

# Layered Protocol Design



# Protocol Layering

- Communications Protocol
  - Set of standardized rules for signaling and formatting data
  - Common language for devices to communicate
  - Layering facilitates modular design
- Modularity
  - Example 1: Use both Email and IM from your computer
    - Different applications
    - Same communication network
  - Example 2: Web browsing from both UMTS and WiFi on iPhone
    - Same application
    - Different communication networks



# OSI Reference Model

- International Standards Organization (ISO) standardized the Open System Interconnect (OSI) Basic Reference Model in late 1970s
- First standard for protocol layering, inspired all modern protocol design
- Pneumonic: Please Do Not Throw Sausage Pizza Away

	Data Unit	Layer	Function
Host Layers	Data	<b>Application</b>	User interface, network consumer
		<b>Presentation</b>	Data representation, encryption
		<b>Session</b>	Interhost communication
	Segment	<b>Transport</b>	Reliable data delivery, flow control
Media Layers	Packet	<b>Network</b>	Global addressing and routing
	Frame	<b>Data Link</b>	Data framing, local addressing, shared medium access
	Bit	<b>Physical</b>	Electrical/RF/Optical signaling, error correction



# Modern Protocol Layering

- Internet Engineering Task Force (IETF) standardizes higher-layer protocols
- Lower layers called PHY and MAC; standardized by IEEE, 3GPP, 3GPP2, ISO, etc

OSI Layer	IETF	Others
Application	Application	Higher Layers
Presentation		
Session		
Transport	TCP or UDP	MAC
Network	IP	
Data Link	Lower Layers	PHY
Physical		



# Major IETF Protocols

- Internet Protocol (IP)
  - Fundamental protocol of all Internet-based networks
  - Provides global addressing of all devices (IP address)
- User Datagram Protocol (UDP)
  - Assigns *port numbers* to applications
  - Allows multiple applications running on a device to share a single IP address
- Transmission Control Protocol (TCP)
  - Same features as UDP
  - Adds reliability features
    - Packet fragmentation
    - Guaranteed delivery
    - In-order delivery
    - Flow control and congestion control



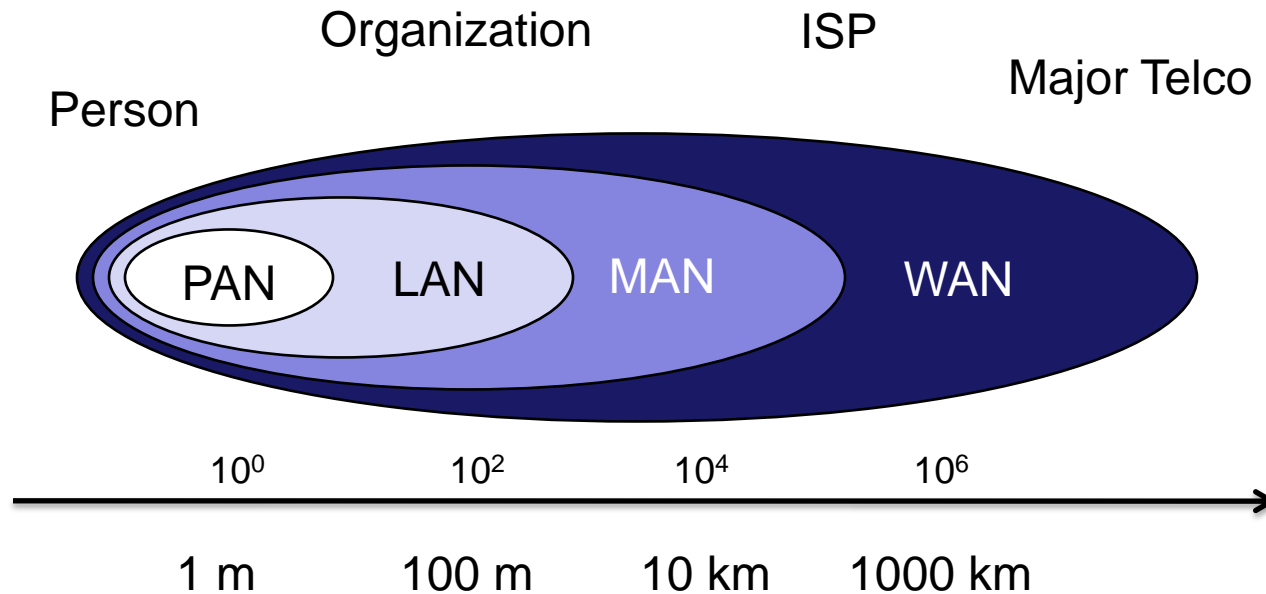
# Major Lower-Layer Protocols

- IEEE 802
  - 802.3: Ethernet
  - 802.11: Wireless LAN (WiFi)
  - 802.15: Wireless PAN (Bluetooth)
  - 802.16: Wireless MAN (WiMAX)
- Cellular Standards
  - GSM, UMTS cellular standards (3GPP)
    - AT&T, Sprint, TMobile
  - IS-95, CDMA2000 cellular standards (3GPP2)
    - Verizon
- ATM and SONET/SDH (ISO)
  - WAN standards



# Different \_ANs

- Different types of networks:
  - Different signaling, protocols
  - Different intended coverage areas



# MAC?

- OSI = Data Link Layer
- Commonly referred to as Medium Access Control (MAC) layer

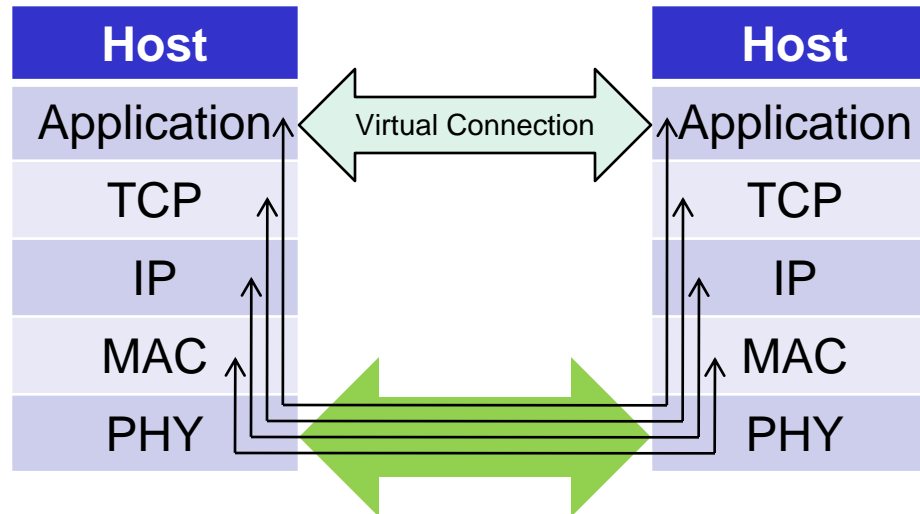
OSI Model	Modern Model
Data Link	Logical Link Control (LLC)
	Medium Access Control (MAC)
Physical	Physical (PHY)

- Data link layer split
  - MAC control who talks when; access to shared medium
  - LLC handles circuit-like features in packet-switched networks
    - Association to access points or base stations
    - Maintaining lower-layer bandwidth allocation requests
    - Sometimes called “upper MAC”



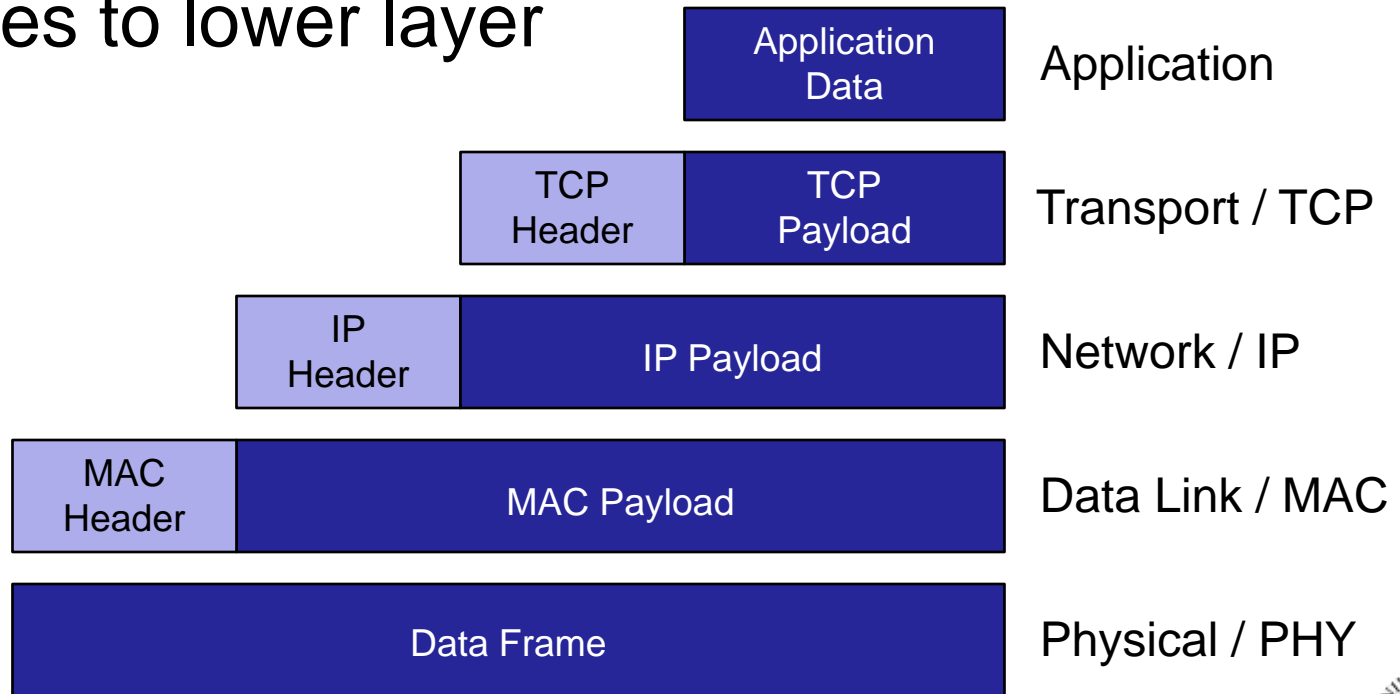
# Protocol Layering Properties

- Data generated by one application, consumed by another application
- Each time it's passed to a lower layer, the lower layer adds its own header
- Allows corresponding layers on remote hosts to communicate directly



# Protocol Layering Properties

- Each layer:
  1. Receives data from higher layer
  2. Adds its own header
  3. Passes to lower layer



# Intermediate Processing

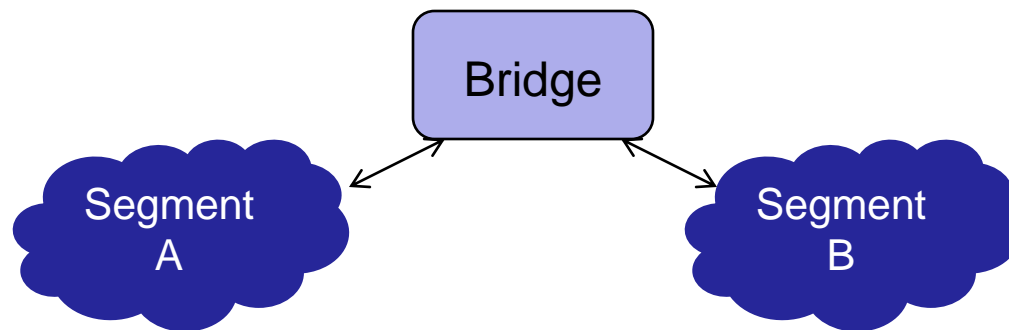
- Intermediate devices in the network need to understand different parts of a packet being transmitted

Layer	Devices	Function
Application	Gateways, IDS	Understand all protocol layers; IDS analyzes packets for security purposes
TCP / UDP	Firewalls	Identifies applications by TCP/UDP ports, and only allows authorized traffic
IP	Routers	Processes IP address and routes it out the proper interface to reach the destination network
MAC	Bridges, Switches	Process MAC address and transmits packet only on output port of destination
PHY	Repeaters	Retransmits any packet received to all outbound ports



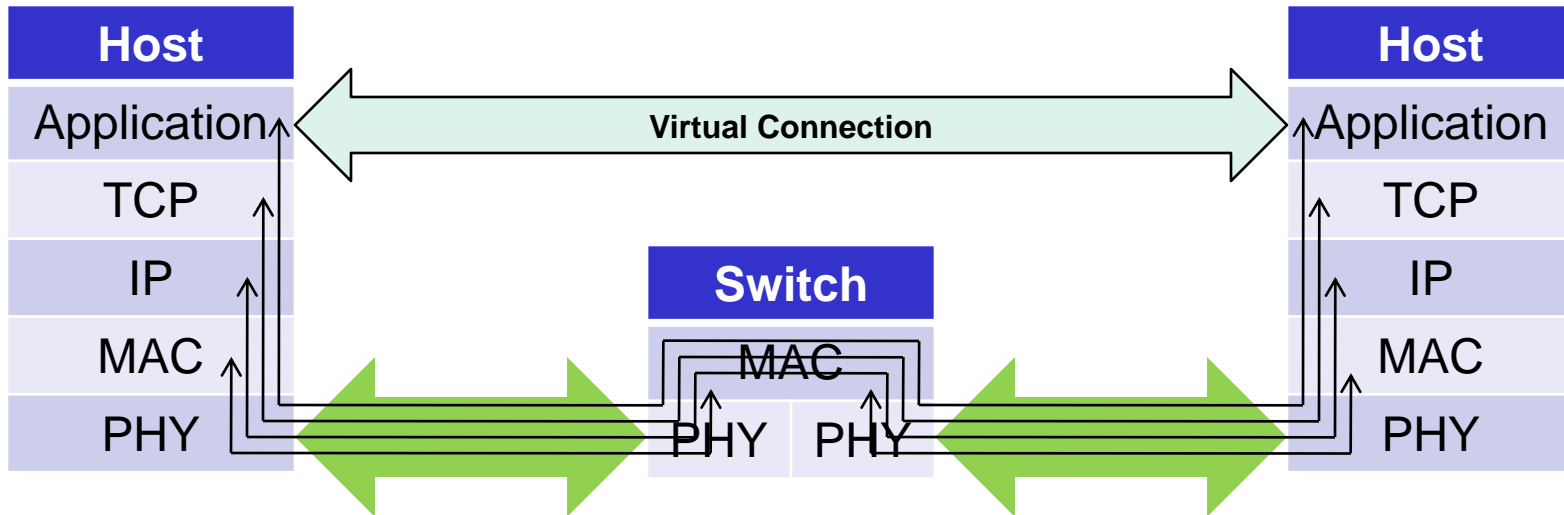
# Intermediate Processing: Bridge / Switch

- Bridge = Switch with two ports
- Observe traffic to determine which MAC addresses reside on which ports; builds table
- Transmits packets only to port where destination MAC resides
- If unknown, broadcast
- SIGNIFICANTLY reduces network traffic; improves security



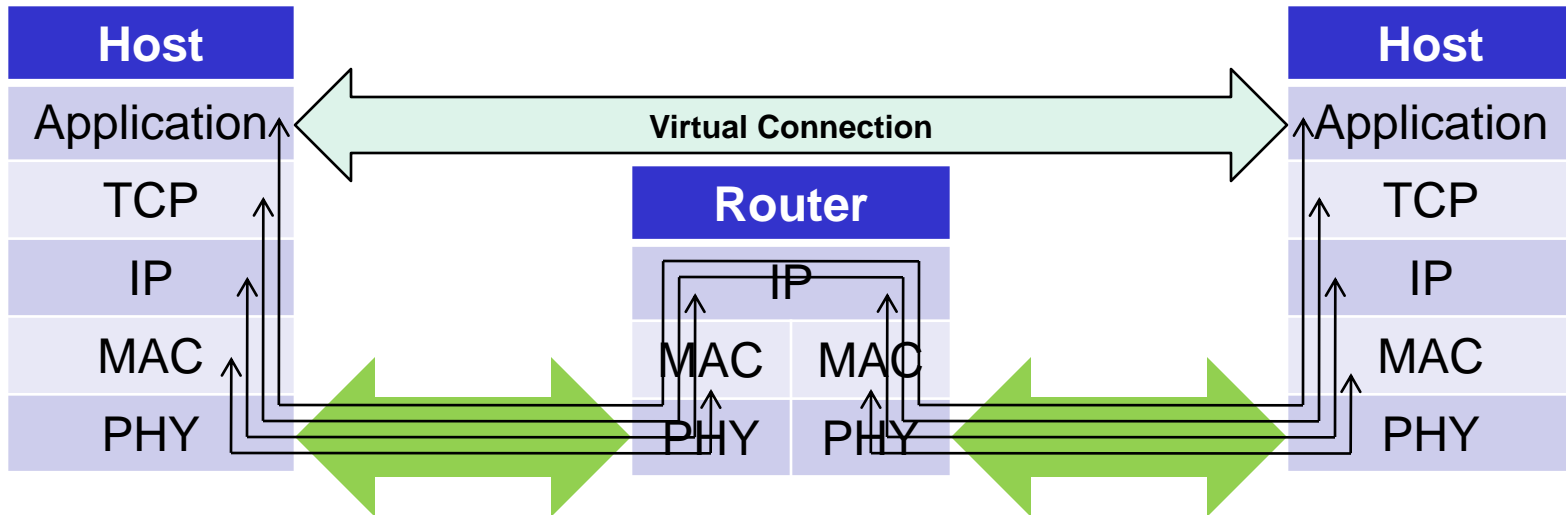
# Intermediate Processing: Bridge / Switch

- Processes MAC-layer header on inbound packets
- Ignores content in the rest of the packet
- Allows communication between different PHY
  - Example: 100 Mbps Ethernet vs 1 Gbps Ethernet



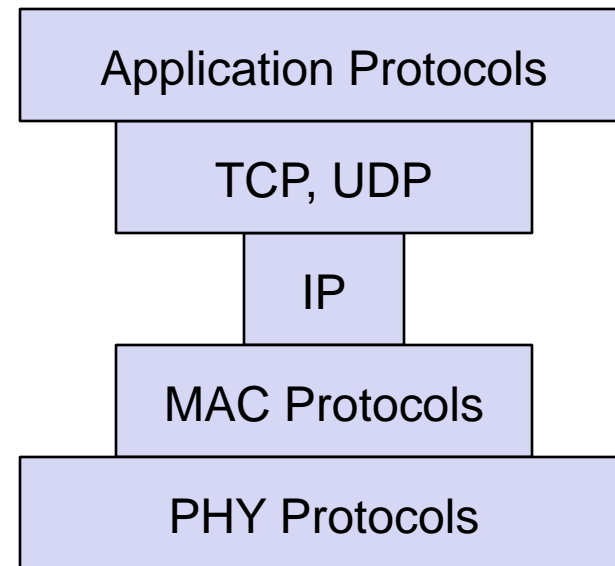
# Intermediate Processing: Router

- Processes IP header on inbound packets
- Uses destination IP address to determine through which interface the packet should be routed



# Conclusion

- Layered protocol design gives us huge flexibility
- IP in the middle provides centerpiece allowing everything to interoperate
- “Hourglass” design:



- Allows innovation of new applications without changing network infrastructure, and new network infrastructure without changing applications

