Chapter 16

Stream Control Transmission Protocol (SCTP)
## Chapter Outline

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Stream Control Transmission Protocol (SCTP) is a new reliable, message-oriented transport-layer protocol. Figure 16.1 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 16.1  TCP/IP Protocol suite

Application layer
- SMTP
- FTP
- ... H.248
- ... H.323
- ... DHCP

Transport layer
- SCTP
- TCP
- UDP

Network layer
- IGMP
- ICMP
- IP
- ARP

Data link layer
- Underlying LAN or WAN technology

Physical layer
SCTP is a message-oriented, reliable protocol that combines the best features of UDP and TCP.
Before discussing the operation of SCTP, let us explain the services offered by SCTP to the application layer processes.
**SCTP Services**

- Process-to-Process Communication
- Multiple Streams
- Multihoming
- Full-Duplex Communication
- Connection-Oriented Service
- Reliable Service
Table 16.1  *Some SCTP applications*

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Port Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IUA</td>
<td>9990</td>
<td>ISDN over IP</td>
</tr>
<tr>
<td>M2UA</td>
<td>2904</td>
<td>SS7 telephony signaling</td>
</tr>
<tr>
<td>M3UA</td>
<td>2905</td>
<td>SS7 telephony signaling</td>
</tr>
<tr>
<td>H.248</td>
<td>2945</td>
<td>Media gateway control</td>
</tr>
<tr>
<td>H.323</td>
<td>1718, 1719, 1720, 11720</td>
<td>IP telephony</td>
</tr>
<tr>
<td>SIP</td>
<td>5060</td>
<td>IP telephony</td>
</tr>
</tbody>
</table>
Figure 16.2 Multiple-stream concept
An association in SCTP can involve multiple streams.
Figure 16.3  Multihoming concept
**Note**

**SCTP association allows multiple IP addresses for each end.**
Let us first discuss the general features of SCTP and then compare them with those of TCP.
Numbering System

- Transmission Sequence Number (TSN)
  - The unit of data in SCTP is a data chunk
  - TSN is used to number the data chunks
- Stream Identifier (SI)
- Stream Sequence Number (SSN)
  - SSN defines each data chunk in each stream
Example

Process A needs to send 11 messages to Process B in 3 streams. The first 4 messages are in the first stream, the second 3 messages are in the second stream, and the last 4 messages are in the third stream. The network allows only 3 data chunks per package.
Figure 16.5  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.
TCP has segments; SCTP has packets.

- **Verification tag** is an association identifier.
In SCTP, control information and data information are carried in separate chunks.
In SCTP, acknowledgment numbers are used to acknowledge only data chunks; control chunks are acknowledged by other control chunks if necessary.
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.
SCTP Packet Format

✓ General Header
✓ Chunks
  ✓ Control chunk
  ✓ Data chunk
In an SCTP packet, control chunks come before data chunks.
### Figure 16.7  General header

<table>
<thead>
<tr>
<th>Source port address 16 bits</th>
<th>Destination port address 16 bits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verification tag 32 bits</td>
<td></td>
</tr>
<tr>
<td>Checksum 32 bits</td>
<td></td>
</tr>
</tbody>
</table>
Figure 16.8 Common layout of a chunk

<table>
<thead>
<tr>
<th>Type</th>
<th>Flag</th>
<th>Length</th>
</tr>
</thead>
</table>

Chunk Information (multiple of 4 bytes)
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.
### Table 16.2  Chunks

<table>
<thead>
<tr>
<th>Type</th>
<th>Chunk</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>DATA</td>
<td>User data</td>
</tr>
<tr>
<td>1</td>
<td>INIT</td>
<td>Sets up an association</td>
</tr>
<tr>
<td>2</td>
<td>INIT ACK</td>
<td>Acknowledges INIT chunk</td>
</tr>
<tr>
<td>3</td>
<td>SACK</td>
<td>Selective acknowledgment</td>
</tr>
<tr>
<td>4</td>
<td>HEARTBEAT</td>
<td>Probes the peer for liveliness</td>
</tr>
<tr>
<td>5</td>
<td>HEARTBEAT ACK</td>
<td>Acknowledges HEARTBEAT chunk</td>
</tr>
<tr>
<td>6</td>
<td>ABORT</td>
<td>Abort an association</td>
</tr>
<tr>
<td>7</td>
<td>SHUTDOWN</td>
<td>Terminates an association</td>
</tr>
<tr>
<td>8</td>
<td>SHUTDOWN ACK</td>
<td>Acknowledges SHUTDOWN chunk</td>
</tr>
<tr>
<td>9</td>
<td>ERROR</td>
<td>Reports errors without shutting down</td>
</tr>
<tr>
<td>10</td>
<td>COOKIE ECHO</td>
<td>Third packet in association establishment</td>
</tr>
<tr>
<td>11</td>
<td>COOKIE ACK</td>
<td>Acknowledges COOKIE ECHO chunk</td>
</tr>
<tr>
<td>14</td>
<td>SHUTDOWN COMPLETE</td>
<td>Third packet in association termination</td>
</tr>
<tr>
<td>192</td>
<td>FORWARD TSN</td>
<td>For adjusting cumulating TSN</td>
</tr>
</tbody>
</table>
**TCP/IP Protocol Suite**

<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>0</td>
</tr>
<tr>
<td>Reserved</td>
<td></td>
</tr>
<tr>
<td>U (unordered)</td>
<td></td>
</tr>
<tr>
<td>B (beginning)</td>
<td></td>
</tr>
<tr>
<td>E (end)</td>
<td></td>
</tr>
<tr>
<td>Length</td>
<td></td>
</tr>
<tr>
<td>Transmission sequence number</td>
<td></td>
</tr>
<tr>
<td>Stream identifier</td>
<td></td>
</tr>
<tr>
<td>Stream sequence number</td>
<td></td>
</tr>
<tr>
<td>Protocol identifier</td>
<td></td>
</tr>
<tr>
<td>User data</td>
<td></td>
</tr>
</tbody>
</table>

- **U (unordered), B (beginning), E (end)**
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.
SCTP, like TCP, is a connection-oriented protocol. However, a connection in SCTP is called an association to emphasize multihoming.

A connection in SCTP is called an association.
Build an Association

✓ Association Establishment
✓ Data Transfer
✓ Association Termination
**Figure 16.19** *Four-way handshaking*

- **INIT** message:
  - Time: 1
  - Init tag: 1200
  - rwnd: 1000
  - Init TSN: 100

- **INIT ACK** message:
  - Time: 2
  - Init tag: 5000
  - rwnd: 2000
  - Init TSN: 1700

- **COOKIE ECHO** message:
  - Time: 3
  - VT: 5000
  - Cookie

- **COOKIE ACK** message:
  - Time: 4
  - VT: 1200
  - Cookie

---

TCP/IP Protocol Suite
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 16.20  Simple data transfer
The acknowledgment in SCTP defines the cumulative TSN, the TSN of the last data chunk received in order.
✓ Multihoming Data Transfer
  ✓ Primary address
  ✓ A source defines the primary address for a destination

✓ Multistream Delivery (U flag)
  ✓ Ordered
  ✓ Unordered: SSN value is ignored

✓ Fragmentation (B and E flags)
  ✓ First fragment: 10
  ✓ Middle fragment: 00
  ✓ Last fragment: 01
  ✓ No fragmentation: 11
Figure 16.21  Association termination

1. Client sends SHUTDOWN with cumulative TSN
2. Server sends SHUTDOWN ACK
3. Client sends SHUTDOWN COMPLETE

Active close
Passive close

Time
Figure 16.22  Association abortion
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.
Figure 16.27  Flow control, receiver site
Figure 16.28  Flow control, sender site

From process

Sending queue

Outstanding chunks

To send

42 41 40 39 38 37 36 35 30 29 28 27 26

37
2000
700

cur TSN
rwnd
inTransit
Figure 16.29  *Flow control scenario*
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. Each implementation uses a different set of entities and timers for the receiver and sender sites. We use a very simple design to convey the concept to the reader.
Figure 16.30 Error-control receiver site

TCP/IP Protocol Suite
Figure 16.31  Error control, sender site

From process

Sending Queue

outstanding chunks

add when timer expires or three SACKs received.

Retransmission Queue

To send

To send

37
2000
1400

curTSN
rwnd
inTransit
SCTP, like TCP, is a transport layer protocol with packets subject to congestion in the network. The SCTP designers have used the same strategies we described for congestion control in Chapter 15 for TCP. SCTP has slow start, congestion avoidance, and congestion detection phases. Like TCP, SCTP also uses fast retransmission and fast recovery.
Summaries:

- To introduce SCTP as a new transport-layer protocol.
- To discuss SCTP services and compare them with TCP.
- To list and explain different packet types used in SCTP and discuss the purpose and field in each packet.
- To discuss SCTP association and explain different scenarios such as association establishment, data transfer, association termination, and association abortion.
- To compare and contrast the state transition diagram of SCTP with the corresponding diagram of TCP.
- To explain flow control, error control, and congestion control mechanism in SCTP and compare them with the similar mechanisms in TCP.