Network Layer: IP Functions

Lecture 7 | CSE421 – Computer Networks

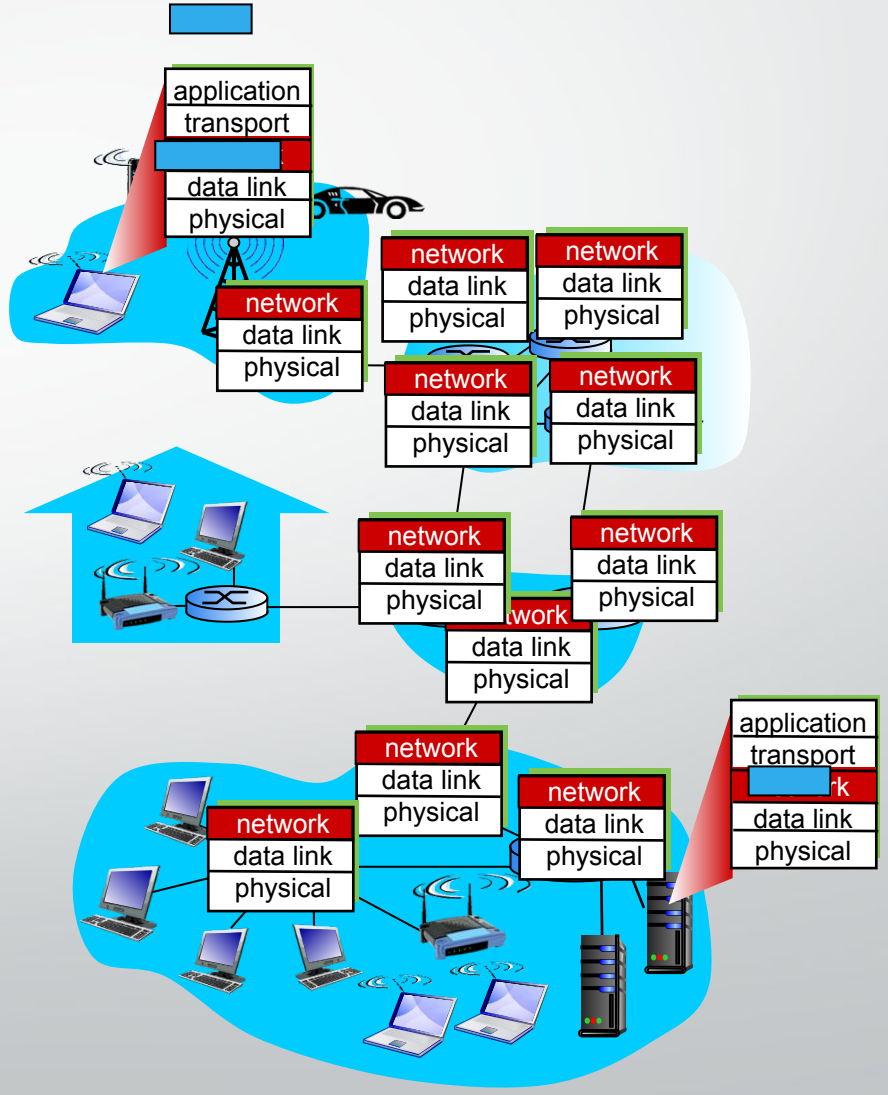
Department of Computer Science and Engineering
School of Data & Science

Objectives

- Short overview of the Network Layer
- Packet Switching: Virtual Circuits & Datagram Networks
- IP Fragmentation & Reassembly

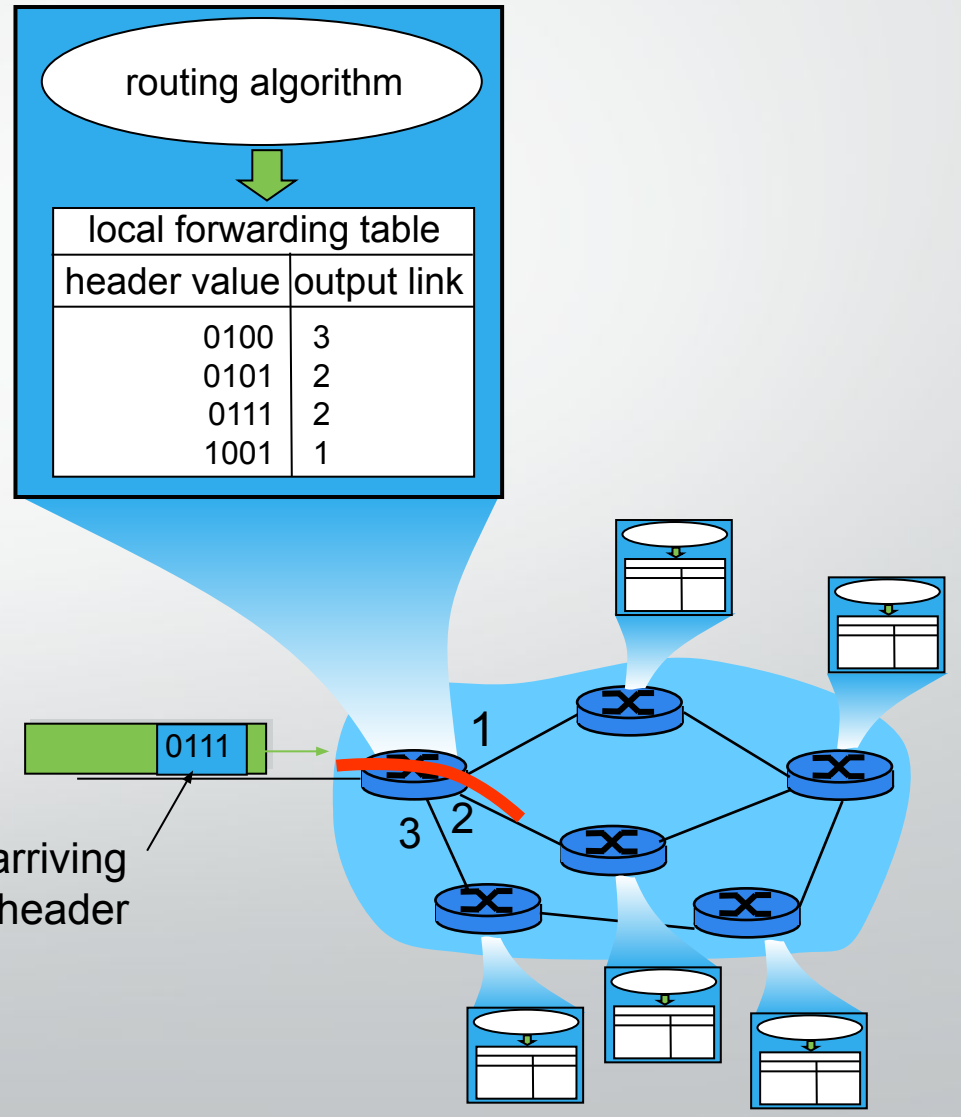
The Network Layer

- Transport segment from sending to receiving host
- On sending side encapsulates segments into packets
- Network layer protocols in every host, router
- Router examines header fields in all IP packets passing through it
- On receiving side, delivers segments to transport layer



Functions of Network Layer

- **Forwarding:** move packets from router's input to appropriate router output
  - Analogy: process of getting through a single interchange
- **Routing:** determine route taken by packets from source to destination
  - The algorithms that calculate the paths are referred to as routing algorithms.
  - Analogy: process of planning trip from source to destination
  - Has various routing algorithms



BRAC UNIVERSITY
Inspiring Excellence

Packet Switching:

Virtual Circuits

Datagram Network

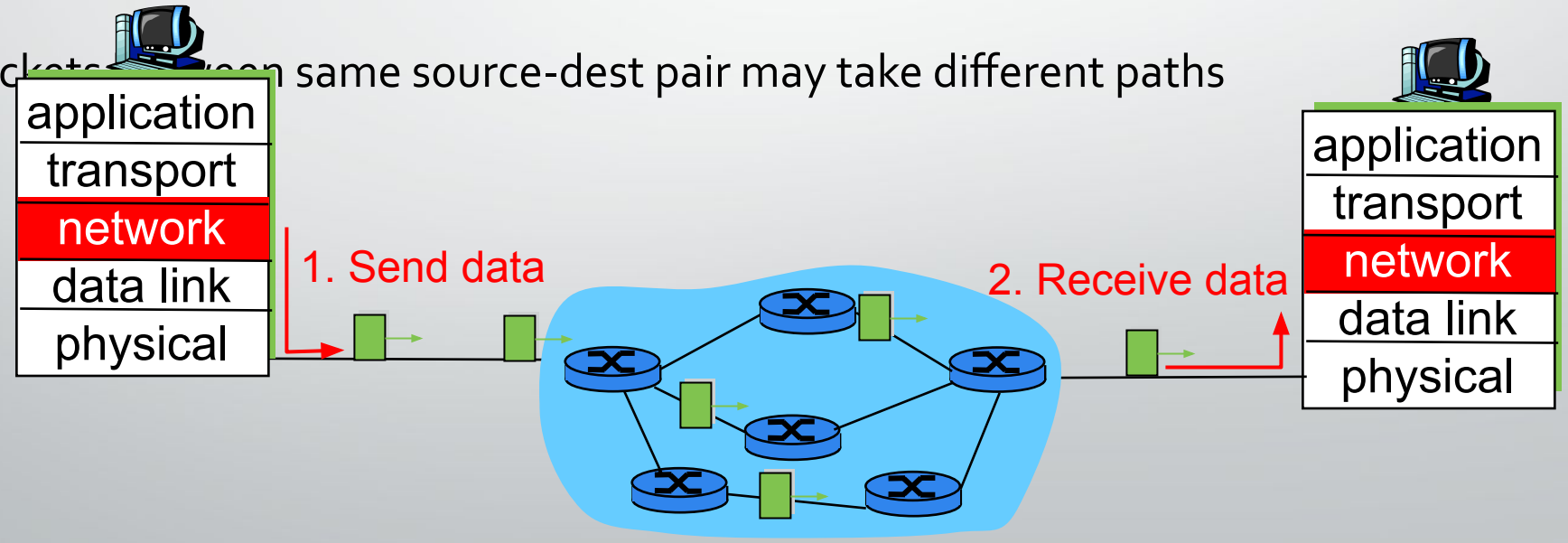
Connection and Connection-less service

BRAC UNIVERSITY
Inspiring Excellence

- The Internet Protocol is a connectionless service. Sometimes called
- **Datagram network** =>
- network-layer connectionless service
- VC network => network-layer connection service
  - analogous to the transport-layer services, but:
  - **service:** host-to-host
  - **no choice:** network provides one or the other
  - **implementation:** in network core

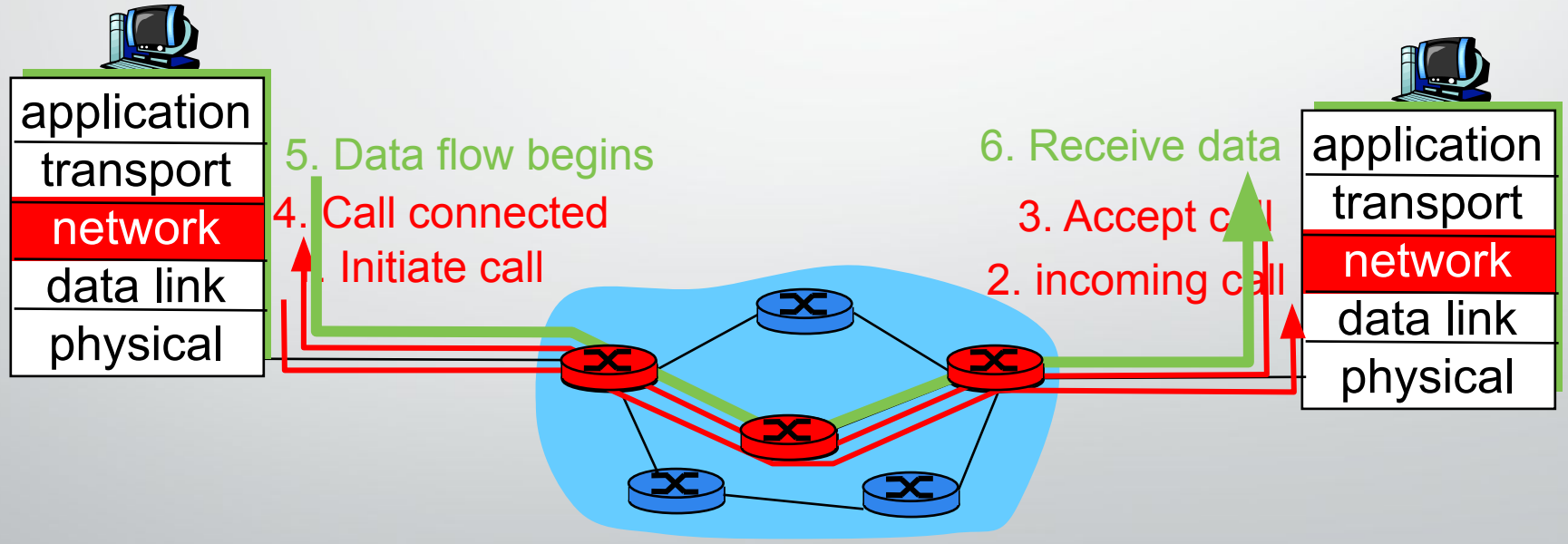
Datagram networks

- No call setup at network layer
- Routers: no state about end-to-end connections
  - no network-level concept of "connection"
- Packets forwarded using destination host address
  - packets between same source-dest pair may take different paths

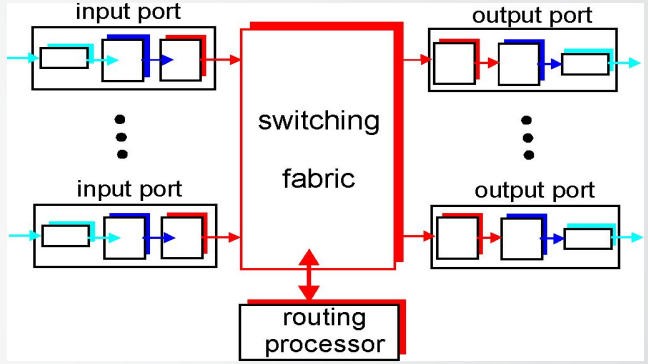


Virtual Circuits: Signaling Protocols

- Used to setup, maintain teardown VC
- Used in ATM, frame-relay, X.25
- Not used in today's Internet



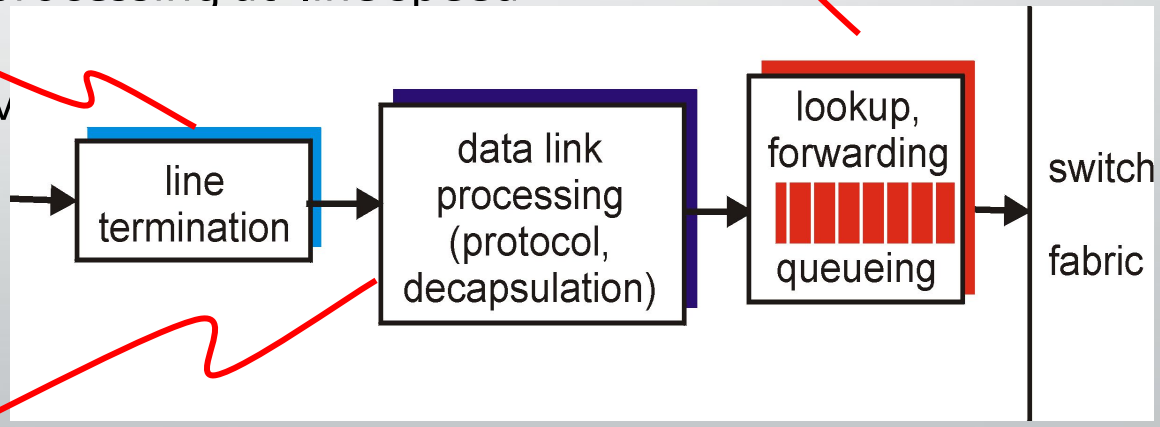
Functions of a Router



- Run routing algorithms/protocol (RIP, OSPF, BGP)
- **Forwarding** datagrams from incoming to outgoing link
- **Decentralized switching:**
  - Given datagram dest., lookup output port using forwarding table in input port memory
  - **Goal:** complete input port processing at 'line speed'
  - **Queuing:** if datagrams arriv

Physical layer:
bit-level reception

Data link layer:
e.g., Ethernet

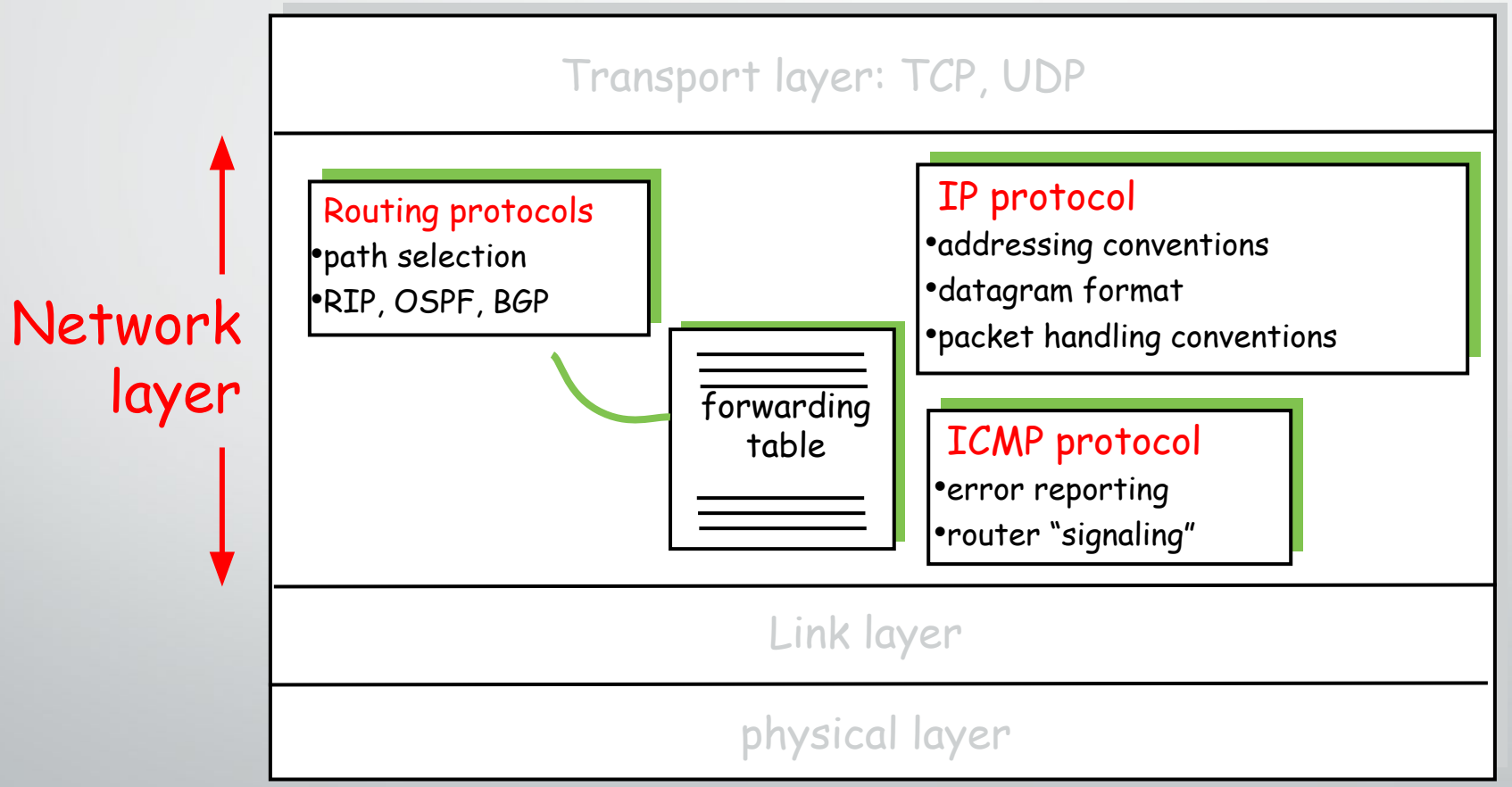


BRAC UNIVERSITY
Inspiring Excellence

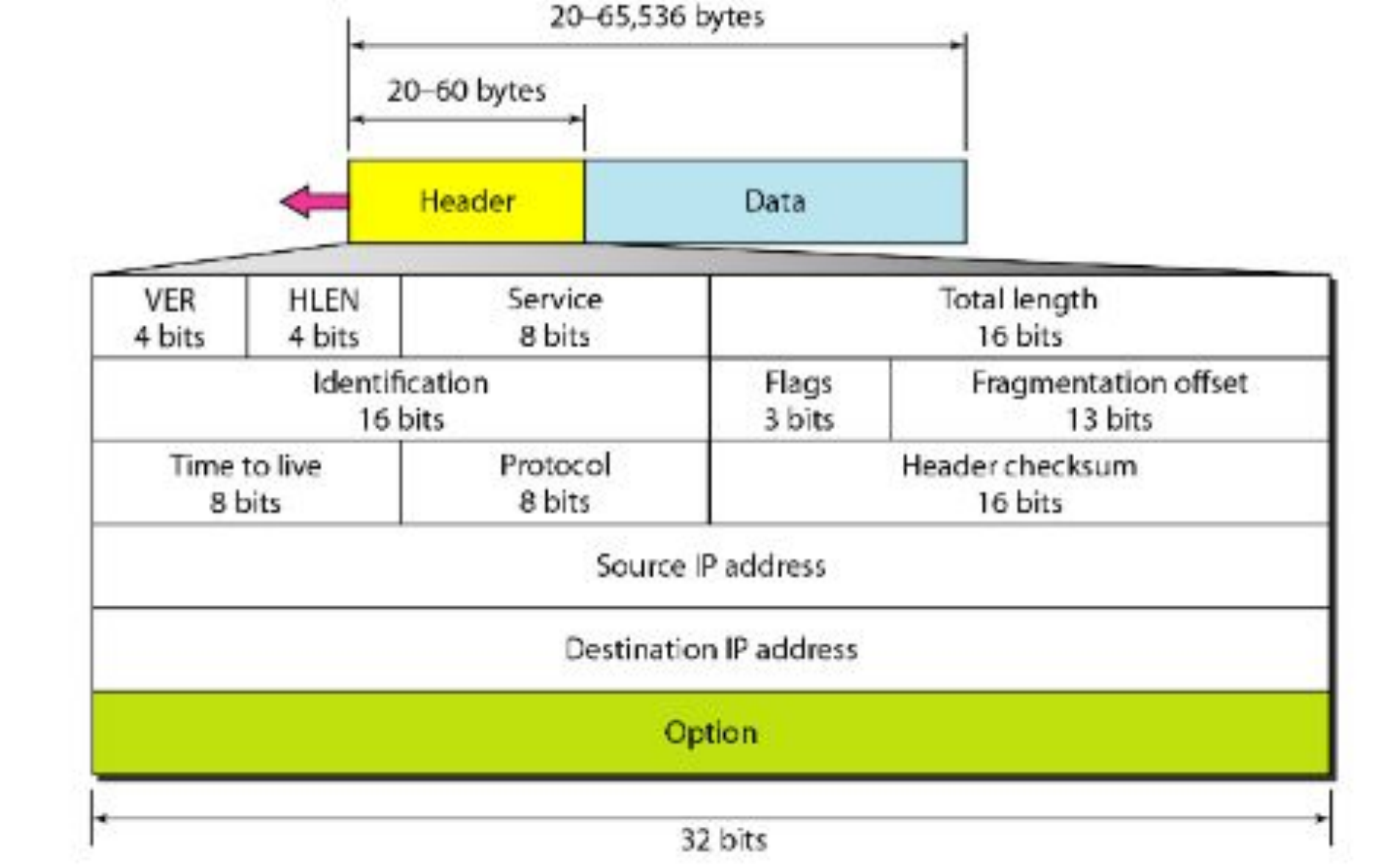
Internet Protocol

Internet Network Layer

- Host, router network layer functions:



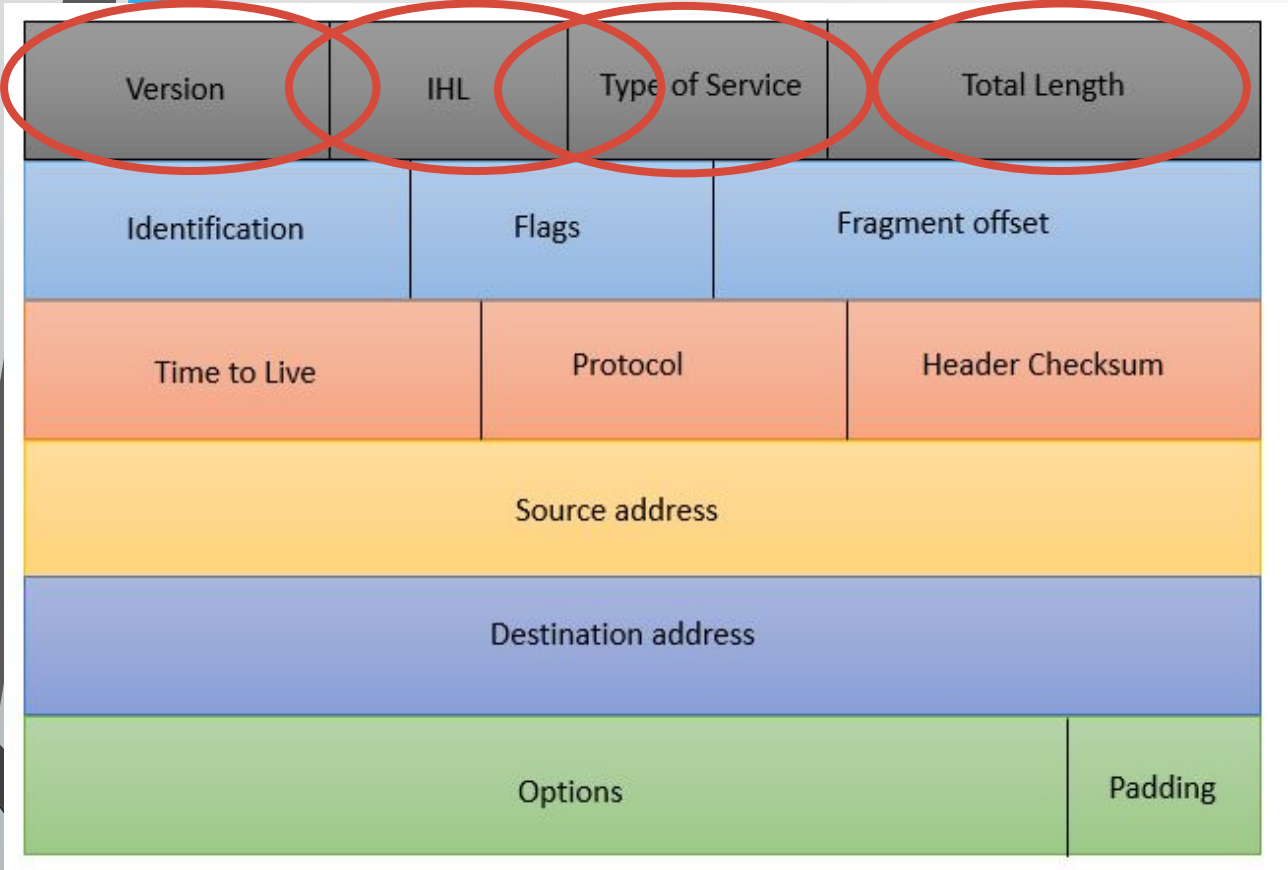
IPv4 Datagram Format



The size of an IP datagram:

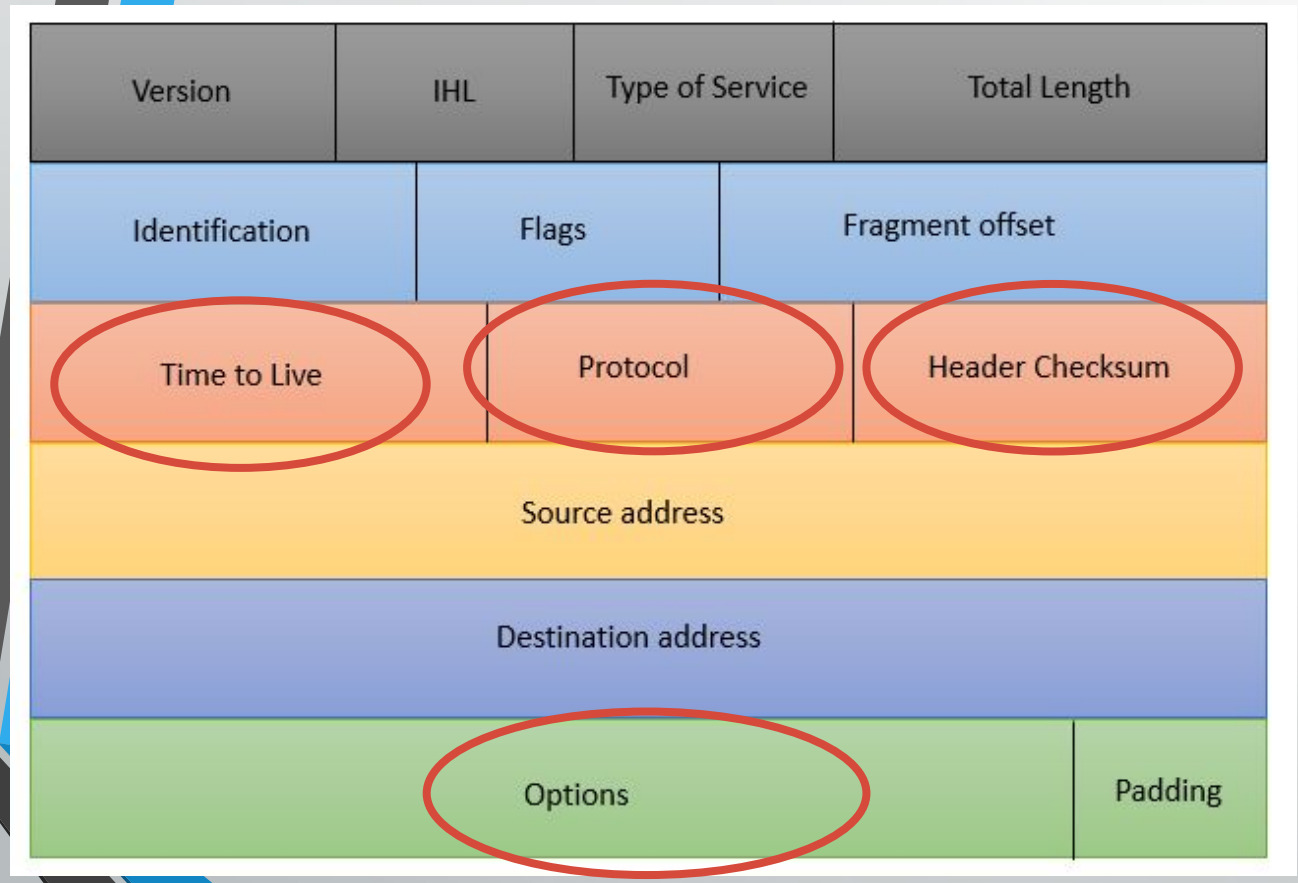
- The minimum size is 20 bytes (if you have no data)
- The maximum size is 65,535 bytes

IPv4 Datagram Format



- **Version:** 4 bits, value of which IP version is being used. For IPv4 the value will be 4 here.
- **Internet Header Length**: 4 bits**,** value of the header length, min 20 bytes, max 60 bytes. Shown in 4 byte word. So min value 5, max 15.
- **Type of Service**: 8 bits, for QoS (Quality of Service). To mark the packet to give special treatment or priority.
- **Total Length:** 16 bits, value of the entire size of the IP packet (header and data) in bytes. The minimum size is 20 bytes (if you have no data) and the maximum size is 65.535 bytes.

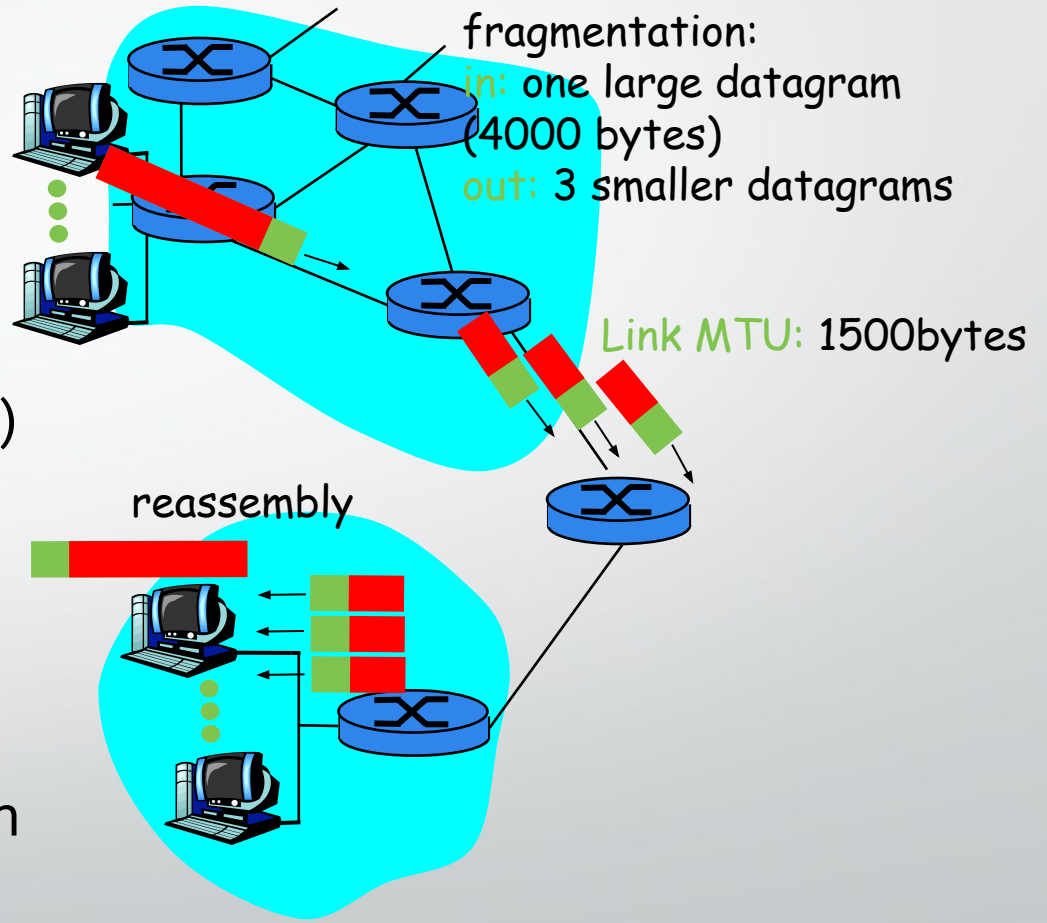
IPv4 Datagram Format



- **Time to Live:** 8 bits, value of how many hops can a packet. Used to prevent packets from looping around forever.
- **Protocol:** 8 bits, value tells us which upper layer protocol is present, for example TCP has value 6 and UDP has value 17.
- **Header Checksum:** 16 bits, to check if there are any errors in the header.
- **Options:** 32 bits, value of any extra information

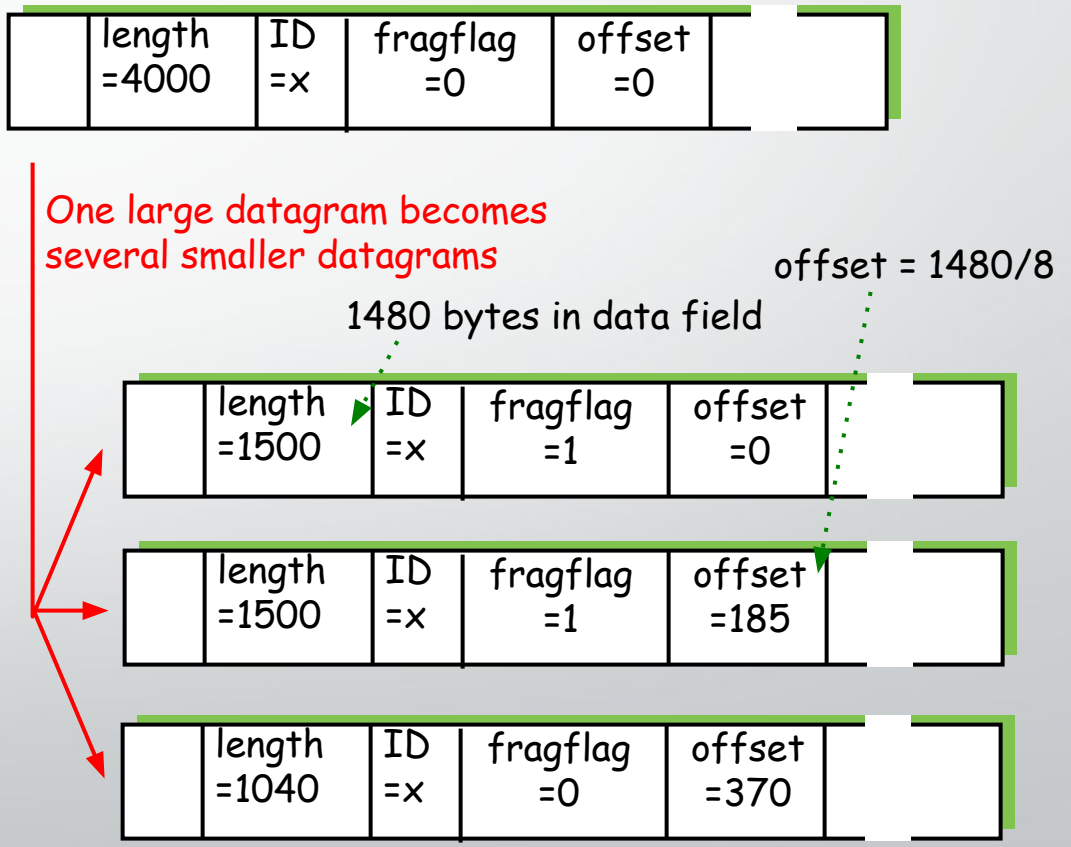
IP Fragmentation & Reassembly

- Network links have **MTU (max. transmission unit - max. transfer size)** - largest possible link-level frame.
  - different link types, different MTUs
- 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



IP Fragmentation & Reassembly

- Example:
  - 4000 Bytes of datagram
  - MTU = 1500 Bytes
    - Header + Data
    - Header size is usually 20 bytes
      - It can differ
  - Offset:
    - The value of the offset is measured in units of 8 bytes.
    - This is done because the length of the offset field is only 13 bits long and cannot represent a sequence of bytes greater than 8191.
    - This forces hosts or routers that fragment datagrams to choose the size of each fragment so that the first byte number is divisible by 8.



IP Fragmentation & Reassembly

BRAC UNIVERSITY
Inspiring Excellence

MTU=20(H)+1480(D)
5140=20(H)+5120(D)
5120-1480=3640 (1st)
3640-1480=2160 (2nd)
2160-1480=680 (3rd)

680+20=700

Original IP Datagram

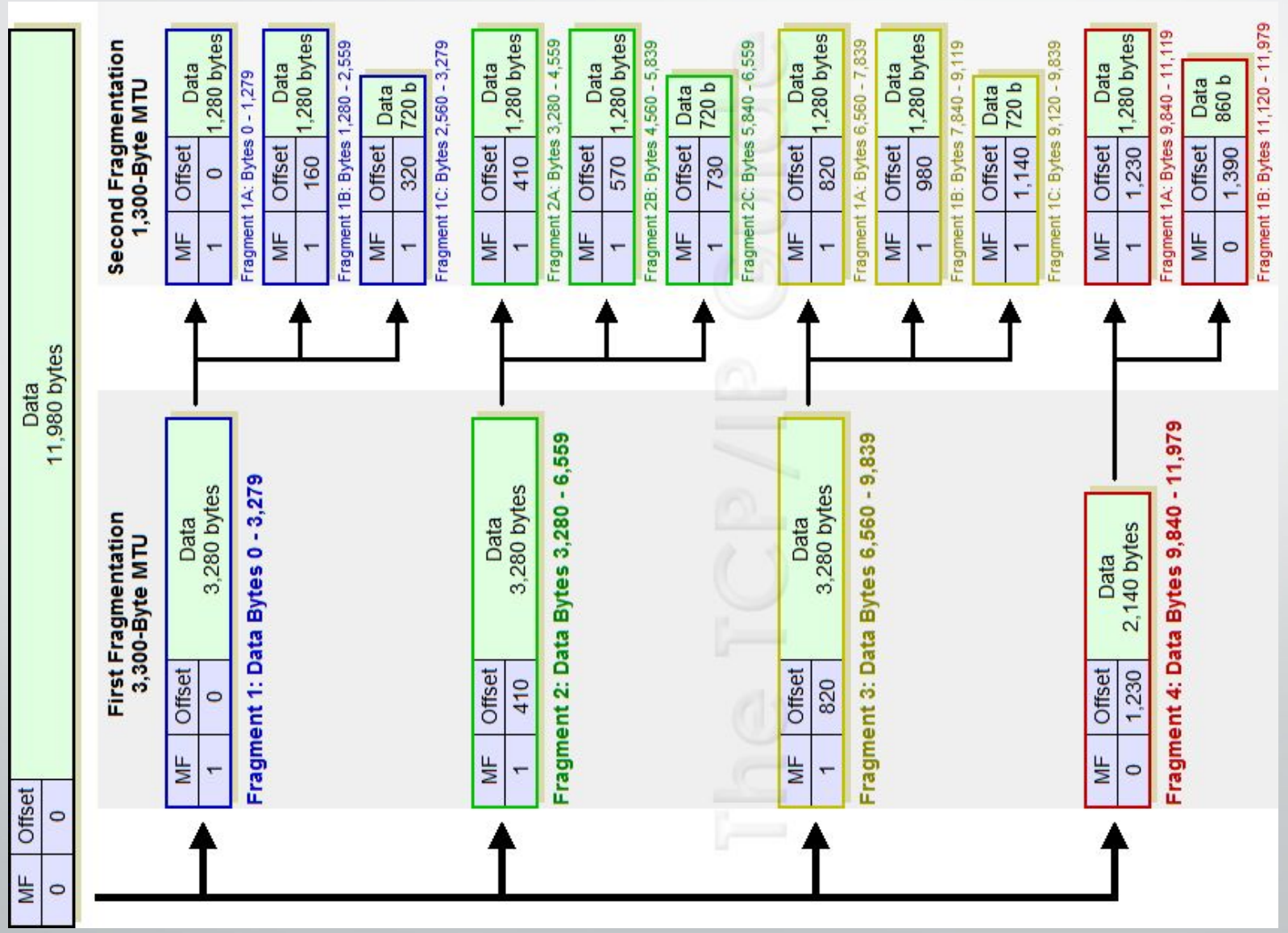
Sequence	Identifier	Total Length	DF May / Don't	MF Last / More	Fragment Offset
0	345	5140	0	0	0

IP Fragments (Ethernet)

Sequence	Identifier	Total Length	DF May / Don't	MF Last / More	Fragment Offset
0-0	345	1500	0	1	0
0-1	345	1500	0	1	185
0-2	345	1500	0	1	370
0-3	345	700	0	0	555

Data Bytes	Fragment Offset
0 -1479	0/8=0
1480-2959	1480/8=185
2960-4439	2960/8=370
4440-5119	4440/8=555

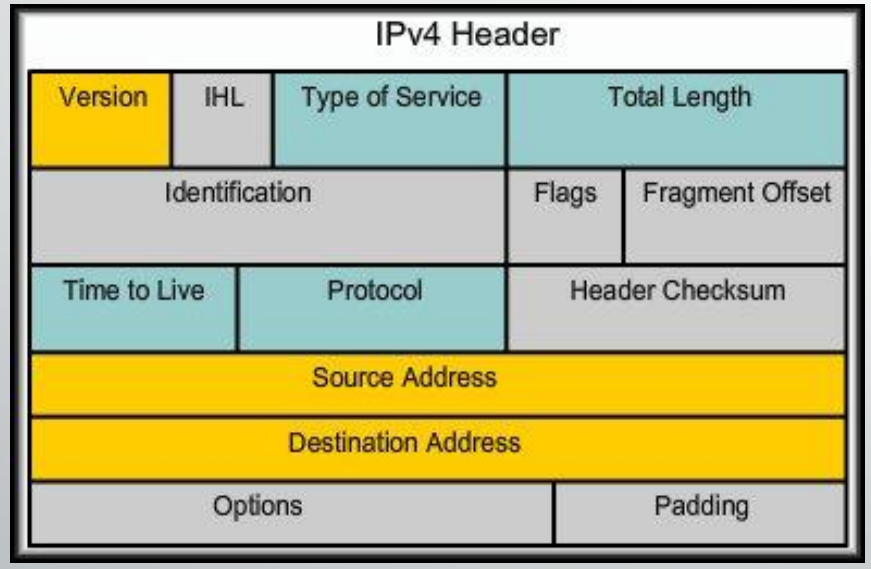
IP Fragmentation Example

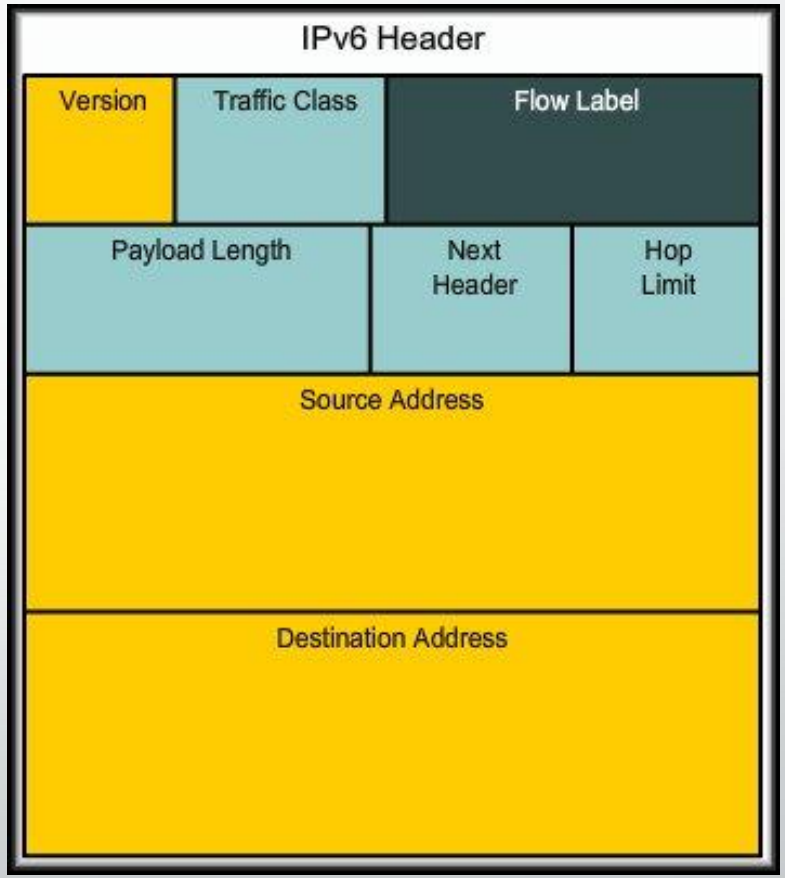


IPv6

Reasons for Using IPv6

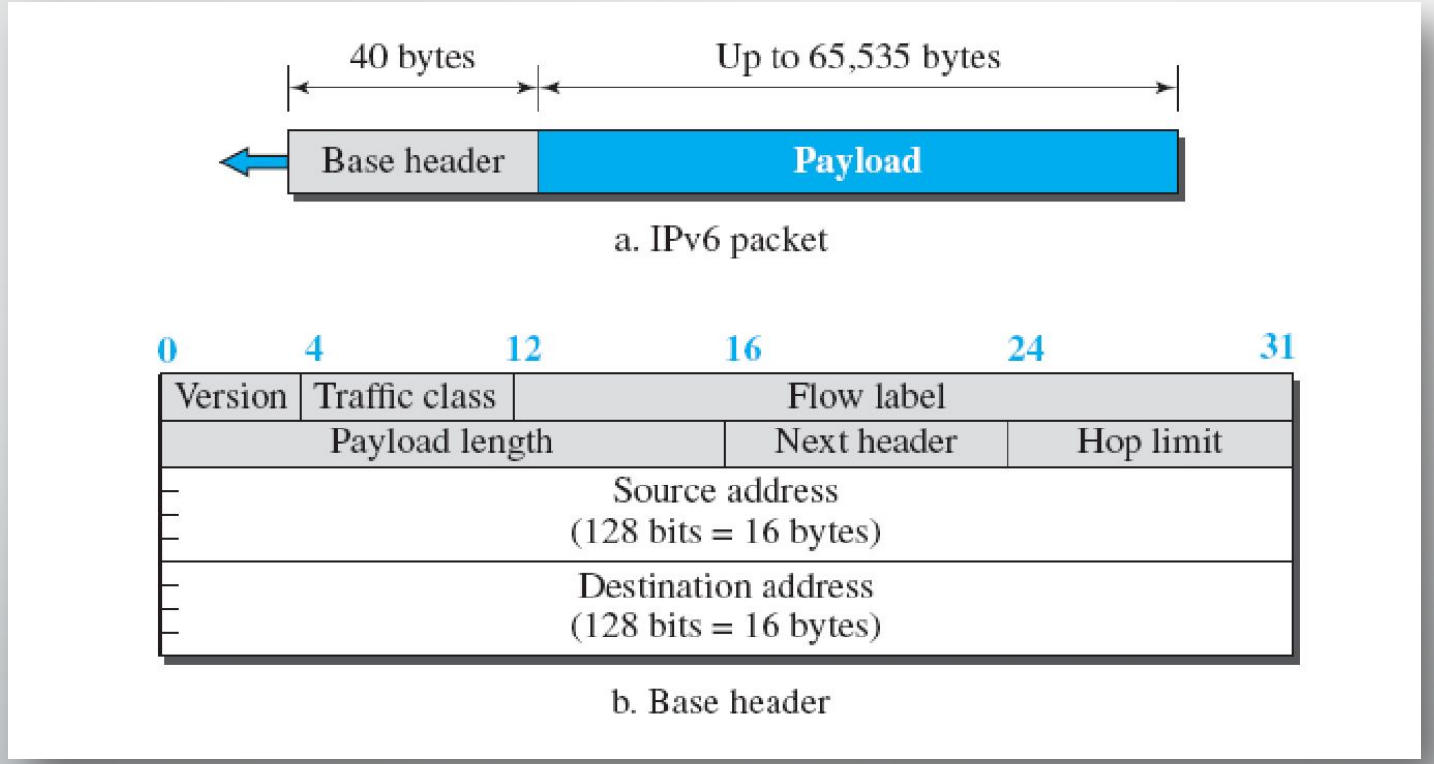
- IPv6 Features:
  - fixed-length 40 byte header
  - no fragmentation allowed



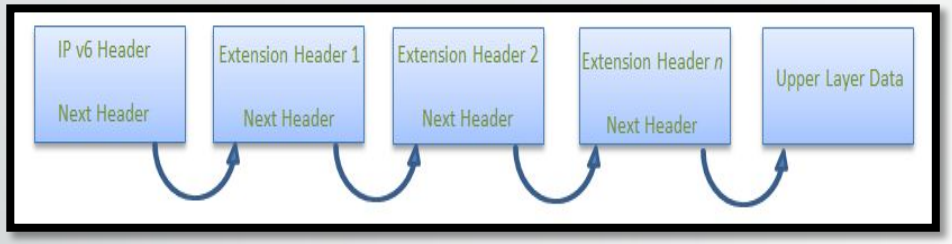


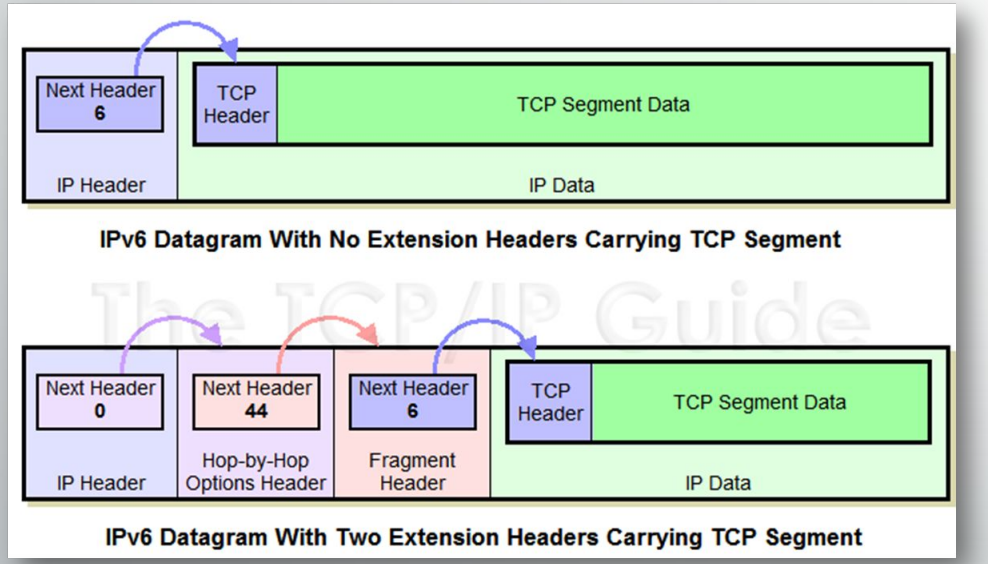
IPv6 Datagram

40 Octets, 8 fields

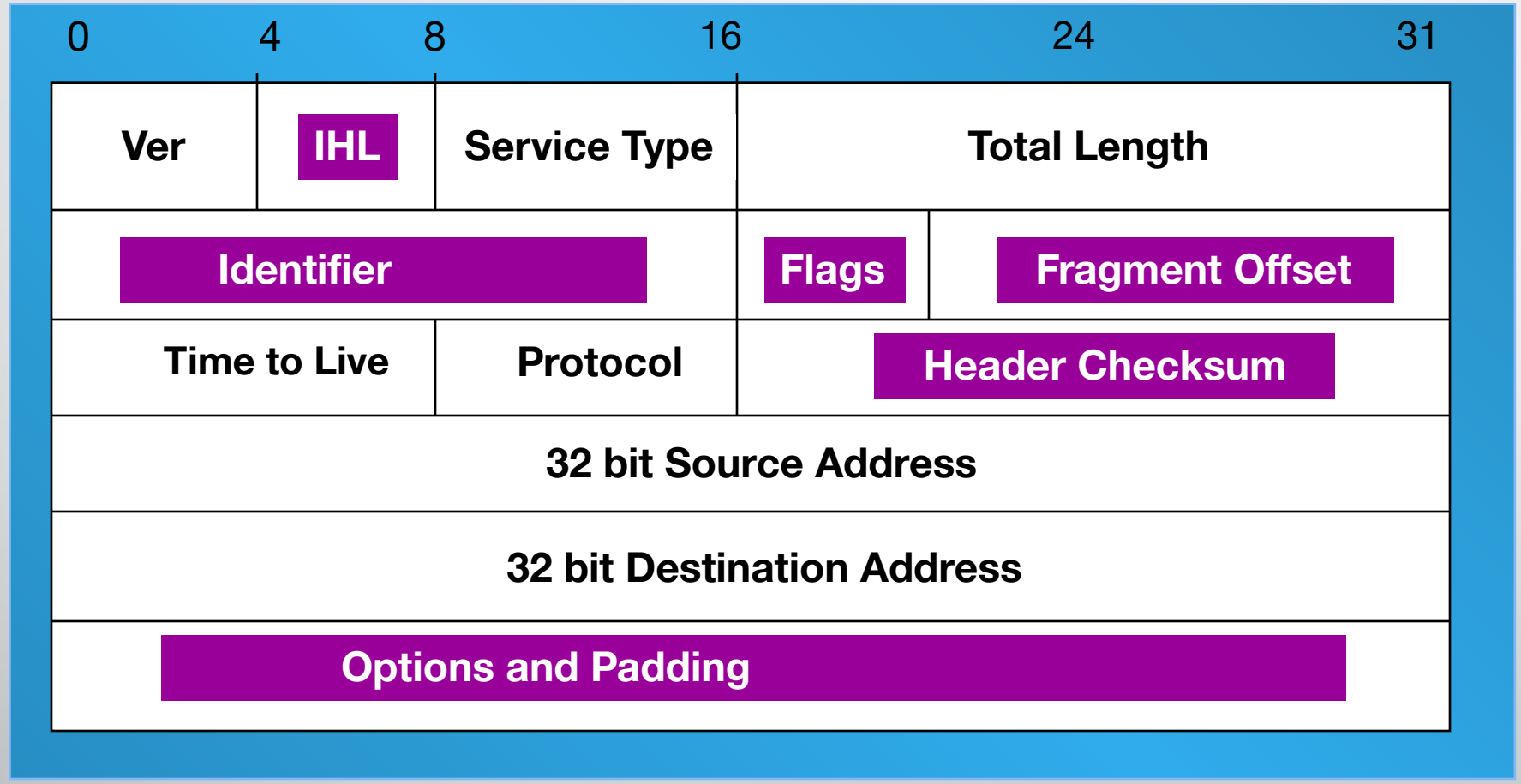


Extension Headers





The IPv4 Header



shaded fields are absent from IPv6 header

Header Changes between IPv4 and IPv6

- Revised
  - Time to Live (Hop Limit)
  - Addresses increased from 32 bits to 128 bits
  - Protocol (Next Header)
  - Precedence & TOS (Traffic Class)
- Extended
  - Flow Label field added (Recommended read: Page 676 of Forouzan's Book)