Stream Control Transmission Protocol (SCTP)

Outline

Introduction Features et **Format**TP Association Flow Sont 8 lngestion Control

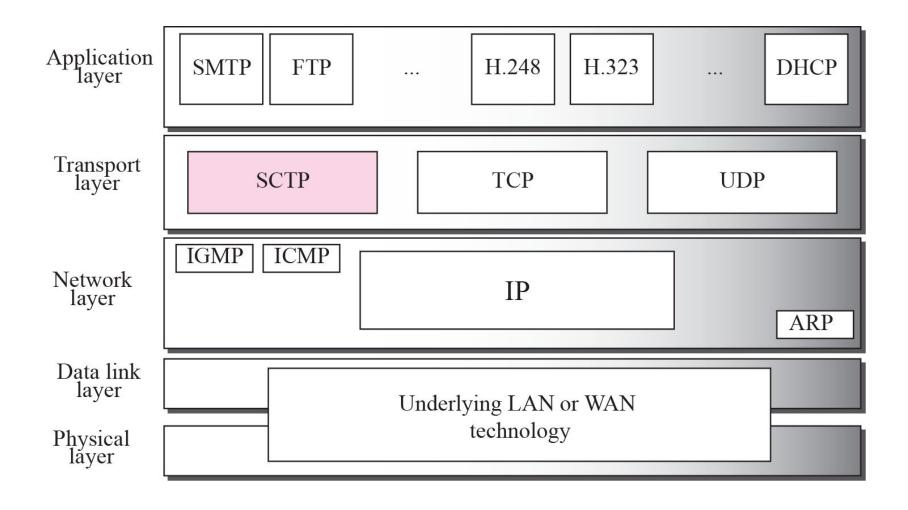
1 INTRODUCTION

Stream Control Transmission Protocol (SCTP) is a new reliable, message-oriented transport-layer protocol.

Figure 1 shows the relationship of SCTP to the other protocols in the Internet protocol suite.

SCTP lies between the application layer and the network layer and serves as the intermediary between the application programs and the network operations.

Figure 1 TCP/IP Protocol suite





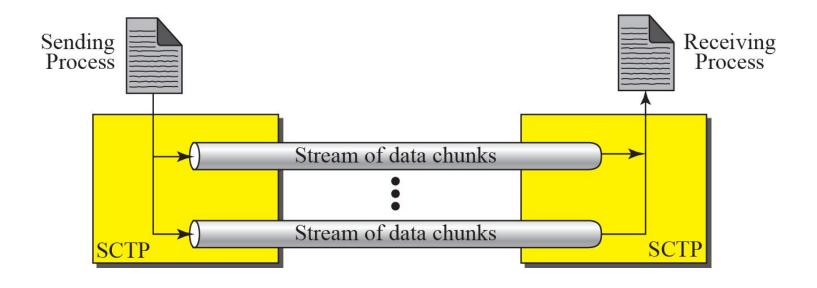
SCTP is a message-oriented, reliable protocol that combines the best features of UDP and TCP.

2 SCTP SERVICES

Before discussing the operation of SCTP, let us explain the services offered by SCTP to the application layer processes.

- **✓** Process-to-Process Communication
- **✓** Multiple Streams
- Multihoming
- **✓** Full-Duplex Communication
- **✓** Connection-Oriented Service
- **✓** Reliable Service

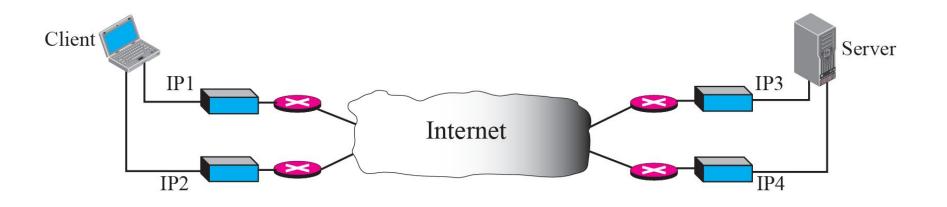
Figure 2 Multiple-stream concept





An association in SCTP can involve multiple streams.

Figure 3 Multihoming concept





SCTP association allows multiple IP addresses for each end.

3 SCTP

REATURES

Let us first discuss the general features of SCTP and then compare them with those of TCP.

- **✓** Transmission Sequence Number (TSN)
- **✓** Stream Identifier (SI)
- **✓** Stream Sequence Number (SSN)
- **✓** Packets
- **✓** Acknowledgment Number
- **✓** Flow Control
- **✓** Error Control
- **✓** Congestion Control



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

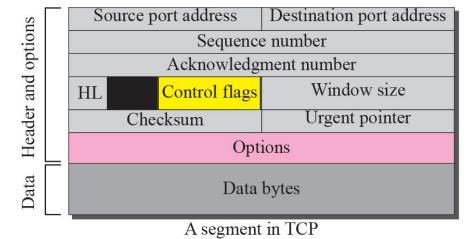


To distinguish between different streams, SCTP uses an SI.



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

Figure 4 Comparison between a TCP segment and an SCTP packet



Source port address	Destination port address	Pr
Verification tag		Header
Checksum		H
Control chunks		ontro
Data chunks		Data
A packe	et in SCTP	



TCP has segments; SCTP has packets.

Differences

- 1. The control information in TCP is part of the header; the control information in SCTP is included in the control chunks. There are several types of control chunks; each is used for a different purpose.
- 2. The data in a TCP segment treated as one entity; an SCTP packet can carry several data chunks; each can belong to a different stream.
- The options section, which can be part of a TCP segment, does not exist in an SCTP packet. Options in SCTP are handled by defining new chunk types.
- 4. The mandatory part of the TCP header is 20 bytes, while the general header in SCTP is only 12 bytes. The SCTP header is shorter due to the following:
 - a) An SCTP sequence number (TSN) belongs to each data chunk, and hence is located in the chunk's header.
 - The acknowledgment number and window size are part of each control chunk.
 - There is no need for a header length field (shown as HL in the TCP segment) because there are no options to make the length of the header variable; the SCTP header length is fixed (12 bytes)
 - There is no need for an urgent pointer in SCTP, (We will discuss Later)

TCP/IP Protocol Suite

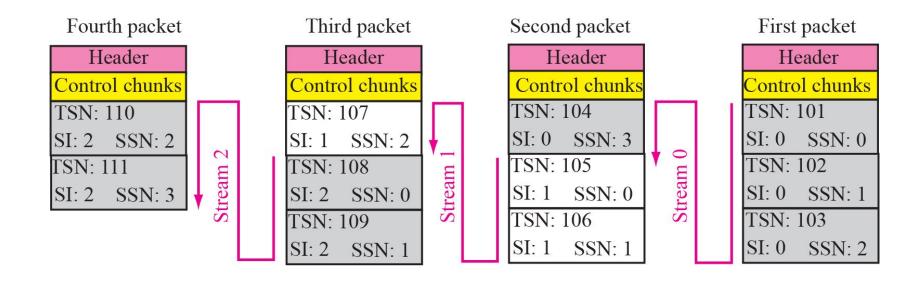
- 5. The checksum in TCP is 16 bits; in SCTP, it is 32 bits.
- The verification tag in SCTP is an association identifier, which does not exist in TCP. In TCP, the combination of IP and port addresses define a connection; in SCTP we may have multihoming using different IP addresses. A unique verification tag is needed to define each association.
- 7. TCP includes one sequence number in the header, which defines the number of the first byte in the data section. An SCTP packet can include several different data chunks. TSNs, ISs, and SSNs define each data chunk.
- Some segments in TCP that carry control information (such as SYN and FIN), need to consume one sequence number; control chunks in SCTP never use a TSN, IS, or SSN number. These three identifiers belong only to data chunks, not to the whole packet.

TCP/IP Protocol Suite



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

Figure 5 Packet, data chunks, and streams



Flow of packets from sender to receiver



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.



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

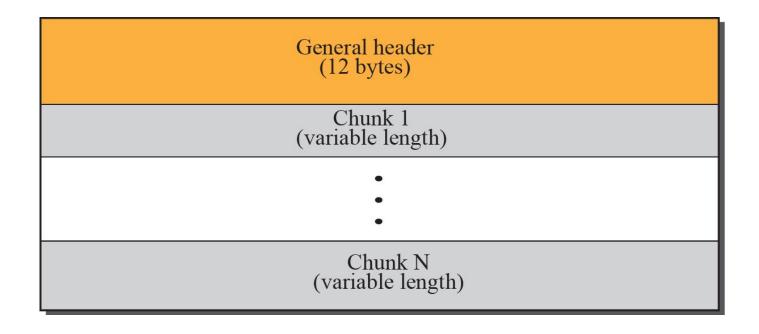
4 PACKET FORMAT

In this section, we show the format of a packet and different types of chunks.

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 6 SCTP packet format





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

Figure 7 General header

Source port address 16 bits	Destination port address 16 bits	
Verification tag 32 bits		
Checksum 32 bits		

Figure 8 Common layout of a chunk

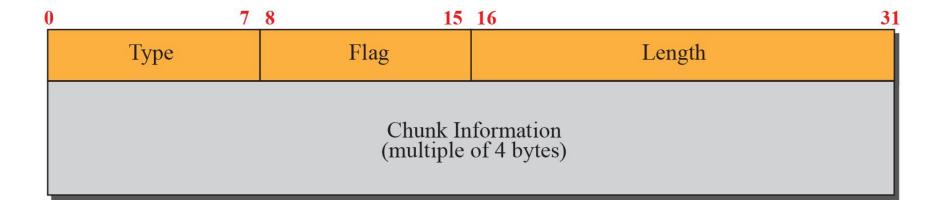


Table 16.2Chunks

Туре	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

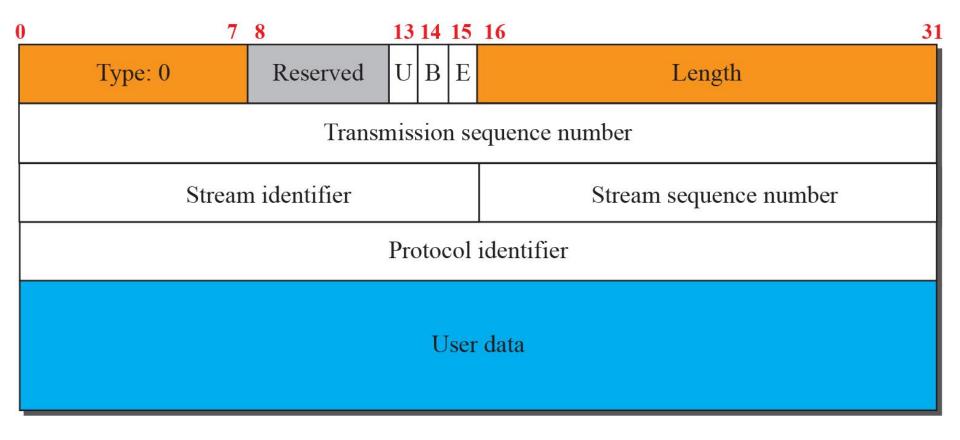


Chunks need to terminate on a 32-bit (4-byte) boundary.



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

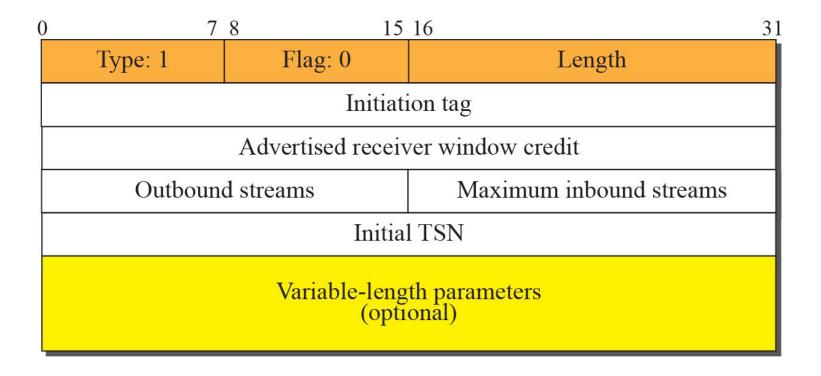
Figure 9 Data chunk





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.

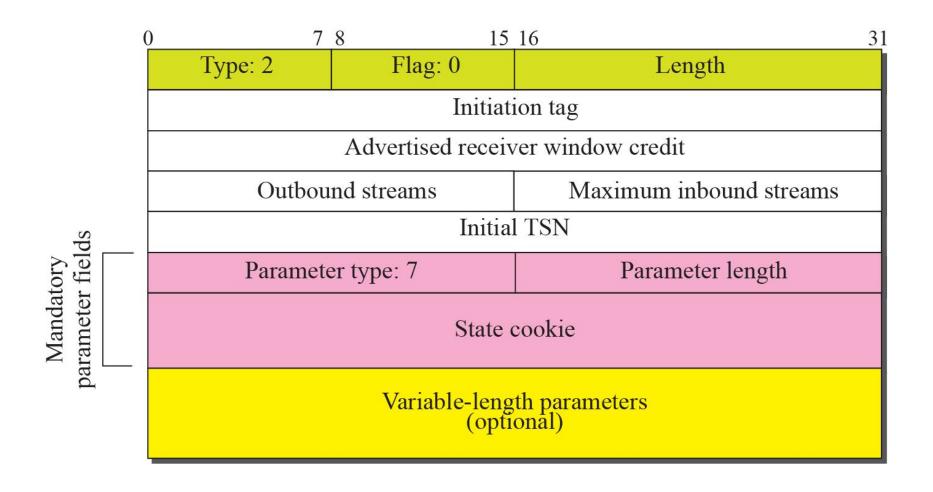
Figure 10 INIT chunk





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

Figure 11 INIT ACK chunk





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

Figure 12 COOKIE ECHO chunk

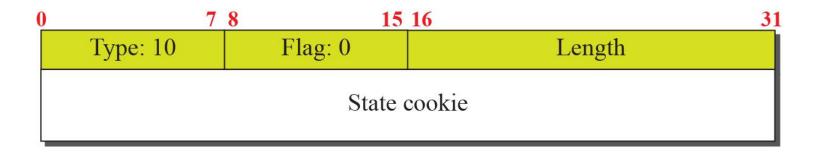


Figure 13 COOKIE ACK

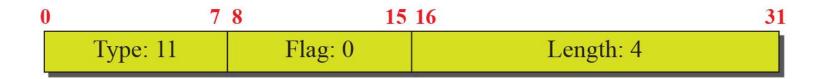


Figure 14 SACK chunk

0 7	8 15	16 31			
Type: 3	Flag: 0	Length			
Cumulative TSN acknowledgement					
Advertised receiver window credit					
Number of gap ACK blocks: N		Number of duplicates: M			
Gap ACK block #1 start TSN offset		Gap ACK block #1 end TSN offset			
Gap ACK block #N start TSN offset		Gap ACK block #N end TSN offset			
Duplicate TSN 1					
•					
Duplicate TSN M					

Figure 15 HEARTBEAT and HEARTBEAT ACK chunk

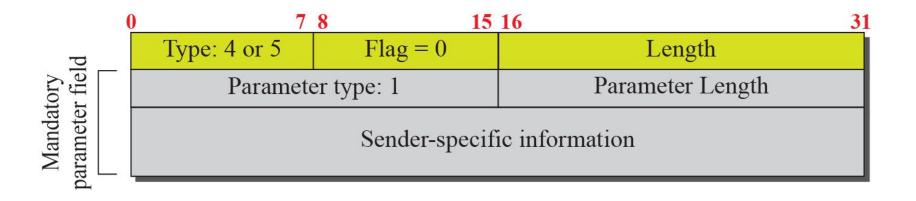


Figure 16 SHUTDOWN chunks

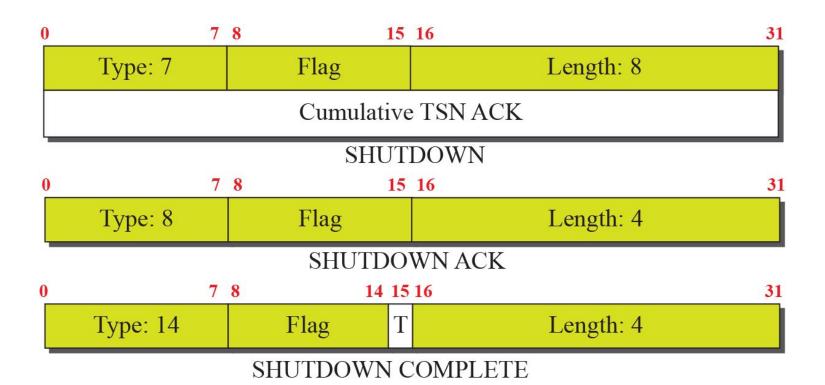


Figure 17 ERROR chunk

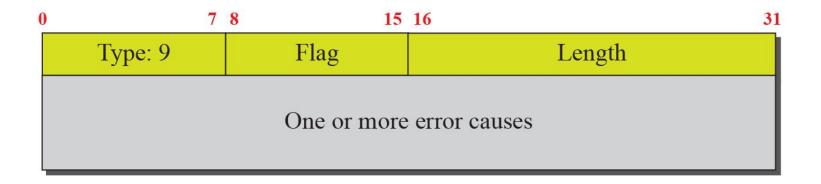
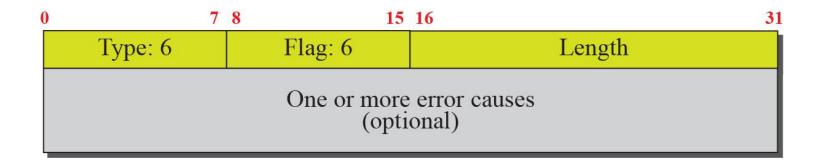


Figure 18 ABORT chunk



5 AN SCTP ASSOCIATION

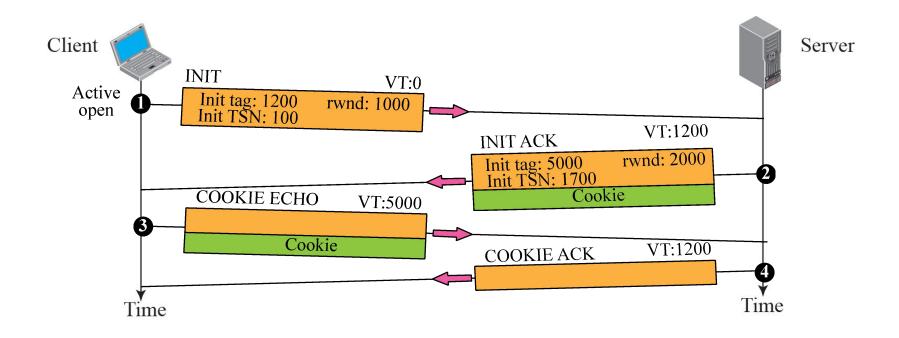
SCTP, like TCP, is a connection-oriented protocol. However, a connection in SCTP is called an association to emphasize multihoming.

- **✓** Association Establishment
- **✓** Data Transfer
- **✓ Association Termination**
- **✓** Association Abortion



A connection in SCTP is called an association.

Figure 19 Four-way handshaking



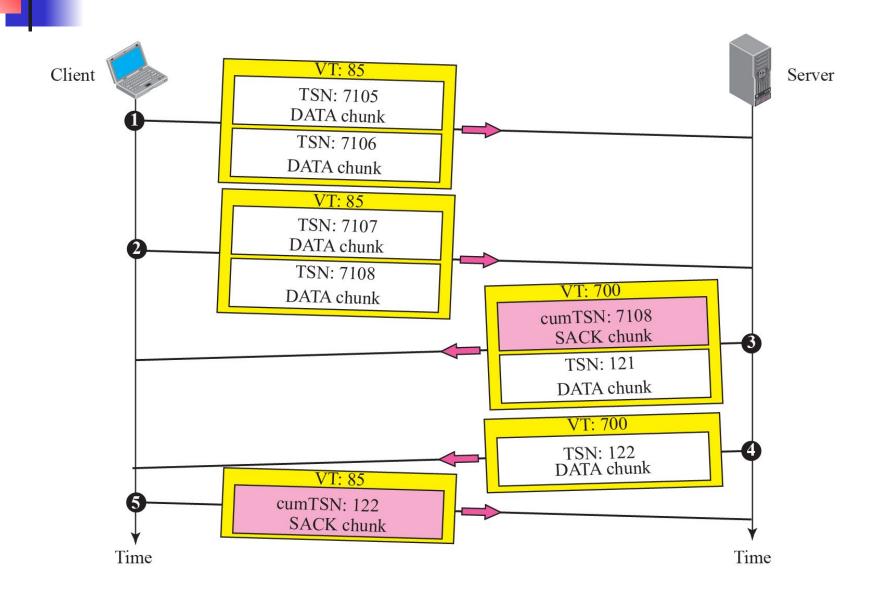


No other chunk is allowed in a packet carrying an INIT or INIT ACK chunk.
A COOKIE ECHO or a COOKIE ACK chunk can carry data chunks.



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

Figure 20 Simple data transfer





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

Figure 21 Association termination

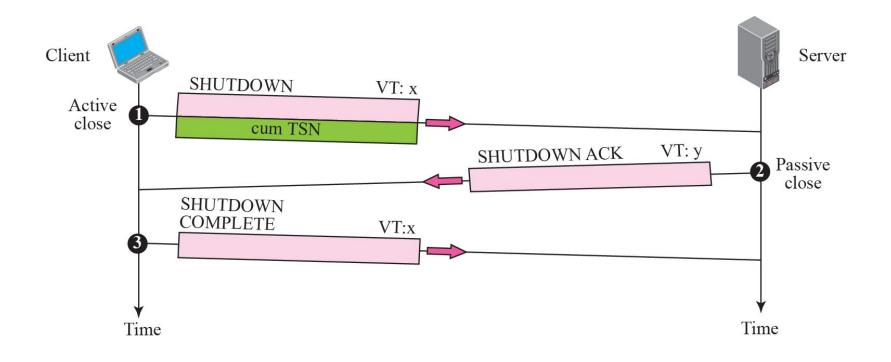


Figure 22 Association abortion

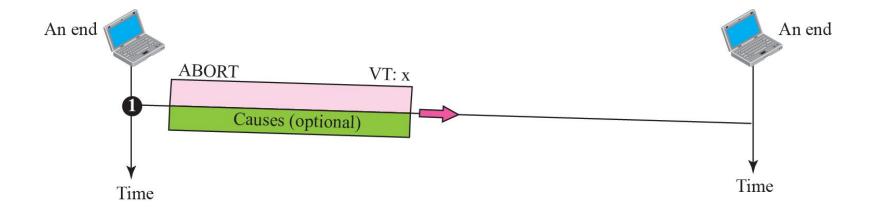


Figure 24 A common scenario of state

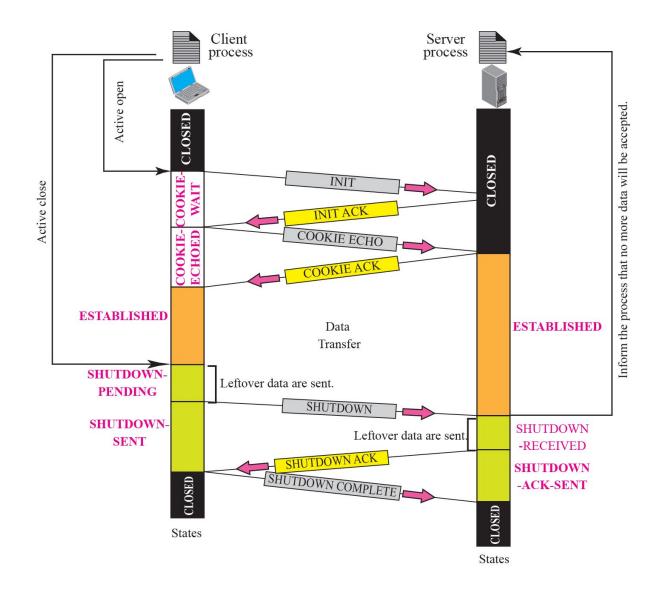


Figure 25 Simultaneous open

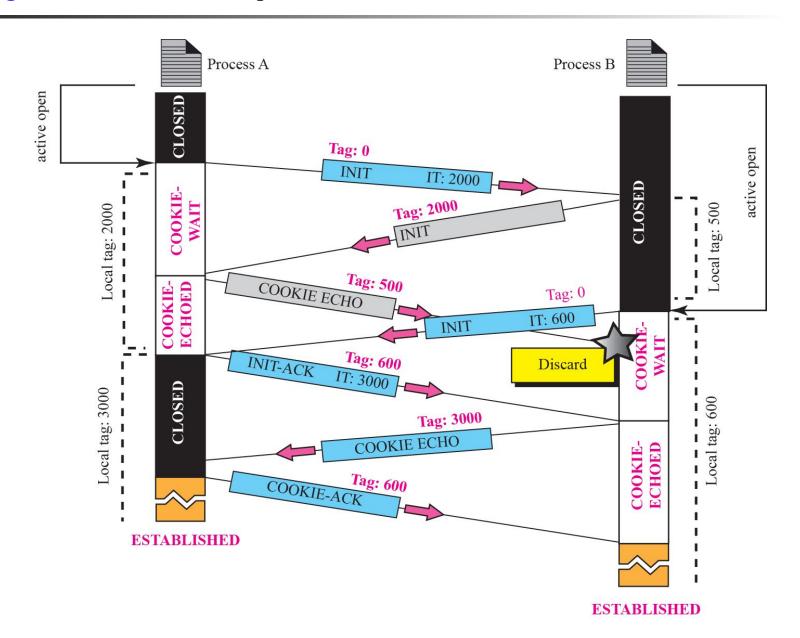
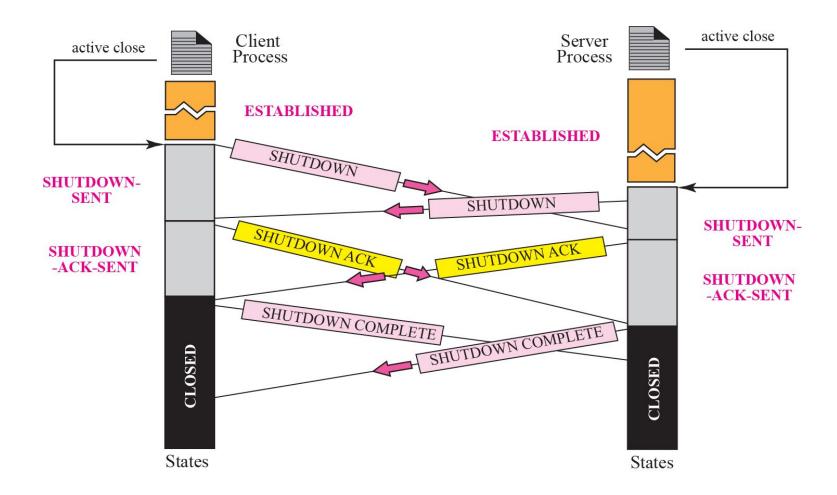


Figure 26 Simultaneous close

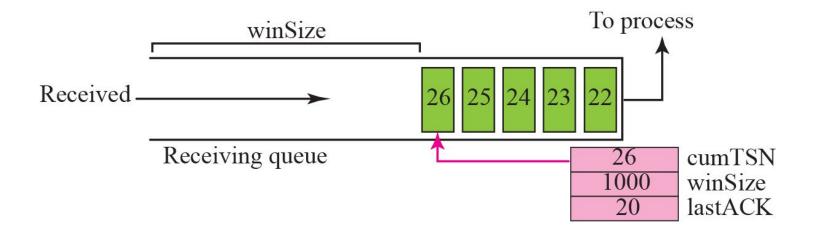


7 FLOW CONTROL

Flow control in SCTP is similar to that in TCP. In TCP, we need to deal with only one unit of data, the byte. In SCTP, we need to handle two units of data, the byte and the chunk. The values of rwnd and *cwnd* are expressed in bytes; the values of TSN and acknowledgments are expressed in chunks.

- **✓** Receiver Site
- **✓** Sender Site
- **✓** A Scenario

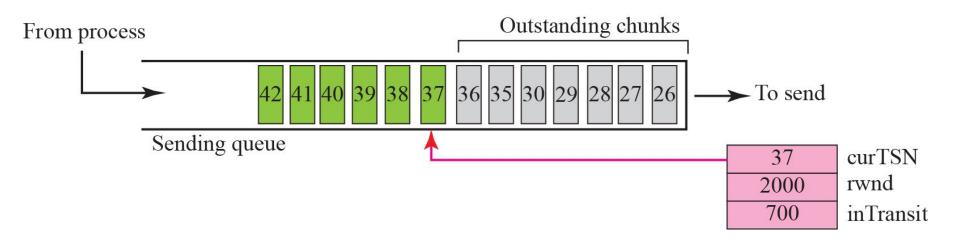
Figure 27 Flow control, receiver site



- When the site receives a data chunk, it stores it at the end of the buffer (queue) and subtracts the size of the chunk from winSize. The TSN number of the chunk is stored in the cumTSN variable.
- When the process reads a chunk, it removes it from the queue and adds the size of the removed chunk to winSize (recycling).
- When the receiver decides to send a SACK, it checks the value of lastAck; if it is less than cumTSN, it sends a SACK with a cumulative TSN number equal to the cumTSN. It also includes the value of winSize as the advertised window size. The value of lastACK is then updated to hold the value of cumTSN.

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Figure 28 Flow control, sender site

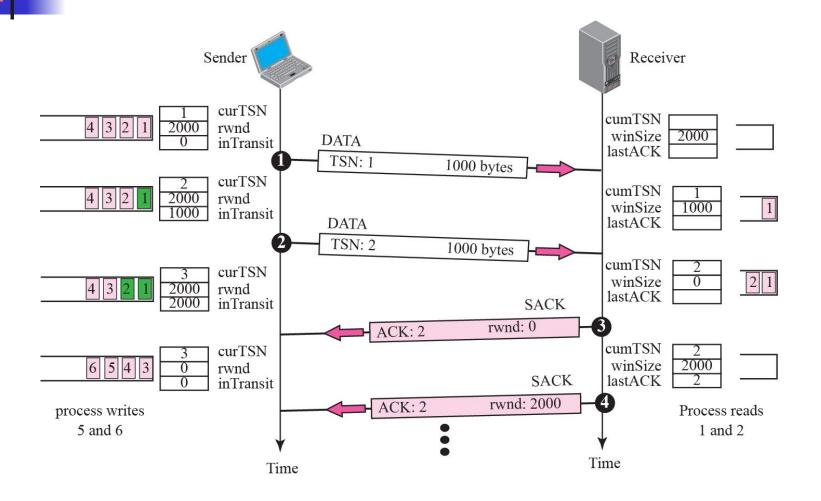


procedure used by the sender.

- A chunk pointed to by curTSN can be sent if the size of the data is less than or equal to the quantity (rwnd inTransit). After sending the chunk, the value of curTSN is incremented by one and now points to the next chunk to be sent. The value of inTransit is incremented by the size of the data in the transmitted chunk.
- When a SACK is received, the chunks with a TSN less than or equal to the cumulative TSN in the SACK are removed from the queue and discarded. The sender does not have to worry about them any more. The value of inTransit is reduced by the total size of the discarded chunks. The value of rwnd is updated with the value of the advertised window in the SACK.

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Figure 29 Flow control scenario



8 ERROR CONTROL

SCTP, like TCP, is a reliable transport-layer protocol. It uses a SACK chunk to report the state of the receiver buffer to the sender.

- **✓** Receiver Site
- **✓** Sender Site
- Sending Data Chunks
- **✓** Generating SANK Chunks

Figure 30 Error-control receiver site

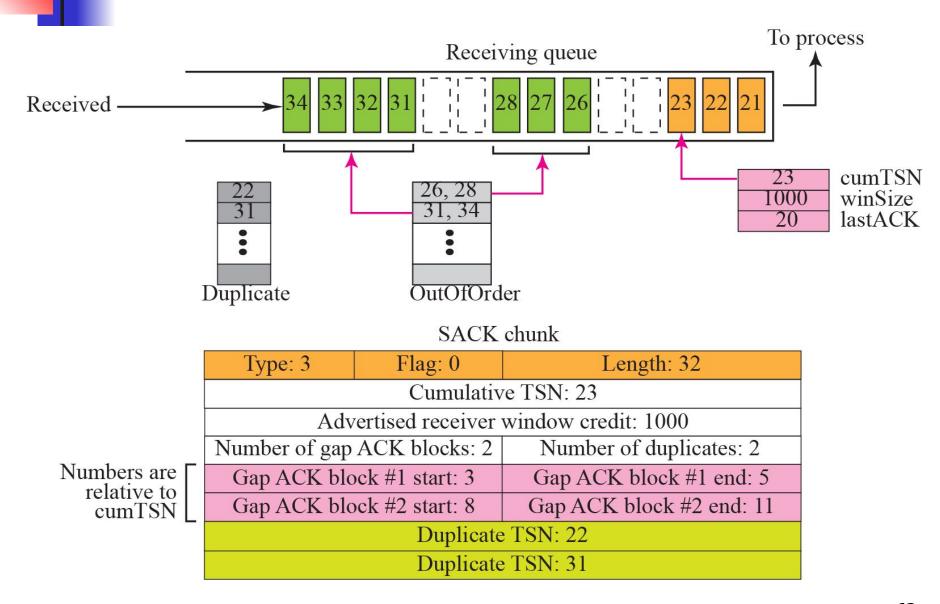


Figure 31 Error control, sender site

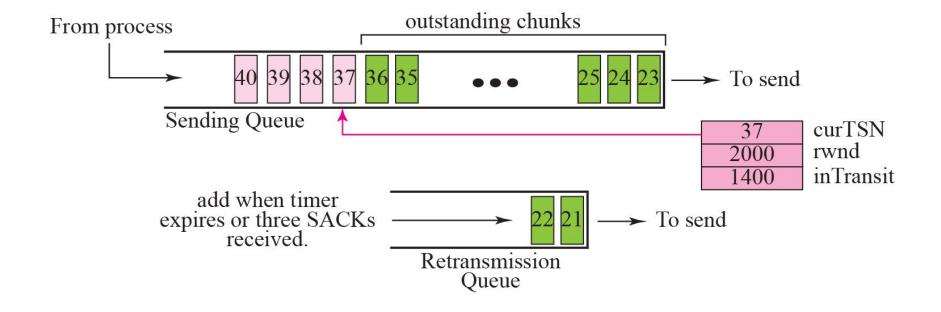
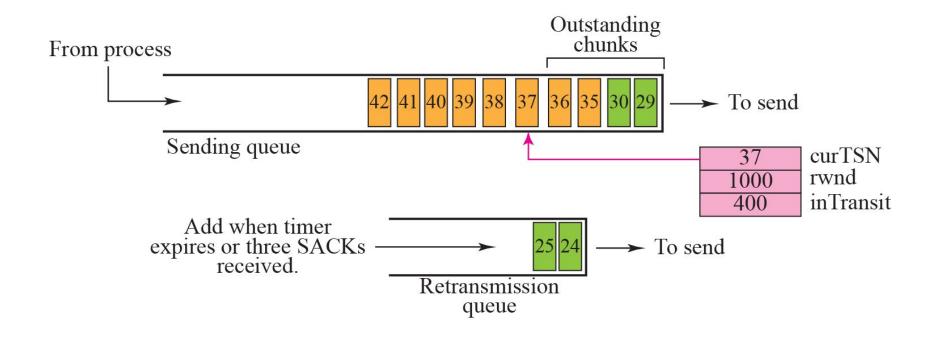


Figure 32 New state at the sender site after receiving a SACK chunk



SCTP vs TCP vs UDP

Services/Features	SCTP	TCP	UDP
Connection-oriented	yes	yes	no
Full duplex	yes	yes	yes
Reliable data transfer	yes	yes	no
Partial-reliable data transfer	optional	no	no
Ordered data delivery	yes	yes	no
Unordered data delivery	yes	no	yes
Flow control	yes	yes	no
Congestion control	yes	yes	no
ECN capable	yes	yes	no
Selective ACKs	yes	optional	no
Preservation of message boundaries	yes	no	yes
Path MTU discovery	yes	yes	no
Application PDU fragmentation	yes	yes	no
Application PDU bundling	yes	yes	no
Multistreaming	yes	no	no
Multihoming	yes	no	no
Protection against SYN flooding attacks	yes	no	n/a
Allows half-closed connections	no	yes	n/a
Reachability check	yes	yes	no
Psuedo-header for checksum	no (uses vtags)	yes	yes
Time wait state	for vtags	for 4-tuple	n/a

Thanks