KF School of Computing and Information Sciences
Florida International University

CNT 4403
Computing and Network Security

Network Security – TCP/IP Networks

Dr. Kemal Akkaya

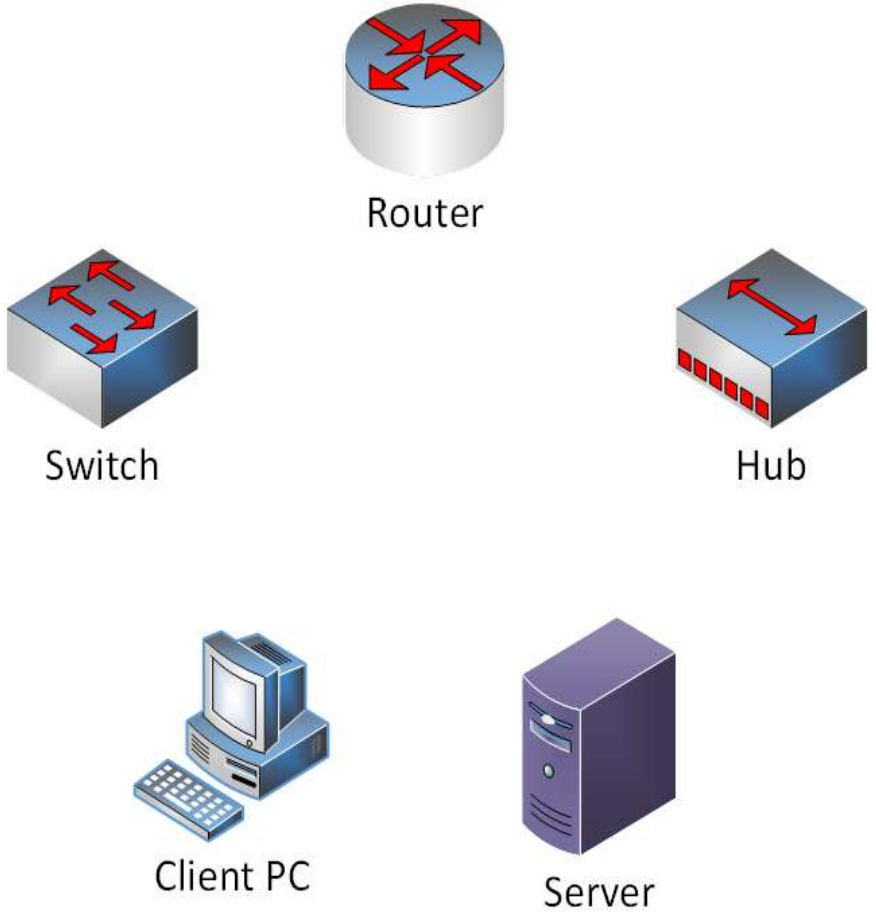
E-mail: *kakkaya@fiu.edu*

Examples of Networks

- **What are some examples of how you use networks every day?**
  - File sharing
  - Video chat (Skype, FaceTime)
  - Web surfing
  - Instant messaging
  - Social Media (Facebook, Twitter, Vine)
  - Voice over IP (VoIP)

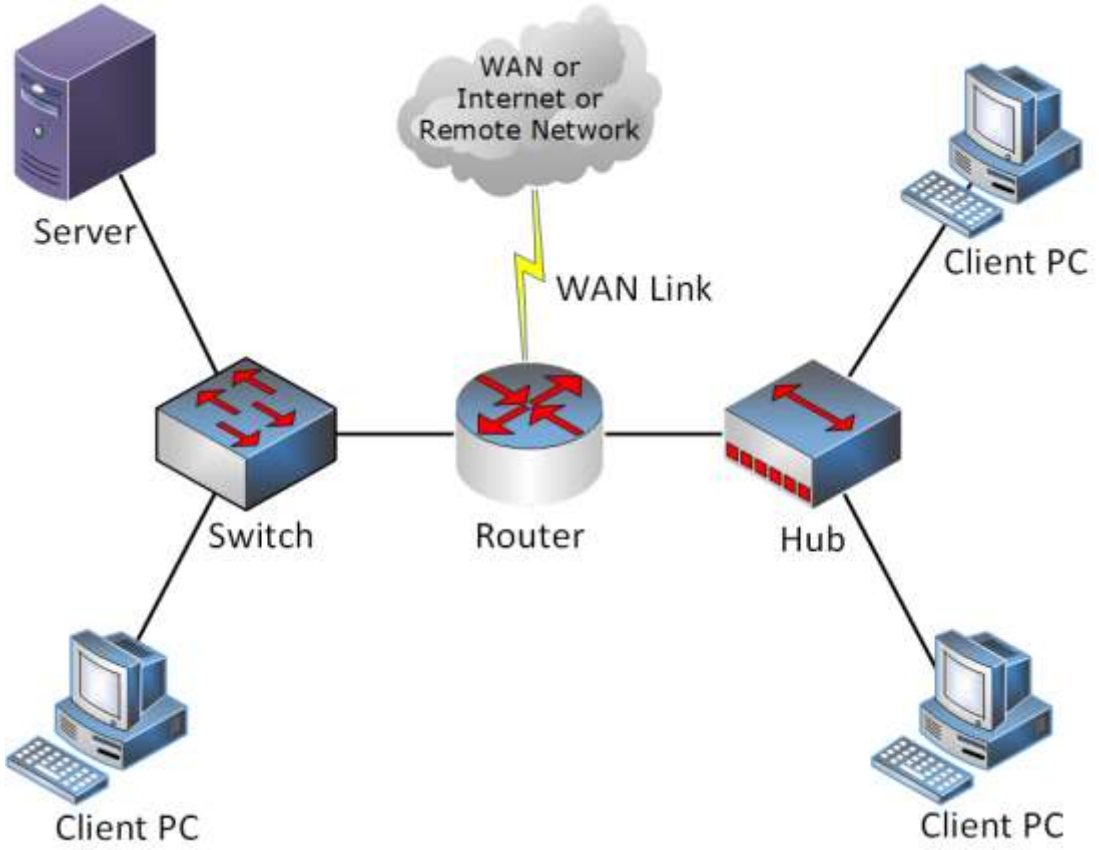
Network Components

- **Icons representing actual equipment:**
  - Router
  - Switch
  - Hub
  - Client
  - Server



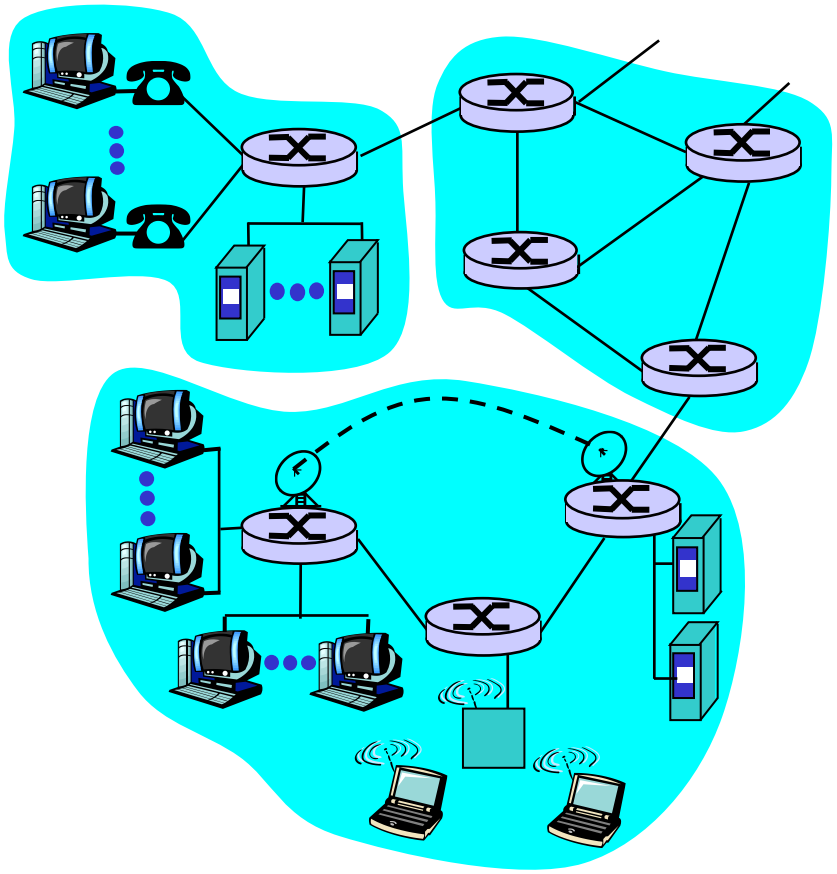
Network Components

- **Connect the components together with some *media* and you have a network!**



Internet: a network of networks

- **Communication *infrastructure* enables distributed applications**
  - Network edge: applications and hosts
  - Network core:
    - ✓ routers
    - ✓ network of networks
  - Physical media: communication links
  - Applications: Web, email, games, e-commerce, file sharing
- **Communication services provided to apps:**
  - Connectionless unreliable
  - Connection-oriented reliable
- **Various *protocols* are used for communication services**



Networks Defined by Geography

- "Geography", in this sense, means how close the components are to each other
  - PAN: Personal-area network
  - LAN: Local-area network
  - CAN: Campus-area network
  - MAN: Metropolitan-area network
  - WAN: Wide-area network

PAN: Personal-area Network

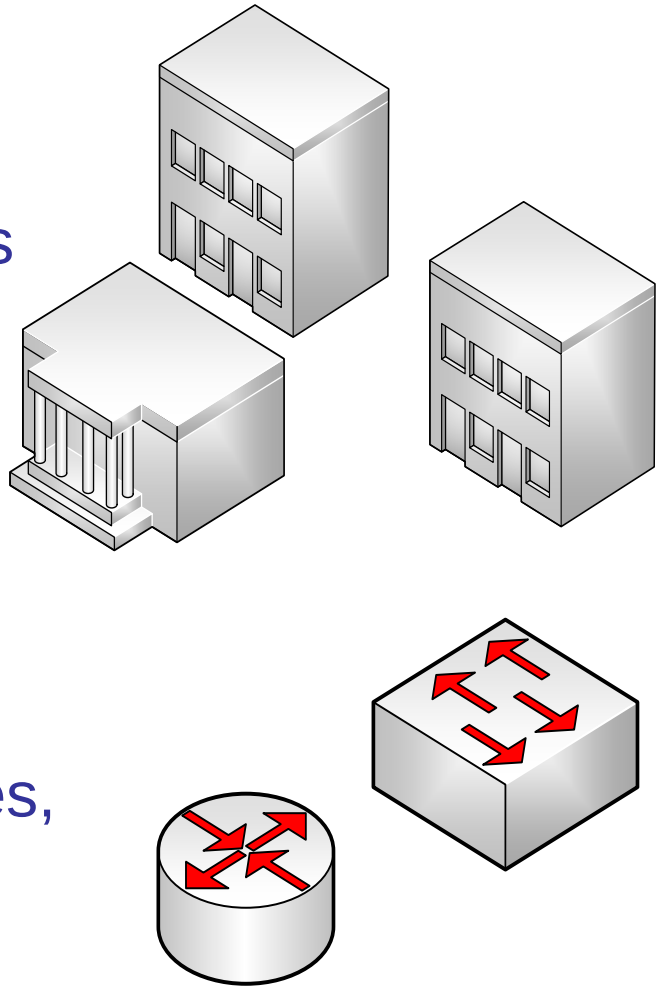
- **Scale** - Human
- **Distance** – a few meters
- **Wired** – USB
- **Wireless** – Bluetooth
- **Components** – PCs, headphones, keyboards, smartphones, etc.

LAN: Local-area Network

- **Scale** – Room or Building
- **Distance** – Usually 100 meters or less
- **Wired** – Cat6 (Gig Ethernet) or Fiber
- **Wireless** – 802.11
- **Components** – PCs, routers, switches, servers, printers, wireless access points, etc.

CAN: Campus-area Network

- **Scale** – Cluster of Buildings
- **Distance** – Usually a mile or less
- **Wired** – Fiber, coax
- **Wireless** – 802.11, microwave
- **Components** – Routers, switches, wireless bridges, etc.



MAN: Metropolitan-area Network

- **Scale** – City
- **Distance** – Usually a few miles or less
- **Wired** – Fiber, coax
- **Wireless** – Microwave
- **Components** – Routers, switches, wireless bridges, etc.

WAN: Wide-area Network

- **Scale** – State, country, global
- **Distance** – A few miles to thousands of miles
- **Wired** – Fiber
- **Wireless** – Microwave
- **Components** – Routers, switches, satellites, etc.

What's a protocol?

Human protocols:

- "What's the time?"
- "I have a question"
- Introductions

… specific msgs sent

… specific actions taken when msgs received, or other events

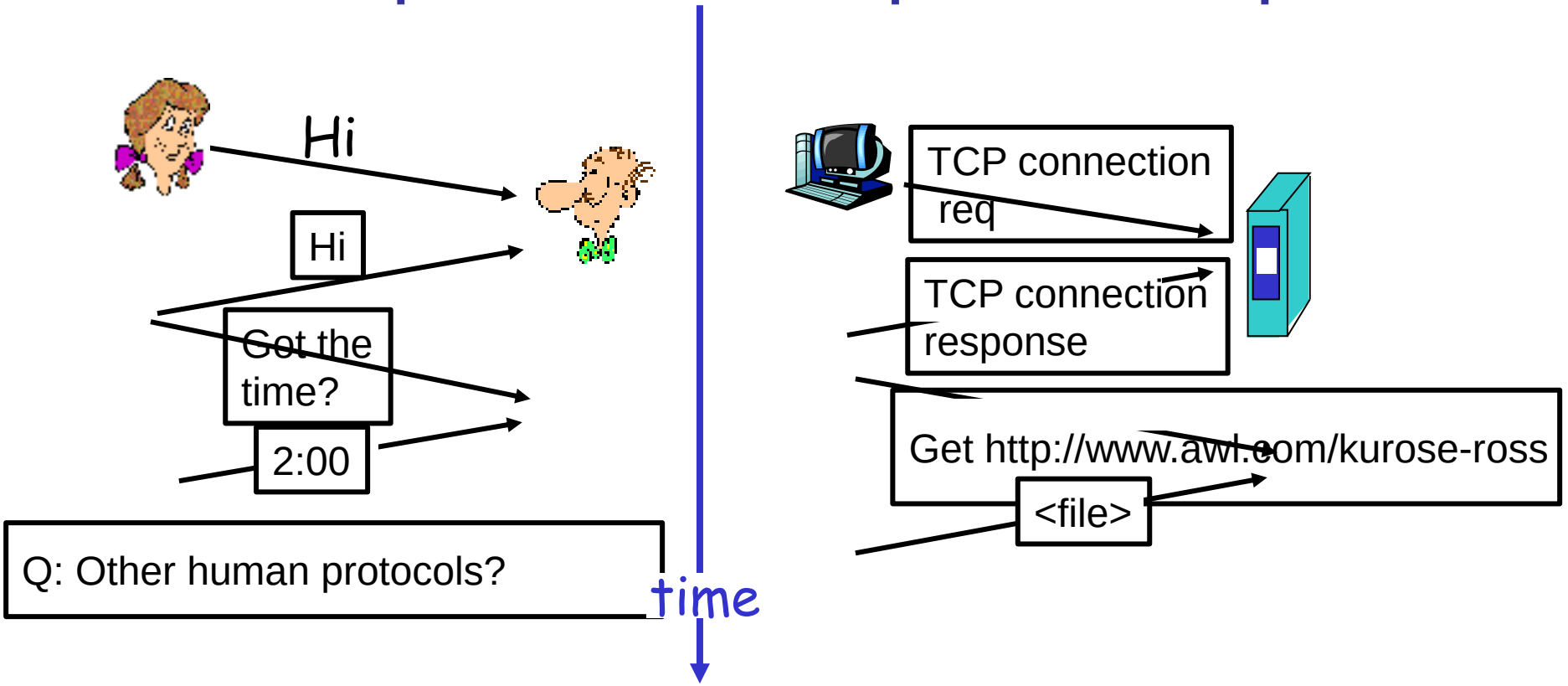
Network protocols:

- Machines rather than humans
- All communication activity in Internet governed by protocols

Protocols define format, order of messages sent and received among network entities, and actions taken on message transmission, receipt

What's a protocol?

❑ A human protocol and a computer network protocol:



❑ Key Elements of a Protocol:

❑ Syntax
- ➢Data formats
- ➢Signal levels

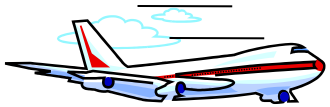
❑ Timing
- ➢Speed matching
- ➢Sequencing

❑ Semantics
- ➢Control information
- ➢Error handling

Protocol "Layers"

- **Networks are complex!**
- **Many "pieces":**
  - hosts
  - routers
  - links of various media
  - applications
  - protocols
  - hardware, software
- **Hard to deal with**
  - Difficult to understand the underlying mechanisms
  - Changes are difficult as they grow
- **Question: Is there any hope of *organizing* structure of network?**
- **This lead researchers to come up with standard protocol stacks/architectures**

Layering of airline functionality



ticket (purchase)			ticket (complain)	ticket
baggage (check)			baggage (claim	baggage
gates (load)			gates (unload)	gate
runway (takeoff)			runway (land)	takeoff/landing
airplane routing	airplane routing	airplane routing	airplane routing	airplane routing
departure airport	intermediate air-traffic control centers		arrival airport	

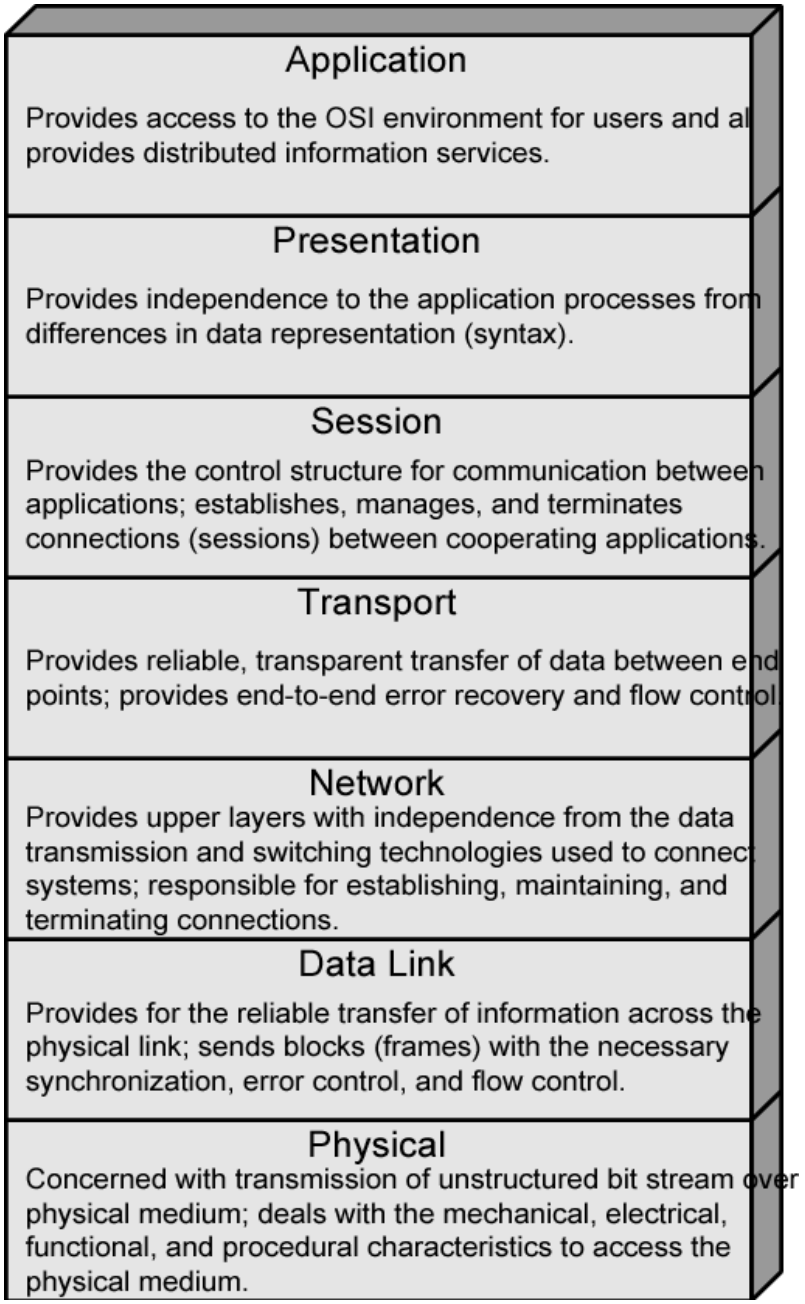
- **Layers: Each layer implements a service**
  - via its own internal-layer actions
  - relying on services provided by layer below
- **Why Layering?**
  - Dealing with complex systems
  - Explicit structure allows identification, relationship of complex system's pieces
    - ✓ Layered reference model for discussion
  - Modularization eases maintenance, updating of system
    - ✓ Change of implementation of layer' s service transparent to rest of system
    - ✓ e.g., change in gate procedure does not affect rest of system

Standardized Protocol Architectures

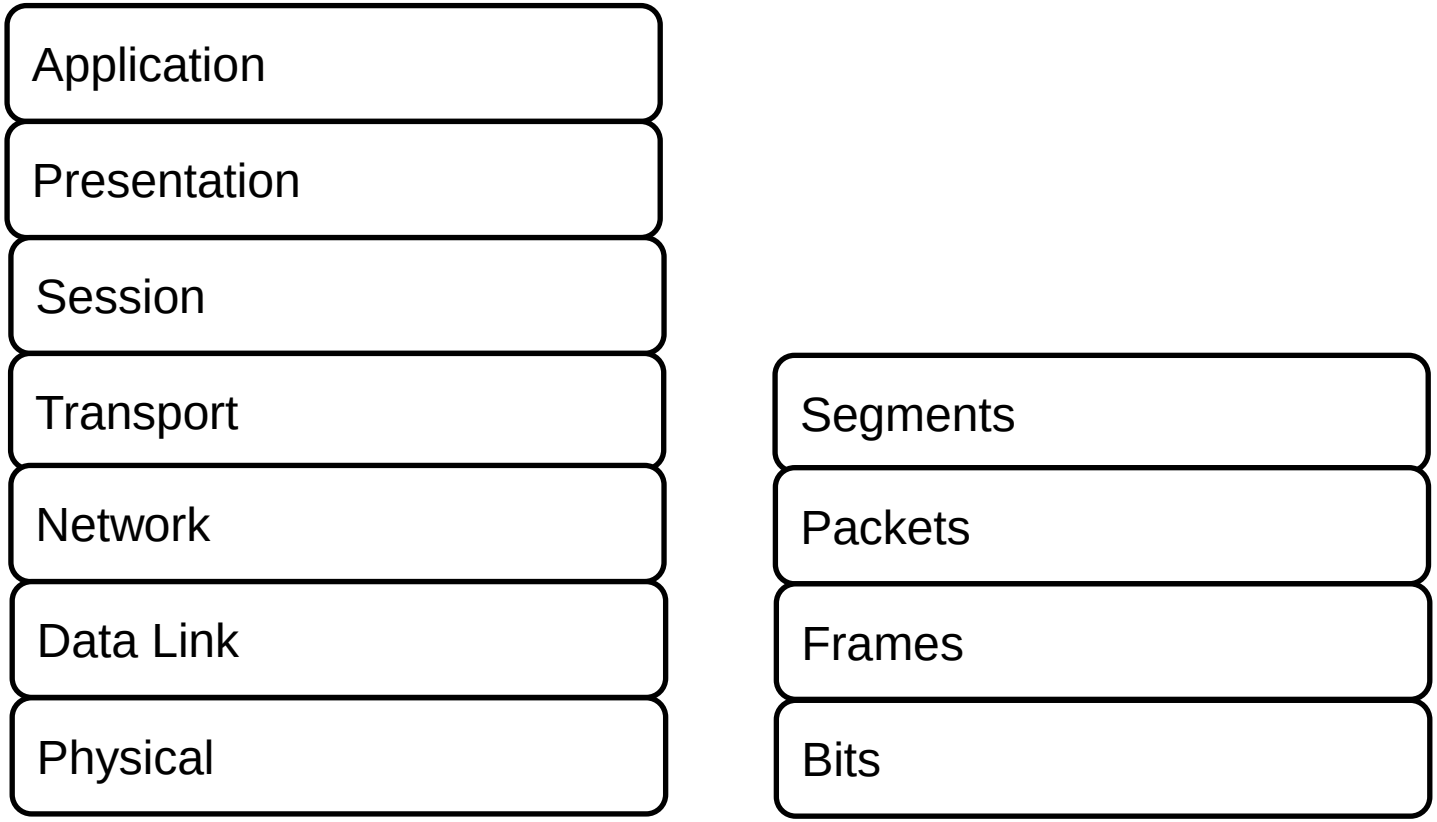
- **Required for devices to communicate**
- **Vendors have more marketable products**
- **Customers can insist on standards based equipment**
- **Two standards:**
  - OSI Reference model
    - ✓ Open Systems Interconnection
    - ✓ Developed by the International Organization for Standardization (ISO)
    - ✓ Seven layers
    - ✓ Never lived up to early promises
  - TCP/IP protocol suite
    - ✓ Most widely used
    - ✓ De facto standard
- **Also: IBM Systems Network Architecture (SNA)**

OSI Reference Model

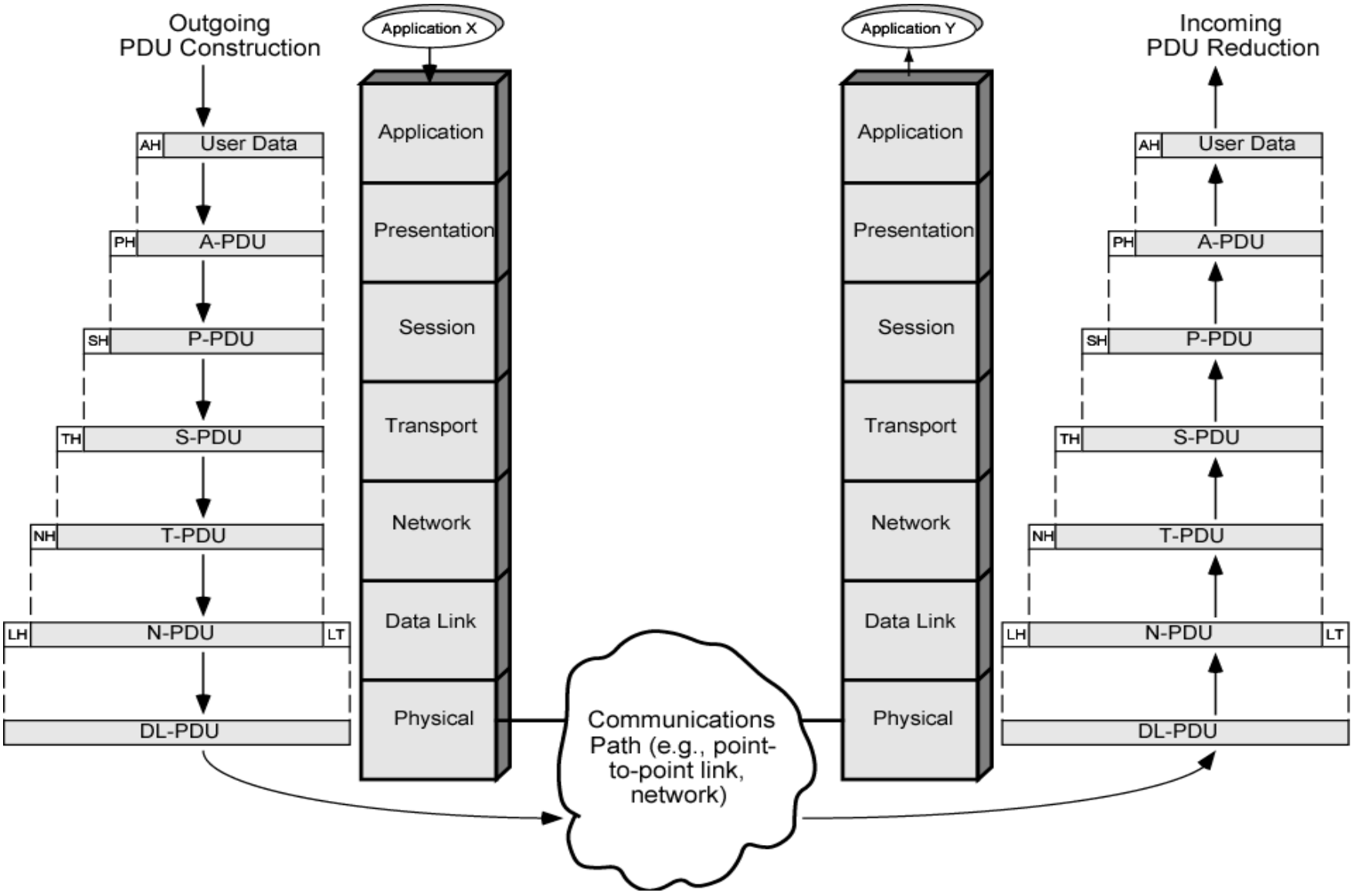
- A layer model
- Each layer performs a subset of the required communication functions
- Each layer relies on the next lower layer to perform more primitive functions
- Each layer provides services to the next higher layer
- Changes in one layer should not require changes in other layers
- Why OSI did not take over the world
  - Bad timing
  - Bad technology
  - Bad implementations
  - Bad politics



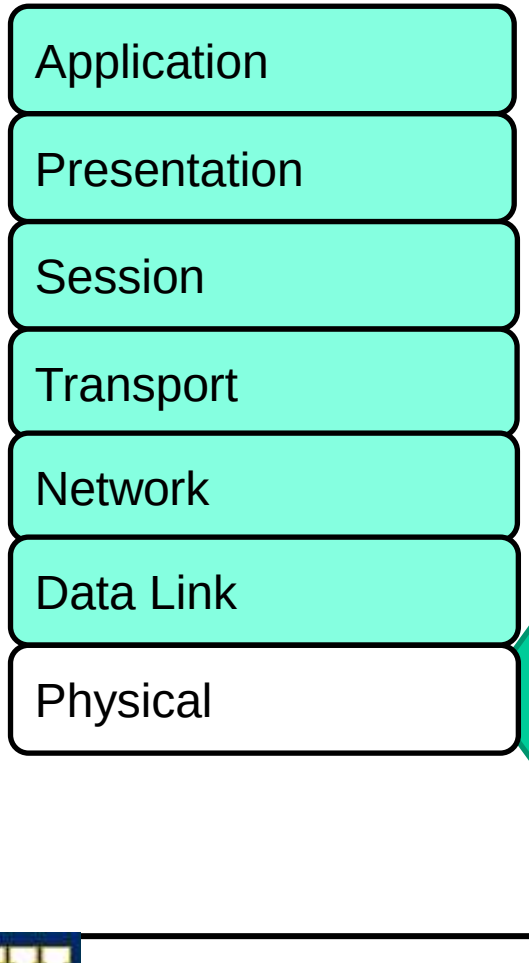
Protocol Data Units



The OSI Environment

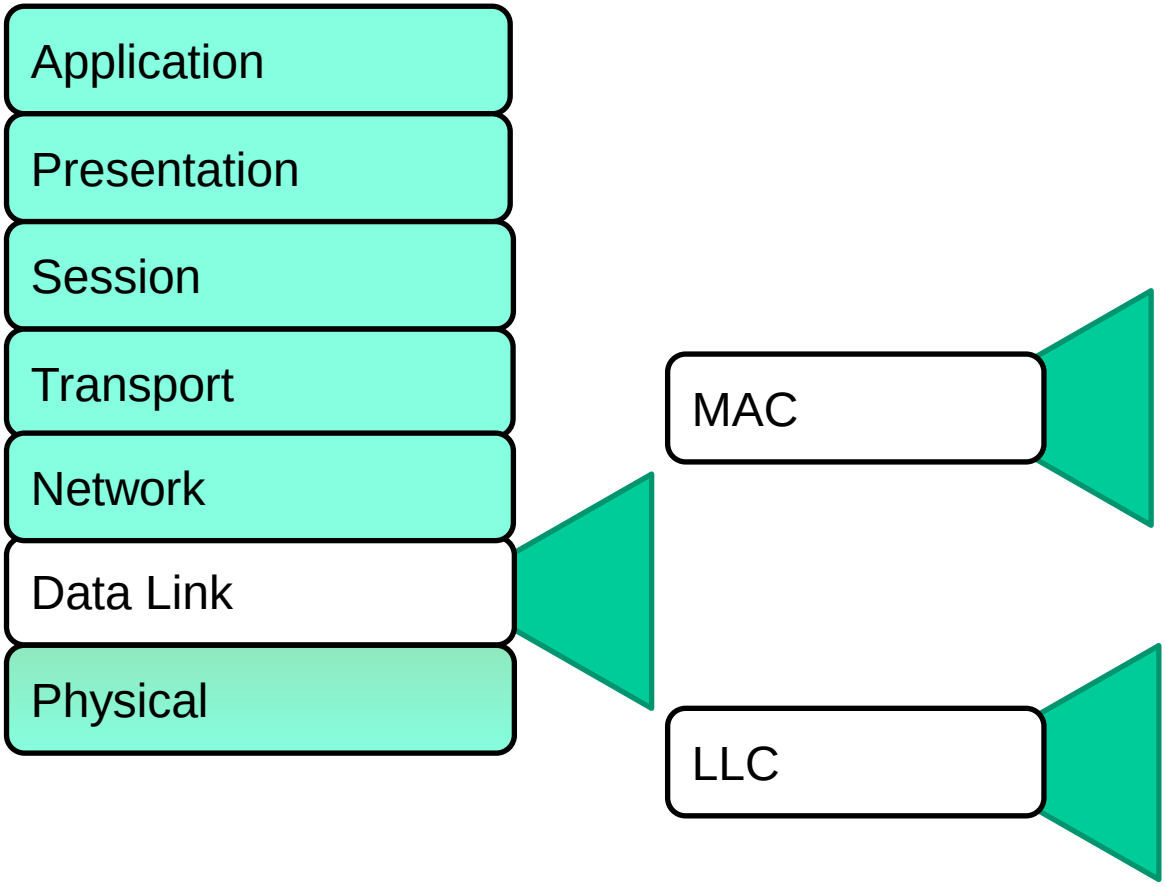


Layer 1 - Physical



- Electrical voltage/light modulation
- Cat6, Cat7, RJ-45 standards
- Physical Topologies – Bus, Ring, Star
- Broadband or Baseband signaling
- Multiplexing – TDM, FDM

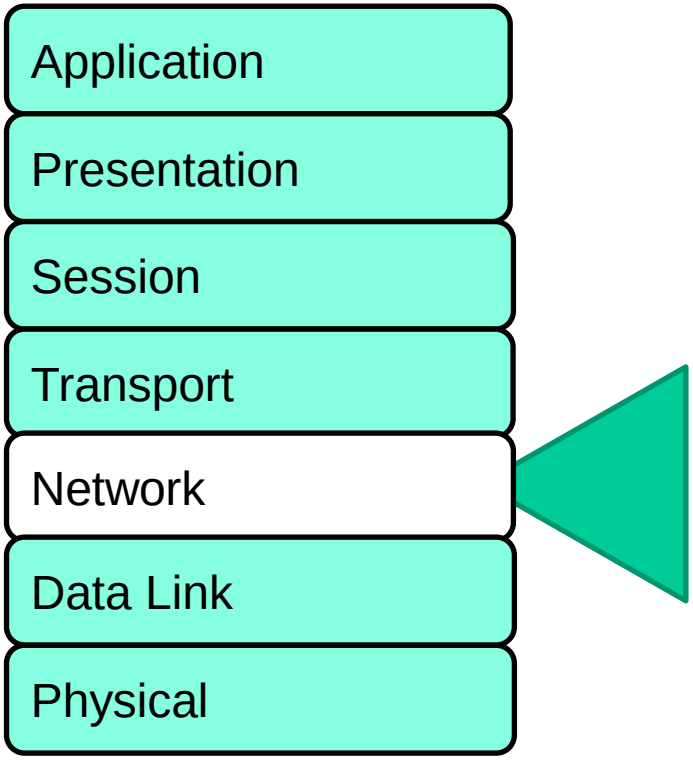
Layer 2 - Data Link



- Physical Addressing - MAC
- Logical topology – Bus, Ring
- Transmission Method

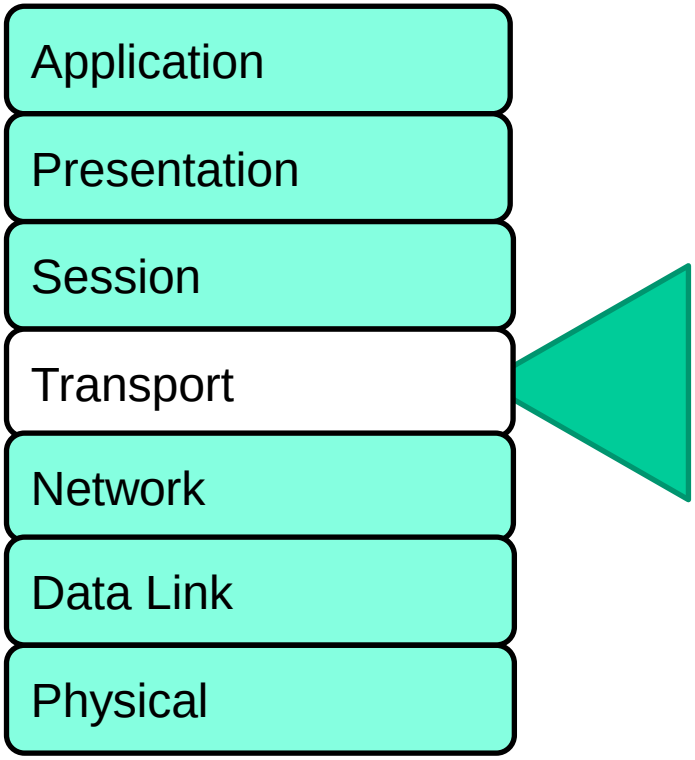
- Flow Control
- Error Control
- Synchronization

Layer 3 - Network



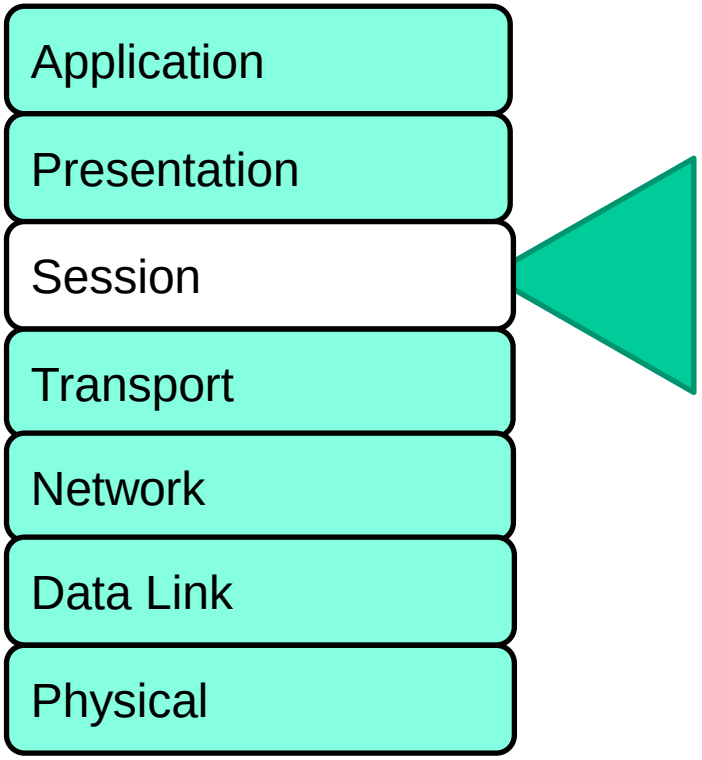
- IP Addressing
- Packet/Circuit/Message Switching
- Routing Protocols – RIP, OSPF, EIGRP

Layer 4 - Transport



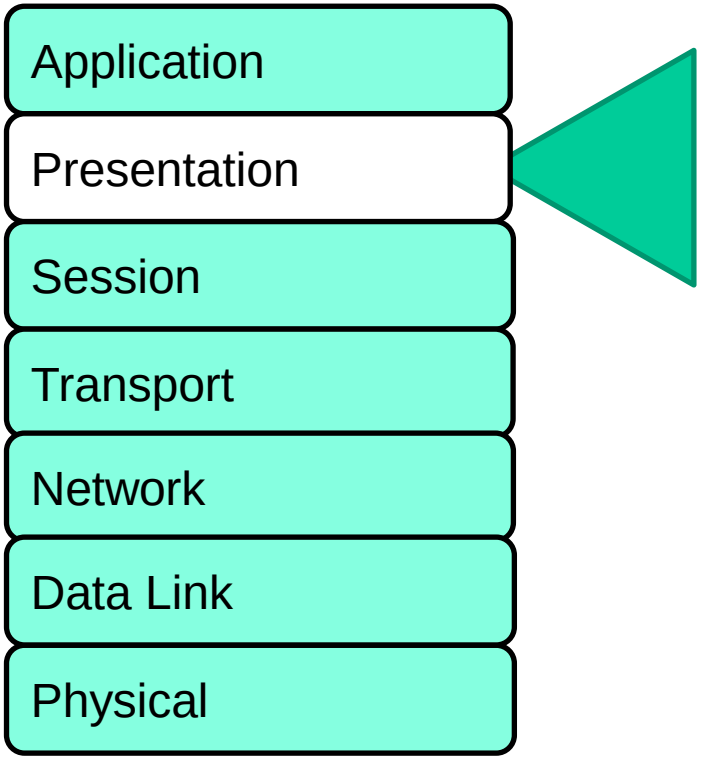
- Transport Protocols
  - TCP
  - UDP
- Flow Control
  - Windowing
  - Buffering
  - Flow Control and Packet Sequencing

Layer 5 - Session



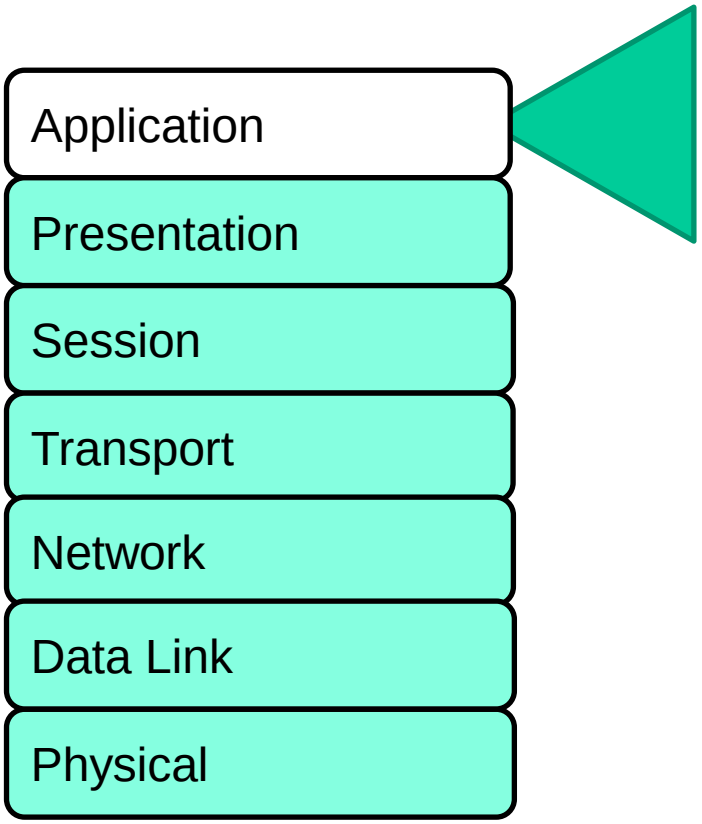
- Setting up a session
  - Identifying flows
- Maintaining a session
  - Transferring Data
- Tearing down a session

Layer 6 - Presentation



- Data formatting
  - ASCII
  - JPG, PNG, BMP
- Encryption

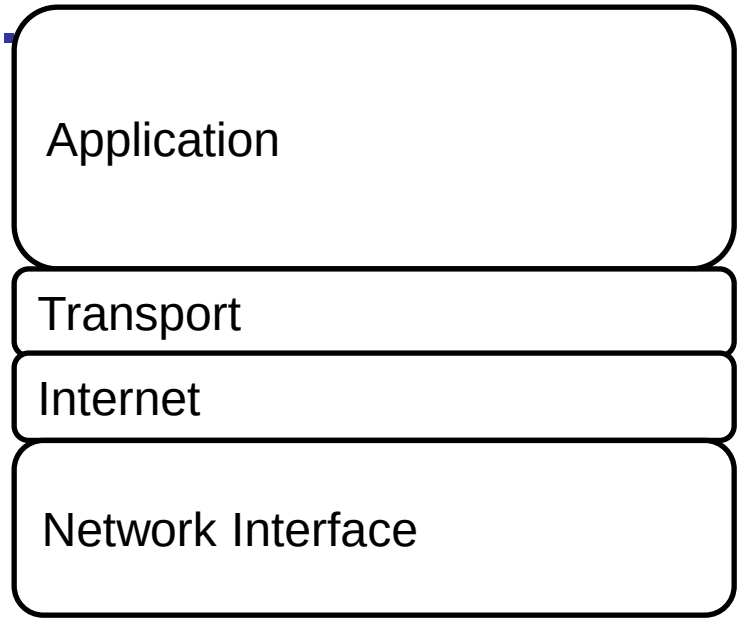
Layer 7 - Application



- Application services
  - HTTP
  - FTP
  - SMTP
- Service advertisement

TCP/IP Protocol Architecture

- **Developed by the US Defense Advanced Research Project Agency (DARPA) for its packet switched network (ARPANET)**
- **Used by the global Internet**
- **No official model but a working one.**
  - Application layer
  - Host to host or transport layer
  - Internet layer
  - Network Interface Layer
    - ✓ Data link layer
    - ✓ Physical layer



- **Problems:**
  - Not a general model
  - No exact separate mention of physical and data link layers
    - ✓ Sometimes called host-to-network layer
  - Minor protocols deeply entrenched, hard to replace

Layer Descriptions

- **Physical Layer**
  - Physical interface between data transmission device (e.g. computer) and transmission medium or network
  - Characteristics of transmission medium
  - Signal levels
  - Data rates
- **Data Link Layer**
  - Exchange of data between neighboring network nodes
  - Invoking services like priority
- **Internet (IP) Layer**
  - Systems may be attached to different networks
  - Routing functions across multiple networks
  - Implemented in end systems and routers
- **Transport Layer (TCP)**
  - Reliable delivery of data
  - Ordering of delivery
- **Application Layer**
  - Support for user applications: HTTP, SMTP

The OSI Model vs. TCP/IP Stack