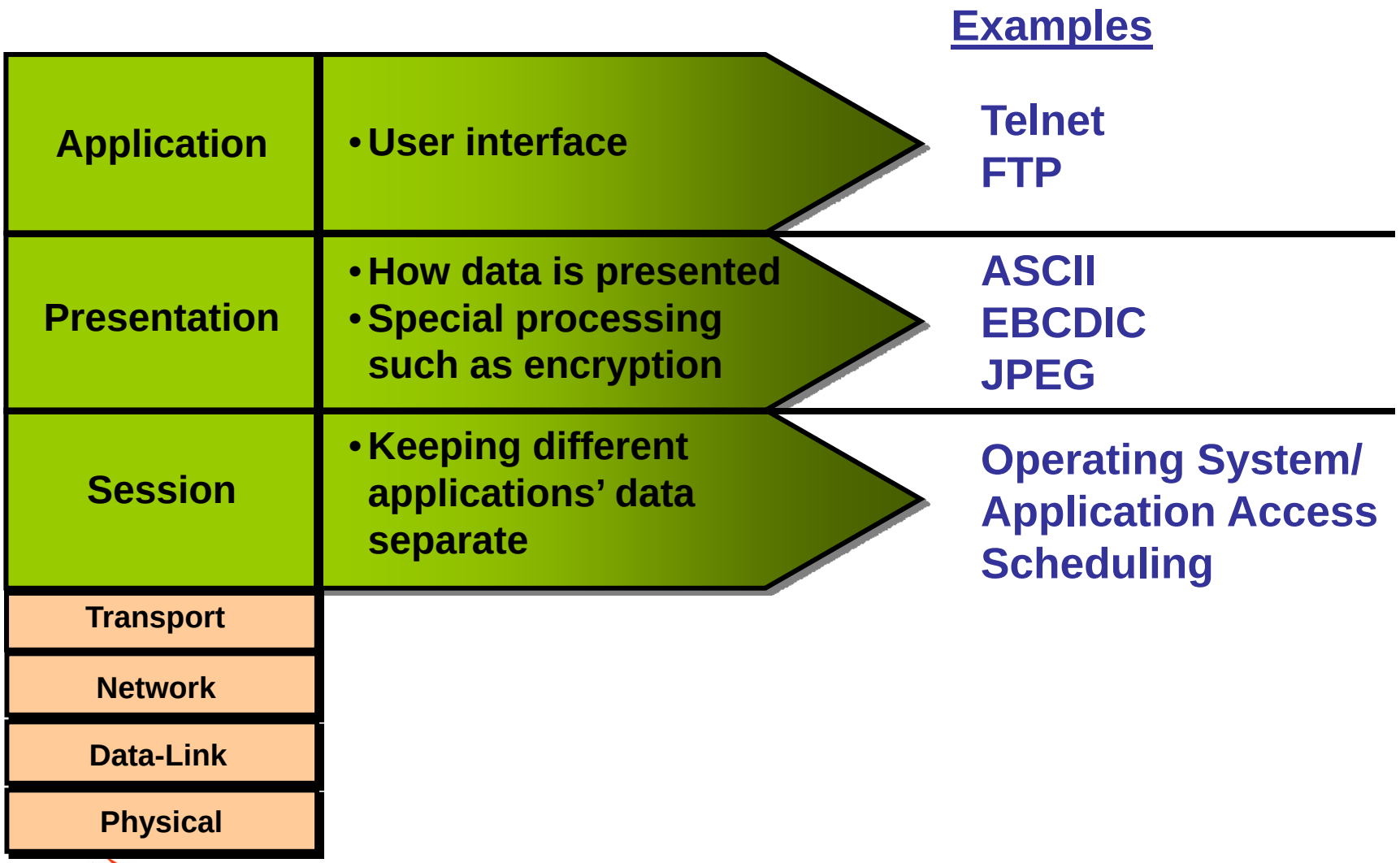
Role of Application Layers



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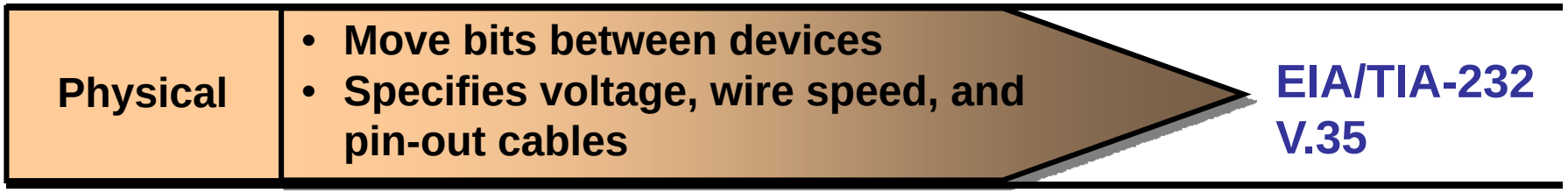
Role of Data Flow Layers

Examples



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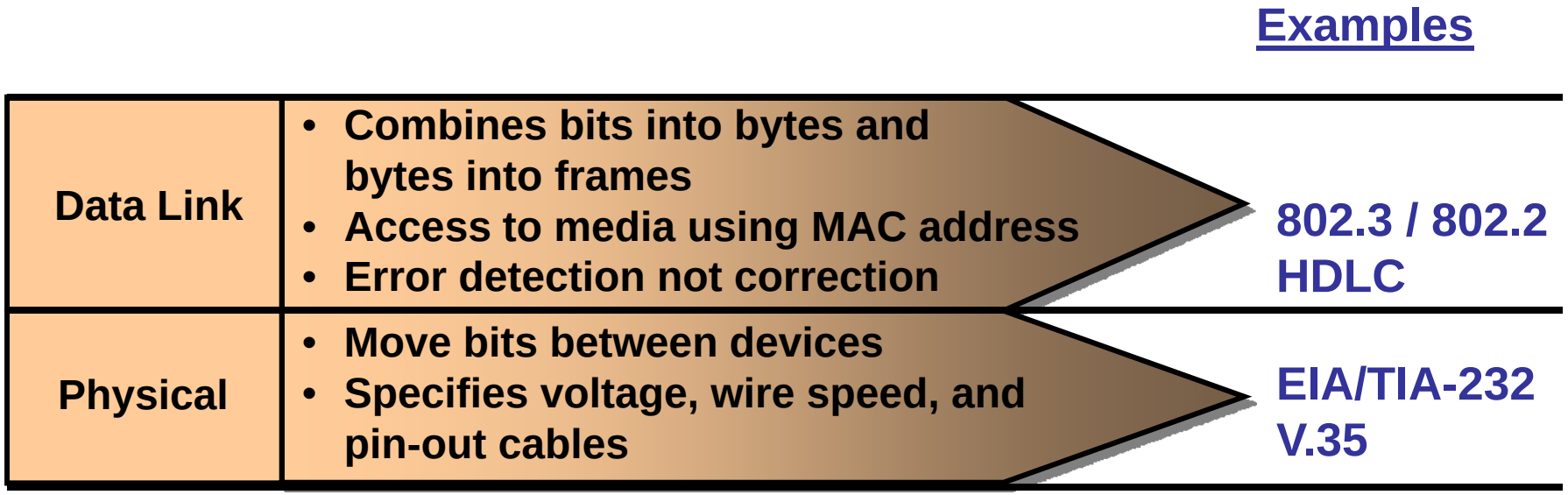
Role of Data Flow Layers



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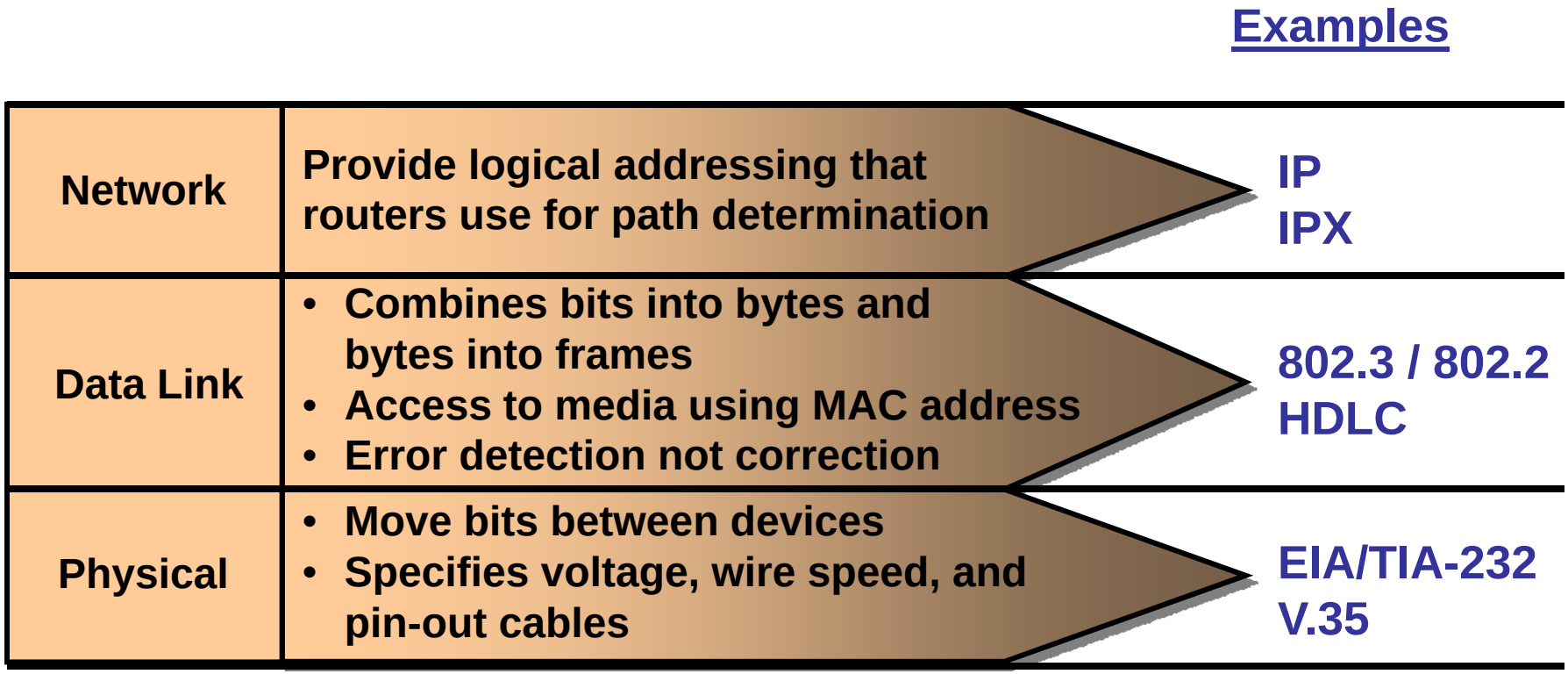
Role of Data Flow Layers



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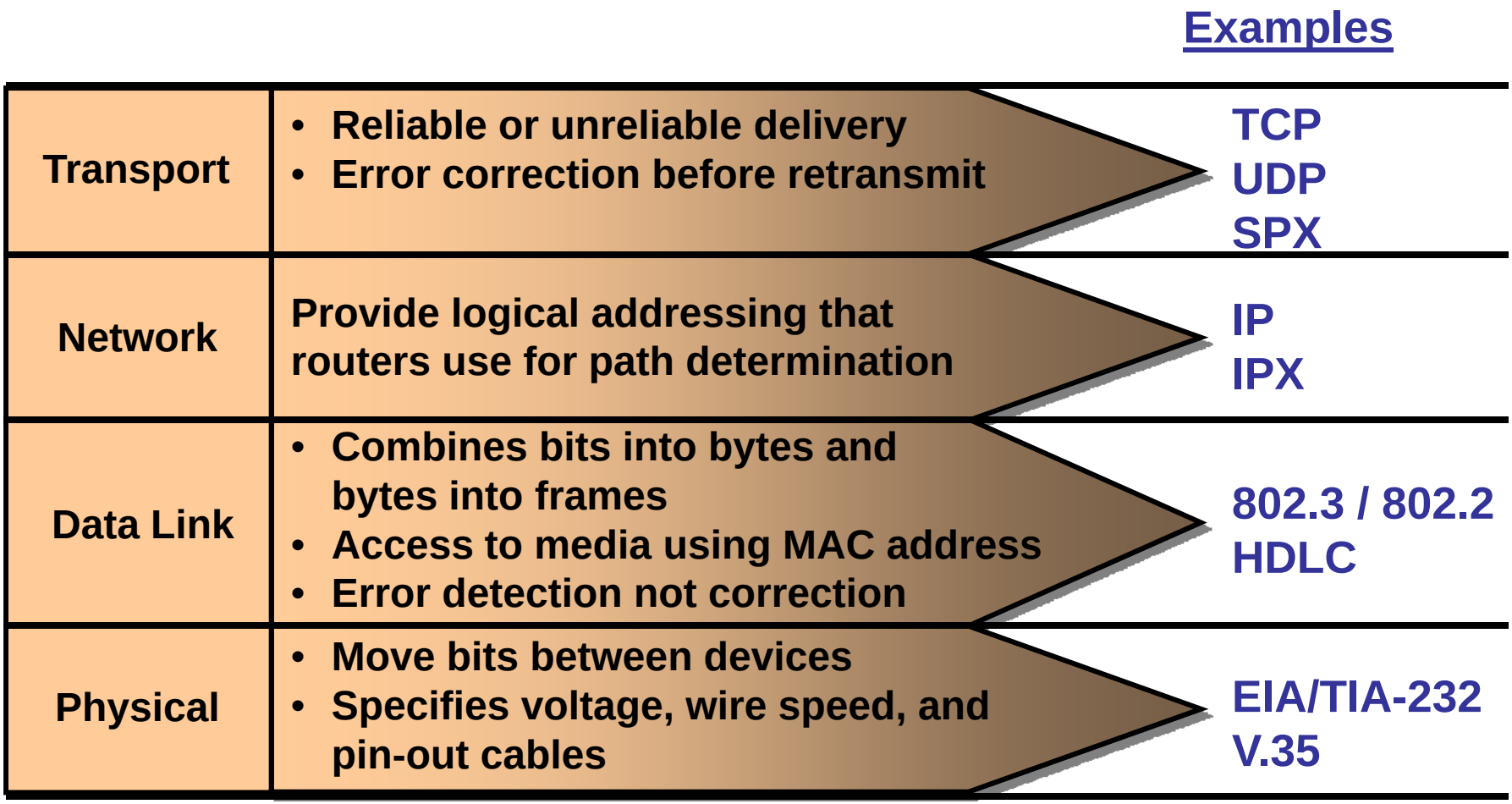
Role of Data Flow Layers



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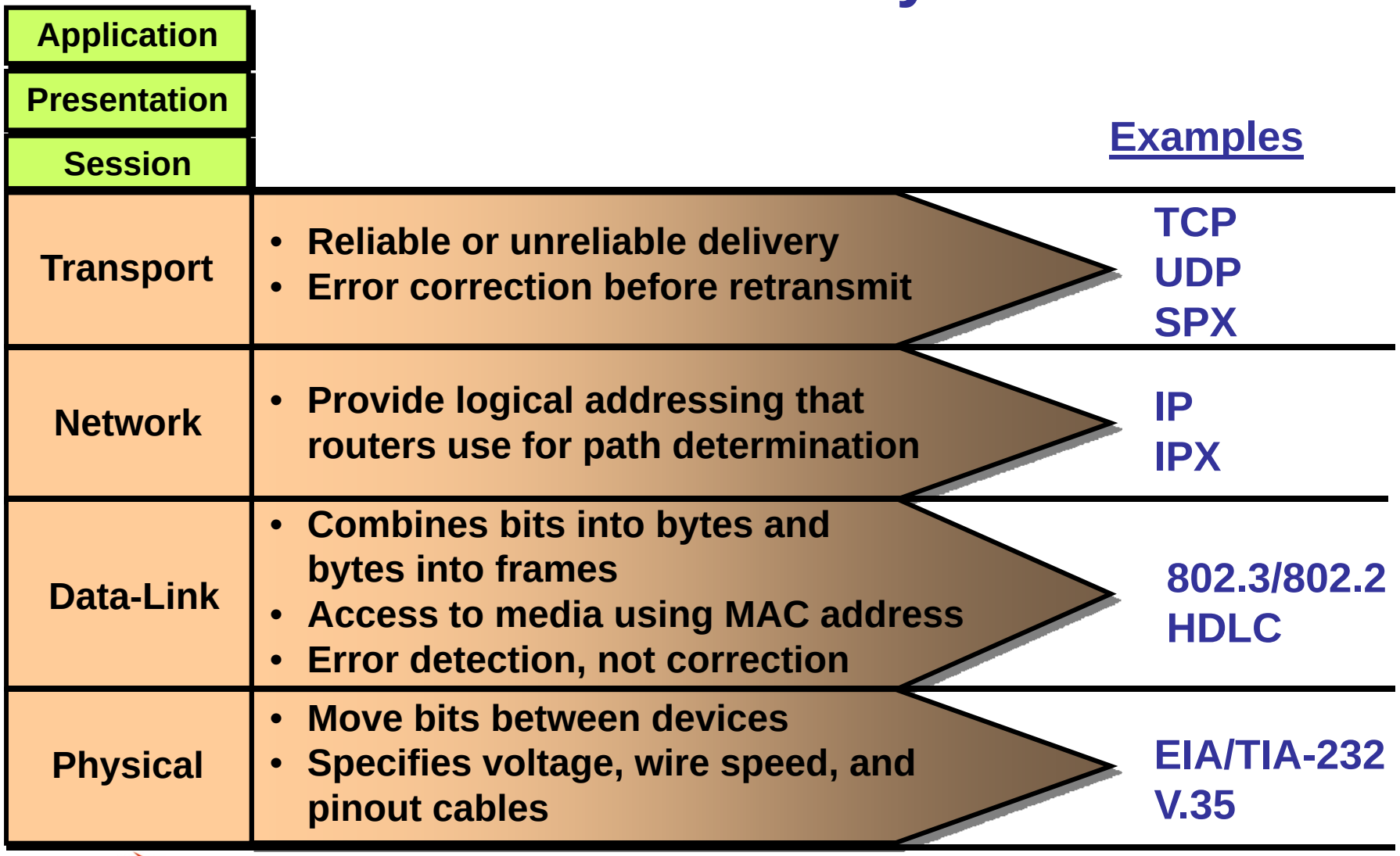
Role of Data Flow Layers



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What Is TCP/IP?

- The large collection of networking protocols and services called TCP/IP denotes far more than the combination of the two key protocols that gives this collection its name

- These protocols deserve an initial introduction: Transmission Control Protocol, or TCP, handles reliable delivery for messages of arbitrary size, and defines a robust delivery mechanism for all kinds of data across a network

- The Internet Protocol, or IP, manages the routing of network transmissions from sender to receiver, along with issues related to network and computer addresses, and much more

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What Is TCP/IP?

- A working understanding of where TCP/IP comes from, and what motivated its original design, can enhance one's understanding of this essential collection of protocols (often called a protocol suite)
- The standards groups that are involved with TCP/IP are as follows:
  - Internet Society (ISOC)
  - Internet Architecture Board (IAB)
  - Internet Engineering Task Force (IETF)
  - Internet Research Task Force (IRTF)
  - Internet Societal Task Force (ISTF)
  - Internet Corporation for Assigned Names and Numbers (ICANN)

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OSI Reference Model and TCP/IP Networking Model Layers

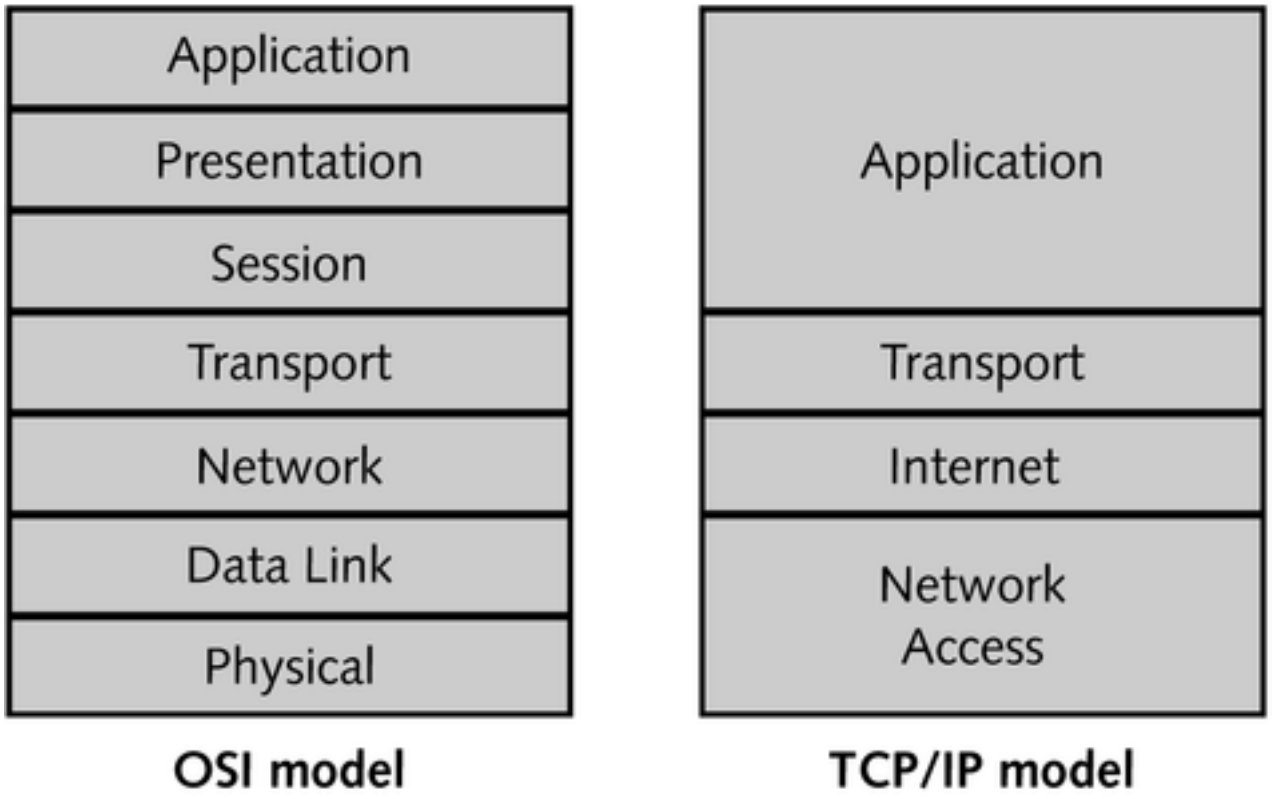

Figure 1-2 OSI reference model and TCP/IP networking model layers

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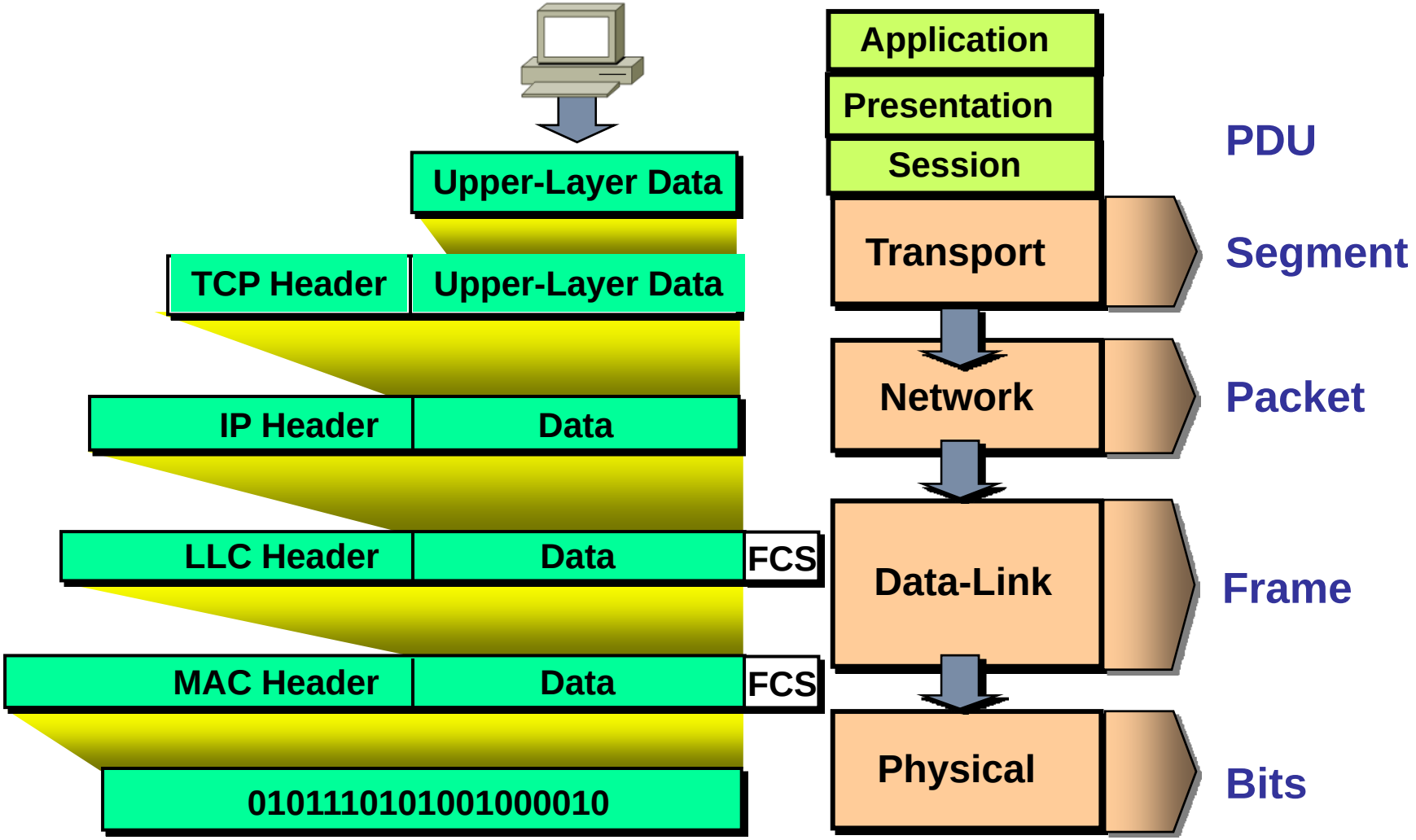
Encapsulating Data



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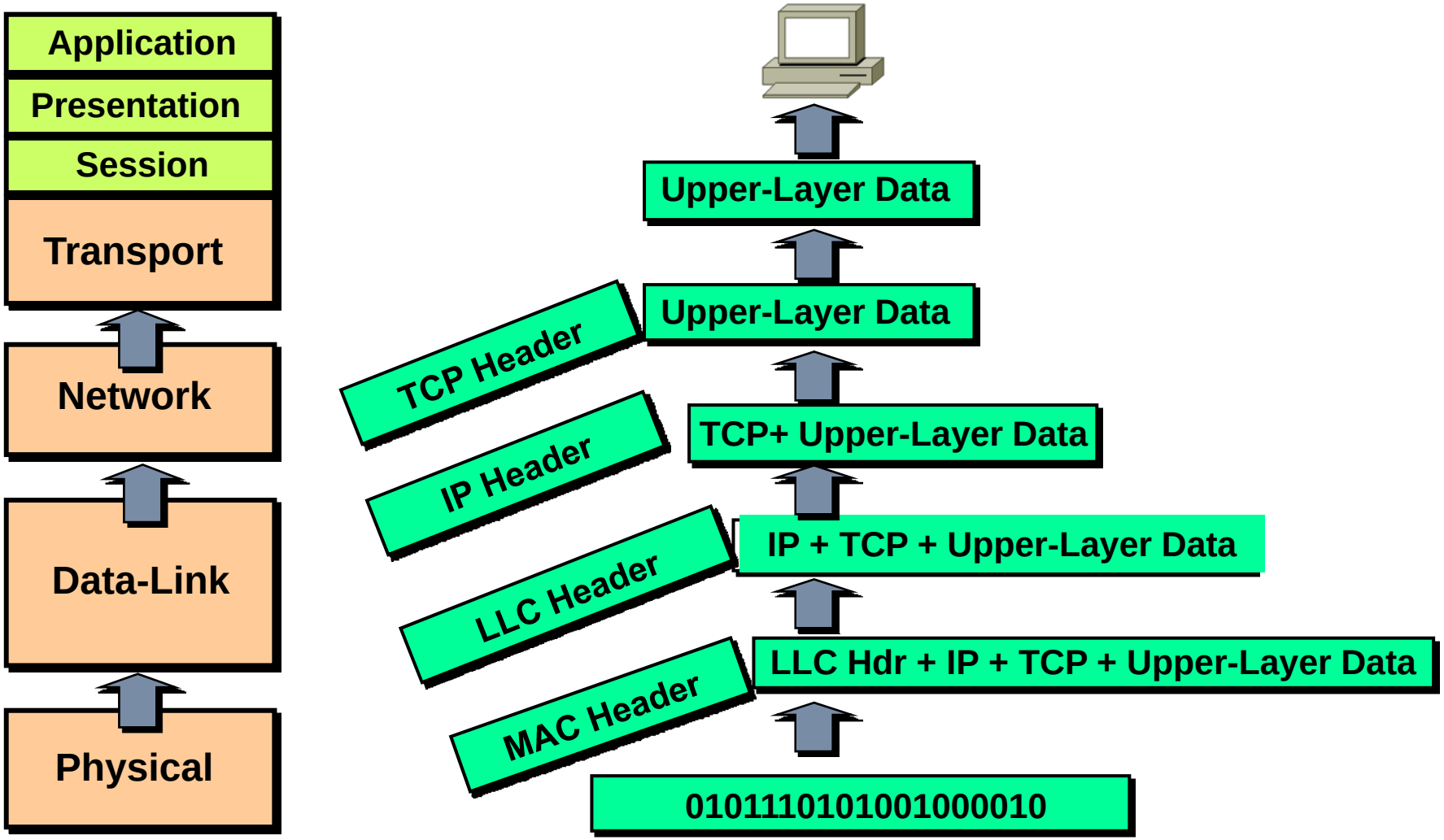
De-encapsulating Data



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End of Section 4.0

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