IP DATAGRAM

PACKETS IN GENERAL

Packets

- Most communication protocols group data into separate pieces
- Each piece of data is commonly called a packet
- Information in a packet often separated into parts:
  - Header control information at start of packet; used to support protocol operation
  - Payload actual data
  - Trailer control information at end of packet; used to support protocol operation
- Not all parts in all packets, e.g. Header + Payload; Header + Payload + Trailer; Header only

PACKET TERMINOLOGY

Packet Terminology

- ► No standard terminology for packets
- ► Other names: frame, datagram, segment, package, message
- ► Differs among protocols and layers, e.g.

  Application message

  Transport TCP segment, UDP datagram

  Network datagram

  Data Link frame

- ► Standards often measure packet sizes in octets
  - ► 1 octet = 8 bits (always true)
  - ► 1 Byte = 8 bits = 1 octet (true in most practical cases today)

PACKET HEADER AND TRAILER

Packet Header (and Trailer)

Networking

Packets

Terminology

Example: IP

Packet Size

Example Packets

What is Purpose of Header?

- ▶ Contains information to support protocol operation
- ▶ Sender includes information in header so receiver can correctly process the data and optionally respond
- ▶ Information often split into fields; each field has a value
- ▶ Number, meaning and size of fields defined in standard
    - ▶ RFC 793 defines TCP segment header fields
    - ▶ IEEE 802.11 defines wireless LAN frame header and trailer fields
- ▶ Many protocols have default, fixed size header, with optional extra fields
    - ▶ TCP: 20 bytes required; optional fields allowed
    - ▶ IEE 802.11 MAC Data: typically 24 byte header and 4 byte trailer; other sizes possible

GENERAL PACKET STRUCTURE

Networking

Packets

Terminology

Example: IP

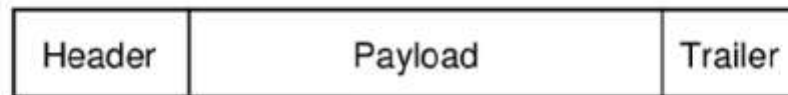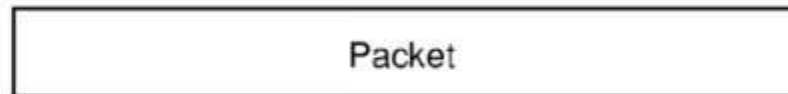Packet Size

Example Packets

General Packet Structure

Packet

Header	Payload	Trailer

Field1 = Value1
Field2 = Value2
...
FieldN = ValueN

Field1 = Value1
Field2 = Value2
...
FieldN = ValueN

HEADER AND TRAILER

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Packet Header and Trailer

Header vs Trailer

- ► Trailer also contains information to support protocol operation
- ► Header before the payload, trailer after the payload
- ► Devices can process packet as it is received; header then payload then trailer
  - ► Info in header can be processed before/as data arrives
    - ► Router can determine where to send the packet before the entire packet has been received
  - ► Trailer often used when dependent on data, e.g. checksum over data
- ► Most protocols use header, some use both header and trailer
- ► (For simplicity, examples often only consider header)

EXAMPLE

Packet Header (and Trailer)

Example Header Fields

- ▶ Source and destination addresses, e.g. IP address, MAC address
- ▶ Packet, payload, header lengths
- ▶ Sequence numbers, e.g. data sequence, ACK number
- ▶ Protocol version, e.g. IPv4
- ▶ Checksums, error detection codes
- ▶ Packet types, e.g. SYN, ACK, RST
- ▶ Flags
    - ▶ Single bit values
    - ▶ 1: flag is set/true, e.g. feature is on
    - ▶ 0: flag is unset/false, e.g. feature is off

IP DATAGRAM FORMAT

Packet Format

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

32 Bits				
0 4 8			16 19	31
Ver	HL	Type of Service	Total Length	
Identification			Flags	Fragment Offset
Time to Live		Upper Layer	Header Checksum	
Source IP Address				
Destination IP Address				
Options				
Data (Variable Length)				
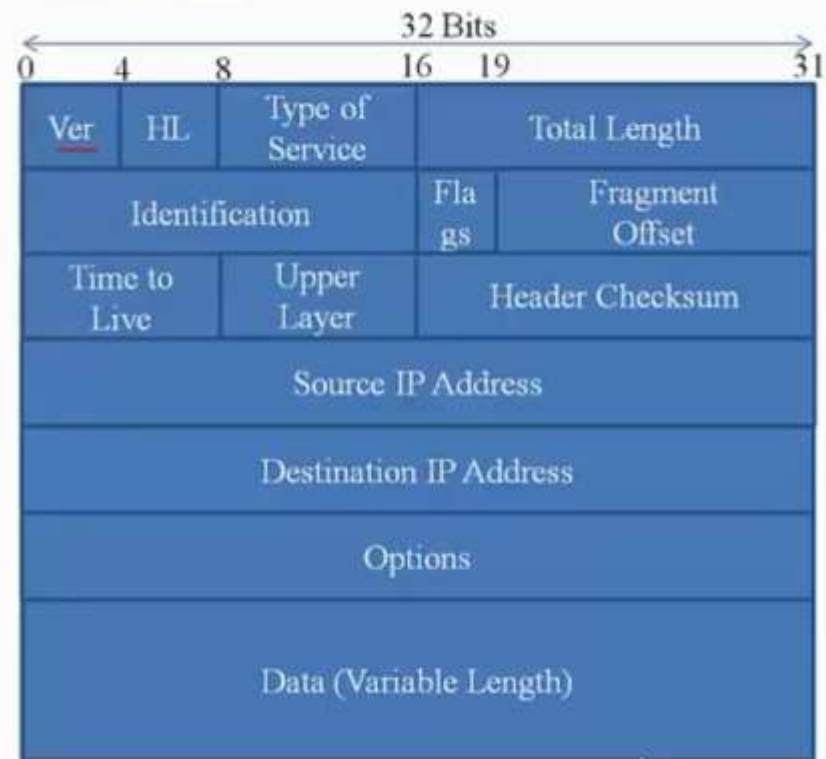
CONTD.......

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

32 Bits					
0 4	8	16	19		31
Ver	HL	Type of Service	Total Length		
Identification			Flags	Fragment Offset	
Time to Live		Upper Layer	Header Checksum		
Source IP Address					
Destination IP Address					
Options					
Data (Variable Length)					
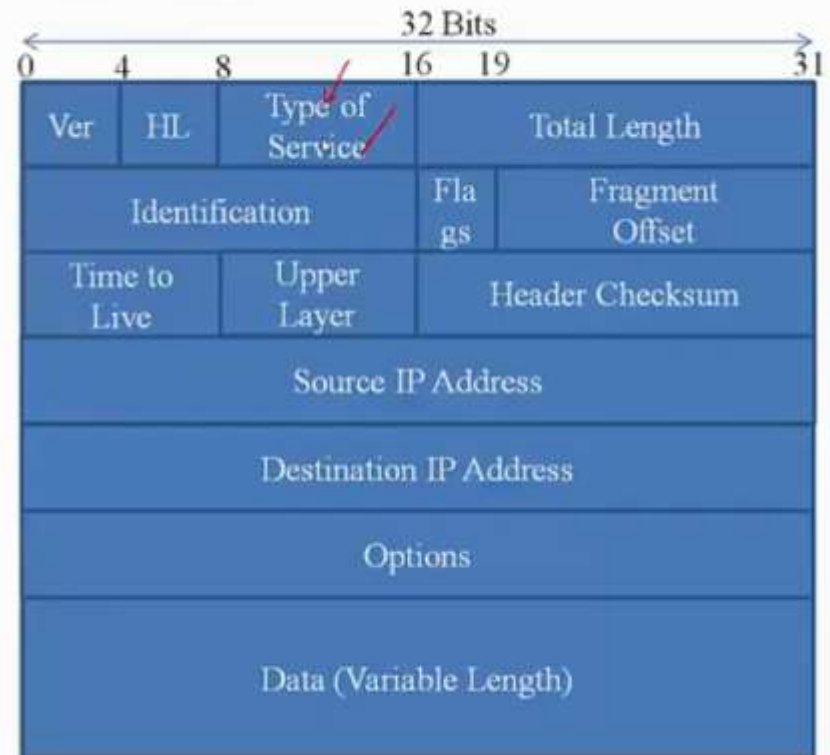
CONTD....

Packet Format

$(2^{16}-1) \text{ bytes}$

- Identification/Flags/ Fragment Offset:

    - Max size of IP packet is 65535 Bytes

    1500 bytes
    - Physical Networks may not support large packets

    - Need Fragmentation and reassembly (more on it soon)

32 Bits				
0 4 8			16 19	31
Ver	HL	Type of Service	Total Length	
Identification			Flags	Fragment Offset
Time to Live		Upper Layer	Header Checksum	
Source IP Address				
Destination IP Address				
Options				
Data (Variable Length)				
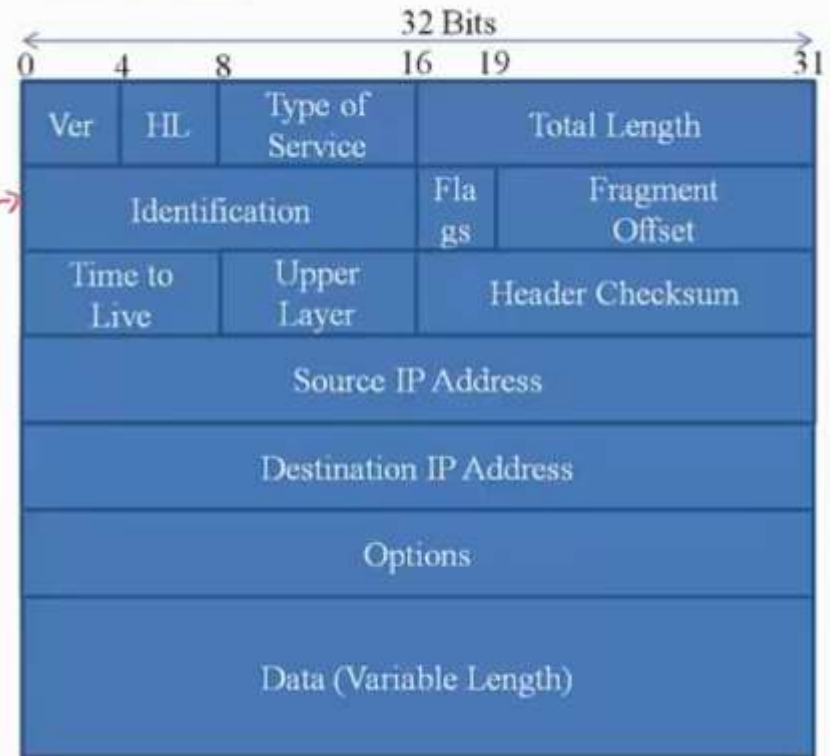
CONTD....

Packet Format

- Time to Live: Helps catch packets doing rounds
  expiry date
  - Not really time but hop count
  - Routers decrement the field by one before forwarding; if zero discard
  - Default value = 64

32 Bits				
Ver	HL	Type of Service	Total Length	
Identification			Flags	Fragment Offset
Time to Live		Upper Layer	Header Checksum	
Source IP Address				
Destination IP Address				
Options				
Data (Variable Length)				
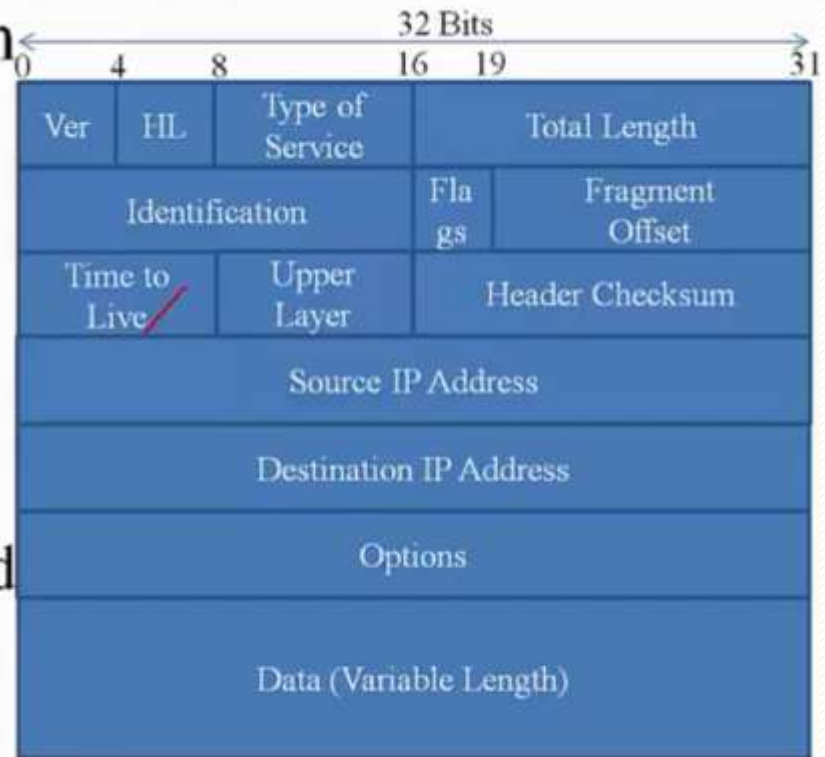
CONTD...

Packet Format

- Protocol: Demux key that identifies higher layer protocol
  - TCP: 6, UDP: 17

- Checksum (Internet): Detects errors in header
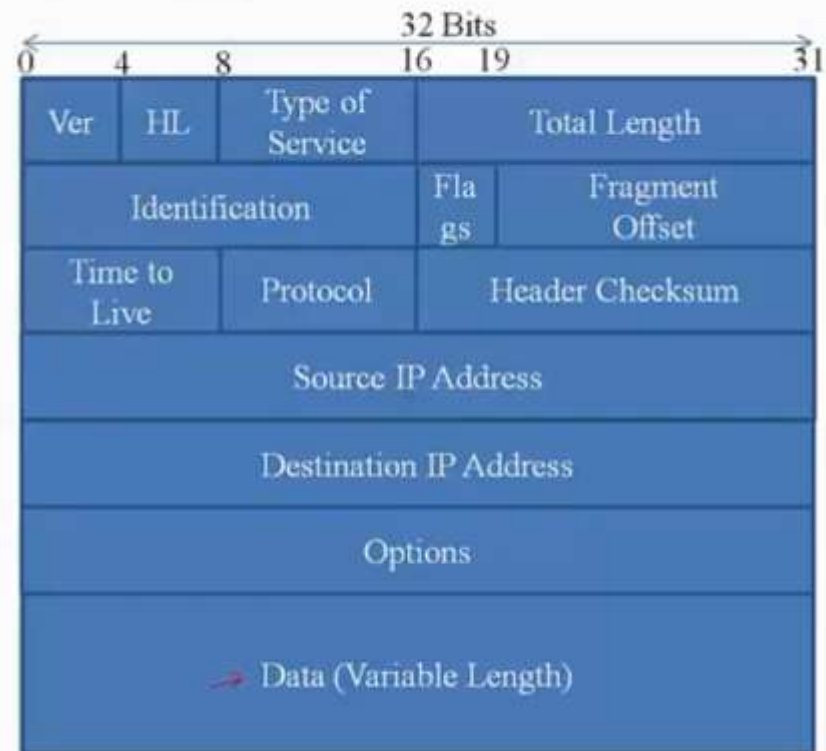
CONTD…..

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)

			32 Bits		
0	4	8	16	19	31
Ver	HL	Type of Service		Total Length	
Identification			Flags	Fragment Offset	
Time to Live		Protocol	Header Checksum		
Source IP Address					
Destination IP Address					
Options					
Data (Variable Length)					
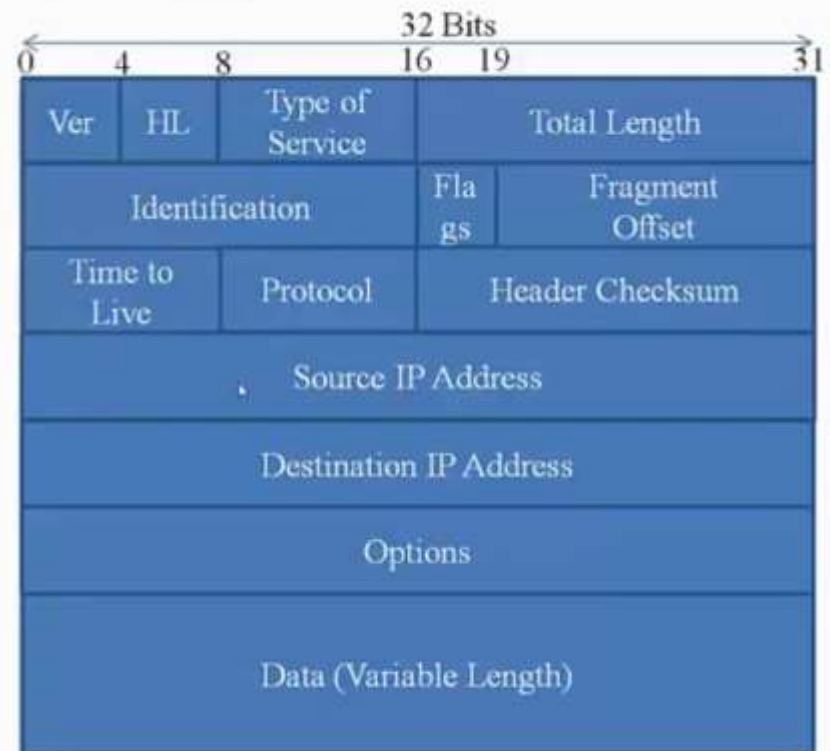
CONTD....

Packet Format

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

32 Bits					
Ver	HL	Type of Service	Total Length		
Identification			Flags	Fragment Offset	
Time to Live		Protocol	Header Checksum		
Source IP Address					
Destination IP Address					
Options					
Data (Variable Length)					

IP DATAGRAM

Example IP Datagram: Meaning

01000101000000000000000111011010000001111000110001000000000000000001000000000000110

0010010101110001000010100000101001100101010000011100101110000011110100010101010010

IETF RFC 791 defines meaning of field values

Version $0100 \rightarrow 4$

Header length $0101 \rightarrow 5 \times 4 = 20$ Bytes

$\cdots$

Source Address 10.10.101.65

Destination Address 203.131.209.82

Networking

Packets

Terminology

Example: IP

Packet Size

Example Packets

STRUCTURE

Networking

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Example: IP

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Example Packets

IP Datagram Structure

| | | 0 | 4 | 8 | 14 | 16 | 19 | 31 |

Version	HLength	DiffServ	ECN	Total Length		
Identification			Flags	Fragment Offset		
Time To Live		Protocol		Header Checksum		
Source IP Address						
Destination IP Address						
Options + Padding (optional)						
Data						

20 Bytes
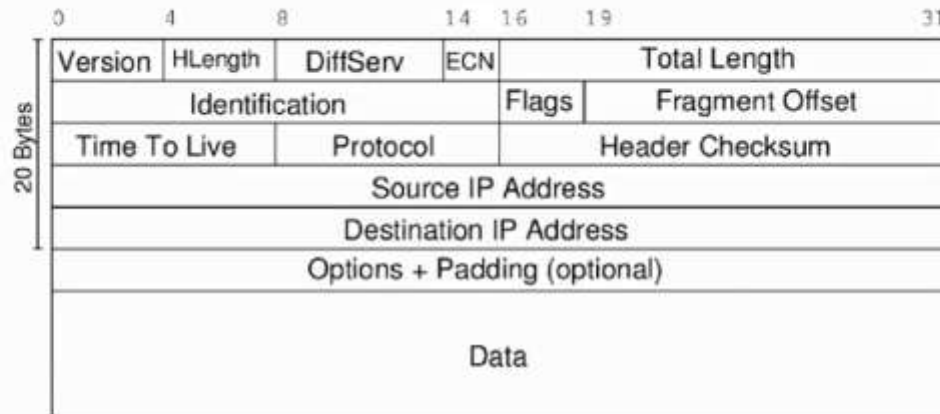
Although packets are just sequence of bits, for convenience headers and header fields often drawn row-by-row

Networking

Packets

Terminology

Example: IP

Packet Size

Example Packets

Example IP Datagram: Meaning

Version 4

Header length 20 Bytes

Differentiated Services Codepoint Default (000000)

Explicit Congestion Notification Not-ECT (00)

Total Length 474 Bytes

Identification 0x078c

Flags 0x02

- ▶ 0... .... = Reserved bit: Not set
- ▶ .1.. .... = Don't fragment: Set
- ▶ ..0. .... = More fragments: Not set

Fragment offset 0

Time to live 64

Protocol TCP (6)

Header checksum 0x2571

Source 10.10.101.65

Destination 203.131.209.82