ECE 358, Computer Networks

Spring 2016

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M+F 8:30-9:50, RCH 101

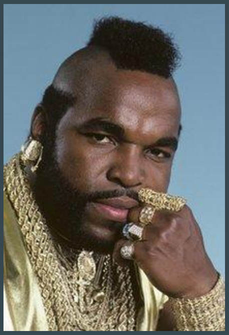
Logistics, etc.

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*[†]
Informal	*Mahesh*



[†] But not Mr. T

What this course is about

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

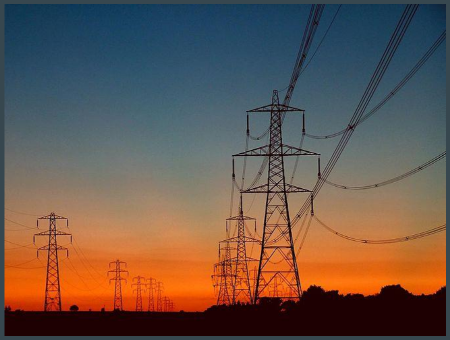
Network - a substrate or infrastructure that enables communication.

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?

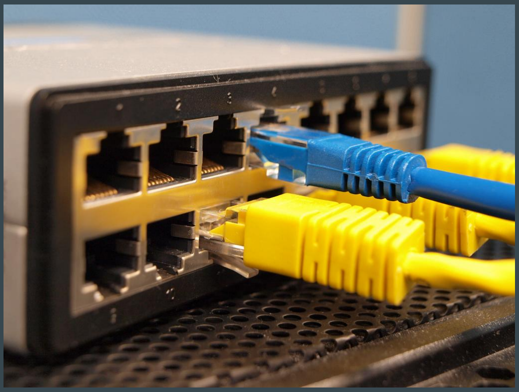
Ability to communicate

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

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

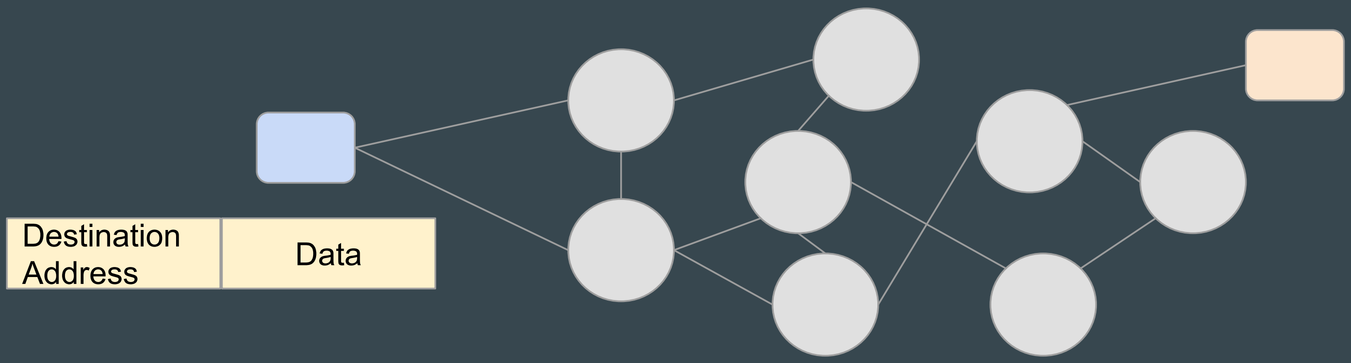
How does a network provide it?

- Communication “lines.”
- Switches
- Protocols



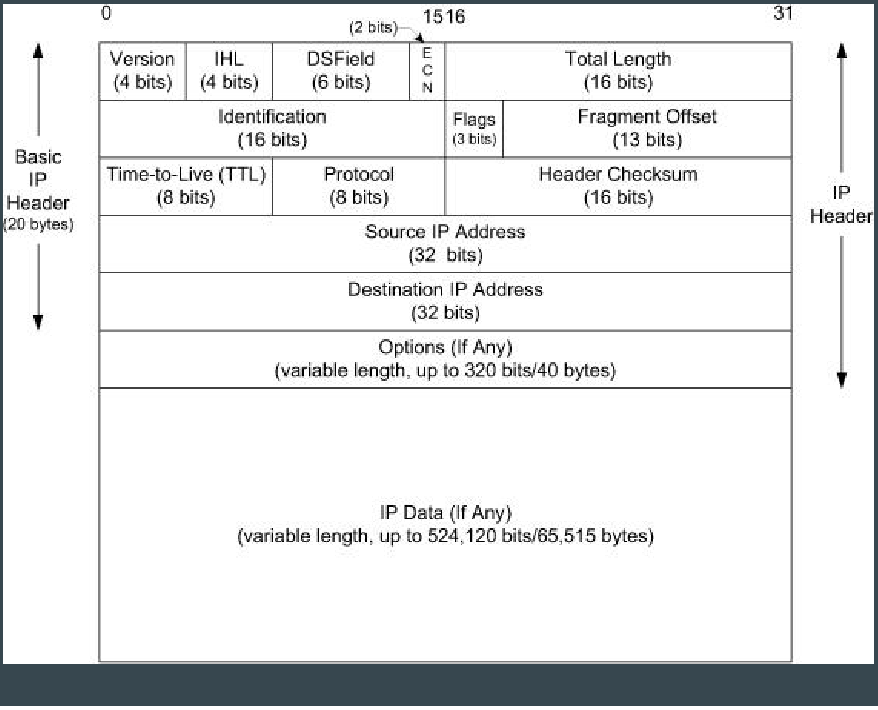
Example - IP

- 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.



Destination Address	Data

Reality - IPv4 Packet Format



0 15 16 31

(2 bits)

Version (4 bits)	IHL (4 bits)	DSField (6 bits)	E C N	Total Length (16 bits)

Identification (16 bits)	Flags (3 bits)	Fragment Offset (13 bits)

Time-to-Live (TTL) (8 bits)	Protocol (8 bits)	Header Checksum (16 bits)

Source IP Address (32 bits)

Destination IP Address (32 bits)

Options (If Any) (variable length, up to 320 bits/40 bytes)

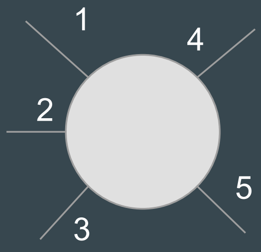
IP Data (If Any) (variable length, up to 524,120 bits/65,515 bytes)

Basic IP Header (20 bytes)

IP Header

How IP-Switching Functions - Routing

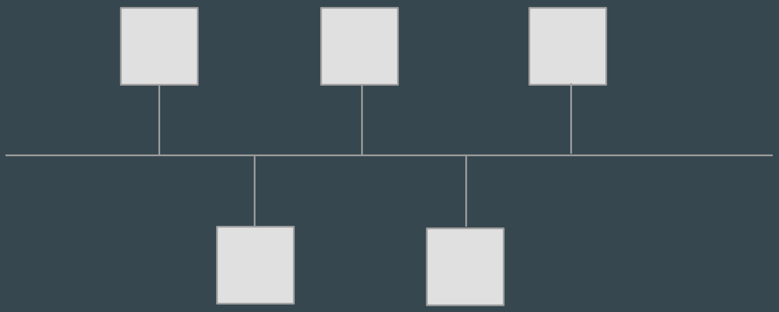
- IP address is a 32-bit string
- By convention, written as i.j.k.l, where each i,j,k,l ∊ [0, 255]
  - E.g., 1.2.3.4, 34.12.255.255
- Each switch maintains a *forwarding-table*.



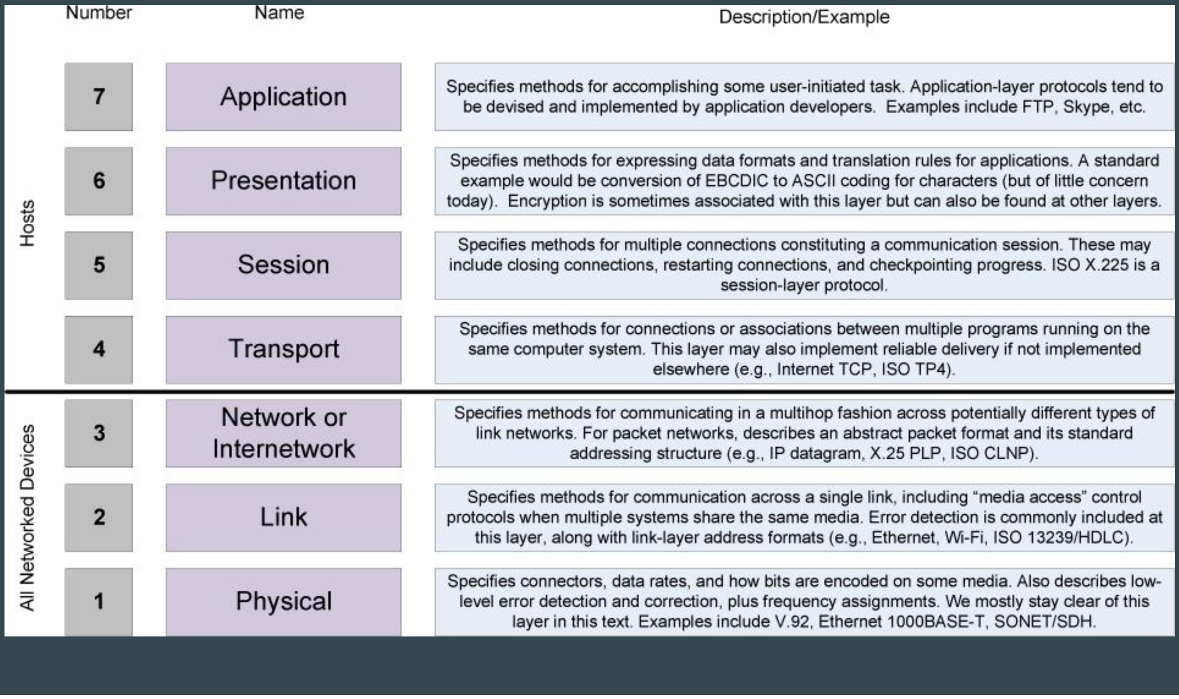
Destination	Output Interface
1.2.3.*	4
10.11.*.*	1
...	...

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.

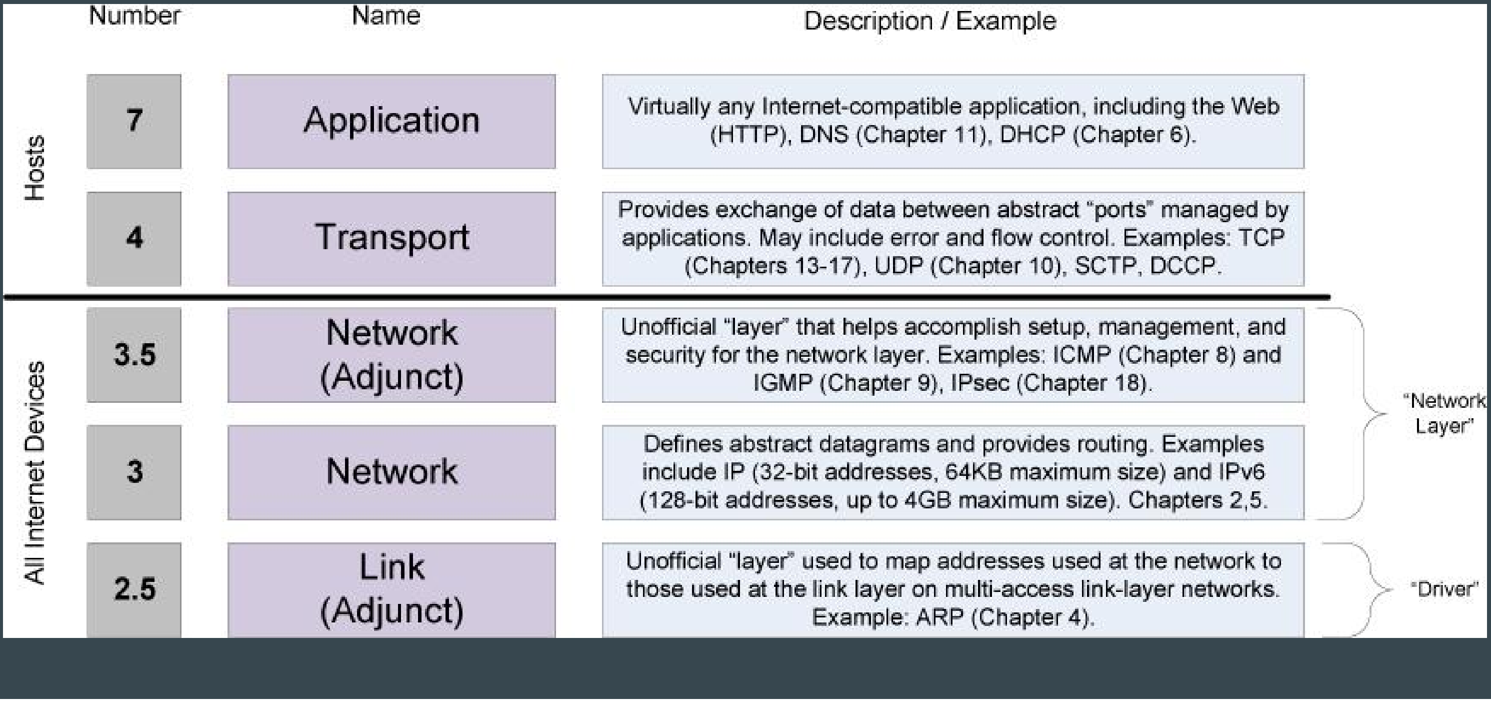


Protocol layering - e.g., OSI



	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.

TCP/IP Protocol Layering

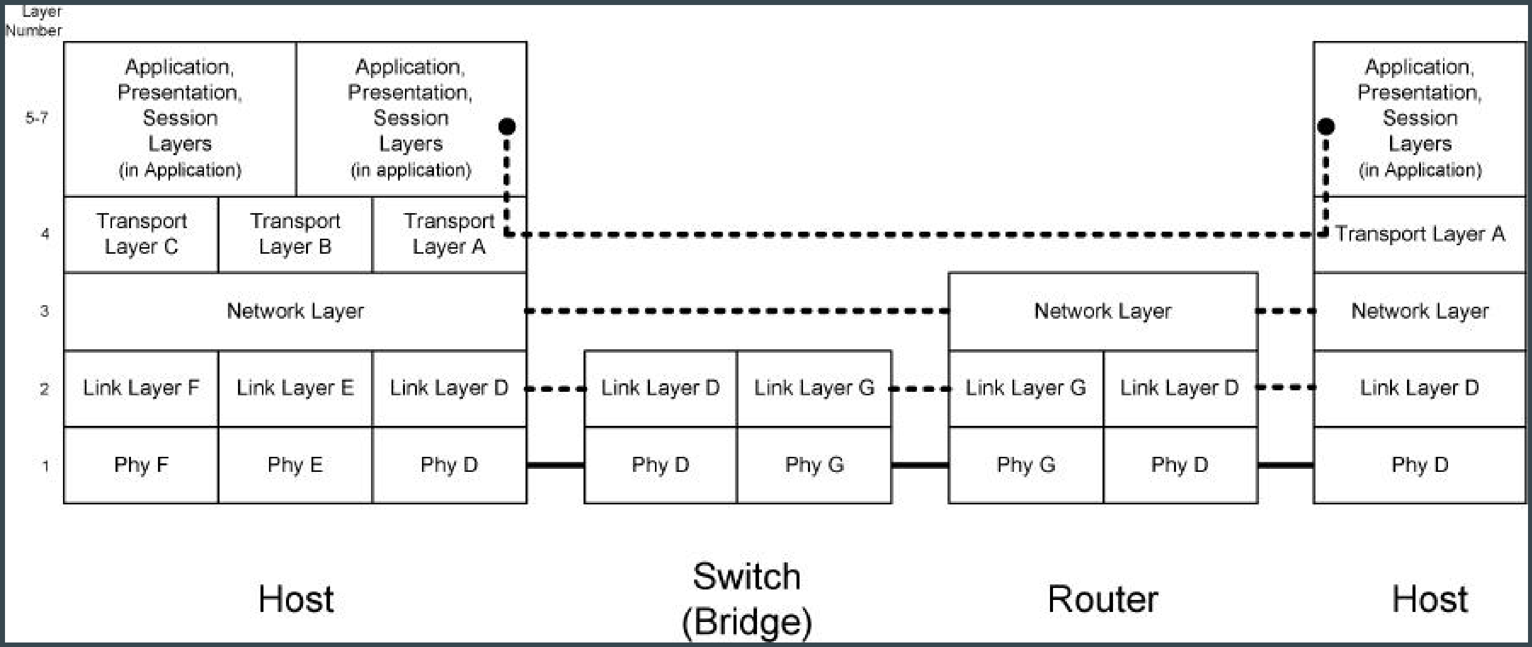


	Number	Name	Description / Example	
Hosts	7	Application	Virtually any Internet-compatible application, including the Web (HTTP), DNS (Chapter 11), DHCP (Chapter 6).	
	4	Transport	Provides exchange of data between abstract "ports" managed by applications. May include error and flow control. Examples: TCP (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"

1 TCP/IP

The application top layer is usually the top tier layer, this can be an actual application or even a service like HTTP or DNS. The transport layer is rather important as it is where TCP lives. The network adjunct layer sets up shit (like security) for the network layer below it (includes ICMP which is essentially `ping`). Then is the network layer which is just IP. The lowest layer is the link layer but as with network there are some protocols in between. The link adjunct layer exists above the link layer and can be used to map addresses from IP to mac or some other form.

An end-to-end view



Layer Number

5-7
4
3
2
1

Application, Presentation, Session Layers (in Application)

Application, Presentation, Session Layers (in application)

Transport Layer C

Transport Layer B

Transport Layer A

Network Layer

Link Layer F

Link Layer E

Link Layer D

Phy F

Phy E

Phy D

Link Layer D

Link Layer G

Phy D

Phy G

Network Layer

Link Layer G

Link Layer D

Phy G

Phy D

Application, Presentation, Session Layers (in Application)

Transport Layer A

Network Layer

Link Layer D

Phy D

Host

Switch (Bridge)

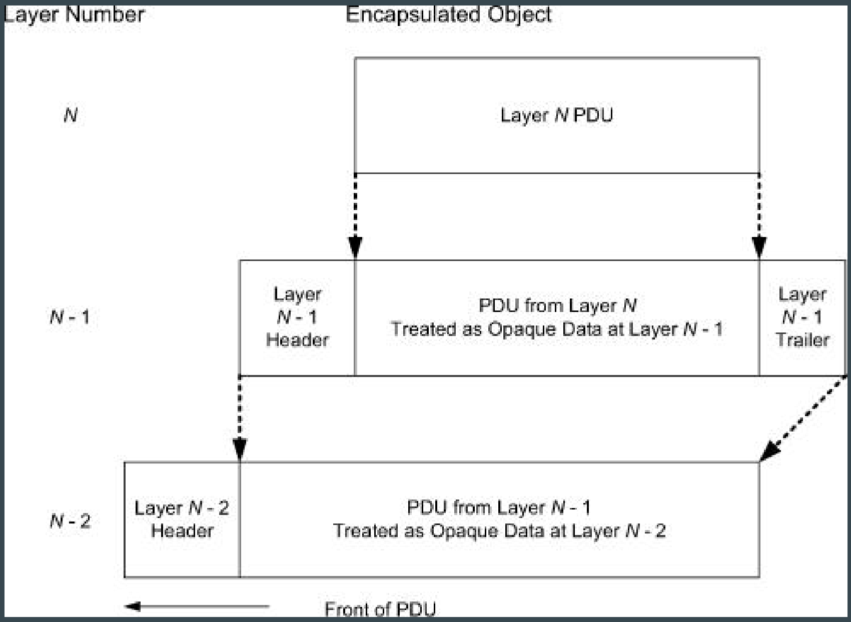
Router

Host

2 Ethernet Frames

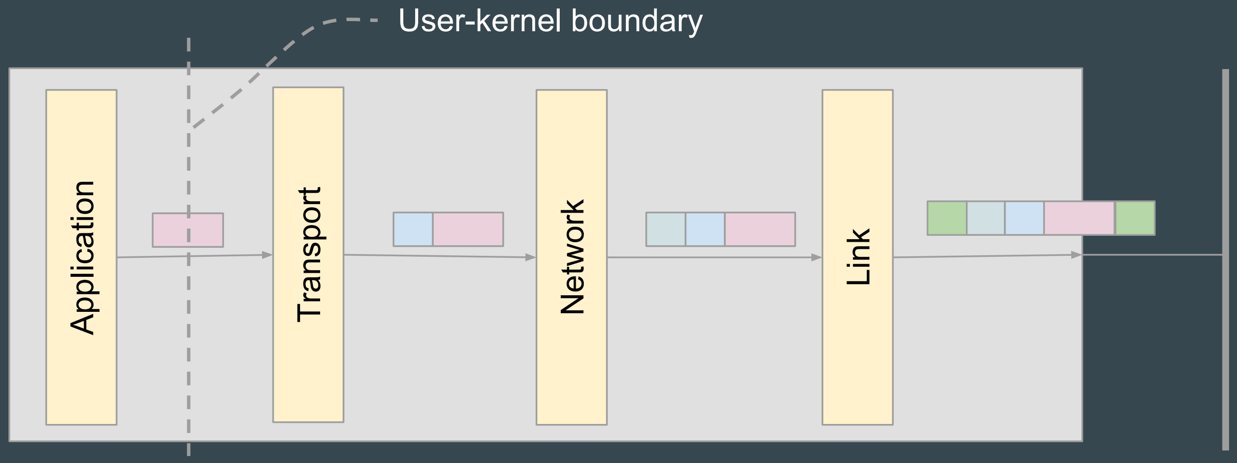
The ethernet standard is very different from the IP standard (the two evolved separately), for instance the ethernet standard has 2 more bytes. The ethernet address is allocated differently. For instance the first couple of bytes might represent the company that manufactured the device. When you send a packet through a ethernet we need to know its ethernet address which is converted in the link adjunct layer.

One layer over an another - Encapsulation



Software view - how an application sends a packet

- *s = socket(...), bind(s, ...)*
- *send(s, buffer, buffer_len), receive(buffer, max_len)*



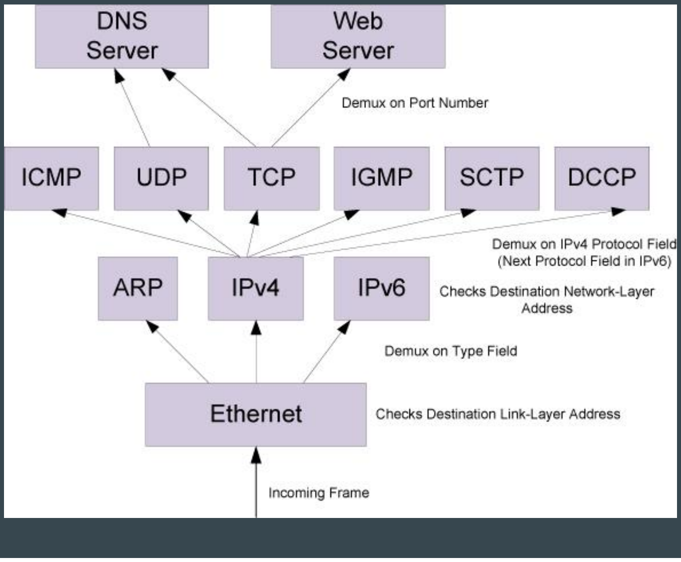
3 Encapsulation

Each layer tacks on more information as the packet goes through, adding information needed by the next layer down.

In the above example you start with UDP which then gets information added when it goes to TCP and again when it goes to IP and so on down the line as more information keeps being added until it gets to the link layer.

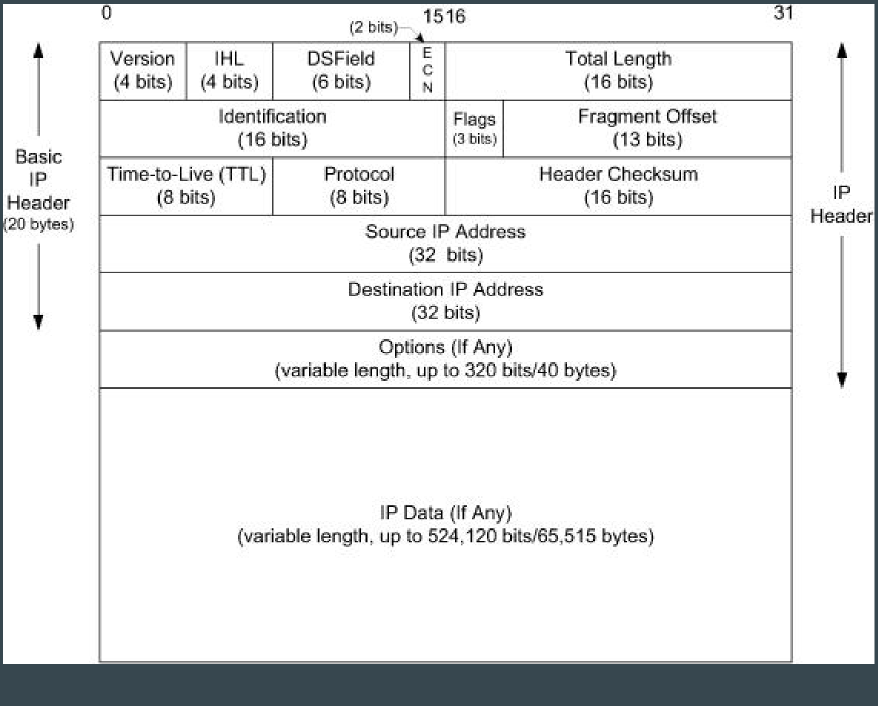
Multiplexing

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


DNS Server
Web Server
Demux on Port Number
ICMP
UDP
TCP
IGMP
SCTP
DCCP
Demux on IPv4 Protocol Field (Next Protocol Field in IPv6)
ARP
IPv4
IPv6
Checks Destination Network-Layer Address
Demux on Type Field
Ethernet
Checks Destination Link-Layer Address
Incoming Frame

This shows the layers that exist as they add information through encapsulation. This allows us to support all kinds of packets with various information.

Reality - IPv4 Packet Format



0

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This is the standard format of a packet. We have codes for each type of data in certain locations to tell how to handle that. As it goes down each layer looks ath athat protocol field and manipulates it as required.