NANJING UNIVERSITY · SOFTWARE INSTITUTE

南京大学 软件学院

Computer Network & Network Reference Model

CISCO SYSTEMS

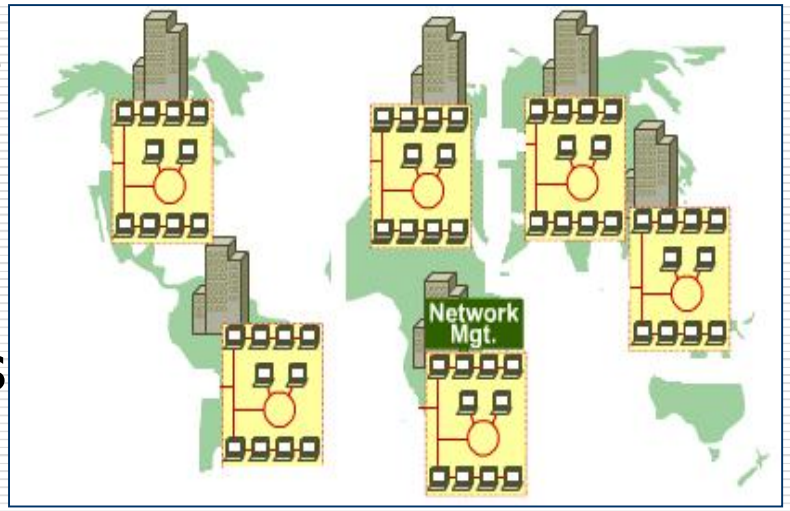
EMPOWERING THE INTERNET GENERATION℠

Computer Network & Network Reference Model

- Overview of Computer Network
- OSI Reference Model
- TCP/IP Model
- Network Topology
- Network Devices

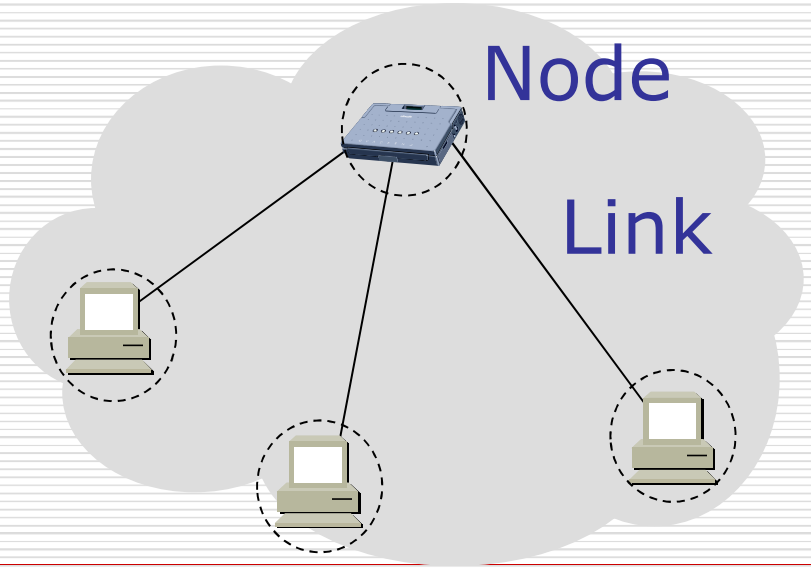
Networks

- What is a network ?
  - A network is an intricately connected system of objects, devices, or people
- Companies created networks
  - As companies expanded, the need for connecting networks at different sites became very important



Data Networks Classifications

- ***LAN***(*Local Area Networks*)
- ***WAN***(*Wide Area Networks*)



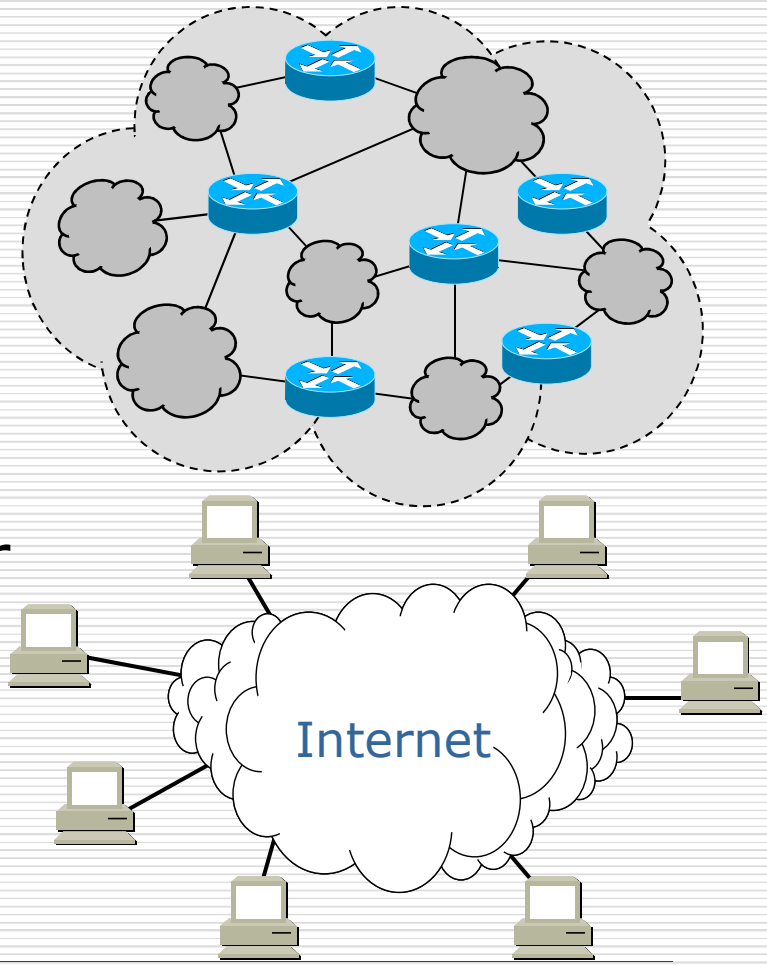
LAN/WAN

- Local Area Networks (LANs)
  - Operate locally (cover small areas)
  - Multi-user access
  - High speeds expected (up to Gbps/10Gbps)
  - Error rate is easily controlled
- Wide Area Networks (WANs)
  - Operate over larger areas
  - Access over serial links, optical links, etc.
  - Traditionally, have Lower speeds
  - Error rate can not be easily controlled

Internet

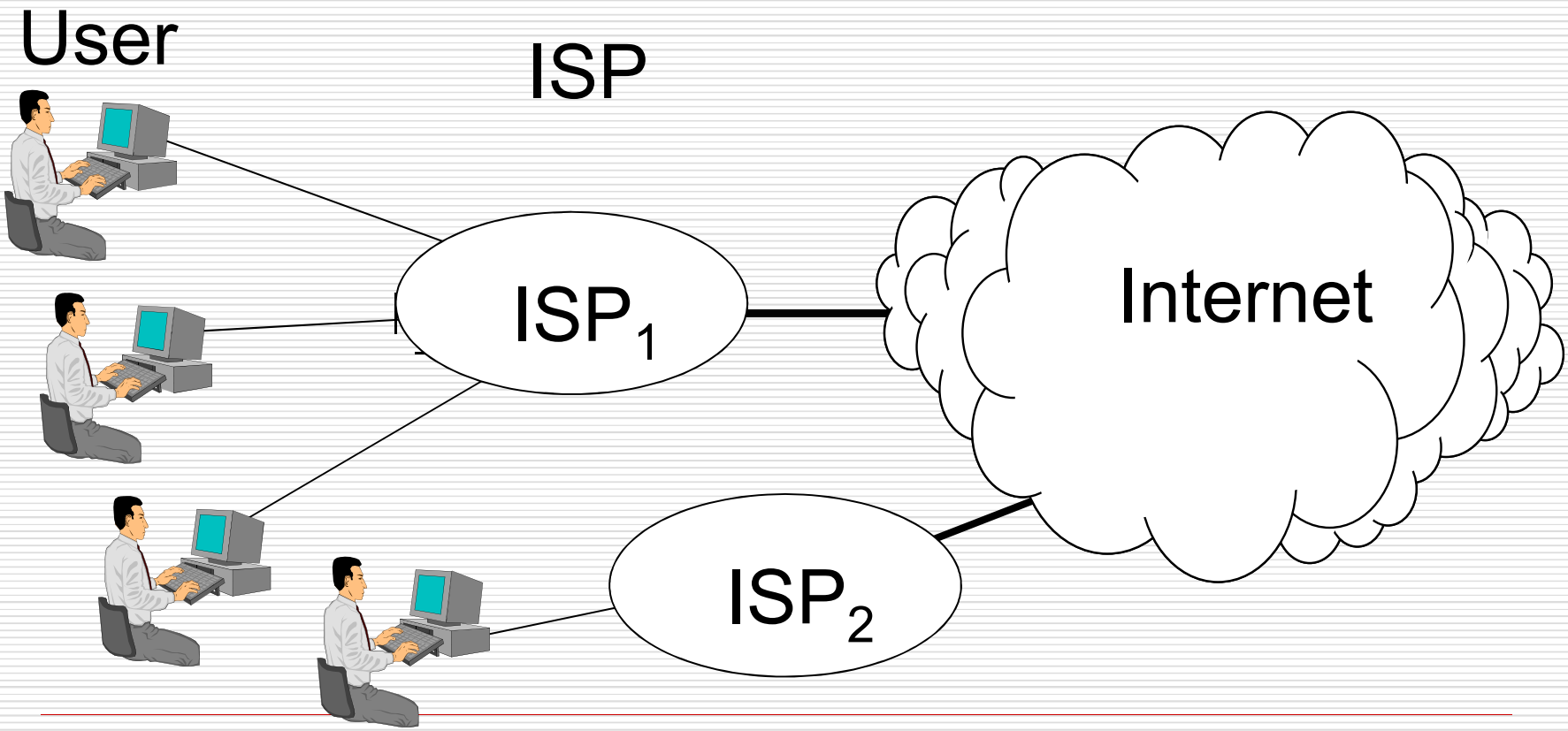
- internet:
  - A network whose nodes are networks

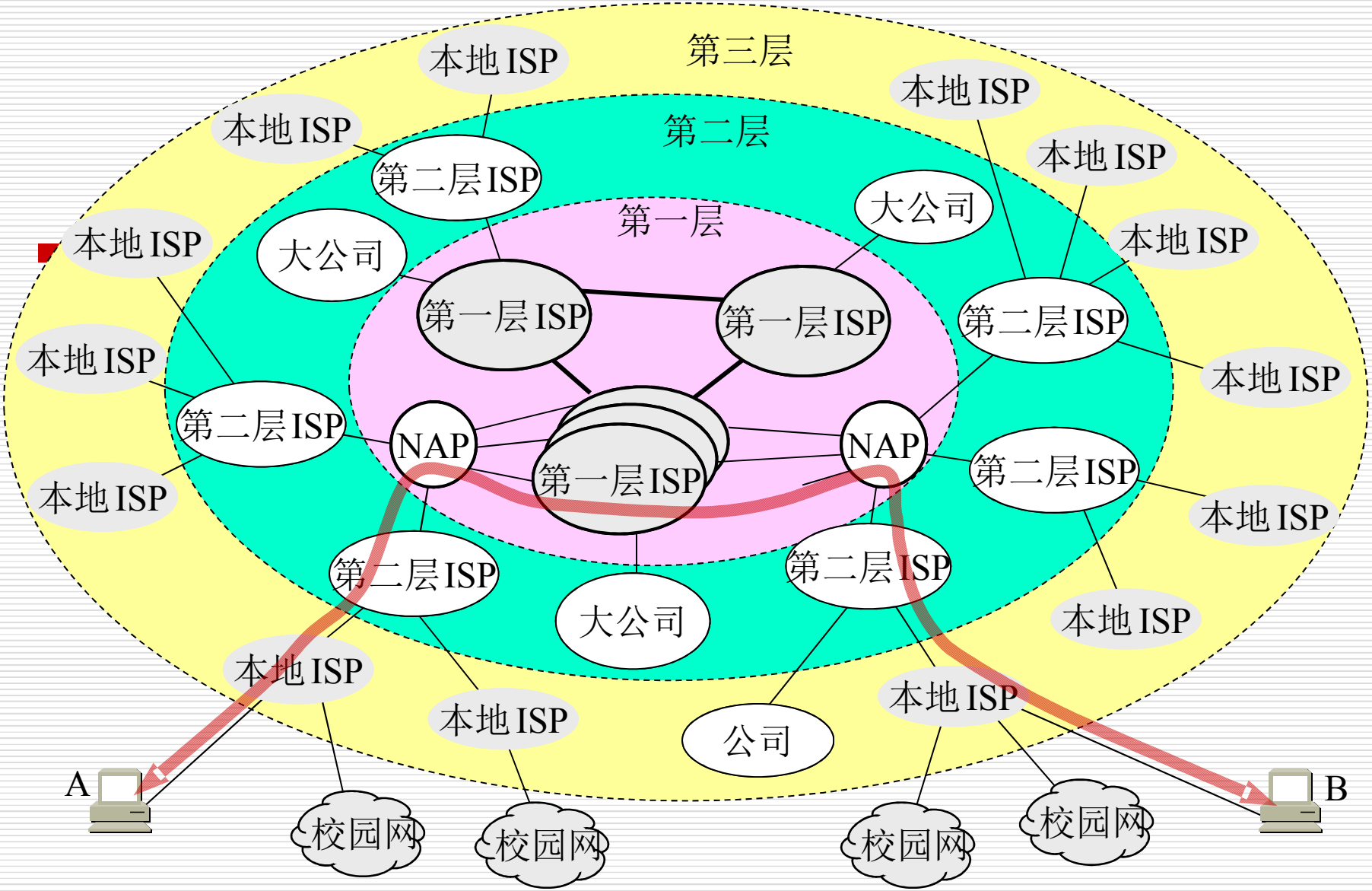
- Internet
  - The largest, open, interconnected computer network in the world.
  - TCP/IP is the reference model of Internet
  - Evolved from ARPANET



Internet with Multi-layer ISP structure

- Internet Service Providers (ISP)



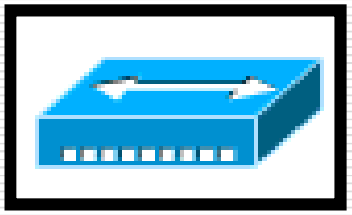


主机A → 本地 ISP → 第二层 ISP → NAP → 第一层 ISP → NAP → 第二层 ISP → 本地 ISP → 主机B

Internet with Multi-layer ISP structure

LAN Devices

Hub

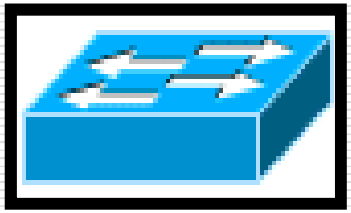


- Multiport repeater, connects PCs; Repeats signals

Bridge

- LAN segmentation; MAC addresses.

Switch



- Multiport-bridge; Full bandwidth

Router

- Path determination; Packet switching

WAN Devices

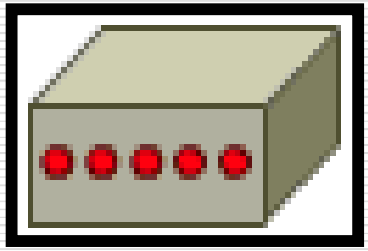
Router

- Path determination; Packet switching

Modem

CSU/DSU

TA/NT1



- Analog to Digital; Remote LAN connections

LAN Services and WAN Services

- LAN service: Ethernet, the most popular service
- WAN services...
  - Modem
  - ISDN
  - DSL
  - Frame Relay
  - ATM
  - T1/E1
  - T3
  - STS-1, STS-3, STS-48 (SONET/SDH)

Data

- Data is sent in bits, 1s and 0s.
- Data is not the information itself
- Data is an encoded form of information which is a series of electrical impulses/optical signals into which information is transmitted for sending

Protocol

- It is possible for different types of computer systems to communicate
- All devices must speak the same "language" or use the same ***protocol*** (use same set of rules).

Data Packets

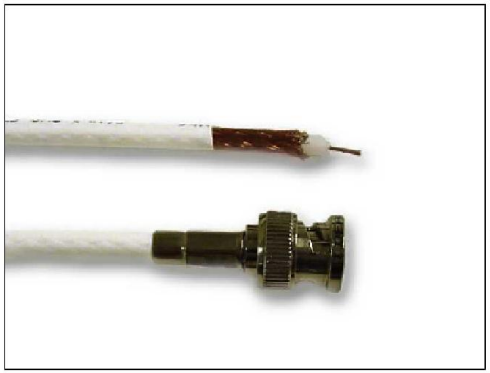
- For transmission, computer data is often broken into small, easily transmitted units
  - Using the OSI model, these units can be called packets, or frames or segments
- Why data packets?
  - Computers can take turns sending packets
  - If packet is lost, only small amount of data must be retransmitted.
  - Data can take different paths.

Source and Destination

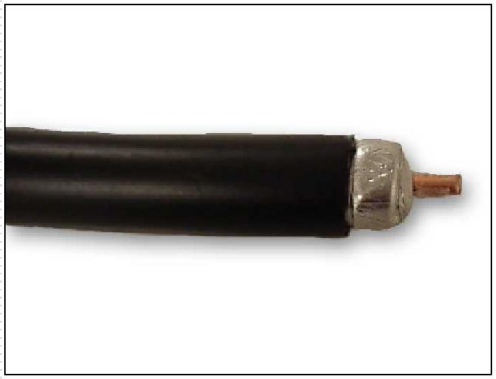
- Source address specifies the identity of the computer sending the packet.
- Destination address specifies the identity of the computer designated to receive the packet.

Media Types

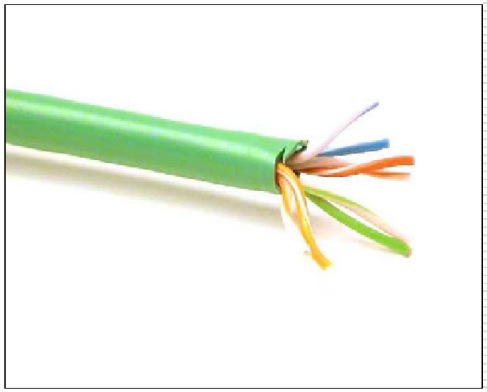
10BASE2 50 Ohm Coax Cable



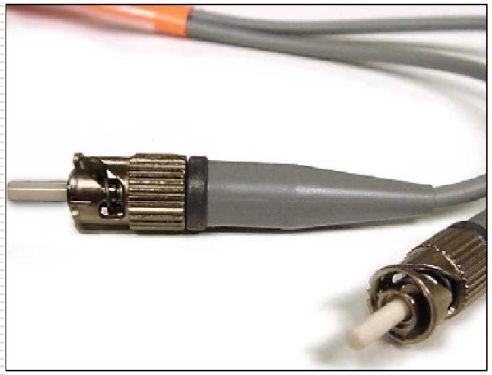
10BASE5 Thicknet Cable



UTP



Fiber Optic Cable Connectors



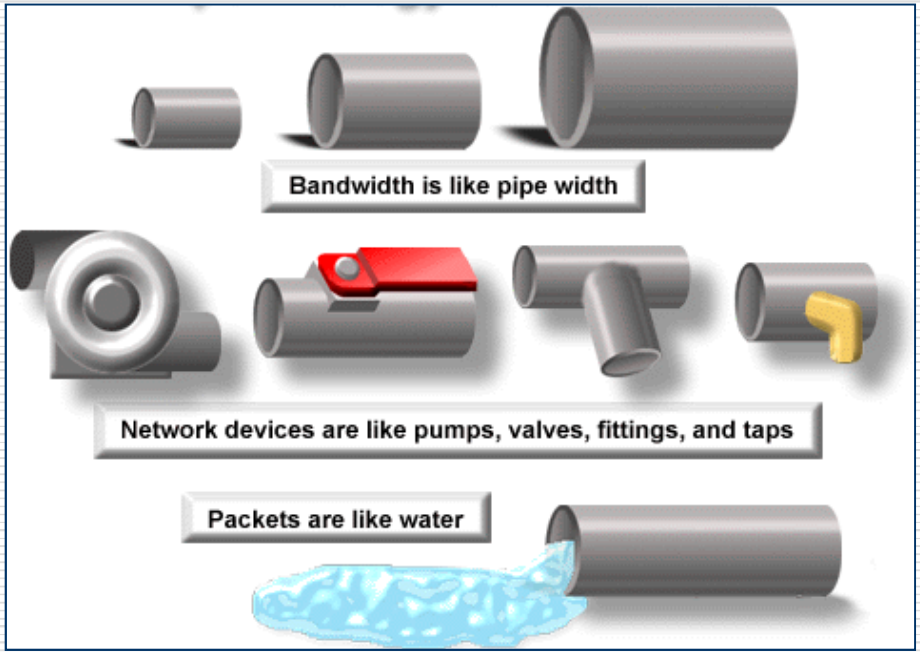
AIR
carries
light, radio,
microwave

Media—material through which data packets travel

Digital Bandwidth

- Bandwidth is the measure of how much information can flow from one place to another in a given amount of time.

Measured in:
bits/second (bps)



Throughput

Actual, measured, bandwidth, at a specific time

Throughput ≤ Bandwidth

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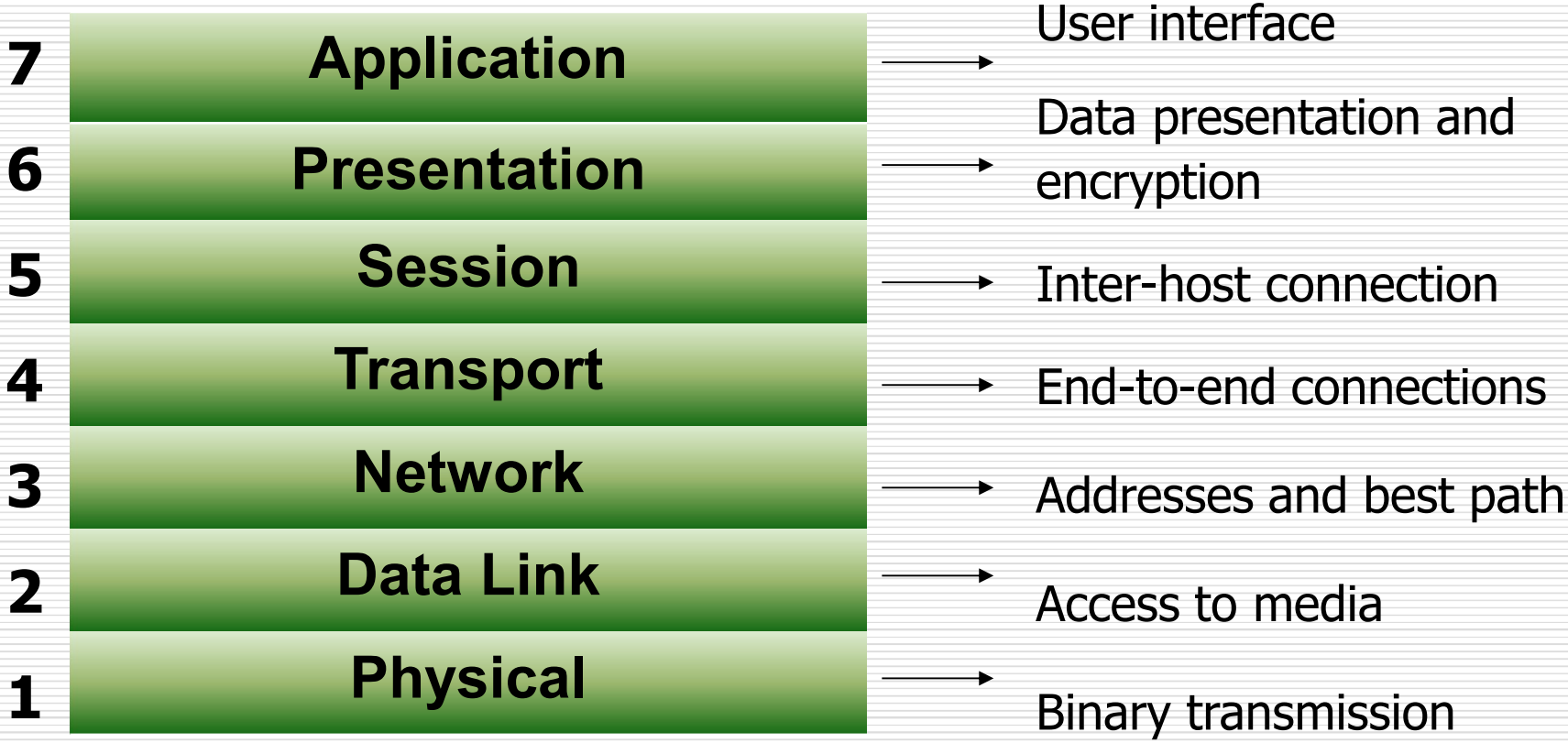
OSI (Open System Interconnection) Model

- Proposed by International Organization for Standardization (ISO)
- A network model that help network builders implement networks that could communicate and work together
- Describes how information or data moves from one computer through a network to another computer
- a ***layered*** communication process
  - Each layer performs a specific task

The OSI Reference Model

Each layer has a unique function.



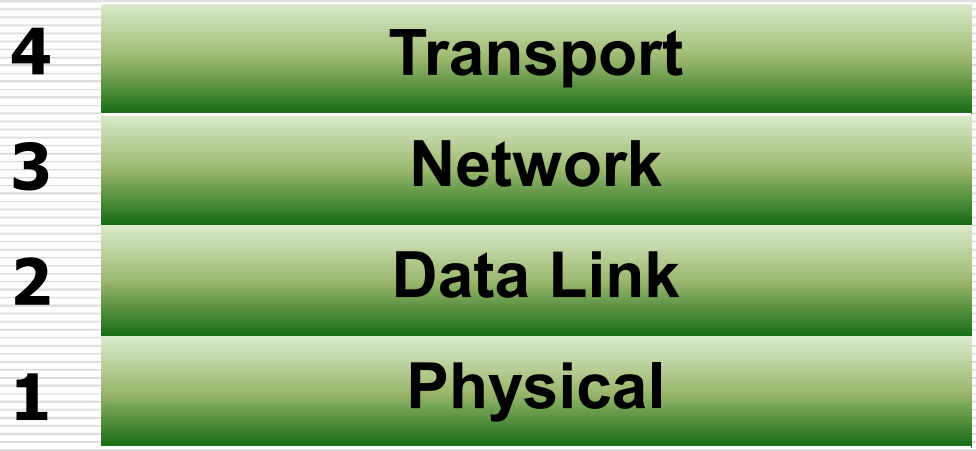
Why a Layered Model?

- Reduce Complexity
- Standardizes interfaces
- Facilitates modular engineering
- Ensures interoperable technology
- Accelerates evolution
- Simplifies teaching and learning

The OSI Reference Model

- The top 3 layers are known as the ***application layers***
  - because they deal with the user interface, data formatting, and the application access.

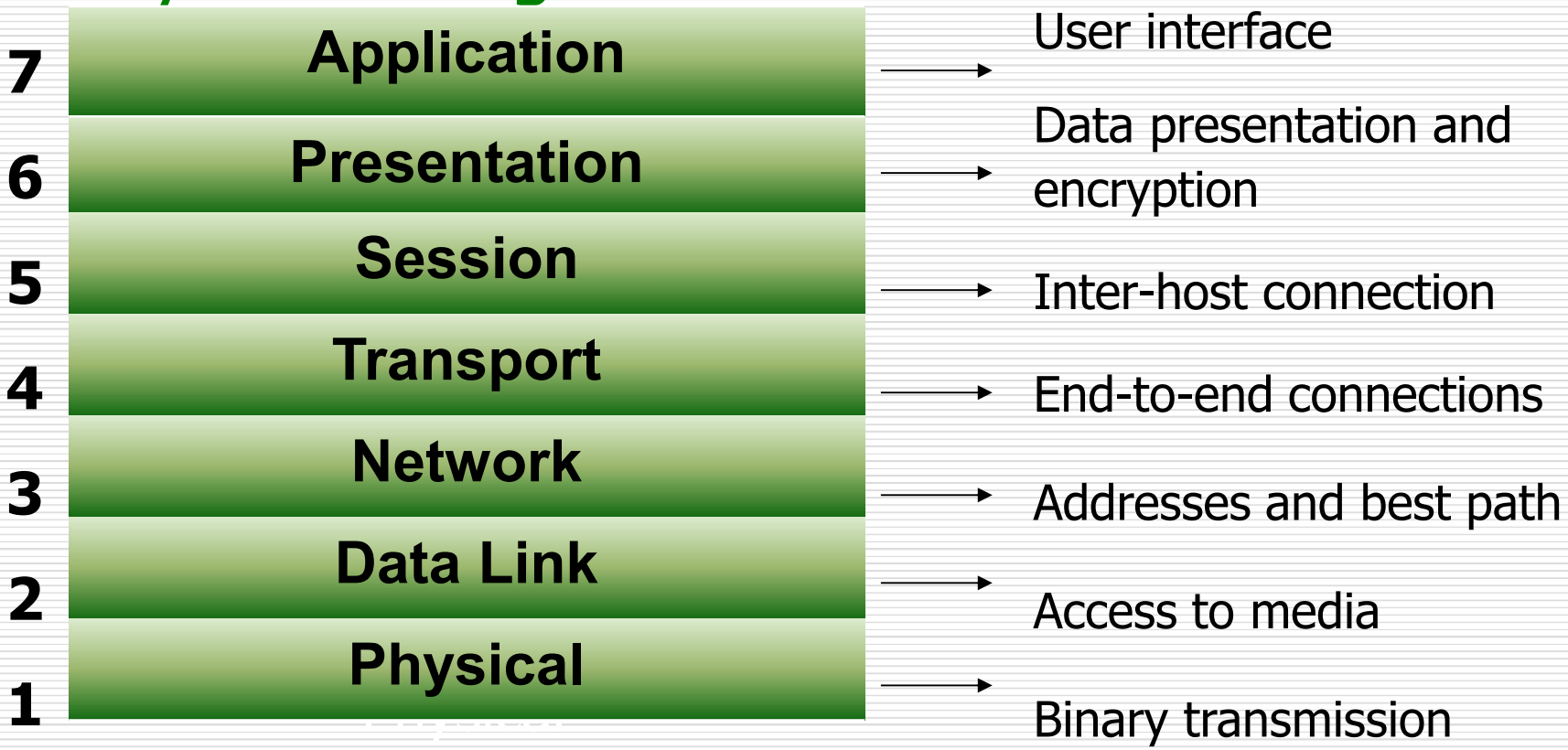
The OSI Reference Model



- Layers 1-4 are known as the ***data flow layers***
  - because they control the physical delivery of messages over the network.

Layer 1: The Physical Layer

Keywords: Signal and Media

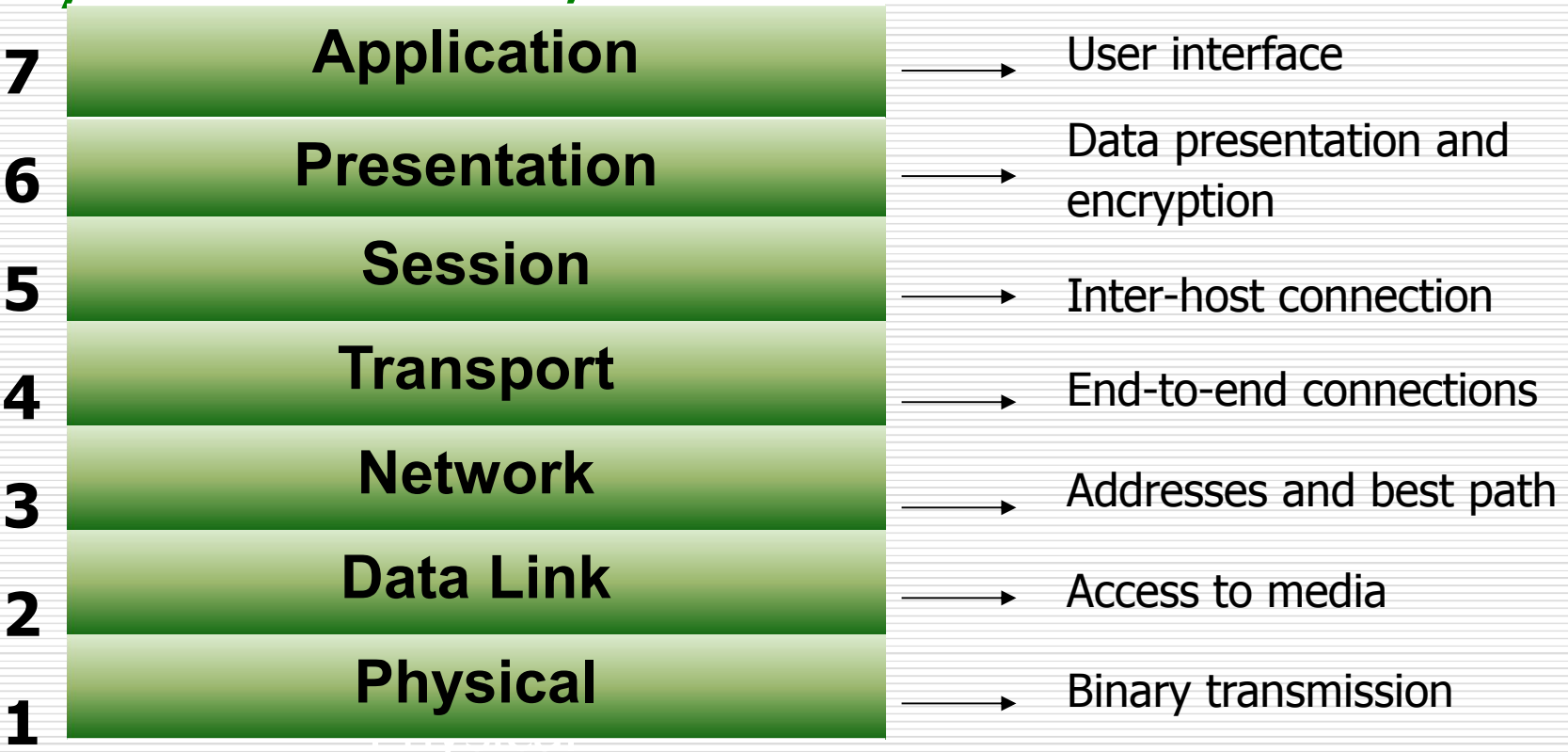


Layer 1: The Physical Layer

- defines the electrical and functional specifications for the link between end systems (including media)
- defines voltage levels, timing of voltage changes, physical data rates, maximum transmission distances, physical connectors, and other, similar attributes

Layer 2: The Data Link Layer

Keywords: frame, media access control

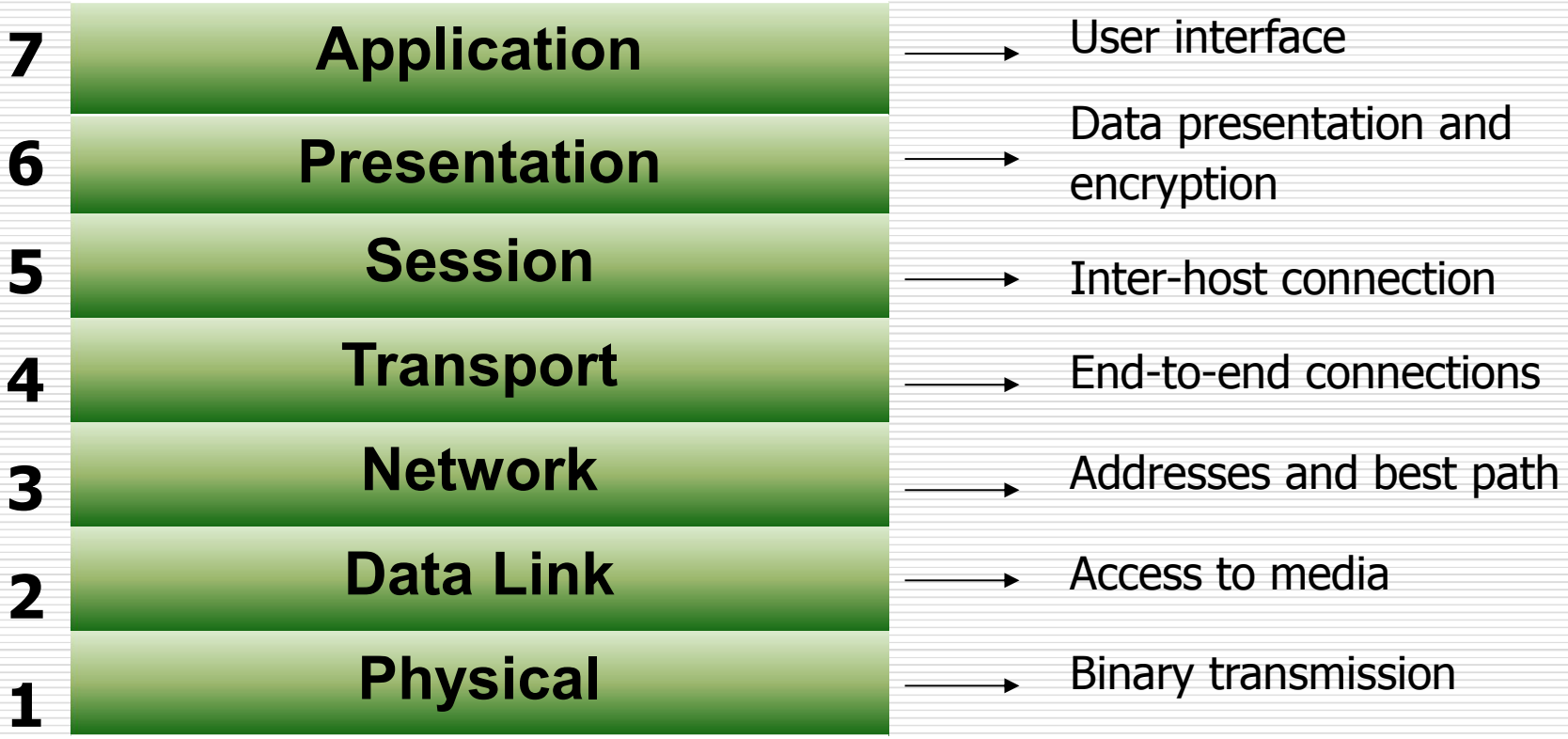


Layer 2: The Data Link Layer

- provides reliable transit of data across a physical link
- is concerned with physical (as opposed to logical) addressing, network topology, network access, error notification, ordered delivery of frames, and flow control

Layer 3: The Network Layer

Keywords: Path selection, Routing, Addressing

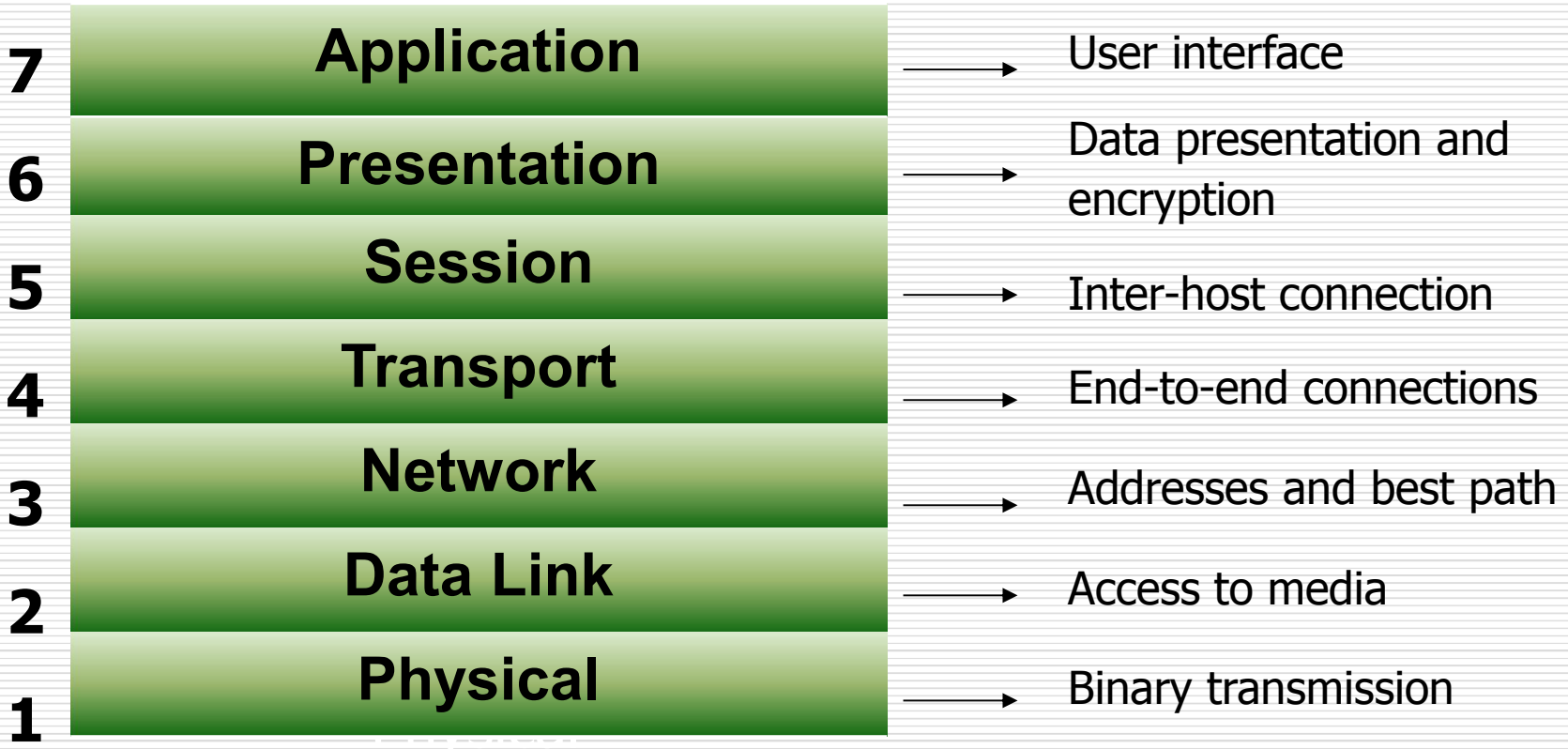


Layer 3: The Network Layer

- Provide connectivity and path selection between two end systems where routing occurs
- These may be located on geographically separated networks

Layer 4: The Transport Layer

Keywords: Reliability, Flow control, Error correction

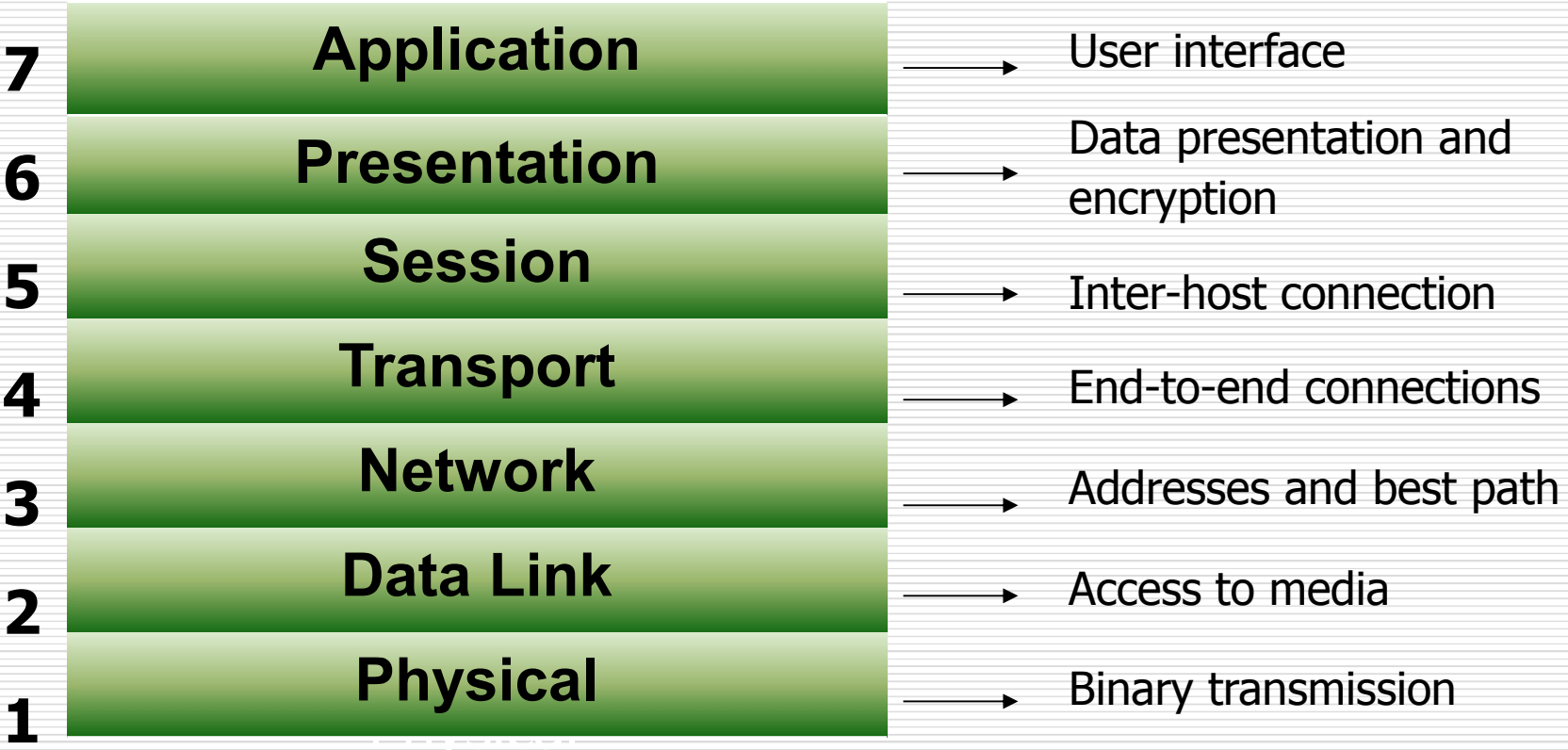


Layer 4: The Transport Layer

- segments and reassembles data into a data stream
- concerned with how reliable transport over an internetwork is accomplished
- responsible for reliable network communication between end nodes and provides mechanisms for the establishment, maintenance, and termination of virtual circuits, transport fault detection and recovery, and information flow control

Layer 5: The Session Layer

Keywords: Dialog and Conversations

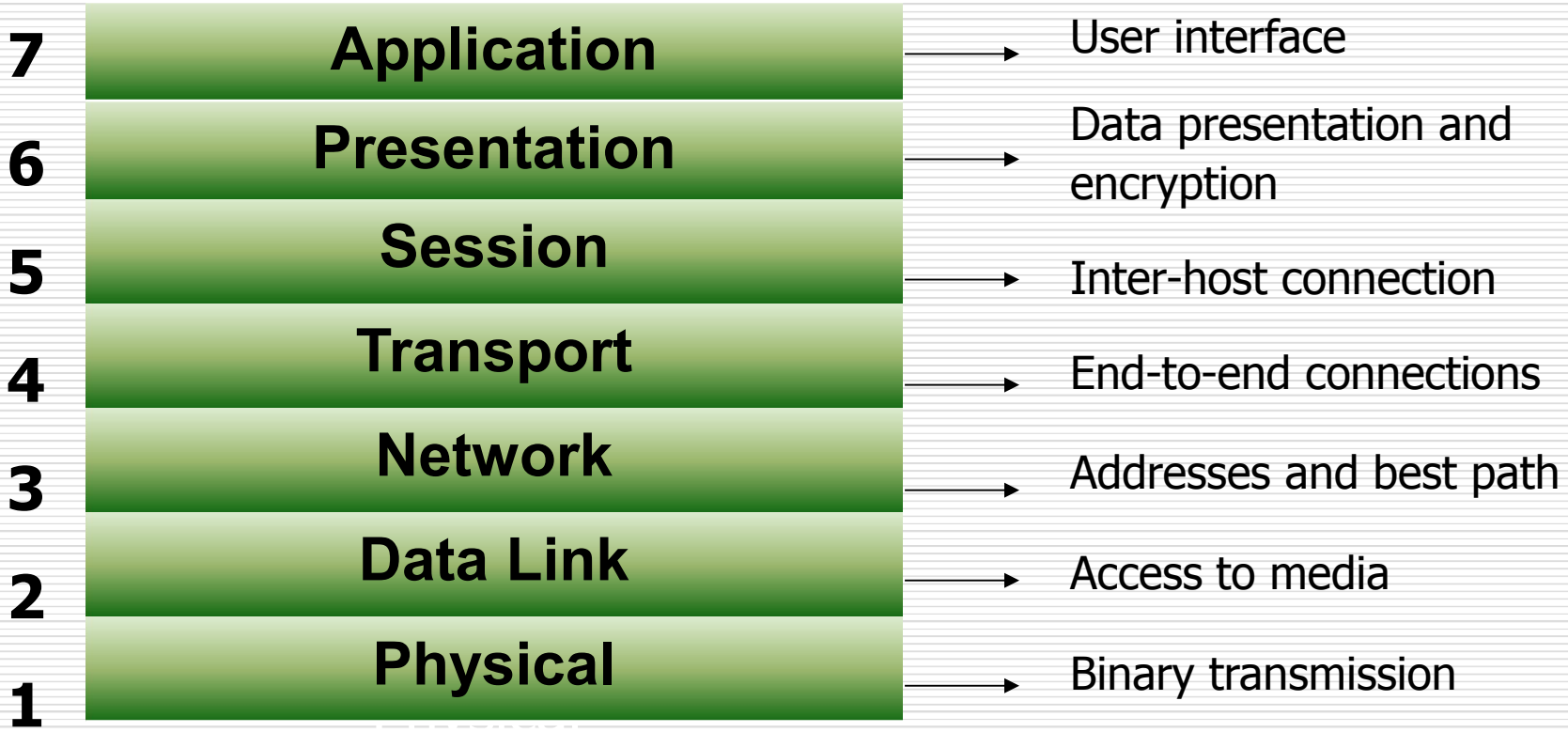


Layer 5: The Session Layer

- establishes, manages, and terminates sessions between communicating hosts
- synchronizes dialog between presentation layer entities and manages their data exchange
- offers provisions for efficient data transfer, class of service, and exception reporting of session, presentation, and application layer problems
- manages data exchange between presentation layer entities

Layer6: The Presentation Layer

Keywords: Common Format

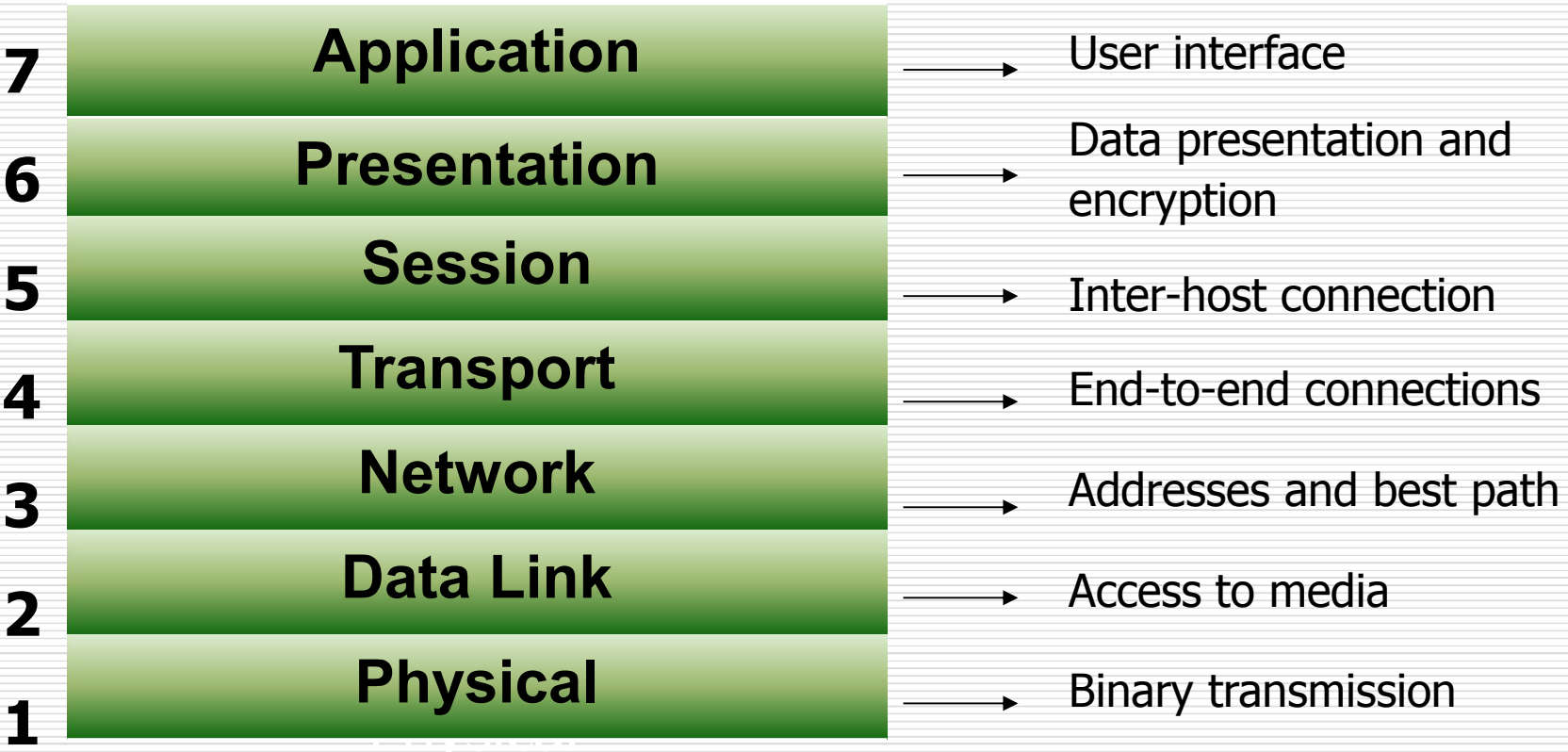


Layer6: The Presentation Layer

- ensures that information sent by the application layer of one system is readable by the application layer of another system
- translates between multiple data representation formats by using a common data representation format
- concerned with data structures and negotiation of data transfer syntax
- responsible for compression and encryption

Layer 7: The Application Layer

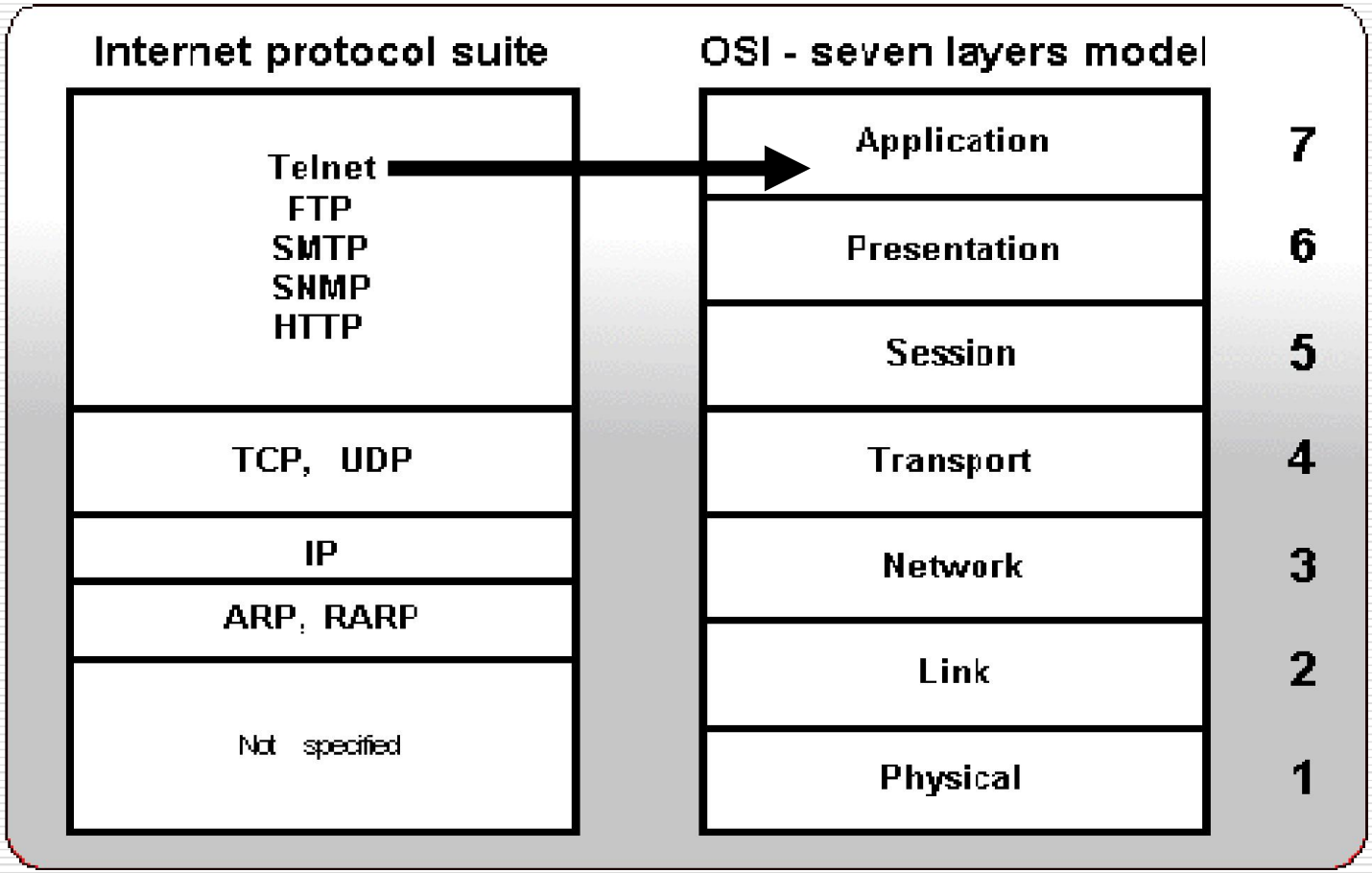
Keyword: Browser



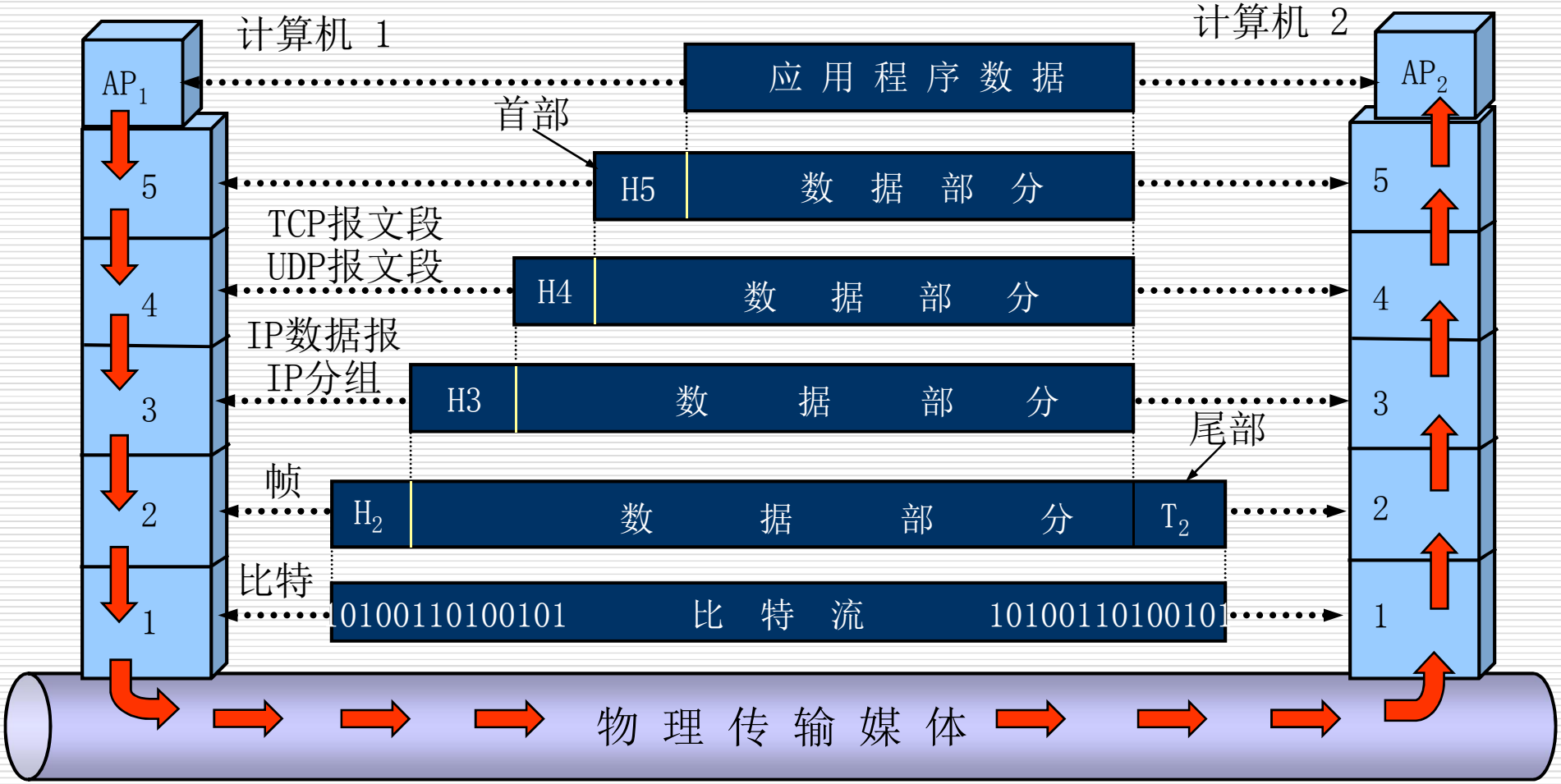
Layer 7: The Application Layer

- closest to the user
- provides network services to user applications
- does not provide services to any other OSI layer

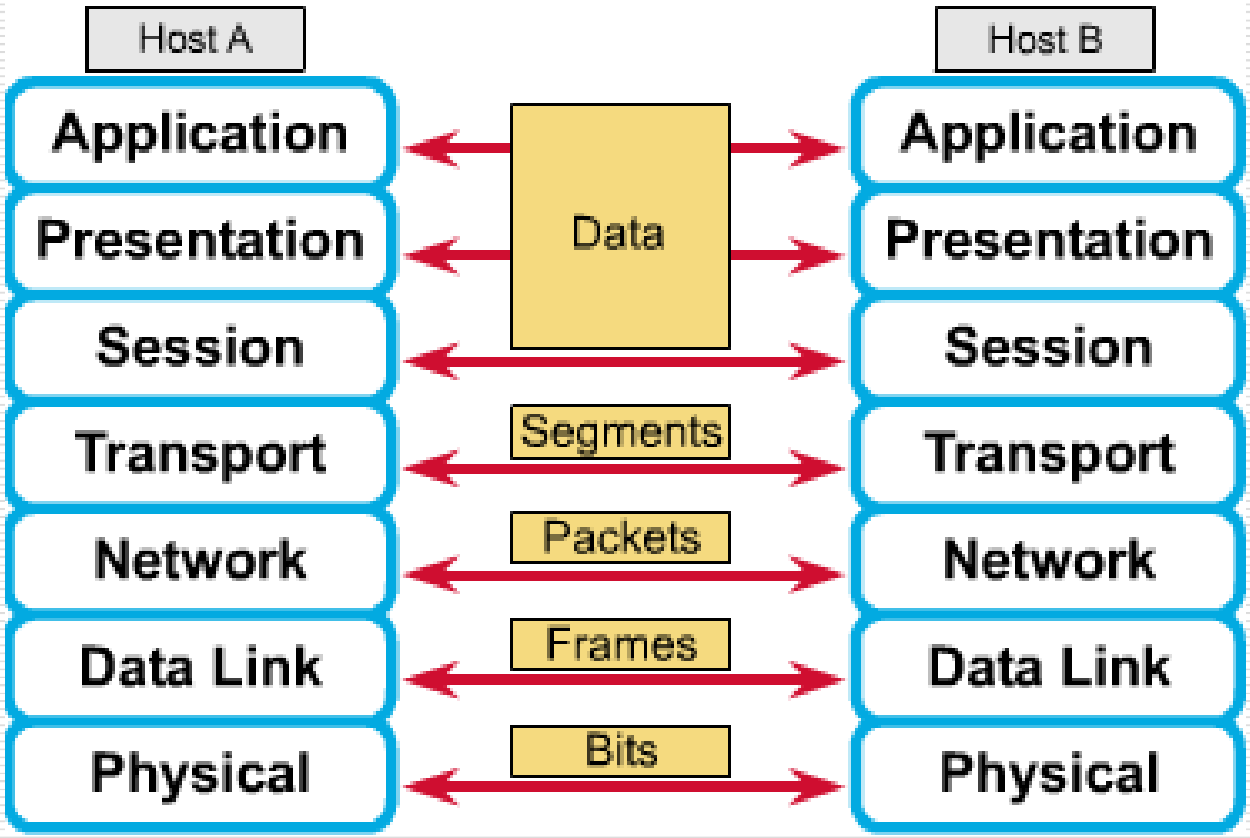
Protocols on ISO layers



Data Encapsulation



Peer-to-Peer Communications



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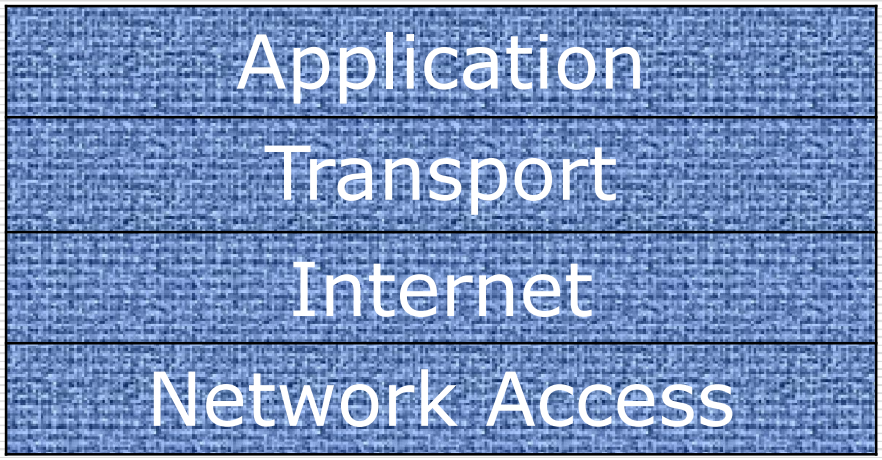
The TCP/IP Model

- The U.S. Department of Defense (*DoD*) created the TCP/IP reference model
- The DoD wants its packets to **get through every time, under any conditions, from any one point to any other point**.
- It brought about the creation of the TCP/IP model
- TCP/IP model has since become the standard on which the Internet has grown

The TCP/IP Model

- The TCP/IP model has only four layers.



The TCP/IP Model - Application Layer

- Handles high-level protocols, issues of representation, encoding, and session control
- TCP/IP combines all application-related issues into one layer, and assures this data is properly packaged for the next layer.

The TCP/IP Model - Transport Layer

- Deals with the quality-of-service issues of **reliability, flow control, and error correction**.
  - **Transmission Control Protocol (TCP)**
  - **User Datagram Protocol(UDP)**
  - It package application layer information into units called **segments**

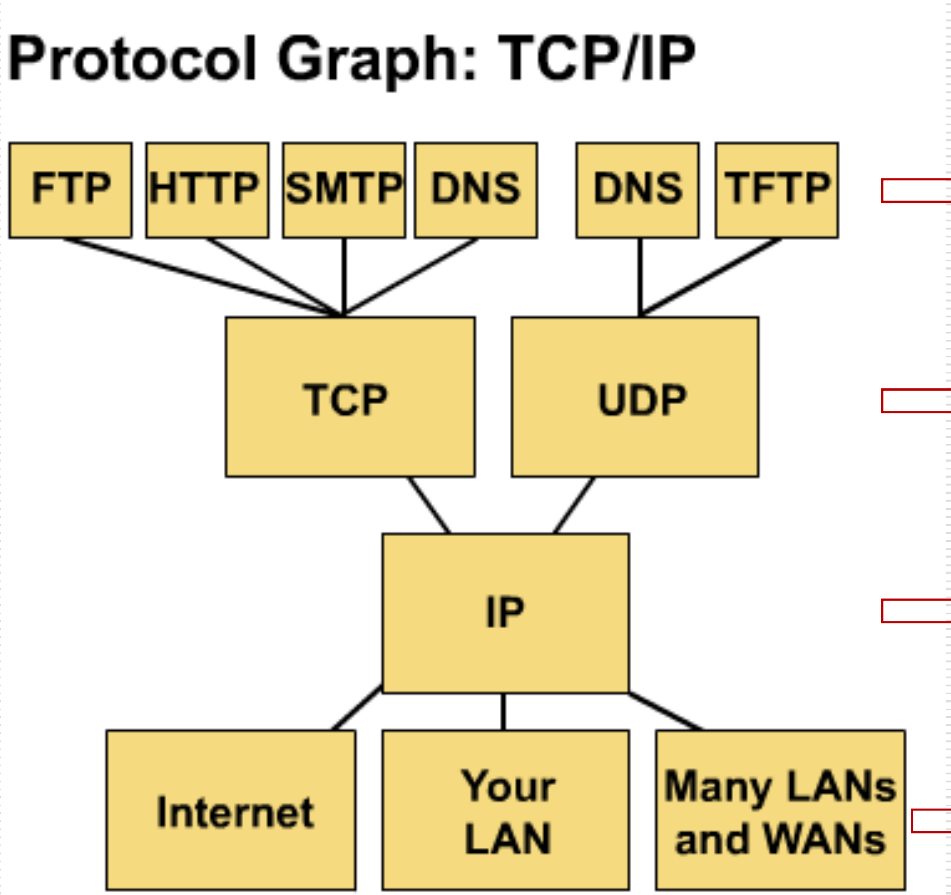
The TCP/IP Model - Internet Layer

- Purpose: Send source packets from any network on the internetwork and have them arrive at the destination **independent of the path and networks**
- **Best path determination** and **packet switching** occur at this layer
- **Internet protocol (IP)**

The TCP/IP Model – Network Access Layer

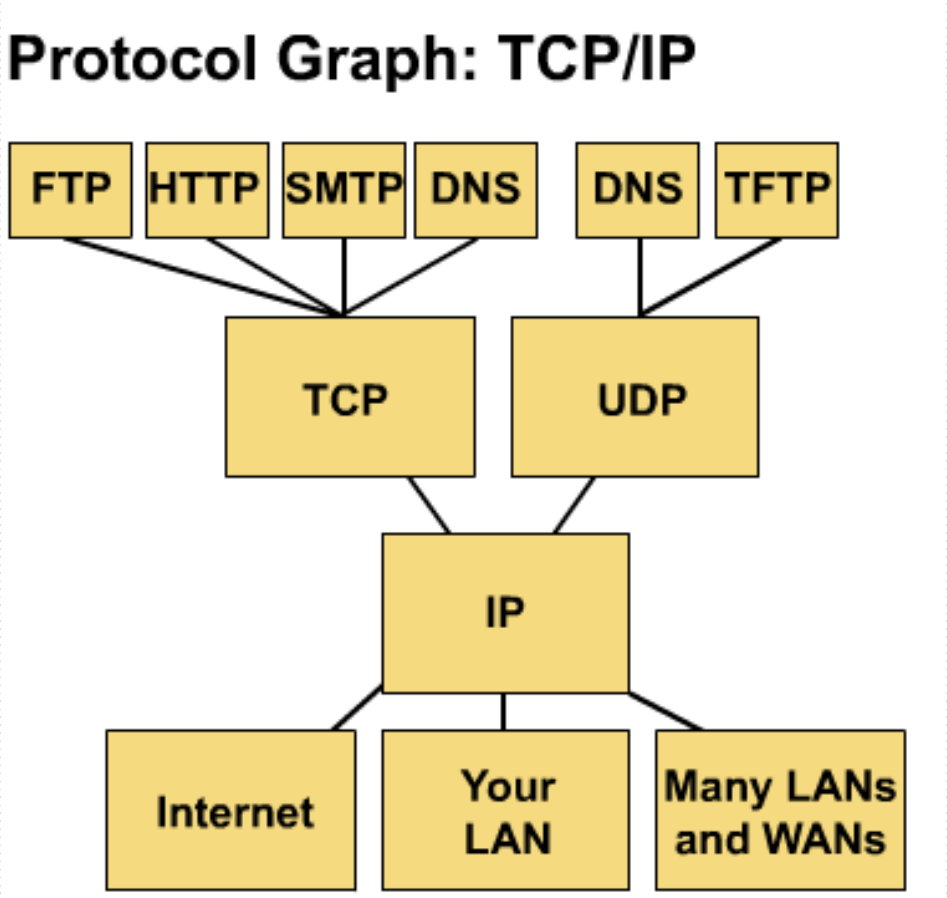
- Is also called the ***host-to-network* layer**.
- It is concerned with all of the issues that an IP packet requires to actually make a physical link, and then to make another physical link.
- It includes the LAN and WAN technology details, and all the details in the OSI physical and data link layers.

Common TCP/IP Protocols



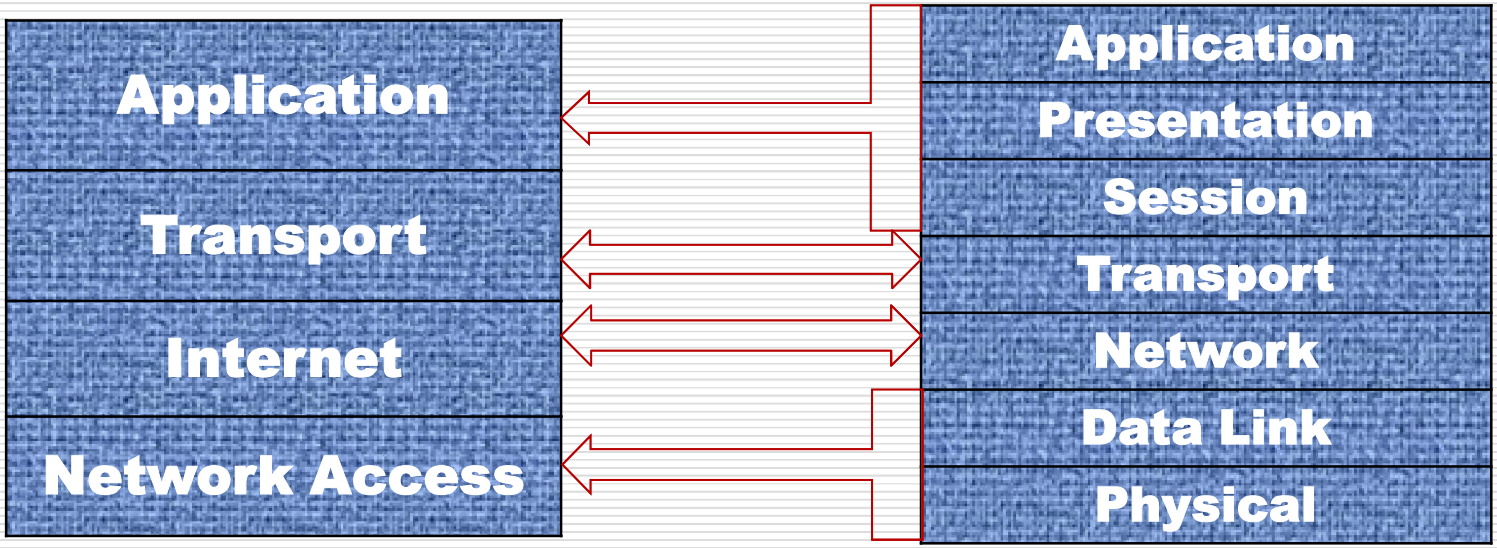
- Application Layer
- Transport Layer
- Internet Layer
- Network Access Layer

Common TCP/IP Protocols



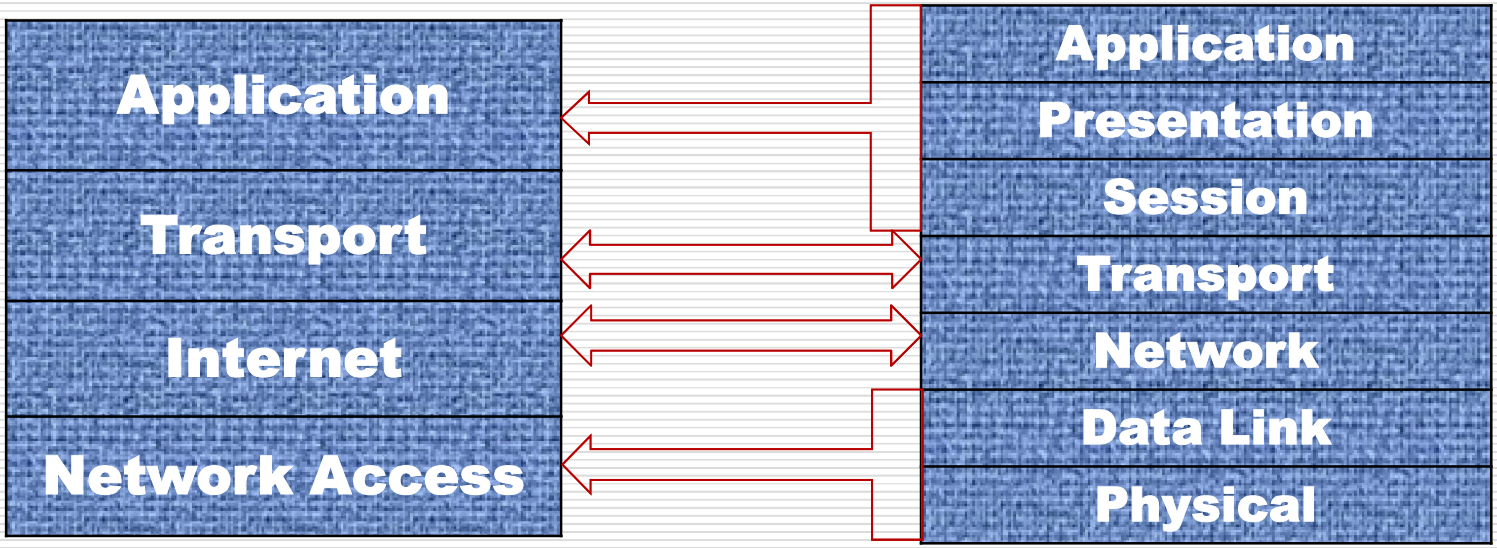
- *FTP* - File Transfer Protocol
- *HTTP* - Hypertext Transfer Protocol
- *SMTP* - Simple Mail Transfer protocol
- *DNS* - Domain Name System
- *TFTP* - Trivial File Transfer Protocol

Similarities of TCP/IP and OSI



- both have layers, networking professionals need to know both
- both have application layers, though they include very different services
- both have comparable transport and network layers
- packet-switched (not circuit-switched) technology is assumed

Differences of TCP/IP and OSI



- TCP/IP appears simpler because it has fewer layers
- TCP/IP protocols are the standards around which the Internet developed, so the TCP/IP model gains credibility just because of its protocols.
- Typically networks aren't built on the OSI protocol, even though the OSI model is used as a guide.

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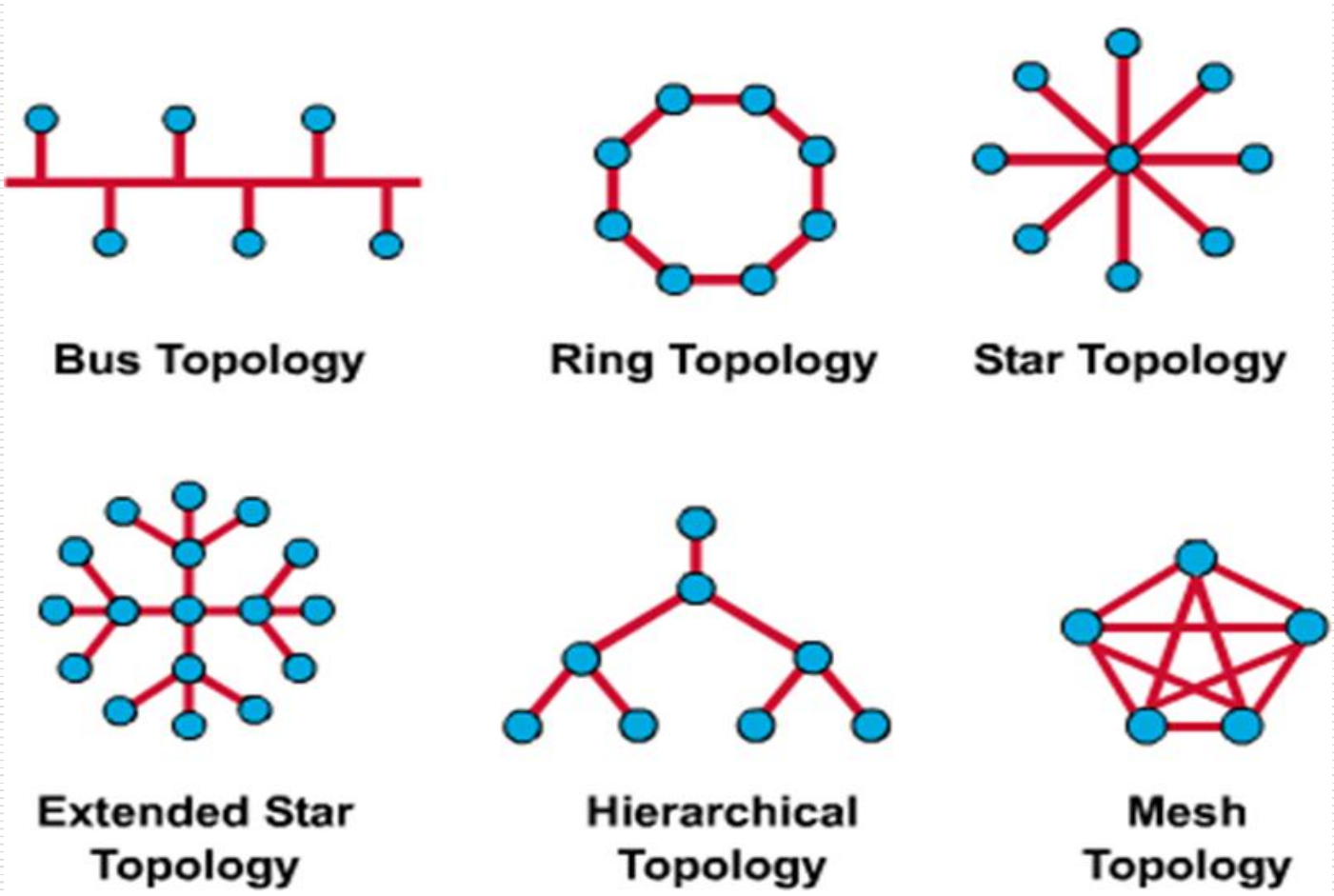
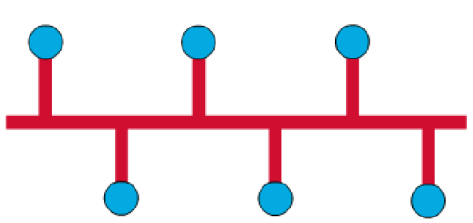
Topology

- Defines the structure of the network
- Physical topology: the actual layout of the wire (media)
  - bus, star, ring, extended star, hierarchical, mesh
- Logical topology: defines how the media is accessed by the hosts
  - token passing

Network Topologies



Network Topologies--Bus



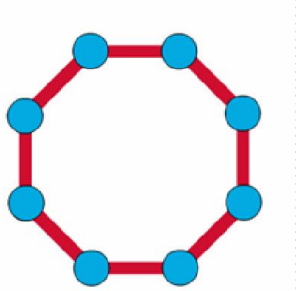
- **Physical Perspective**

  Each host is wired to a common wire.

  - Advantage: all hosts can communicate directly.
  - Disadvantage: A break in the cable disconnects hosts from each other.

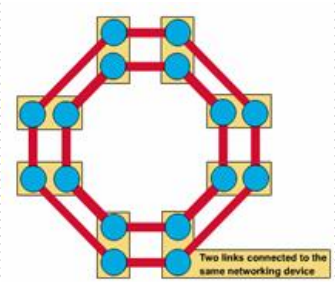
- **Logical Perspective**
  - Every networking device to see all signals from all other devices (advantage?)

Network Topologies--Ring



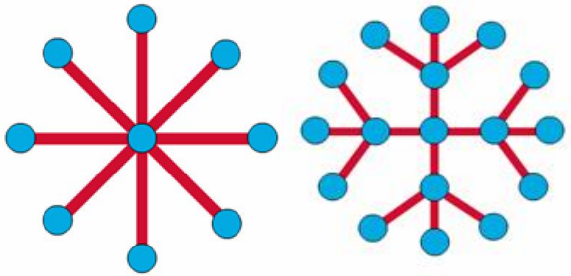
- **Physical Perspective**
  - All devices wired directly to each other in what is called a daisy-chain.
- **Logical Perspective**
  - In order for information to flow, each station must pass the information to its adjacent station.

Network Topologies — Dual Ring



- **Physical Perspective**
  - A dual ring topology is the same as a ring topology, except that there is a second, redundant ring, that connects the same devices.
  - Advantages: provide reliability and flexibility
- **Logical Perspective**
  - A dual ring topology acts like two independent rings, of which, only one at a time is used.

Network Topologies—Star



- Physical Perspective

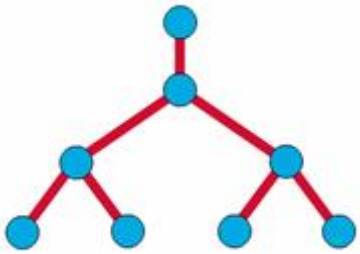
  A star topology has a central node with all links radiating from it.

  - Advantage: it allows all other nodes to communicate with each other, conveniently. It also might be desirable for security or restricted access reasons
  - disadvantage: if the central node fails, the whole network becomes disconnected. Depending on the type of networking device used, collisions can be a problem.

- Logical Perspective

  The flow of all information would go through one device.

Network Topologies—Tree

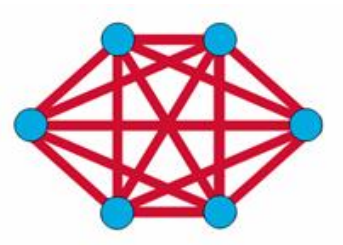


- The tree topology uses a trunk node from which it branches to other nodes.
  - binary tree (each node splits into two links)
  - backbone tree (a backbone trunk has branch nodes with links hanging from it).
- **Physical Perspective**

  The trunk is a wire that has several layers of branches.
- **Logical Perspective**

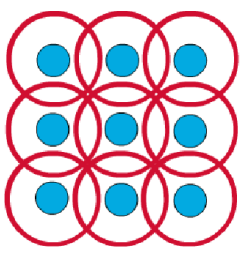
  The flow of information is hierarchical.

Network Topologies—Complete (Mesh)



- Physical Perspective
  - has distinct advantages and disadvantages
    - Advantage: the maximum connectivity and reliability.
    - Disadvantage: the amount of media for the links, and the amount of connections to the links becomes overwhelming.
- Logical Perspective
  - The behavior of a complete, or mesh topology depends greatly on the devices used.

Network Topologies—Cellular



- Physical Perspective
  - The cellular topology is for wireless technology
  - Sometimes the receiving nodes move (e.g. cell phone), and sometimes the sending nodes move (e.g. satellite)
- Logical Perspective
  - Nodes communicate with each other directly (though sometimes extremely difficult), or communicate only with their adjacent cells, which is extremely inefficient.

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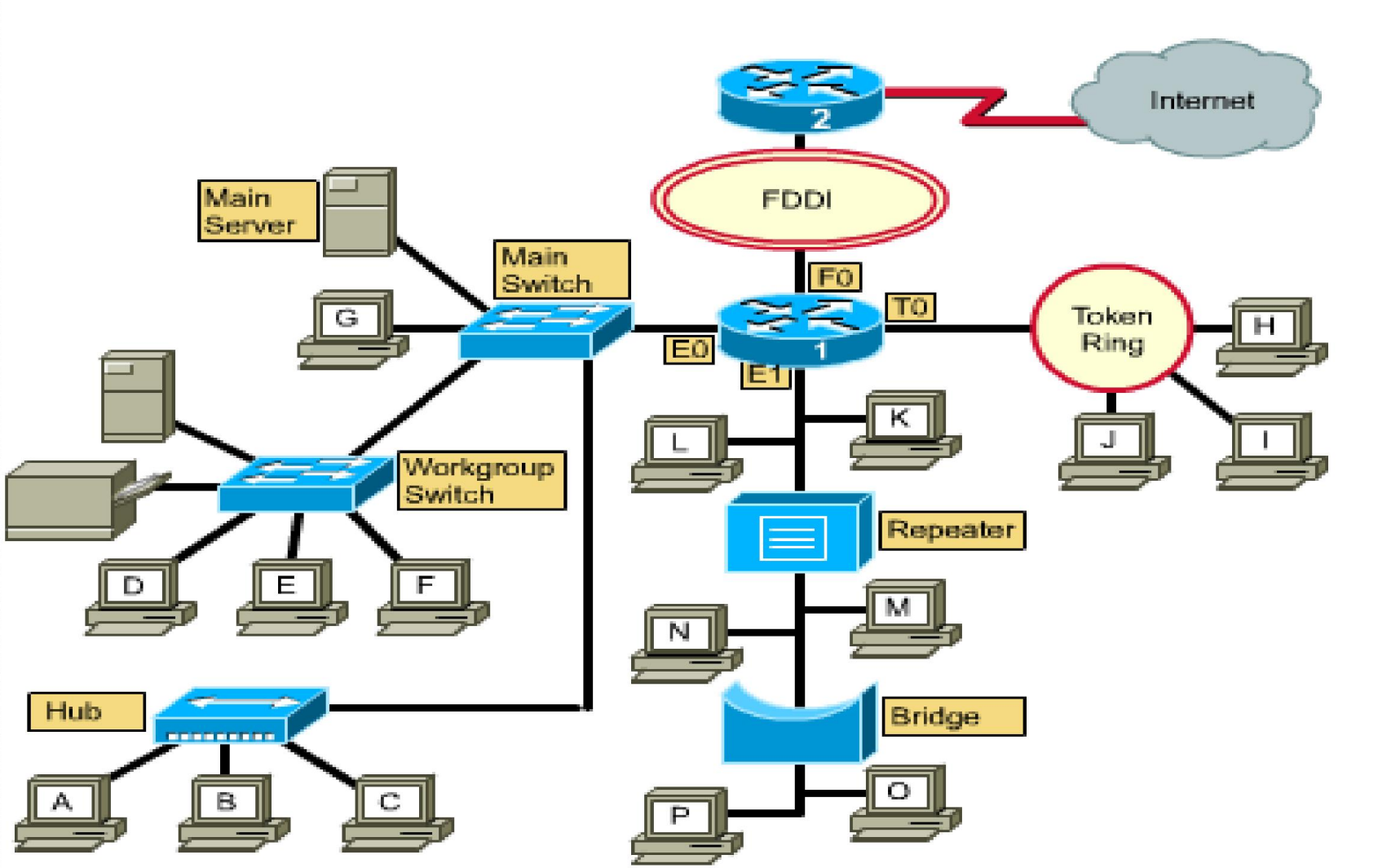
- Overview of Computer Network
- OSI Reference Model
- TCP/IP Model
- Network Topology
- Network Devices

LAN Devices in a Topology

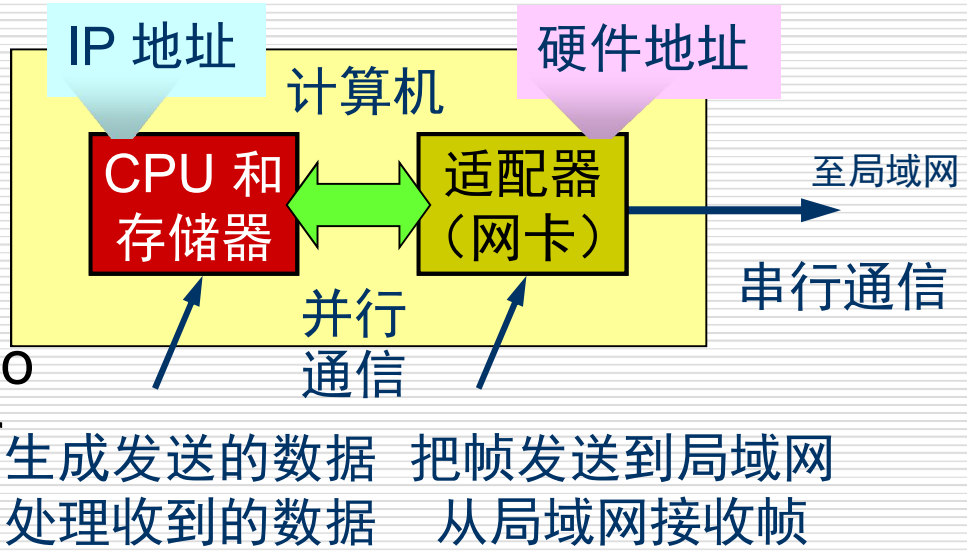
- Hosts—devices connected directly to network segment
  - printers, computers, servers, FAX, copier
- Hosts—not part of any layer, but the functions of the OSI model are performed in software inside host

LAN Devices in a Topology



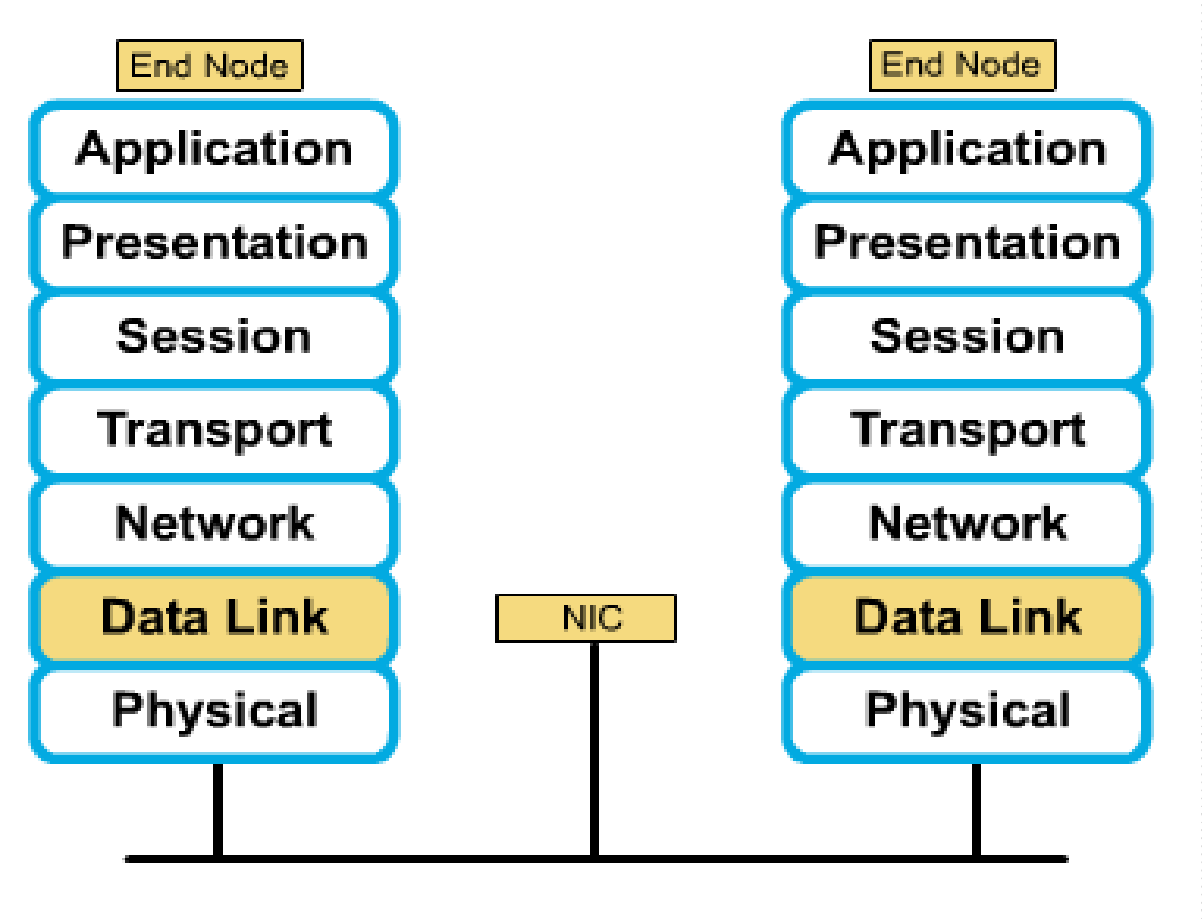
NICs – Layer 2

- Carries a unique code called a MAC address
- Is used to control data communication for the host on the network
- Translates parallel signal produced by computer into serial format to send over the network
- Transceiver used to convert signals as well as send and receive bits



- Provides the host's access to the medium

NICs – Layer 2

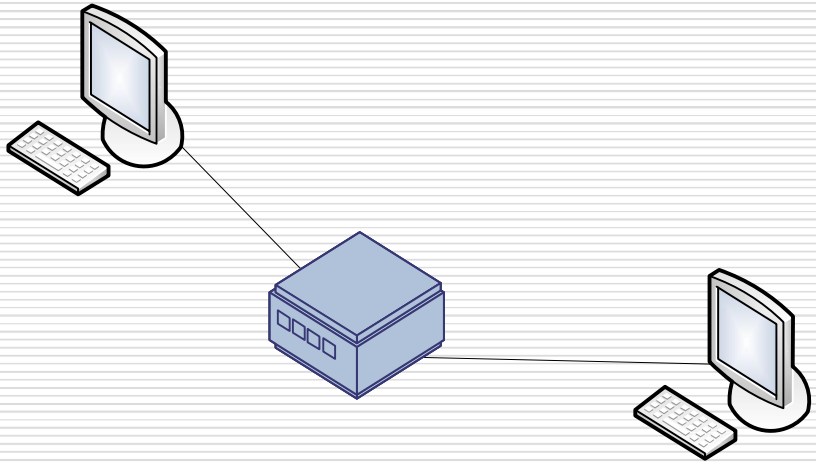

End Node
Application
Presentation
Session
Transport
Network
Data Link
Physical
NIC
End Node
Application
Presentation
Session
Transport
Network
Data Link
Physical

Media – Layer 1

- Carries a flow of information in bits
- The means by which signals travel from one networked device to another

Repeaters – Layer 1

- used to extend the length of the network
- clean, amplify, and resend signals that are weakened by long cable



- regenerate (amplify) and retime network signals at the bit level to allow them to travel a longer distance on the media
- perform no filtering

Hubs – Layer 1

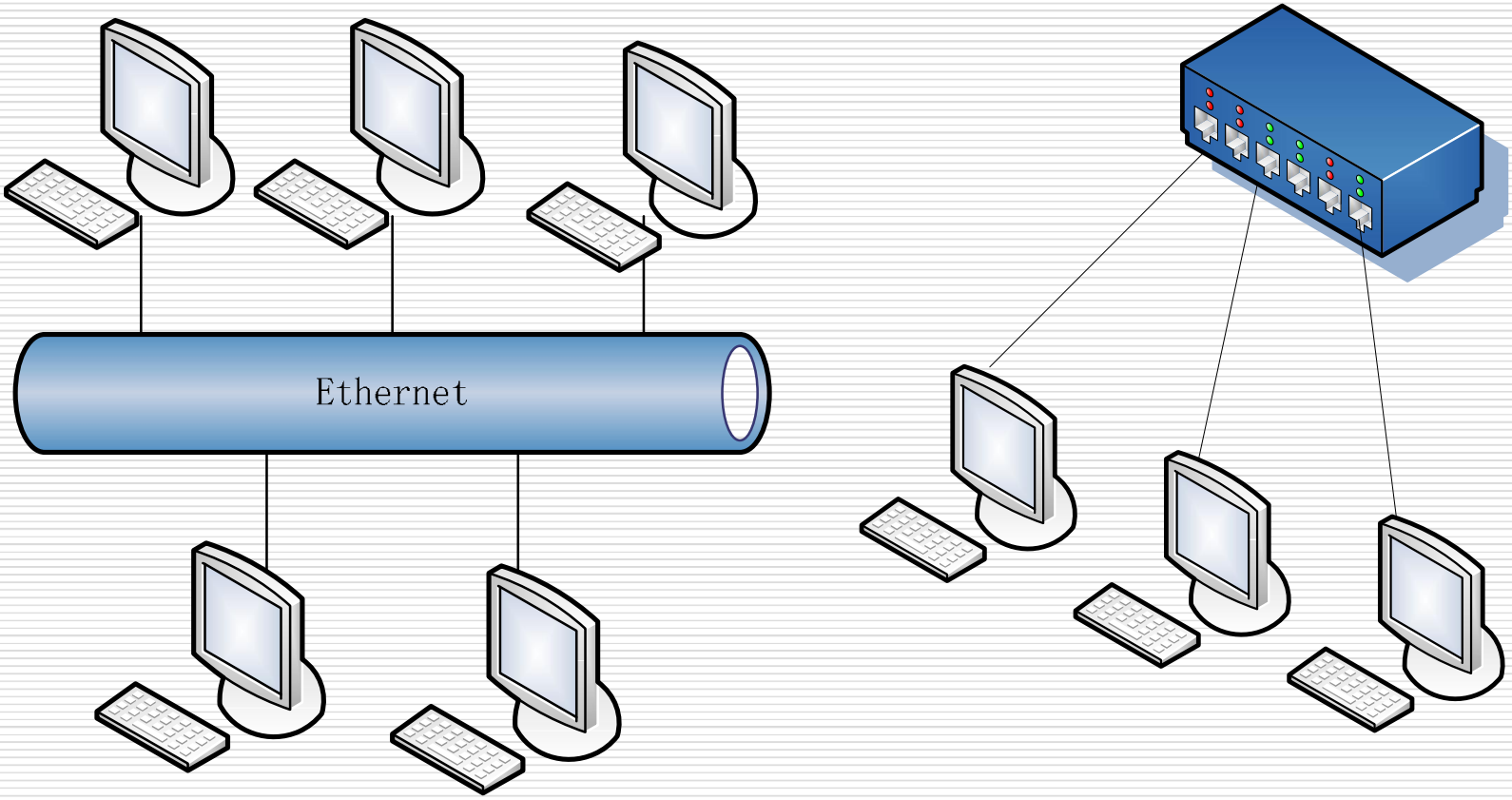
- used to regenerate and retime network signals
- propagate signals
- cannot filter traffic
- cannot determine the best path
- used as network concentration points

- sometimes called multiport repeaters

Repeaters/Hubs - Differences

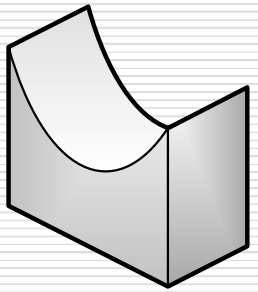
- Repeater typically has only two ports and a hub generally has from four to twenty or more ports.
- Repeater receives on one port and repeats on the other, while hubs receive on one port and transmit on all other ports.
- Hubs most commonly found in Ethernet 10Base T or 100Base T networks.

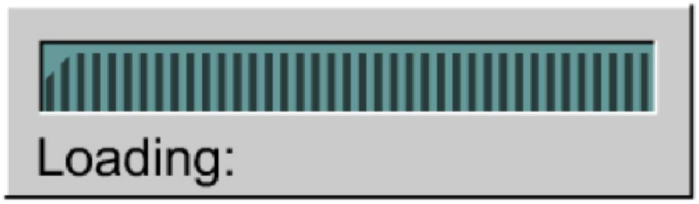
Hub



Bridges – Layer 2

- purpose is to filter traffic on a LAN—to keep traffic local—yet allow connectivity to other segments of the LAN for traffic that is directed there
- keep track of MAC addresses that are on each side of the bridge and make decisions based on this MAC address list
- more intelligent than hubs
- collect and pass packets between segments
- create collision domains
- maintain address tables

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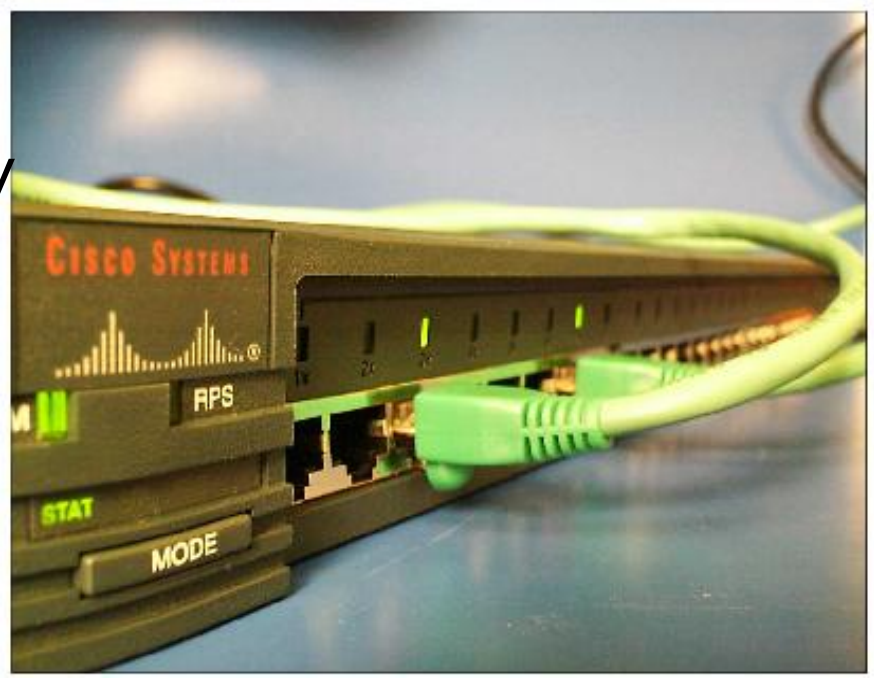
Switches – Layer 2

- used to concentrate connectivity
- combine the connectivity of a hub with the traffic regulation of a bridge
- switch frames from incoming ports to outgoing ports providing each port with full bandwidth
- provide separate data paths

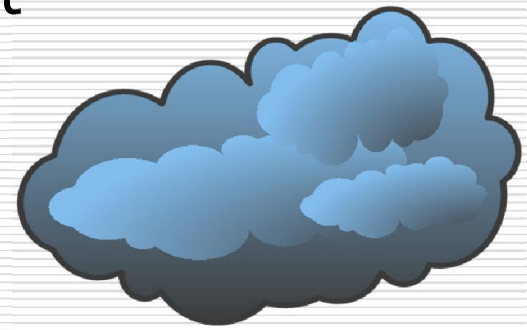


Routers – Layer 3

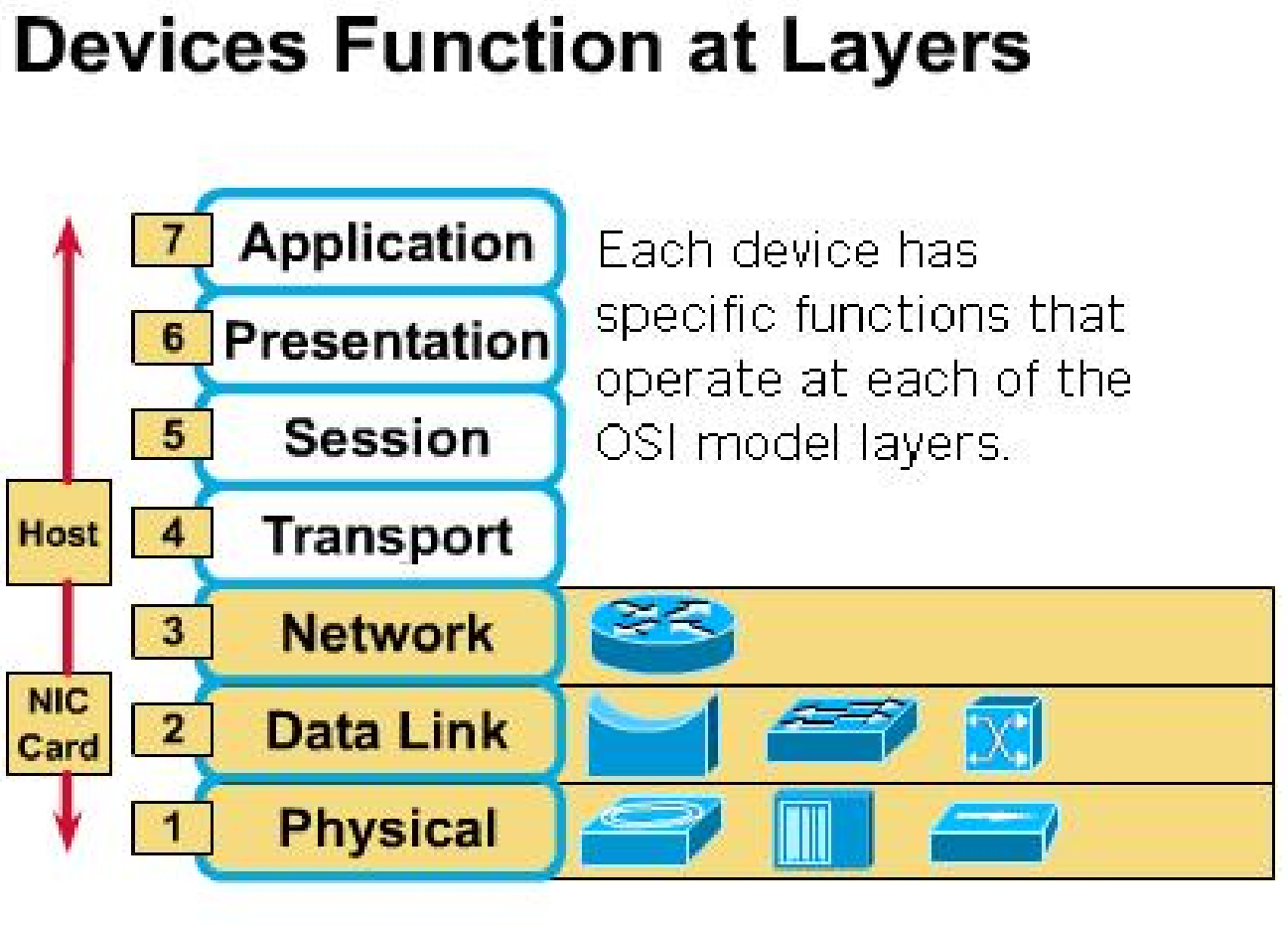
- important traffic-regulating device in large networks
- Make decisions based on network addresses
- examine packets (Layer 3 data), choose the best path for them, and then switch them out the proper outgoing port
- two primary purposes: path selection and switching of packets to best route

Clouds – Layers 1-7

- all the devices that connect your computer to some very distant com-puter, perhaps on another continent
- contain NICs, switches, bridges, routers, gateways, and other net-working devices



Evolution of Networking Devices and the OSI Layers



Evolution of Networking Devices and the OSI Layers

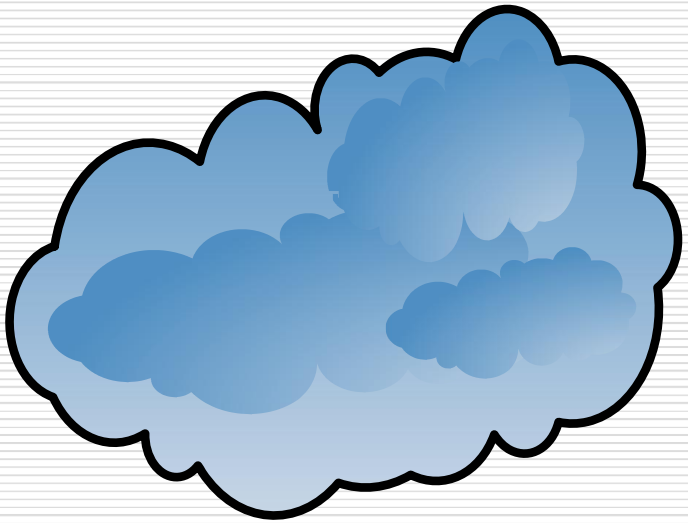
- hosts and servers operate at Layers 1 – 7; they perform the *encapsulation* process
- transceivers, repeaters, and hubs are all considered active Layer 1 devices because they act only on *bits* and require energy
- patch cables, patch panels, and other interconnection components are considered passive Layer 1 components because they simply provide some sort of conducting path

Evolution of Networking Devices and the OSI Layers

- NICs are Layer 2 devices because they are the location of the MAC address; but because they often handle signaling and encoding, they are also Layer 1 devices.
- Bridges and switches are Layer 2 devices because they use Layer 2 information to make decisions about whether to forward packets.
- Routers are Layer 3 devices because they use Layer 3 addresses to choose best paths and to switch packets to proper route.

Packet Flow Through Clouds

- NICs
- Switches
- Bridges
- Routers
- Gateways (protocol transformation)
- PCs
  (all devices that operate at all levels of the OSI model)



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