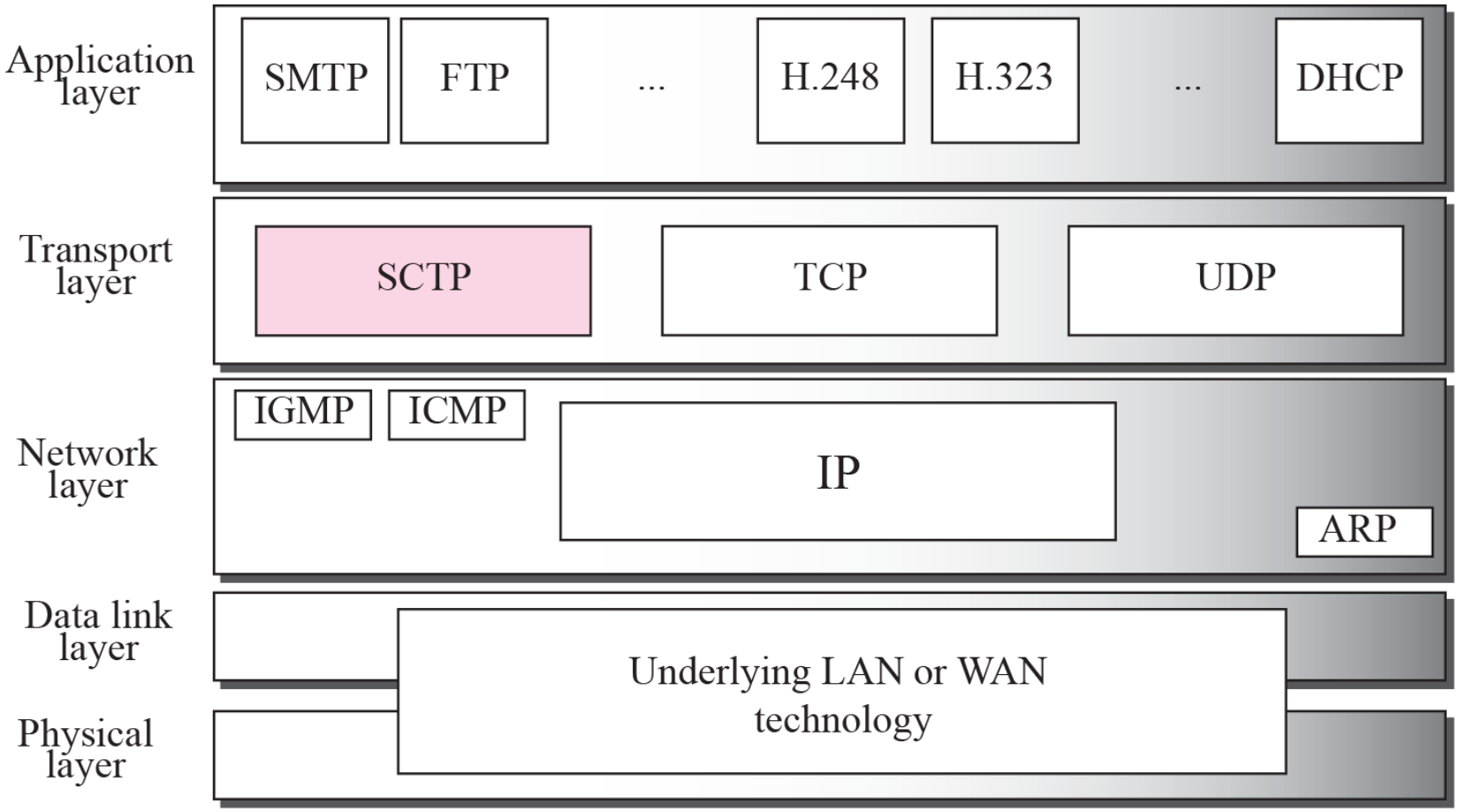
Figure 16.1 *TCP/IP Protocol suite*



Note

SCTP is a message-oriented, reliable protocol that combines the best features of UDP and TCP.

Comparison

- UDP: Message-oriented, Unreliable
- TCP: Byte-oriented, Reliable
- SCTP
  - Message-oriented, Reliable
  - Other innovative features
    - Association, Data transfer/Delivery
    - Fragmentation, Error/Congestion Control

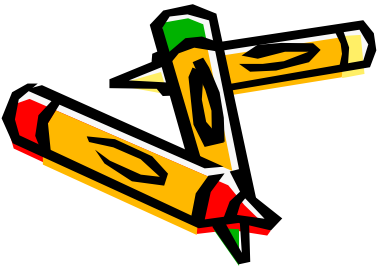


Figure 16.2 *Multiple-stream concept*

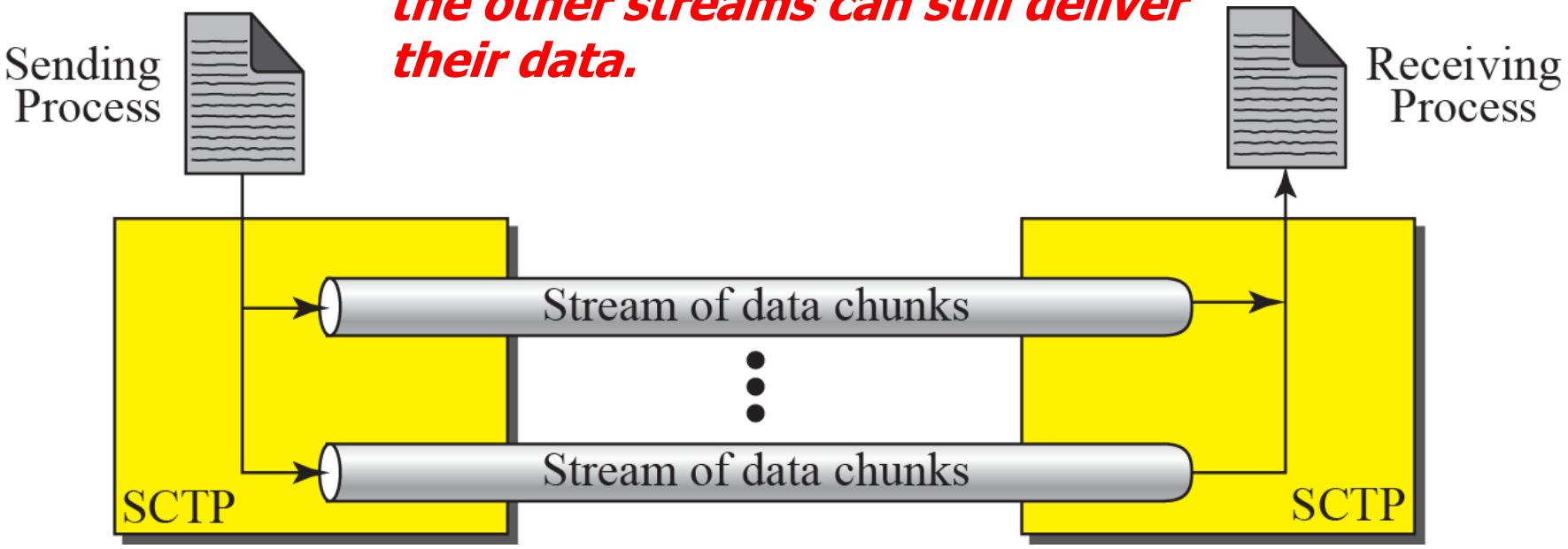
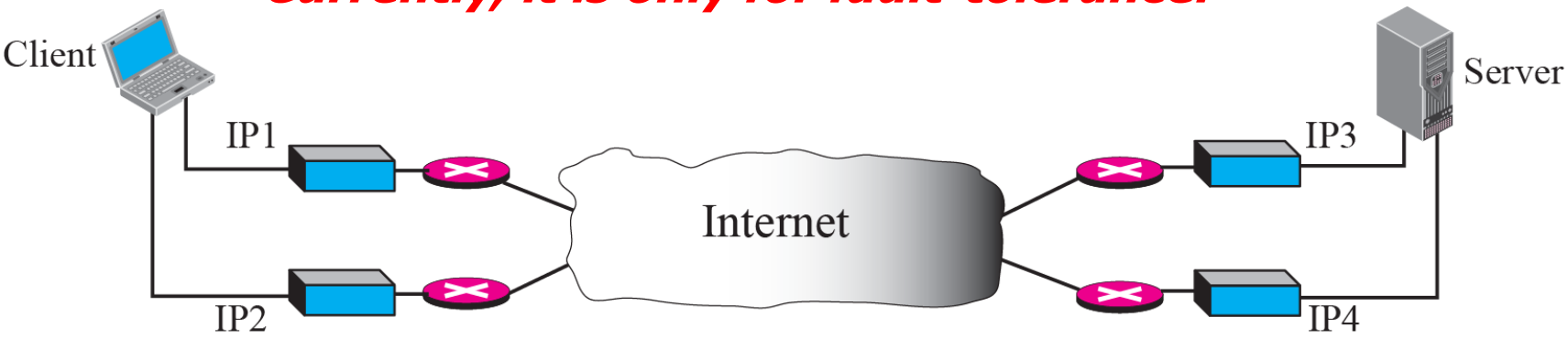


Figure 16.3 *Multihoming concept*

At present, SCTP does not allow load sharing between different path.

Currently, it is only for fault-tolerance.



Note

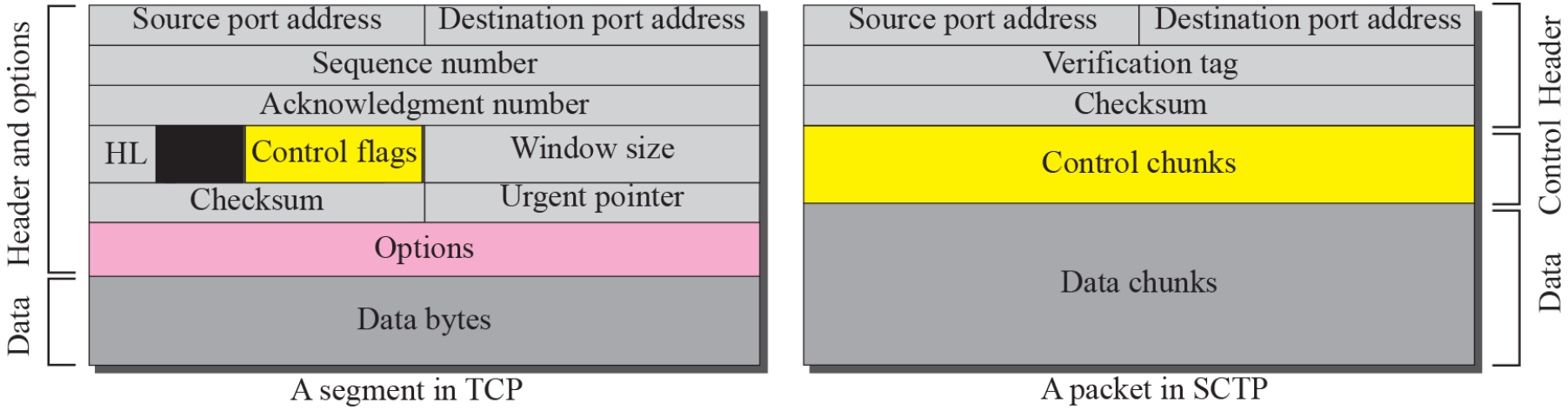
SCTP association allows multiple IP addresses for each end.

In SCTP, a data chunk is numbered using a TSN.

To distinguish between different streams, SCTP uses an SI.

To distinguish between different data chunks belonging to the same stream, SCTP uses SSNs.

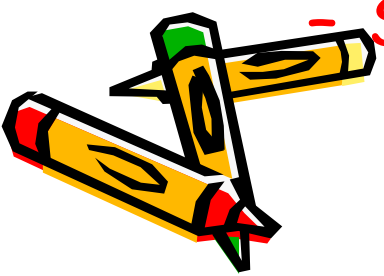
Figure 16.4 *Comparison between a TCP segment and an SCTP packet*



TCP has segments; SCTP has packets.

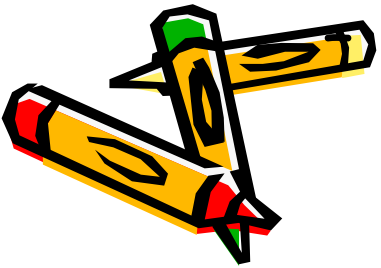
SCTP vs. TCP (1)

- Control information
  - TCP: part of the header
  - SCTP: several types of control chunks
- Data
  - TCP: one entity in a TCP segment
  - SCTP: several data chunks in a packet
- Option
  - TCP: part of the header
  - SCTP: handled by defining new chunk types



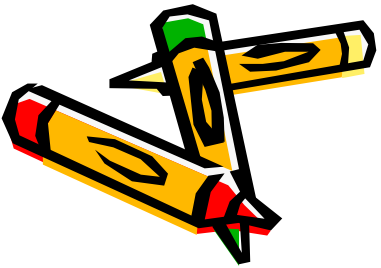
SCTP vs. TCP (2)

- Mandatory part of the header
  - TCP: 20 bytes, SCTP: 12 bytes
  - Reason:
    - TSN in data chunk's header
    - Ack. # and window size are part of control chunk
    - No need for header length field (∵no option)
    - No need for an urgent pointer
- Checksum
  - TCP: 16 bits, SCTP: 32 bit



SCTP vs. TCP (3)

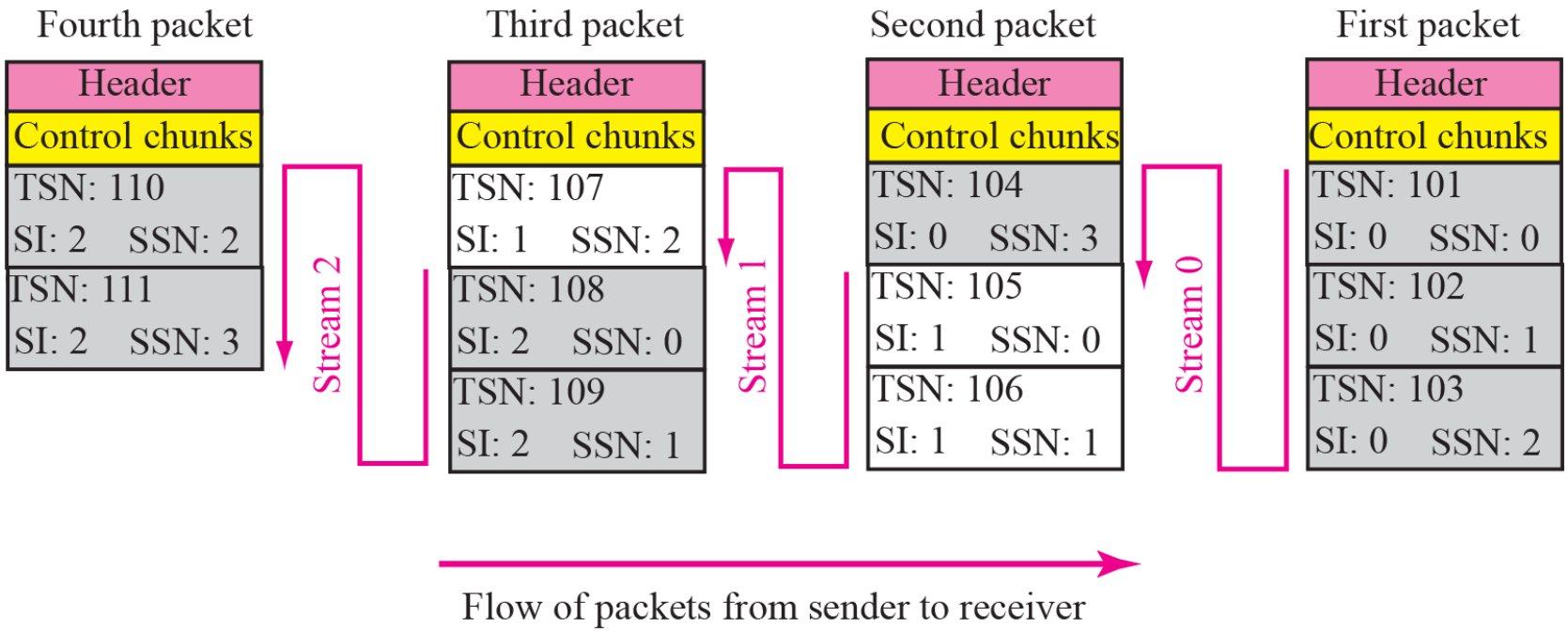
- Association identifier
  - TCP: none, SCTP: verification tag
  - Multihoming in SCTP
- Sequence number
  - TCP: one # in the header
  - SCTP: TSN, SI and SSN define each data chunk
  - SYN and FIN need to consume one seq. #
  - Control chunks never use a TSN, SI, or SSN number



Note

In SCTP, control information and data information are carried in separate chunks.

Figure 16.5 *Packet, data chunks, and streams*



Note

Data chunks are identified by three identifiers: TSN, SI, and SSN. TSN is a cumulative number identifying the association; SI defines the stream; SSN defines the chunk in a stream.

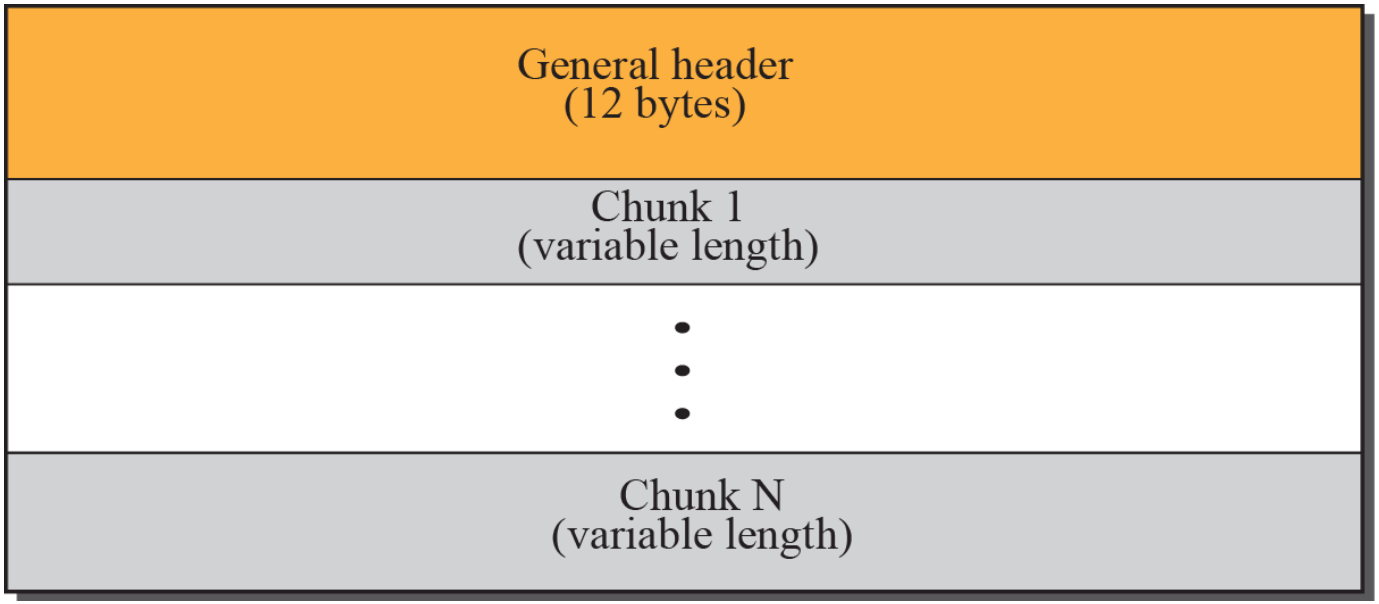
Note

In SCTP, acknowledgment numbers are used to acknowledge only data chunks; control chunks are acknowledged by other control chunks if necessary.

16-4 PACKET FORMAT

In this section, we show the format of a packet and different types of chunks. Most of the information presented in this section will become clear later; this section can be skipped in the first reading or used only as the reference. 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.

Figure 16.6 *SCTP packet format*



In an SCTP packet, control chunks come before data chunks.

Figure 16.7 *Common layout of a chunk*

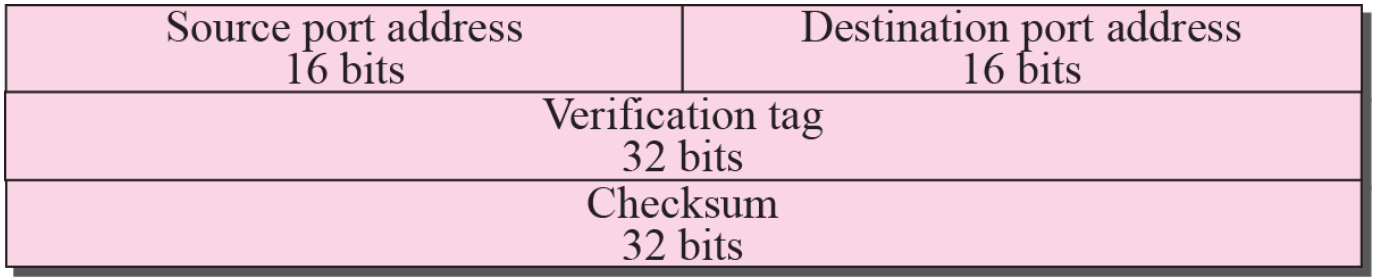
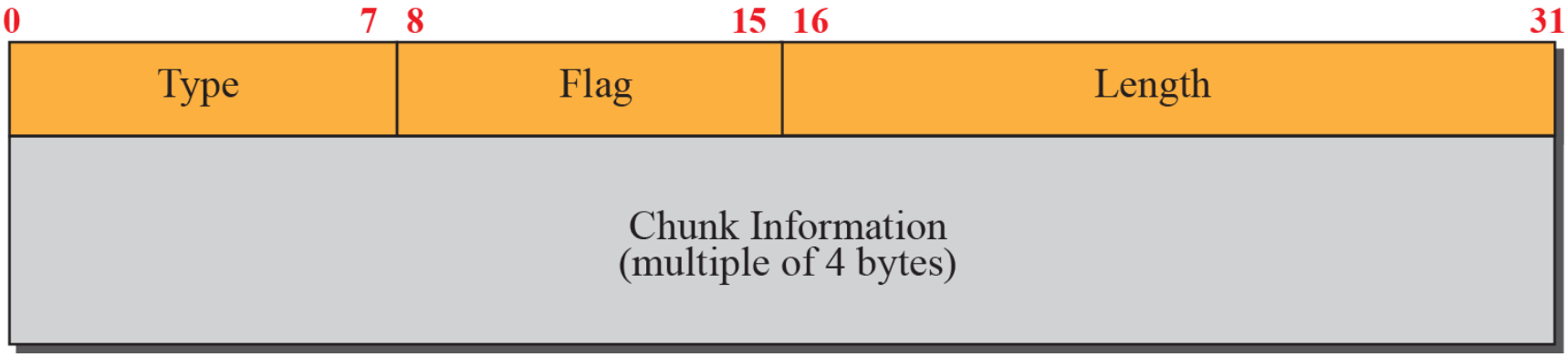


Figure 16.8 *Multiple-stream concept*



Chunks need to terminate on a 32-bit (4-byte) boundary.

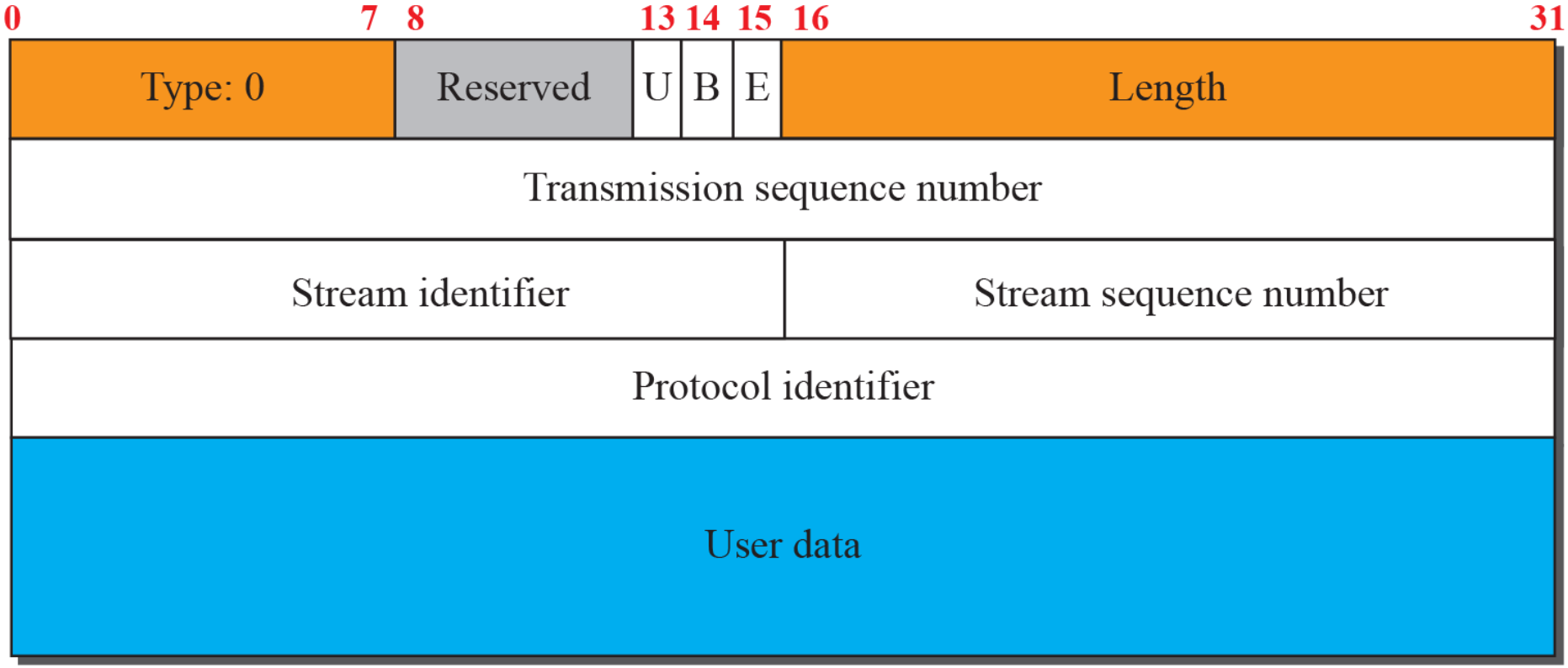
Table 16.2 *Chunks*

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	Abort 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

Note

The number of padding bytes is not included in the value of the length field.

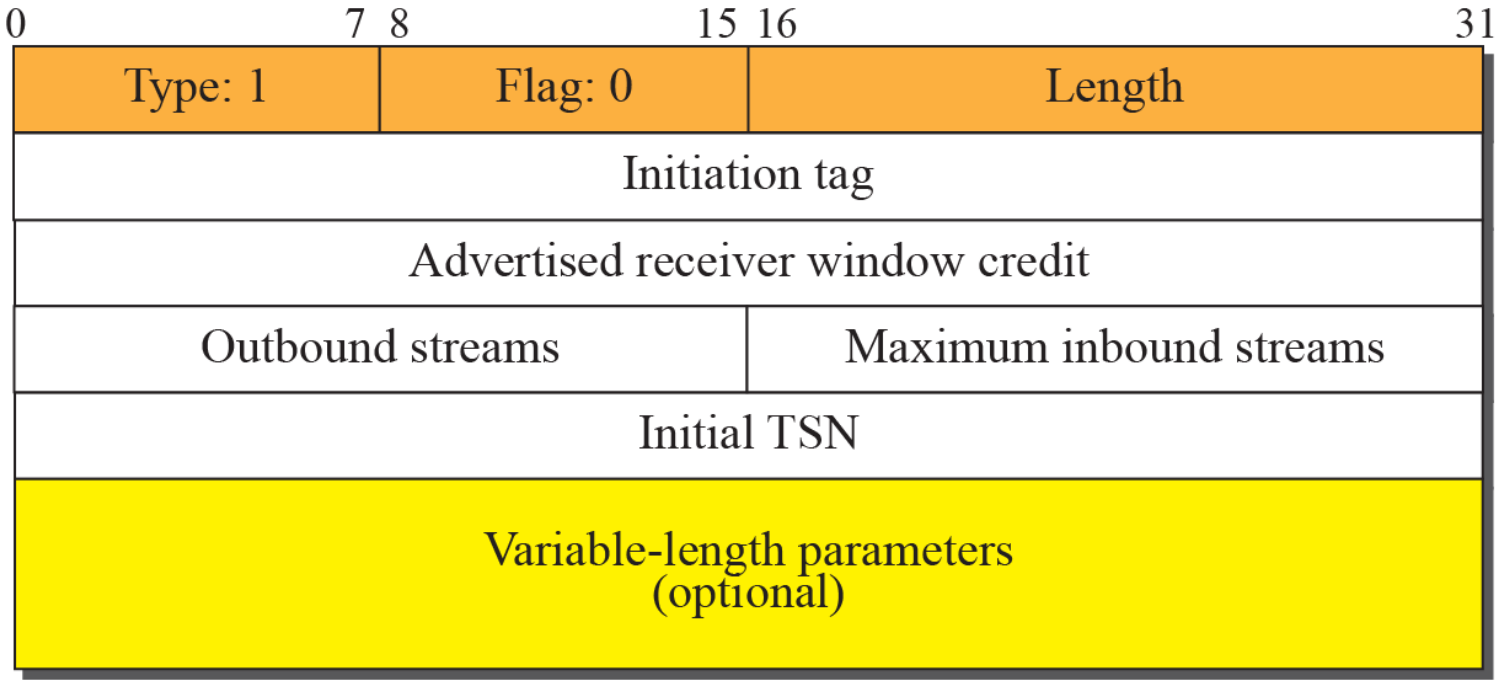
Figure 16.9 *Data chunk*



Note

A DATA chunk cannot carry data belonging to more than one message, but a message can be split into several chunks. The data field of the DATA chunk must carry at least one byte of data, which means the value of length field cannot be less than 17.

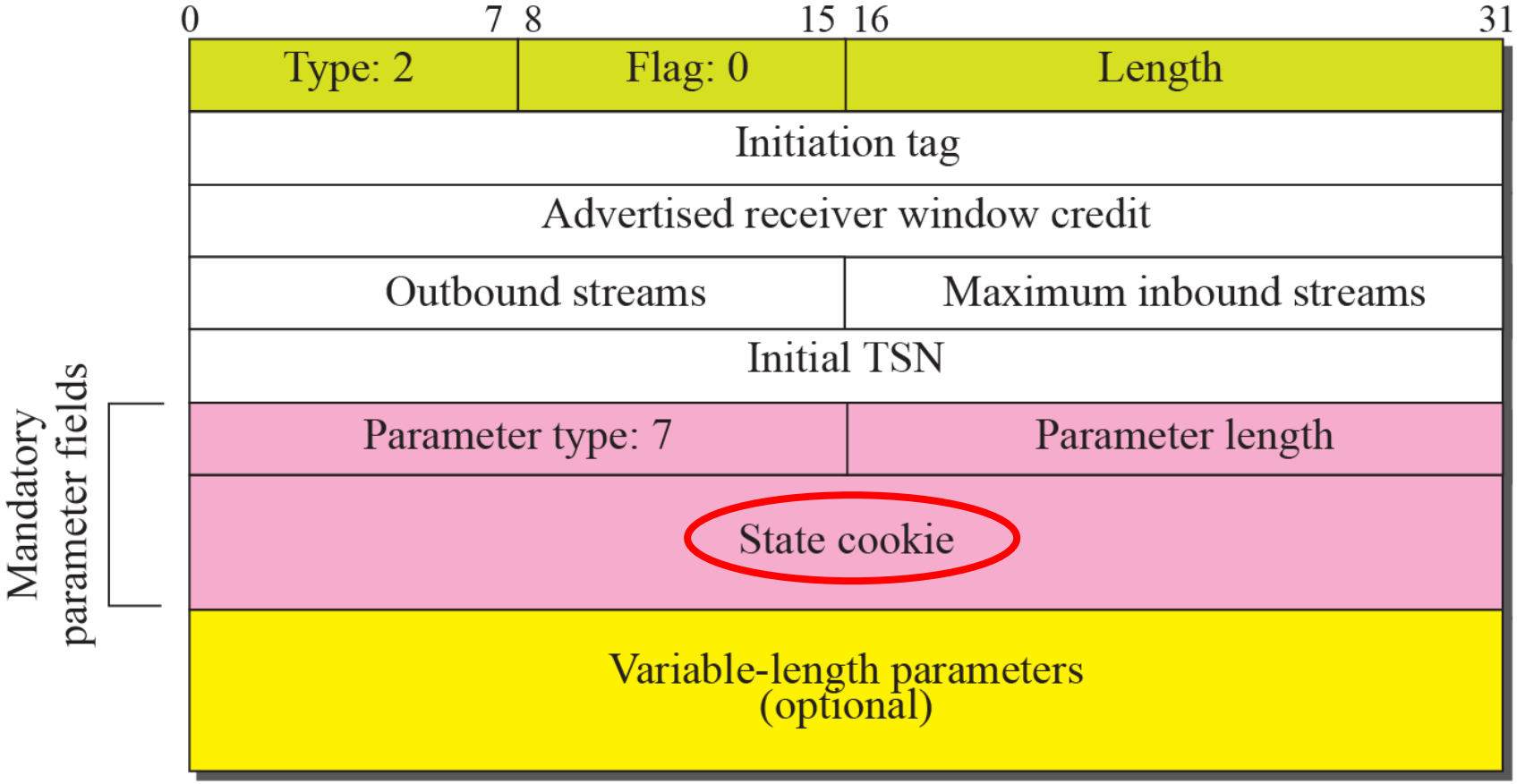
Figure 16.10 *INIT chunk*



Note

No other chunk can be carried in a packet that carries an INIT chunk.

Figure 16.11 *INIT ACK chunk*



Note

No other chunk can be carried in a packet that carries an INIT ACK chunk.

Figure 16.12 *COOKIE ECHO chunk*

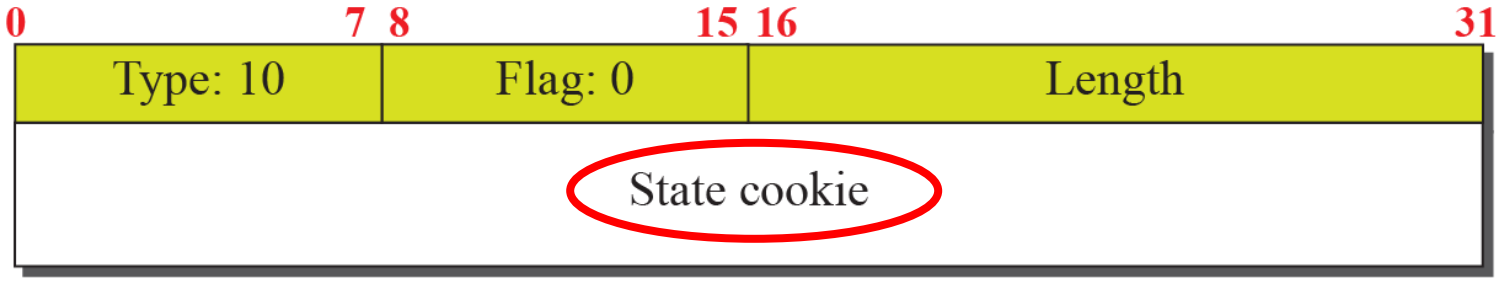


Figure 16.13 *COOKIE ACK*

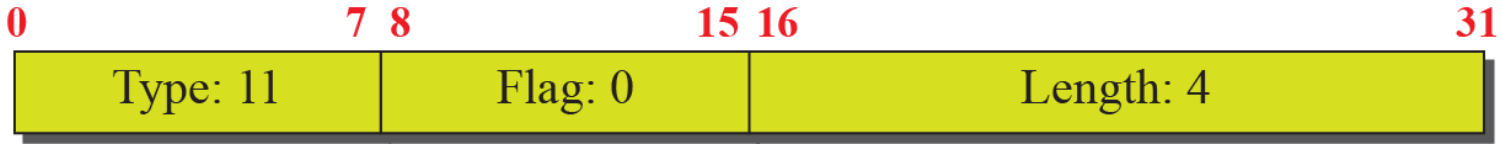


Figure 16.14 *SACK chunk*

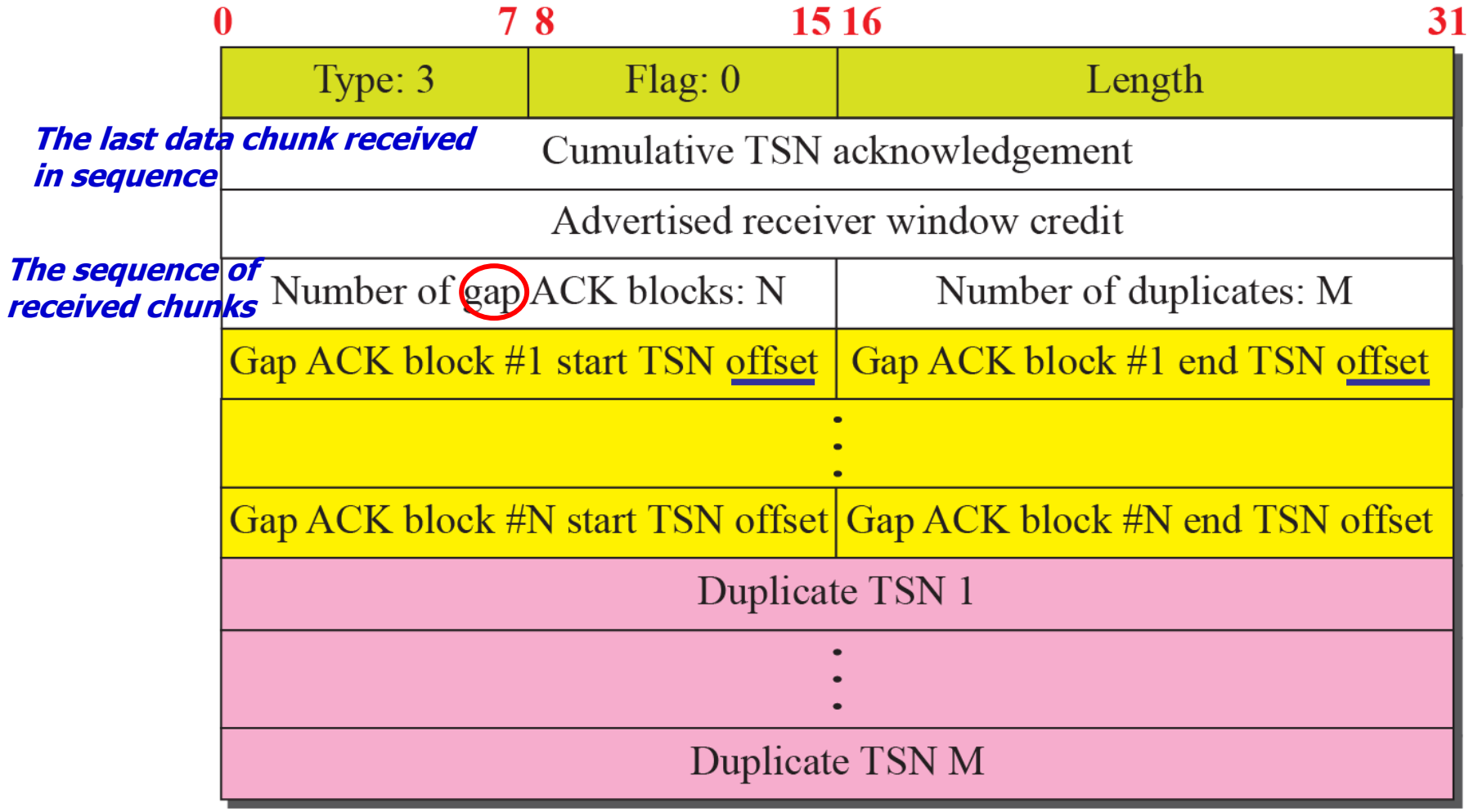
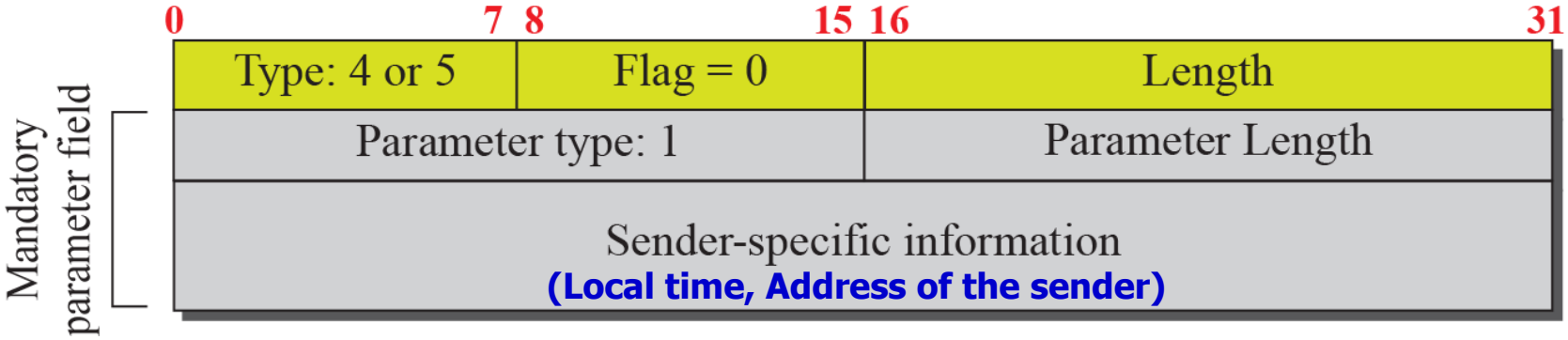


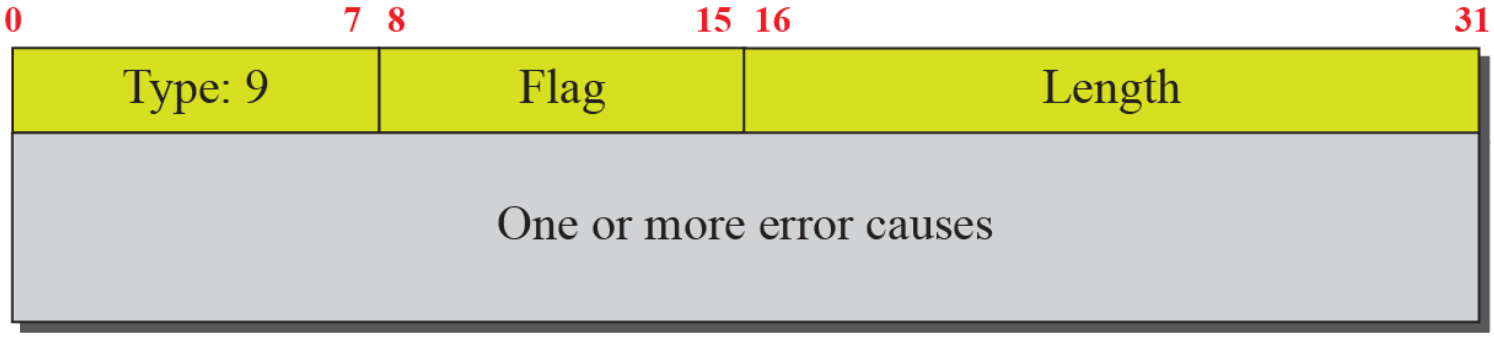
Figure 16.15 *HEARTBEAT and HEARTBEAT ACK chunk*



Used to periodically probe the condition of an association

Figure 16.16 *SHUTDOWN chunks*

Figure 16.17 *ERROR chunk*

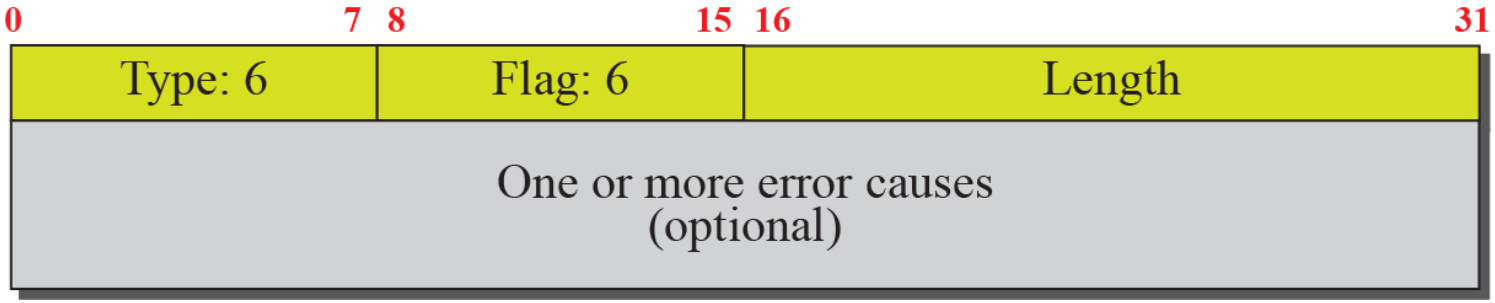


Sent when an end point finds some error in a received packet
But, which packet is with the error?

Table 16.3 *Errors*

Code	*Description*
1	Invalid stream identifier
2	Missing mandatory parameter
3	State cookie error
4	Out of resource
5	Unresolvable address
6	Unrecognized chunk type
7	Invalid mandatory parameters
8	Unrecognized parameter
9	No user data
10	Cookie received while shutting down

Figure 16.18 *ABORT chunk*



Forward TSN Chunk

- Recently added to the standard (RFC 3758)
- Used to inform the receiver to adjust its cumulative TSN
- It provides partial reliable service

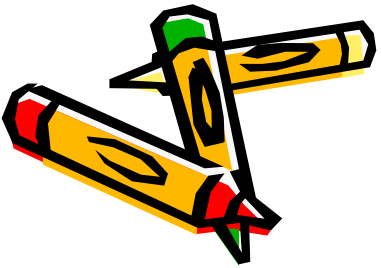
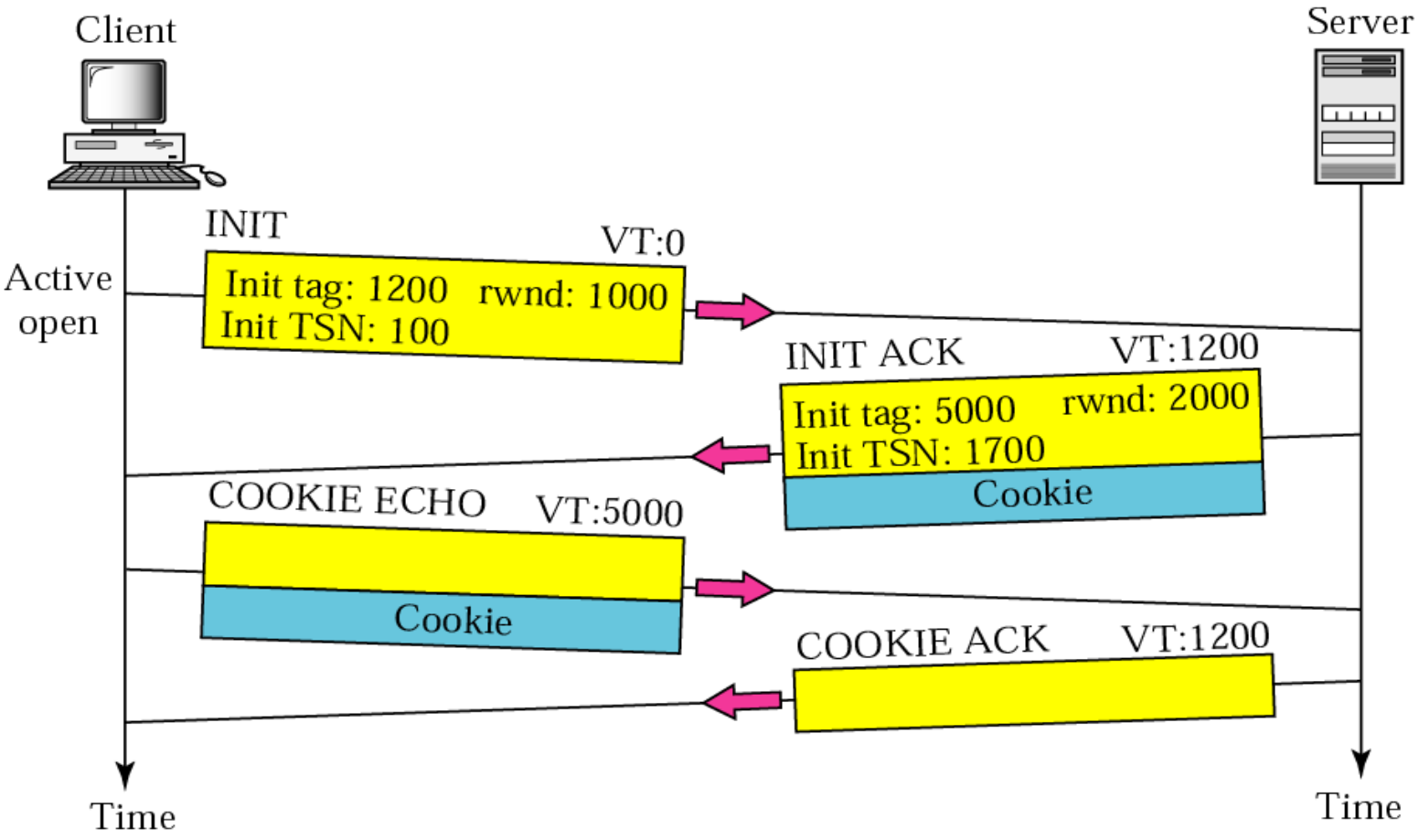


Figure 16.19 *Four-way handshaking*



Verification Tag

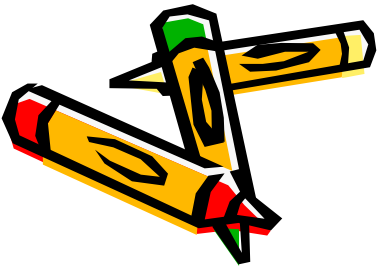
- In TCP, a connection is identified by a combination of IP addresses and port numbers
  - A blind attacker can send segments to a TCP server using randomly chosen source and destination port numbers
  - Delayed segment from a previous connection can show up in a new connection that uses the same source and destination port addresses (incarnation)

TIME-WAIT timer

- Two verification tags, one for each direction, identify an association

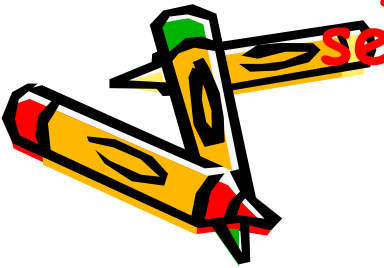
Cookie (1)

- In TCP
  - Each time the server receives a SYN segment, it sets up a TCB and allocates other resources
- In SCTP
  - Postpone the allocation of resources until the reception of the third packet, when the IP address of the sender is verified



Cookie (2)

- In SCTP
  - The information received in the first packet must somehow be saved until the third packet arrives
  - Solution: to pack the information and send it back to the client (cookie)
  - The above strategy works if no entity can "eat" a cookie "baked" by the server
  - To guarantee this, the server creates a digest from the information using its own secret key



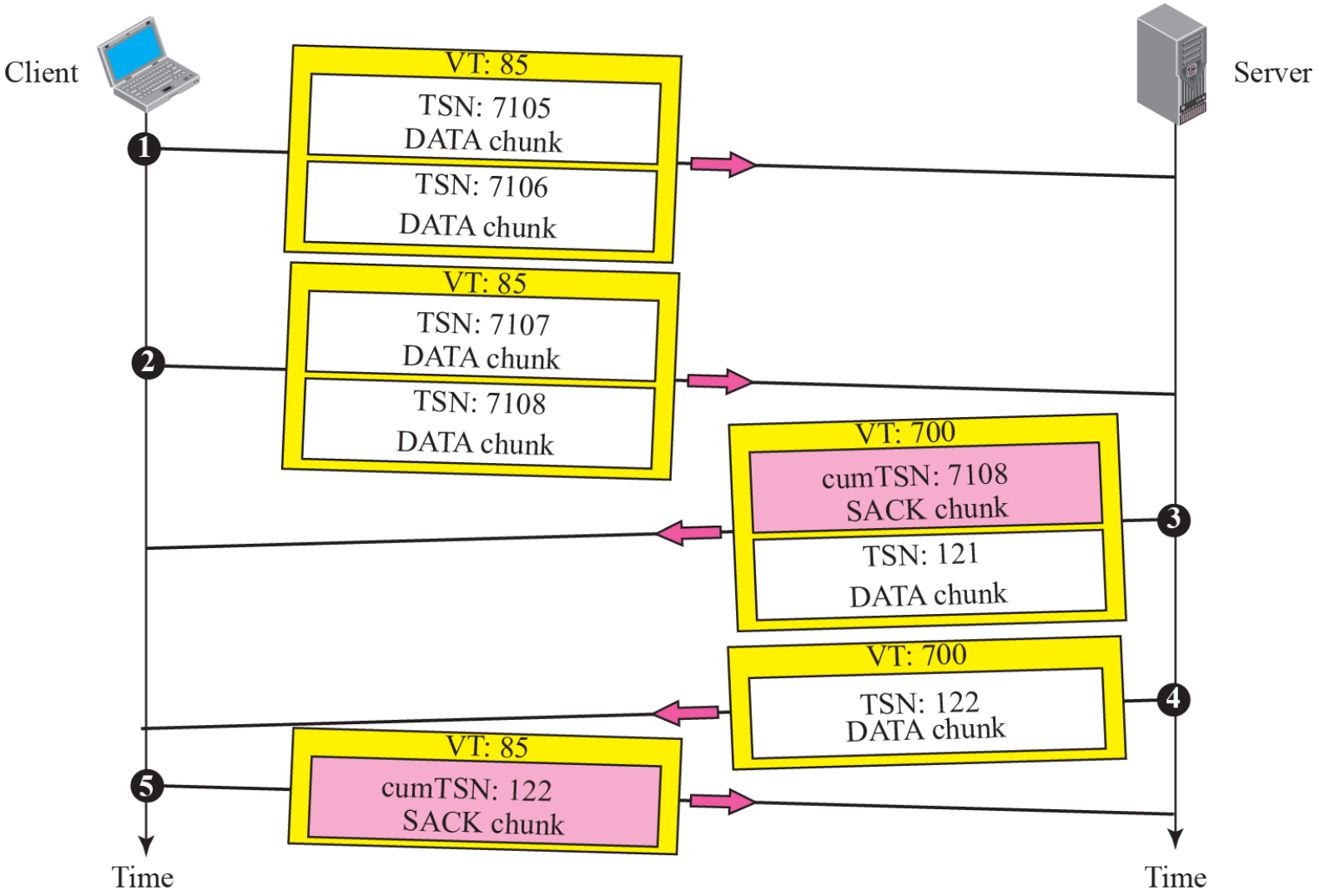
Note

No other chunk is allowed in a packet carrying an INIT or INIT ACK chunk. A COOKIE ECHO or a COOKIE ACK chunk can carry data chunks.

Note

In SCTP, only data chunks consume TSNs; data chunks are the only chunks that are acknowledged.

Figure 16.20 *Simple data transfer*

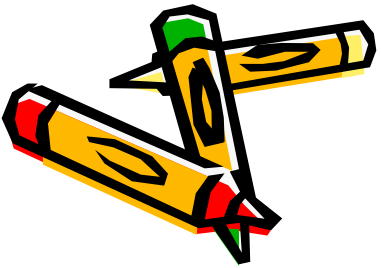


Note

The acknowledgment in SCTP defines the cumulative TSN, the TSN of the last data chunk received in order.

Multi-homing Data Transfer

- Primary address
  - The rest are alternative addresses
  - Defined during association establishment
  - Determined by the other end
  - The process can always override the primary address (explicitly)
  - SACK is sent to the address from which the corresponding SCTP packet originated



Multi-stream Delivery

- Interesting feature in SCTP
  - Distinction between data transfer and data delivery
  - Data transfer: TSN (error/flow control)
  - Data delivery: SI, SSN
- **Data delivery** (in each stream)
  - Ordered (default)
  - Unordered: using the U flag, do not consume SSNs (U flag with fragmentation?)

Fragmentation

- IP fragmentation vs. SCTP
  - SCTP preserves the boundaries of the msg from process to process when creating a DATA chunk from a message if the size of the msg does not exceed the MTU of the path
- SCTP fragmentation
  - Each fragment carries a different TSN
  - All header chunks carries the same SI, SSN, payload protocol ID, and U flag
  - Combination of B and E flag: 11,10,00,01

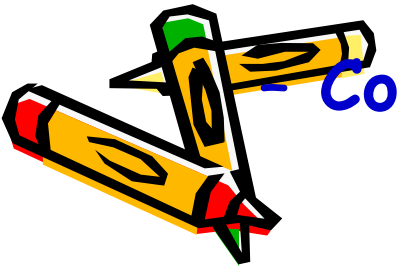


Figure 16.21 *Association termination*

SCTP does not allow a "half-closed" association

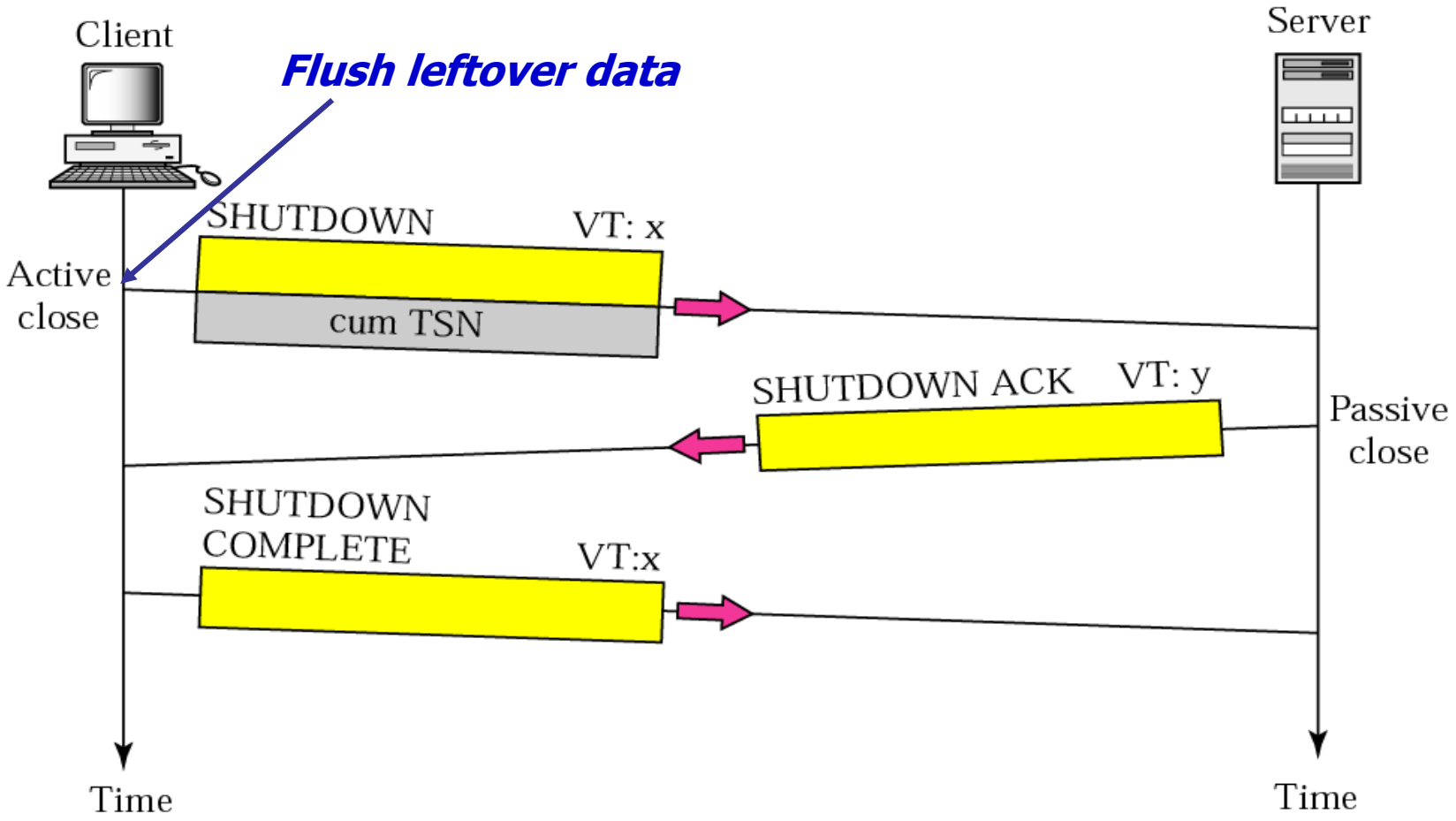


Figure 16.22 *Association abortion*