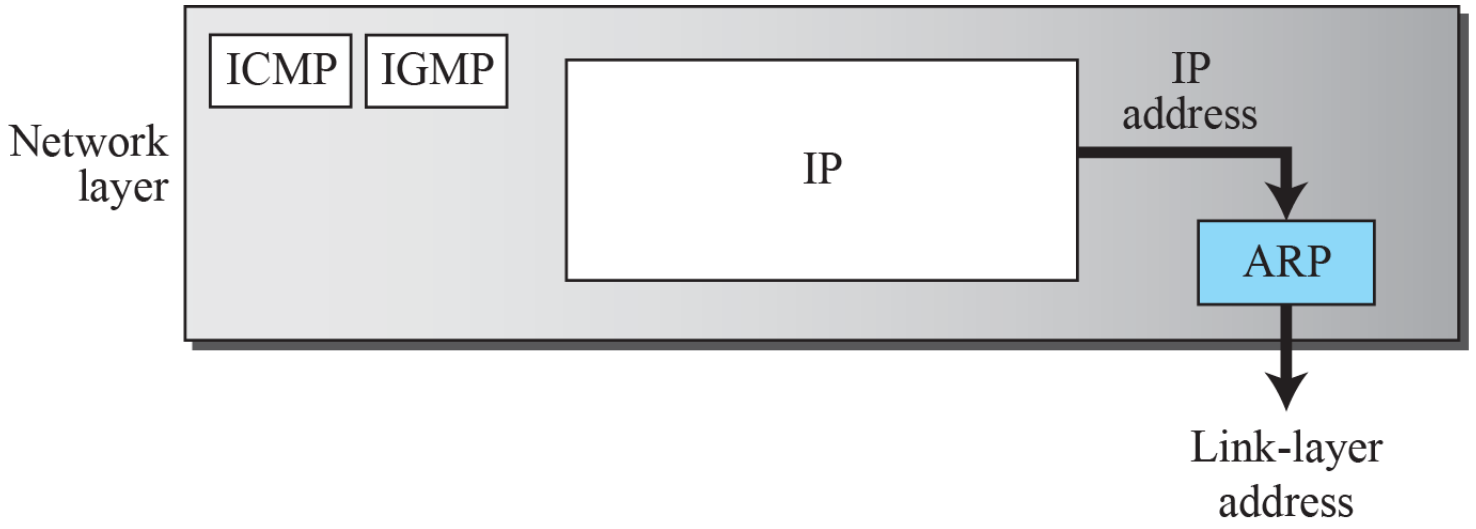
# Protocols

# Topics of Discussion

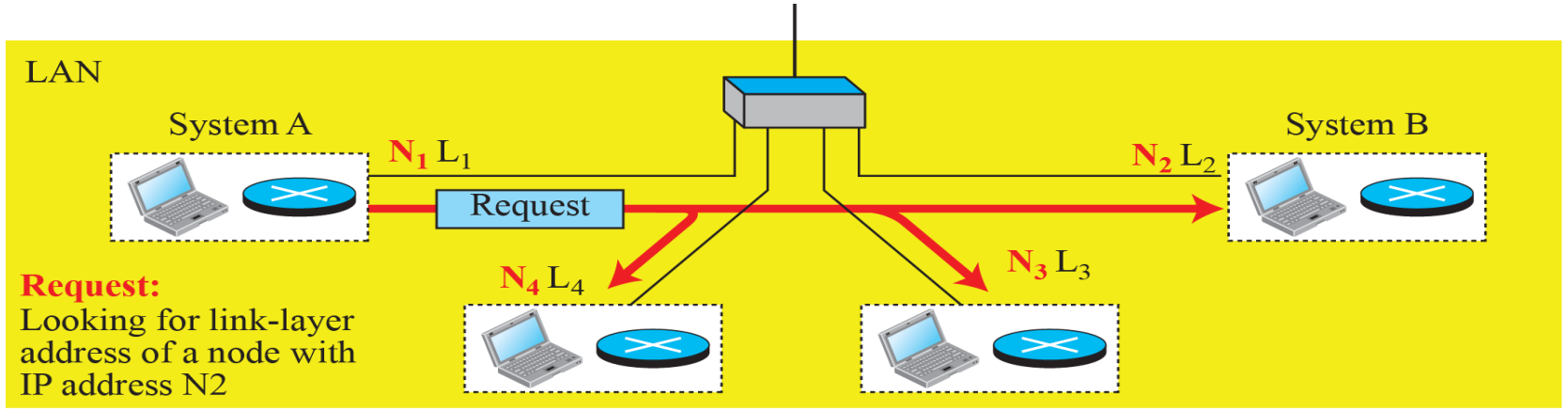
- ***ARP Header***
- ***IP Header***
- ***Transport layer protocols***
  - ***User Datagram Protocol***
    - *UDP Header Format*
  - ***Transmission Control Protocol***
    - *TCP Header Format*
  - ***Stream Control Transmission Protocol***
    - *Services*
    - *Features*
- ***Port Numbers***

# Address Resolution Protocol (ARP)

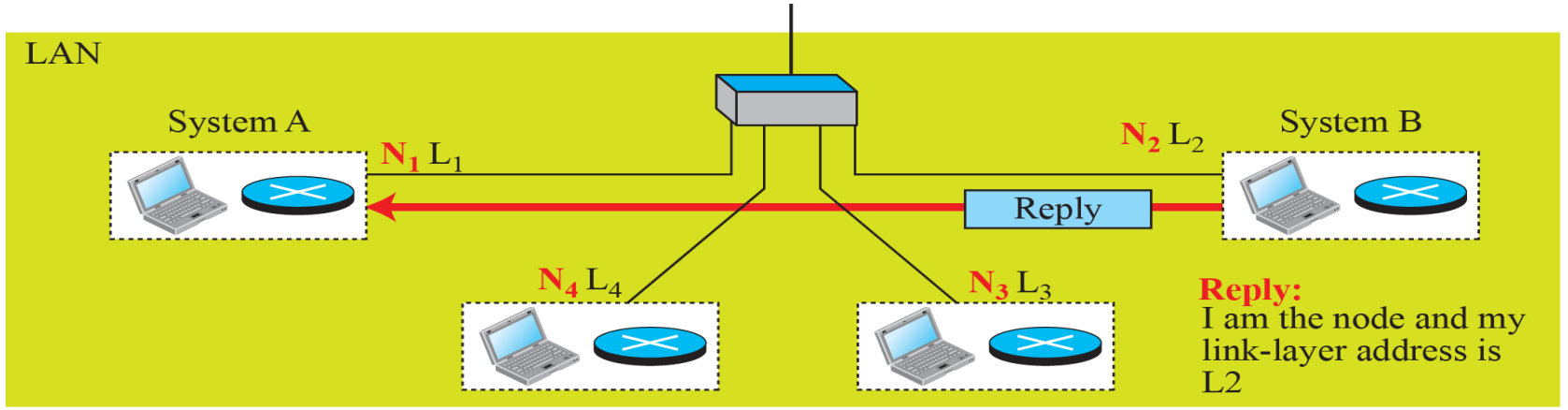
- Anytime a node has an IP datagram to send to another node in a link, it has the IP address of the receiving node.
- However, the IP address of the next node is not helpful in moving a frame through a link; we need the link-layer address of the next node.
- This is the time when the Address Resolution Protocol (ARP) becomes helpful.
- Position of ARP in TCP/IP protocol suite is shown  below.



# ARP Operation



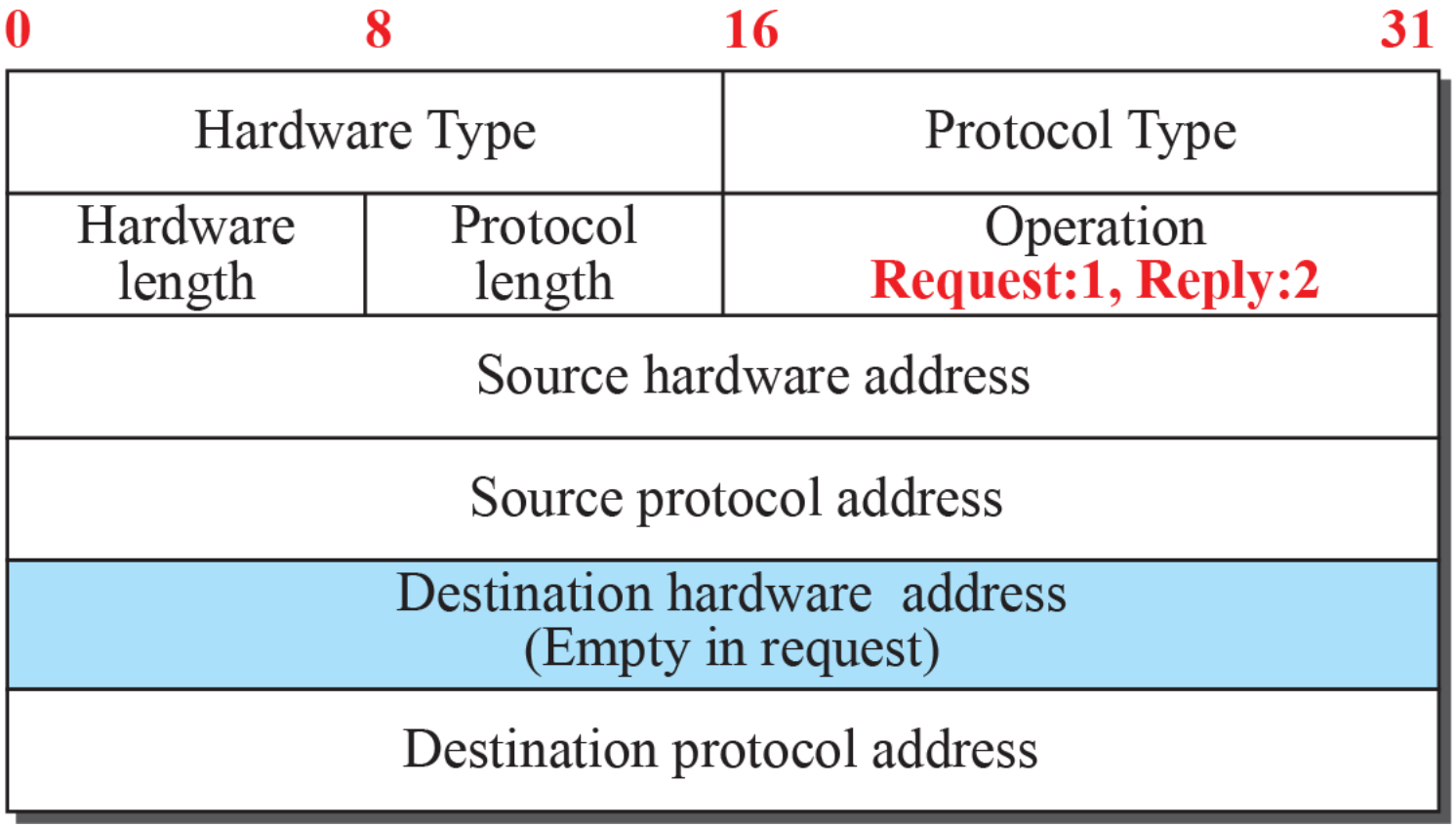

a. ARP request is broadcast




b. ARP reply is unicast

# ARP Packet Format

**Hardware:** LAN or WAN protocol
**Protocol:** Network-layer protocol

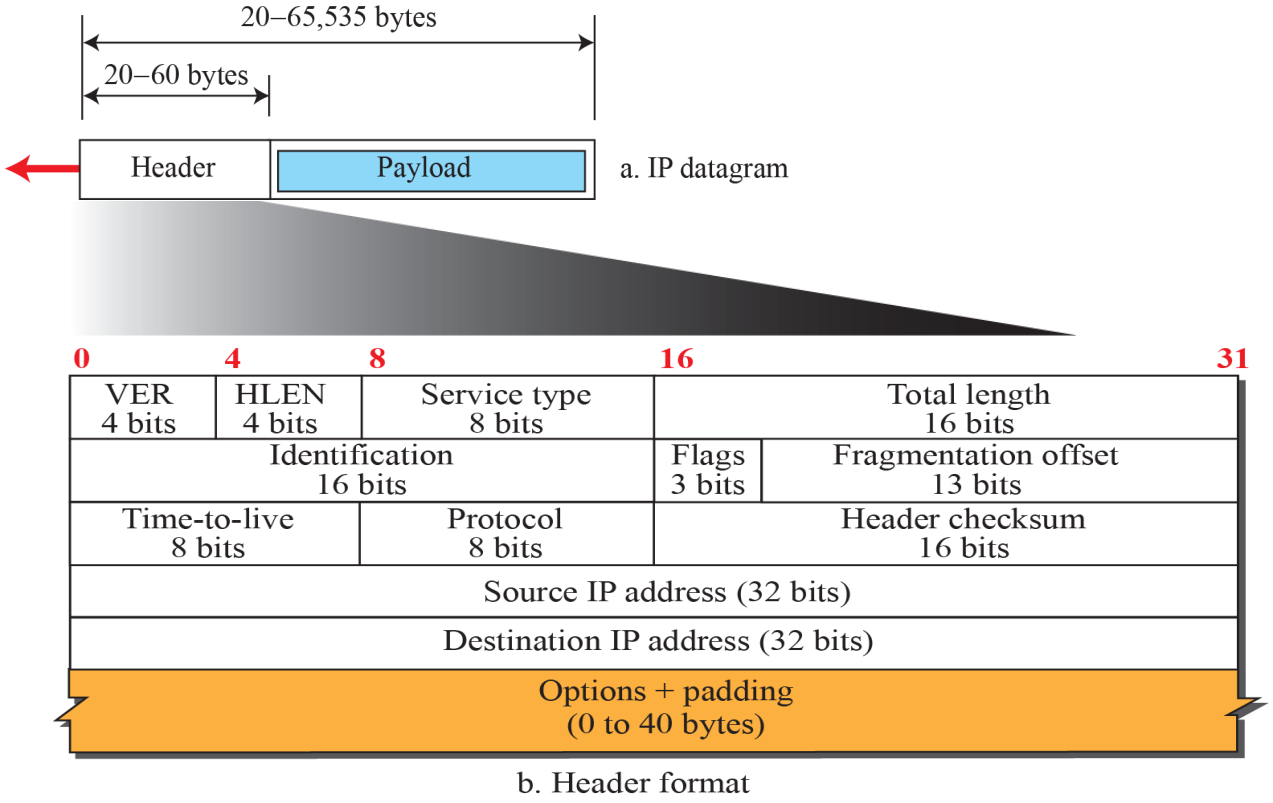


# IPv4 protocol

Legend

VER: version number
HLEN: header length
byte: 8 bits

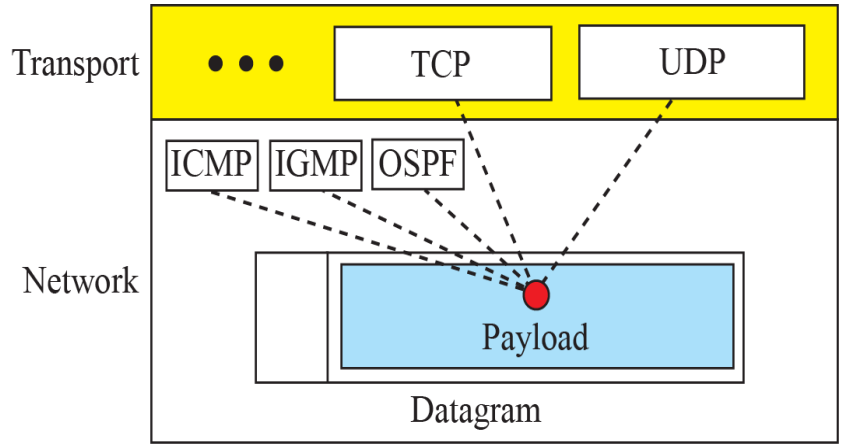
- Packets used by the IP are called datagrams. Figure below shows the IPv4 datagram format.
- A datagram is a variable-length packet consisting of two parts: **header and payload (data).**
- The header is 20 to 60 bytes in length and contains information essential to routing and delivery.
- It is customary in TCP/IP to show the header in 4-byte sections.




b. Header format

ICMP: 01 UDP: 17
IGMP: 02 OSPF: 89
TCP: 06

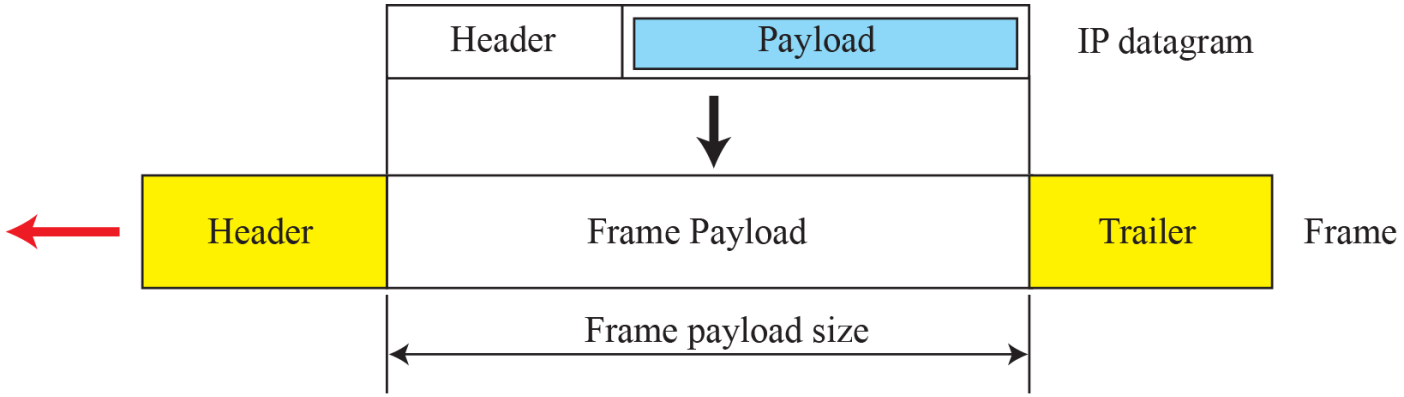
Some protocol values




a. Multiplexing

# Fragmentation Offset

- A datagram can travel through different networks.
- Each router decapsulates the IP datagram from the frame it receives, processes it, and then encapsulates it in another frame.
- The format and size of the received frame depend on the protocol used by the physical network through which the frame has just traveled.
- The format and size of the sent frame depend on the protocol used by the physical network through which the frame is going to travel.
- For example, if a router connects a LAN to a WAN, it receives a frame in the LAN format and sends a frame in the WAN format.

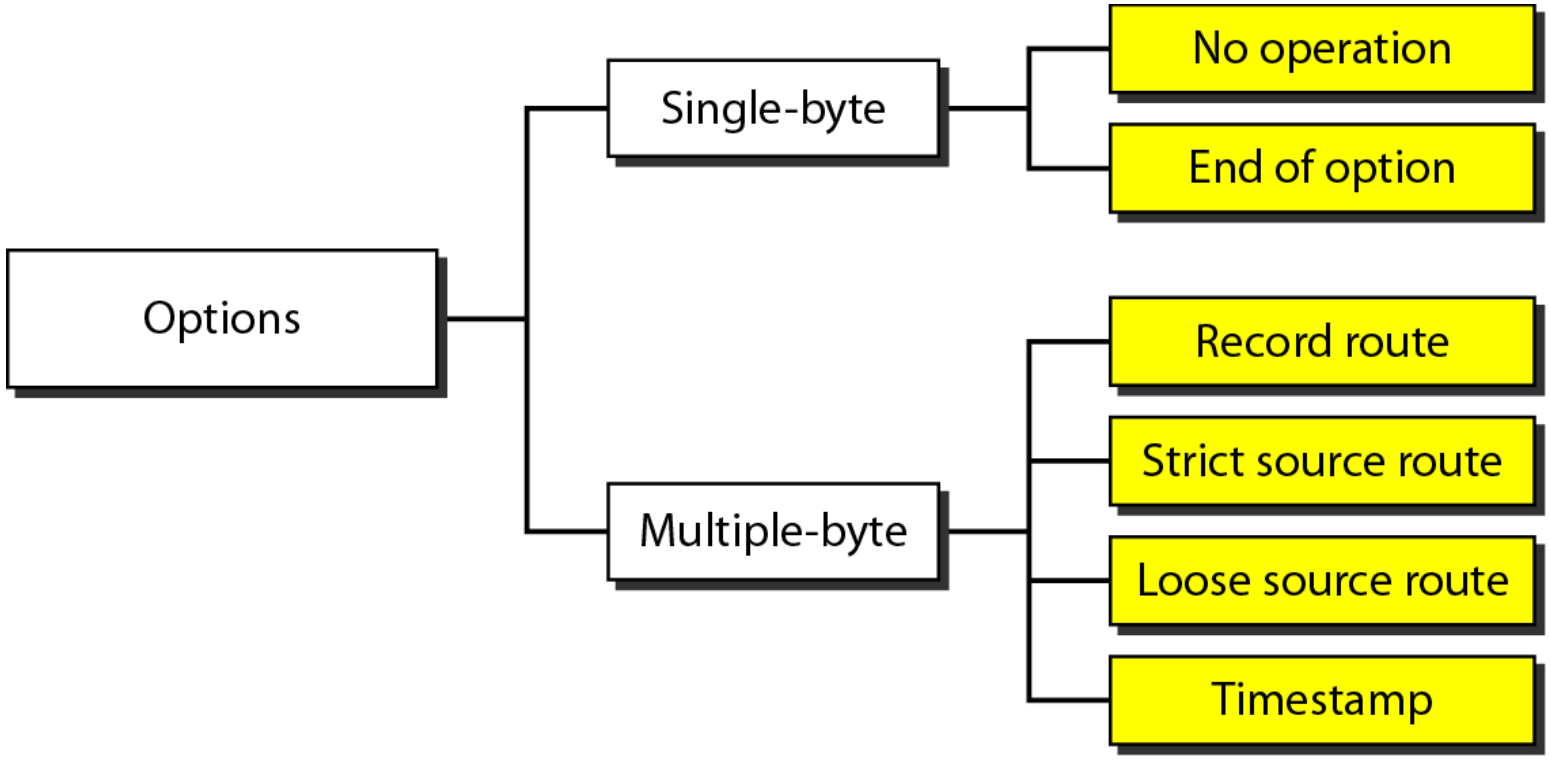



**MTU**: Maximum size of frame payload

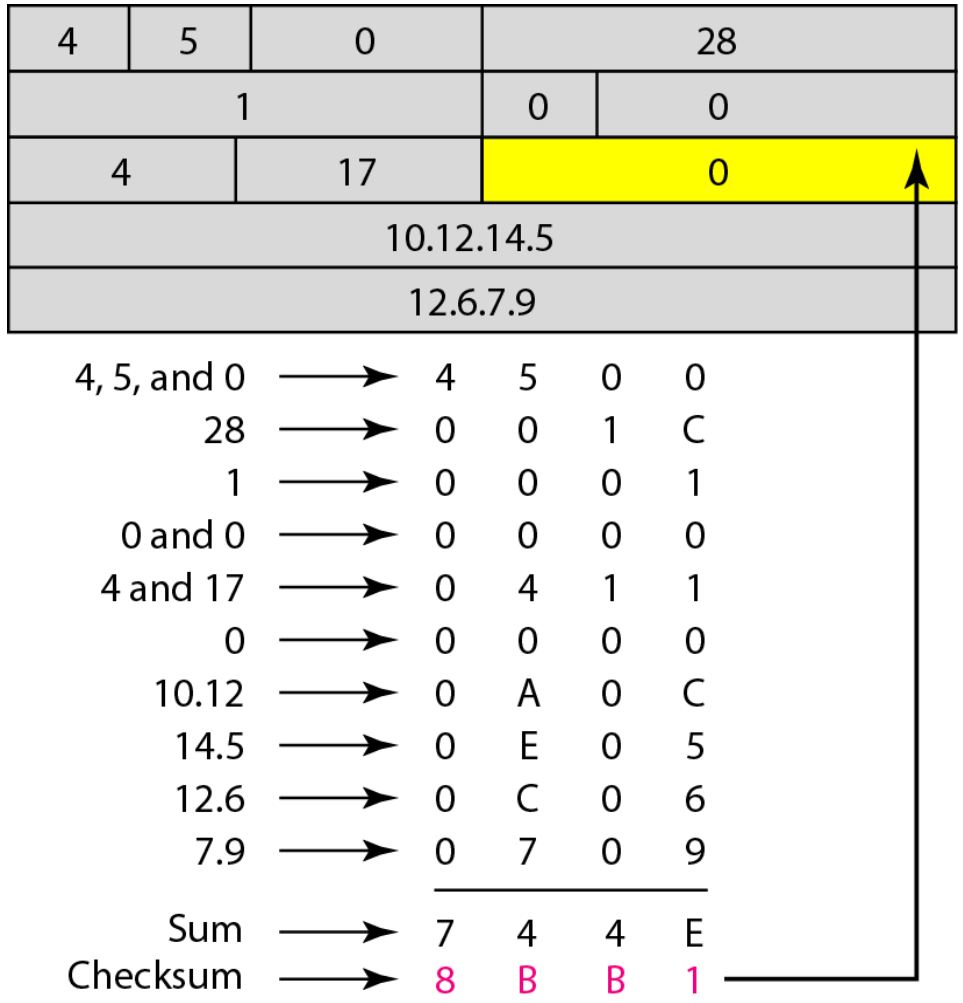
# Options in the frame format

- The header of the IPv4 datagram is made of two parts: **a fixed part and a variable part.**
- The fixed part is 20 bytes long and was discussed in the previous section.
- The variable part comprises the options that can be a maximum of 40 bytes (in multiples of 4-bytes) to preserve the boundary of the header.

## Figure 20.14 *Taxonomy of options in IPv4*

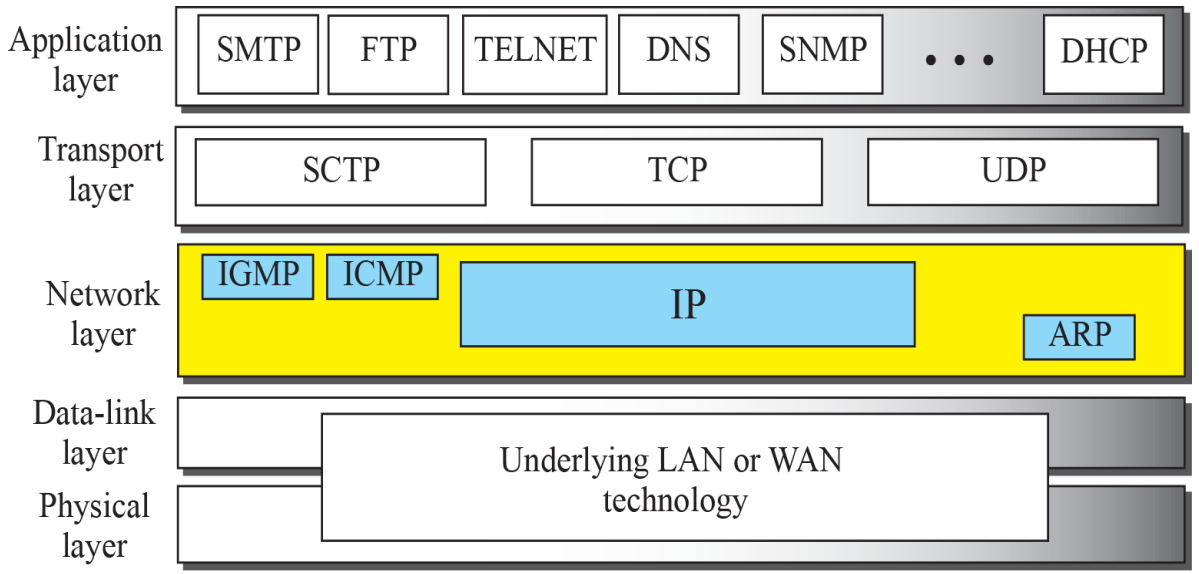


## Figure 20.13 *Example of checksum calculation in IPv4*



# Transport Layer Protocols

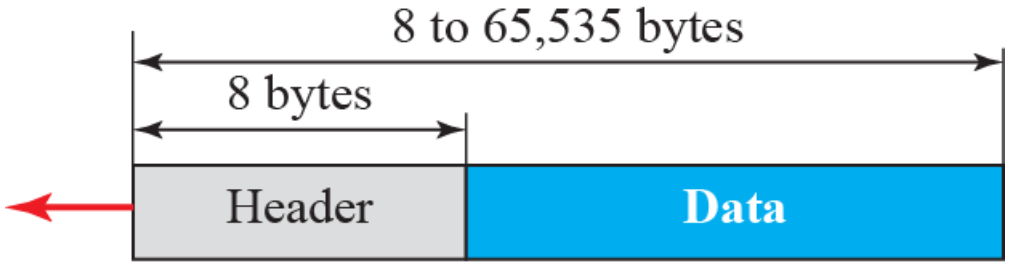
- A transport-layer protocol usually has several responsibilities.
- One is to create a **process-to-process** communication; these protocols use **port numbers** to accomplish this.
- Port numbers provide **end-to-end addresses** at the transport layer and allow multiplexing and demultiplexing at this layer, just as IP addresses do at the network layer.



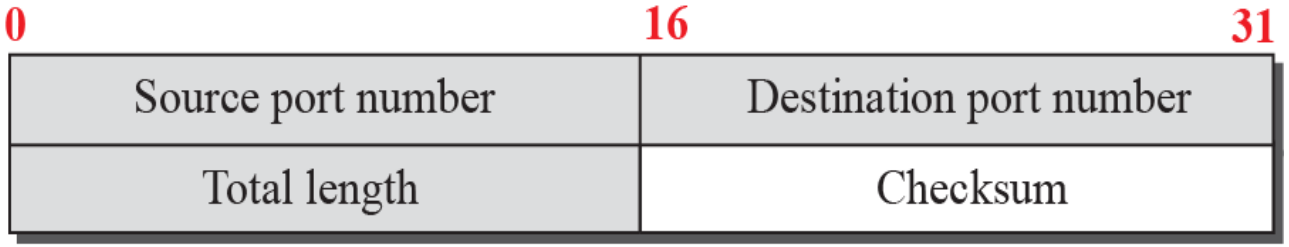

| *Port* | *Protocol* | *UDP* | *TCP* | *Description* |
|---|---|---|---|---|
| 7 | Echo | √ | | Echoes back a received datagram |
| 9 | Discard | √ | | Discards any datagram that is received |
| 11 | Users | √ | √ | Active users |
| 13 | Daytime | √ | √ | Returns the date and the time |
| 17 | Quote | √ | √ | Returns a quote of the day |
| 19 | Chargen | √ | √ | Returns a string of characters |
| 20, 21 | FTP | | √ | File Transfer Protocol |
| 23 | TELNET | | √ | Terminal Network |
| 25 | SMTP | | √ | Simple Mail Transfer Protocol |
| 53 | DNS | √ | √ | Domain Name Service |
| 67 | DHCP | √ | √ | Dynamic Host Configuration Protocol |
| 69 | TFTP | √ | | Trivial File Transfer Protocol |
| 80 | HTTP | | √ | Hypertext Transfer Protocol |
| 111 | RPC | √ | √ | Remote Procedure Call |
| 123 | NTP | √ | √ | Network Time Protocol |
| 161, 162 | SNMP | | √ | Simple Network Management Protocol |

# UDP protocol

- The User Datagram Protocol (UDP) is a **connectionless, unreliable transport protocol**.
- UDP is a very simple protocol using a minimum of overhead.
- UDP packets, called user datagrams, have a fixed-size header of 8 bytes made of four fields, each of 2 bytes (16 bits).




a. UDP user datagram

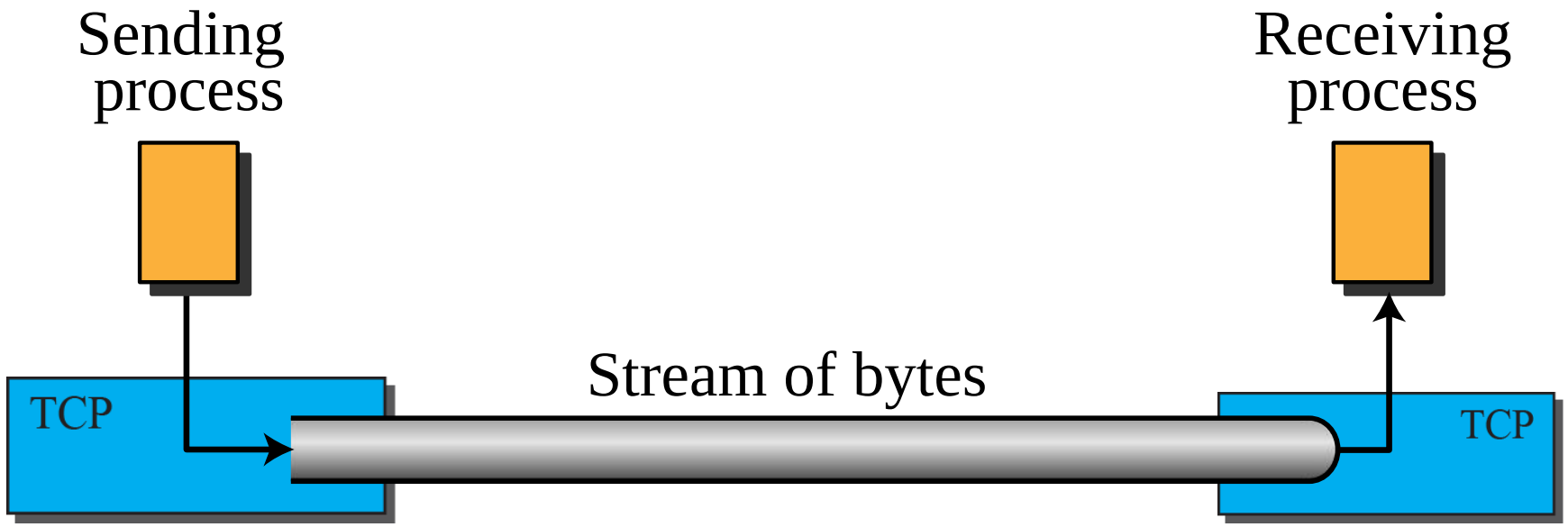



b. Header format

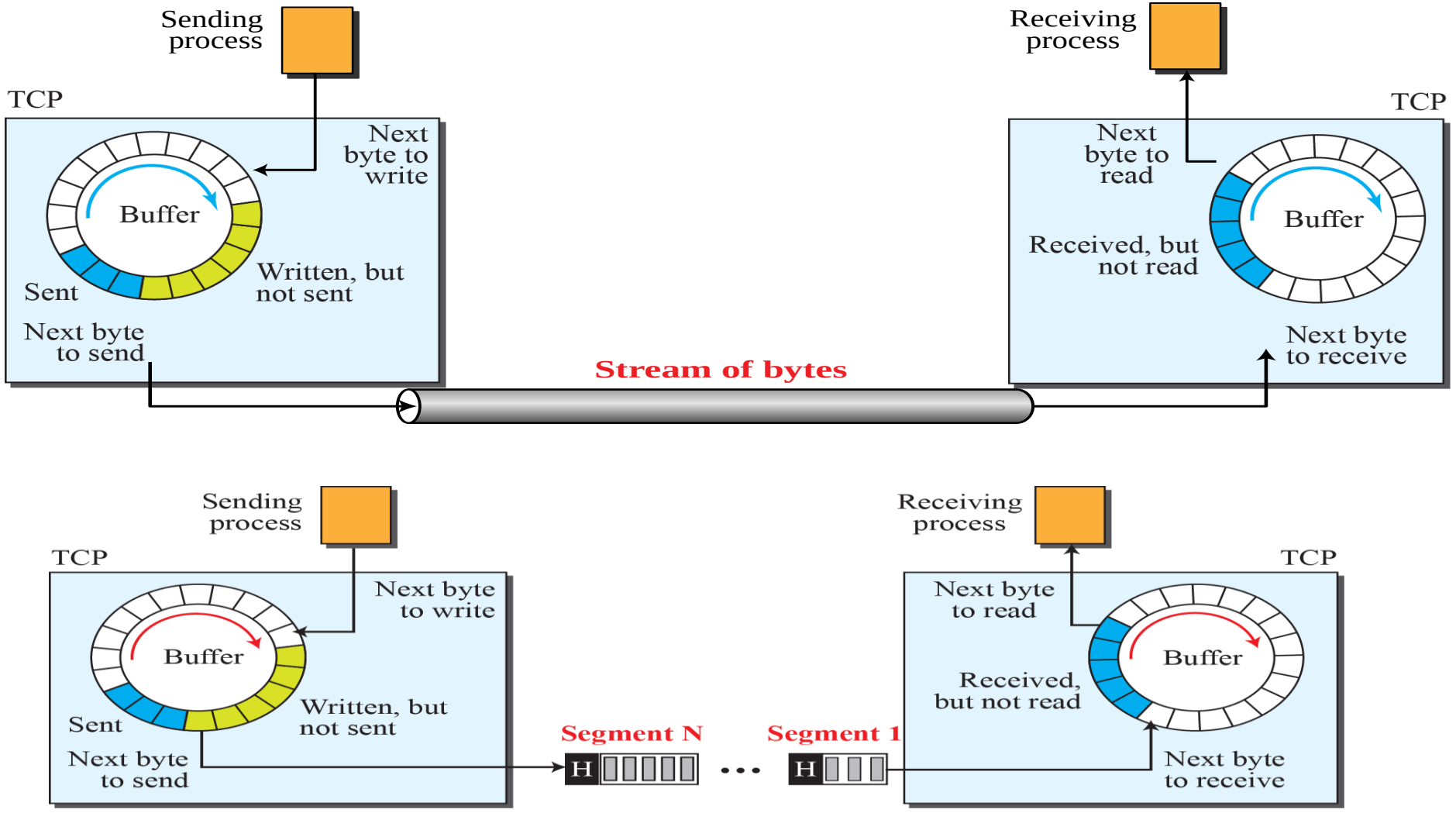
- The first two fields define the source and destination port numbers.
- The third field defines the total length of the user datagram, (header plus data).
- The 16 bits can define a total length of 0 to 65,535 bytes.
- However, the total length needs to be less because a UDP user datagram is stored in an IP datagram with the total length of 65,535 bytes.
- The last field can carry the optional checksum (explained later).

# TCP Protocol

- Transmission Control Protocol (TCP) is a connection-oriented, reliable protocol.
- TCP explicitly defines connection establishment, data transfer, and connection teardown phases to provide a connection-oriented service.
- TCP uses a combination of GBN(Go-Back-N) and SR(Selective Repeat) protocols to provide reliability.

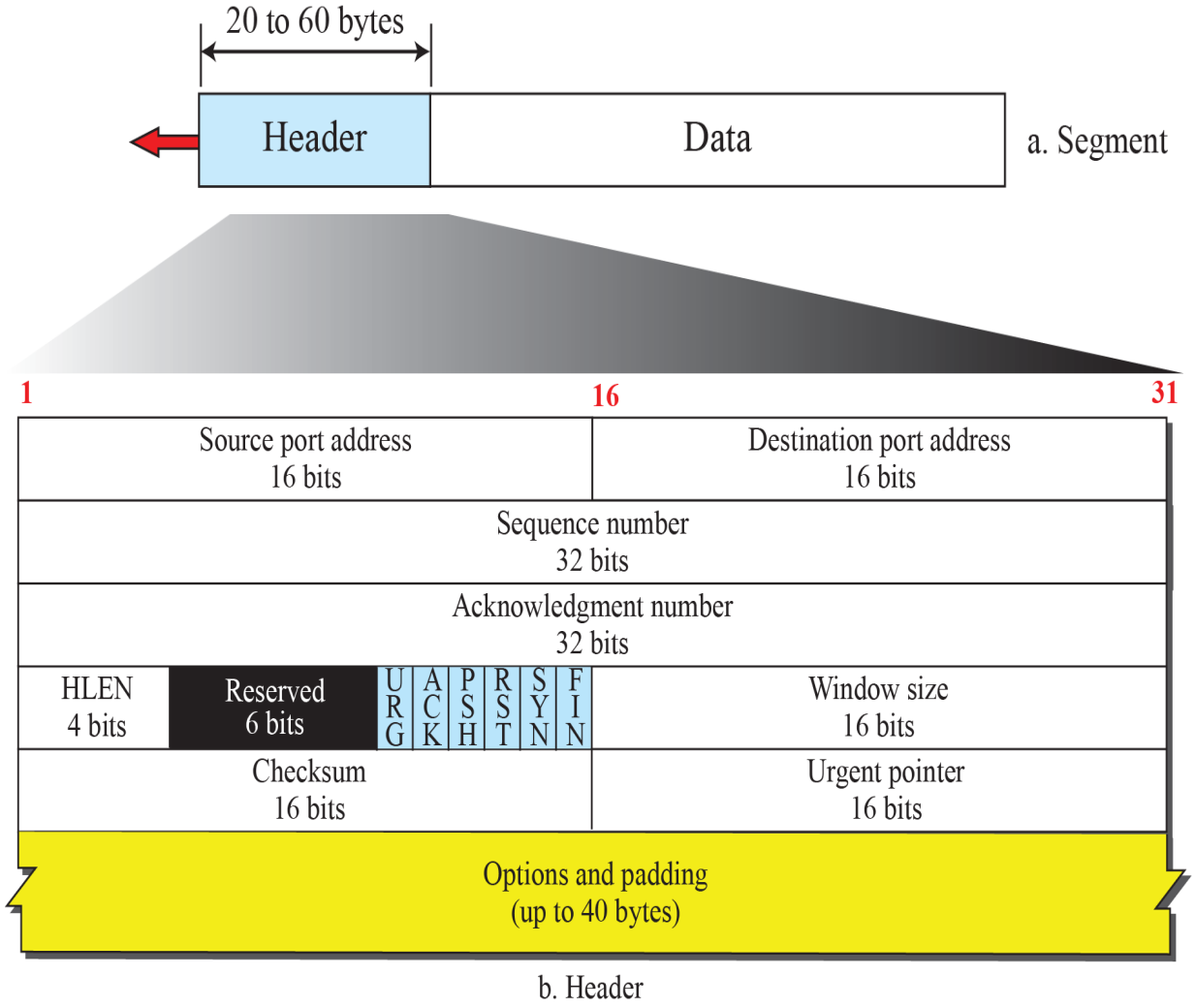


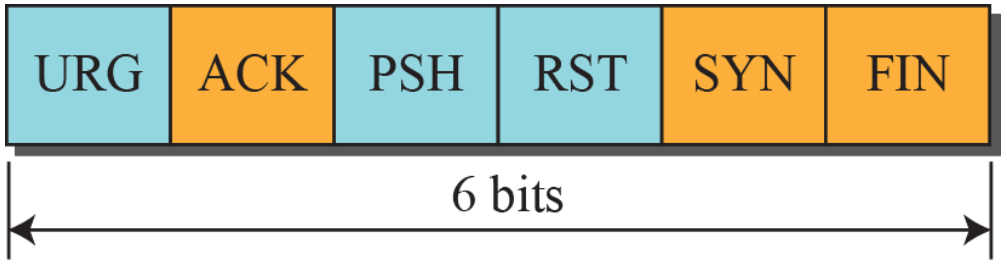
# Sending and Receiving Buffers




**TCP Segment**

# TCP Segment Format

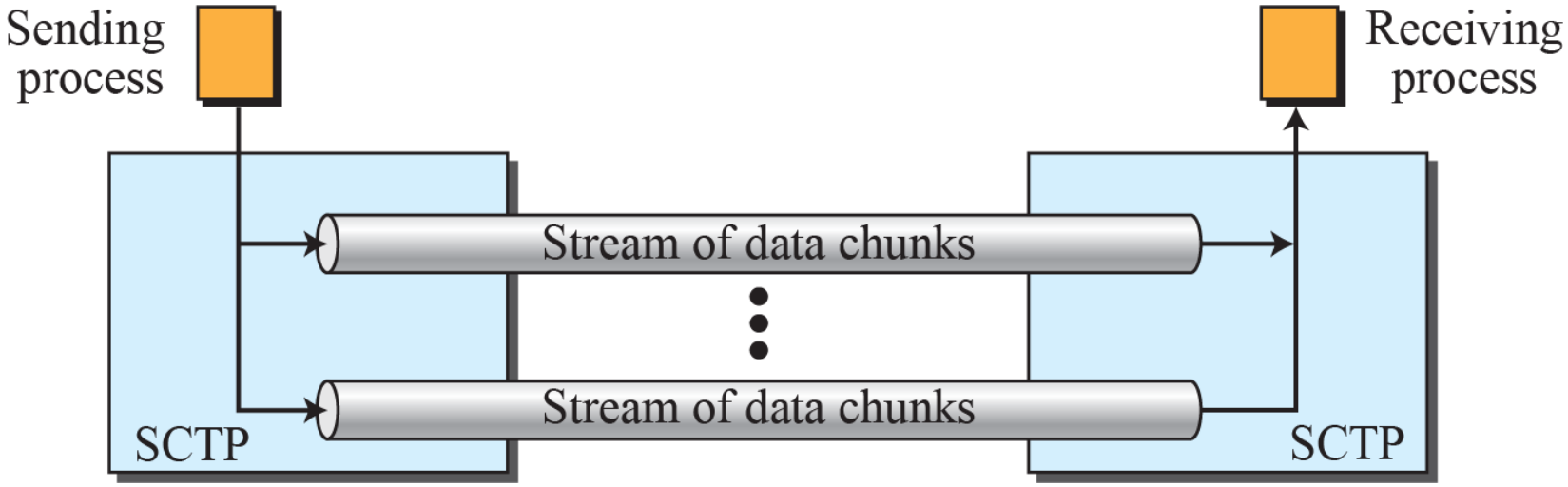



URG: Urgent pointer is valid
ACK: Acknowledgment is valid
PSH: Request for push
RST: Reset the connection
SYN: Synchronize sequence numbers
FIN: Terminate the connection

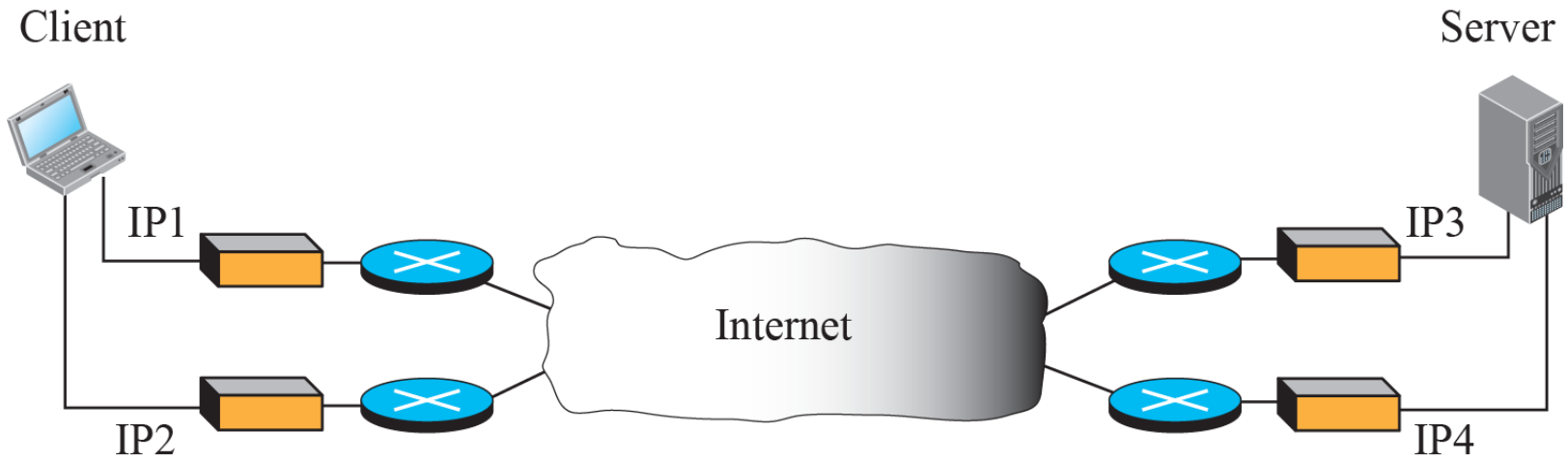
# SCTP Protocol

Stream Control Transmission Protocol (SCTP) is a new transport-layer protocol designed to combine some features of UDP and TCP in an effort to create a protocol for multimedia communication.

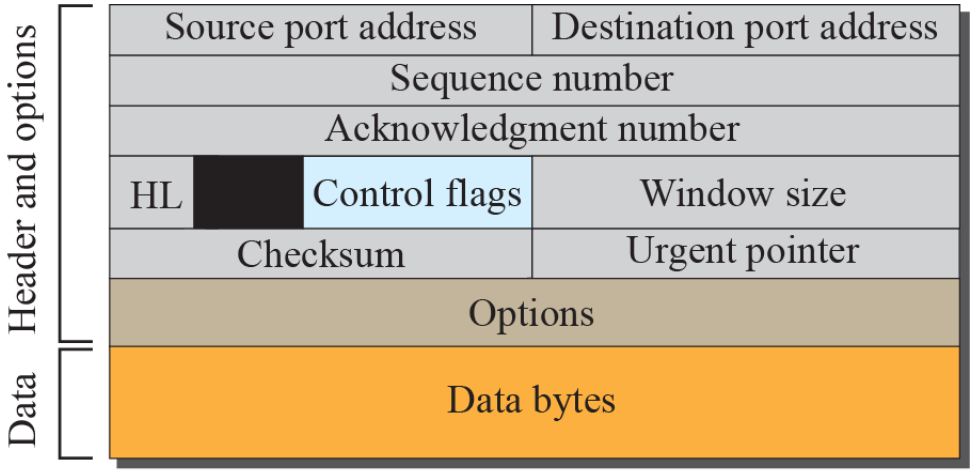



**Multiple-stream concept**

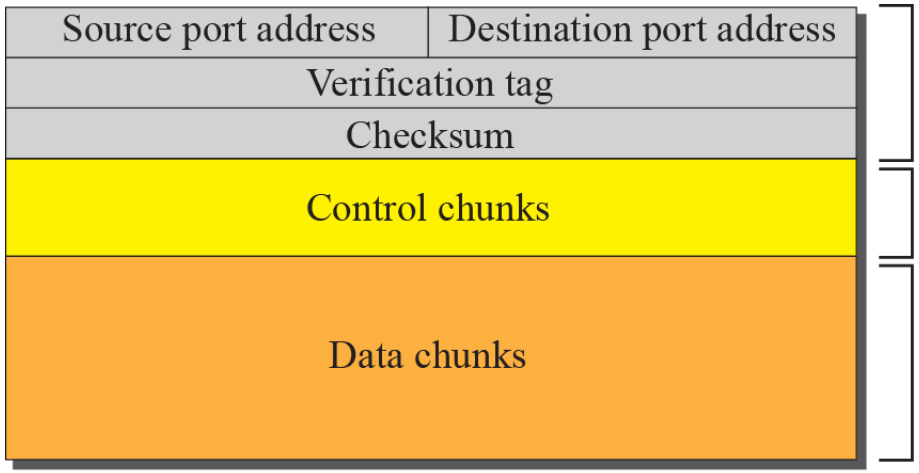
*Figure 39 :* ***Multihoming concept***



## *Figure 40 : Comparison between a TCP segment and an SCTP packet*




A segment in TCP




A packet in SCTP

# SCTP Features

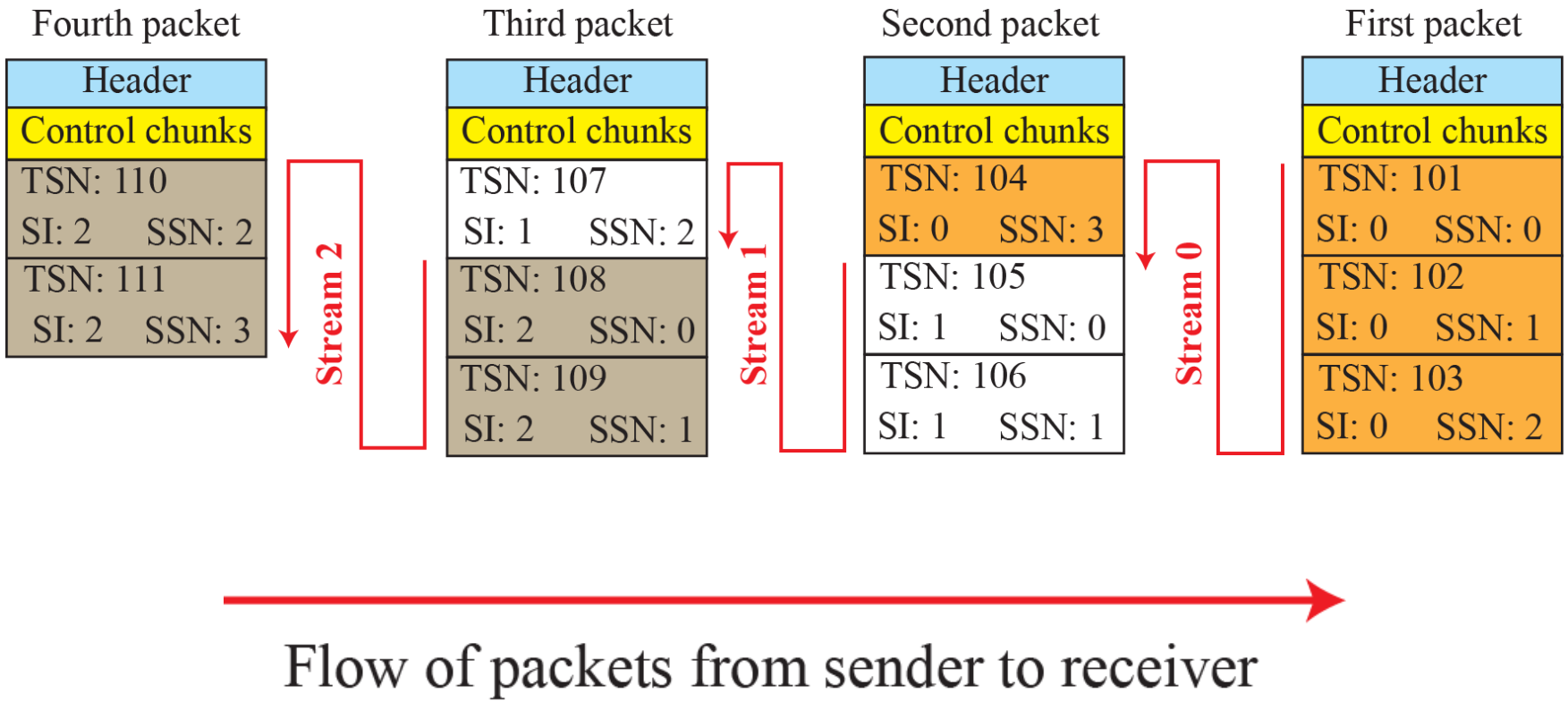
*The following shows the general features of SCTP:*

***Transmission Sequence Number (TSN)***

***Stream Identifier (SI)***

***Stream Sequence Number (SSN)***

*Figure 41 : Packets, data chunks, and streams*



# Packet Format

- *An SCTP packet has a mandatory general header and a set of blocks called chunks.*
- *There are two types of chunks: control chunks and data chunks.*
- *A control chunk controls and maintains the association; a data chunk carries user data.*
- *In a packet, the control chunks come before the data chunks.*
- *Figure 42 shows the general format of an SCTP packet.*

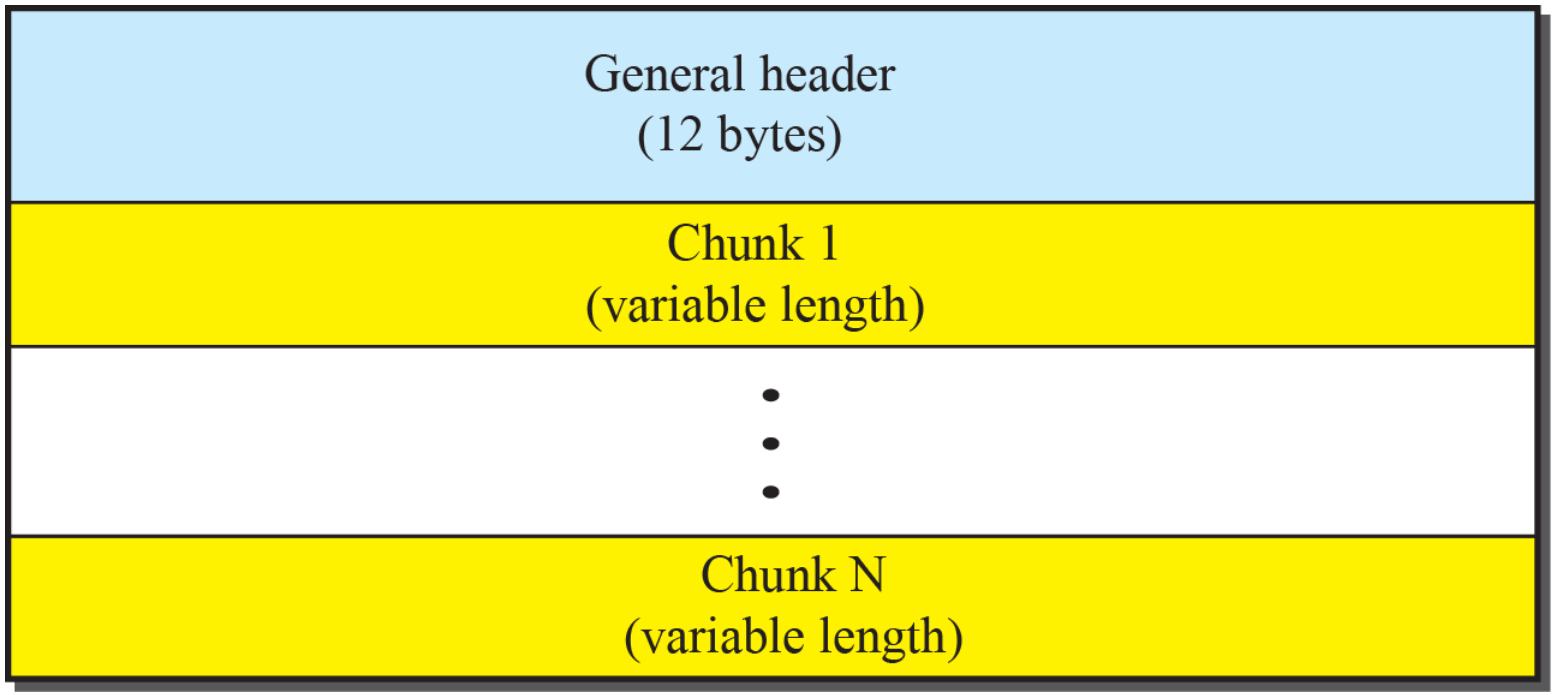
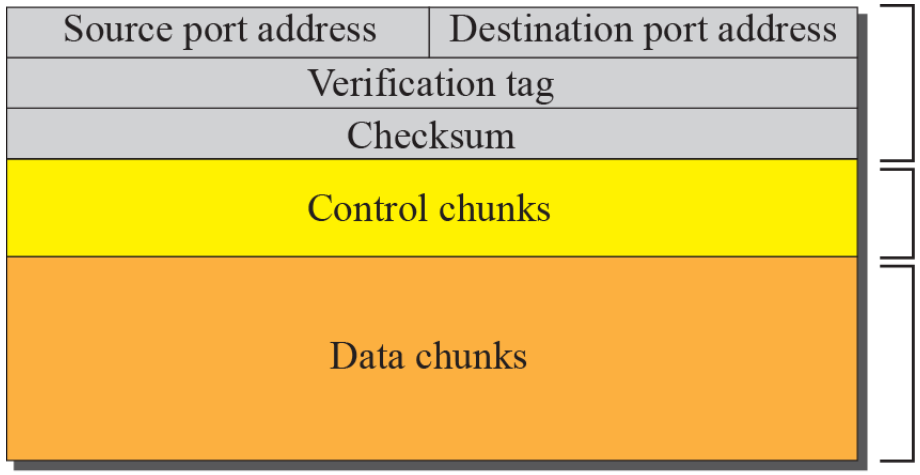
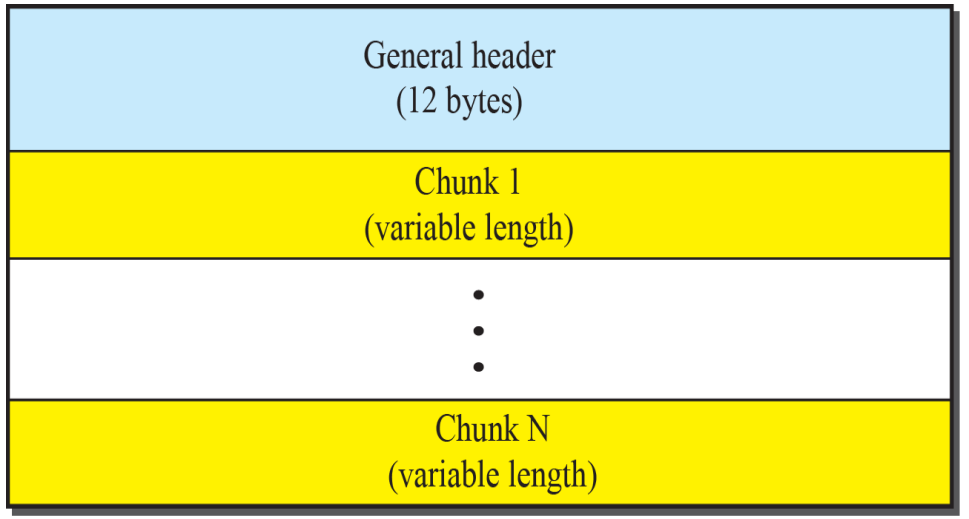



*Figure 42 : SCTP packet format*

# SCTP Frame format and Chunks




A packet in SCTP




- An SCTP packet has a mandatory general header and a set of blocks called chunks.
- There are two types of chunks: **control chunks and data chunks.**
- A control chunk controls and maintains the association; a data chunk carries user data.
- In a packet, the control chunks come before the data chunks.
- Figure above shows the general format of an SCTP packet.

# Chunks

| *Type* | *Chunk* | *Description* |
|---|---|---|
| 0 | DATA | User data |
| 1 | INIT | Sets up an association |
| 2 | INIT ACK | Acknowledges INIT chunk |
| 3 | SACK | Selective acknowledgment |
| 4 | HEARTBEAT | Probes the peer for liveliness |
| 5 | HEARTBEAT ACK | Acknowledges HEARTBEAT chunk |
| 6 | ABORT | Aborts an association |
| 7 | SHUTDOWN | Terminates an association |
| 8 | SHUTDOWN ACK | Acknowledges SHUTDOWN chunk |
| 9 | ERROR | Reports errors without shutting down |
| 10 | COOKIE ECHO | Third packet in association establishment |
| 11 | COOKIE ACK | Acknowledges COOKIE ECHO chunk |
| 14 | SHUTDOWN COMPLETE | Third packet in association termination |
| 192 | FORWARD TSN | For adjusting cumulating TSN |

# Port Numbers

| Port Number | Transport Protocol | Service Name | RFC |
|---|---|---|---|
| 20, 21 | TCP | File Transfer Protocol (FTP) | RFC 959 |
| 22 | TCP and UDP | Secure Shell (SSH) | RFC 4250-4256 |
| 23 | TCP | Telnet | RFC 854 |
| 25 | TCP | Simple Mail Transfer Protocol (SMTP) | RFC 5321 |
| 53 | TCP and UDP | Domain Name Server (DNS) | RFC 1034-1035 |
| 67, 68 | UDP | Dynamic Host Configuration Protocol (DHCP) | RFC 2131 |
| 69 | UDP | Trivial File Transfer Protocol (TFTP) | RFC 1350 |
| 80 | TCP | HyperText Transfer Protocol (HTTP) | RFC 2616 |
| 110 | TCP | Post Office Protocol (POP3) | RFC 1939 |
| 119 | TCP | Network News Transport Protocol (NNTP) | RFC 8977 |
| 123 | UDP | Network Time Protocol (NTP) | RFC 5905 |
| 135-139 | TCP and UDP | NetBIOS | RFC 1001-1002 |
| 143 | TCP and UDP | Internet Message Access Protocol (IMAP4) | RFC 3501 |
| 161, 162 | TCP and UDP | Simple Network Management Protocol (SNMP) | RFC 1901-1908, 3411-3418 |
| 179 | TCP | Border Gateway Protocol (BGP) | RFC 4271 |
| 389 | TCP and UDP | Lightweight Directory Access Protocol | RFC 4510 |
| 443 | TCP and UDP | HTTP with Secure Sockets Layer (SSL) | RFC 2818 |
| 500 | UDP | Internet Security Asspciation and Key Management Protocol (ISAKMP) / Internet Key Exchange (IKE) | RFC 2408 - 2409 |
| 636 | TCP and UDP | Lightweight Directory Access Protocol over TLS/SSL (LDAPS | RFC 4513 |
| 989/990 | TCP | FTP over TLS/SSL | RFC 4217 |

# Summary

In this section we have discussed the following:

- ✓ARP, IP, TCP, UDP and SCTP working and frame formats