

# Internet Protocol (IP)

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# Recap

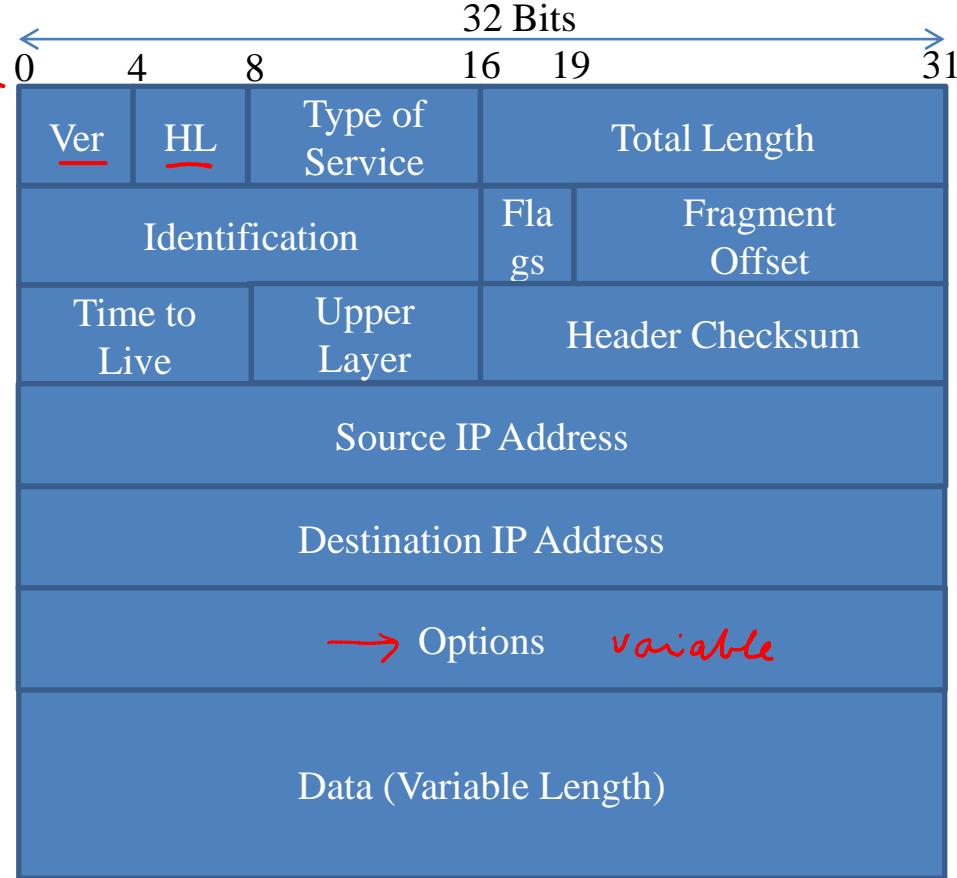
- IP Protocol: Needed functionality
  - IP Protocol: Packet format, addressing
  - Forwarding
  - Routing
  - Error reporting and host signaling
- Focus: Packet Format and Fragmentation and re-assembly

# Packet Format

- Version: Specifies the version of the protocol
  - IPv4, IPv6
- Header Length: Specifies the header in 32-bit words
  - 5 words (without options)

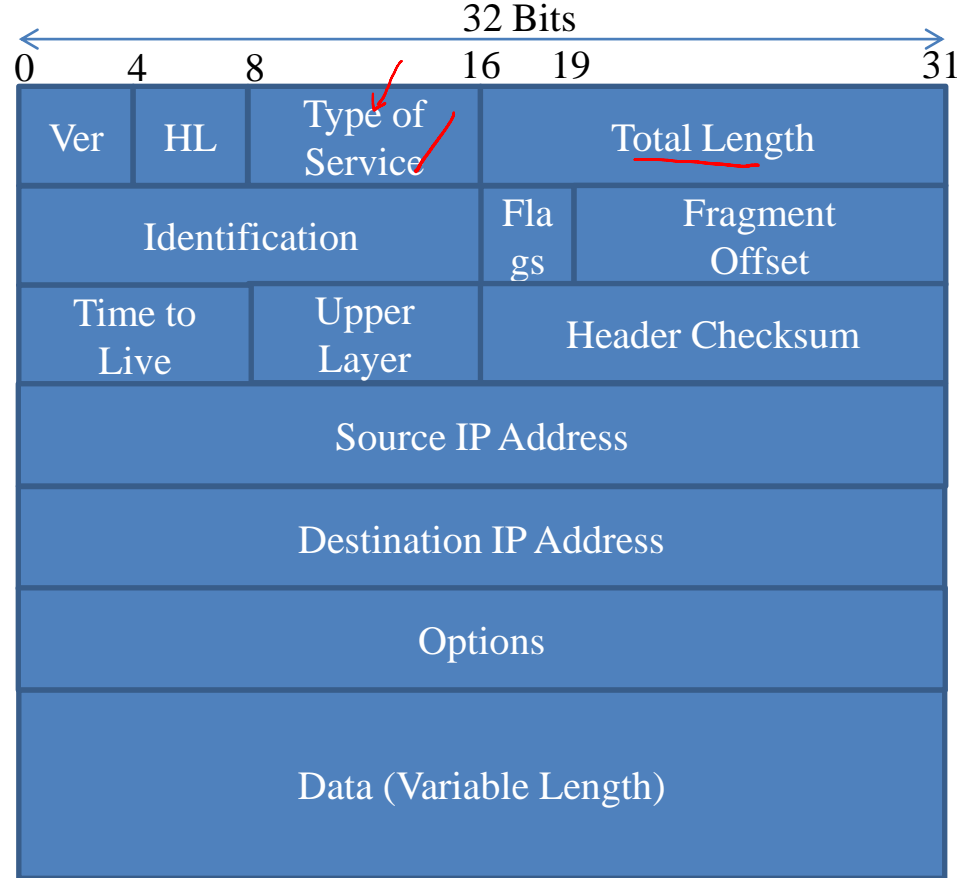
$HL = 5$

$5 \times 32$   
 $= 160 \text{ bits}$



# Packet Format

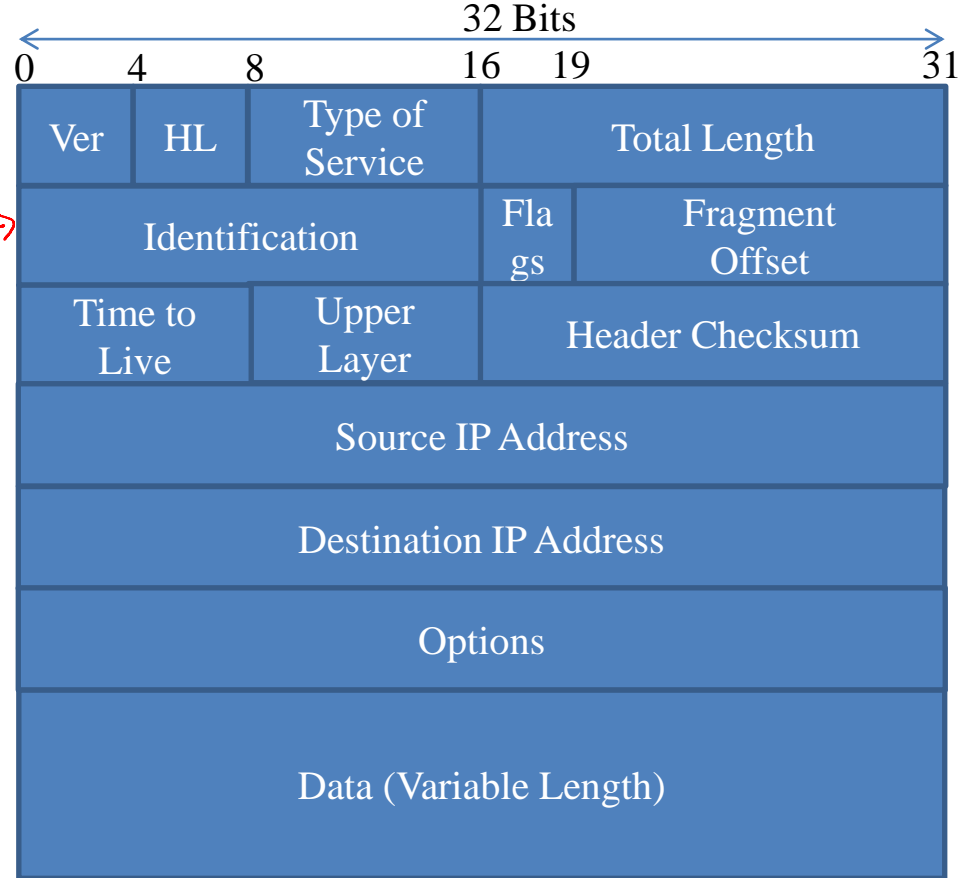
- Type of Service:  
Permits packets to be treated differently
  - Research Focus
- Total Length: Specifies the length of the datagram (in bytes) including header



# Packet Format

$(2^{16} - 1)$  byte 16

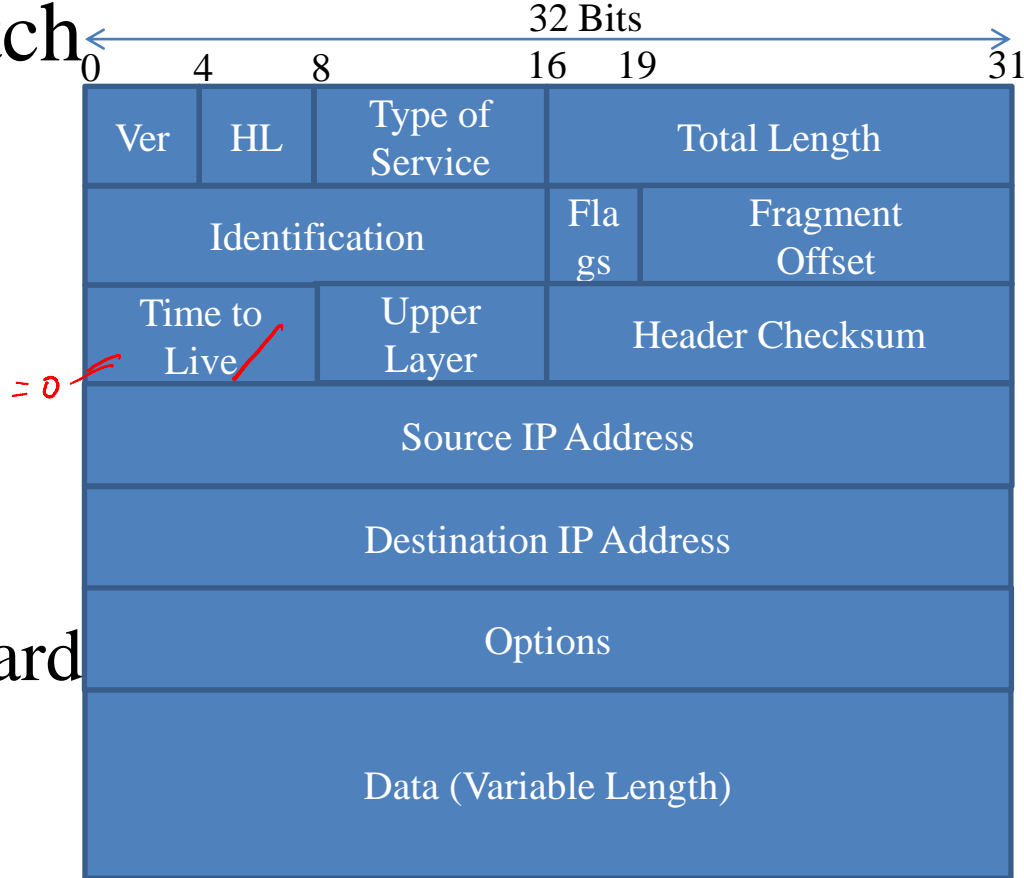
- Identification/Flags/  
Fragment Offset:
  - Max size of IP packet is 65535 Bytes
  - Physical Networks may not support large packets
  - Need Fragmentation and reassembly (more on it soon)



# Packet Format

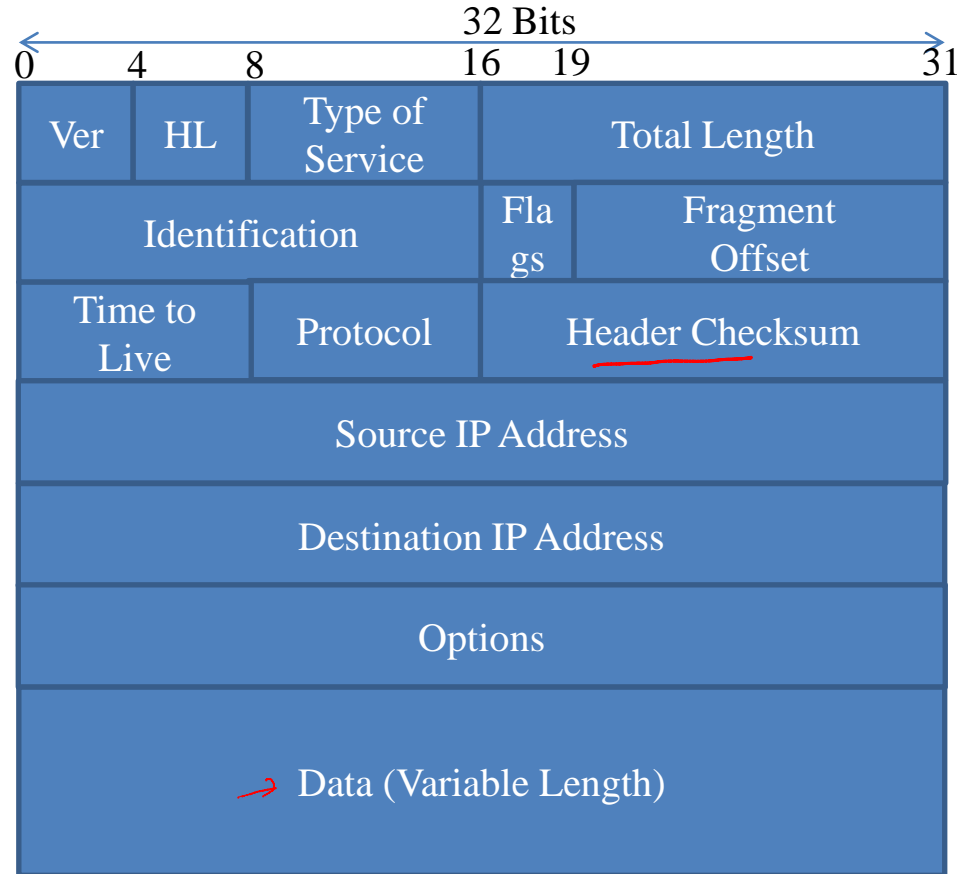
- Time to Live: Helps catch packets doing rounds

- Not really time but <sup>expiry date</sup> ~~hop~~ ~~sec~~ count
- Routers decrement the field by one before forwarding; if zero discard
- Default value = 64



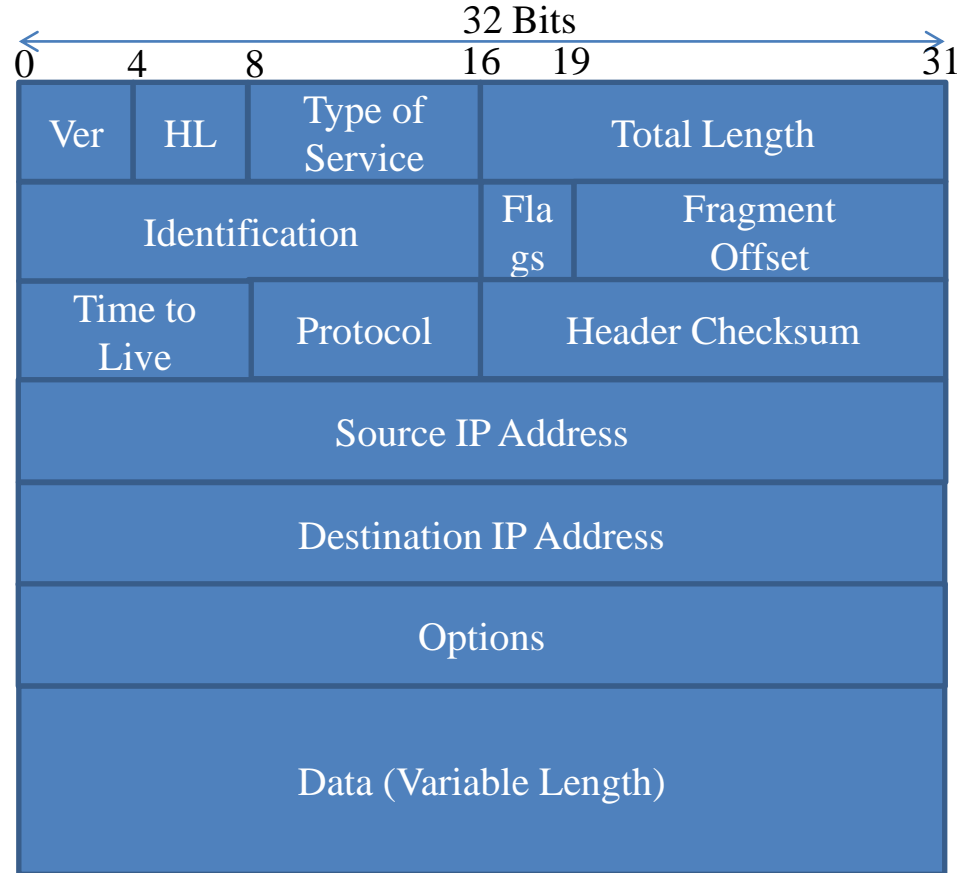
# Packet Format

- Protocol: Demux key that identifies higher layer protocol
  - TCP: 6, UDP: 17
- Checksum (Internet): Detects errors in header



# Packet Format

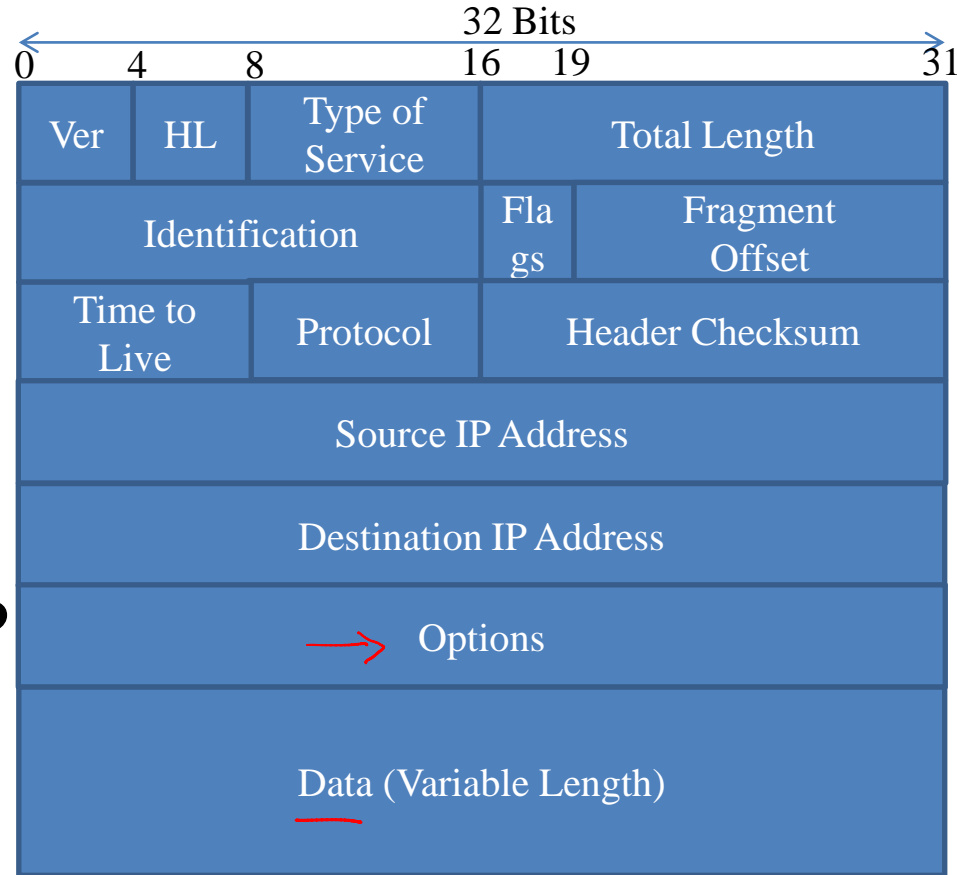
- Source/Destination IP address: 32-bit
  - Destination key to forwarding
  - Source for replying back
  - Global address space, independent of physical network address (MAC)





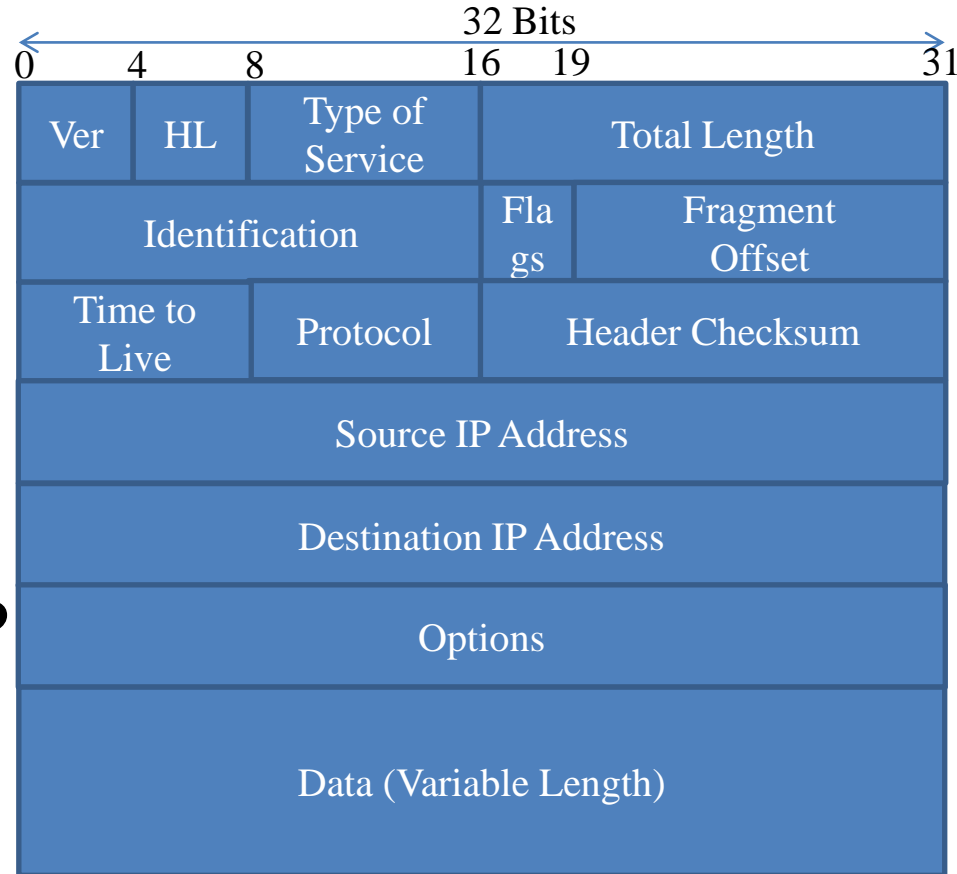
# Packet Format

- Options: Rarely used
  - Record Time stamp
  - Record route taken
  - Specify source route
- Data/Payload: Higher Layer Data (TCP or UDP segment)



# Packet Format

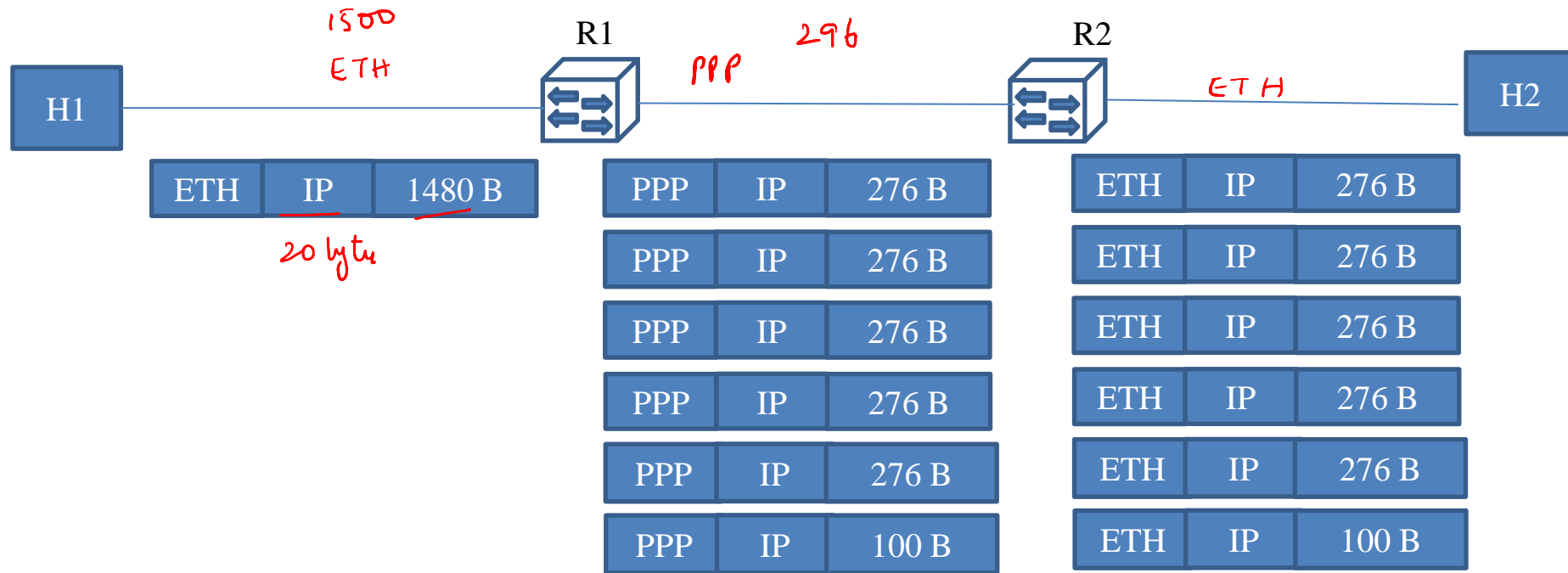
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# Fragmentation and Reassembly

- Goal: Interconnect heterogeneous networks
- Problem: Each technology has different Maximum Transmission Unit (MTU) size
  - MTU: Largest IP datagram that can be carried in a frame
  - E.g. Ethernet: 1500, FDDI: 4352, PPP: 296 (Negotiable), WiFi: 7981

- At host: Select MTU of link it is connected to
- At intermediate router: Forward datagram on a network with smaller MTU
  - Need to fragment the datagram
- Where to reassemble?
  - Next hop router? Increases overhead and datagram may again be fragmented
  - Destination is the best place



Note: Above values not true in practice due to Offset field having to be a multiple of 8

# Fragmentation Fields

- Identification: Helps identify a datagram
  - All fragments carry same identification

- Flags: 3 bits



- bit 0: Reserved, set to zero
- bit 1: Don't Fragment (DF); Useful for path MTU discovery
- bit 2: More Fragments (MF); Set to one to indicate more fragments to follow

# Fields

- Fragmentation Offset: 13 bits long
  - Measures data/payload in units of eight-byte blocks
  - For a particular fragment, offset specifies start of data relative to the beginning of the original unfragmented IP datagram.
    - E.g first fragment would have an offset of zero



# Example

- Original datagram:  
1500B

→ TCP/UDP

20B

- Data within is 1480B

- MTU: 296B

276

- Max Data within is  
276B
- Offset has to be multiple  
of 8 → Data within  
272B

Original Datagram

Length= <u>1500</u>	ID= <u>x</u>	Fragflag= <u>0</u>	Offset= <u>0</u>
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8 bytes  
↓

$$272 \times 5 = 1360$$

$$1480 - 1360 = 120$$

Fragmented Datagrams

20

Length= <u>292</u>	ID= <u>x</u>	Fragflag= <u>1</u>	Offset= <u>0</u>
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<u>272</u> + 20 Length=292	ID= <u>x</u>	Fragflag= <u>1</u>	Offset= <u>34</u>
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$$272 / 8$$

Length=292	ID= <u>x</u>	Fragflag= <u>1</u>	Offset= <u>68</u>
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Length=292	ID= <u>x</u>	Fragflag= <u>1</u>	Offset= <u>102</u>
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<u>Length=292</u>	ID= <u>x</u>	Fragflag= <u>1</u>	Offset= <u>136</u>
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7

<u>Length=140</u>	ID= <u>x</u>	Fragflag= <u>0</u>	Offset= <u>170</u>
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7



# Summary

- Looked at IP packet format
- Looked at fragmentation and reassembly
- Next: Addressing and Forwarding