Introduction to TCP/IP networking

Web Programming

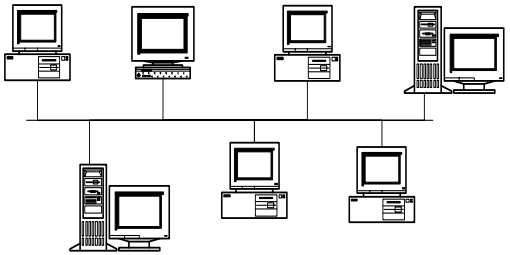
Outline

- Networks
- OSI
- TCP/IP
- IP addressing

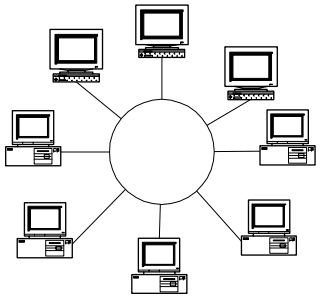
Local Area Networks

- High speed, data network over small region
  - Few thousand meters
- Network technologies:
  - Ethernet
  - FDDI
  - Token ring
- Data link layer
  - Packets routed based on physical address (MAC)

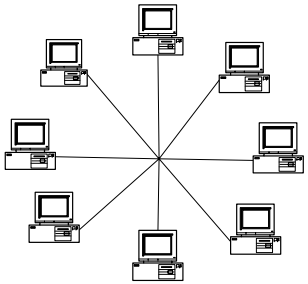
LAN Topologies



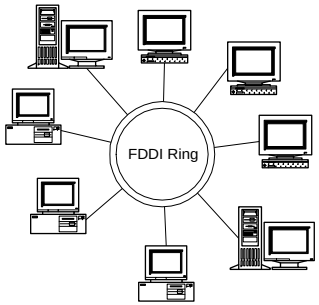
Bus architecture (Ethernet)



Ring architecture (Token Ring)



Star architecture (switched Ethernet)



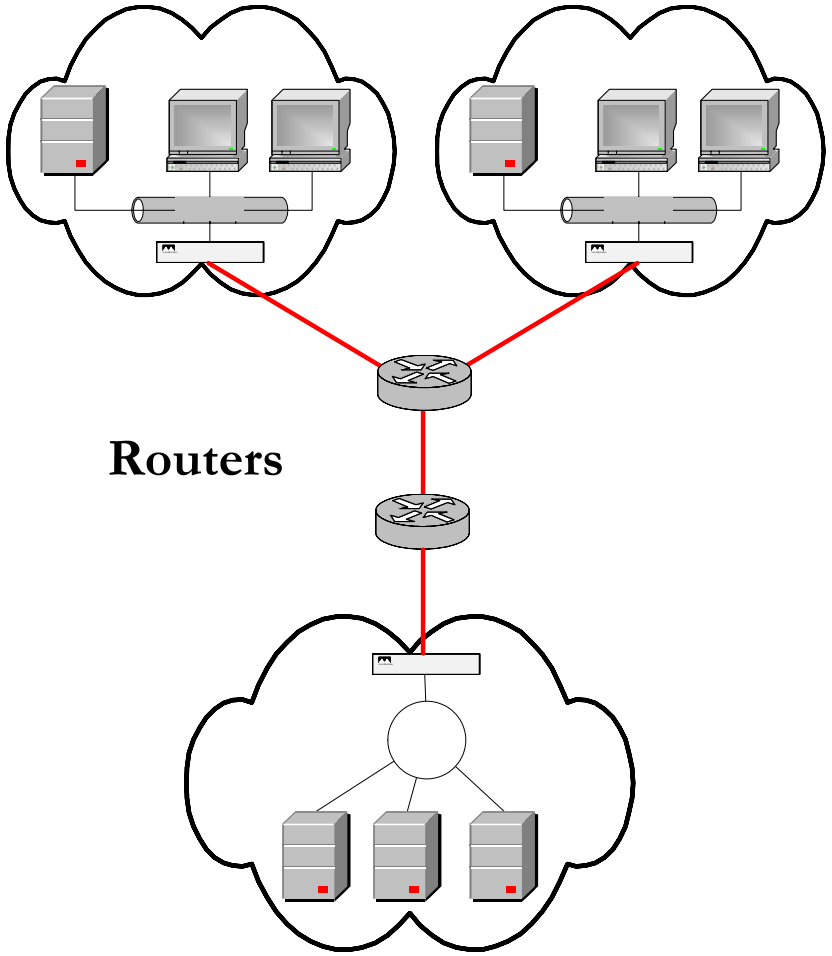
Double ring architecture (FDDI)

Network Equipments

- **Hub**
  - Center of star topology
  - In Ethernet, multiport repeater or concentrator
- **Bridge**
  - Connects 2 networks of same technology – extended LAN
  - Filters/forwards/floods based on MAC
- **Switch**
  - Connects 2+ networks – packet-switched network
  - Reduces collisions

Equipments

- Router
  - Forwards packets based on network layer info (IP)
  - Separate broadcast domains
  - In each domain, IP packet encapsulated in domain-specific packet



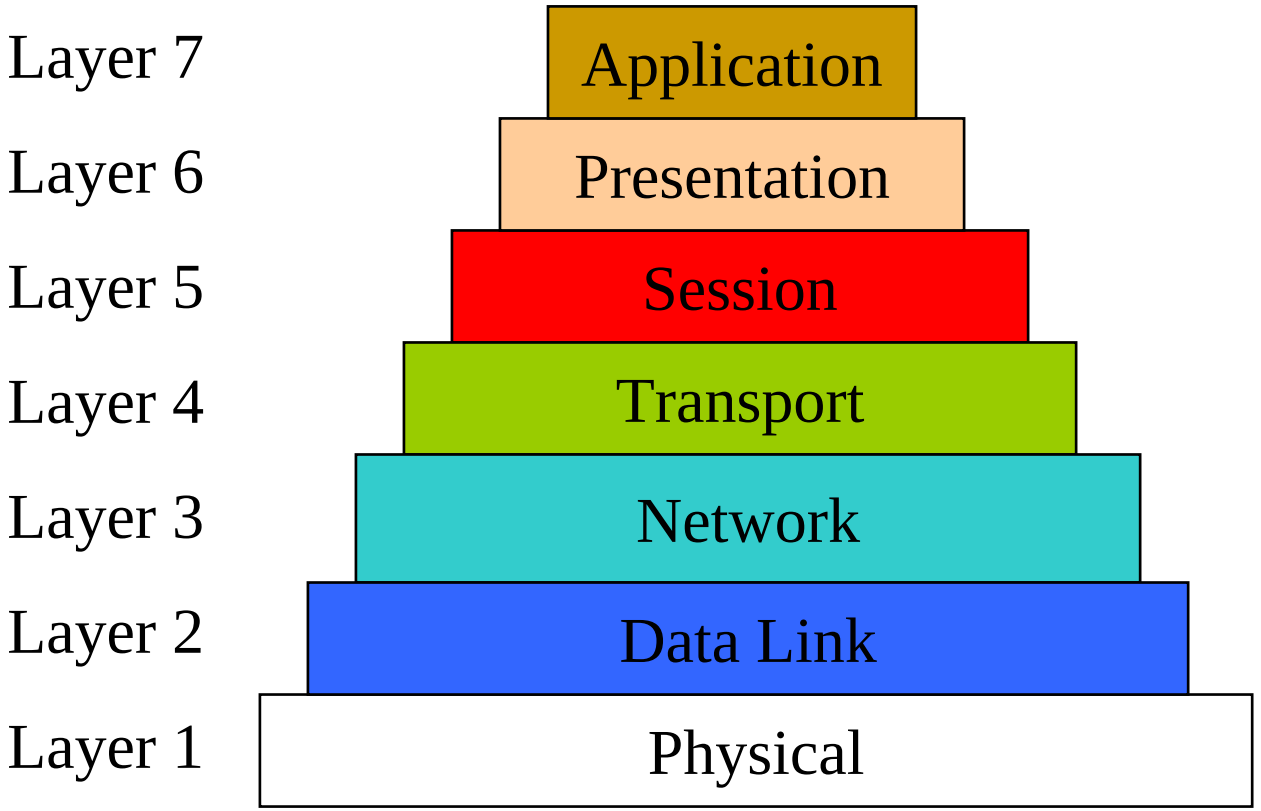
WAN Topologies

- Connection-oriented networks
  - Continuous allocation of channel (connection)
  - Fixed path is allocated to each connection
  - Examples: ATM
- Connectionless networks
  - Shared allocation of channel
  - Each packet travels independently
  - Example: Internet Protocol (IP)

Network Model: OSI

- **O**pen **S**ystems **I**nterconnection model is fundamental to all communications between network devices
- Forms the *theoretical model* for how communication takes place between network devices.

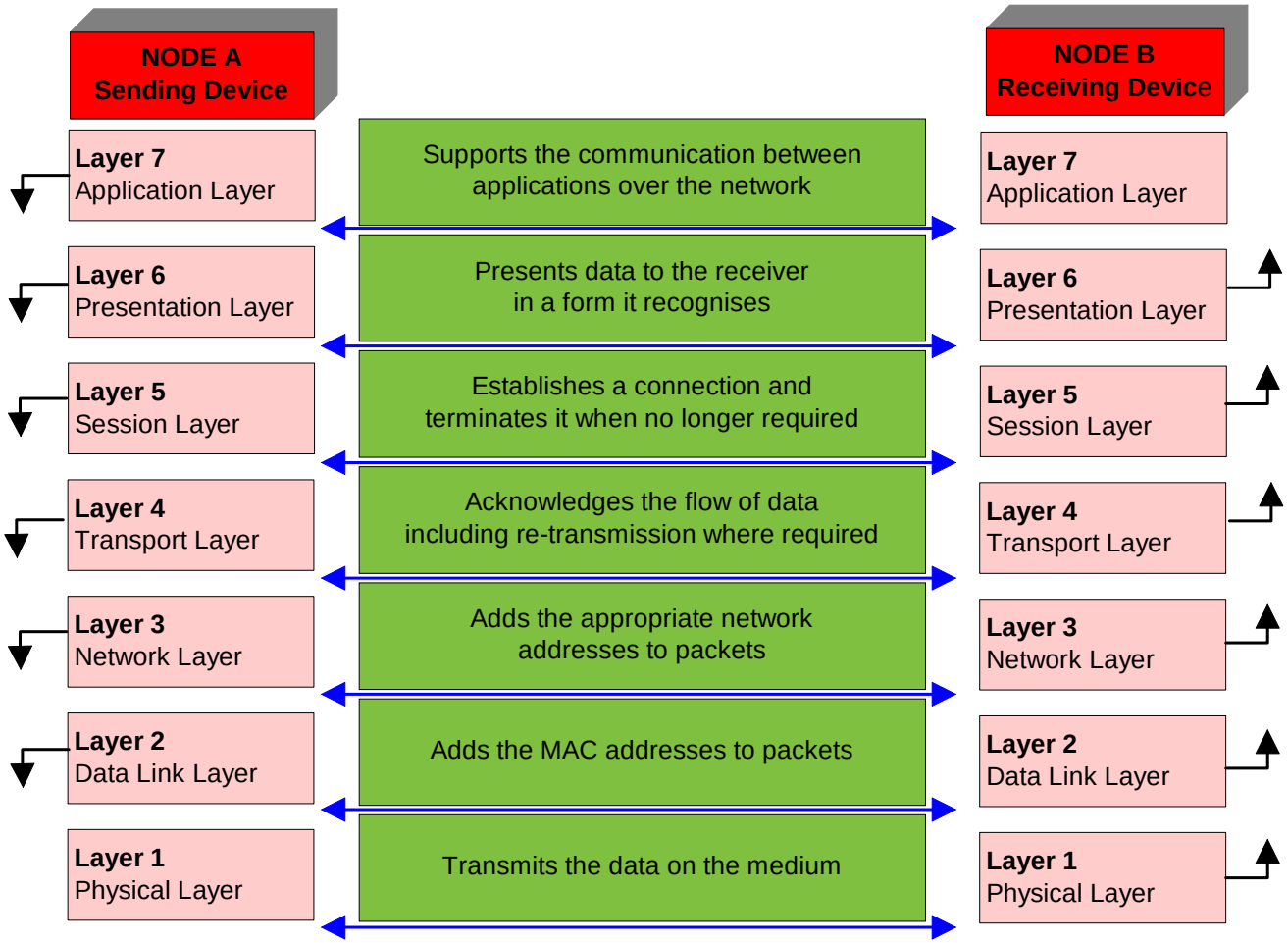
OSI model the 7 layers



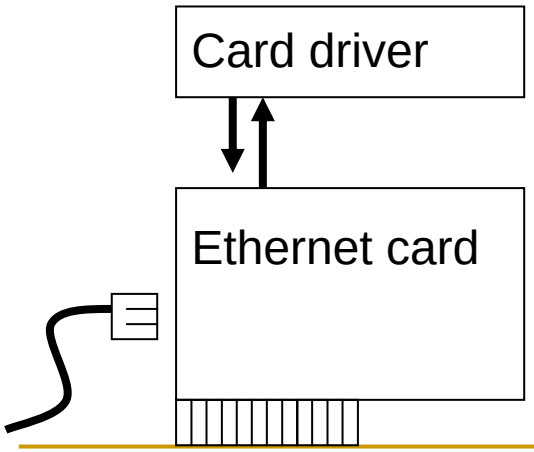
OSI Model

- When communicating, each OSI layer talks with the same layer in the other device
- E.g. the Application Layer of Device A communicates with the Application Layer of Device B, by passing the data through the other layers
- The Application Layer of each device is not concerned with how the other layers are functioning, but it does rely on them to do their job

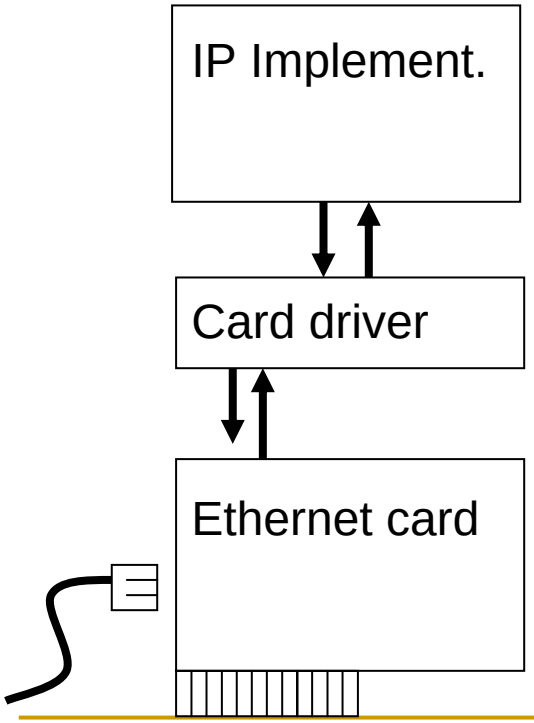
OSI


NODE A
Sending Device
NODE B
Receiving Device
Layer 7
Application Layer
Supports the communication between applications over the network
Layer 7
Application Layer
Layer 6
Presentation Layer
Presents data to the receiver in a form it recognises
Layer 6
Presentation Layer
Layer 5
Session Layer
Establishes a connection and terminates it when no longer required
Layer 5
Session Layer
Layer 4
Transport Layer
Acknowledges the flow of data including re-transmission where required
Layer 4
Transport Layer
Layer 3
Network Layer
Adds the appropriate network addresses to packets
Layer 3
Network Layer
Layer 2
Data Link Layer
Adds the MAC addresses to packets
Layer 2
Data Link Layer
Layer 1
Physical Layer
Transmits the data on the medium
Layer 1
Physical Layer

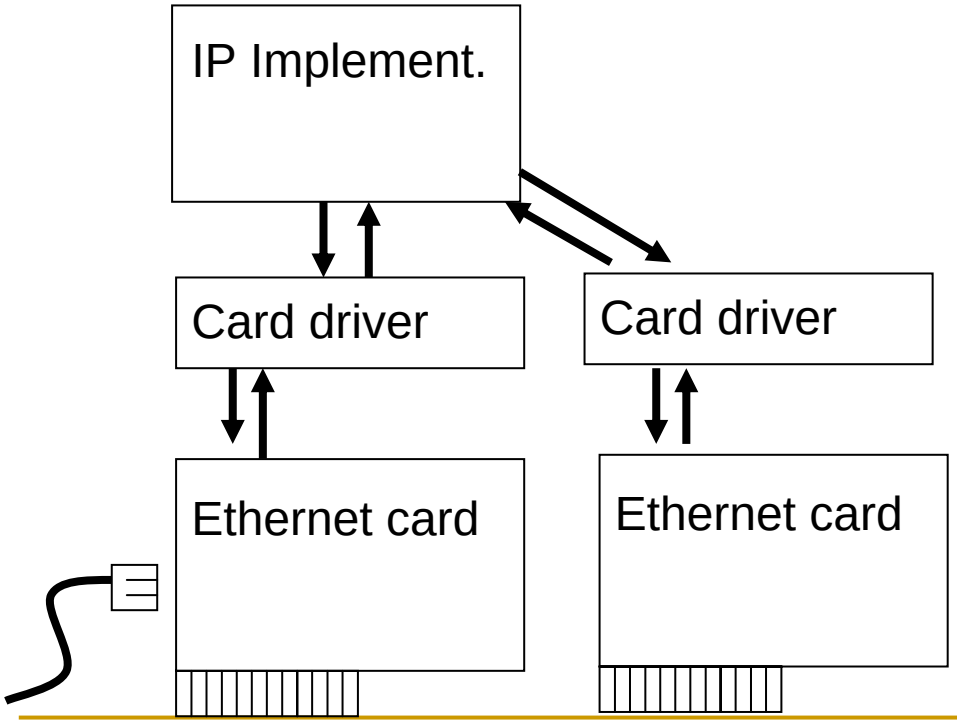
From Wire to Application



From Wire to Application



From Wire to Application



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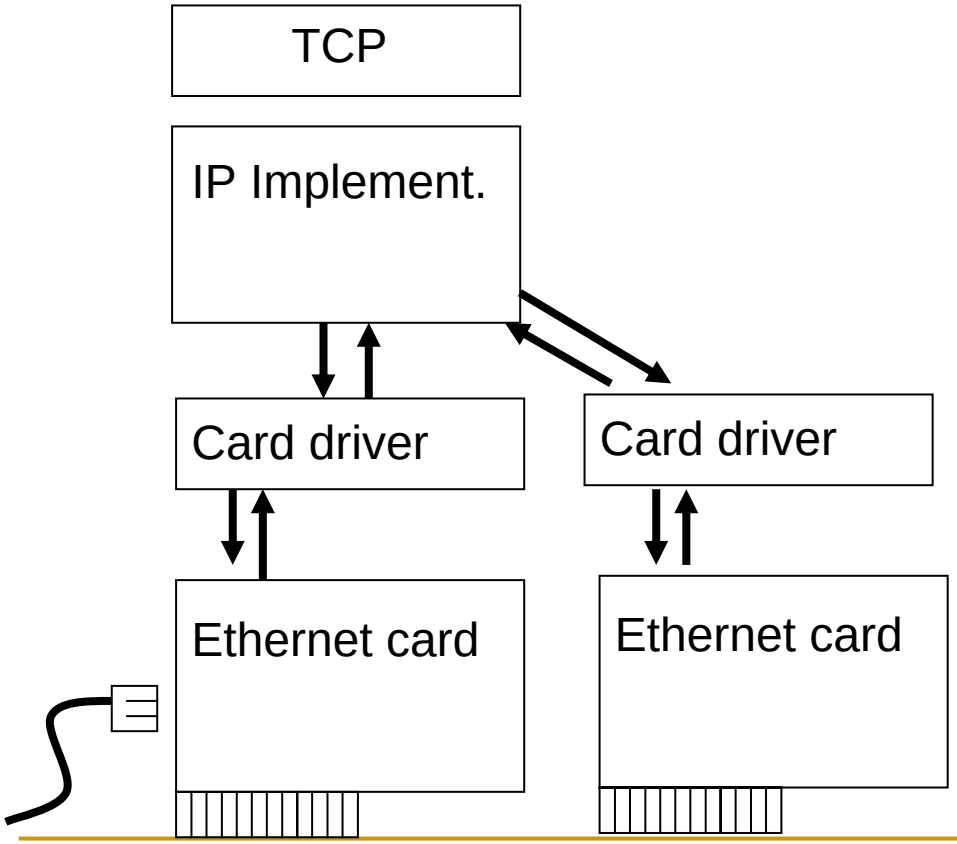
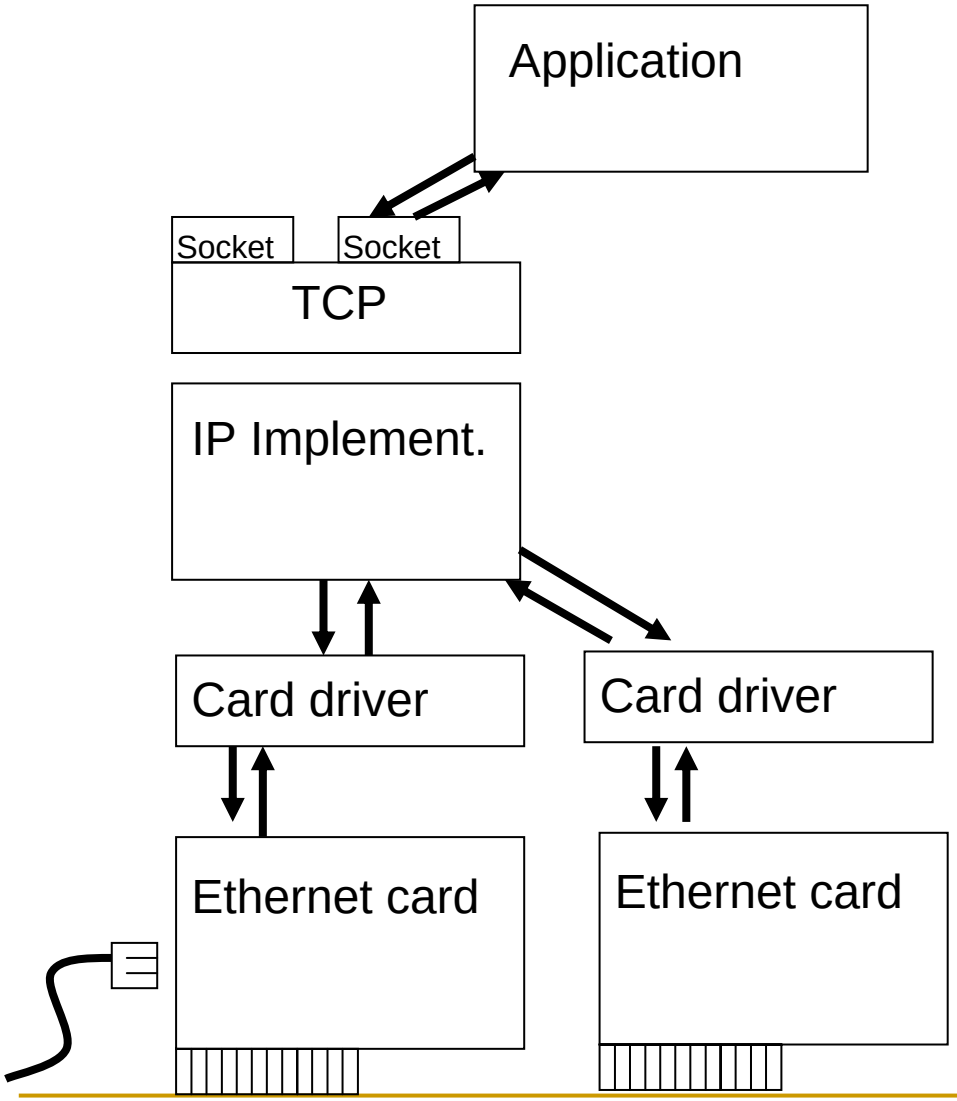
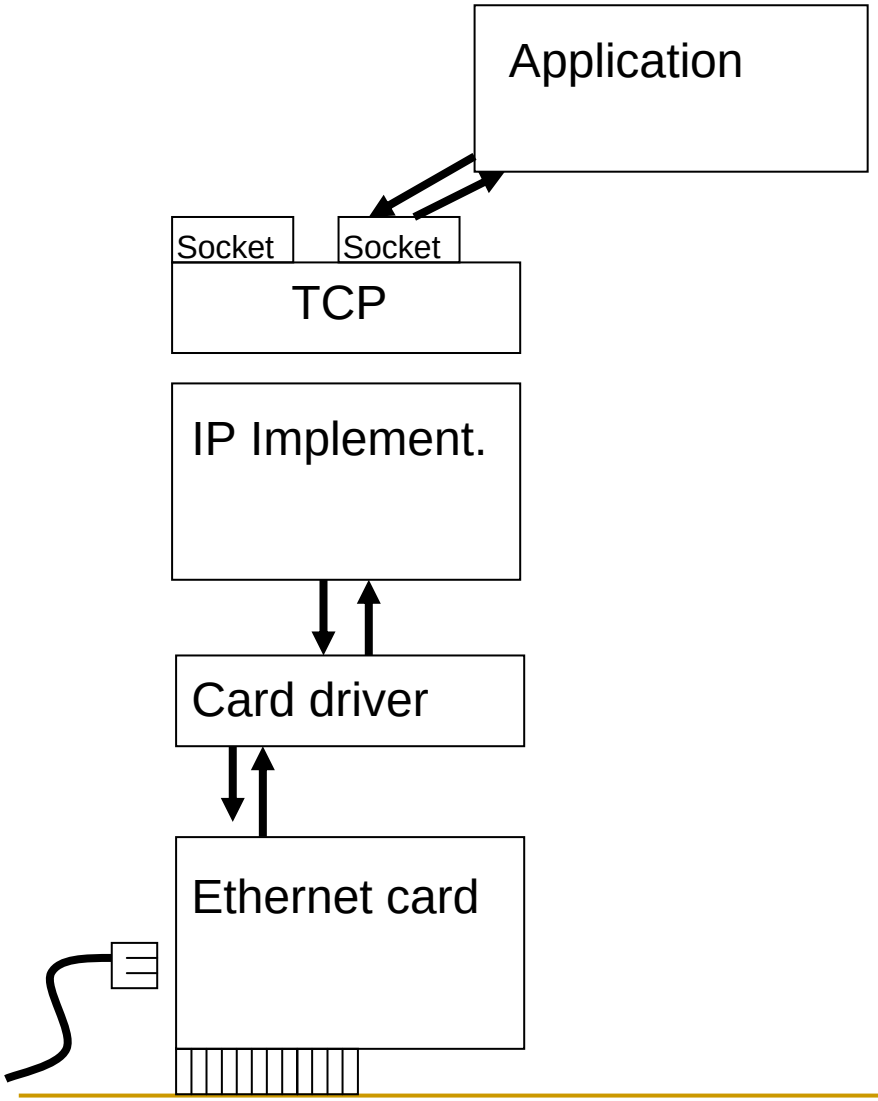


From Wire to Application

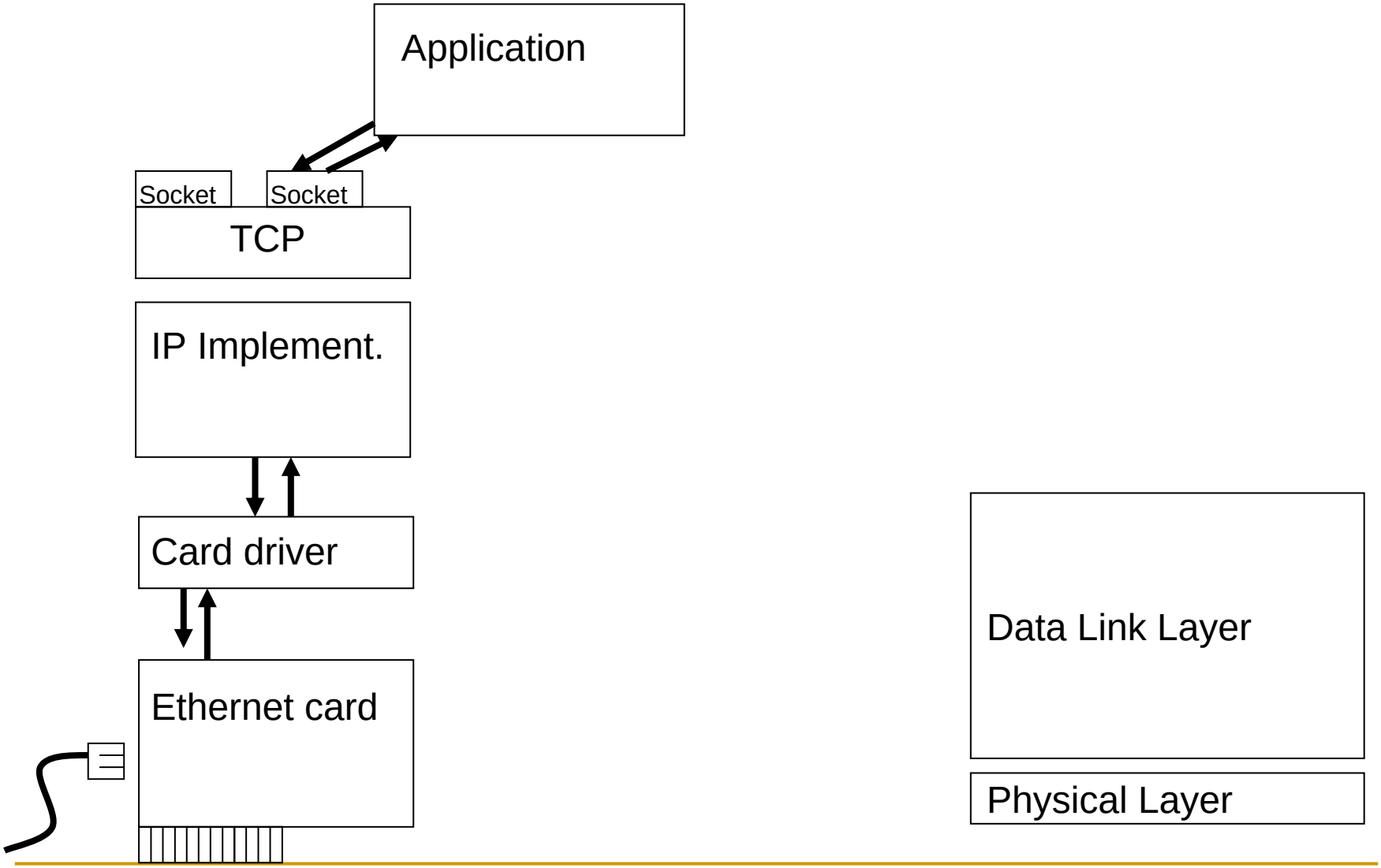


Protocol Layers

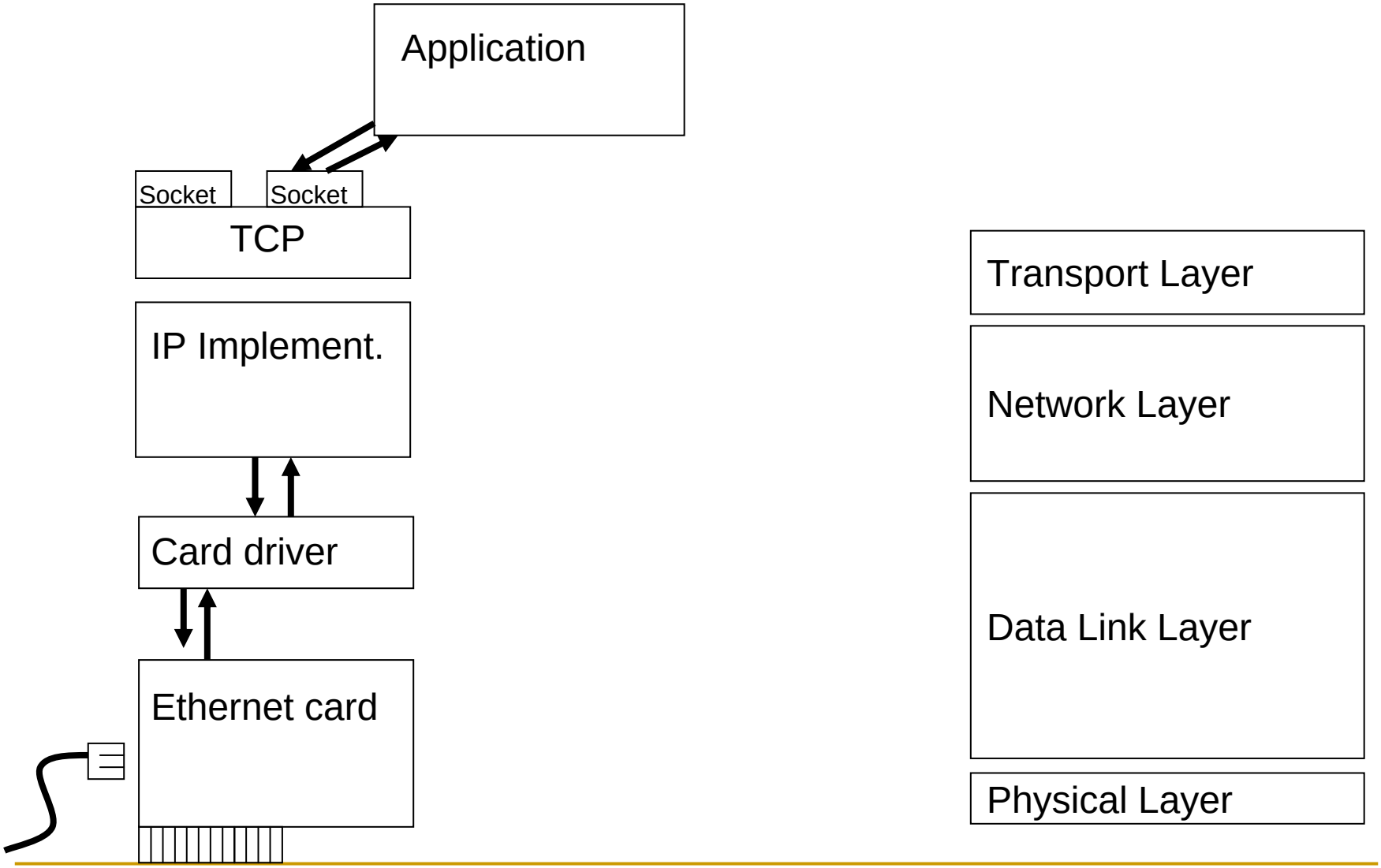


Physical Layer

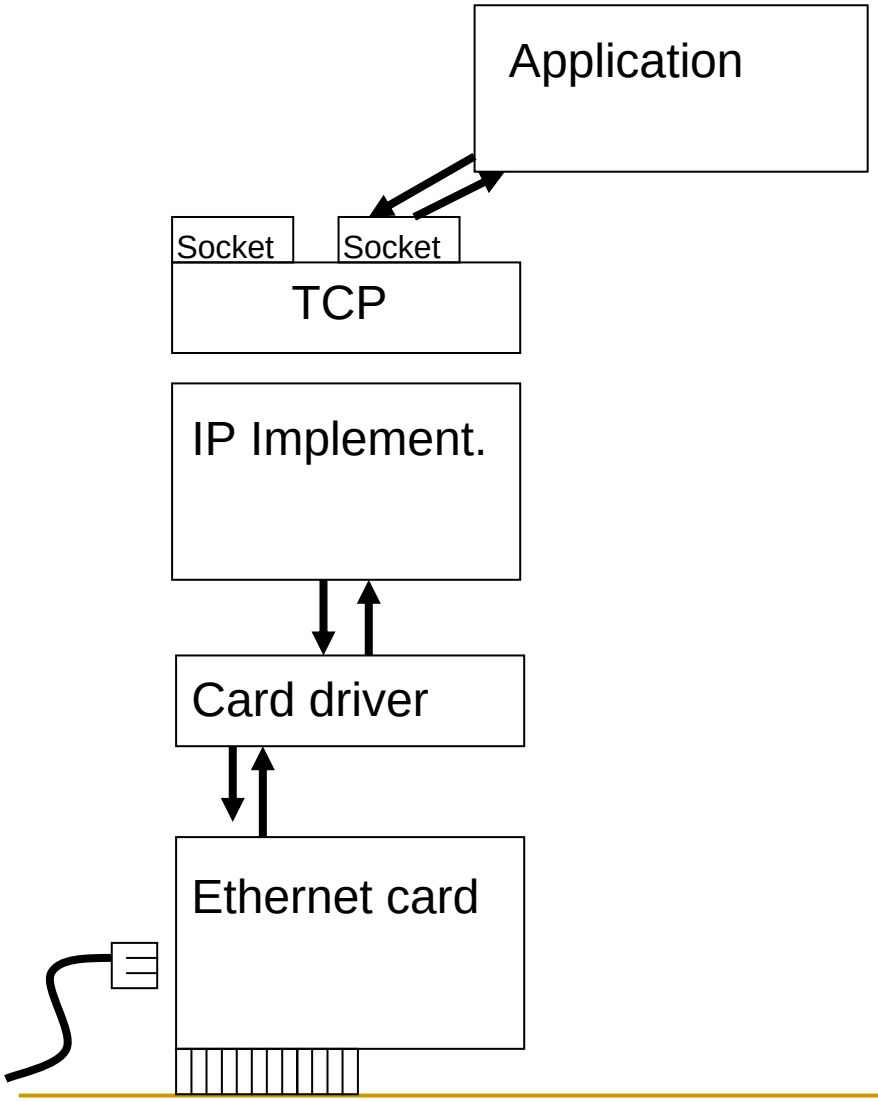
Protocol Layers



Protocol Layers



Protocol Layers => OSI Stack



Application Layer

Presentation Layer

Session Layer

Transport Layer

Network Layer

Data Link Layer

Physical Layer

TCP/IP and the Internet

- The Internet is a huge collection of networks.
- The U.S. DoD created the TCP/IP reference model because it wanted a network that could survive any conditions.
- TCP/IP model has become the **Internet standard**.

Some Hidtory

- 1969 ARPAnet
  - Experimental packet-switching network
  - Study robust, reliable, vendor-independent data communication
  - With four nodes by the end of 1969
- Connect to Europe 1973
- 1981 TCP and IP was written

- 1983 TCP/IP protocols were adopted as Military Standards
  - TCP/IP was implemented in Berkeley Unix.
  - ARPAnet was divided into MILNET and ARPAnet
- 1994: the World Wide Web Consortium (W3C) lead the development of protocols for the World Wide Web

The Internet

- Today Internet is build by commercial providers.
  - Infrastructure is being created by
    - National network provider
    - Regional network provider
  - Local access and user services is provided by Internet Service Providers (ISPs)
  - Network Access Points (NAPS): major interconnection points

The Internet

- How the internet is managed today
  - Commercial force
  - Several organization
    - Internet Corporation for Assigned Names and Numbers (ICANN)
      - www.icann.org
    - Internet Engineering Task Force (IETE)
      - www.ietf.org
    - Internet Society (ISOC)
      - www.isoc.org

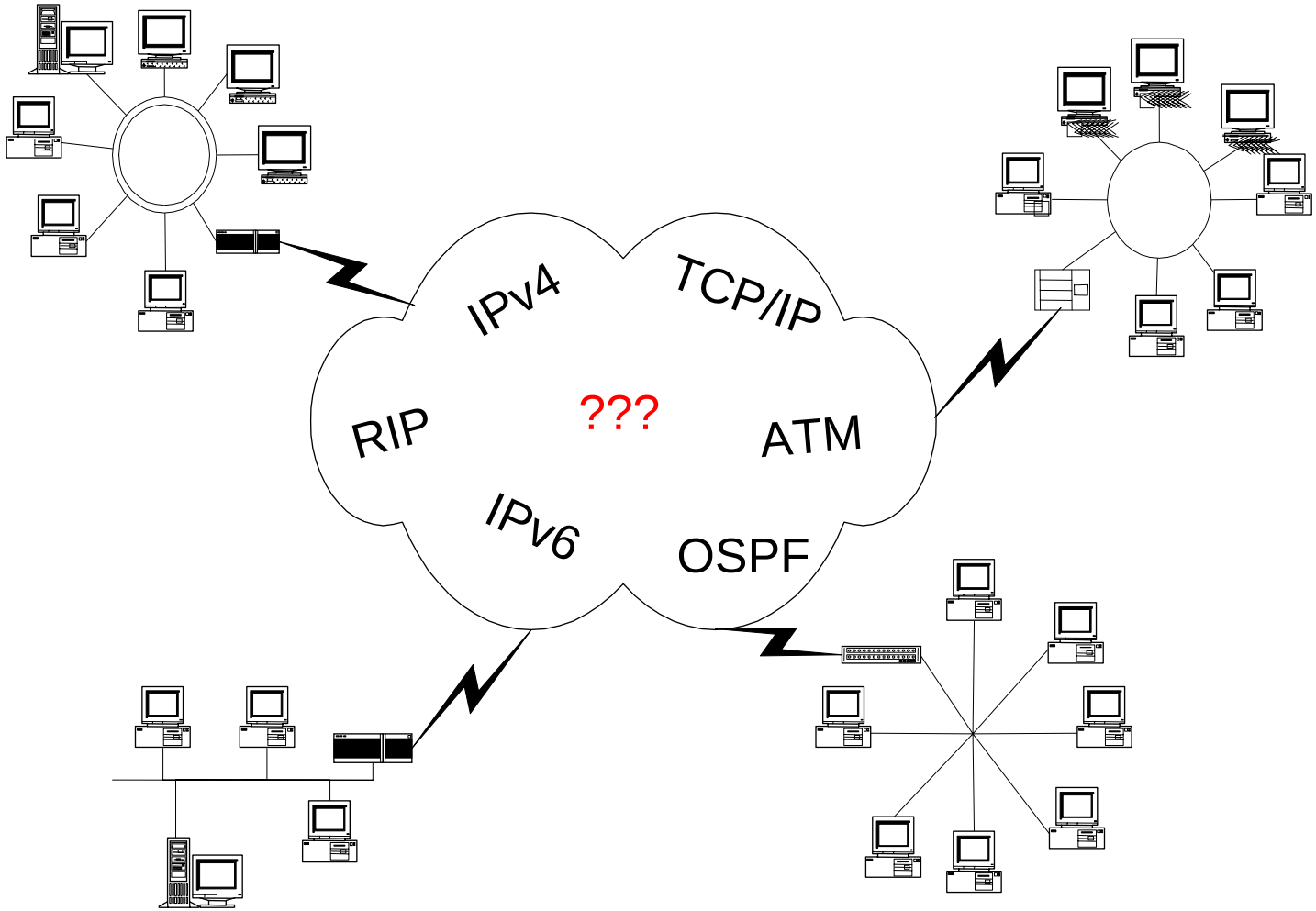
Top Level Domain (TLD)

- World-wide generic top-level domains (TLDs) include:
  - *.com*: Commercial organizations (administered by VeriSign Global Registry Services
  - *.edu*: Educational institutions; (administered by EDUCAUSE)
  - *.net*: Network providers; initially limited to hosts actually part of an operational network
  - *.org*: Non-profit organizations
  - *.int*: Organizations established by international treaty
  - *.gov*: U.S. Federal government agencies
  - *.mil*: U.S. military (managed by the U.S. Department of Defense Network Information Center)

TLD

- In 2000 seven new TLDs, are approved:
  - **.aero** - aviation industry,
  - **.biz** - businesses, application by JVTeam, (administered by NeuLevel)
  - **.coop** - business cooperatives, application by National Cooperative Business Association (NCBA)
  - **.info** - general use, application by Afilias, (administered by Afilias)
  - **.museum** - museums, application by Museum Domain Management Association (MDMA)
  - **.name** - individuals, application by Global Name Registry, LTD
  - **.pro** - professionals, application by RegistryPro, LTD

The Internete



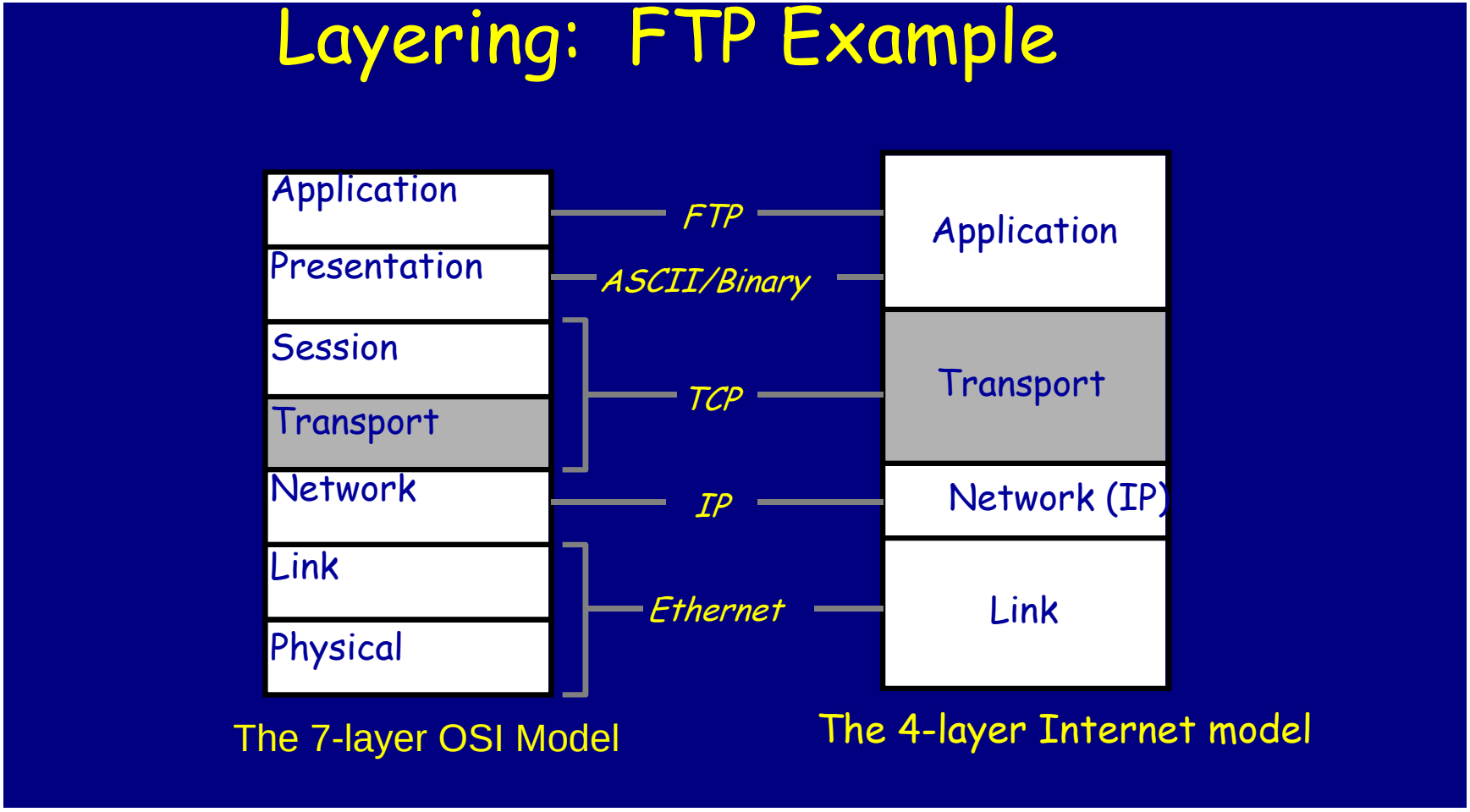
TCP/IP components

- IP, the Internet Protocol
  - routes data packets from one machine to another
- ICMP, the Internet Control Message Protocol
  - Provides several kinds of low-level support for IP
    - Error message
    - Routing assistance
    - Debugging help
- ARP, the Address Resolution Protocol
  - Translates IP addresses to hardware addresses

TCP/IP Components

- UDP, the User Datagram Protocol
  - Delivers data to specific applications on the destination machine
  - Provides “unverified”, “best effort” transport for individual messages
- TCP, the Transmission Control Protocol
  - Delivers data to specific applications on the destination machine
  - Provides reliable, flow controlled, error corrected conversation between processes on two hosts.

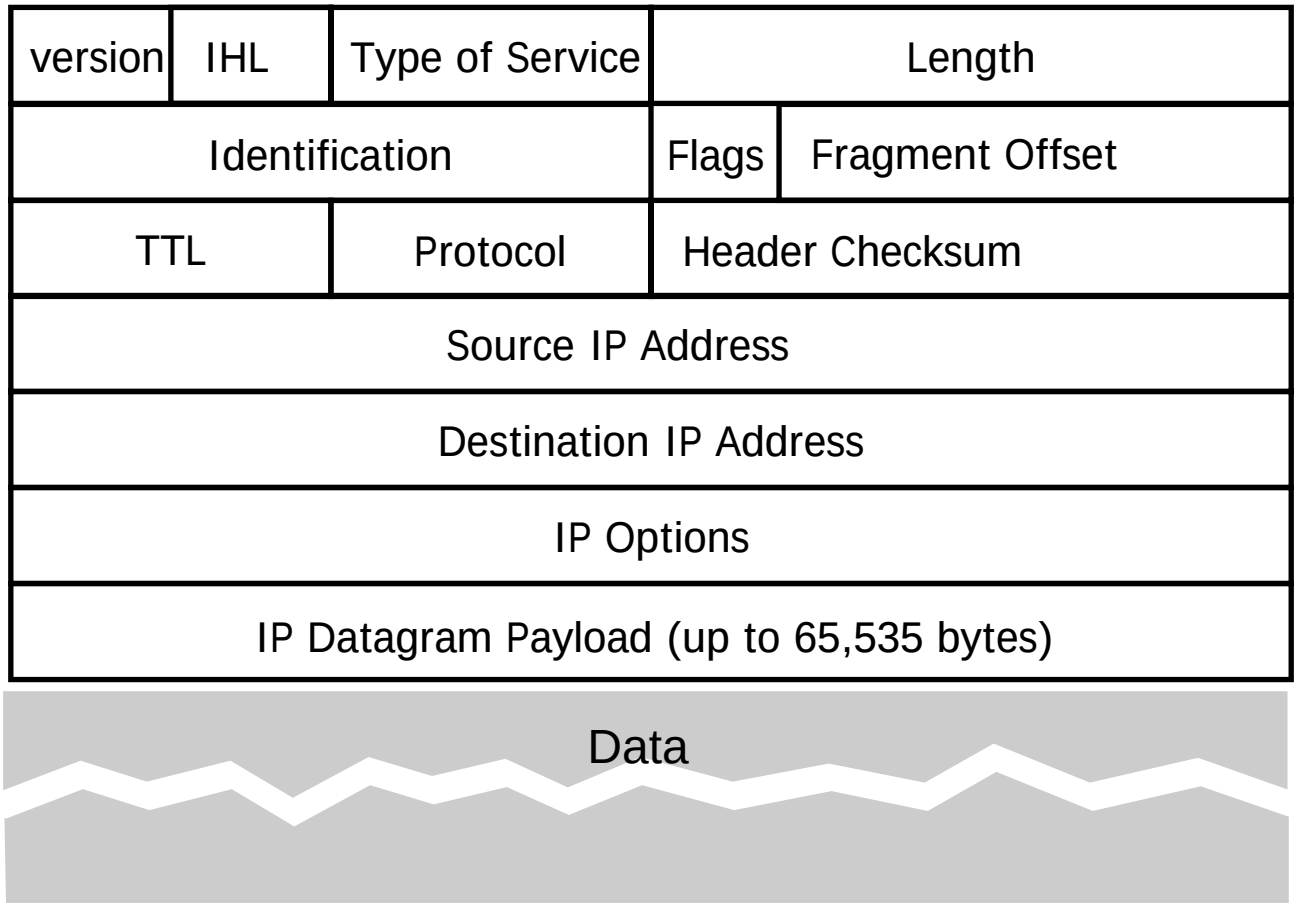
OSI vs. TCP/IP layers



How does it work?

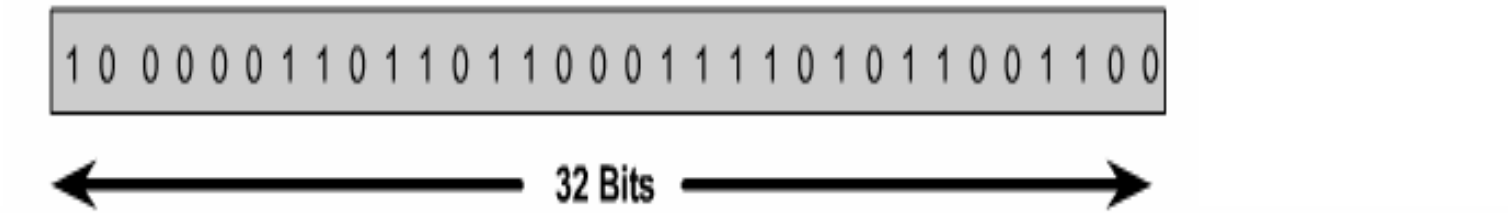
- Data travels on a network in the form of packets
- Each packet consists of
  - A header – where it came from and where it's going, protocol info, checksum, etc.
  - A payload - data
- As a packet travels down the protocol stack
  - encapsulation
    - Each protocol adds its own header information
    - Each protocol's finished packet becomes the payload part of the packet generated by the next protocol.
- On a receiving machine, the encapsulation is reversed as the packet travels back up the protocol stack

IPv4 Header


version
IHL
Type of Service
Length
Identification
Flags
Fragment Offset
TTL
Protocol
Header Checksum
Source IP Address
Destination IP Address
IP Options
IP Datagram Payload (up to 65,535 bytes)
Data

IP addressing

- An IP address is a 32-bit sequence of 1s and 0s.
- To make the IP address easier to use, the address is usually written as four decimal numbers separated by periods.
- This way of writing the address is called the dotted decimal format.

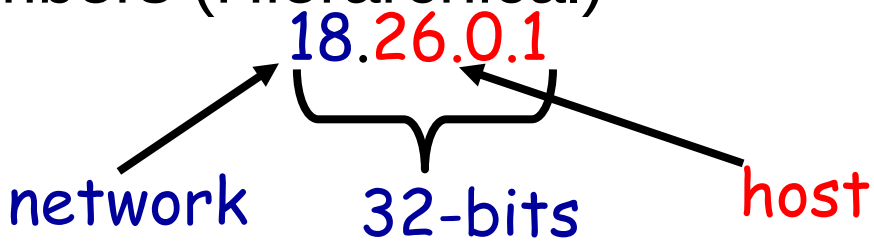


Binary : 11000000.10101000.00000001.00001000 and 11000000.10101000.00000001.00001001

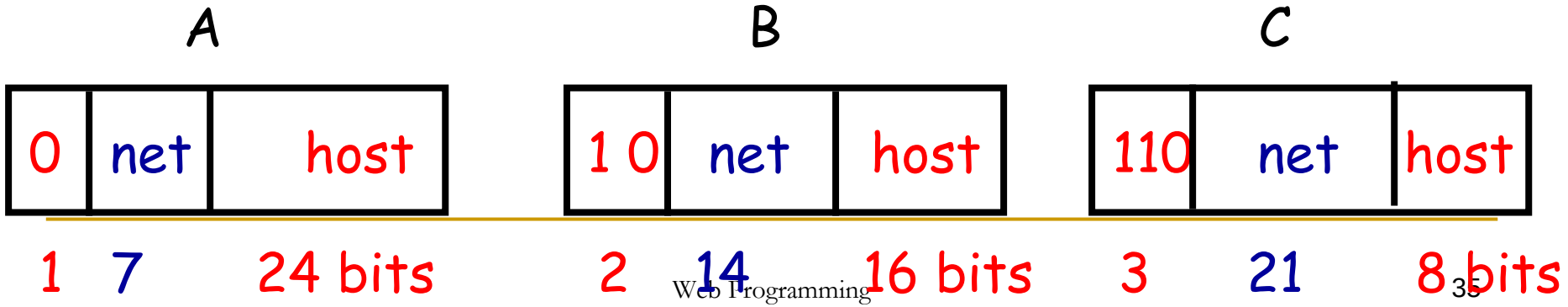
Decimal : 192.168.1.8 and 192.168.1.9

IP Addresses

- 4 8-bit numbers (Hierarchical)



- Specifies both network and host
- Number of bits allocated to specify network varies
- Three classes:



IP Addresses

- IP (Version 4) Addresses are 32 bits long
- IP Addresses Assigned Statically or Dynamically
- IPv6 addresses are 128 bits long

IP Address Space

- Originally, 3 Classes
  - A, B, C
- Problem
  - Classes too rigid (C too small, B too big)
- Solution
  - Subnetting
  - Classless Interdomain Routing (CIDR)

Classes

- A Class A address has an 8-bit NET_ID and 24-bit HOST_ID.
  - Class A addresses are intended for very large networks
  - can address up to 16,777,214 (2^{24}-2) hosts per network.
  - NETID occupies the first byte, so (only 128 (2^{7}) class A).
- A Class B address has a 16-bit NET_ID and 16-bit HOST_ID.
  - for moderate sized networks
  - can address up to 65,534 (2^{16}-2) hosts per network. The first two bits of a Class B address are 10 so that the first digit of a Class B address will be a number between 128 and 191

Classes

- A Class C address has a 24-bit NET_ID and 8-bit HOST_ID.
  - Small networks
  - Can address up to 254 (2^8-2) hosts per network.
  - The first three bits of a Class C address are 110 so that the first digit of a Class C address will be a number between 192 and 223.

IP Routing

- Routing: moving data from a source to a destination
  - Next-Hop
- Hop-by-Hop
- Thus IP makes no guarantees
  - except to try it's best ("Best Effort")
  - packets may get there out of order, garbled, duplicated
  - may not get there at all!
  - Unreliable datagram service