

# ECE 358, Computer Networks

## Spring 2016



Mahesh V. Tripunitara  
M+F 8:30-9:50, RCH 101

# Logistics, etc.

## On Learn

- Logistics, Schedule
- Piazza for discussions
- Prior exams + previews



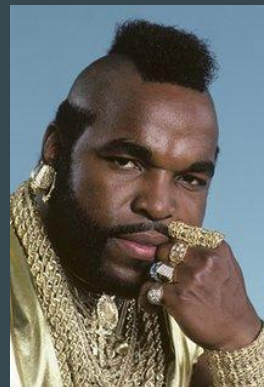
# What to call me

Formal                      *Prof. Tripunitara, Dr. Tripunitara*

Semi-formal              *Prof. T, Dr. T<sup>†</sup>*

Informal                  *Mahesh*

<sup>†</sup> But not Mr. T



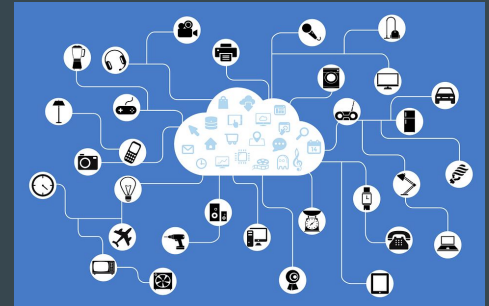
# What this course is about

*Communication* - the exchange of information from a principal to another.

*Network* - a substrate or infrastructure that enables communication.

*Protocol* - rules and formatting by which parties communicate over a network.

*TCP/IP* - a suite of protocols that underlies the Internet.



# Two ways for end-to-end communication

- Circuit-switching
- Packet-switching



# Circuit-Switching

- Network provides notion of a *connection*.
- Data is exchanged once connection is setup.
- Once data is exchanged, connection is torn down.



# Packet-Switching

- Network transfers *packets* of data.
- No state maintained by network across packets.
- The Internet is packet-switched.



# What does a network provide?

Ability to communicate

- Reliably?
- Securely?
- In a connection-oriented manner?

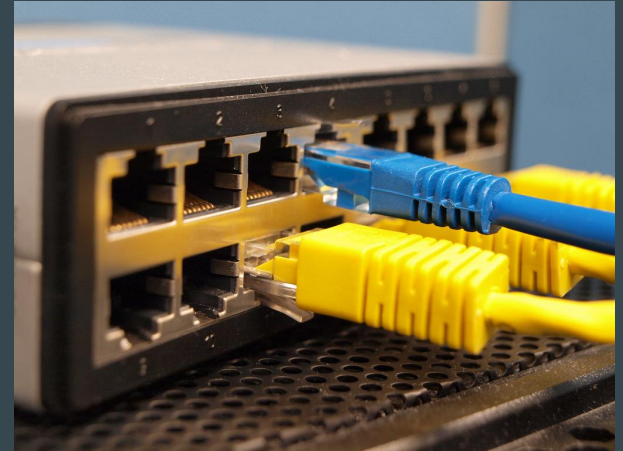
Answer: depends on the protocol(s) we use.





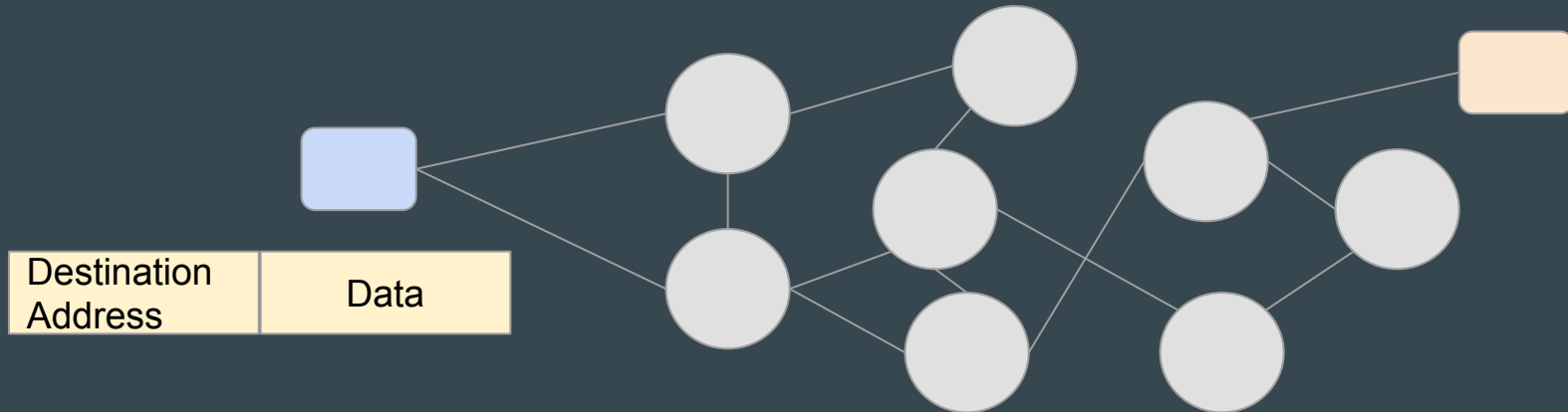
# How does a network provide it?

- Communication “lines.”
- Switches
- Protocols

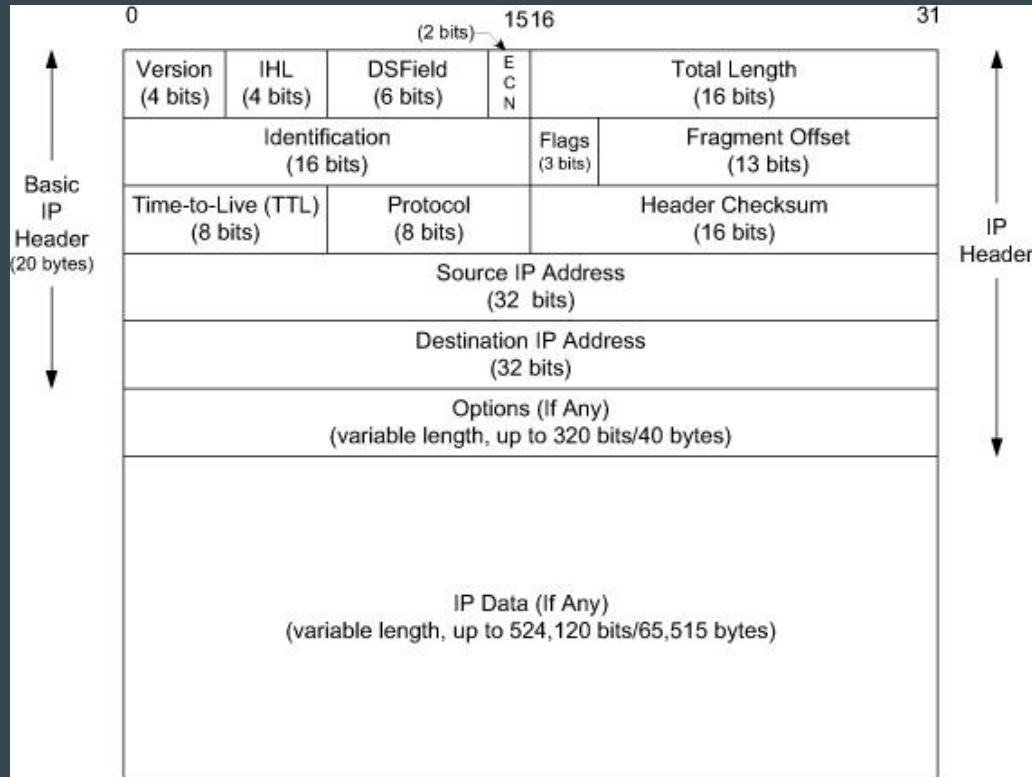


# Example - IP

- Every entity has an identity, an *address*
- A sender constructs a *packet*, places it on “wire.”
- Switches in the network deliver the packet to destination.

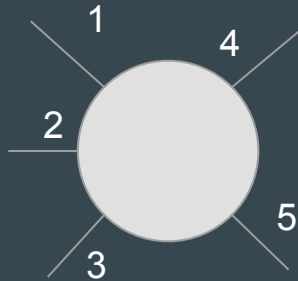


# Reality - IPv4 Packet Format



# How IP-Switching Functions - Routing

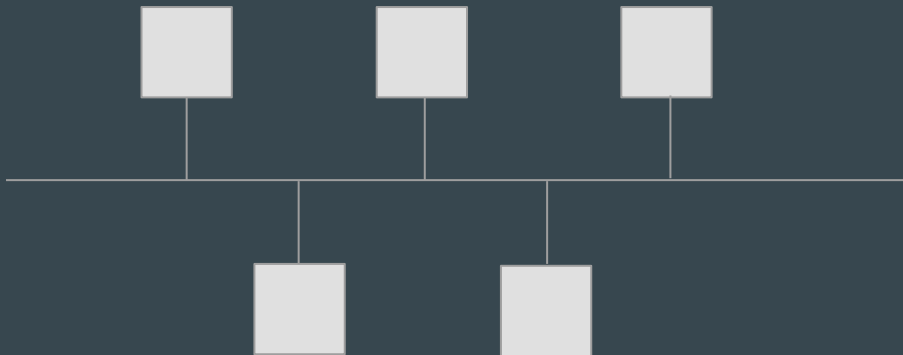
- IP address is a 32-bit string
- By convention, written as i.j.k.l, where each  $i,j,k,l \in [0, 255]$ 
  - E.g., 1.2.3.4, 34.12.255.255
- Each switch maintains a *forwarding-table*.



Destination	Output Interface
1.2.3.*	4
10.11.*.*	1
...	...

# What IP Provides

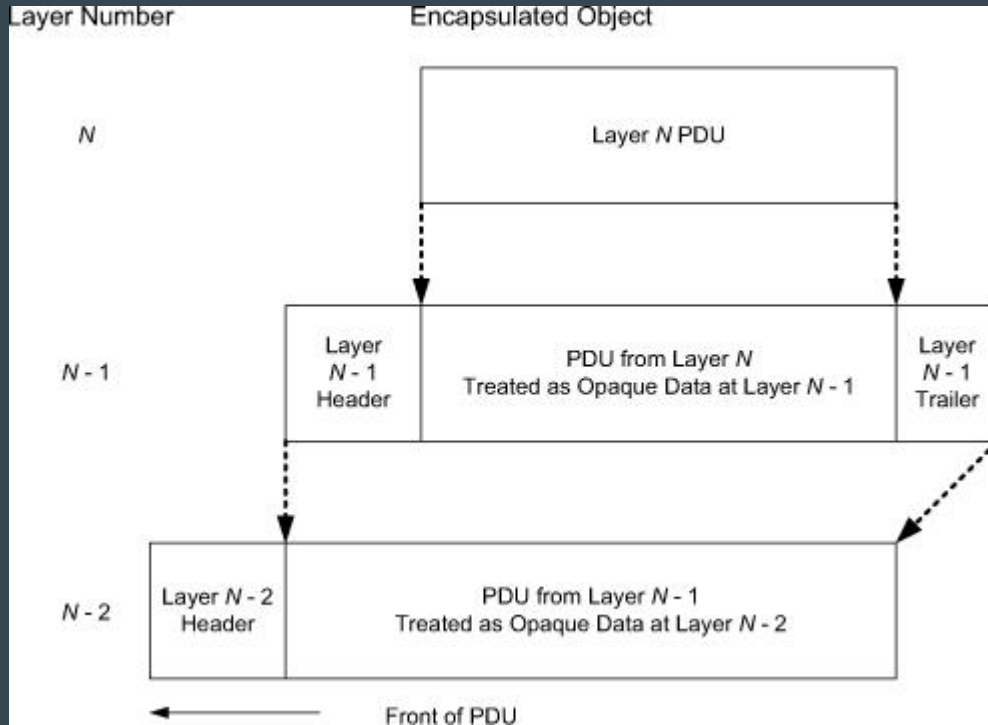
- Best-effort, packet-switching
- Internetworking - connecting networks to one another
- What is a “network,” from the standpoint of IP?
  - Answer: something that “directly” connects hosts to one another.
  - E.g., Ethernet.



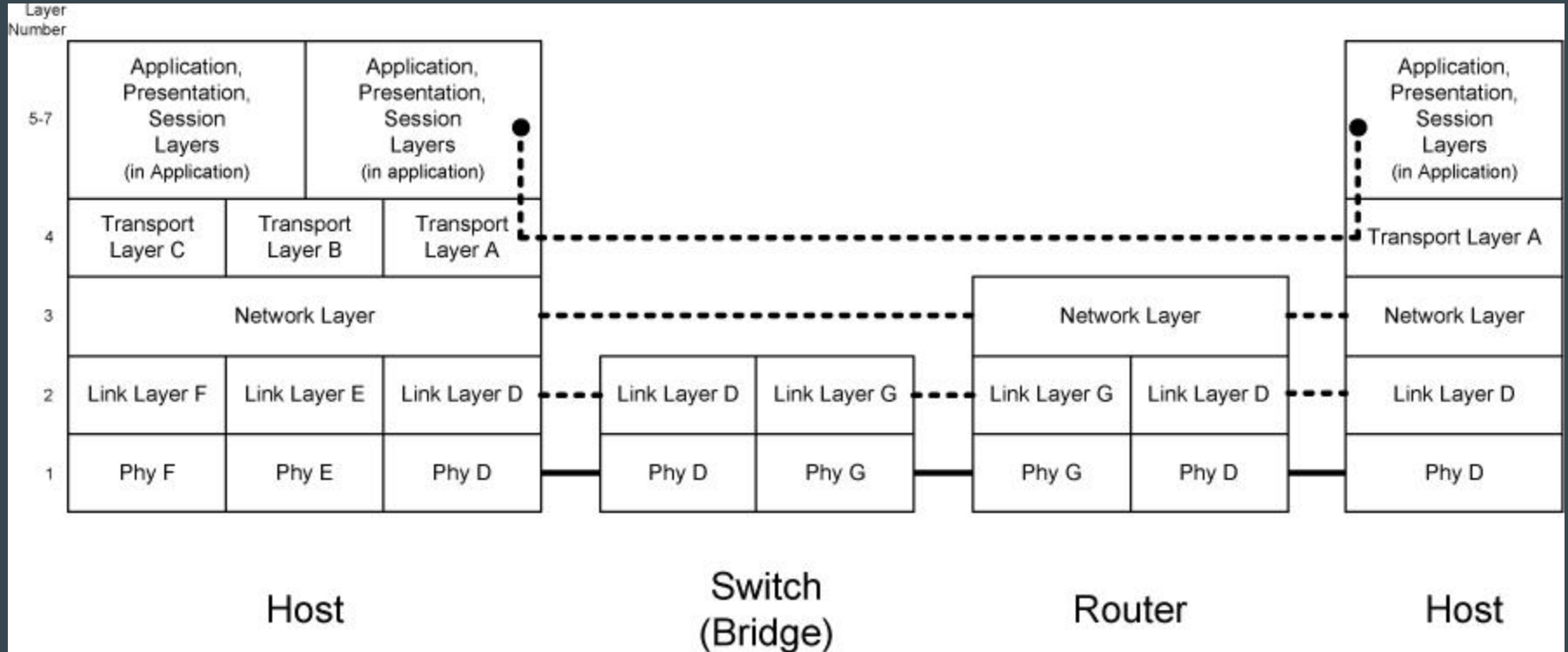
# Protocol layering - e.g., OSI

	Number	Name	Description/Example
Hosts	7	Application	Specifies methods for accomplishing some user-initiated task. Application-layer protocols tend to be devised and implemented by application developers. Examples include FTP, Skype, etc.
	6	Presentation	Specifies methods for expressing data formats and translation rules for applications. A standard example would be conversion of EBCDIC to ASCII coding for characters (but of little concern today). Encryption is sometimes associated with this layer but can also be found at other layers.
	5	Session	Specifies methods for multiple connections constituting a communication session. These may include closing connections, restarting connections, and checkpointing progress. ISO X.225 is a session-layer protocol.
	4	Transport	Specifies methods for connections or associations between multiple programs running on the same computer system. This layer may also implement reliable delivery if not implemented elsewhere (e.g., Internet TCP, ISO TP4).
All Networked Devices	3	Network or Internetwork	Specifies methods for communicating in a multihop fashion across potentially different types of link networks. For packet networks, describes an abstract packet format and its standard addressing structure (e.g., IP datagram, X.25 PLP, ISO CLNP).
	2	Link	Specifies methods for communication across a single link, including "media access" control protocols when multiple systems share the same media. Error detection is commonly included at this layer, along with link-layer address formats (e.g., Ethernet, Wi-Fi, ISO 13239/HDLC).
	1	Physical	Specifies connectors, data rates, and how bits are encoded on some media. Also describes low-level error detection and correction, plus frequency assignments. We mostly stay clear of this layer in this text. Examples include V.92, Ethernet 1000BASE-T, SONET/SDH.

# One layer over another - Encapsulation



# An end-to-end view



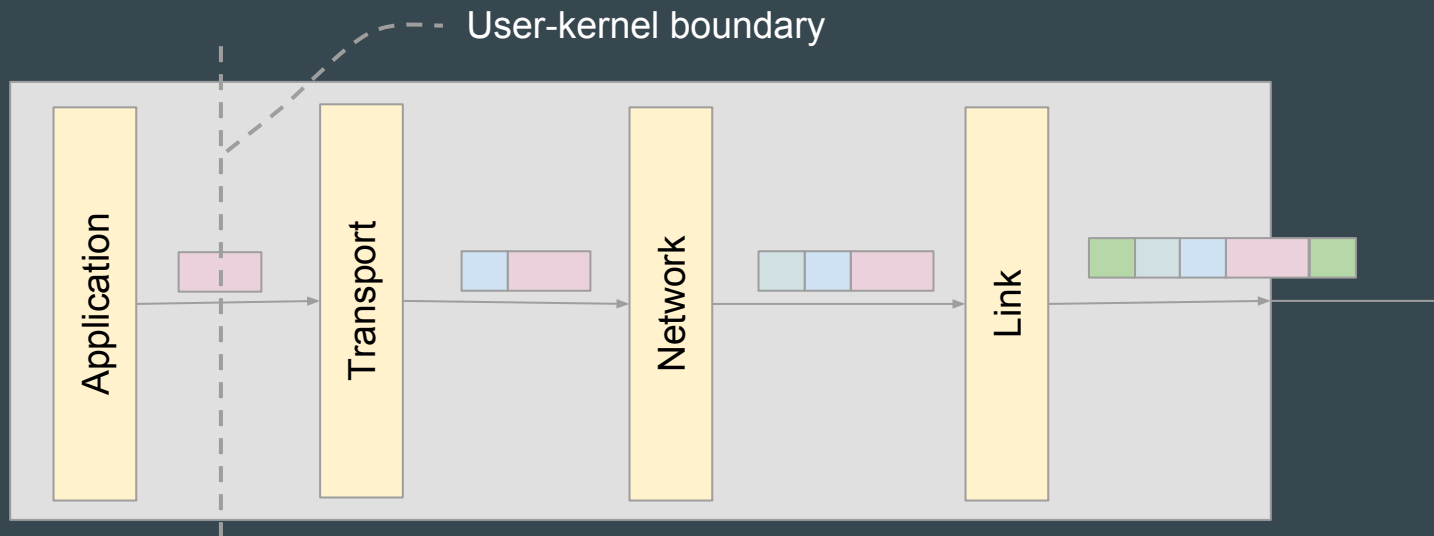


# TCP/IP Protocol Layering

	Number	Name	Description / Example	
Hosts	7	Application	Virtually any Internet-compatible application, including the Web (HTTP), DNS (Chapter 11), DHCP (Chapter 6).	
	4	Transport	Provides exchange of data between abstract "ports" managed by applications. May include error and flow control. Examples: TCP (Chapters 13-17), UDP (Chapter 10), SCTP, DCCP.	
All Internet Devices	3.5	Network (Adjunct)	Unofficial "layer" that helps accomplish setup, management, and security for the network layer. Examples: ICMP (Chapter 8) and IGMP (Chapter 9), IPsec (Chapter 18).	"Network Layer"
	3	Network	Defines abstract datagrams and provides routing. Examples include IP (32-bit addresses, 64KB maximum size) and IPv6 (128-bit addresses, up to 4GB maximum size). Chapters 2,5.	
	2.5	Link (Adjunct)	Unofficial "layer" used to map addresses used at the network to those used at the link layer on multi-access link-layer networks. Example: ARP (Chapter 4).	"Driver"

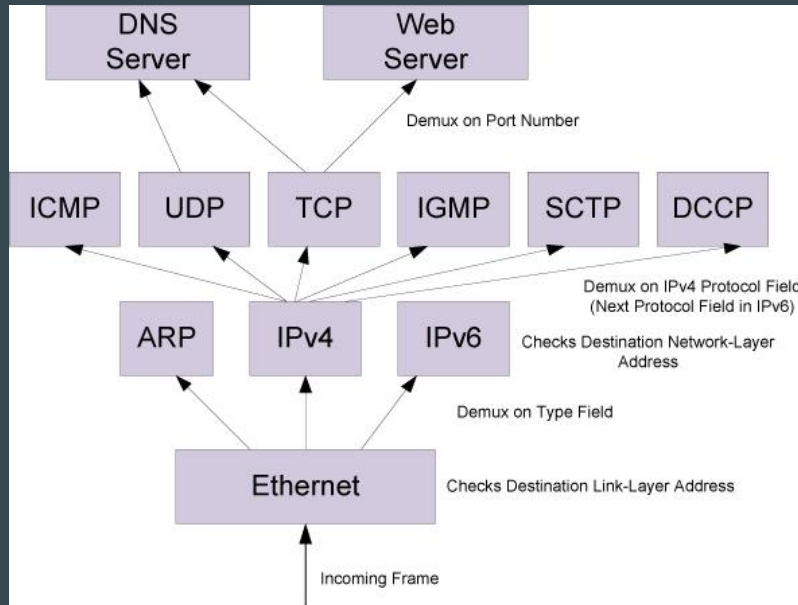
# Software view - how an application sends a packet

- *s = socket(...), bind(s, ...)*
- *send(s, buffer, buffer\_len), receive(buffer, max\_len)*



# Multiplexing

- Multiple, “simultaneous” use of a single thing
- E.g., multiple processes on a machine sharing same IP address



# Artwork credit

- Fall & Stevens
- ... (to be completed)