Networking Devices

Equipment that connects directly to a network segment is referred to as a device.

These devices are broken up into two classifications.

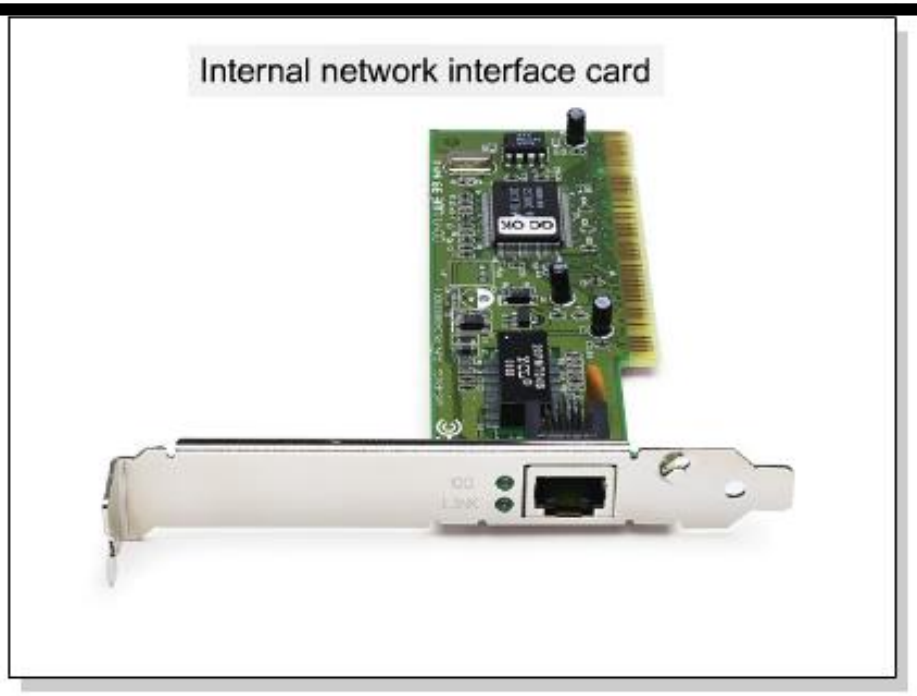
- End-user devices
- Network devices

End-user devices include computers, printers, scanners, and other devices that provide services directly to the user.

Network devices include all the devices that connect the end-user devices together to allow them to communicate.

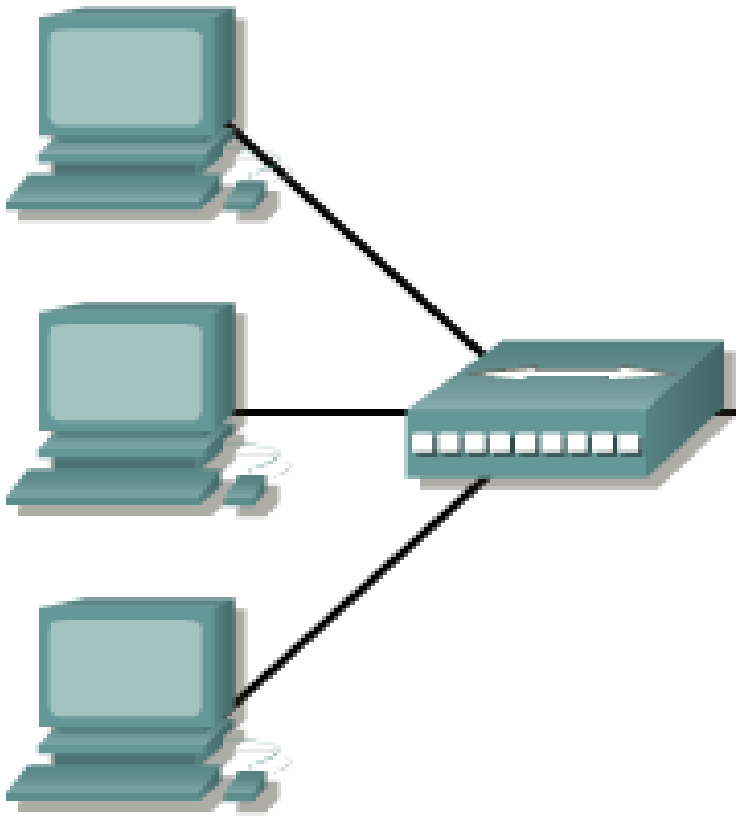
Network Interface Card (NIC)

A network interface card (NIC) is a printed circuit board that provides network communication capabilities to and from a personal computer. Also called a LAN adapter.



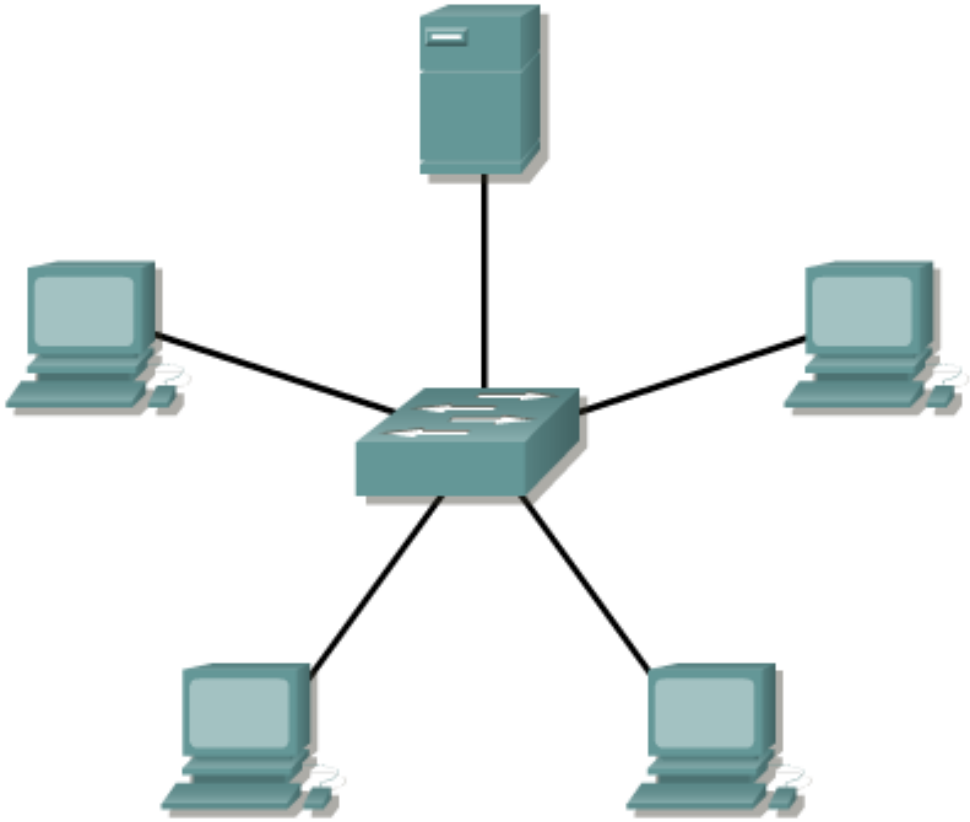
Hub

Connects a group of Hosts



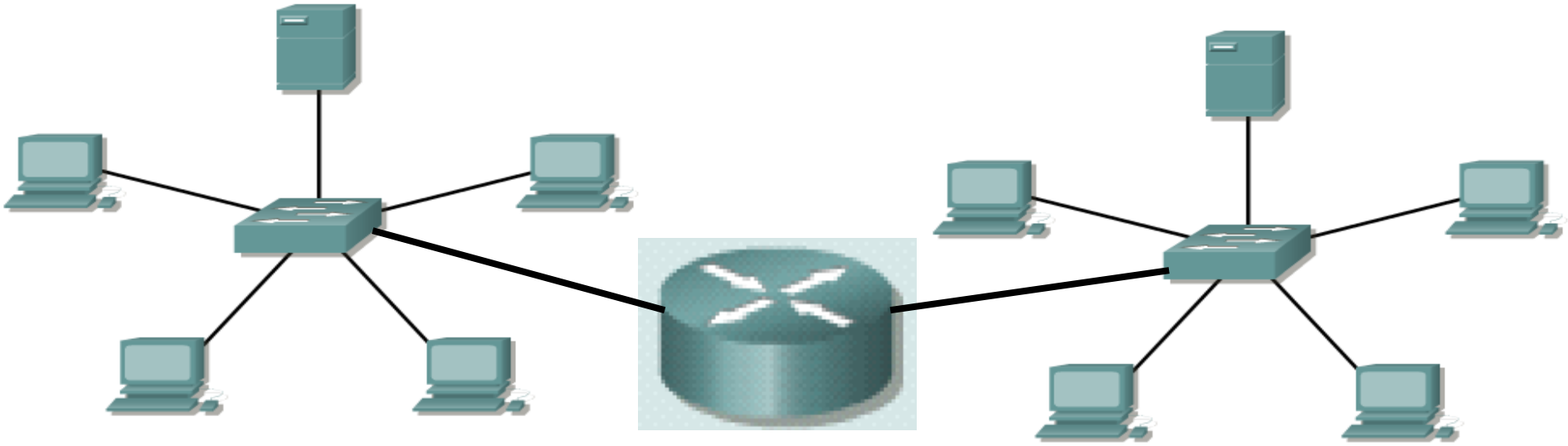
Switch

Switches add more intelligence to data transfer management.



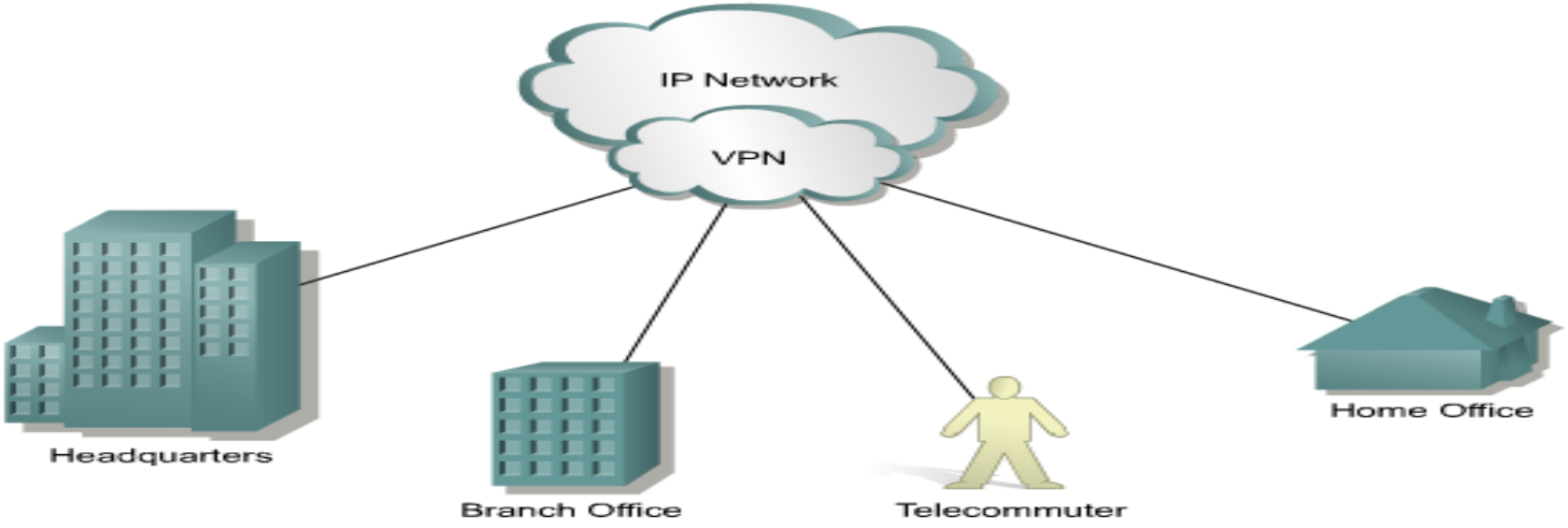
Router

- Routers are used to connect networks together
- Route packets of data from one network to another
- Cisco became the de facto (في الواقع) standard of routers because of their high-quality router products
- Routers, by default, break up a *broadcast domain*



Virtual Private Network

A VPN is a private network that is constructed within a public network infrastructure such as the global Internet. Using VPN, a telecommuter(عن بعد) can access the network of the company headquarters(المقر الرئيسي للشركة) through the Internet by building a secure tunnel between the telecommuter's PC and a VPN router in the headquarters.



Bandwidth

Why bandwidth is important:

- Bandwidth is limited by physics and technology
- Bandwidth is not free
- Bandwidth requirements are growing at a rapid rate
- Bandwidth is critical to network performance

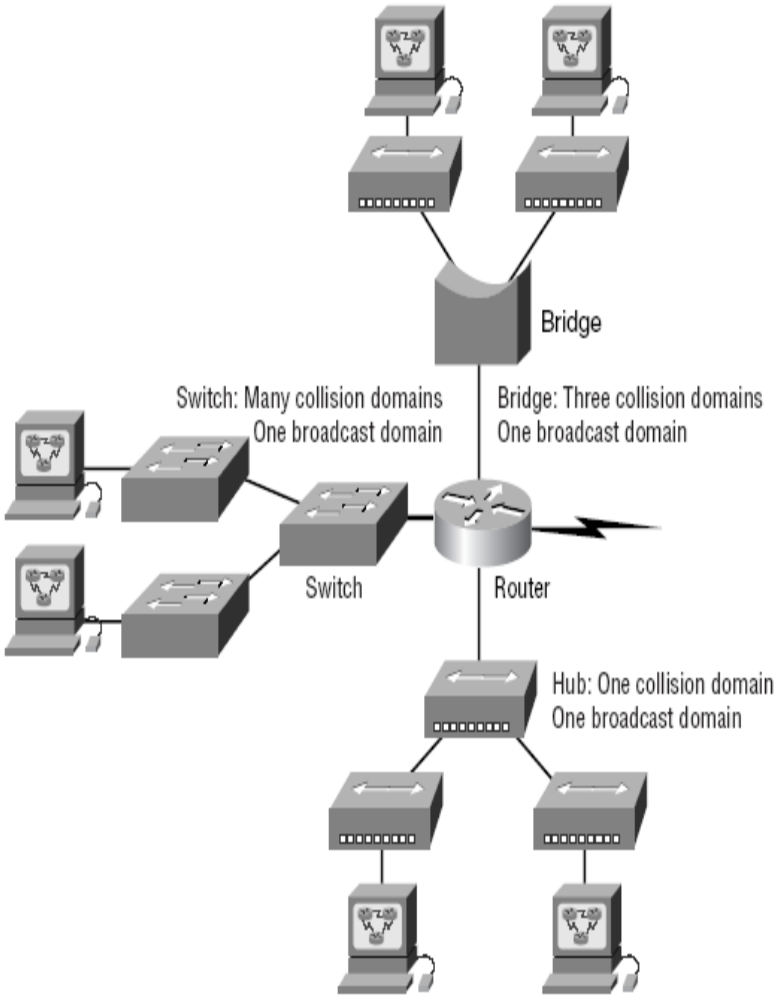
Bandwidth is like the number of lanes on a highway.

Measuring Bandwidth

Unit of Bandwidth	Abbreviation	Equivalence
Bits per second	bps	1 bps = fundamental unit of bandwidth
Kilobits per second	kbps	1 kbps = ~1,000 bps = 10^3 bps
Megabits per second	Mbps	1 Mbps = ~1,000,000 bps = 10^6 bps
Gigabits per second	Gbps	1 Gbps = ~1,000,000,000 bps = 10^9 bps
Terabits per second	Tbps	1 Tbps = ~1,000,000,000,000 bps = 10^{12} bps

Internetworking Devices

When you looked at Figure beside, did you notice that the router is found at center stage, and that it connects each physical network together? We have to use this layout because of the older technologies involved——bridges and hubs. Once we have only switches in our network, things change a lot! The LAN switches would then be placed at the center of the network world and the routers would be found connecting only logical networks together. If I've implemented this kind of setup, I've created virtual LANs (VLANs).



PANs and MANs

- Metropolitan Area Networks (MANs): Interconnect office locations in a metropolitan area.
  - Limited availability
  - Very high speed connectivity
  - Redundant
- Personal Area Networks(PANs):
  - Interconnect two devices.
  - Limited distance
  - Limited throughput

Exambles:

- Bluetooth: Class 2 Bluetooth devices have a distance limitation of 10 meters and a data rate of 3 Mbps.
- Infrared (الاشعة تحت الحمراء)

The OSI Model

Why do we need the OSI Model?

- To address the problem of networks increasing in size and in number, the International Organization for Standardization (ISO) researched many network schemes and recognized that there was a need to create a network model

- This would help network builders implement networks that could communicate and work together

Don’t Get Confused

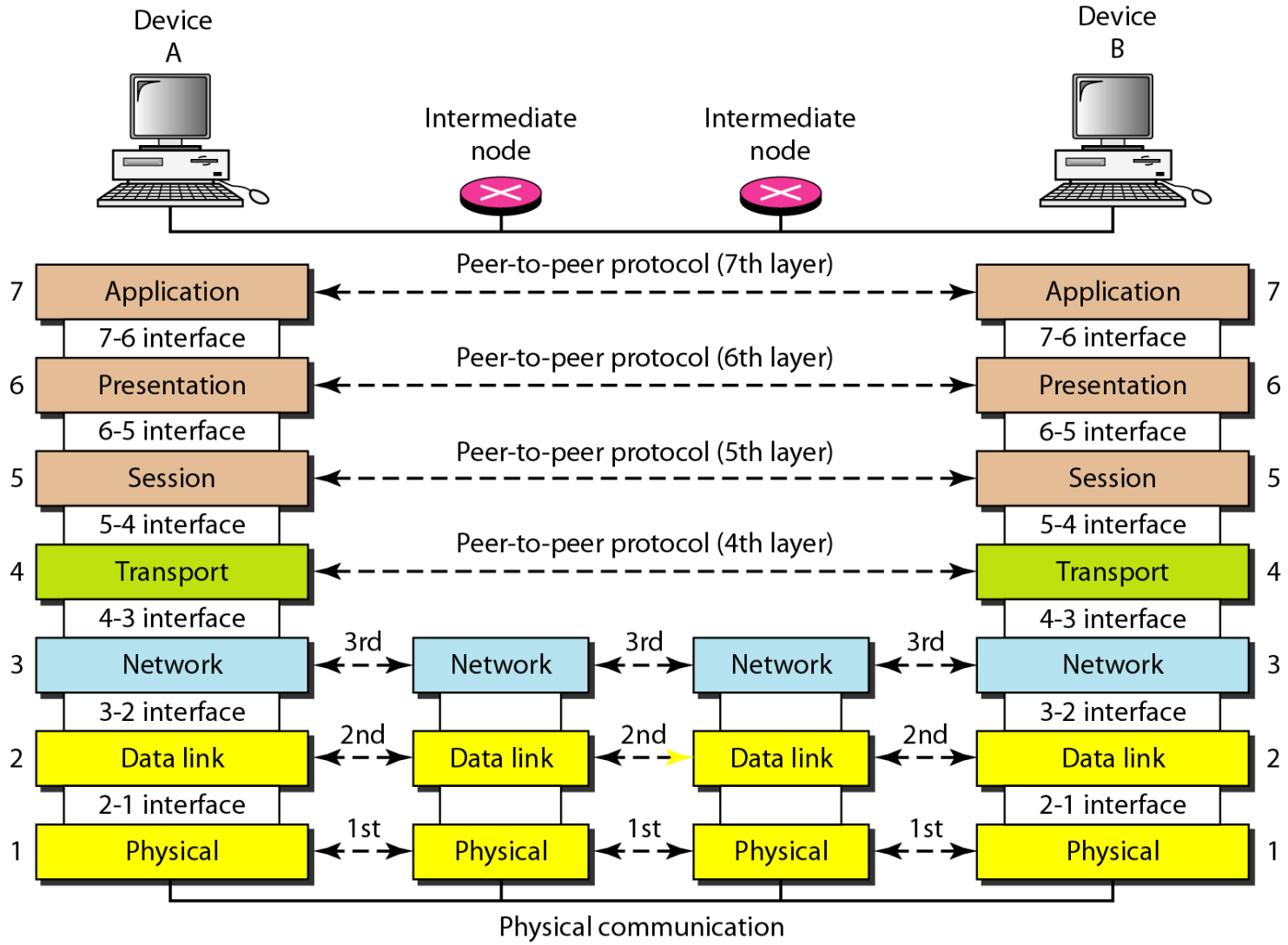
ISO - International Organization for Standardization

OSI - Open System Interconnection

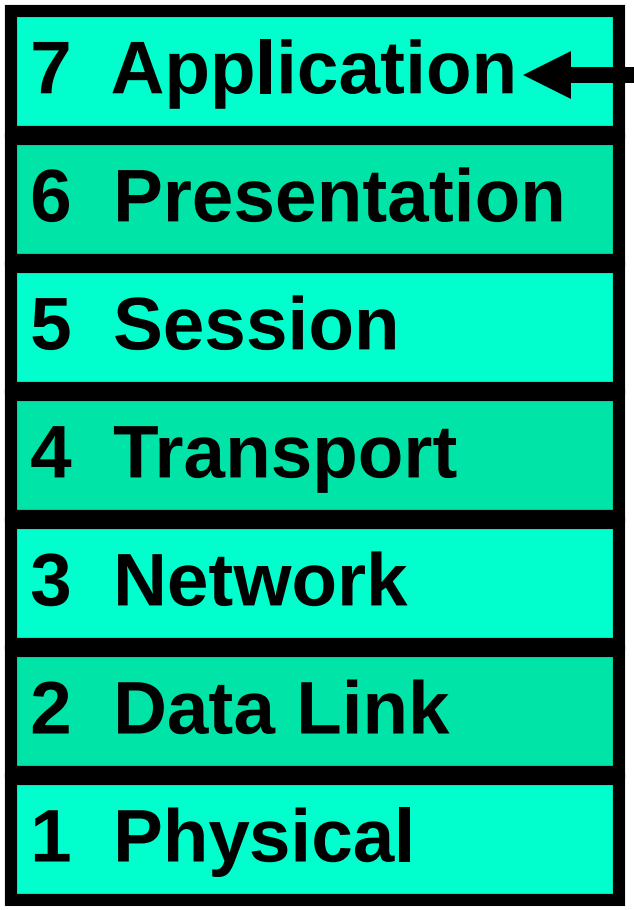
IOS - Internetwork Operating System

To avoid confusion, some people say “International Standard Organization.”

The interaction between layers in the OSI model



Layer 7 - The Application Layer



This layer deal with:

- Networking applications. Also, it contains services that support applications.
- Service Advertisement, such as printing services.

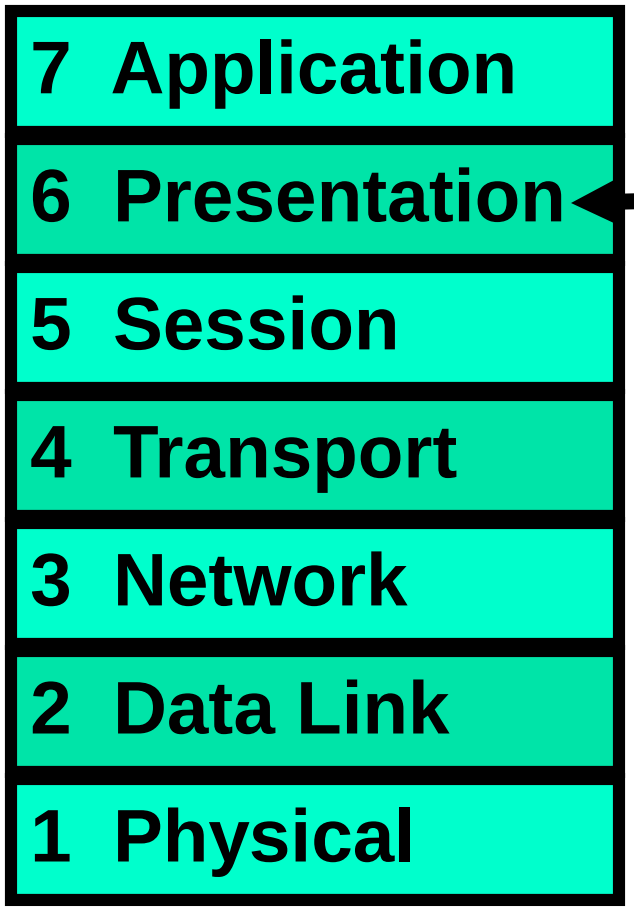
Examples:

- **Email (SMTP and POP)**
- **Web browsers (HTTP)**

PDU - User Data

Each of the layers have Protocol Data Unit (PDU)

Layer 6 - The Presentation Layer



This layer is responsible for presenting the data in the required format which may include:

❑Data Formatting

- American Standard Code for Information Interchange(ASCII)

A text-encoding standard based on the English alphabet.

- ***Extended Binary Code Decimal Interchange Code (EBCDIC)***

A text-encoding approach developed by IBM for their mainframe computers.

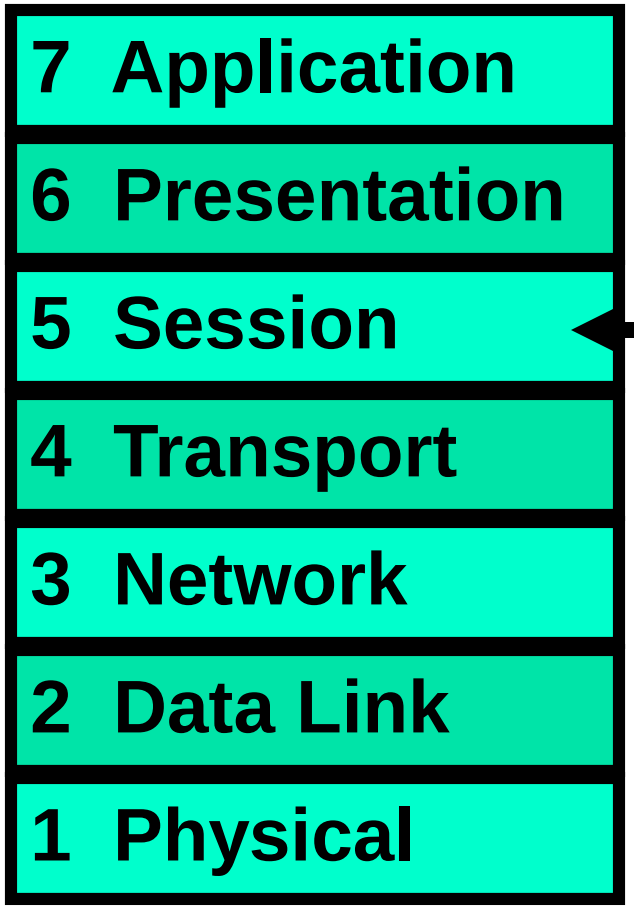
❑Encryption

Scramble (خلط) data so that the data can only be read by an intended recipient. The recipient might need a secret key to read the data.

❑Compression

PDU - Formatted Data

Layer 5 - The Session Layer



- This layer setting up (ينشأ), maintaining and tearing down (يهدم) sessions between two communicating hosts.
- Dialog Control
- Organize their communication by offering three different modes:

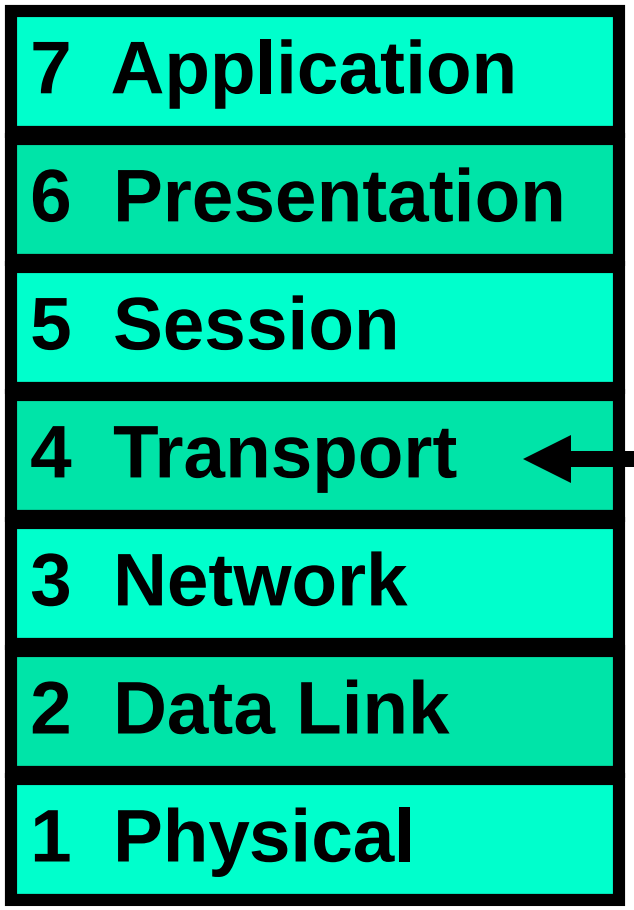
  Simplex , Half Duplex and Full Duplex

- **Network Basic Input/Output System (NetBIOS):** A session layer protocol used on IBM's early "PC Network with maximum 80 PC".
- **NetBIOS Extended User Interface (NetBEUI):** An enhancement of NetBIOS.

Example: Client Software (Used for logging in)

PDU - Formatted Data

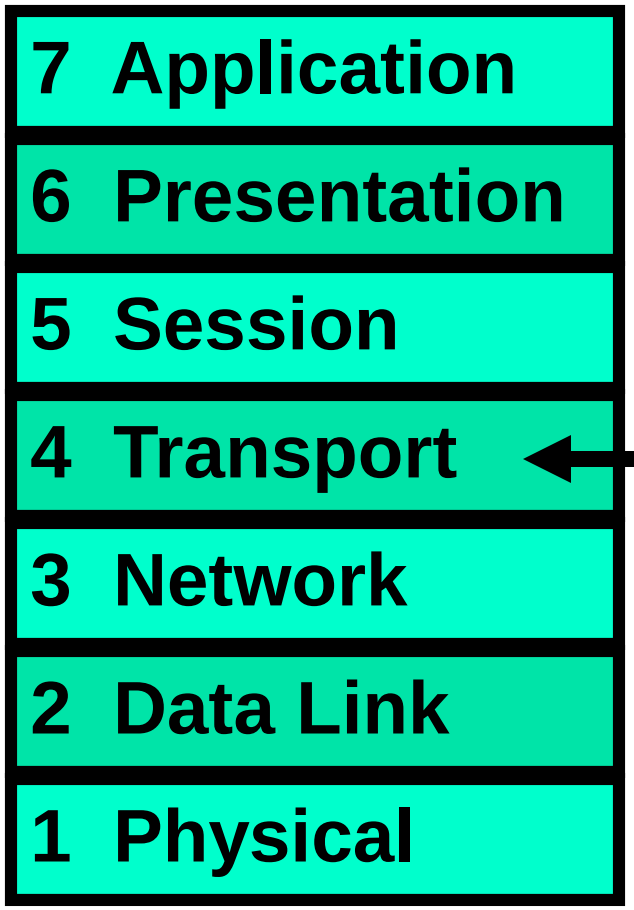
Layer 4 - The Transport Layer



- ***Protocols:***
  - Transmission Control Protocol (TCP): used for reliable or connection- oriented (i.e. Acknowledged) communication.
  - User Datagram Protocol (UDP): used for unreliable or connectionless (i.e. unacknowledged) communication.
  - Real-time Transport Protocol (RTP): Is encapsulated in another layer 4 protocol UDP and transmits voice in a Voice over IP (VoIP) networks.
- ***Windowing:*** Slides windowing allows the TCP window size (i.e. the number of segments that can be sent before an acknowledgment is received) to grow, based on network reliability.

PDU - Segments

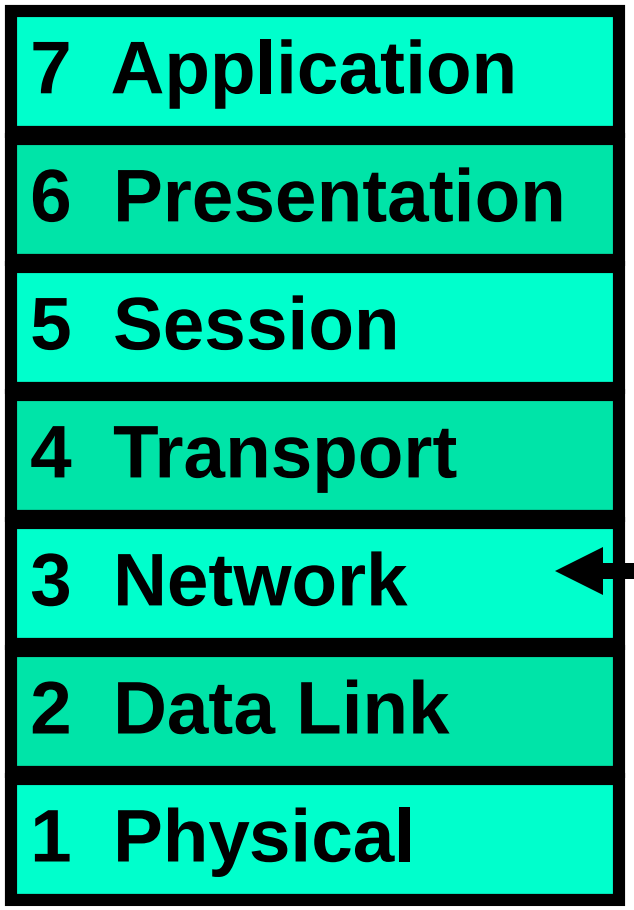
Layer 4 - The Transport Layer



- ***Buffering:*** (it is important in a Quality of Service (QoS) study)
  - **Queue (Buffer):** Memory used by a router's output interface to store packets until bandwidth becomes available to transmit those packets
  - Transport Layer deals with ports (number) address.

PDU - Segments

Layer 3 - The Network Layer

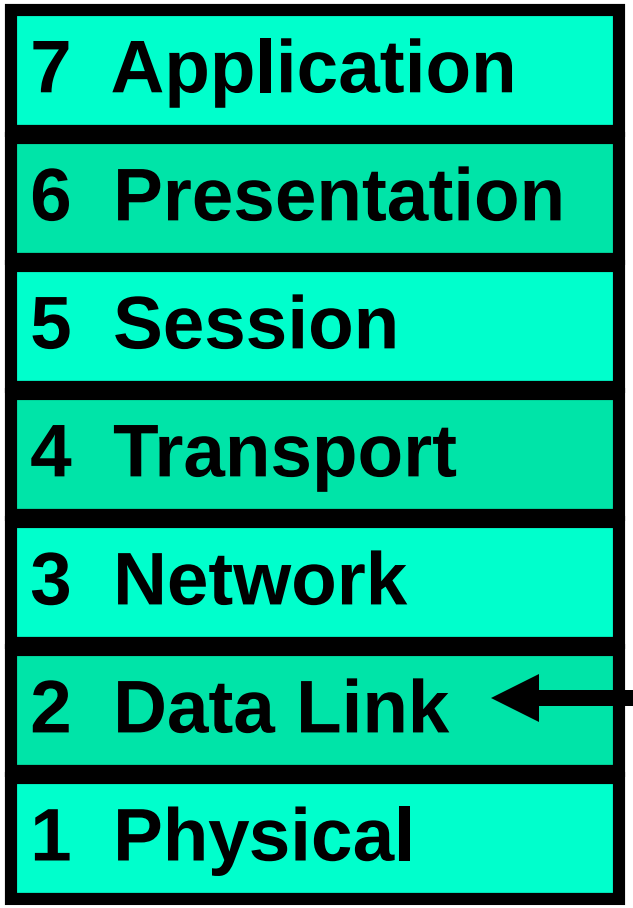


- Logical (IP) Addressing (Ex: IPv4, IPv6, IPX and AppleTalk)
- Switching(send a packet from one device to another device. Three types of switching: Packet, Circuit and Message)
- Route discovery and selection (Directly connected, Statically configured or Dynamically learned).
- Connection Services (Flow control, Packet Reordering)

- Router is layer 3 device

PDU – Packets

Layer 2 - The Data Link Layer



1-MAC Sub-layer

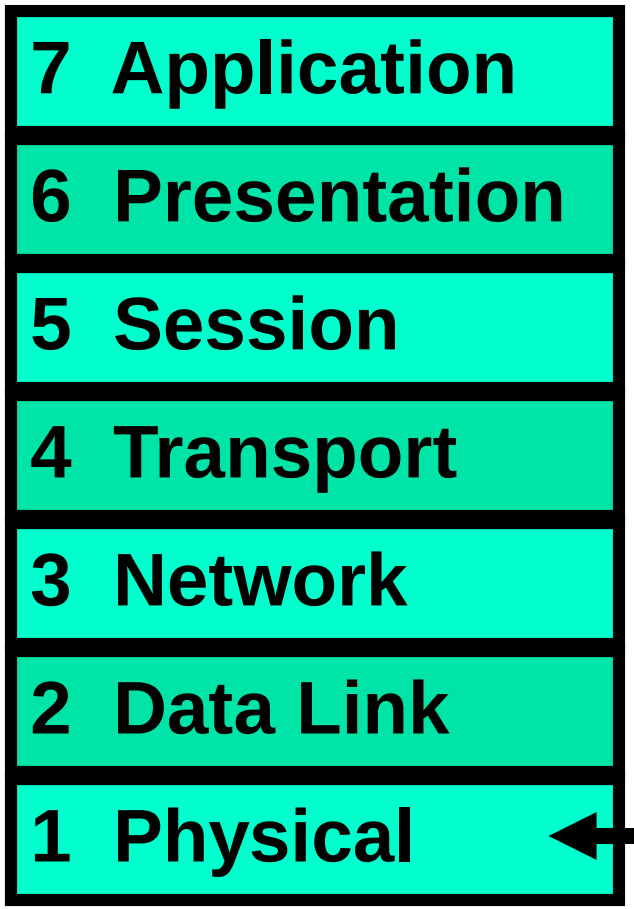
- ❑Performs Physical (MAC) Addressing.
- ❑Logical (data flow) topology (Ex: Token Ring is used MAU. Physically star but Logically ring)
- ❑Method of transmitting on the media (Ethernet (CAMA/CD), or Token ring).

2- LLC Sub-layer

- ❑Connection services (Flow control, Error control)
- ❑Synchronizing transmission (Isochronous, Asynchronous, Synchronous)
- ❑Switches are layer 2 devices

PDU - Frames

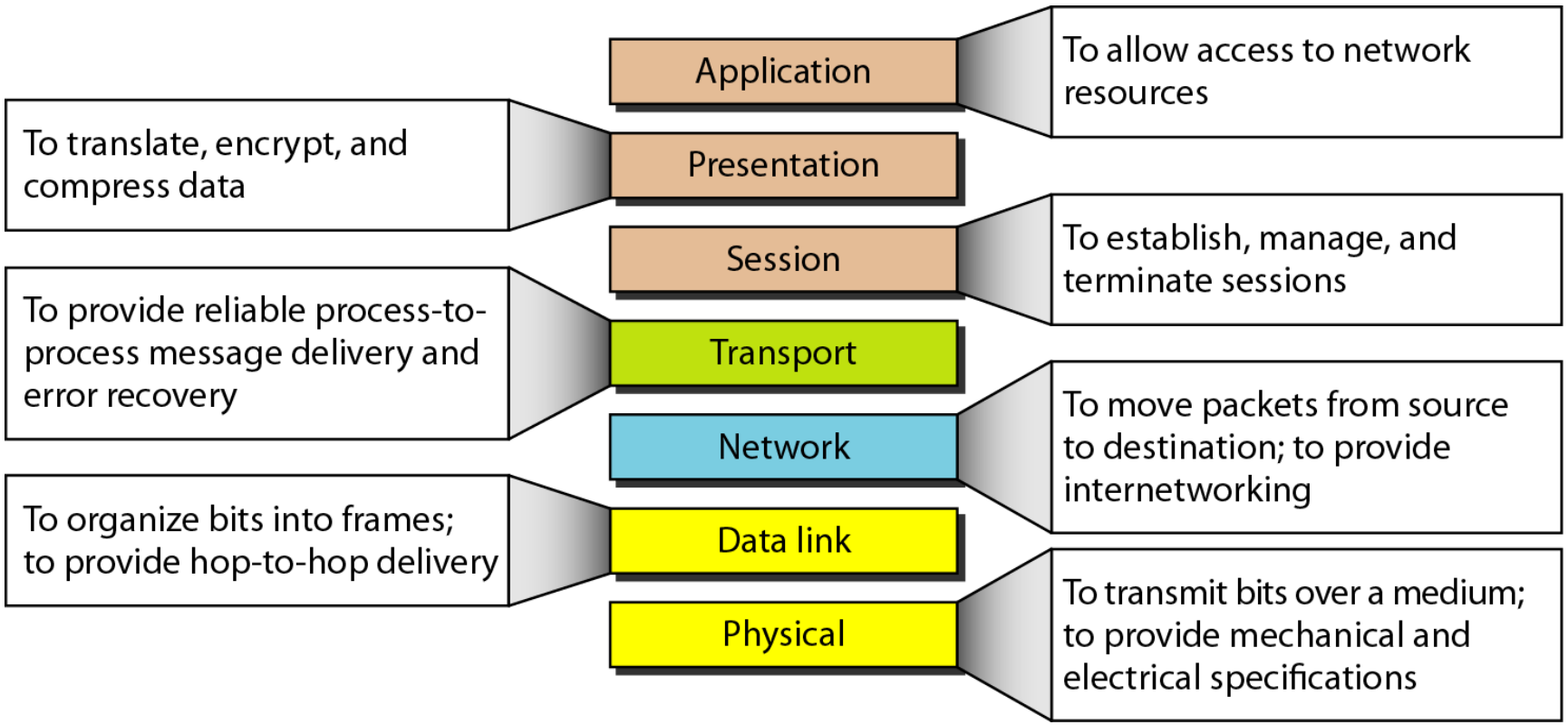
Layer 1 - The Physical Layer



- How bits are represented on the medium.
- Wiring and connectors.
- Physical Topology (star, mesh, ….).
- Synchronizing bits (Asynchronous (The sender sends start & stop bits, the receiver uses an internal clock), Synchronous (Both the sender and receiver use internal clocks)).
- Bandwidth usage (Broadband (like TV), Baseband).
- Multiplexing strategy (TDM, FDM (like cable TV)).
- Hub is Layer 1 device (PDU is bits)

PDU - Bits

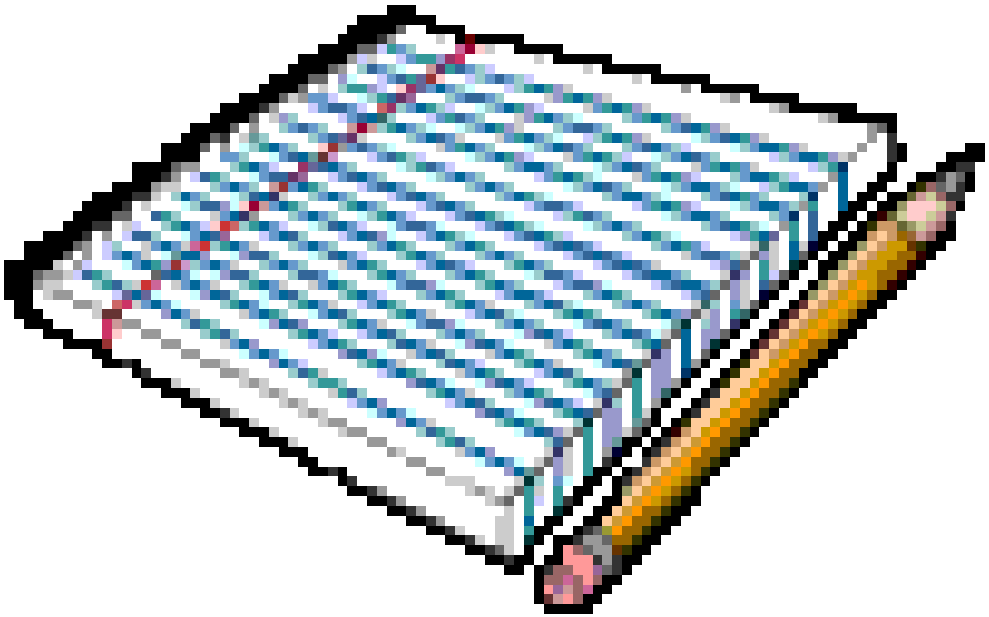
Summary of layers



OSI Model Analogy
Application Layer - Source Host

After riding your new bicycle a few times in Baghdad, you decide that you want to give it to a friend who lives in Dubai.

OSI Model Analogy
Presentation Layer - Source Host

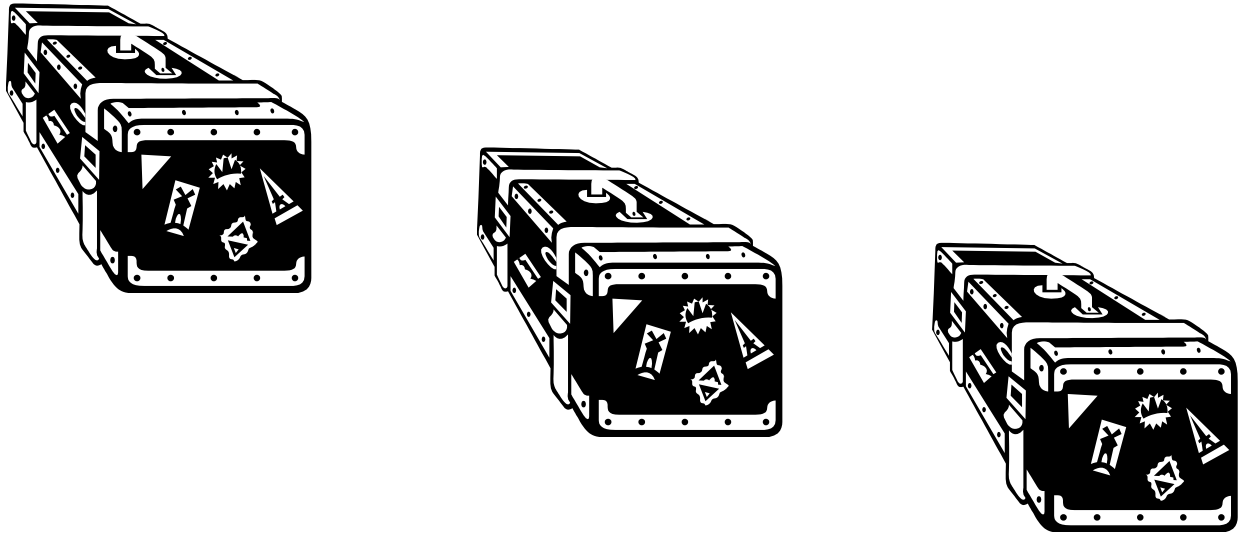


Make sure you have the proper directions to disassemble and reassemble the bicycle.

OSI Model Analogy
Session Layer - Source Host

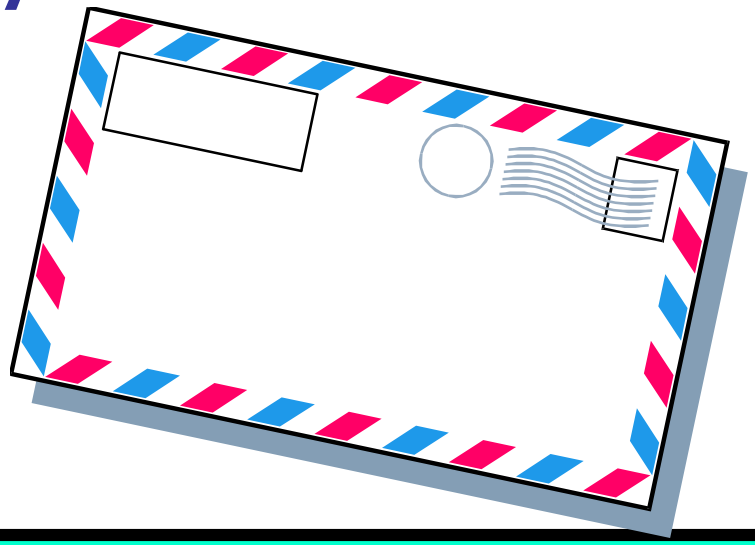
Call your friend and make sure you have his correct address.

OSI Model Analogy
Transport Layer - Source Host



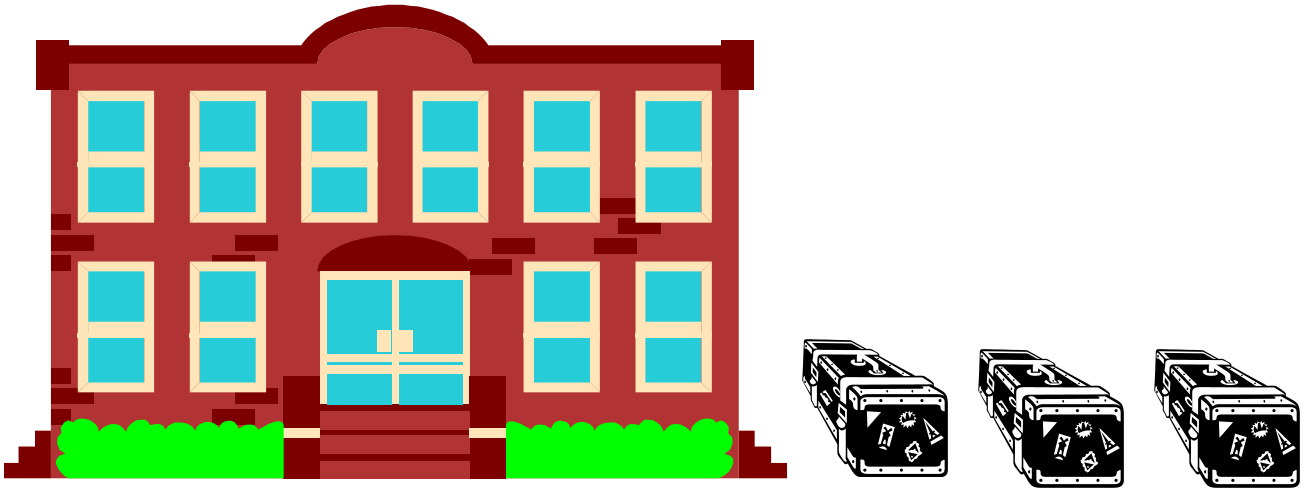
Disassemble the bicycle and put different pieces in different boxes. The boxes are labeled "1 of 3", "2 of 3", and "3 of 3".

OSI Model Analogy
Network Layer - Source Host



Put your friend's complete mailing address (and yours) on each box.Since the packages are too big for your mailbox (and since you don’t have enough stamps) you determine that you need to go to the post office.

OSI Model Analogy
Data Link Layer – Source Host

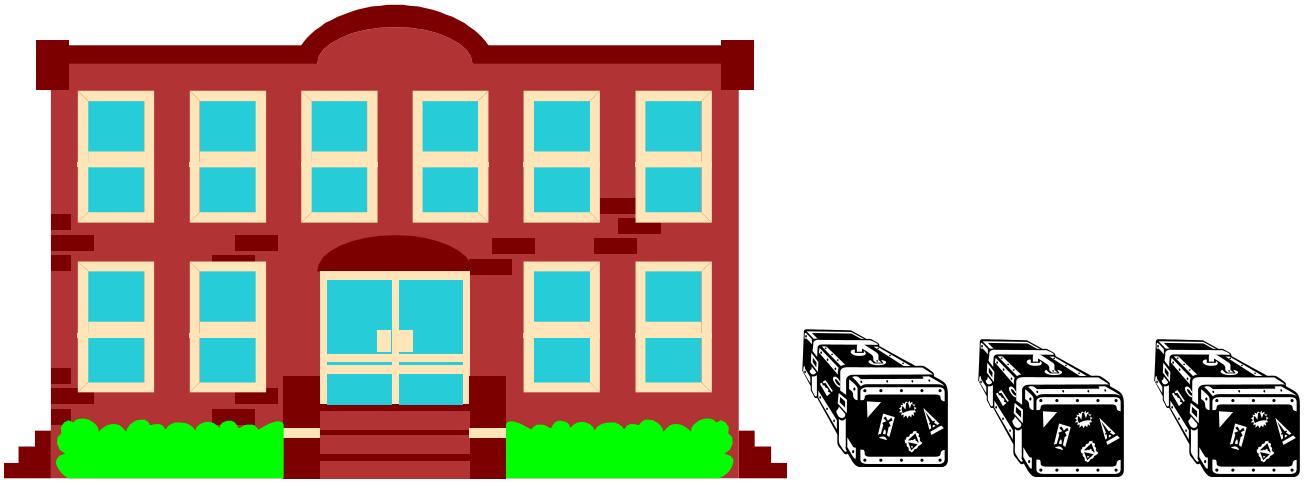


Baghdad post office takes possession (حيازة, امتلاك) of the boxes.

OSI Model Analogy
Physical Layer - Media

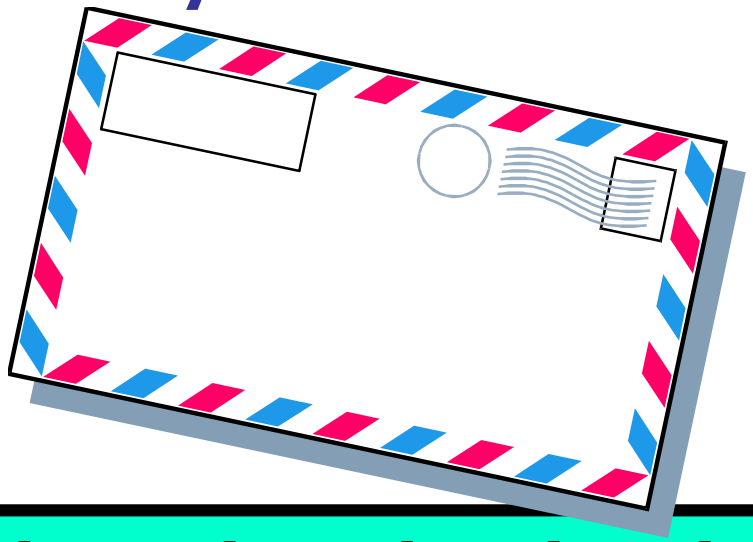
The boxes are flown from Baghdad to Dubai.

OSI Model Analogy
Data Link Layer - Destination



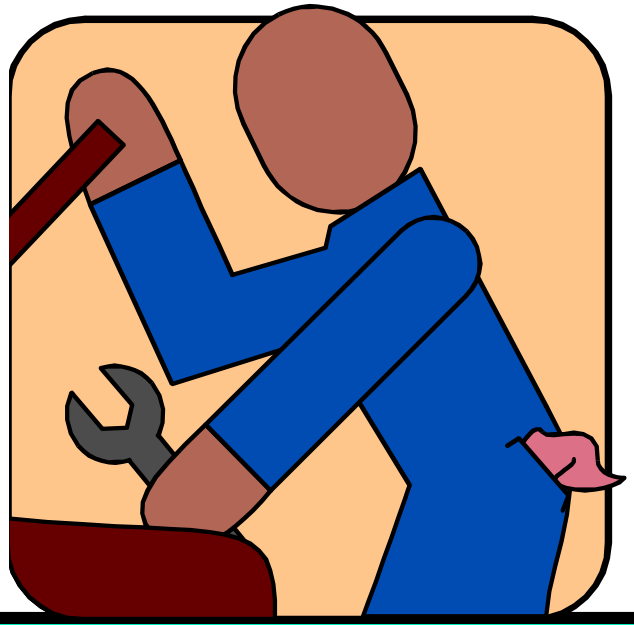
Dubai post office receives your boxes.

OSI Model Analogy
Network Layer - Destination



Upon examining the destination address, Dubai post office determines that your boxes should be delivered to your written home address.

OSI Model Analogy
Transport Layer - Destination



Your friend calls you and tells you he got all 3 boxes and he is having another friend named Ahmed reassemble the bicycle.

OSI Model Analogy
Session Layer - Destination

Your friend hangs up because he is done talking to you.

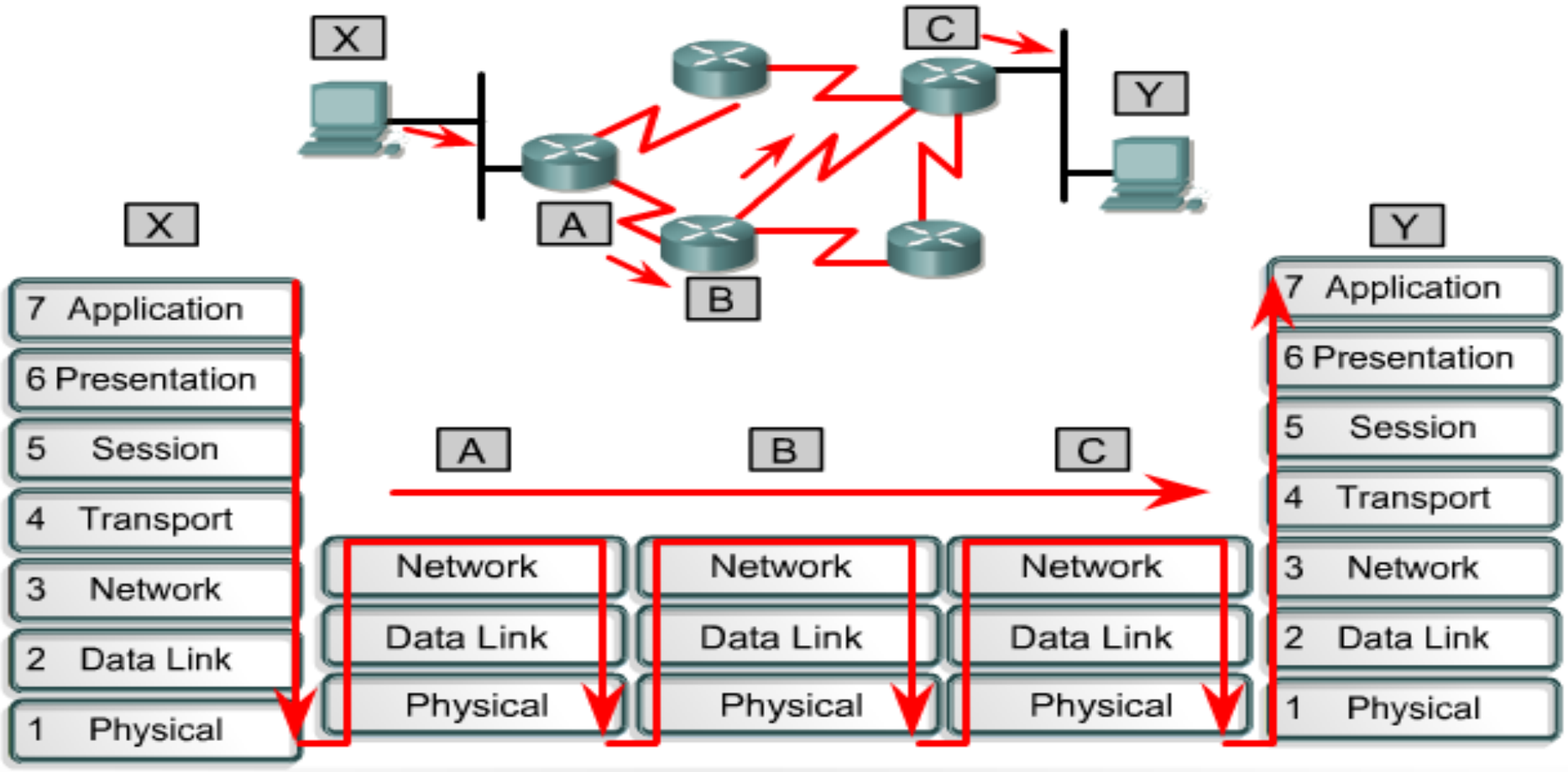
OSI Model Analogy
Presentation Layer - Destination

Ahmed is finished and "presents" the bicycle to your friend. Another way to say it is that your friend is finally getting him "present".

OSI Model Analogy
Application Layer - Destination

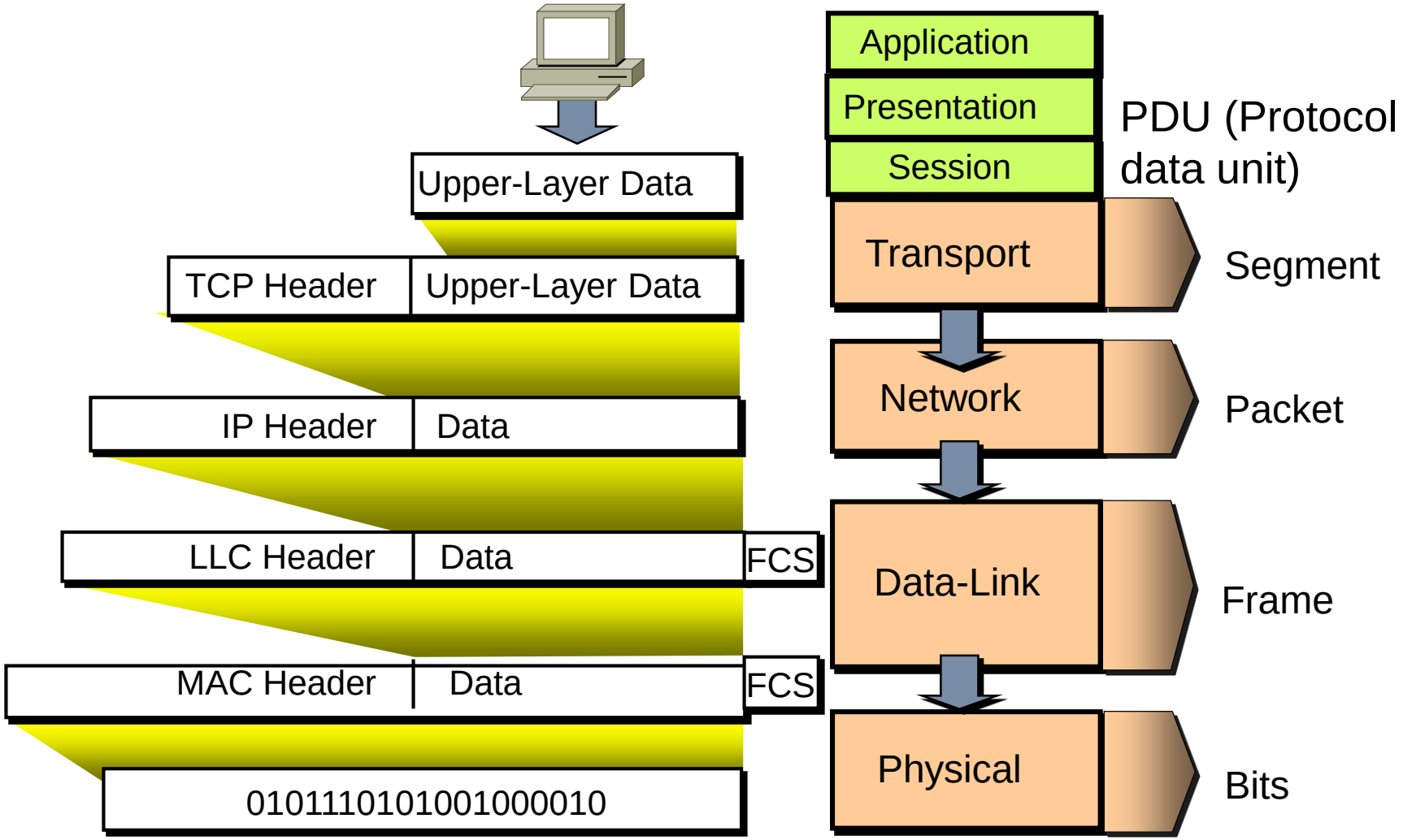
Your friend enjoys riding his new bicycle in Dubai.

Data Flow Through a Network



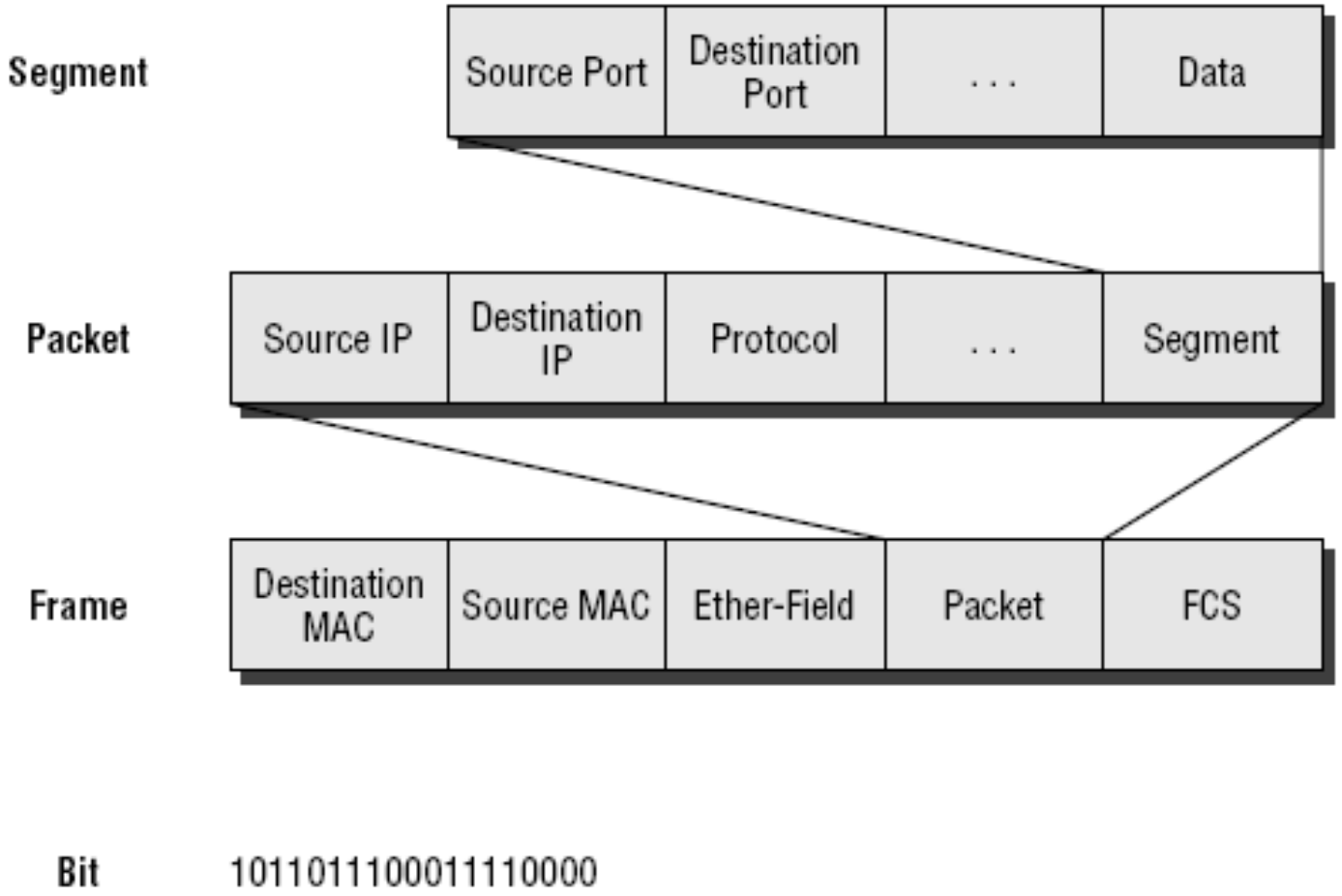
Data flow in a network focuses on layers one, two and three of the OSI model. This is after being transmitted by the sending host and before arriving at the receiving host.

Data Encapsulation



FCS (Frame Check Sequence), LLC (Logical Link Control)
MAC (Media Access Control)

Data Encapsulation



TCP/IP MODEL

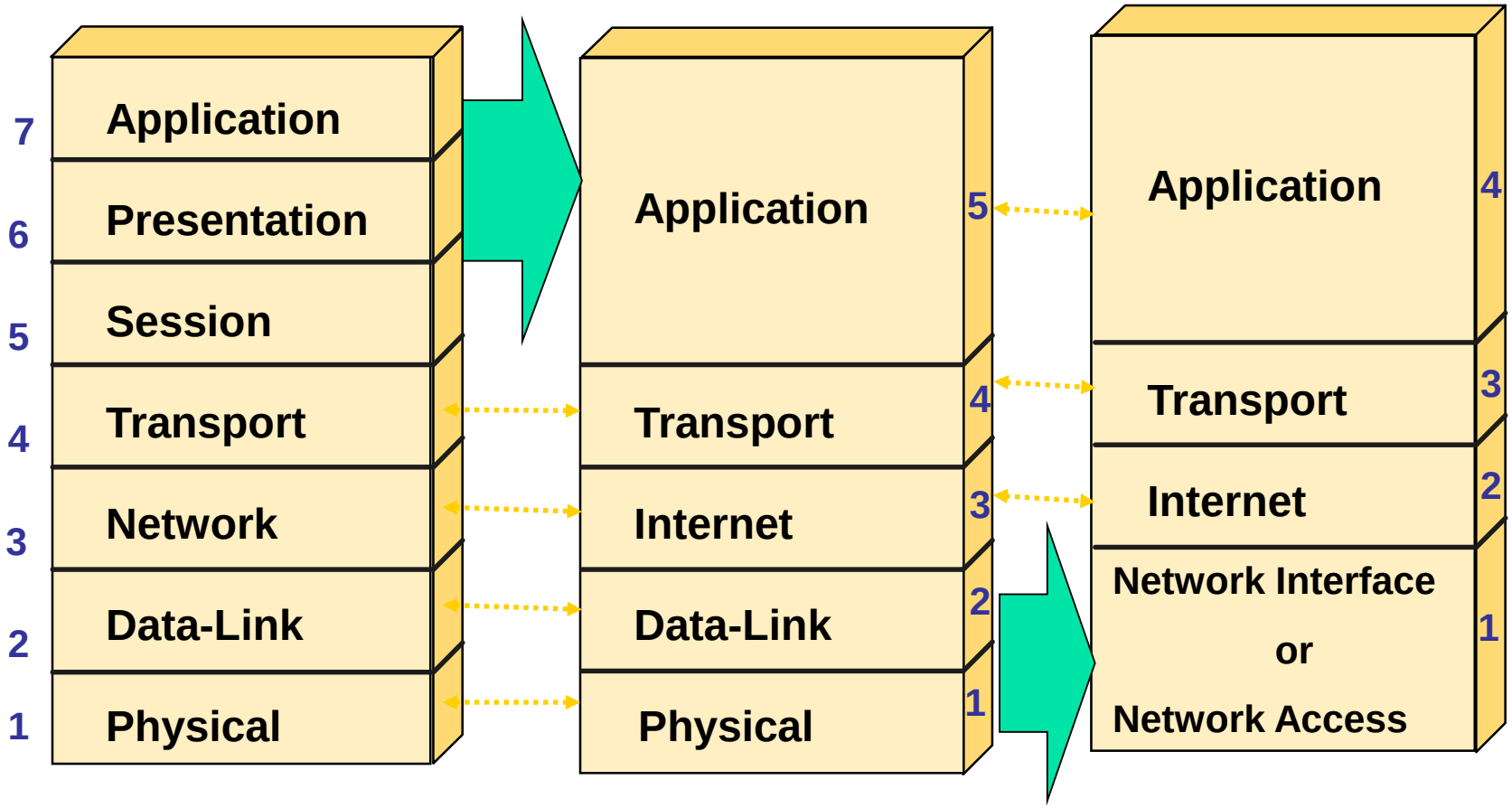
Why Another Model?

Although the OSI reference model is universally recognized, the historical and technical open standard of the Internet is Transmission Control Protocol / Internet Protocol (TCP/IP).

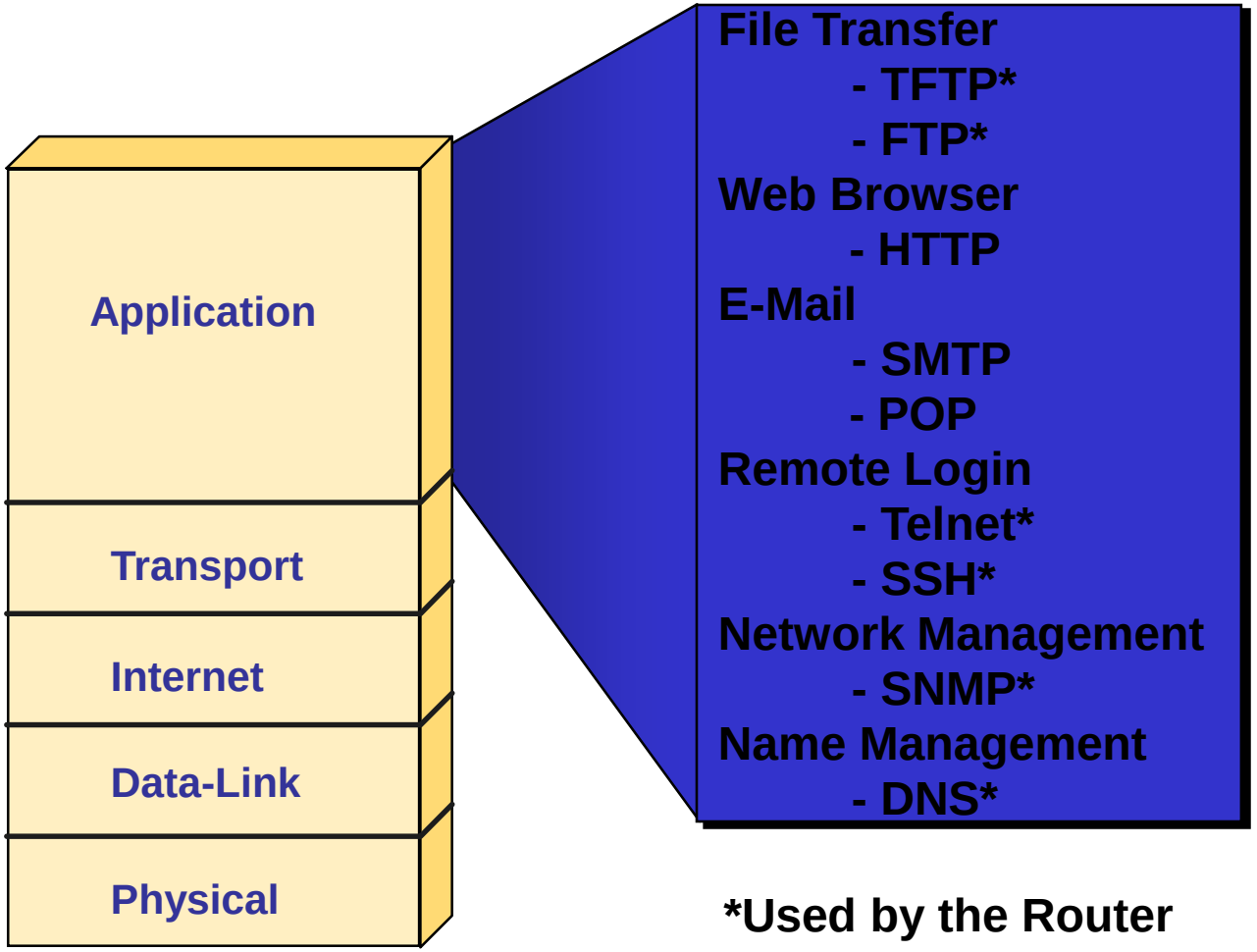
The TCP/IP reference model and the TCP/IP protocol stack make data communication possible between any two computers, anywhere in the world, at nearly the speed of light.

The U.S. Department of Defense (DoD) created the TCP/IP reference model because it wanted a network that could survive any conditions, even a nuclear war.

TCP/IP Protocol Stack

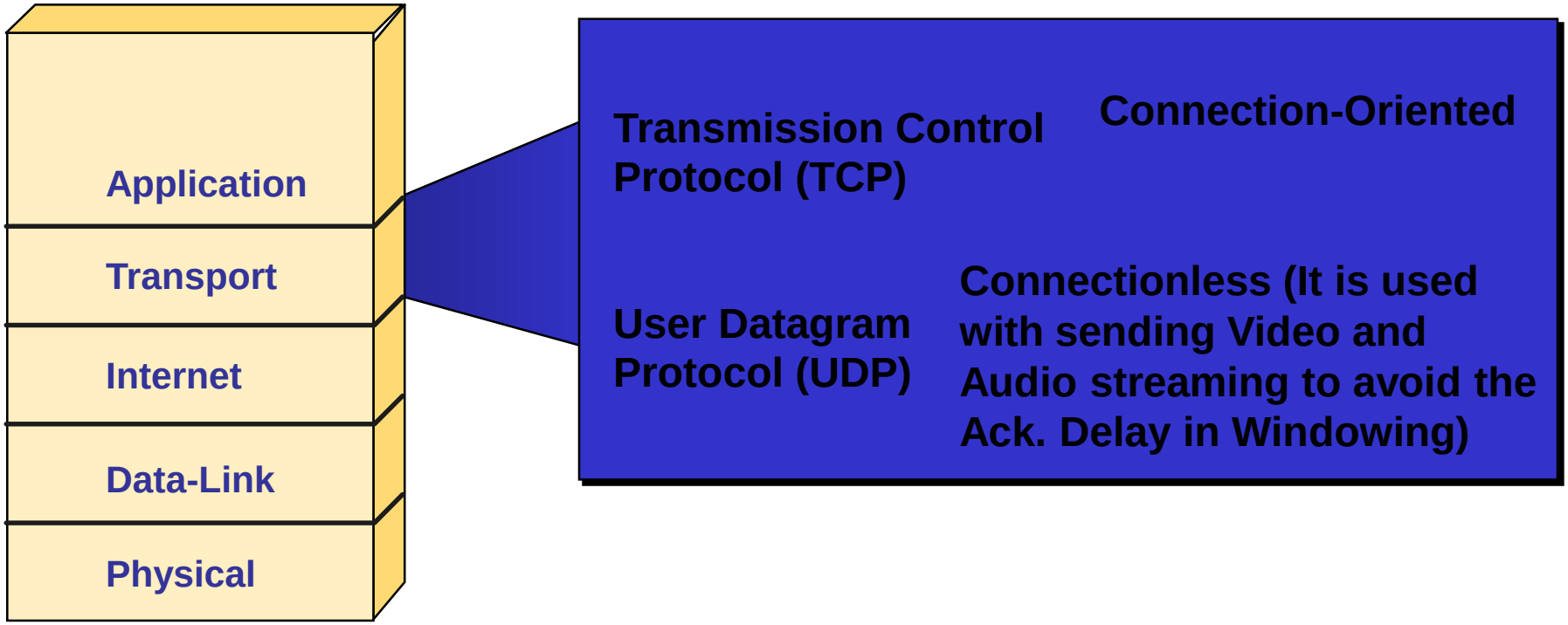


Application Layer Overview

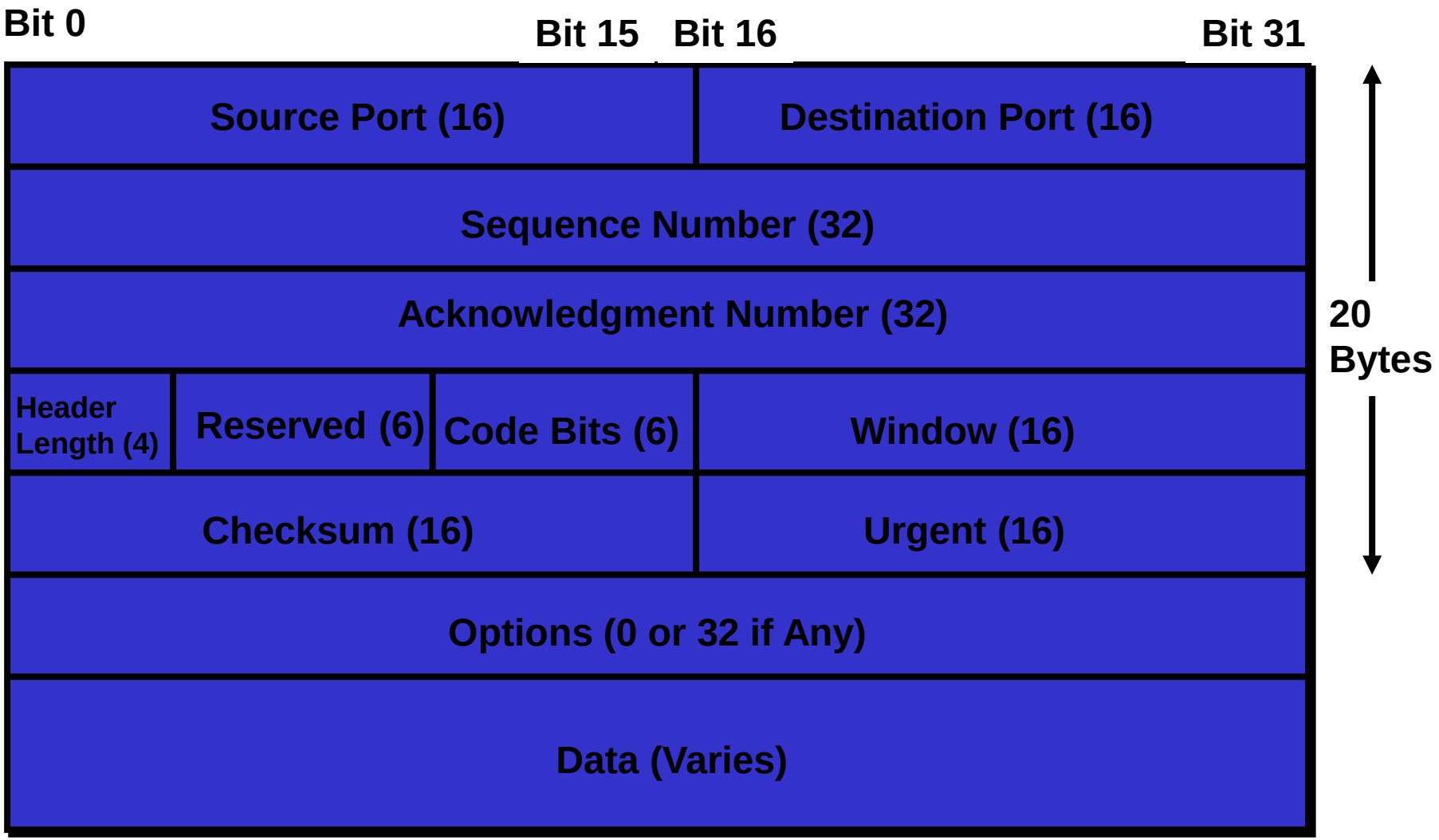


*Used by the Router

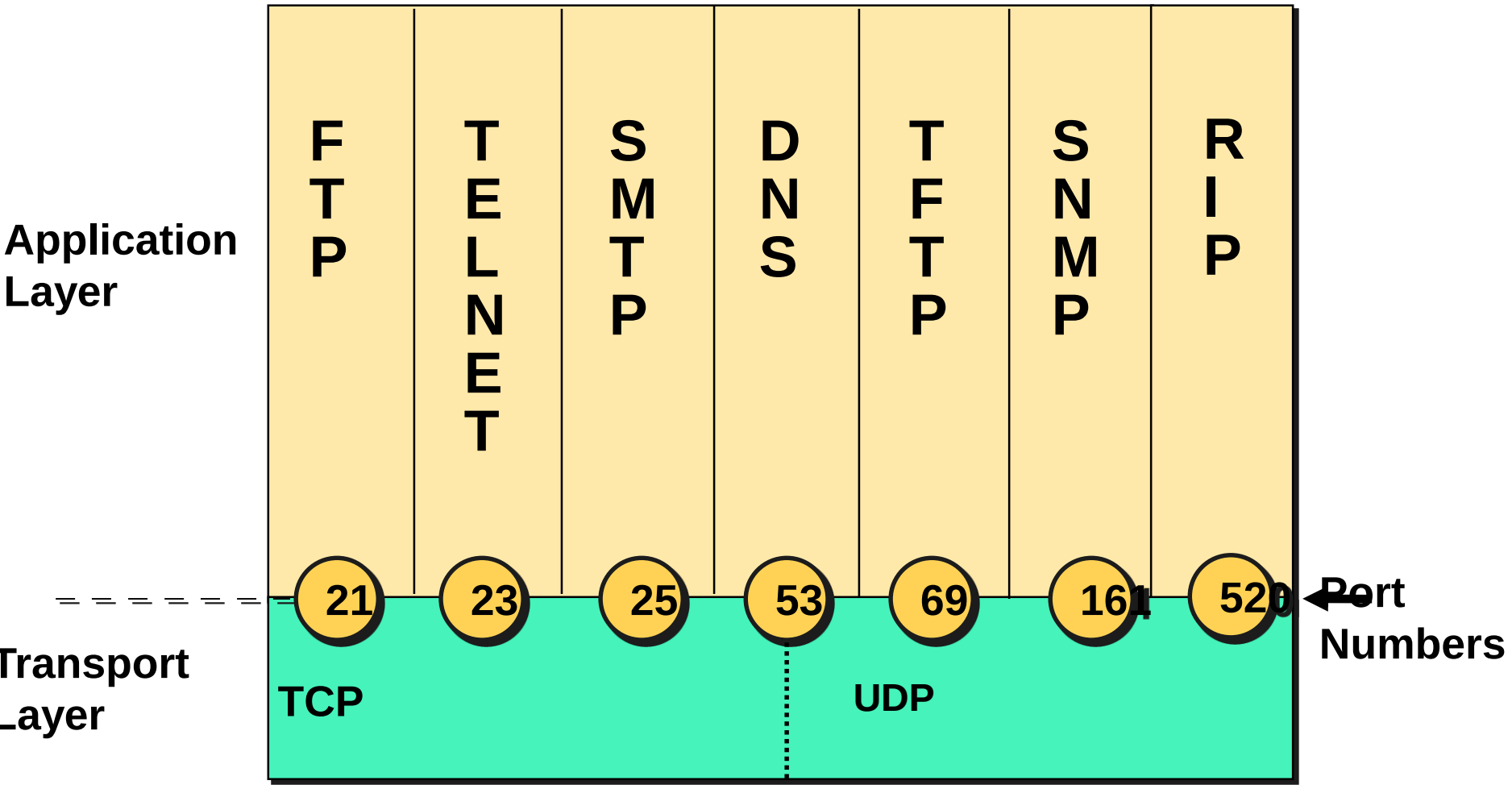
Transport Layer Overview



TCP Segment Format



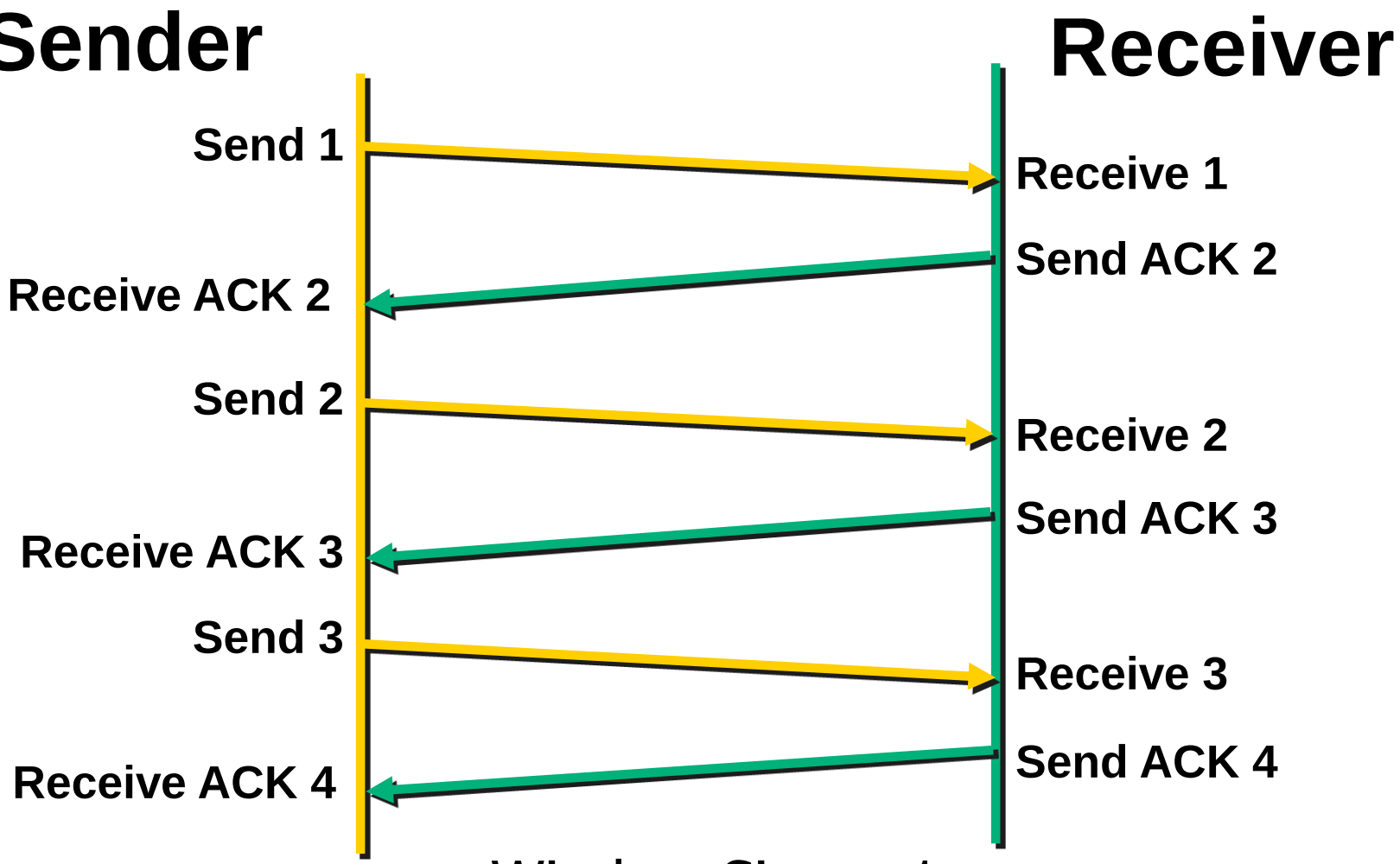
Port Numbers



Windowing

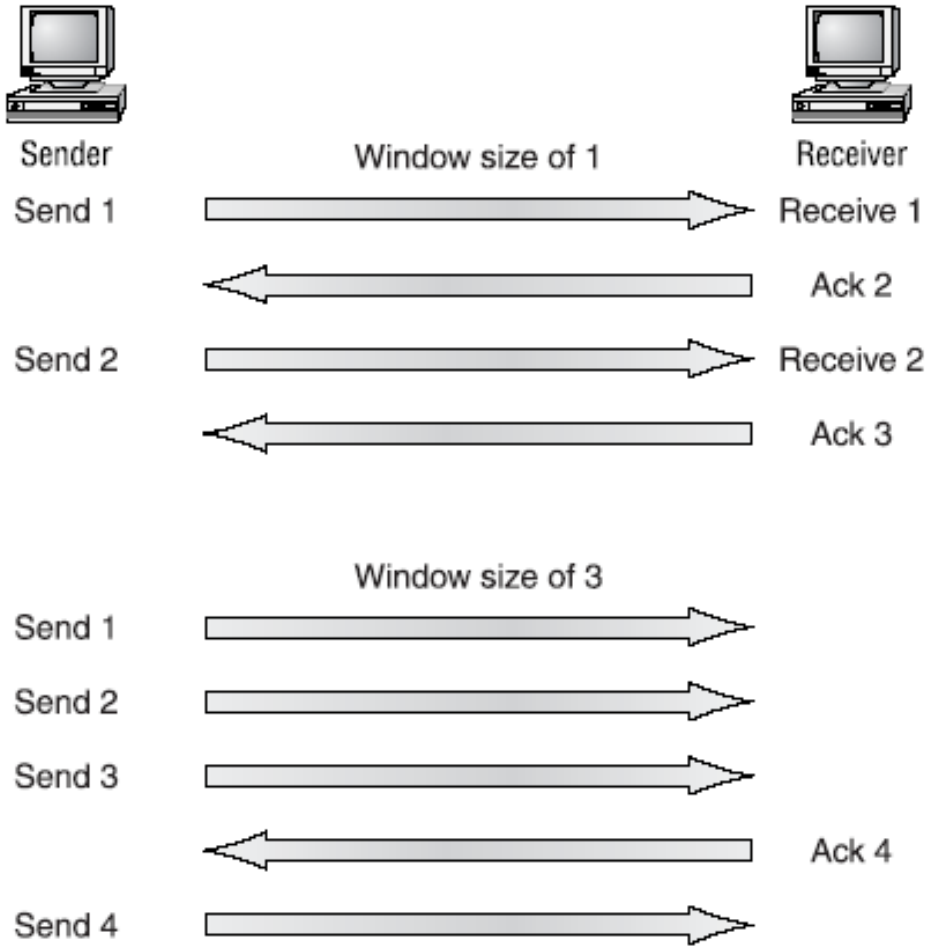
- Windowing in networking means the quantity of data segments which is measured in bytes that a machine can transmit/send on the network without receiving an acknowledgement

TCP Simple Acknowledgment

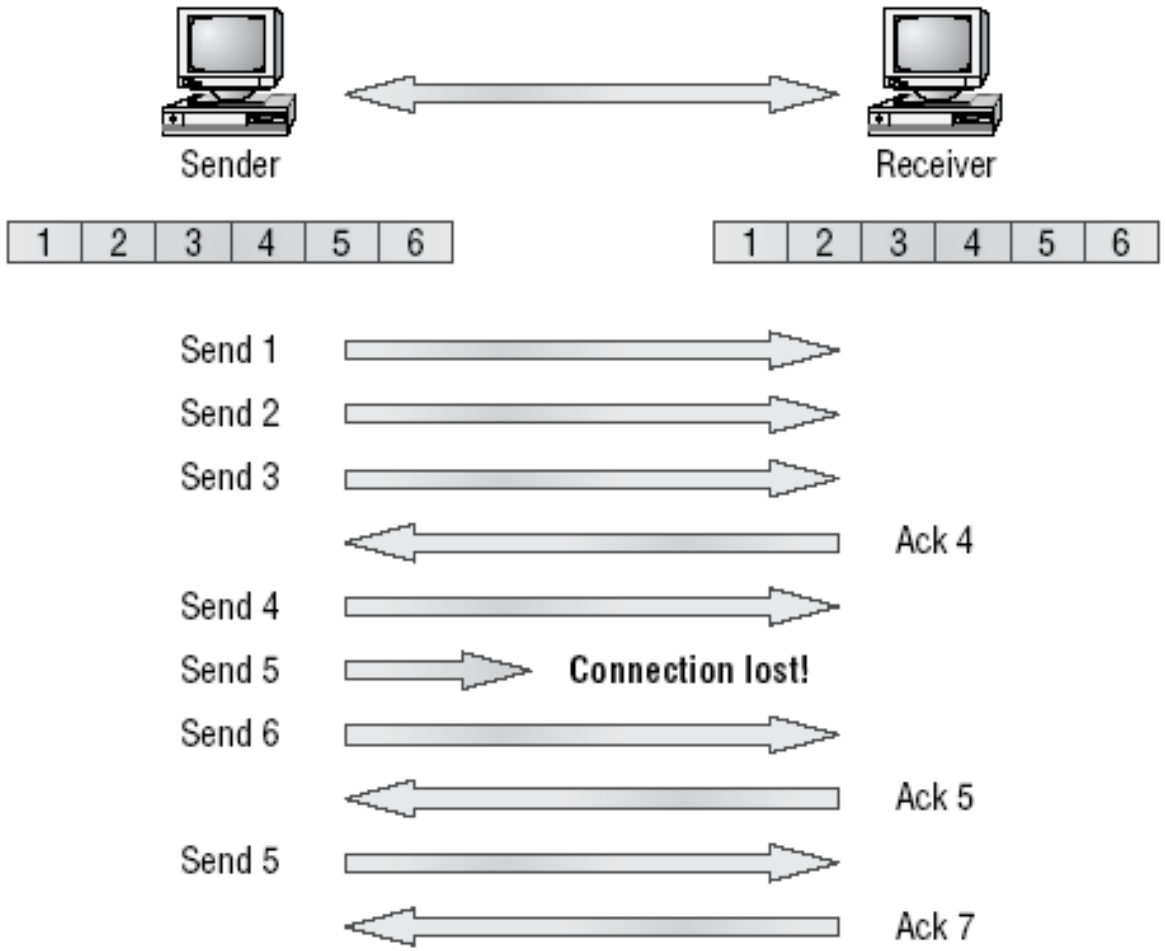


- Window Size = 1

Windowing


Sender
Window size of 1
Receiver
Send 1
Receive 1
Ack 2
Send 2
Receive 2
Ack 3
Window size of 3
Send 1
Send 2
Send 3
Ack 4
Send 4

Transport Layer Reliable Delivery



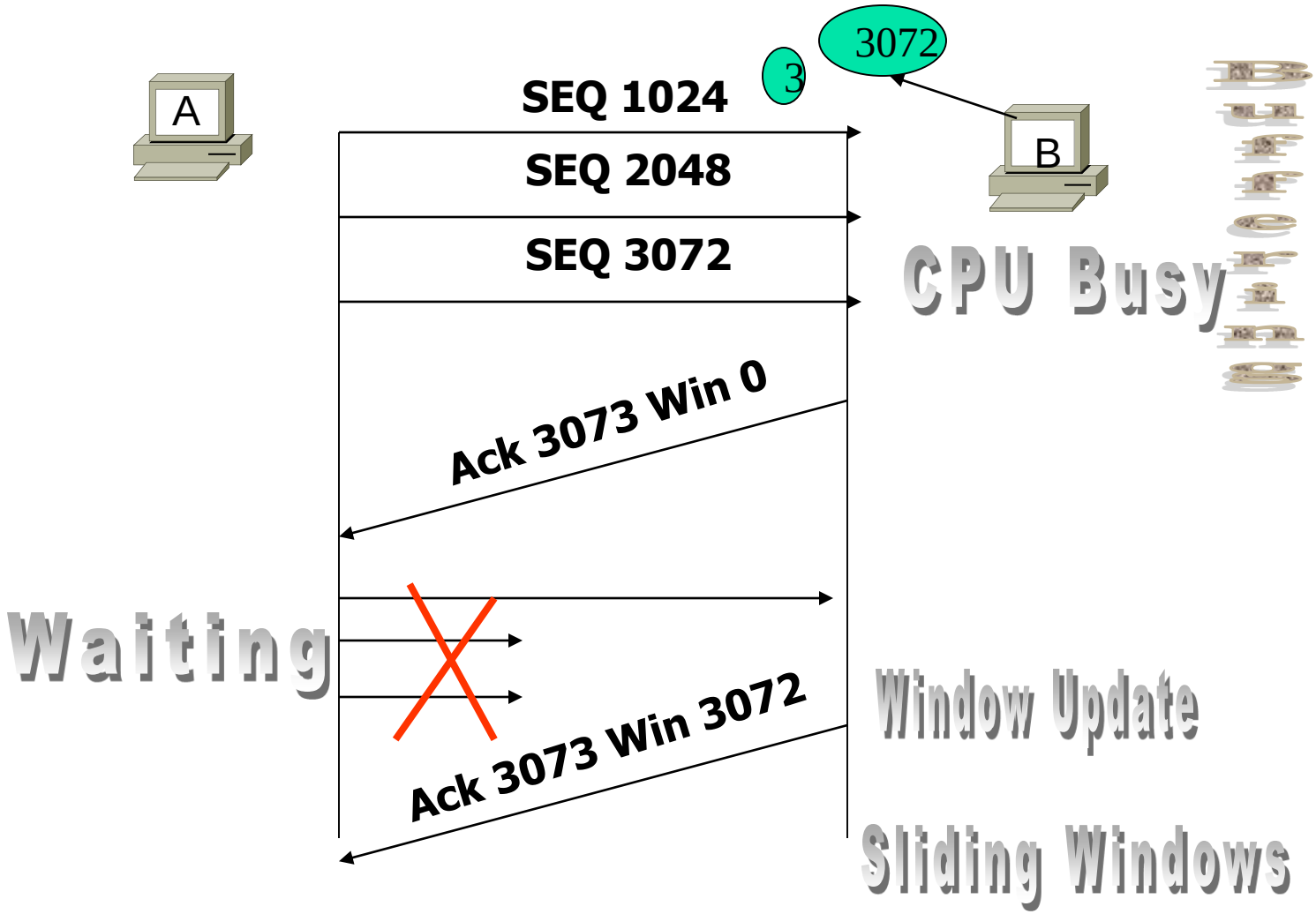
Flow Control

- Another function of the transport layer is to provide optional flow control.

- Flow control is used to ensure that networking devices don’t send too much information to the destination, overflowing its receiving buffer space, and causing it to drop the sent information

- The purpose of flow control is to ensure the destination doesn't get overrun by too much information sent by the source

Flow Control



User Datagram Protocol (UDP)

User Datagram Protocol (UDP) is the connectionless transport protocol in the TCP/IP protocol stack.

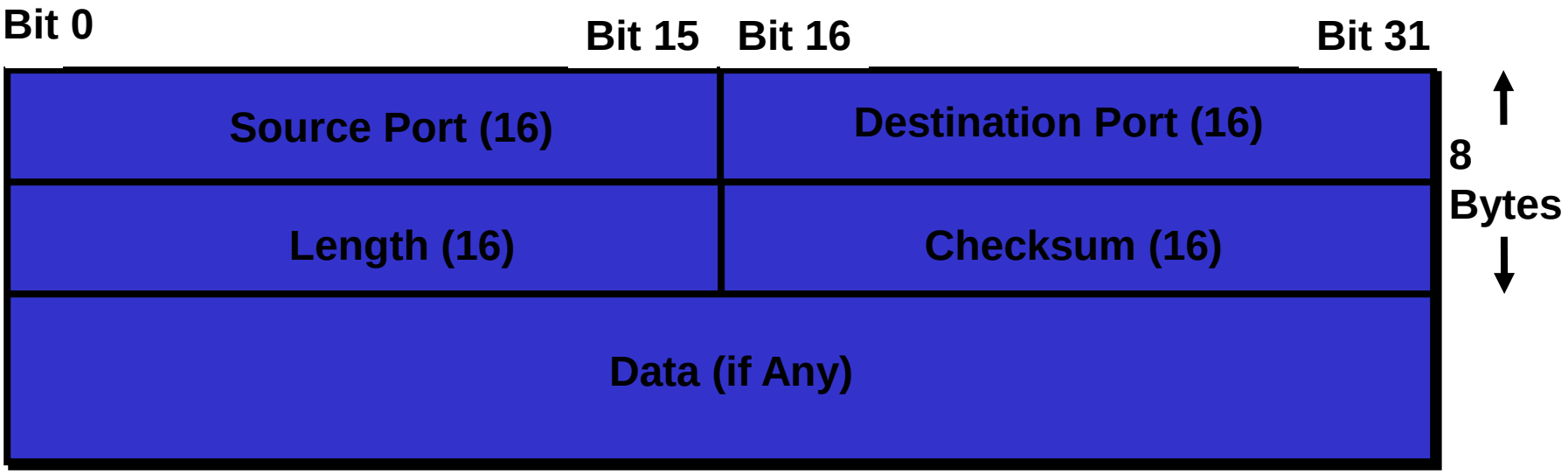
UDP is a simple protocol that exchanges datagrams, without acknowledgments or guaranteed delivery. Error processing and retransmission must be handled by higher layer protocols.

UDP is designed for applications that do not need to put sequences of segments together.

The protocols that use UDP include:

- TFTP (Trivial File Transfer Protocol)
- SNMP (Simple Network Management Protocol)
- DHCP (Dynamic Host Control Protocol)
- DNS (Domain Name System)

UDP Segment Format

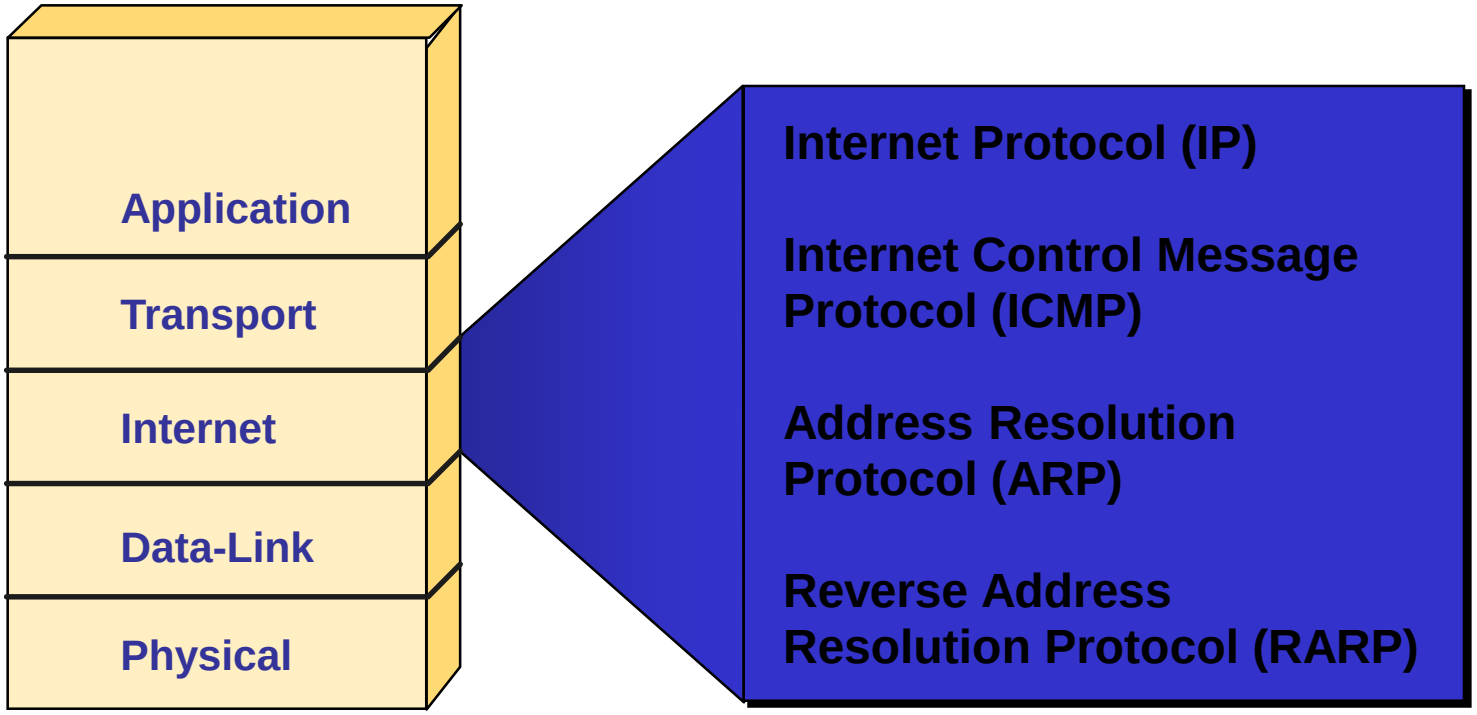


- No sequence or acknowledgment fields

TCP vs UDP

TCP	UDP
Sequenced	Unsequenced
Reliable	Unreliable
Connection-oriented	Connectionless
Virtual circuit	Low overhead
Acknowledgments	No acknowledgment
Windowing flow control	No windowing or flow control

Internet Layer Overview



- In the OSI reference model, the network layer corresponds to the TCP/IP Internet layer.

Network Access (Interface) Layer