CS 331: Computer Networks

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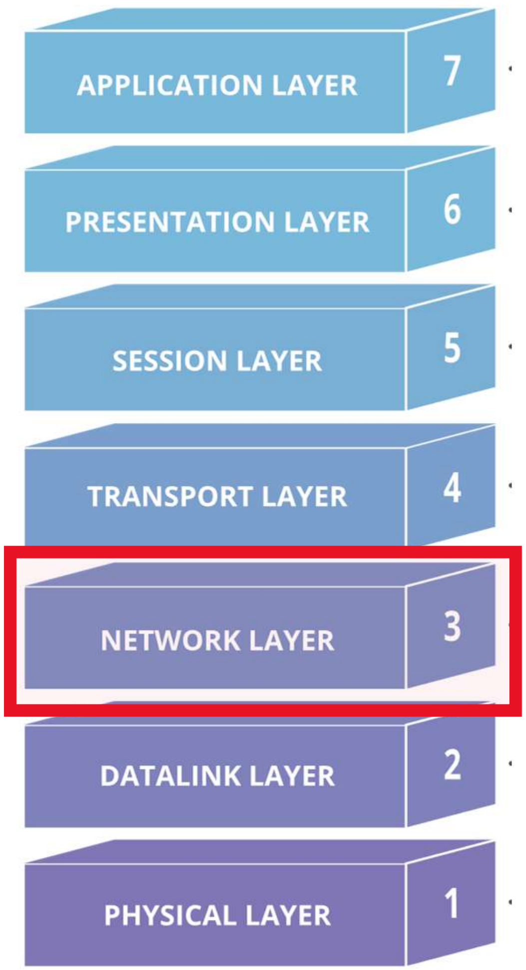
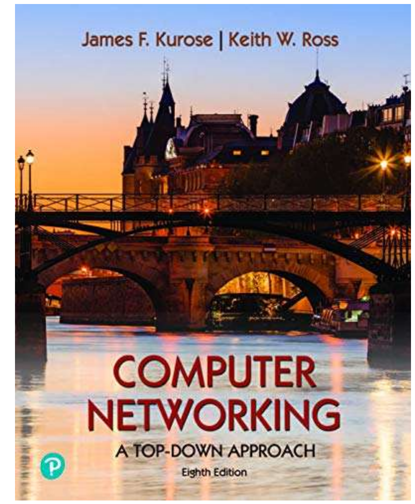


Chapter 4, 5 Network Layer:



Computer Networking: A Top Down Approach
8th edition
Jim Kurose, Keith Ross
Addison-Wesley

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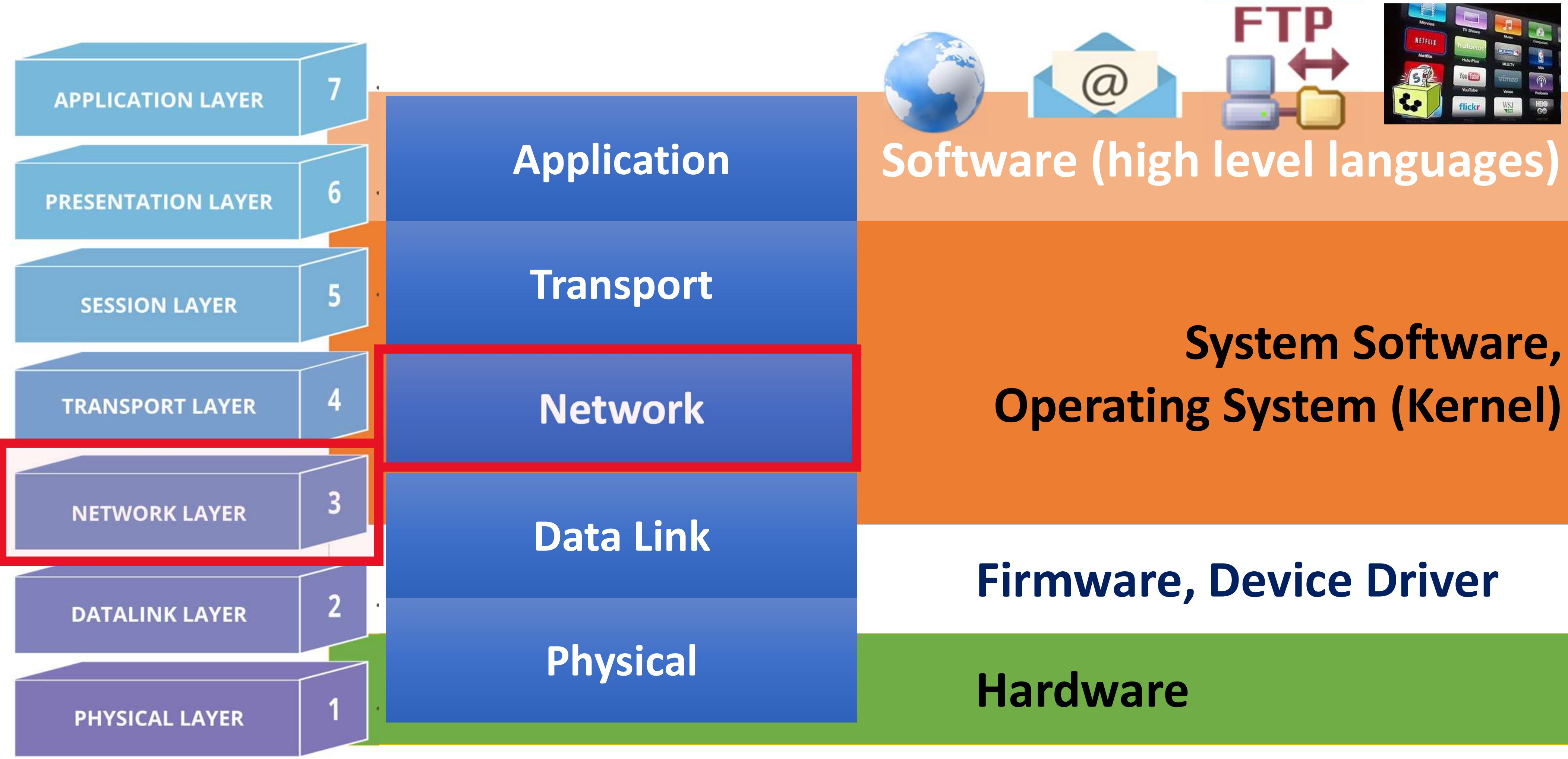
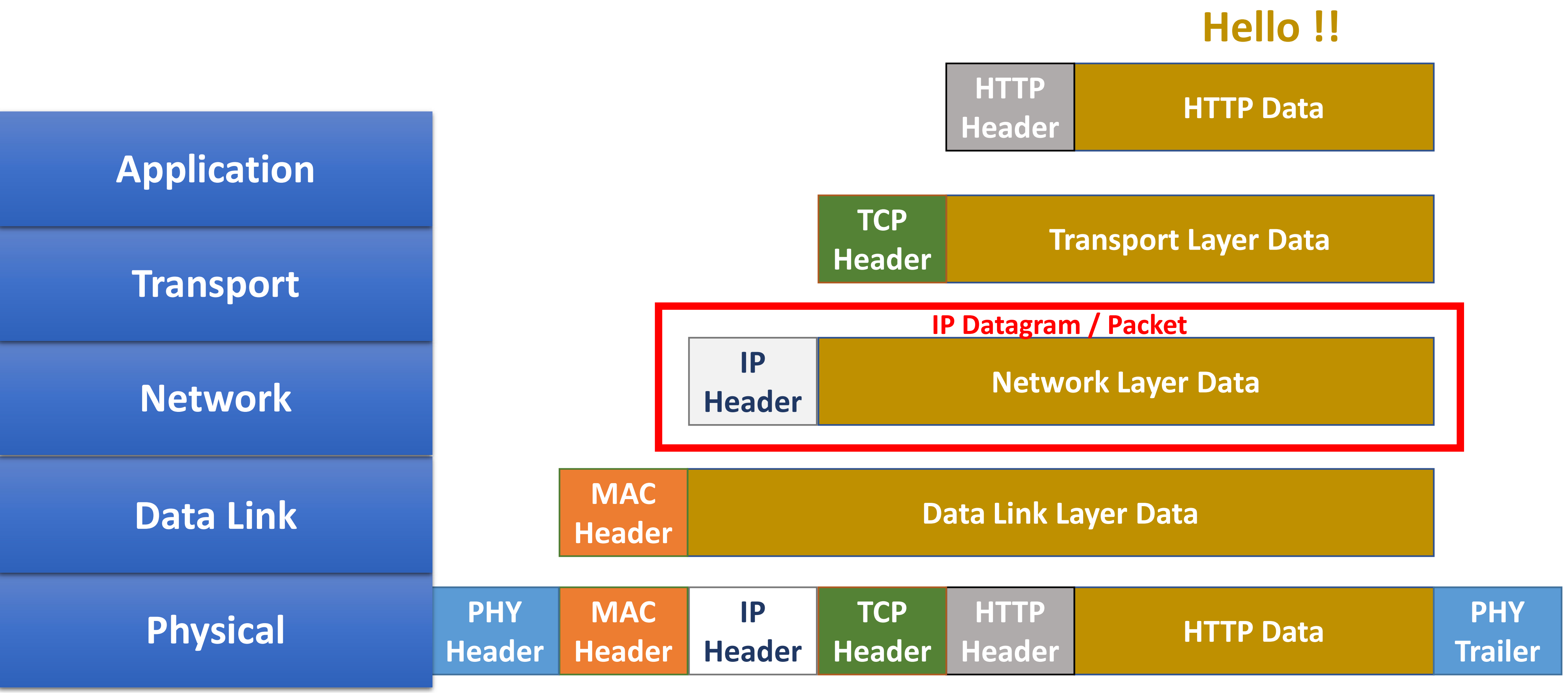
Thanks and enjoy! JFK/KWR

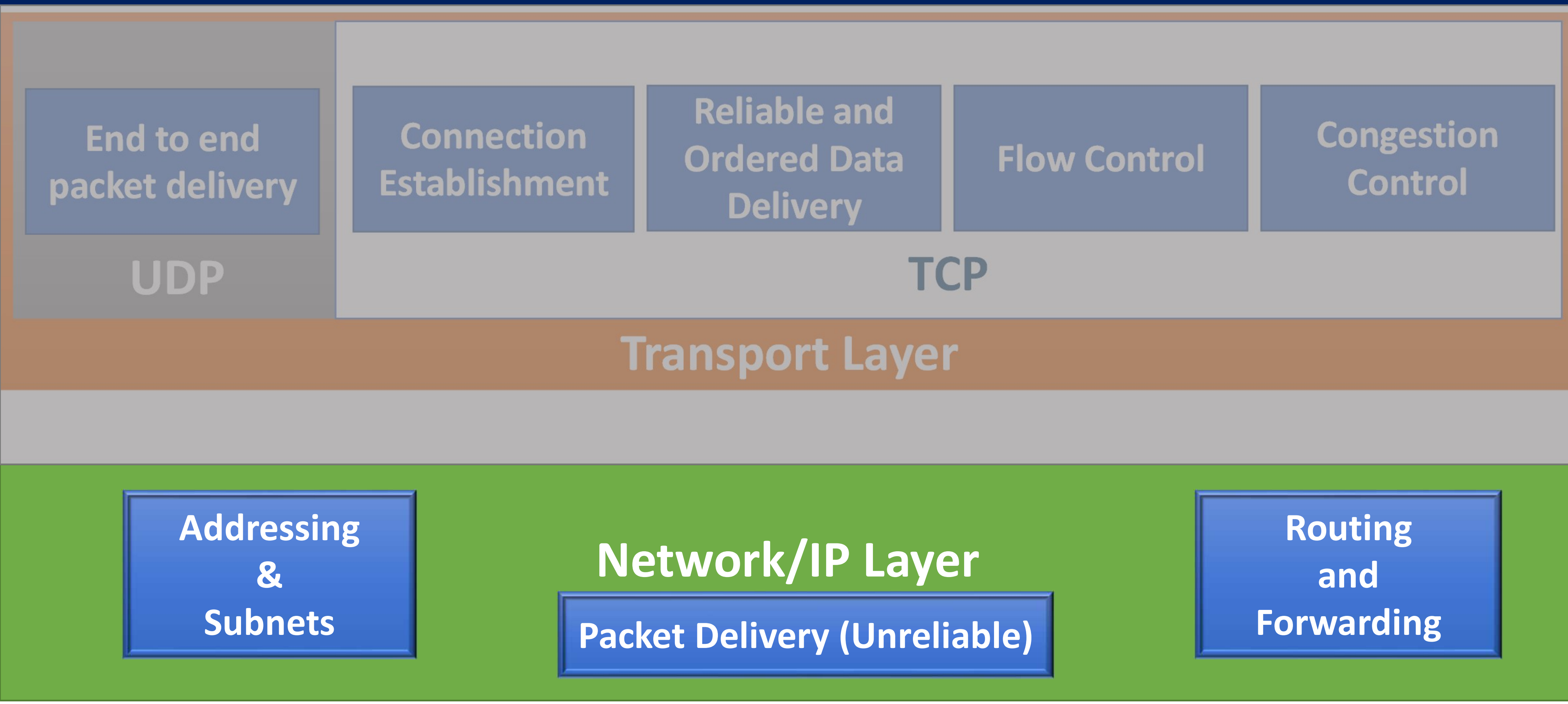
PROTOCOL STACK IMPLEMENTATION IN A HOST



How Application Data Passes Through Different Layers

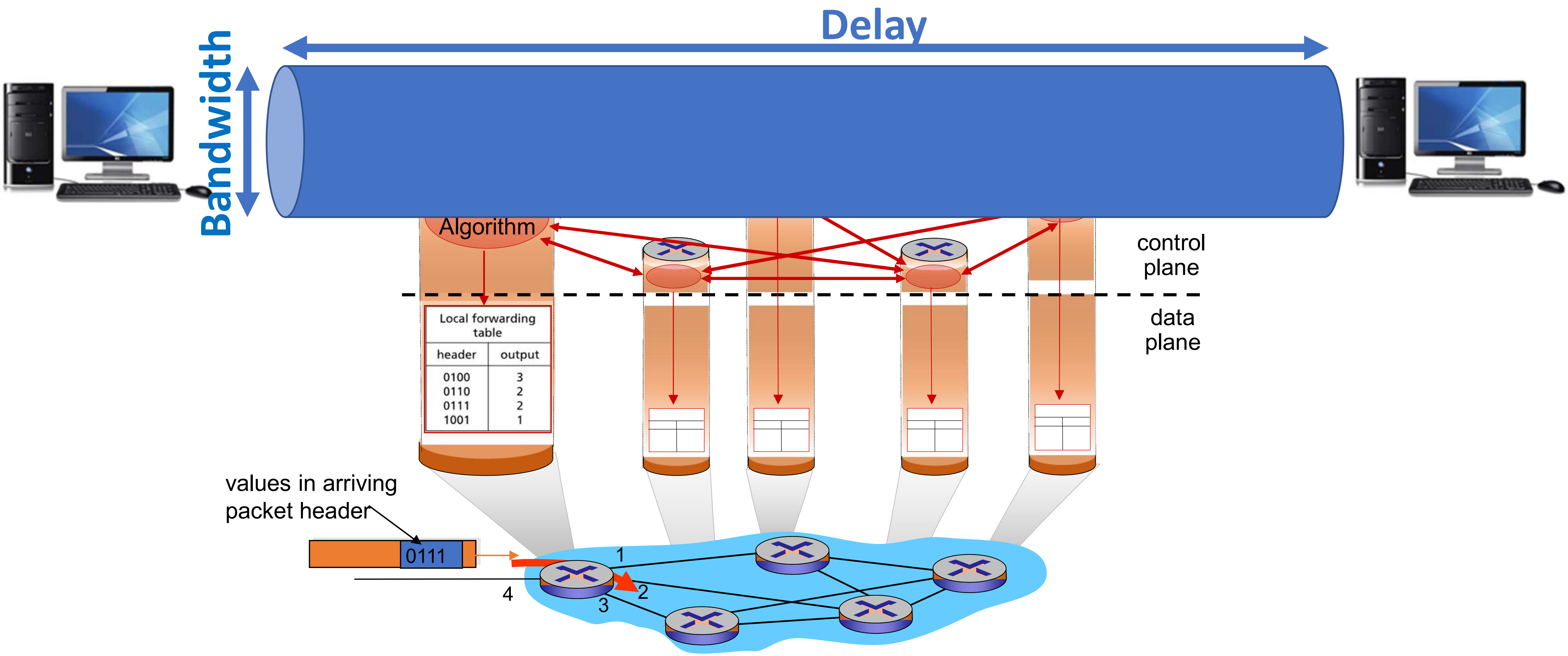


NETWORK LAYER SERVICES

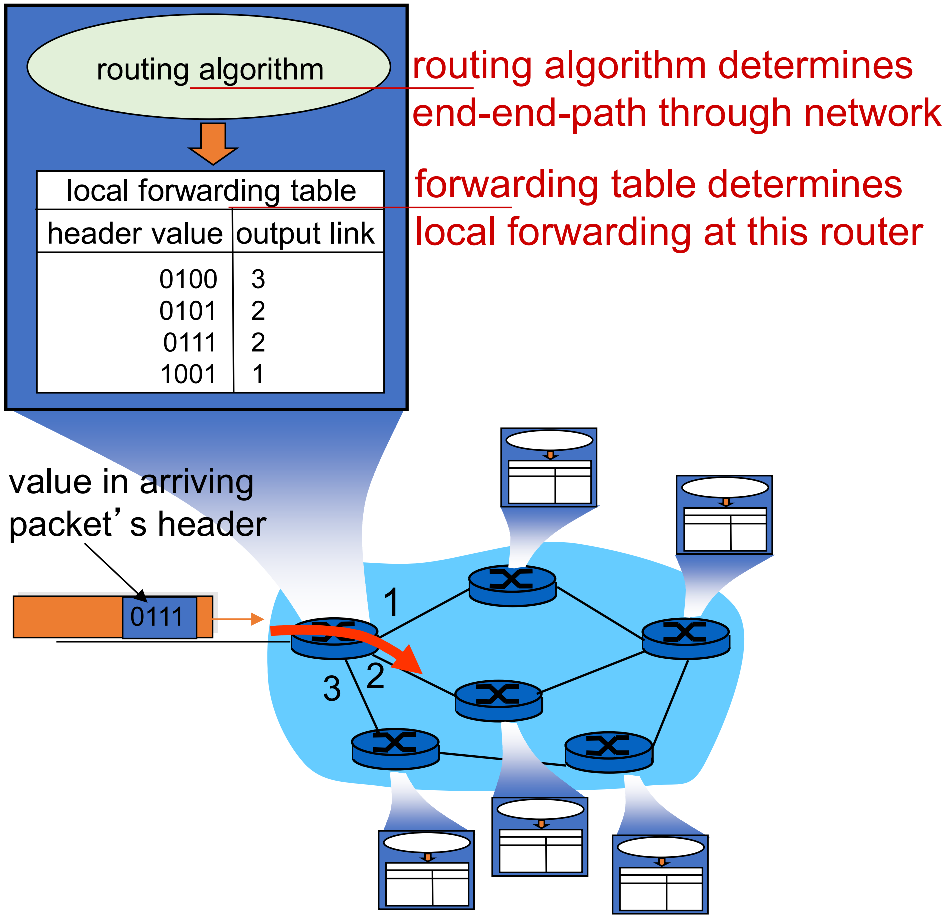


Network - Routers Control and Data Plane

Routing algorithm components *in each & every router* interact in the control plane



Interplay between Forwarding and Routing



Control plane

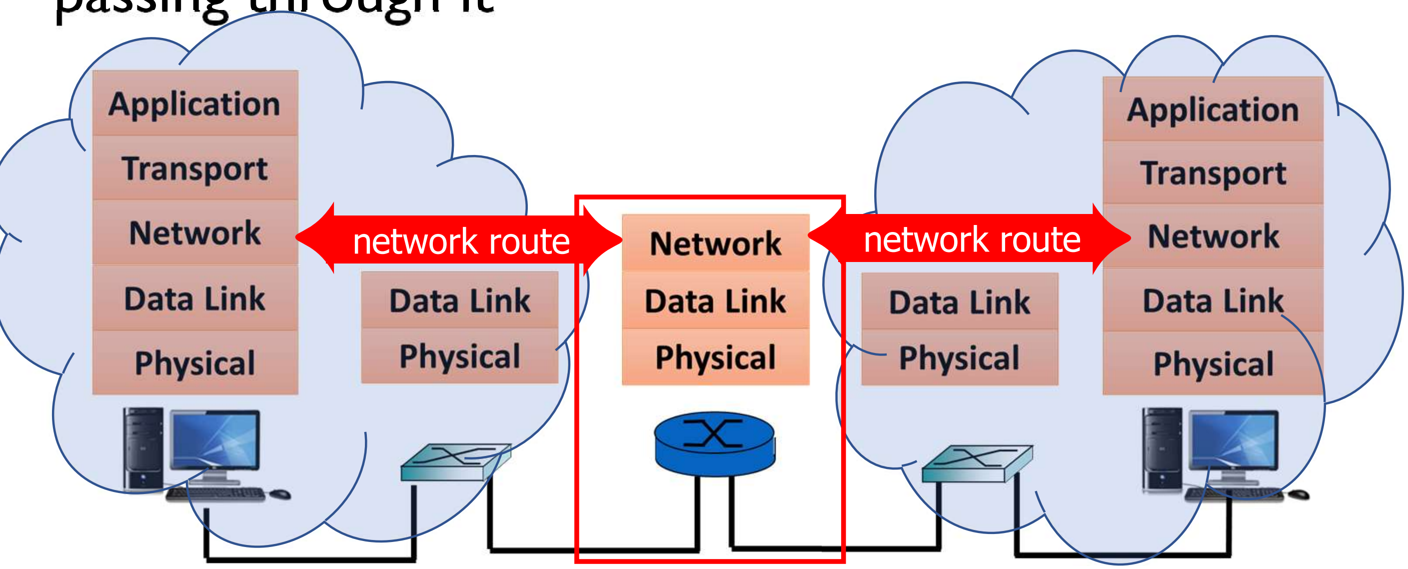
- network-wide logic
- Routing function: determines how datagram is routed among routers along end-end path from source host to destination host
- two control-plane approaches:
  - *traditional routing algorithms – per router*
  - *software-defined networking (SDN) -- centralized*

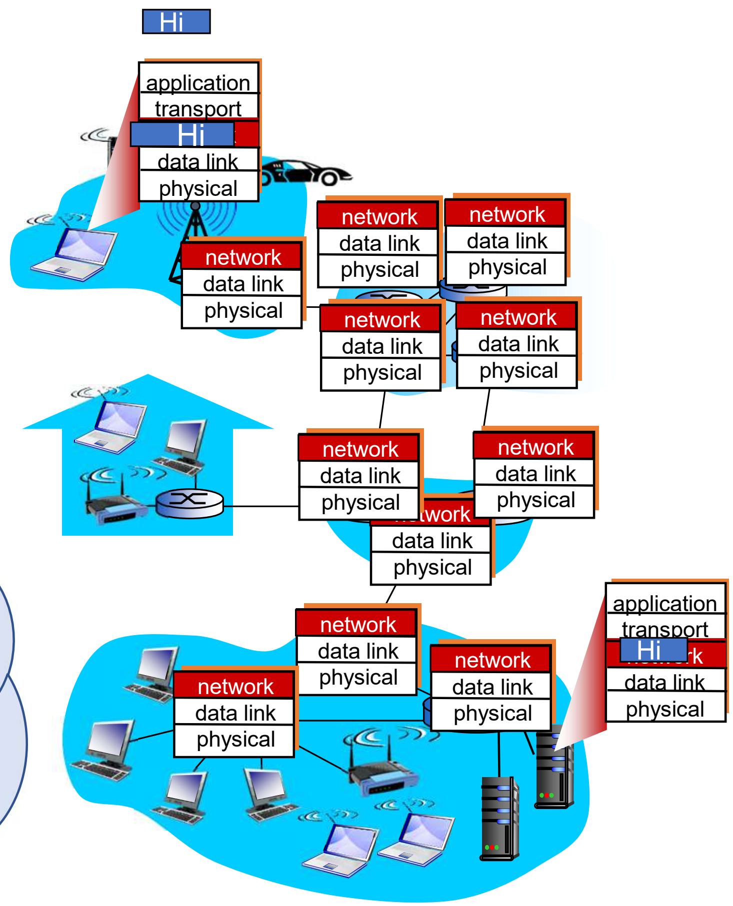
Data plane

- local, per-router function
- forwarding function: determines how datagram arriving on router input port is forwarded to router output port

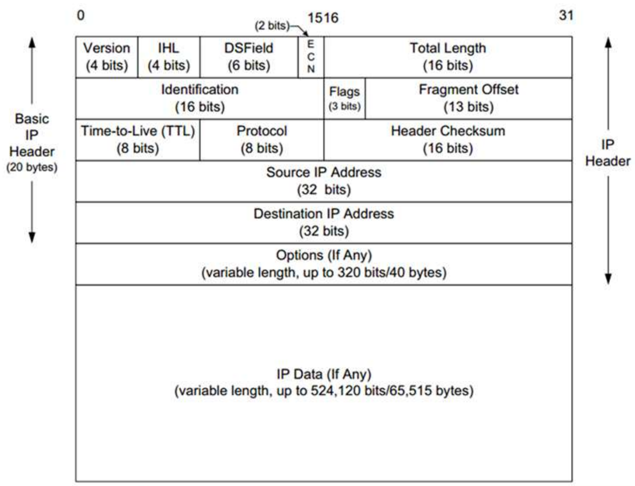
Summary of Network layer Services

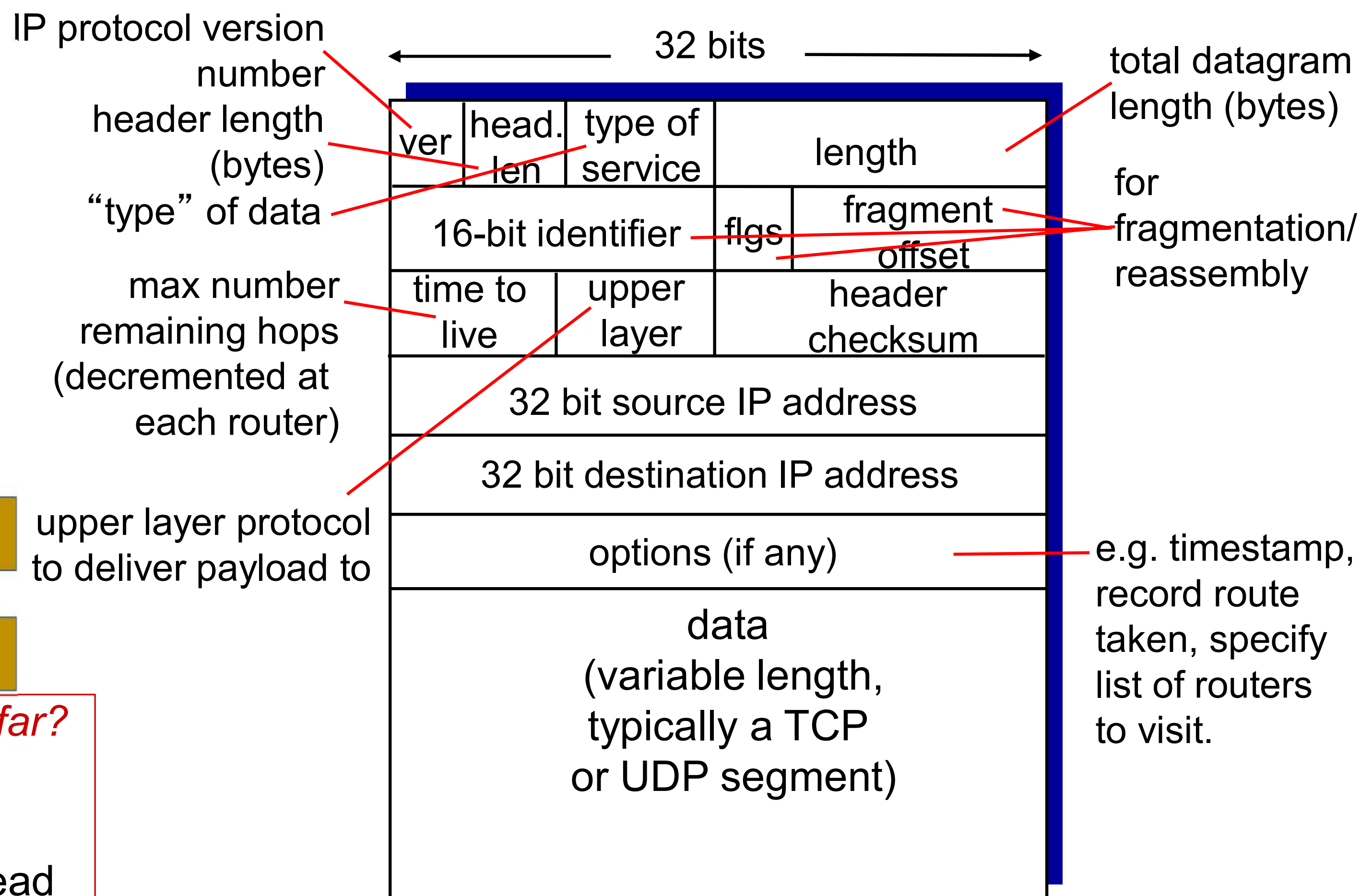
- transport segments from sending to receiving host
- network layer protocols run in *every* host, router
- sending side encapsulates *segments* into *datagrams*
- receiving side, delivers *segments* to transport layer
- router examines *header fields* in all IP datagrams passing through it





IP (V4) DATAGRAM FORMAT





how much of (min) overhead so far?

- 20 bytes of TCP header
- 20 bytes of IP header
- = 40 bytes + app layer overhead

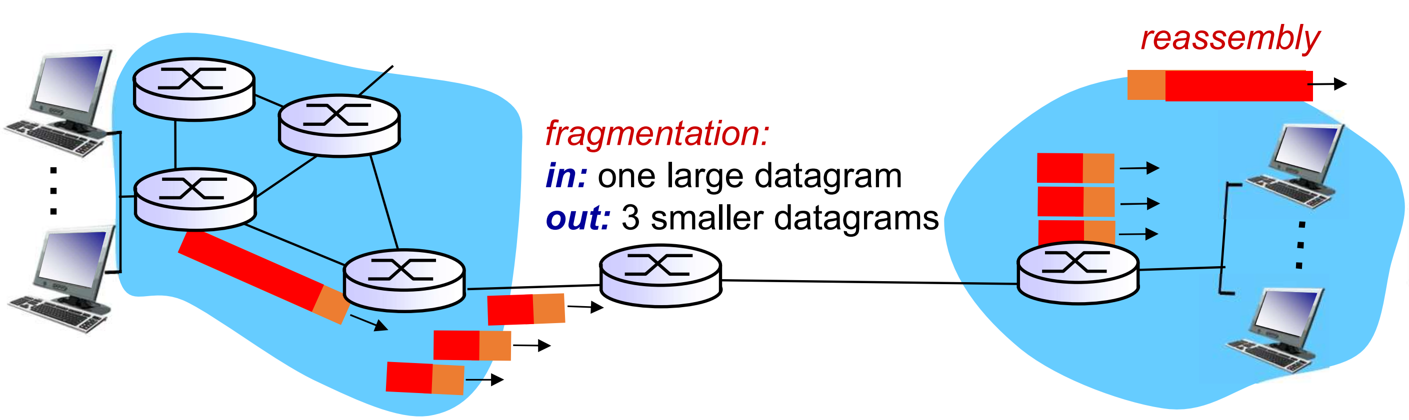
So, what happened to IPv1-v3?

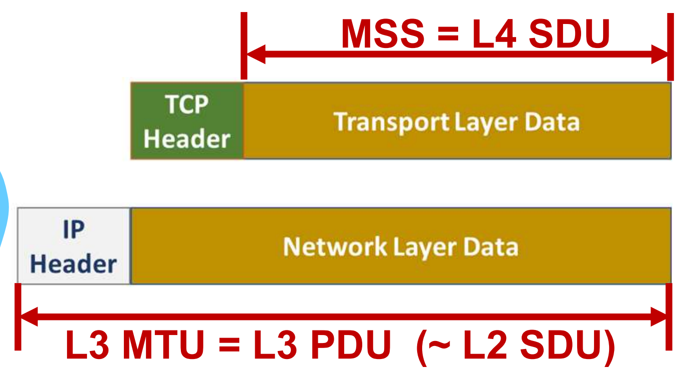
IP FRAGMENTATION, REASSEMBLY

- network links have MTU (max. transfer unit) - largest possible size of link-level frame
  - different link types, different MTUs – depends on the kind of interconnecting link type

Link Type	(L3) MTU (in bytes)
Ethernet (IEEE 802.3)	1500
WiFi (IEEE 802.11)	2304
FDDI	4352
Token Ring (IEEE 802.5)	4464

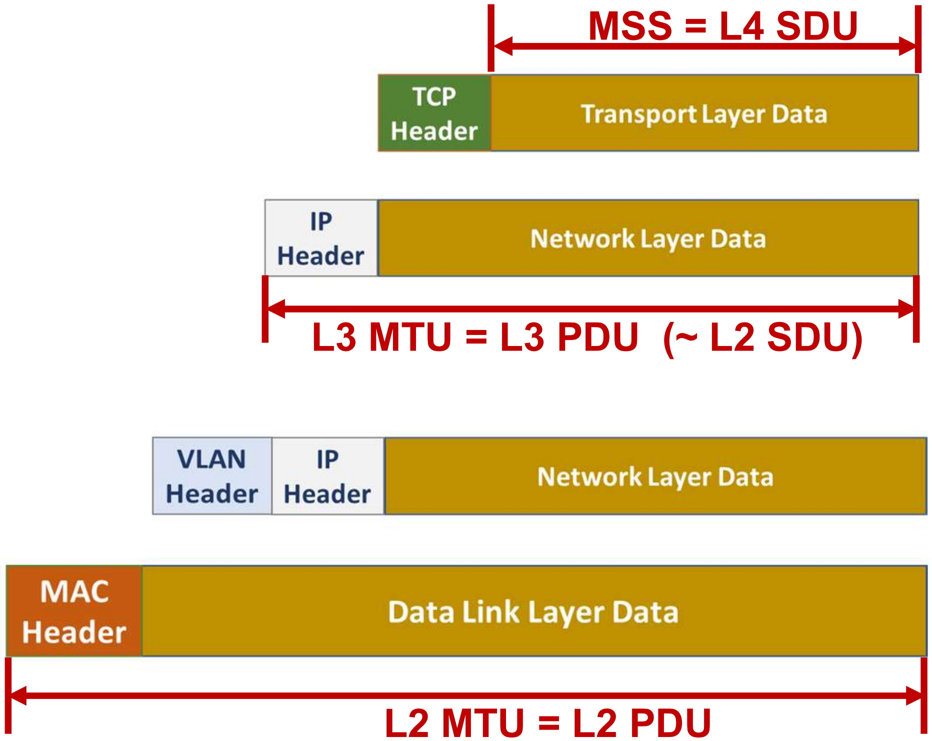
- large IP datagram divided ("fragmented") within net
  - one datagram becomes several datagrams
  - "reassembled" only at final destination
  - IP header bits used to identify, order related fragments





Path MTU discovery [RFC1191, RFC4821] algorithm

Relation between MTU and MSS

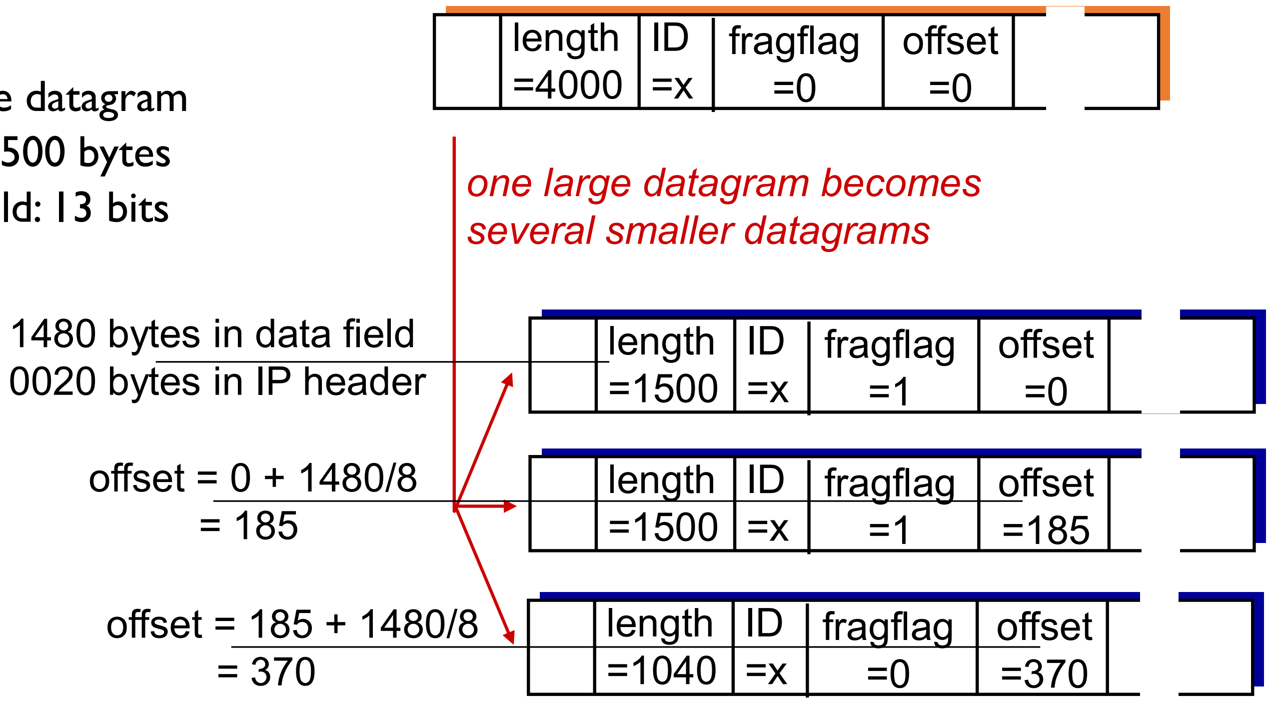


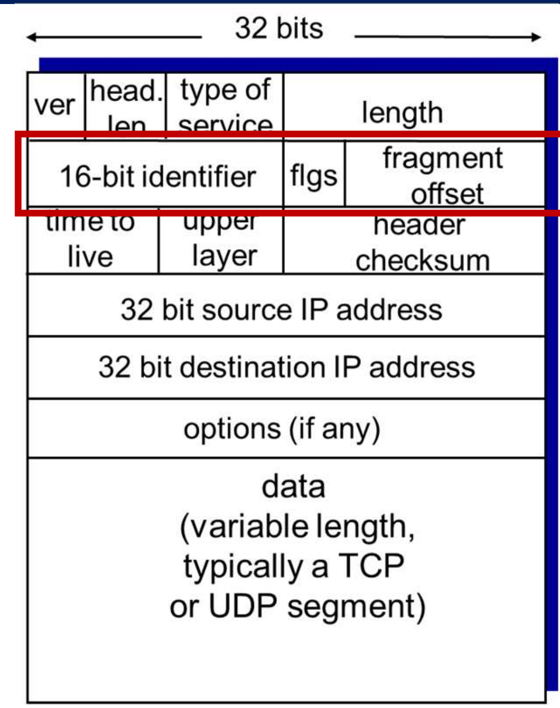
L3 MTU	= 1500 Bytes
Min TCP Header	= 20 Bytes
Min IP Header	= 20 bytes
MSS	= MTU – 40 Bytes

Original packet: 4000 bytes → 3980 bytes payload + 20 bytes IP Header;

example:

- 4000 byte datagram
- MTU = 1500 bytes
- Offset field: 13 bits





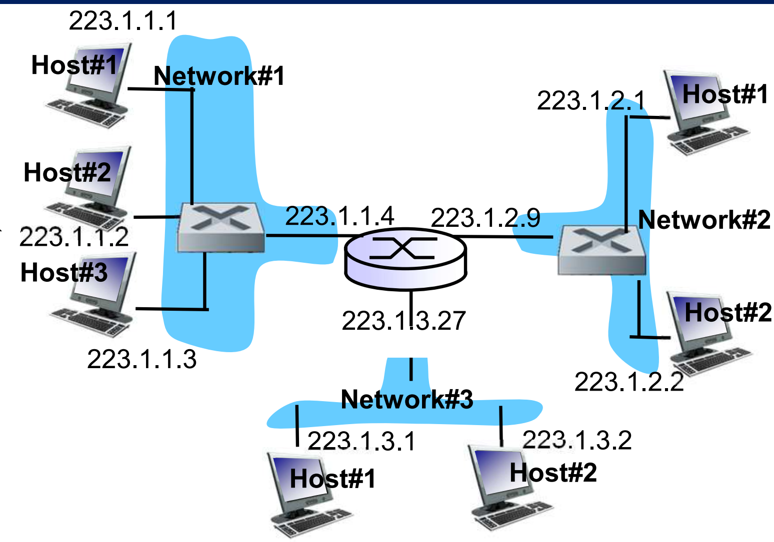
Original packet: 4000 bytes → 3980 bytes payload + 20 bytes IP Header;
Fragmented packets: 1500 bytes → 1480 bytes payload + 20 bytes IP Header;
Fragments=3 Packet size → 1500+1500+1040=4400; Data = 1480+1480+1020=3980

SAMPLE QUESTIONS

4. Consider a L3 PDU of size 4020 bytes on host A to be transmitted via Router-1 and Router 2 to the destination host B. Router 1 has an MTU of 1520 on its outgoing link and the adjacent Router2 has MTU of 1020. Answer the following (Assume 20 bytes IP header): **(10 pts)**
   a. How many fragments will be delivered to the destination? **(2 pts)**
   b. Indicate the packet length and offset value for all the fragmented packets **(5 pts)**
   c. If the MTU at R1 was also changed to 1020 bytes, how many fragments would be delivered to destination B **(1 pts)**
   d. What would be the difference if any, in case the L3 PDU at A were to be of 4016 bytes instead of 4020 bytes. **(2 pts)**

IP (V4) ADDRESSING: INTRODUCTION

- *IP (v4) address:* 32-bit identifier for host, router ***interface***
- *interface:* connection between host/router and physical link
  - router's typically have multiple interfaces
  - host typically has few (one/two?) interfaces (e.g., Ethernet, WiFi)
- *IP addresses are associated with each interface of L3 device*
  - *32-bits as 4-octets define {network ID, Host ID}*



$$223.1.1.1 = \underbrace{11011111}_{223}\ \underbrace{00000001}_{1}\ \underbrace{00000001}_{1}\ \underbrace{00000001}_{1}$$

- *Historical Class-based Addressing:*

Address Class	Address Range	First Octet	Subnet Mask	# IP Addresses in n/w	# Networks
Class A (0)	0. 0 – 127.255.255.255	0-127	255.0.0.0 (8)	2^{24}	128 (2^{7})
Class B (10)	128.0 – 191.255.255.255	128-191	255.255.0.0 (16)	2^{16}	16384 (2^{14})
Class C (110)	192.0 – 223.255.255.255	192-223	255.255.255.0 (24)	2^{8}	2097152 (2^{21})
Class D (1110)	224.0 – 239.255.255.255	224-239	-	2^{28} (multicast groups)	-
Class E (1111)	240.0 – 255.255.255.255	240-255	-	2^{28} (reserved space)	-