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**Sockets API Extensions for Stream Control Transmission Protocol (SCTP)  
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Abstract

This document describes a mapping of the Stream Control Transmission

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Protocol SCTP [RFC2960](#) [[RFC2960](#)] into a sockets API. The benefits of this mapping include compatibility for TCP applications, access to new SCTP features and a consolidated error and event notification scheme.

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## 1. Introduction

The sockets API has provided a standard mapping of the Internet Protocol suite to many operating systems. Both TCP [RFC793](#) [[RFC0793](#)] and UDP [RFC768](#) [[RFC0768](#)] have benefited from this standard representation and access method across many diverse platforms.

SCTP

is a new protocol that provides many of the characteristics of TCP but also incorporates semantics more akin to UDP. This document defines a method to map the existing sockets API for use with SCTP, providing both a base for access to new features and compatibility

so

that most existing TCP applications can be migrated to SCTP with few (if any) changes.

There are three basic design objectives:

- 1) Maintain consistency with existing sockets APIs:

We define a sockets mapping for SCTP that is consistent with other sockets API protocol mappings (for instance, UDP, TCP, IPv4, and IPv6).

- 2) Support a one-to-many style interface

This set of semantics is similar to that defined for connection-less protocols, such as UDP. A one-to-many style SCTP socket should be able to control multiple SCTP associations. This is similar to an UDP socket, which can communicate with many peer

end

points. Each of these associations is assigned an association ID so that an applications can use the ID to differentiate them. Note that SCTP is connection-oriented in nature, and it does not support broadcast or multicast communications, as UDP does.

- 3) Support a one-to-one style interface

This interface supports a similar semantics as sockets for connection-oriented protocols, such as TCP. A one-to-one style SCTP socket should only control one SCTP association. One purpose of defining this interface is to allow existing applications built on other connection-oriented protocols be ported to use SCTP with very little effort. And developers familiar with those semantics can easily adapt to SCTP. Another purpose is to make sure that existing mechanisms in most Oses to deal with socket, such as `select()`, should continue to work with this style of socket.

Extensions are added to this mapping to provide mechanisms to exploit new features of SCTP.

Goals 2 and 3 are not compatible, so in this document we define two modes of mapping, namely the one-to-many style mapping and the one-to-one style mapping. These two modes share some common data structures and operations, but will require the use of two different application programming styles. Note that all new SCTP features can be used with both styles of socket. The decision on which one to

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depends mainly on the nature of applications.

A mechanism is defined to extract a one-to-many style SCTP association into a one-to-one style socket.

Some of the SCTP mechanisms cannot be adequately mapped to existing socket interface. In some cases, it is more desirable to have new interface instead of using existing socket calls. [Section 8](#) of this document describes those new interface.

## **2. Conventions**

### **2.1. Data Types**

Whenever possible, data types from Draft 6.6 (March 1997) of POSIX 1003.1g are used: `uintN_t` means an unsigned integer of exactly N bits (e.g., `uint16_t`). We also assume the argument data types from 1003.1g when possible (e.g., the final argument to `setsockopt()` is a `size_t` value). Whenever buffer sizes are specified, the POSIX 1003.1 `size_t` data type is used.

## **3. one-to-many style Interface**

The one-to-many style interface has the following characteristics:

- A) Outbound association setup is implicit.
- B) Messages are delivered in complete messages (with one notable exception).
- C) There is a 1 to MANY relationship between socket and association.

### **3.1. Basic Operation**

A typical server in this style uses the following socket calls in sequence to prepare an endpoint for servicing requests:

1. `socket()`
2. `bind()`
3. `listen()`
4. `recvmsg()`
5. `sendmsg()`
6. `close()`

A typical client uses the following calls in sequence to setup an association with a server to request services:



1. `socket()`
2. `sendmsg()`
3. `recvmsg()`
4. `close()`

In this style, by default, all the associations connected to the endpoint are represented with a single socket. Each associations is assigned an association ID (type is `sctp_assoc_t`) so that an application can use it to differentiate between them. In some implementations, the peer endpoints addresses can also be used for this purpose. But this is not required for performance reasons. If an implementation does not support using addresses to differentiate between different associations, the `sendto()` call can only be used to setup an association implicitly. It cannot be used to send data to an established association as the association ID cannot be specified.

Once as association ID is assigned to an SCTP association, that ID will not be reused until the application explicitly terminates the association. The resources belonged to that association will not be freed until that happens. This is similar to the `close()` operation on a normal socket. The only exception is when the `SCTP_AUTOCLOSE` option ([section 7.1.8](#)) is set. In this case, after the association is terminated gracefully automatically, the association ID assigned to it can be reused. All applications using this option should be aware of this to avoid the possible problem of sending data to an incorrect peer end point.

If the server or client wishes to branch an existing association off to a separate socket, it is required to call `sctp_peeloff()` and in the parameter specifies the association identification. The `sctp_peeloff()` call will return a new socket which can then be used with `recv()` and `send()` functions for message passing. See [Section 8.2](#) for more on branched-off associations.

Once an association is branched off to a separate socket, it becomes completely separated from the original socket. All subsequent control and data operations to that association must be done through the new socket. For example, the close operation on the original socket will not terminate any associations that have been branched off to a different socket.

We will discuss the one-to-many style socket calls in more details in the following subsections.

### **3.1.1. socket() - one-to-many style socket**

Applications use `socket()` to create a socket descriptor to represent an SCTP endpoint.



The syntax is,

```
sd = socket(PF_INET, SOCK_SEQPACKET, IPPROTO_SCTP);
```

or,

```
sd = socket(PF_INET6, SOCK_SEQPACKET, IPPROTO_SCTP);
```

Here, SOCK\_SEQPACKET indicates the creation of a one-to-many style socket.

The first form creates an endpoint which can use only IPv4 addresses, while, the second form creates an endpoint which can use both IPv6 and IPv4 addresses.

### **3.1.2. bind() - one-to-many style socket**

Applications use bind() to specify which local address the SCTP endpoint should associate itself with.

An SCTP endpoint can be associated with multiple addresses. To do this, sctp\_bindx() is introduced in section [Section 8.1](#) to help applications do the job of associating multiple addresses.

These addresses associated with a socket are the eligible transport addresses for the endpoint to send and receive data. The endpoint will also present these addresses to its peers during the association initialization process, see [RFC2960](#) [[RFC2960](#)].

After calling bind(), if the endpoint wishes to accept new associations on the socket, it must call listen() (see section [Section 3.1.3](#)).

The syntax of bind() is,

```
ret = bind(int sd, struct sockaddr *addr, socklen_t addrlen);
```

sd - the socket descriptor returned by socket().  
addr - the address structure (struct sockaddr\_in or struct sockaddr\_in6 [RFC2553](#) [[RFC2553](#)]).  
addrlen - the size of the address structure.

If sd is an IPv4 socket, the address passed must be an IPv4 address.  
If the sd is an IPv6 socket, the address passed can either be an IPv4 or an IPv6 address.

Applications cannot call bind() multiple times to associate multiple addresses to an endpoint. After the first call to bind(), all





subsequent calls will return an error.

If `addr` is specified as a wildcard (`INADDR_ANY` for an IPv4 address, or as `IN6ADDR_ANY_INIT` or `in6addr_any` for an IPv6 address), the operating system will associate the endpoint with an optimal address set of the available interfaces.

If a `bind()` is not called prior to a `sendmsg()` call that initiates a new association, the system picks an ephemeral port and will choose an address set equivalent to binding with a wildcard address. One of those addresses will be the primary address for the association. This automatically enables the multi-homing capability of SCTP.

### **3.1.3. listen() - One-to-many style socket**

By default, new associations are not accepted for one-to-many style sockets. An application uses `listen()` to mark a socket as being able to accept new associations. The syntax is,

```
int listen(int sd, int backlog);
```

`sd` - the socket descriptor of the endpoint.  
`backlog` - if `backlog` is non-zero, enable listening else disable listening.

Note that one-to-many style socket consumers do not need to call `accept` to retrieve new associations. Calling `accept()` on a one-to-many style socket should return `EOPNOTSUPP`. Rather, new associations are accepted automatically, and notifications of the new associations are delivered via `recvmsg()` with the `SCTP_ASSOC_CHANGE` event (if these notifications are enabled). Clients will typically not call `listen()`, so that they can be assured that the only associations on the socket will be ones they actively initiated. Server or peer-to-peer sockets, on the other hand, will always accept new associations, so a well-written application using server one-to-many style sockets must be prepared to handle new associations from unwanted peers.

Also note that the `SCTP_ASSOC_CHANGE` event provides the association ID for a new association, so if applications wish to use the association ID as input to other socket calls, they should ensure that the `SCTP_ASSOC_CHANGE` event is enabled.

### **3.1.4. sendmsg() and recvmsg() - one-to-many style socket**

An application uses `sendmsg()` and `recvmsg()` call to transmit data to

and receive data from its peer.

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```
ssize_t sendmsg(int sd, const struct msghdr *message, int flags);
```

```
ssize_t recvmsg(int sd, struct msghdr *message, int flags);
```

sd - the socket descriptor of the endpoint.

message: pointer to the msghdr structure which contains a single user

message and possibly some ancillary data. See [Section 5](#) for complete description of the data structures.

flags - No new flags are defined for SCTP at this level. See [Section 5](#) for SCTP-specific flags used in the msghdr structure.

As we will see in [Section 5](#), along with the user data, the ancillary data field is used to carry the sctp\_sndrcvinfo and/or the sctp\_initmsg structures to perform various SCTP functions including specifying options for sending each user message. Those options, depending on whether sending or receiving, include stream number, stream sequence number, various flags, context and payload protocol Id, etc.

When sending user data with sendmsg(), the msg\_name field in msghdr structure will be filled with one of the transport addresses of the intended receiver. If there is no association existing between the sender and the intended receiver, the sender's SCTP stack will set up a new association and then send the user data (see [Section 3.2](#) for more on implicit association setup).

If a peer sends a SHUTDOWN, a SCTP\_SHUTDOWN\_EVENT notification will be delivered if that notification has been enabled, and no more data can be sent to that association. Any attempt to send more data will cause sendmsg() to return with an ESHUTDOWN error. Note that the socket is still open for reading at this point so it is possible to retrieve notifications.

When receiving a user message with recvmsg(), the msg\_name field in msghdr structure will be populated with the source transport address of the user data. The caller of recvmsg() can use this address information to determine to which association the received user message belongs. Note that if SCTP\_ASSOC\_CHANGE events are disabled, applications must use the peer transport address provided in the msg\_name field by recvmsg() to perform correlation to an association, since they will not have the association ID.

If all data in a single message has been delivered, MSG\_EOR will be set in the msg\_flags field of the msghdr structure (see section [Section 5.1](#)).

If the application does not provide enough buffer space to

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receive a data message, MSG\_EOR will not be set in msg\_flags.

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Successive reads will consume more of the same message until the entire message has been delivered, and MSG\_EOR will be set.

If the SCTP stack is running low on buffers, it may partially deliver a message. In this case, MSG\_EOR will not be set, and more calls to `recvmsg()` will be necessary to completely consume the message. Only one message at a time per stream can be partially delivered.

Note, if the socket is a branched-off socket that only represents one association (see [Section 3.1](#)), the `msg_name` field can be used to override the primary address when sending data.

### **3.1.5. close() - one-to-many style socket**

Applications use `close()` to perform graceful shutdown (as described in [Section 10.1 of RFC2960](#) [[RFC2960](#)]) on ALL the associations currently represented by a one-to-many style socket.

The syntax is:

```
ret = close(int sd);
```

`sd` - the socket descriptor of the associations to be closed.

To gracefully shutdown a specific association represented by the one-to-many style socket, an application should use the `sendmsg()` call, and including the `SCTP_EOF` flag. A user may optionally terminate an association non-gracefully by sending with the `SCTP_ABORT` flag and possibly passing a user specified abort code in the data field.

Both flags `SCTP_EOF` and `SCTP_ABORT` are passed with ancillary data (see [Section 5.2.2](#)) in the `sendmsg` call.

If `sd` in the `close()` call is a branched-off socket representing only one association, the shutdown is performed on that association only.

### **3.1.6. connect() - one-to-many style socket**

An application may use the `connect()` call in the one-to-many style to initiate an association without sending data.

The syntax is:

```
ret = connect(int sd, const struct sockaddr *nam, socklen_t len);
```



sd - the socket descriptor to have a new association added to.  
nam - the address structure (either struct sockaddr\_in or struct  
sockaddr\_in6 defined in [RFC2553](#) [[RFC2553](#)]).  
len - the size of the address.  
Multiple connect() calls can be made on the same socket to create  
multiple associations. This is different from the semantics of  
connect() on a UDP socket.

### **3.2. Implicit Association Setup**

Once the bind() call is complete on a one-to-many style socket, the  
application can begin sending and receiving data using the  
sendmsg()/  
recvmsg() or sendto()/recvfrom() calls, without going through any  
explicit association setup procedures (i.e., no connect() calls  
required).

Whenever sendmsg() or sendto() is called and the SCTP stack at the  
sender finds that there is no association existing between the  
sender  
and the intended receiver (identified by the address passed either  
in  
the msg\_name field of msghdr structure in the sendmsg() call or the  
dest\_addr field in the sendto() call), the SCTP stack will  
automatically setup an association to the intended receiver.

Upon the successful association setup a SCTP\_COMM\_UP notification  
will be dispatched to the socket at both the sender and receiver  
side. This notification can be read by the recvmsg() system call  
(see [Section 3.1.3](#)).

Note, if the SCTP stack at the sender side supports bundling, the  
first user message may be bundled with the COOKIE ECHO message  
[RFC2960](#) [[RFC2960](#)].

When the SCTP stack sets up a new association implicitly, it first  
consults the sctp\_initmsg structure, which is passed along within  
the  
ancillary data in the sendmsg() call (see [Section 5.2.1](#) for details  
of the data structures), for any special options to be used on the  
new association.

If this information is not present in the sendmsg() call, or if the  
implicit association setup is triggered by a sendto() call, the  
default association initialization parameters will be used. These  
default association parameters may be set with respective  
setsockopt() calls or be left to the system defaults.

Implicit association setup cannot be initiated by send()/recv()  
calls.





### **3.3. Non-blocking mode**

Some SCTP users might want to avoid blocking when they call socket interface function.

Once all bind() calls are complete on a one-to-many style socket, the application must set the non-blocking option by a fcntl() (such as O\_NONBLOCK). After which the sendmsg() function returns immediately, and the success or failure of the data message (and possible SCTP\_INITMSG parameters) will be signaled by the SCTP\_ASSOC\_CHANGE event with SCTP\_COMM\_UP or CANT\_START\_ASSOC. If user data could not be sent (due to a CANT\_START\_ASSOC), the sender will also receive a SCTP\_SEND\_FAILED event. Those event(s) can be received by the user calling of recvmsg(). A server (having called listen()) is also notified of an association up event by the reception of a SCTP\_ASSOC\_CHANGE with SCTP\_COMM\_UP via the calling of recvmsg() and possibly the reception of the first data message.

In order to shutdown the association gracefully, the user must call sendmsg() with no data and with the SCTP\_EOF flag set. The function returns immediately, and completion of the graceful shutdown is indicated by an SCTP\_ASSOC\_CHANGE notification of type SHUTDOWN\_COMPLETE (see [Section 5.3.1.1](#)). Note that this can also be done using the sctp\_send() call described in [Section 8.10](#).

An application is recommended to use caution when using select() (or poll()) for writing on a one-to-many style socket. The reason being that interpretation of select on write is implementation specific. Generally a positive return on a select on write would only indicate that one of the associations represented by the one-to-many socket is writable. An application that writes after the select return may still block since the association that was writeable is not the destination association of the write call. Likewise select (or poll()) for reading from a one-to-many socket will only return an indication that one of the associations represented by the socket has data to be read.

An application that wishes to know that a particular association is ready for reading or writing should either use the one-to-one style or use the sctp\_peeloff() (see [Section 8.2](#)) function to separate the association of interest from the one-to-many socket.

### **3.4. Special considerations**

The fact that a one-to-many style socket can provide access to many SCTP associations through a single socket descriptor has important implications for both application programmers and system programmers implementing this API. A key issue is how buffer space inside the



sockets layer is managed. Because this implementation detail directly affects how application programmers must write their code to ensure correct operation and portability, this section provides some guidance to both implementors and application programmers.

An important feature that SCTP shares with TCP is flow control: specifically, a sender may not send data faster than the receiver can consume it.

For TCP, flow control is typically provided for in the sockets API as follows. If the reader stops reading, the sender queues messages in the socket layer until it uses all of its socket buffer space allocation creating a "stalled connection". Further attempts to write to the socket will block or return the error EAGAIN or EWOULDBLOCK for a non-blocking socket. At some point, either the connection is closed, or the receiver begins to read again freeing space in the output queue.

For one-to-one style SCTP sockets (this includes sockets descriptors that were separated from a one-to-many style socket with `sctp_peeloff()`) the behavior is identical. For one-to-many style SCTP sockets, the fact that we have multiple associations on a single socket makes the situation more complicated. If the implementation uses a single buffer space allocation shared by all associations, a single stalled association can prevent the further sending of data on all associations active on a particular one-to-many style socket.

For a blocking socket, it should be clear that a single stalled association can block the entire socket. For this reason, application programmers may want to use non-blocking one-to-many style sockets. The application should at least be able to send messages to the non-stalled associations.

But a non-blocking socket is not sufficient if the API implementor has chosen a single shared buffer allocation for the socket. A single stalled association would eventually cause the shared allocation to fill, and it would become impossible to send even to non-stalled associations.

The API implementor can solve this problem by providing each association with its own allocation of outbound buffer space. Each association should conceptually have as much buffer space as it would have if it had its own socket. As a bonus, this simplifies the implementation of `sctp_peeloff()`.

To ensure that a given stalled association will not prevent other

non-stalled associations from being writable, application  
programmers  
should either:

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- (a) demand that the underlying implementation dedicates independent buffer space allotments to each association (as suggested above), or
  - (b) verify that their application layer protocol does not permit large amounts of unread data at the receiver (this is true of some request-response protocols, for example), or
  - (c) use one-to-one style sockets for association which may potentially stall (either from the beginning, or by using `sctp_peeloff` before sending large amounts of data that may cause a stalled condition).
- An implementation which dedicates independent buffer space for each association should define `HAVE_SCTP_MULTIBUF` to 1.

#### **4. one-to-one style Interface**

The goal of this style is to follow as closely as possible the current practice of using the sockets interface for a connection oriented protocol, such as TCP. This style enables existing applications using connection oriented protocols to be ported to SCTP with very little effort.

Note that some new SCTP features and some new SCTP socket options can only be utilized through the use of `sendmsg()` and `recvmsg()` calls, see [Section 4.1.8](#). Also note that some socket interfaces may not be able to provide data on the third leg of the association set up with this interface style.

##### **4.1. Basic Operation**

A typical server in one-to-one style uses the following system call sequence to prepare an SCTP endpoint for servicing requests:

1. `socket()`
2. `bind()`
3. `listen()`
4. `accept()`

The `accept()` call blocks until a new association is set up. It returns with a new socket descriptor. The server then uses the new socket descriptor to communicate with the client, using `recv()` and `send()` calls to get requests and send back responses.

Then it calls



5. close()

to terminate the association.

A typical client uses the following system call sequence to setup an association with a server to request services:

1. socket()

2. connect()

After returning from connect(), the client uses send() and recv() calls to send out requests and receive responses from the server.

The client calls

3. close()

to terminate this association when done.

#### **4.1.1. socket() - one-to-one style socket**

Applications calls socket() to create a socket descriptor to represent an SCTP endpoint.

The syntax is:

```
int socket(PF_INET, SOCK_STREAM, IPPROTO_SCTP);
```

or,

```
int socket(PF_INET6, SOCK_STREAM, IPPROTO_SCTP);
```

Here, SOCK\_STREAM indicates the creation of a one-to-one style socket.

The first form creates an endpoint which can use only IPv4 addresses,  
while the second form creates an endpoint which can use both IPv6 and  
IPv4 addresses.

#### **4.1.2. bind() - one-to-one style socket**

Applications use bind() to pass an address to be associated with an SCTP endpoint to the system. bind() allows only either a single address or a IPv4 or IPv6 wildcard address to be bound. An SCTP endpoint can be associated with multiple addresses. To do this, sctp\_bindx() is introduced in [Section 8.1](#) to help applications do the  
job of associating multiple addresses.





These addresses associated with a socket are the eligible transport addresses for the endpoint to send and receive data. The endpoint will also present these addresses to its peers during the association initialization process, see [RFC2960](#) [[RFC2960](#)].

The syntax is:

```
int bind(int sd, struct sockaddr *addr, socklen_t addrlen);
```

sd: the socket descriptor returned by `socket()` call.  
addr: the address structure (either `struct sockaddr_in` or `struct sockaddr_in6` defined in [RFC2553](#) [[RFC2553](#)]).  
addrlen: the size of the address structure.

If sd is an IPv4 socket, the address passed must be an IPv4 address. Otherwise, i.e., the sd is an IPv6 socket, the address passed can either be an IPv4 or an IPv6 address.

Applications cannot call `bind()` multiple times to associate multiple addresses to the endpoint. After the first call to `bind()`, all subsequent calls will return an error.

If addr is specified as a wildcard (`INADDR_ANY` for an IPv4 address, or as `IN6ADDR_ANY_INIT` or `in6addr_any` for an IPv6 address), the operating system will associate the endpoint with an optimal address set of the available interfaces.

If a `bind()` is not called prior to the `connect()` call, the system picks an ephemeral port and will choose an address set equivalent to binding with a wildcard address. One of those addresses will be the primary address for the association. This automatically enables the multi-homing capability of SCTP.

The completion of this `bind()` process does not ready the SCTP endpoint to accept inbound SCTP association requests. Until a `listen()` system call, described below, is performed on the socket, the SCTP endpoint will promptly reject an inbound SCTP INIT request with an SCTP ABORT.

#### **4.1.3. listen() - one-to-one style socket**

Applications use `listen()` to ready the SCTP endpoint for accepting inbound associations.

The syntax is:

```
int listen(int sd, int backlog);
```



sd: the socket descriptor of the SCTP endpoint.  
backlog: this specifies the max number of outstanding associations allowed in the socket's accept queue. These are the associations that have finished the four-way initiation handshake (see [Section 5 of RFC2960](#) [[RFC2960](#)]) and are in the ESTABLISHED state. Note,

a backlog of '0' indicates that the caller no longer wishes to receive new associations.

#### **4.1.4. accept() - one-to-one style socket**

Applications use `accept()` call to remove an established SCTP association from the accept queue of the endpoint. A new socket descriptor will be returned from `accept()` to represent the newly formed association.

The syntax is:

```
new_sd = accept(int sd, struct sockaddr *addr, socklen_t *addrlen);
```

new\_sd - the socket descriptor for the newly formed association.  
sd - the listening socket descriptor.  
addr - on return, will contain the primary address of the peer endpoint.  
addrlen - on return, will contain the size of addr.

#### **4.1.5. connect() - one-to-one style socket**

Applications use `connect()` to initiate an association to a peer.

The syntax is:

```
int connect(int sd, const struct sockaddr *addr, socklen_t addrlen);
```

sd - the socket descriptor of the endpoint.  
addr - the peer's address.  
addrlen - the size of the address.

This operation corresponds to the ASSOCIATE primitive described in [section 10.1 of RFC2960](#) [[RFC2960](#)].

By default, the new association created has only one outbound stream.

The `SCTP_INITMSG` option described in [Section 7.1.3](#) should be used before connecting to change the number of outbound streams.

If a `bind()` is not called prior to the `connect()` call, the system picks an ephemeral port and will choose an address set equivalent to binding with `INADDR_ANY` and `IN6ADDR_ANY` for IPv4 and IPv6 socket respectively. One of those addresses will be the primary address for



the association. This automatically enables the multi-homing capability of SCTP.

Note that SCTP allows data exchange, similar to T/TCP [RFC1644](#) [[RFC1644](#)], during the association set up phase. If an application wants to do this, it cannot use `connect()` call. Instead, it should use `sendto()` or `sendmsg()` to initiate an association. If it uses `sendto()` and it wants to change initialization behavior, it needs to use the `SCTP_INITMSG` socket option before calling `sendto()`. Or it can use `SCTP_INIT` type `sendmsg()` to initiate an association without doing the `setsockopt()`. Note that some sockets implementations may not support the sending of data to initiate an association with the one-to-one style (implementations that do not support T/TCP normally have this restriction). Implementations which allow sending of data to initiate an association without calling `connect()` define the preprocessor constant `HAVE_SCTP_NOCONNECT` to 1.

SCTP does not support half close semantics. This means that unlike T/TCP, `MSG_EOF` should not be set in the flags parameter when calling `sendto()` or `sendmsg()` when the call is used to initiate a connection.

`MSG_EOF` is not an acceptable flag with SCTP socket.

#### **4.1.6. close() - one-to-one style socket**

Applications use `close()` to gracefully close down an association.

The syntax is:

```
int close(int sd);
```

`sd` - the socket descriptor of the association to be closed.

After an application calls `close()` on a socket descriptor, no further socket operations will succeed on that descriptor.

#### **4.1.7. shutdown() - one-to-one style socket**

SCTP differs from TCP in that it does not have half closed semantics.

Hence the `shutdown()` call for SCTP is an approximation of the TCP `shutdown()` call, and solves some different problems. Full TCP-compatibility is not provided, so developers porting TCP applications

to SCTP may need to recode sections that use `shutdown()`. (Note that it is possible to achieve the same results as half close in SCTP using SCTP streams.)

The syntax is:

```
int shutdown(int sd, int how);
```

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sd - the socket descriptor of the association to be closed.  
how - Specifies the type of shutdown. The values are as follows:  
SHUT\_RD - Disables further receive operations. No SCTP protocol  
action is taken.  
SHUT\_WR - Disables further send operations, and initiates the  
SCTP  
shutdown sequence.  
SHUT\_RDWR - Disables further send and receive operations and  
initiates the SCTP shutdown sequence.

The major difference between SCTP and TCP shutdown() is that SCTP  
SHUT\_WR initiates immediate and full protocol shutdown, whereas TCP  
SHUT\_WR causes TCP to go into the half closed state. SHUT\_RD  
behaves

the same for SCTP as TCP. The purpose of SCTP SHUT\_WR is to close  
the SCTP association while still leaving the socket descriptor open,  
so that the caller can receive back any data SCTP was unable to  
deliver (see [Section 5.3.1.4](#) for more information).

To perform the ABORT operation described in [RFC2960](#) [[RFC2960](#)]  
[section](#)  
[10.1](#), an application can use the socket option SO\_LINGER. It is  
described in [Section 7.1.4](#).

#### [4.1.8](#). `sendmsg()` and `recvmsg()` - one-to-one style socket

With a one-to-one style socket, the application can also use  
`sendmsg()` and `recvmsg()` to transmit data to and receive data from  
its

peer. The semantics is similar to those used in the one-to-many  
style (section [Section 3.1.3](#)), with the following differences:

1) When sending, the `msg_name` field in the `msg_hdr` is not used to  
specify the intended receiver, rather it is used to indicate a  
preferred peer address if the sender wishes to discourage the stack  
from sending the message to the primary address of the receiver. If  
the transport address given is not part of the current association,  
the data will not be sent and a `SCTP_SEND_FAILED` event will be  
delivered to the application if send failure events are enabled.

#### [4.1.9](#). `getpeername()`

Applications use `getpeername()` to retrieve the primary socket  
address  
of the peer. This call is for TCP compatibility, and is not multi-  
homed. It does not work with one-to-many style sockets. See  
[Section 8.3](#) for a multi-homed/one-to-many style version of the call.

The syntax is:

```
int getpeername(int sd, struct sockaddr *address,  
                socklen_t *len);
```





sd - the socket descriptor to be queried.  
address - On return, the peer primary address is stored in this buffer. If the socket is an IPv4 socket, the address will be IPv4. If the socket is an IPv6 socket, the address will be either an IPv6 or IPv4 address.  
len - The caller should set the length of address here. On return, this is set to the length of the returned address.

If the actual length of the address is greater than the length of the supplied sockaddr structure, the stored address will be truncated.

## **5. Data Structures**

We discuss in this section important data structures which are specific to SCTP and are used with `sendmsg()` and `recvmsg()` calls to control SCTP endpoint operations and to access ancillary information and notifications.

### **5.1. The `msg_hdr` and `cmsghdr` Structures**

The `msg_hdr` structure used in the `sendmsg()` and `recvmsg()` calls, as well as the ancillary data carried in the structure, is the key for the application to set and get various control information from the SCTP endpoint.

The `msg_hdr` and the related `cmsghdr` structures are defined and discussed in details in [RFC2292](#) [[RFC2292](#)]. Here we will cite their definitions from [RFC2292](#) [[RFC2292](#)].

The `msg_hdr` structure:

```
struct msg_hdr {
    void      *msg_name;          /* ptr to socket address structure */
    socklen_t  msg_namelen;       /* size of socket address structure */
    struct iovec *msg_iov;        /* scatter/gather array */
    size_t     msg_iovlen;        /* # elements in msg_iov */
    void      *msg_control;       /* ancillary data */
    socklen_t  msg_controllen;    /* ancillary data buffer length */
    int        msg_flags;         /* flags on received message */
};
```

The `cmsghdr` structure:



```
struct cmsghdr {
    socklen_t  cmsg_len; /* #bytes, including this header */
    int        cmsg_level; /* originating protocol */
    int        cmsg_type; /* protocol-specific type */
                /* followed by unsigned char cmsg_data[]; */
};
```

In the `msg_hdr` structure, the usage of `msg_name` has been discussed in previous sections (see [Section 3.1.3](#) and [Section 4.1.8](#)).

The scatter/gather buffers, or I/O vectors (pointed to by the `msg_iov` field) are treated as a single SCTP data chunk, rather than multiple chunks, for both `sendmsg()` and `recvmsg()`.

The `msg_flags` are not used when sending a message with `sendmsg()`.

If a notification has arrived, `recvmsg()` will return the notification with the `MSG_NOTIFICATION` flag set in `msg_flags`. If the `MSG_NOTIFICATION` flag is not set, `recvmsg()` will return data. See [Section 5.3](#) for more information about notifications.

If all portions of a data frame or notification have been read, `recvmsg()` will return with `MSG_EOR` set in `msg_flags`.

## 5.2. SCTP `msg_control` Structures

A key element of all SCTP-specific socket extensions is the use of ancillary data to specify and access SCTP-specific data via the struct `msg_hdr`'s `msg_control` member used in `sendmsg()` and `recvmsg()`. Fine-grained control over initialization and sending parameters are handled with ancillary data.

Each ancillary data item is preceded by a struct `cmsghdr` (see [Section 5.1](#)), which defines the function and purpose of the data contained in in the `msg_data[]` member.

There are two kinds of ancillary data used by SCTP: initialization data, and, header information (`SNDRCV`). Initialization data (one-to-many style only) sets protocol parameters for new associations. [Section 5.2.1](#) provides more details. Header information can set or report parameters on individual messages in a stream. See [Section 5.2.2](#) for how to use `SNDRCV` ancillary data.

By default on a one-to-one style socket, SCTP will pass no ancillary data; on a one-to-many style socket, SCTP will only pass `SCTP_SNDRCV` and `SCTP_ASSOC_CHANGE` information. Specific ancillary data items can be enabled with socket options defined for SCTP; see [Section 7.3](#).



Note that all ancillary types are fixed length; see [Section 5.4](#) for further discussion on this. These data structures use struct sockaddr\_storage (defined in [RFC2553](#) [[RFC2553](#)]) as a portable, fixed length address format.

Other protocols may also provide ancillary data to the socket layer consumer. These ancillary data items from other protocols may intermingle with SCTP data. For example, the IPv6 socket API definitions ([RFC2292](#) [[RFC2292](#)] and [RFC2553](#) [[RFC2553](#)]) define a number of ancillary data items. If a socket API consumer enables delivery of both SCTP and IPv6 ancillary data, they both may appear in the same msg\_control buffer in any order. An application may thus need to handle other types of ancillary data besides that passed by SCTP.

The sockets application must provide a buffer large enough to accommodate all ancillary data provided via recvmsg(). If the buffer is not large enough, the ancillary data will be truncated and the msghdr's msg\_flags will include MSG\_CTRUNC.

### **5.2.1. SCTP Initiation Structure (SCTP\_INIT)**

This cmsghdr structure provides information for initializing new SCTP associations with sendmsg(). The SCTP\_INITMSG socket option uses this same data structure. This structure is not used for recvmsg().

cmsghdr_level	cmsghdr_type	cmsghdr_data[]
-----	-----	-----
IPPROTO_SCTP	SCTP_INIT	struct sctp_initmsg

Here is the definition of the sctp\_initmsg structure:

```

struct sctp_initmsg {
    uint16_t sinit_num_ostreams;
    uint16_t sinit_max_instreams;
    uint16_t sinit_max_attempts;
    uint16_t sinit_max_init_timeo;
};

```

sinit\_num\_ostreams: 16 bits (unsigned integer)

This is an integer number representing the number of streams that the application wishes to be able to send to. This number is confirmed in the SCTP\_COMM\_UP notification and must be verified since it is a negotiated number with the remote endpoint. The default value of 0 indicates to use the endpoint default value.

sinit\_max\_instreams: 16 bits (unsigned integer)



This value represents the maximum number of inbound streams the application is prepared to support. This value is bounded by the actual implementation. In other words the user MAY be able to support more streams than the Operating System. In such a case, the Operating System limit overrides the value requested by the user. The default value of 0 indicates to use the endpoints default value.

sinit\_max\_attempts: 16 bits (unsigned integer)

This integer specifies how many attempts the SCTP endpoint should make at resending the INIT. This value overrides the system SCTP 'Max.Init.Retransmits' value. The default value of 0 indicates to use the endpoints default value. This is normally set to the system's default 'Max.Init.Retransmit' value.

sinit\_max\_init\_timeo: 16 bits (unsigned integer)

This value represents the largest Time-Out or RTO value (in milliseconds) to use in attempting an INIT. Normally the 'RTO.Max' is used to limit the doubling of the RTO upon timeout. For the INIT message this value MAY override 'RTO.Max'. This value MUST NOT influence 'RTO.Max' during data transmission and is only used to bound the initial setup time. A default value of 0 indicates to use the endpoints default value. This is normally set to the system's 'RTO.Max' value (60 seconds).

### **5.2.2. SCTP Header Information Structure (SCTP\_SNDRCV)**

This cmsghdr structure specifies SCTP options for sendmsg() and describes SCTP header information about a received message through recvmsg().

cmsgh_level	cmsgh_type	cmsgh_data[]
-----	-----	-----
IPPROTO_SCTP	SCTP_SNDRCV	struct sctp_sndrcvinfo

Here is the definition of sctp\_sndrcvinfo:

```
struct sctp_sndrcvinfo {
    uint16_t sinfo_stream;
    uint16_t sinfo_ssn;
    uint16_t sinfo_flags;
    uint32_t sinfo_ppid;
    uint32_t sinfo_context;
    uint32_t sinfo_timetolive;
    uint32_t sinfo_tsn;
    uint32_t sinfo_cumtsn;
    sctp_assoc_t sinfo_assoc_id;
```





```
};
```

sinfo\_stream: 16 bits (unsigned integer)

For `recvmsg()` the SCTP stack places the message's stream number in this value. For `sendmsg()` this value holds the stream number that the application wishes to send this message to. If a sender specifies an invalid stream number an error indication is returned and the call fails.

sinfo\_ssn: 16 bits (unsigned integer)

For `recvmsg()` this value contains the stream sequence number that the remote endpoint placed in the DATA chunk. For fragmented messages this is the same number for all deliveries of the message (if more than one `recvmsg()` is needed to read the message). The `sendmsg()` call will ignore this parameter.

sinfo\_ppid: 32 bits (unsigned integer)

This value in `sendmsg()` is an unsigned integer that is passed to the remote end in each user message. In `recvmsg()` this value is the same

information that was passed by the upper layer in the peer application. Please note that the SCTP stack performs no byte order modification of this field. For example, if the DATA chunk has to contain a given value in network byte order, the SCTP user has to perform the `htonl()` computation.

sinfo\_context: 32 bits (unsigned integer)

This value is an opaque 32 bit context datum that is used in the `sendmsg()` function. This value is passed back to the upper layer if a error occurs on the send of a message and is retrieved with each undelivered message (Note: if a endpoint has done multiple sends, all of which fail, multiple different `sinfo_context` values will be returned. One with each user data message).

sinfo\_flags: 16 bits (unsigned integer)

This field may contain any of the following flags and is composed of a bitwise OR of these values.

`recvmsg()` flags:



SCTP\_UNORDERED - This flag is present when the message was sent non-ordered.

sendmsg() flags:

SCTP\_UNORDERED - This flag requests the un-ordered delivery of the message. If this flag is clear the datagram is considered an ordered send.

SCTP\_ADDR\_OVER - This flag, in the one-to-many style, requests the SCTP stack to override the primary destination address with the address found with the sendto/sendmsg call.

SCTP\_ABORT - Setting this flag causes the specified association to abort by sending an ABORT message to the peer (one-to-many style only). The ABORT chunk will contain an error cause 'User Initiated Abort' with cause code 12. The cause specific information of this error cause is provided in msg\_iov.

SCTP\_EOF - Setting this flag invokes the SCTP graceful shutdown procedures on the specified association. Graceful shutdown assures that all data enqueued by both endpoints is successfully transmitted before closing the association (one-to-many style only).

SCTP\_SENDAALL - This flag, if set, will cause a one-to-many model socket to send the message to all associations that are currently established on this socket. For the one-to-one socket, this flag has no effect.

sinfo\_timetolive: 32 bit (unsigned integer)

For the sending side, this field contains the message time to live in milliseconds. The sending side will expire the message within the specified time period if the message has not been sent to the peer within this time period. This value will override any default value set using any socket option. Also note that the value of 0 is special in that it indicates no timeout should occur on this message.

sinfo\_tsn: 32 bit (unsigned integer)

For the receiving side, this field holds a TSN that was assigned to one of the SCTP Data Chunks.

sinfo\_cumtsn: 32 bit (unsigned integer)

This field will hold the current cumulative TSN as known by the underlying SCTP layer. Note this field is ignored when sending and only valid for a receive operation when sinfo\_flags are set to



SCTP\_UNORDERED.

sinfo\_assoc\_id: sizeof (sctp\_assoc\_t)

The association handle field, `sinfo_assoc_id`, holds the identifier for the association announced in the `SCTP_COMM_UP` notification. All notifications for a given association have the same identifier. Ignored for one-to-one style sockets.

A `sctp_sndrcvinfo` item always corresponds to the data in `msg_iov`.

### 5.2.3. Extended SCTP Header Information Structure (SCTP\_EXTRCV)

This `cmsghdr` structure specifies SCTP options for SCTP header information about a received message via `recvmsg()`. Note that this structure is an extended version of `SCTP_SNDRCV` and will only be received if the user has set the socket option `SCTP_USE_EXT_RCVINFO` to true in addition to any event subscription needed to receive ancillary data..

<code>cmsgh_level</code>	<code>cmsgh_type</code>	<code>cmsgh_data[]</code>
-----	-----	-----
<code>IPPROTO_SCTP</code>	<code>SCTP_SNDRCV</code>	<code>struct sctp_sndrcvinfo</code>

Here is the definition of `sctp_sndrcvinfo`:

```

struct sctp_extrcvinfo {
    uint16_t sinfo_stream;
    uint16_t sinfo_ssn;
    uint16_t sinfo_flags;
    uint32_t sinfo_ppid;
    uint32_t sinfo_context;
    uint32_t sinfo_timetolive;
    uint32_t sinfo_tsn;
    uint32_t sinfo_cumtsn;
    sctp_assoc_t sinfo_assoc_id;
    uint16_t next_flags;
    uint16_t next_stream;
    uint32_t next_asocid;
    uint32_t next_length;
    uint32_t next_ppid;
};

```

`sinfo_stream`: 16 bits (unsigned integer)

For `recvmsg()` the SCTP stack places the message's stream number in this value. For `sendmsg()` this value holds the stream number that



the application wishes to send this message to. If a sender specifies an invalid stream number an error indication is returned and the call fails.

sinfo\_ssn: 16 bits (unsigned integer)

For `recvmsg()` this value contains the stream sequence number that the remote endpoint placed in the DATA chunk. For fragmented messages this is the same number for all deliveries of the message (if more than one `recvmsg()` is needed to read the message). The `sendmsg()` call will ignore this parameter.

sinfo\_ppid: 32 bits (unsigned integer)

This value in `sendmsg()` is an unsigned integer that is passed to the remote end in each user message. In `recvmsg()` this value is the same information that was passed by the upper layer in the peer application. Please note that the SCTP stack performs no byte order modification of this field. For example, if the DATA chunk has to contain a given value in network byte order, the SCTP user has to perform the `htonl()` computation.

sinfo\_context: 32 bits (unsigned integer)

This value is an opaque 32 bit context datum that is used in the `sendmsg()` function. This value is passed back to the upper layer if a error occurs on the send of a message and is retrieved with each undelivered message (Note: if a endpoint has done multiple sends, all of which fail, multiple different `sinfo_context` values will be returned. One with each user data message).

sinfo\_flags: 16 bits (unsigned integer)

This field may contain any of the following flags and is composed of a bitwise OR of these values.

`recvmsg()` flags:

SCTP\_UNORDERED - This flag is present when the message was sent non-ordered.

`sendmsg()` flags:

SCTP\_UNORDERED - This flag requests the un-ordered delivery of the message. If this flag is clear the datagram is considered an ordered send.





SCTP\_ADDR\_OVER - This flag, in the one-to-many style, requests the SCTP stack to override the primary destination address with the address found with the sendto/sendmsg call.

SCTP\_ABORT - Setting this flag causes the specified association to abort by sending an ABORT message to the peer (one-to-many style only). The ABORT chunk will contain an error cause 'User Initiated Abort' with cause code 12. The cause specific information of this error cause is provided in msg\_iov.

SCTP\_EOF - Setting this flag invokes the SCTP graceful shutdown procedures on the specified association. Graceful shutdown assures that all data enqueued by both endpoints is successfully transmitted before closing the association (one-to-many style only).

SCTP\_SENDAALL - This flag, if set, will cause a one-to-many model socket to send the message to all associations that are currently established on this socket. For the one-to-one socket, this flag has no effect.

sinfo\_timetolive: 32 bit (unsigned integer)

For the sending side, this field contains the message time to live in milliseconds. The sending side will expire the message within the specified time period if the message has not been sent to the peer within this time period. This value will override any default value set using any socket option. Also note that the value of 0 is special in that it indicates no timeout should occur on this message.

sinfo\_tsn: 32 bit (unsigned integer)

For the receiving side, this field holds a TSN that was assigned to one of the SCTP Data Chunks.

sinfo\_cumtsn: 32 bit (unsigned integer)

This field will hold the current cumulative TSN as known by the underlying SCTP layer. Note this field is ignored when sending and only valid for a receive operation when sinfo\_flags are set to SCTP\_UNORDERED.

sinfo\_assoc\_id: sizeof (sctp\_assoc\_t)

The association handle field, sinfo\_assoc\_id, holds the identifier for the association announced in the SCTP\_COMM\_UP notification. All notifications for a given association have the same identifier. Ignored for one-to-one style sockets.



A `sctp_sndrcvinfo` item always corresponds to the data in `msg_iov`.

`next_flags`: 16 bit (unsigned integer)

This bitmask will hold one or more of the following values:

`SCTP_NEXT_MSG_AVAIL` - This bit, when set to 1, indicates that next message information is available i.e.: `next_stream`, `next_asocid`, `next_length` and `next_ppid` fields all have valid values. If this bit is set to 0, then these fields are not valid and should be ignored.

`SCTP_NEXT_MSG_ISCOMPLETE` - This bit, when set, indicates that the next message is completely in the receive buffer. The `next_length` field thus contains the entire message size. If this flag is set to 0, then the `next_length` field only contains part of the message size since the message is still being received (it is being partially delivered).

`SCTP_NEXT_MSG_IS_UNORDERED` - This bit, when set, indicates that the next message to be received was sent by the peer as unordered. If this bit is not set (i.e the bit is 0) the next message to be read is an ordered message in the stream specified.

`next_stream`: 16 bit (unsigned integer)

This value, when valid (see `next_flags`), contains the next stream number that will be received on a subsequent call to one of the receive message functions.

`next_asocid`: 32 bit (unsigned integer)

This value, when valid (see `next_flags`), contains the next association identification that will be received on a subsequent call to one of the receive message functions.

`next_length`: 32 bit (unsigned integer)

This value, when valid (see `next_flags`), contains the length of the next message that will be received on a subsequent call to one of the receive message functions. Note that this length may be a partial length depending on the settings of `next_flags`.

`next_ppid`: 32 bit (unsigned integer)

This value, when valid (see `next_flags`), contains the ppid of the next message that will be received on a subsequent call to one of

the  
receive message functions.

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### **5.3. SCTP Events and Notifications**

An SCTP application may need to understand and process events and errors that happen on the SCTP stack. These events include network status changes, association startups, remote operational errors and undeliverable messages. All of these can be essential for the application.

When an SCTP application layer does a `recvmsg()` the message read is normally a data message from a peer endpoint. If the application wishes to have the SCTP stack deliver notifications of non-data events, it sets the appropriate socket option for the notifications it wants. See [Section 7.3](#) for these socket options. When a notification arrives, `recvmsg()` returns the notification in the application-supplied data buffer via `msg_iov`, and sets `MSG_NOTIFICATION` in `msg_flags`.

This section details the notification structures. Every notification structure carries some common fields which provides general information.

A `recvmsg()` call will return only one notification at a time. Just as when reading normal data, it may return part of a notification if the `msg_iov` buffer is not large enough. If a single read is not sufficient, `msg_flags` will have `MSG_EOR` clear. The user **MUST** finish reading the notification before subsequent data can arrive.

#### **5.3.1. SCTP Notification Structure**

The notification structure is defined as the union of all notification types.

```
union sctp_notification {
  struct {
    uint16_t sn_type;           /* Notification type. */
    uint16_t sn_flags;
    uint32_t sn_length;
  } sn_header;
  struct sctp_assoc_change    sn_assoc_change;
  struct sctp_paddr_change   sn_paddr_change;
  struct sctp_remote_error   sn_remote_error;
  struct sctp_send_failed    sn_send_failed;
  struct sctp_shutdown_event sn_shutdown_event;
  struct sctp_adaptation_event sn_adaptation_event;
  struct sctp_pdapi_event    sn_pdapi_event;
  struct sctp_authkey_event  sn_auth_event;
};
```



sn\_type: 16 bits (unsigned integer)

The following list describes the SCTP notification and event types for the field sn\_type.

SCTP\_ASSOC\_CHANGE: This tag indicates that an association has either been opened or closed. Refer to [Section 5.3.1.1](#) for details.

SCTP\_PEER\_ADDR\_CHANGE: This tag indicates that an address that is part of an existing association has experienced a change of state (e.g. a failure or return to service of the reachability of an endpoint via a specific transport address). Please see [Section 5.3.1.2](#) for data structure details.

SCTP\_REMOTE\_ERROR: The attached error message is an Operational Error received from the remote peer. It includes the complete TLV sent by the remote endpoint. See [Section 5.3.1.3](#) for the detailed format.

SCTP\_SEND\_FAILED: The attached datagram could not be sent to the remote endpoint. This structure includes the original SCTP\_SNDRCVINFO that was used in sending this message i.e. this structure uses the sctp\_sndrcvinfo per [Section 5.3.1.4](#).

SCTP\_SHUTDOWN\_EVENT: The peer has sent a SHUTDOWN. No further data should be sent on this socket.

SCTP\_ADAPTATION\_INDICATION: This notification holds the peers indicated adaptation layer. Please see [Section 5.3.1.6](#).

SCTP\_PARTIAL\_DELIVERY\_EVENT: This notification is used to tell a receiver that the partial delivery has been aborted. This may indicate the association is about to be aborted. Please see [Section 5.3.1.7](#)

SCTP\_AUTHENTICATION\_EVENT: This notification is used to tell a receiver that either an error occurred on authentication, or a new key was made active. [Section 5.3.1.8](#)

All standard values for sn\_type are greater than  $2^{15}$ . Values from  $2^{15}$  and down are reserved.

sn\_flags: 16 bits (unsigned integer)

These are notification-specific flags.

sn\_length: 32 bits (unsigned integer)

This is the length of the whole sctp\_notification structure including the sn\_type, sn\_flags, and sn\_length fields.

#### [5.3.1.1](#). SCTP\_ASSOC\_CHANGE

Communication notifications inform the ULP that an SCTP association has either begun or ended. The identifier for a new association is





provided by this notification. The notification information has the following format:

```
struct sctp_assoc_change {
    uint16_t sac_type;
    uint16_t sac_flags;
    uint32_t sac_length;
    uint16_t sac_state;
    uint16_t sac_error;
    uint16_t sac_outbound_streams;
    uint16_t sac_inbound_streams;
    sctp_assoc_t sac_assoc_id;
    uint8_t sac_info[0];
};
```

sac\_type:

It should be SCTP\_ASSOC\_CHANGE.

sac\_flags: 16 bits (unsigned integer)

Currently unused.

sac\_length: 32 bits (unsigned integer)

This field is the total length of the notification data, including the notification header.

sac\_state: 16 bits (signed integer)

This field holds one of a number of values that communicate the event that happened to the association. They include:

Event Name Description

- 
- SCTP\_COMM\_UP - A new association is now ready and data may be exchanged with this peer.
  - SCTP\_COMM\_LOST - The association has failed. The association is now in the closed state. If SEND FAILED notifications are turned on, a SCTP\_COMM\_LOST is followed by a series of SCTP\_SEND\_FAILED events, one for each outstanding message.
  - SCTP\_RESTART - SCTP has detected that the peer has restarted.
  - SCTP\_SHUTDOWN\_COMP - The association has gracefully closed.



SCTP\_CANT\_STR\_ASSOC - The association failed to setup. If non blocking mode is set and data was sent (in the udp mode), a SCTP\_CANT\_STR\_ASSOC is followed by a series of SCTP\_SEND\_FAILED events, one for each outstanding message.

sac\_error: 16 bits (signed integer)

If the state was reached due to a error condition (e.g. SCTP\_COMM\_LOST) any relevant error information is available in this field. This corresponds to the protocol error codes defined in [RFC2960](#) [[RFC2960](#)].

sac\_outbound\_streams: 16 bits (unsigned integer)

sac\_inbound\_streams: 16 bits (unsigned integer)

The maximum number of streams allowed in each direction are available in sac\_outbound\_streams and sac\_inbound streams.

sac\_assoc\_id: sizeof (sctp\_assoc\_t)

The association id field, holds the identifier for the association. All notifications for a given association have the same association identifier. For one-to-one style socket, this field is ignored.

sac\_info: variable

If the sac\_state is SCTP\_COMM\_LOST and an ABORT chunk was received for this association, sac\_info[] contains the complete ABORT chunk as defined in the SCTP specification [RFC2960](#) [[RFC2960](#)] [section 3.3.7](#).

#### **5.3.1.2. SCTP\_PEER\_ADDR\_CHANGE**

When a destination address on a multi-homed peer encounters a change an interface details event is sent. The information has the following structure:

```
struct sctp_paddr_change {
    uint16_t spc_type;
    uint16_t spc_flags;
    uint32_t spc_length;
    struct sockaddr_storage spc_aaddr;
    uint32_t spc_state;
    uint32_t spc_error;
    sctp_assoc_t spc_assoc_id;
}
```



spc\_type:

It should be SCTP\_PEER\_ADDR\_CHANGE.

spc\_flags: 16 bits (unsigned integer)

Currently unused.

spc\_length: 32 bits (unsigned integer)

This field is the total length of the notification data, including the notification header.

spc\_addr: sizeof (struct sockaddr\_storage)

The affected address field, holds the remote peer's address that is encountering the change of state.

spc\_state: 32 bits (signed integer)

This field holds one of a number of values that communicate the event that happened to the address. They include:

Event Name Description

-----

SCTP\_ADDR\_AVAILABLE - This address is now reachable.

SCTP\_ADDR\_UNREACHABLE - The address specified can no longer be reached. Any data sent to this address is rerouted to an alternate until this address becomes reachable.

SCTP\_ADDR\_REMOVED - The address is no longer part of the association.

SCTP\_ADDR\_ADDED - The address is now part of the association.

SCTP\_ADDR\_MADE\_PRIM - This address has now been made to be the primary destination address.

SCTP\_ADDR\_CONFIRMED - This address has now been confirmed as a valid address.

spc\_error: 32 bits (signed integer)

If the state was reached due to any error condition (e.g. SCTP\_ADDR\_UNREACHABLE) any relevant error information is available in this field.

spc\_assoc\_id: sizeof (sctp\_assoc\_t)

The association id field, holds the identifier for the association. All notifications for a given association have the same association identifier. For one-to-one style socket, this field is ignored.



### **5.3.1.3. Sctp\_remote\_error**

A remote peer may send an Operational Error message to its peer. This message indicates a variety of error conditions on an association. The entire ERROR chunk as it appears on the wire is included in a Sctp\_remote\_error event. Please refer to the SCTP specification [RFC2960](#) [[RFC2960](#)] and any extensions for a list of possible error formats. SCTP error notifications have the format:

```
struct sctp_remote_error {
    uint16_t sre_type;
    uint16_t sre_flags;
    uint32_t sre_length;
    uint16_t sre_error;
    sctp_assoc_t sre_assoc_id;
    uint8_t sre_data[0];
};
```

sre\_type:

It should be Sctp\_remote\_error.

sre\_flags: 16 bits (unsigned integer)

Currently unused.

sre\_length: 32 bits (unsigned integer)

This field is the total length of the notification data, including the notification header and the contents of sre\_data.

sre\_error: 16 bits (unsigned integer)

This value represents one of the Operational Error causes defined in the SCTP specification, in network byte order.

sre\_assoc\_id: sizeof (sctp\_assoc\_t)

The association id field, holds the identifier for the association. All notifications for a given association have the same association identifier. For one-to-one style socket, this field is ignored.

sre\_data: variable

This contains the ERROR chunk as defined in the SCTP specification [RFC2960](#) [[RFC2960](#)] [section 3.3.10](#).





#### 5.3.1.4. Sctp\_send\_failed

If SCTP cannot deliver a message it may return the message as a notification.

```
struct sctp_send_failed {
    uint16_t ssf_type;
    uint16_t ssf_flags;
    uint32_t ssf_length;
    uint32_t ssf_error;
    struct sctp_sndrcvinfo ssf_info;
    sctp_assoc_t ssf_assoc_id;
    uint8_t ssf_data[0];
};
```

ssf\_type:

It should be Sctp\_send\_failed.

The flag value will take one of the following values:

Sctp\_data\_unsent - Indicates that the data was never put on the wire.

Sctp\_data\_sent - Indicates that the data was put on the wire. Note that this does not necessarily mean that the data was (or was not) successfully delivered.

ssf\_length: 32 bits (unsigned integer)

This field is the total length of the notification data, including the notification header and the payload in ssf\_data.

ssf\_error: 16 bits (unsigned integer)

This value represents the reason why the send failed, and if set, will be a SCTP protocol error code as defined in [RFC2960](#) [\[RFC2960\]](#) [section 3.3.10](#).

ssf\_info: sizeof (struct sctp\_sndrcvinfo)

The original send information associated with the undelivered message.

ssf\_assoc\_id: sizeof (sctp\_assoc\_t)

The association id field, sf\_assoc\_id, holds the identifier for the association. All notifications for a given association have the same



association identifier. For one-to-one style socket, this field is ignored.

ssf\_data: variable length

The undelivered message, exactly as delivered by the caller to the original send\*() call.

#### **5.3.1.5. Sctp\_shutdown\_event**

When a peer sends a SHUTDOWN, SCTP delivers this notification to inform the application that it should cease sending data.

```
struct sctp_shutdown_event {
    uint16_t sse_type;
    uint16_t sse_flags;
    uint32_t sse_length;
    sctp_assoc_t sse_assoc_id;
};
```

sse\_type

It should be Sctp\_shutdown\_event

sse\_flags: 16 bits (unsigned integer)

Currently unused.

sse\_length: 32 bits (unsigned integer)

This field is the total length of the notification data, including the notification header. It will generally be sizeof (struct sctp\_shutdown\_event).

sse\_flags: 16 bits (unsigned integer)

Currently unused.

sse\_assoc\_id: sizeof (sctp\_assoc\_t)

The association id field, holds the identifier for the association. All notifications for a given association have the same association identifier. For one-to-one style socket, this field is ignored.

#### **5.3.1.6. Sctp\_adaptation\_indication**

When a peer sends a Adaptation Layer Indication parameter , SCTP delivers this notification to inform the application that of the



peers requested adaptation layer.

```
struct sctp_adaptation_event {
    uint16_t sai_type;
    uint16_t sai_flags;
    uint32_t sai_length;
    uint32_t sai_adaptation_ind;
    sctp_assoc_t sai_assoc_id;
};
```

sai\_type

It should be SCTP\_ADAPTATION\_INDICATION

sai\_flags: 16 bits (unsigned integer)

Currently unused.

sai\_length: 32 bits (unsigned integer)

This field is the total length of the notification data, including the notification header. It will generally be sizeof (struct sctp\_adaptation\_event).

sai\_adaptation\_ind: 32 bits (unsigned integer)

This field holds the bit array sent by the peer in the adaptation layer indication parameter. The bits are in network byte order.

sai\_assoc\_id: sizeof (sctp\_assoc\_t)

The association id field, holds the identifier for the association. All notifications for a given association have the same association identifier. For one-to-one style socket, this field is ignored.

#### **5.3.1.7. SCTP\_PARTIAL\_DELIVERY\_EVENT**

When a receiver is engaged in a partial delivery of a message this notification will be used to indicate various events.

```
struct sctp_pdapi_event {
    uint16_t pdapi_type;
    uint16_t pdapi_flags;
    uint32_t pdapi_length;
    uint32_t pdapi_indication;
    sctp_assoc_t pdapi_assoc_id;
};
```



pdapi\_type

It should be SCTP\_PARTIAL\_DELIVERY\_EVENT

pdapi\_flags: 16 bits (unsigned integer)

Currently unused.

pdapi\_length: 32 bits (unsigned integer)

This field is the total length of the notification data, including the notification header. It will generally be sizeof (struct sctp\_pdapi\_event).

pdapi\_indication: 32 bits (unsigned integer)

This field holds the indication being sent to the application possible values include:

SCTP\_PARTIAL\_DELIVERY\_ABORTED

pdapi\_assoc\_id: sizeof (sctp\_assoc\_t)

The association id field, holds the identifier for the association. All notifications for a given association have the same association identifier. For one-to-one style socket, this field is ignored.

#### **5.3.1.8. SCTP\_AUTHENTICATION\_EVENT**

When a receiver is using authentication this message will provide notifications regarding new keys being made active as well as errors.

```
struct sctp_authkey_event {
    uint16_t auth_type;
    uint16_t auth_flags;
    uint32_t auth_length;
    uint32_t auth_keynumber;
    uint32_t auth_altkeynumber;
    uint32_t auth_indication;
    sctp_assoc_t auth_assoc_id;
};
```

auth\_type

It should be SCTP\_AUTHENTICATION\_EVENT

auth\_flags: 16 bits (unsigned integer)





Currently unused.

auth\_length: 32 bits (unsigned integer)

This field is the total length of the notification data, including the notification header. It will generally be sizeof (struct sctp\_authkey\_event).

auth\_keynumber: 32 bits (unsigned integer)

This field holds the keynumber set by the user for the effected key. If more than one key is involved, this will contain one of the keys involved in the notification.

auth\_altkeynumber: 32 bits (unsigned integer)

This field holds an alternate keynumber which is used by some notifications.

auth\_indication: 32 bits (unsigned integer)

This field hold the error or indication being reported. The following values are currently defined:

SCTP\_AUTH\_NEWKEY - this report indicates that a new key has been made active (used for the first time by the peer) and is now the active key. The auth\_keynumber field holds the user specified key number.

auth\_assoc\_id: sizeof (sctp\_assoc\_t)

The association id field, holds the identifier for the association. All notifications for a given association have the same association identifier.

#### **5.4. Ancillary Data Considerations and Semantics**

Programming with ancillary socket data contains some subtleties and pitfalls, which are discussed below.

##### **5.4.1. Multiple Items and Ordering**

Multiple ancillary data items may be included in any call to sendmsg() or recvmsg(); these may include multiple SCTP or non-SCTP items, or both.

The ordering of ancillary data items (either by SCTP or another protocol) is not significant and is implementation-dependent, so applications must not depend on any ordering.



SCTP\_SNDRCV items must always correspond to the data in the msghdr's msg\_iov member. There can be only a single SCTP\_SNDRCV info for each sendmsg() or recvmsg() call.

#### **5.4.2. Accessing and Manipulating Ancillary Data**

Applications can infer the presence of data or ancillary data by examining the msg\_iovlen and msg\_controllen msghdr members, respectively.

Implementations may have different padding requirements for ancillary data, so portable applications should make use of the macros CMSG\_FIRSTHDR, CMSG\_NXTHDR, CMSG\_DATA, CMSG\_SPACE, and CMSG\_LEN. See

[RFC2292](#) [[RFC2292](#)] and your SCTP implementation's documentation for more information. Following is an example, from [RFC2292](#) [[RFC2292](#)], demonstrating the use of these macros to access ancillary data:

```
struct msghdr    msg;
struct cmsghdr  *cmsgptr;

/* fill in msg */

/* call recvmsg() */

for (cmsgptr = CMSG_FIRSTHDR(&msg); cmsgptr != NULL;
     cmsgptr = CMSG_NXTHDR(&msg, cmsgptr)) {
    if (cmsgptr->cmsg_level == ... && cmsgptr->cmsg_type == ... ) {
        u_char *ptr;

        ptr = CMSG_DATA(cmsgptr);
        /* process data pointed to by ptr */
    }
}
```

#### **5.4.3. Control Message Buffer Sizing**

The information conveyed via SCTP\_SNDRCV events will often be fundamental to the correct and sane operation of the sockets application. This is particularly true of the one-to-many semantics, but also of the one-ton-one semantics. For example, if an application needs to send and receive data on different SCTP streams, SCTP\_SNDRCV events are indispensable.

Given that some ancillary data is critical, and that multiple ancillary data items may appear in any order, applications should be carefully written to always provide a large enough buffer to contain all possible ancillary data that can be presented by recvmsg(). If

the buffer is too small, and crucial data is truncated, it may pose  
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fatal error condition.

Thus it is essential that applications be able to deterministically calculate the maximum required buffer size to pass to `recvmsg()`.

One

constraint imposed on this specification that makes this possible is that all ancillary data definitions are of a fixed length. One way to calculate the maximum required buffer size might be to take the sum the sizes of all enabled ancillary data item structures, as calculated by `CMSG_SPACE`. For example, if we enabled `SCTP_SNDRCV_INFO` and `IPV6_RECVPKTINFO` [RFC2292](#) [[RFC2292](#)], we would calculate and allocate the buffer size as follows:

```
size_t total;
void *buf;

total = CMSG_SPACE(sizeof (struct sctp_sndrcvinfo)) +
        CMSG_SPACE(sizeof (struct in6_pktinfo));

buf = malloc(total);
```

We could then use this buffer for `msg_control` on each call to `recvmsg()` and be assured that we would not lose any ancillary data to truncation.

## **6. Common Operations for Both Styles**

### **6.1. `send()`, `recv()`, `sendto()`, `recvfrom()`**

Applications can use `send()` and `sendto()` to transmit data to the peer of an SCTP endpoint. `recv()` and `recvfrom()` can be used to receive data from the peer.

The syntax is:

```
ssize_t send(int sd, const void *msg, size_t len, int flags);
ssize_t sendto(int sd, const void *msg, size_t len, int flags,
               const struct sockaddr *to, socklen_t tolen);
ssize_t recv(int sd, void *buf, size_t len, int flags);
ssize_t recvfrom(int sd, void *buf, size_t len, int flags,
                 struct sockaddr *from, socklen_t *fromlen);
```

`sd` - the socket descriptor of an SCTP endpoint.  
`msg` - the message to be sent.



len - the size of the message or the size of buffer.  
to - one of the peer addresses of the association to be used to send the message.  
tolen - the size of the address.  
buf - the buffer to store a received message.  
from - the buffer to store the peer address used to send the received message.  
fromlen - the size of the from address  
flags - (described below).

These calls give access to only basic SCTP protocol features. If either peer in the association uses multiple streams, or sends unordered data these calls will usually be inadequate, and may deliver the data in unpredictable ways.

SCTP has the concept of multiple streams in one association. The above calls do not allow the caller to specify on which stream a message should be sent. The system uses stream 0 as the default stream for send() and sendto(). recv() and recvfrom() return data from any stream, but the caller can not distinguish the different streams. This may result in data seeming to arrive out of order. Similarly, if a data chunk is sent unordered, recv() and recvfrom() provide no indication.

SCTP is message based. The msg buffer above in send() and sendto() is considered to be a single message. This means that if the caller wants to send a message which is composed by several buffers, the caller needs to combine them before calling send() or sendto(). Alternately, the caller can use sendmsg() to do that without combining them. recv() and recvfrom() cannot distinguish message boundaries.

In receiving, if the buffer supplied is not large enough to hold a complete message, the receive call acts like a stream socket and returns as much data as will fit in the buffer.

Note, the send() and recv() calls may not be used for a one-to-many style socket.

Note, if an application calls a send function with no user data and no ancillary data the SCTP implementation should reject the request with an appropriate error message. An implementation is NOT allowed to send a Data chunk with no user data [RFC2960](#) [[RFC2960](#)].

## **6.2. setsockopt(), getsockopt()**

Applications use setsockopt() and getsockopt() to set or retrieve socket options. Socket options are used to change the default





behavior of sockets calls. They are described in [Section 7](#)

The syntax is:

```
ret = getsockopt(int sd, int level, int optname, void *optval,  
                socklen_t *optlen);  
ret = setsockopt(int sd, int level, int optname, const void *optval,  
                socklen_t optlen);
```

sd - the socket descriptor.

level - set to IPPROTO\_SCTP for all SCTP options.

optname - the option name.

optval - the buffer to store the value of the option.

optlen - the size of the buffer (or the length of the option  
returned).

All socket options set on a 1-to-1 listening sockets also apply all  
accepted sockets. All socket options set on a 1-to-many socket  
using  
the assoc\_id 0 applies for all future assocs on the socket.

### [6.3.](#) read() and write()

Applications can use read() and write() to send and receive data to  
and from peer. They have the same semantics as send() and recv()  
except that the flags parameter cannot be used.

Note, these calls, when used in the one-to-many style, may only be  
used with branched off socket descriptors (see [Section 8.2](#)).

### [6.4.](#) getsockname()

Applications use getsockname() to retrieve the locally-bound socket  
address of the specified socket. This is especially useful if the  
caller let SCTP chose a local port. This call is for where the  
endpoint is not multi-homed. It does not work well with multi-homed  
sockets. See [Section 8.5](#) for a multi-homed version of the call.

The syntax is:

```
int getsockname(int sd, struct sockaddr *address,  
                socklen_t *len);
```

sd - the socket descriptor to be queried.



address - On return, one locally bound address (chosen by the SCTP stack) is stored in this buffer. If the socket is an IPv4 socket, the address will be IPv4. If the socket is an IPv6 socket, the address will be either an IPv6 or IPv4 address.  
len - The caller should set the length of address here. On return, this is set to the length of the returned address.

If the actual length of the address is greater than the length of the supplied sockaddr structure, the stored address will be truncated.

If the socket has not been bound to a local name, the value stored in the object pointed to by address is unspecified.

## **7. Socket Options**

The following sub-section describes various SCTP level socket options that are common to both styles. SCTP associations can be multi-homed. Therefore, certain option parameters include a sockaddr\_storage structure to select which peer address the option should be applied to.

For the one-to-many style sockets, an sctp\_assoc\_t structure (association ID) is used to identify the the association instance that the operation affects. So it must be set when using this style.

For the one-to-one style sockets and branched off one-to-many style sockets (see [Section 8.2](#)) this association ID parameter is ignored.

Note that socket or IP level options are set or retrieved per socket.

This means that for one-to-many style sockets, those options will be applied to all associations belonging to the socket. And for one-to-one style, those options will be applied to all peer addresses of the association controlled by the socket. Applications should be very careful in setting those options.

For some IP stacks getsockopt() is read-only; so a new interface will be needed when information must be passed both in to and out of the SCTP stack. The syntax for sctp\_opt\_info() is,

```
int sctp_opt_info(int sd,
                  sctp_assoc_t id,
                  int opt,
```

```
void *arg,  
socklen_t *size);
```

The `sctp_opt_info()` call is a replacement for `getsockopt()` only and will not set any options associated with the specified socket. A

setsockopt() must be used to set any writeable option.

For one-to-many style sockets, id specifies the association to query.

For one-to-one style sockets, id is ignored.

opt specifies which SCTP socket option to get. It can get any socket

option currently supported that requests information (either read/write options or read only) such as:

SCTP\_RTOINFO  
SCTP\_ASSOCINFO  
SCTP\_DEFAULT\_SEND\_PARAM  
SCTP\_GET\_PEER\_ADDR\_INFO  
SCTP\_PRIMARY\_ADDR  
SCTP\_PEER\_ADDR\_PARAMS  
SCTP\_STATUS  
SCTP\_AUTH\_ACTIVE\_KEY  
SCTP\_PEER\_AUTH\_CHUNKS  
SCTP\_LOCAL\_AUTH\_CHUNKS

arg is an option-specific structure buffer provided by the caller. See [Section 8.5](#) subsections for more information on these options and option-specific structures.

sctp\_opt\_info() returns 0 on success, or on failure returns -1 and sets errno to the appropriate error code.

All options that support specific settings on an association by filling in either an association id variable or a sockaddr\_storage SHOULD also support setting of the same value for the entire endpoint

(i.e. future associations). To accomplish this the following logic is used when setting one of these options:

- a) If an address is specified via a sockaddr\_storage that is included in the structure, the address is used to lookup the association and the settings are applied to the specific address (if appropriate) or to the entire association.
- b) If an association identification is filled in but not a sockaddr\_storage (if present), the association is found using the association identification and the settings should be applied to the entire association (since a specific address is not specified). Note this also applies to options that hold an association identification in their structure but do not have a sockaddr\_storage field.
- c) If neither the sockaddr\_storage or association identification is set, i.e. the sockaddr\_storage is set to all 0's (INADDR\_ANY) and the association identification is 0, the settings are a default and to be applied to the endpoint (all future associations).



## **7.1. Read / Write Options**

### **7.1.1. Retransmission Timeout Parameters (SCTP\_RTOINFO)**

The protocol parameters used to initialize and bound retransmission timeout (RTO) are tunable. See [RFC2960](#) [[RFC2960](#)] for more information on how these parameters are used in RTO calculation.

The following structure is used to access and modify these parameters:

```
struct sctp_rtoinfo {
    sctp_assoc_t      srto_assoc_id;
    uint32_t          srto_initial;
    uint32_t          srto_max;
    uint32_t          srto_min;
};
```

srto\_initial - This contains the initial RTO value.

srto\_max and srto\_min - These contain the maximum and minimum bounds for all RTOs.

srto\_assoc\_id - (one-to-many style socket) This is filled in the application, and identifies the association for this query. If this parameter is '0' (on a one-to-many style socket), then the change effects the entire endpoint.

All parameters are time values, in milliseconds. A value of 0, when modifying the parameters, indicates that the current value should not be changed.

To access or modify these parameters, the application should call `getsockopt` or `setsockopt()` respectively with the option name `SCTP_RTOINFO`.

### **7.1.2. Association Parameters (SCTP\_ASSOCINFO)**

This option is used to both examine and set various association and endpoint parameters.

See [RFC2960](#) [[RFC2960](#)] for more information on how this parameter is used. The peer address parameter is ignored for one-to-one style socket.

The following structure is used to access and modify this parameters:





```
struct sctp_assocparams {
    sctp_assoc_t    sasoc_assoc_id;
    uint16_t        sasoc_asocmaxrxt;
    uint16_t        sasoc_number_peer_destinations;
    uint32_t        sasoc_peer_rwnd;
    uint32_t        sasoc_local_rwnd;
    uint32_t        sasoc_cookie_life;
};
```

sasoc\_asocmaxrxt - This contains the maximum retransmission attempts to make for the association.

sasoc\_number\_peer\_destinations - This is the number of destination addresses that the peer has.

sasoc\_peer\_rwnd - This holds the current value of the peers rwnd (reported in the last SACK) minus any outstanding data (i.e. data in flight).

sasoc\_local\_rwnd - This holds the last reported rwnd that was sent to the peer.

sasoc\_cookie\_life - This is the associations cookie life value used when issuing cookies.

sasoc\_assoc\_id - This is filled in the application, and identifies the association for this query.

This information may be examined for either the endpoint or a specific association. To examine a endpoints default parameters the association id (sasoc\_assoc\_id) should must be set to the value '0'. The values of the sasoc\_peer\_rwnd is meaningless when examining endpoint information.

All parameters are time values, in milliseconds. A value of 0, when modifying the parameters, indicates that the current value should not be changed.

The values of the sasoc\_asocmaxrxt and sasoc\_cookie\_life may be set on either an endpoint or association basis. The rwnd and destination counts (sasoc\_number\_peer\_destinations, sasoc\_peer\_rwnd, sasoc\_local\_rwnd) are NOT settable and any value placed in these is ignored.

To access or modify these parameters, the application should call getsockopt or setsockopt() respectively with the option name SCTP\_ASSOCINFO.

The maximum number of retransmissions before an address is considered unreachable is also tunable, but is address-specific, so it is covered in a separate option. If an application attempts to set the value of the association maximum retransmission parameter to more than the sum of all maximum retransmission parameters, setsockopt()



shall return an error. The reason for this, from [RFC2960](#) [[RFC2960](#)] [section 8.2](#):

Note: When configuring the SCTP endpoint, the user should avoid having the value of 'Association.Max.Retrans' larger than the summation of the 'Path.Max.Retrans' of all the destination addresses for the remote endpoint. Otherwise, all the destination addresses may become inactive while the endpoint still considers the peer endpoint reachable.

### **7.1.3. Initialization Parameters (SCTP\_INITMSG)**

Applications can specify protocol parameters for the default association initialization. The structure used to access and modify these parameters is defined in [Section 5.2.1](#)). The option name argument to `setsockopt()` and `getsockopt()` is `SCTP_INITMSG`.

Setting initialization parameters is effective only on an unconnected socket (for one-to-many style sockets only future associations are effected by the change). With one-to-one style sockets, this option is inherited by sockets derived from a listener socket.

### **7.1.4. SO\_LINGER**

An application using the one-to-one style socket can use this option to perform the SCTP ABORT primitive. The linger option structure is:

```
struct linger {
    int    l_onoff;           /* option on/off */
    int    l_linger;         /* linger time */
};
```

To enable the option, set `l_onoff` to 1. If the `l_linger` value is set to 0, calling `close()` is the same as the ABORT primitive. If the value is set to a negative value, the `setsockopt()` call will return an error. If the value is set to a positive value `linger_time`, the `close()` can be blocked for at most `linger_time` ms. If the graceful shutdown phase does not finish during this period, `close()` will return but the graceful shutdown phase continues in the system.

Note, this is a socket level option NOT an SCTP level option. So when setting `SO_LINGER` you must specify a level of `SOL_SOCKET` in the `setsockopt()` call.

### **7.1.5. SCTP\_NODELAY**

Turn on/off any Nagle-like algorithm. This means that packets are generally sent as soon as possible and no unnecessary delays are



introduced, at the cost of more packets in the network. Expects an integer boolean flag.

#### **7.1.6. SO\_RCVBUF**

Sets receive buffer size in octets. For SCTP one-to-one style sockets, this controls the receiver window size. For one-to-many style sockets the meaning depends on the constant HAVE\_SCTP\_MULTIBUF (see [Section 3.4](#)). If the implementation defines HAVE\_SCTP\_MULTIBUF as 1, this controls the receiver window size for each association bound to the socket descriptor. If the implementation defines HAVE\_SCTP\_MULTIBUF as 0, this controls the size of the single receive buffer for the whole socket. The call expects an integer.

#### **7.1.7. SO\_SNDBUF**

Sets send buffer size. For SCTP one-to-one style sockets, this controls the amount of data SCTP may have waiting in internal buffers to be sent. This option therefore bounds the maximum size of data that can be sent in a single send call. For one-to-many style sockets, the effect is the same, except that it applies to one or all associations (see [Section 3.4](#)) bound to the socket descriptor used in the setsockopt() or getsockopt() call. The option applies to each association's window size separately. The call expects an integer.

#### **7.1.8. Automatic Close of associations (SCTP\_AUTOCLOSE)**

This socket option is applicable to the one-to-many style socket only. When set it will cause associations that are idle for more than the specified number of seconds to automatically close using the graceful shutdown procedure. An association being idle is defined as an association that has NOT sent or received user data. The special value of '0' indicates that no automatic close of any associations should be performed, this is the default value. The option expects an integer defining the number of seconds of idle time before an association is closed.

An application using this option should enable receiving the association change notification. This is the only mechanism an application is informed about the closing of an association. After an association is closed, the association ID assigned to it can be reused. An application should be aware of this to avoid the possible problem of sending data to an incorrect peer end point.

#### **7.1.9. Set Peer Primary Address (SCTP\_SET\_PEER\_PRIMARY\_ADDR)**

Requests that the peer mark the enclosed address as the association primary. The enclosed address must be one of the association's

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locally bound addresses. The following structure is used to make a set primary request:

```
struct sctp_setpeerprim {
    sctp_assoc_t      sspp_assoc_id;
    struct sockaddr_storage sspp_addr;
};
```

sspp\_addr - The address to set as primary  
sspp\_assoc\_id - This is filled in by the application, and identifies the association for this request.

This functionality is optional. Implementations that do not support this functionality should return EOPNOTSUPP.

#### **7.1.10. Set Primary Address (SCTP\_PRIMARY\_ADDR)**

Requests that the local SCTP stack use the enclosed peer address as the association primary. The enclosed address must be one of the association peer's addresses. The following structure is used to make a set peer primary request:

```
struct sctp_setprim {
    sctp_assoc_t      ssp_assoc_id;
    struct sockaddr_storage ssp_addr;
};
```

ssp\_addr - The address to set as primary  
ssp\_assoc\_id - This is filled in by the application, and identifies the association for this request.

#### **7.1.11. Set Adaptation Layer Indicator (SCTP\_ADAPTATION\_LAYER)**

Requests that the local endpoint set the specified Adaptation Layer Indication parameter for all future INIT and INIT-ACK exchanges.

```
struct sctp_setadaptation {
    uint32_t  ssb_adaptation_ind;
};
```

ssb\_adaptation\_ind - The adaptation layer indicator that will be included in any outgoing Adaptation Layer Indication parameter

#### **7.1.12. Enable/Disable message fragmentation (SCTP\_DISABLE\_FRAGMENTS)**

This option is a on/off flag and is passed an integer where a non-





zero is on and a zero is off. If enabled no SCTP message fragmentation will be performed. Instead if a message being sent exceeds the current PMTU size, the message will NOT be sent and instead a error will be indicated to the user.

### **7.1.13. Peer Address Parameters (SCTP\_PEER\_ADDR\_PARAMS)**

Applications can enable or disable heartbeats for any peer address of an association, modify an address's heartbeat interval, force a heartbeat to be sent immediately, and adjust the address's maximum number of retransmissions sent before an address is considered unreachable. The following structure is used to access and modify an address's parameters:

```
struct sctp_paddrparams {
    sctp_assoc_t      spp_assoc_id;
    struct sockaddr_storage spp_address;
    uint32_t          spp_hbinterval;
    uint16_t          spp_pathmaxrxt;
    uint32_t          spp_pathmtu;
    uint32_t          spp_sackdelay;
    uint32_t          spp_flags;
    uint32_t          spp_ipv6_flowlabel;
    uint8_t           spp_ipv4_tos;
};
```

spp\_assoc\_id - (one-to-many style socket) This is filled in the application, and identifies the association for this query.

spp\_address - This specifies which address is of interest.

spp\_hbinterval - This contains the value of the heartbeat interval, in milliseconds. Note that unless the spp\_flag is set to SPP\_HB\_ENABLE the value of this field is ignored. Note also that a value of zero indicates the current setting should be left unchanged. To set an actual value of zero the use of the flag SPP\_HB\_TIME\_IS\_ZERO should be used.

spp\_pathmaxrxt - This contains the maximum number of retransmissions before this address shall be considered unreachable. Note that unless the spp\_flag is set to SPP\_PMTUD\_ENABLE the value of this field is ignored. Note also that a value of zero indicates the current setting should be left unchanged.

spp\_pathmtu - When Path MTU discovery is disabled the value specified

here will be the "fixed" path mtu (i.e. the value of the

spp\_flags

field must include the flag SPP\_PMTUD\_DISABLE for this field to have any effect). Note that if the spp\_address field is empty then all associations on this address will have this fixed path mtu set upon them. If an address is specified, then only that address will be effected.



spp\_sackdelay - When delayed sack is enabled, this value specifies the number of milliseconds that sacks will be delayed for. This value will apply to all addresses of an association if the spp\_address field is empty. Note that unless the spp\_flag is set to SPP\_SACKDELAY\_ENABLE the value of this field is ignored. Note also that a value of zero indicates the current setting should be left unchanged.

spp\_ipv6\_flowlabel- This field is used in conjunction with the SPP\_IPV4\_FLOWLABEL flag.

spp\_ipv4\_tos- This field is used in conjunction with the SPP\_IPV4\_TOS flag.

spp\_flags- These flags are used to control various features on an association. The flag field is a bit mask which may contain zero or more of the following options:

SPP\_HB\_ENABLE - Enable heartbeats on the specified address. Note that if the address field is empty all addresses for the association have heartbeats enabled upon them.

SPP\_HB\_DISABLE - Disable heartbeats on the specified address. Note that if the address field is empty all addresses for the association will have their heartbeats disabled. Note also that SPP\_HB\_ENABLE and SPP\_HB\_DISABLE are mutually exclusive, only one of these two should be specified. Enabling both fields will have undetermined results.

SPP\_HB\_DEMAND - Request a user initiated heartbeat to be made immediately.

SPP\_HB\_TIME\_IS\_ZERO - Specify's that the time for heartbeat delay is to be set to the value of 0 milliseconds.

SPP\_PMTUD\_ENABLE - This field will enable PMTU discovery upon the specified address. Note that if the address field is empty then all addresses on the association are effected.

SPP\_PMTUD\_DISABLE - This field will disable PMTU discovery upon the specified address. Note that if the address field is

empty

then all addresses on the association are effected. Not also that SPP\_PMTUD\_ENABLE and SPP\_PMTUD\_DISABLE are mutually exclusive. Enabling both will have undetermined results.

SPP\_SACKDELAY\_ENABLE - Setting this flag turns on delayed sack. The time specified in spp\_sackdelay is used to specify the

sack

delay for this address. Note that if spp\_address is empty

then

all addresses will enable delayed sack and take on the sack delay value specified in spp\_sackdelay.

SPP\_SACKDELAY\_DISABLE - Setting this flag turns off delayed sack. If the spp\_address field is blank then delayed sack is

disabled

for the entire association. Note also that this field is mutually exclusive to SPP\_SACKDELAY\_ENABLE, setting both will have undefined results.



SPP\_IPV6\_FLOWLABEL - Setting this flag enables setting of the  
IPV6  
flowlabel value associated with either the association or the  
specific address. If the address field is filled in, then the  
specific destination address has this value set upon it. If  
the association is specified, but not the address, then the  
flowlabel value is set for any future destination addresses  
that may be added. The value is obtained in the  
spp\_ipv6\_flowlabel field.

Upon retrieval, this flag will be set to indicate that the  
spp\_ipv6\_flowlabel field has a valid value returned. If a  
specific destination addresses is set (in the spp\_address  
field) when called then the value returned is that of the  
address. If just an association is specified (and no address)  
then the association default flowlabel is returned. If

neither  
an association nor an destination is specified, then the  
sockets default flowlabel is returned. For non IPv6 sockets,  
then this flag will be left cleared.

SPP\_IPV4\_TOS - Setting this flag enables setting of the IPV4 tos  
value associated with either the association or specific  
address. If the address field is filled in, then the specific  
destination address has this value set upon it. If the  
association is specified, but not the address, then the tos  
value is set for any future destination addresses that may be  
added. The value is obtained in the spp\_ipv4\_tos field.

Upon retrieval, this flag will be set to indicate that the  
spp\_ipv4\_tos field has a valid value returned. If a specific  
destination addresses is set when called (in the spp\_address  
field) then that specific destination addresses tos value is  
returned. If just an association is specified then the  
association default tos is returned. If neither an

association  
nor an destination is specified, then the sockets default tos  
is returned. For non IPv4 sockets, then this flag will be  
left  
cleared.

To read or modify these parameters, the application should call  
sctp\_opt\_info() with the SCTP\_PEER\_ADDR\_PARAMS option.

#### **7.1.14. Set default send parameters (SCTP\_DEFAULT\_SEND\_PARAM)**

Applications that wish to use the sendto() system call may wish to  
specify a default set of parameters that would normally be supplied  
through the inclusion of ancillary data. This socket option allows  
such an application to set the default sctp\_sndrcvinfo structure.  
The application that wishes to use this socket option simply passes  
in to this call the sctp\_sndrcvinfo structure defined in  
[Section 5.2.2](#)) The input parameters accepted by this call include



sinfo\_stream, sinfo\_flags, sinfo\_ppid, sinfo\_context, sinfo\_timetolive. The sinfo\_assoc\_id field specifies the default association used for send operations on one-to-many style sockets. It is ignored on the one-to-one style. Note that setting the sinfo\_assoc\_id field to zero indicates that the users wishes to set the endpoint default send parameters for all future associations.

#### **7.1.15. Set notification and ancillary events (SCTP\_EVENTS)**

This socket option is used to specify various notifications and ancillary data the user wishes to receive. Please see [Section 7.3](#)) for a full description of this option and its usage.

#### **7.1.16. Set/clear IPv4 mapped addresses (SCTP\_I\_WANT\_MAPPED\_V4\_ADDR)**

This socket option is a boolean flag which turns on or off mapped V4 addresses. If this option is turned on and the socket is type PF\_INET6, then IPv4 addresses will be mapped to V6 representation. If this option is turned off, then no mapping will be done of V4 addresses and a user will receive both PF\_INET6 and PF\_INET type addresses on the socket.

By default this option is turned on and expects an integer to be passed where non-zero turns on the option and zero turns off the option.

#### **7.1.17. Set the maximum fragmentation size (SCTP\_MAXSEG)**

This socket option specifies the maximum size to put in any outgoing SCTP DATA chunk. If a message is larger than this size it will be fragmented by SCTP into the specified size. Note that the underlying SCTP implementation may fragment into smaller sized chunks when the PMTU of the underlying association is smaller than the value set by the user. The option expects an integer.

The default value for this option is '0' which indicates the user is NOT limiting fragmentation and only the PMTU will effect SCTP's choice of DATA chunk size.

#### **7.1.18. Add a chunk that must be authenticated (SCTP\_AUTH\_CHUNK)**

This option adds a chunk type that the user is requesting to be received only in an authenticated way. Changes to the list of chunks will only effect future associations on the socket.





```
struct sctp_authchunk {
    uint8_t          sauth_chunk;
};
```

sauth\_chunks - This parameter contains a chunk type that the user is requesting to be authenticated.

The chunk types for INIT, INIT-ACK, COOKIE-ECHO, COOKIE-ACK, SHUTDOWN-COMPLETE, and AUTH chunks MUST not be used. If they are used an error MUST be returned. The usage of this option enables SCTP-AUTH in cases where it is not required by other means (for example the use of ADD-IP).

#### **7.1.19. Get or set the list of supported HMAC Identifiers (SCTP\_HMAC\_IDENT)**

This option gets or sets the list of HMAC algorithms that the local endpoint requires the peer to use.

```
struct sctp_hmacalgo {
    uint32_t          shmac_idents[];
};
```

shmac\_idents - This parameter contains an array of HMAC Identifiers that the local endpoint is requesting the peer to use, in priority order.

#### **7.1.20. Set a shared key (SCTP\_AUTH\_KEY)**

This option will set a shared secret key which is used to build an association shared key.

```
struct sctp_authkey {
    sctp_assoc_t      sca_assoc_id;
    uint32_t          sca_keynumber;
    uint8_t           sca_key[];
};
```

sca\_assoc\_id - This parameter, if non-zero, indicates what association that the shared key is being set upon. Note that if this element contains zero, then the shared key is set upon the endpoint and all future associations will use this key (if not changed by subsequent calls to SCTP\_AUTH\_KEY). For one-to-one sockets, this parameter is ignored. Note, however, that this



option will set a key on the association if the socket is connected, otherwise this will set a key on the endpoint.  
sca\_keynumber - this parameter is the shared key identifier by which the application will refer to this key. If a key of the specified index already exists, then this new key will replace the old existing key. Note that shared key identifier '0' defaults to a null key.  
sca\_key - This parameter contains an array of bytes that is to be used by the endpoint (or association) as the shared secret key. Note, if the length of this field is zero, a null key is set.

#### **7.1.21. Get or set the active shared key (SCTP\_AUTH\_ACTIVE\_KEY)**

This option will get or set the active shared key to be used to build the association shared key.

```
struct sctp_authkeyid {  
    sctp_assoc_t          scact_assoc_id;  
    uint32_t             scact_keynumber;  
};
```

scact\_assoc\_id - This parameter, if non-zero, indicates what association that the shared key identifier is being set active upon. Note that if this element contains zero, then the activation applies to the endpoint and all future associations will use the specified shared key identifier. For one-to-one sockets, this parameter is ignored. Note, however, that this option will set the active key on the association if the socket is connected, otherwise this will set the default active key for the endpoint.  
scact\_keynumber - this parameter is the shared key identifier which the application is requesting to become the active shared key to be used for sending authenticated chunks. The key identifier MUST correspond to an existing shared key. Note that shared key identifier '0' defaults to a null key.

#### **7.1.22. Delete a shared key (SCTP\_AUTH\_DELETE\_KEY)**

This option will delete a shared secret key from use.

```
struct sctp_authkeyid {  
    sctp_assoc_t          scact_assoc_id;  
    uint32_t             scact_keynumber;  
};
```



scact\_assoc\_id - This parameter, if non-zero, indicates what association that the shared key identifier is being deleted from. Note that if this element contains zero, then the shared key is deleted from the endpoint and all associations will no longer use the specified shared key identifier (unless otherwise set on the association using SCTP\_AUTH\_KEY). For one-to-one sockets, this parameter is ignored. Note, however, that this option will delete the key from the association if the socket is connected, otherwise this will delete the key from the endpoint.

scact\_keynumber - this parameter is the shared key identifier which the application is requesting to be deleted. The key identifier MUST correspond to an existing shared key and MUST NOT be the current active key. Note if this parameter is zero, use of the null key identifier '0' is disabled on the endpoint and/or association.

#### **7.1.23. Get or set delayed ack timer (SCTP\_DELAYED\_ACK\_TIME)**

This options will get or set the delayed ack timer. The time is set in milliseconds. If the assoc\_id is 0, then this sets or gets the endpoints default delayed ack timer value. If the assoc\_id field is non-zero, then the set or get effects the specified association.

```
struct sctp_assoc_value {
    sctp_assoc_t      assoc_id;
    uint32_t          assoc_value;
};
```

assoc\_id - This parameter, indicates which association the user is performing an action upon. Note that if this field's value is zero then the endpoints default value is changed (effecting future associations only).

assoc\_value - This parameter contains the number of milliseconds that the user is requesting the delayed ACK timer be set to. Note that this value is defined in the standard to be between 200 and 500 milliseconds.

#### **7.1.24. Get or set fragmented interleave (SCTP\_FRAGMENT\_INTERLEAVE)**

This options will at a minimum specify if the implementation is doing fragmented interleave. Fragmented interleave, for a one to many socket, is when subsequent calls to receive a message may return parts of messages from different associations. Some implementations may allow you to turn this value on or off. If so, when turned off,

no fragment interleave will occur (which will cause a head of line blocking amongst multiple associations sharing the same one to many

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socket). When this option is turned on, then each receive call may come from a different association (thus the user must receive data with the extended calls (e.g. `sctp_recvmsg`) to keep track of which association each receive belongs to.

This option takes a boolean value. A non-zero value indicates that fragmented interleave is on. A value of zero indicates that fragmented interleave is off.

Note that it is important that an implementation that allows this option to be turned on, have it off by default. Otherwise an unaware application using the one to many model may become confused and act incorrectly.

#### **7.1.25. Set or Get the sctp partial delivery point** (`SCTP_PARTIAL_DELIVERY_POINT`)

This option will set or get the SCTP partial delivery point. This point is the size of a message where the partial delivery API will be invoked to help free up rwnd space for the peer. Setting this to a lower value will cause partial delivery's to happen more often. The calls argument is an integer that sets or gets the partial delivery point.

#### **7.1.26. Set or Get the use of extended receive info** (`SCTP_USE_EXT_RCVINFO`)

This option will enable or disable the use of the extended version of the `sctp_sndrcvinfo` structure. If this option is disabled, then the normal `sctp_sndrcvinfo` structure is returned in all receive message calls. If this option is enabled then the `sctp_extrcvinfo` structure is returned in all receive message calls.

Note that the `sctp_extrcvinfo` structure is never used in any send call.

#### **7.1.27. Set or Get the auto asconf flag (SCTP\_AUTO\_ASCONF)**

This option will enable or disable the use of the automatic generation of ASCONF chunks to add and delete addresses to an existing association. Note that this option has two caveats namely: a) it only effects sockets that are bound to all addresses on the machine, and b) the system administrator may have an overriding control that turns the asconf feature off no matter what setting the socket option may have.





### **7.1.28. Set or Get the maximum burst (SCTP\_MAX\_BURST)**

This option will allow a user to change the maximum burst of packets that can be emitted by this association. Note that the default value is 4, and some implementations may restrict this setting so that it can only be lowered.

### **7.1.29. Set or Get the default context (SCTP\_CONTEXT)**

The context field in the `sctp_sndrcvinfo` structure is normally only used when a failed message is retrieved holding the value that was sent down on the actual send call. This option allows the setting of a default context on an association basis that will be received on reading messages from the peer. This is especially helpful in the one-2-many model for an application to keep some reference to an internal state machine that is processing messages on the association. Note that the setting of this value only effects received messages from the peer and does not effect the value that is saved with outbound messages.

To set or get this option the user fills in the following structure:

```
struct sctp_assoc_value {
    sctp_assoc_t      assoc_id;
    uint32_t          assoc_value;
};
```

`assoc_id` - This parameter, indicates which association the user is performing an action upon. Note that if this field's value is zero then the endpoints default value is changed (effecting future associations only).  
`assoc_value` - This parameter contains the context.

## **7.2. Read-Only Options**

### **7.2.1. Association Status (SCTP\_STATUS)**

Applications can retrieve current status information about an association, including association state, peer receiver window size, number of unacked data chunks, and number of data chunks pending receipt. This information is read-only. The following structure is used to access this information:



```
struct sctp_status {
    sctp_assoc_t    sstat_assoc_id;
    int32_t        sstat_state;
    uint32_t        sstat_rwnd;
    uint16_t        sstat_unackdata;
    uint16_t        sstat_penddata;
    uint16_t        sstat_instrms;
    uint16_t        sstat_outstrms;
    uint32_t        sstat_fragmentation_point;
    struct sctp_paddrinfo sstat_primary;
};
```

sstat\_state - This contains the association's current state one of the following values:

SCTP\_CLOSED  
SCTP\_BOUND  
SCTP\_LISTEN  
SCTP\_COOKIE\_WAIT  
SCTP\_COOKIE\_ECHOED  
SCTP\_ESTABLISHED  
SCTP\_SHUTDOWN\_PENDING  
SCTP\_SHUTDOWN\_SENT  
SCTP\_SHUTDOWN\_RECEIVED  
SCTP\_SHUTDOWN\_ACK\_SENT

sstat\_rwnd - This contains the association peer's current receiver window size.

sstat\_unackdata - This is the number of unacked data chunks.

sstat\_penddata - This is the number of data chunks pending receipt.

sstat\_primary - This is information on the current primary peer address.

sstat\_assoc\_id - (one-to-many style socket) This holds the an identifier for the association. All notifications for a given association have the same association identifier.

sstat\_instrms - The number of streams that the peer will be using inbound.

sstat\_outstrms - The number of streams that the endpoint is allowed to use outbound.

sstat\_fragmentation\_point - The size at which SCTP fragmentation will occur.

To access these status values, the application calls `getsockopt()` with the option name `SCTP_STATUS`. The `sstat_assoc_id` parameter is ignored for one-to-one style socket.

### **7.2.2. Peer Address Information (SCTP\_GET\_PEER\_ADDR\_INFO)**

Applications can retrieve information about a specific peer address



of an association, including its reachability state, congestion window, and retransmission timer values. This information is read-only. The following structure is used to access this information:

```
struct sctp_paddrinfo {
    sctp_assoc_t    spinfo_assoc_id;
    struct sockaddr_storage spinfo_address;
    int32_t        spinfo_state;
    uint32_t       spinfo_cwnd;
    uint32_t       spinfo_srtt;
    uint32_t       spinfo_rto;
    uint32_t       spinfo_mtu;
};
```

`spinfo_address` - This is filled in the application, and contains the peer address of interest.

On return from `getsockopt()`:

`spinfo_state` - This contains the peer addresses's state (either `SCTP_ACTIVE` or `SCTP_INACTIVE` and possibly the modifier `SCTP_UNCONFIRMED`)

`spinfo_cwnd` - This contains the peer addresses's current congestion window.

`spinfo_srtt` - This contains the peer addresses's current smoothed round-trip time calculation in milliseconds.

`spinfo_rto` - This contains the peer addresses's current retransmission timeout value in milliseconds.

`spinfo_mtu` - The current P-MTU of this address.

`spinfo_assoc_id` - This is field may be filled in by the application, if so, this field will have priority in looking up the association

over the address specified in `spinfo_address`. Note that if the address does not belong to the association specified then this call will fail. If the application does NOT fill in the `spinfo_assoc_id`, then the address will be used to lookup the association and on return this field will have the valid association id. In other words, this call can be used to translate a address into an association id.

To retrieve this information, use `sctp_opt_info()` with the `SCTP_GET_PEER_ADDR_INFO` options.

### **7.2.3. Get the list of chunks the peer requires to be authenticated (SCTP\_PEER\_AUTH\_CHUNKS)**

This option gets a list of chunks for a specified association that the peer requires to be received authenticated only.



```
struct sctp_authchunks {
    sctp_assoc_t      gauth_assoc_id;
    uint8_t          gauth_chunks[];
};
```

`gauth_assoc_id` - This parameter, indicates which association the user is requesting the list of peer authenticated chunks. For one-to-one sockets, this parameter is ignored.  
`gauth_chunks` - This parameter contains an array of chunks that the peer is requesting to be authenticated.

#### **7.2.4. Get the list of chunks the local endpoint requires to be authenticated (SCTP\_LOCAL\_AUTH\_CHUNKS)**

This option gets a list of chunks for a specified association that the local endpoint requires to be received authenticated only.

```
struct sctp_authchunks {
    sctp_assoc_t      gauth_assoc_id;
    uint8_t          gauth_chunks[];
};
```

`gauth_assoc_id` - This parameter, indicates which association the user is requesting the list of local authenticated chunks. For one-to-one sockets, this parameter is ignored.  
`gauth_chunks` - This parameter contains an array of chunks that the local endpoint is requesting to be authenticated.

#### **7.2.5. Get the list of current associations (SCTP\_GET\_ASOC\_ID\_LIST)**

This option gets a list of current associations that are associated with a socket.

```
struct sctp_assoc_ids {
    uint16_t asls_assoc_start;      /* array of index's start at
0 */
    uint8_t asls_numb_present;
    uint8_t asls_more_to_get;
    sctp_assoc_t asls_assoc_id[MAX_ASOC_IDS_RET];
};
```





asls\_assoc\_start - This parameter gives an initial starting place to begin collecting association information. Normally a user sets this initially to 0. Subsequent calls that need to get more association identifications (in cases where the socket has more than MAX\_ASOC\_IDS\_RET established i.e asls\_more\_to\_get returns set to false) are made by incrementing the asls\_assoc\_start by the number of previous association id's seen. This cycle is repeated until the asls\_more\_to\_get field becomes true, indicating that all association id's have been retrieved.

asls\_numb\_present - This field holds the total number of associations that have been copied into the asls\_assoc\_id array. This value will NOT be larger than MAX\_ASOC\_IDS\_RET.

asls\_more\_to\_get - This field holds a boolean flag indicating to the caller if more association id's are available then asked for. Subsequent calls to this option will be needed to gather these association id's.

asls\_assoc\_id - an array of association id's that are currently active under this socket.

MAX\_ASOC\_IDS\_RET This value is a constant defined to limit the number of association identifications returned with each call. This value can be no larger than 255..

### **7.3. Ancillary Data and Notification Interest Options**

Applications can receive per-message ancillary information and notifications of certain SCTP events with `recvmsg()`.

The following optional information is available to the application:

1. SCTP\_SNDRCV (`sctp_data_io_event`): Per-message information (i.e. stream number, TSN, SSN, etc. described in [Section 5.2.2](#))
2. SCTP\_ASSOC\_CHANGE (`sctp_association_event`): (described in [Section 5.3.1.1](#))
3. SCTP\_PEER\_ADDR\_CHANGE (`sctp_address_event`): (described in [Section 5.3.1.2](#))
4. SCTP\_SEND\_FAILED (`sctp_send_failure_event`): (described in [Section 5.3.1.4](#))
5. SCTP\_REMOTE\_ERROR (`sctp_peer_error_event`): (described in [Section 5.3.1.3](#))
6. SCTP\_SHUTDOWN\_EVENT (`sctp_shtudown_event`): (described in [Section 5.3.1.5](#))
7. SCTP\_PARTIAL\_DELIVERY\_EVENT (`sctp_partial_delivery_event`): (described in [Section 5.3.1.7](#))
8. SCTP\_ADAPTATION\_INDICATION (`sctp_adaptation_layer_event`): (described in [Section 5.3.1.6](#))
9. SCTP\_AUTHENTICATION\_INDICATION (`sctp_authentication_event`): (described in [Section 5.3.1.8](#))



To receive any ancillary data or notifications, first the application registers its interest by calling the `SCTP_EVENTS` `setsockopt()` with the following structure.

```
struct sctp_event_subscribe{
    uint8_t sctp_data_io_event;
    uint8_t sctp_association_event;
    uint8_t sctp_address_event;
    uint8_t sctp_send_failure_event;
    uint8_t sctp_peer_error_event;
    uint8_t sctp_shutdown_event;
    uint8_t sctp_partial_delivery_event;
    uint8_t sctp_adaptation_layer_event;
    uint8_t sctp_authentication_event;
};
```

`sctp_data_io_event` - Setting this flag to 1 will cause the reception of `SCTP_SNDRCV` information on a per message basis. The application will need to use the `recvmsg()` interface so that it can receive the event information contained in the `msg_control` field. Please see [Section 5.2](#) for further details. Setting the flag to 0 will disable reception of the message control information.

`sctp_association_event` - Setting this flag to 1 will enable the reception of association event notifications. Setting the flag to 0 will disable association event notifications. For more information on event notifications please see [Section 5.3](#).

`sctp_address_event` - Setting this flag to 1 will enable the reception of address event notifications. Setting the flag to 0 will disable address event notifications. For more information on event notifications please see [Section 5.3](#).

`sctp_send_failure_event` - Setting this flag to 1 will enable the reception of send failure event notifications. Setting the flag to 0 will disable send failure event notifications. For more information on event notifications please see [Section 5.3](#).

`sctp_peer_error_event` - Setting this flag to 1 will enable the reception of peer error event notifications. Setting the flag to 0 will disable peer error event notifications. For more information on event notifications please see [Section 5.3](#).

`sctp_shutdown_event` - Setting this flag to 1 will enable the reception of shutdown event notifications. Setting the flag to 0 will disable shutdown event notifications. For more information on event notifications please see [Section 5.3](#).



sctp\_partial\_delivery\_event - Setting this flag to 1 will enable the reception of partial delivery notifications. Setting the flag to 0 will disable partial delivery event notifications. For more information on event notifications please see [Section 5.3](#).

sctp\_adaptation\_layer\_event - Setting this flag to 1 will enable the reception of adaptation layer notifications. Setting the flag to 0 will disable adaptation layer event notifications. For more information on event notifications please see [Section 5.3](#).

sctp\_authentication\_event - Setting this flag to 1 will enable the reception of authentication layer notifications. Setting the flag to 0 will disable authentication layer event notifications. For More information please see [Section 5.3](#).

An example where an application would like to receive data io events and association events but no others would be as follows:

```
{
    struct sctp_event_subscribe event;

    memset(&event,0,sizeof(event));

    event.sctp_data_io_event = 1;
    event.sctp_association_event = 1;

    setsockopt(fd, IPPROTO_SCTP, SCTP_EVENTS, &event, sizeof(event));
}
```

Note that for one-to-many style SCTP sockets, the caller of `recvmsg()` receives ancillary data and notifications for ALL associations bound to the file descriptor. For one-to-one style SCTP sockets, the caller receives ancillary data and notifications for only the single association bound to the file descriptor.

By default both the one-to-one style and one-to-many style socket has all options off.

## **8. New Interfaces**

Depending on the system, the following interface can be implemented as a system call or library function.

### **8.1. sctp\_bindx()**

The syntax of `sctp_bindx()` is,



```
int sctp_bindx(int sd, struct sockaddr *addrs, int addrcnt,  
              int flags);
```

If sd is an IPv4 socket, the addresses passed must be IPv4 addresses.

If the sd is an IPv6 socket, the addresses passed can either be IPv4 or IPv6 addresses.

A single address may be specified as INADDR\_ANY or IN6ADDR\_ANY, see [Section 3.1.2](#) for this usage.

addrs is a pointer to an array of one or more socket addresses. Each

address is contained in its appropriate structure. For an IPv6 socket, an array of sockadr\_in6 would be returned. For a IPv4 socket, an array of sockadr\_in would be returned. The caller specifies the number of addresses in the array with addrcnt. Note that the wildcard addresses cannot be used with this function, doing so will result in an error.

On success, sctp\_bindx() returns 0. On failure, sctp\_bindx() returns

-1, and sets errno to the appropriate error code.

For SCTP, the port given in each socket address must be the same, or sctp\_bindx() will fail, setting errno to EINVAL.

The flags parameter is formed from the bitwise OR of zero or more of the following currently defined flags:

SCTP\_BINDX\_ADD\_ADDR

SCTP\_BINDX\_REM\_ADDR

SCTP\_BINDX\_ADD\_ADDR directs SCTP to add the given addresses to the association, and SCTP\_BINDX\_REM\_ADDR directs SCTP to remove the given

addresses from the association. The two flags are mutually exclusive; if both are given, sctp\_bindx() will fail with EINVAL. A caller may not remove all addresses from an association;

sctp\_bindx() will reject such an attempt with EINVAL.

An application can use sctp\_bindx(SCTP\_BINDX\_ADD\_ADDR) to associate additional addresses with an endpoint after calling bind(). Or use sctp\_bindx(SCTP\_BINDX\_REM\_ADDR) to remove some addresses a listening socket is associated with so that no new association accepted will be

associated with those addresses. If the endpoint supports dynamic address a SCTP\_BINDX\_REM\_ADDR or SCTP\_BINDX\_ADD\_ADDR may cause a endpoint to send the appropriate message to the peer to change the peers address lists.

Adding and removing addresses from a connected association is

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optional functionality. Implementations that do not support this functionality should return EOPNOTSUPP.

## **8.2. Branched-off Association**

After an association is established on a one-to-many style socket, the application may wish to branch off the association into a separate socket/file descriptor.

This is particularly desirable when, for instance, the application wishes to have a number of sporadic message senders/receivers remain under the original one-to-many style socket but branch off those associations carrying high volume data traffic into their own separate socket descriptors.

The application uses `sctp_peeloff()` call to branch off an association

into a separate socket (Note the semantics are somewhat changed from the traditional one-to-one style `accept()` call). Note that the new socket is a one-to-one style socket. Thus it will be confined to operations allowed for a one-to-one style socket.

The syntax is:

```
new_sd = sctp_peeloff(int sd, sctp_assoc_t assoc_id);
```

the new socket descriptor representing the branched-off association.

the original one-to-many style socket descriptor returned from the

`socket()` system call (see [Section 3.1.1](#)).

the specified identifier of the association that is to be branched

off to a separate file descriptor (Note, in a traditional one-to-one style `accept()` call, this would be an out parameter, but for the one-to-many style call, this is an in parameter).

## **8.3. `sctp_getpaddrs()`**

`sctp_getpaddrs()` returns all peer addresses in an association. The syntax is,

```
int sctp_getpaddrs(int sd, sctp_assoc_t id,  
                  struct sockaddr **addrs);
```

On return, `addrs` will point to an array dynamically allocated `sockaddr` structures of the appropriate type for the socket type.

The

caller should use `sctp_freepaddrs()` to free the memory. Note that the in/out parameter `addrs` must not be NULL.



If `sd` is an IPv4 socket, the addresses returned will be all IPv4 addresses. If `sd` is an IPv6 socket, the addresses returned can be a mix of IPv4 or IPv6 addresses.

For one-to-many style sockets, `id` specifies the association to query.

For one-to-one style sockets, `id` is ignored.

On success, `sctp_getpaddr()` returns the number of peer addresses in the association. If there is no association on this socket, `sctp_getpaddr()` returns 0, and the value of `*addr` is undefined.

If

an error occurs, `sctp_getpaddr()` returns -1, and the value of `*addr` is undefined.

#### **8.4. sctp\_freepaddr()**

`sctp_freepaddr()` frees all resources allocated by `sctp_getpaddr()`. Its syntax is,

```
void sctp_freepaddr(struct sockaddr *addr);  
addr is the array of peer addresses returned by sctp_getpaddr().
```

#### **8.5. sctp\_getladdr()**

`sctp_getladdr()` returns all locally bound address(es) on a socket. The syntax is,

```
int sctp_getladdr(int sd, sctp_assoc_t id,  
                 struct sockaddr **ss);
```

On return, `addr` will point to a dynamically allocated array of `sockaddr` structures of the appropriate type for the socket type.

The

caller should use `sctp_freeladdr()` to free the memory. Note that the in/out parameter `addr` must not be NULL.

If `sd` is an IPv4 socket, the addresses returned will be all IPv4 addresses. If `sd` is an IPv6 socket, the addresses returned can be a mix of IPv4 or IPv6 addresses.

For one-to-many style sockets, `id` specifies the association to query.

For one-to-one style sockets, `id` is ignored.

If the `id` field is set to the value '0' then the locally bound addresses are returned without regard to any particular association.



On success, `sctp_getladdrs()` returns the number of local addresses bound to the socket. If the socket is unbound, `sctp_getladdrs()` returns 0, and the value of `*addrs` is undefined. If an error occurs, `sctp_getladdrs()` returns -1, and the value of `*addrs` is undefined.

#### **8.6. sctp\_freeladdrs()**

`sctp_freeladdrs()` frees all resources allocated by `sctp_getladdrs()`. Its syntax is,

```
void sctp_freeladdrs(struct sockaddr *addrs);
```

`addrs` is the array of peer addresses returned by `sctp_getladdrs()`.

#### **8.7. sctp\_sendmsg()**

An implementation may provide a library function (or possibly system call) to assist the user with the advanced features of SCTP.

`sctp_sendmsg()`. Its syntax is,

```
ssize_t sctp_sendmsg(int sd,  
                    const void *msg,  
                    size_t len,  
                    const struct sockaddr *to,  
                    socklen_t tolen,  
                    uint32_t ppid,  
                    uint32_t flags,  
                    uint16_t stream_no,  
                    uint32_t timetolive,  
                    uint32_t context)
```

`sd` - is the socket descriptor  
`msg` - is the message to be sent.  
`len` - is the length of the message.  
`to` - is the destination address of the message.  
`tolen` - is the length of the destination address.  
`ppid` - is the same as `sinfo_ppid` (see [section 5.2.2](#))  
`flags` - is the same as `sinfo_flags` (see [section 5.2.2](#))  
`stream_no` - is the same as `sinfo_stream` (see [section 5.2.2](#))  
`timetolive` - is the same as `sinfo_timetolive` (see [section 5.2.2](#))  
`context` - is the same as `sinfo_context` (see [section 5.2.2](#))

#### **8.8. sctp\_recvmmsg()**

An implementation may provide a library function (or possibly system



call) to assist the user with the advanced features of SCTP. Note that in order for the `sctp_sndrcvinfo` structure to be filled in by `sctp_recvmsg()` the caller must enable the `sctp_data_io_events` with the `SCTP_EVENTS` option. Note that the setting of the `SCTP_USE_EXT_RCVINFO` will effect this function as well, causing the `sctp_sndrcvinfo` information to be extended.

`sctp_recvmsg()`. Its syntax is,

```
ssize_t sctp_recvmsg(int sd,
                    void *msg,
                    size_t len,
                    struct sockaddr *from,
                    socklen_t *fromlen,
                    struct sctp_sndrcvinfo *sinfo,
                    int *msg_flags)
```

`sd` - is the socket descriptor

`msg` - is a message buffer to be filled.

`len` - is the length of the message buffer.

`from` - is a pointer to a address to be filled with the sender of this messages address.

`fromlen` - is the from length.

`sinfo` - A pointer to a `sctp_sndrcvinfo` structure to be filled upon receipt of the message.

`msg_flags` - A pointer to a integer to be filled with any message flags (e.g. `MSG_NOTIFICATION`).

### **8.9. sctp\_connectx()**

An implementation may provide a library function (or possibly system call) to assist the user with associating to an endpoint that is multi-homed. Much like `sctp_bindx()` this call allows a caller to specify multiple addresses at which a peer can be reached. The way the SCTP stack uses the list of addresses to set up the association is implementation dependent. This function only specifies that the stack will try to make use of all the addresses in the list when needed.

Note that the list of addresses passed in is only used for setting up

the association. It does not necessarily equal the set of addresses the peer uses for the resulting association. If the caller wants to find out the set of peer addresses, it must use `sctp_getpaddrs()` to retrieve them after the association has been set up.





sctp\_connectx(). Its syntax is,

```
int sctp_connectx(int sd,  
                  struct sockaddr *addrs,  
                  int addrcnt)
```

sd - is the socket descriptor  
addrs - is an array of addresses.  
addrcnt - is the number of addresses in the array.

#### **8.10. sctp\_send()**

An implementation may provide another alternative function or system call to assist an application with the sending of data without the use of the CMSG header structures. The function takes the following form:

sctp\_send(). Its syntax is,

```
int sctp_send(int sd,  
              const void *msg,  
              size_t len,  
              const struct sctp_sndrcvinfo *sinfo,  
              int flags);
```

sd - is the socket descriptor  
msg - The message to be sent  
len - The length of the message  
sinfo - A pointer to a sctp\_sndrcvinfo structure used as described  
in  
5.2.2 for a sendmsg call.  
flags - is used in the same format as the sendmsg call flags (e.g. MSG\_DONTROUTE).

This function call may also be used to terminate an association using an association identification by setting the sinfo.sinfo\_flags to SCTP\_EOF and the sinfo.sinfo\_assoc\_id to the association that needs to be terminated. In such a case the len of the message would be zero.

#### **8.11. sctp\_sendx()**

An implementation may provide another alternative function or system call to assist an application with the sending of data without the use of the CMSG header structures that also gives a list of addresses. The list of addresses is provided for implicit



association setup. In such a case the list of addresses serves the same purpose as the addresses given in `sctp_connectx` (see [Section 8.9](#)).

`sctp_sendx()`. Its syntax is,

```
int sctp_sendx(int sd,
               const void *msg,
               size_t len,
               struct sockaddr *addrs,
               int addrcnt,
               struct sctp_sndrcvinfo *sinfo,
               int flags);
```

`sd` - is the socket descriptor

`msg` - The message to be sent

`len` - The length of the message

`addrs` - is an array of addresses.

`addrcnt` - is the number of addresses in the array.

`sinfo` - A pointer to a `sctp_sndrcvinfo` structure used as described

in

5.2.2 for a `sendmsg` call.

`flags` - is used in the same format as the `sendmsg` call flags (e.g. `MSG_DONTROUTE`).

Note that on return from this call the `sinfo` structure will have changed in that the `sinfo_assoc_id` will be filled in with the new association id.

This function call may also be used to terminate an association using

an association identification by setting the `sinfo.sinfo_flags` to `SCTP_EOF` and the `sinfo.sinfo_assoc_id` to the association that needs to be terminated. In such a case the `len` of the message would be zero.

### **8.12. sctp\_getaddrlen**

For application binary portability it is sometimes desirable to know what the kernel thinks is the length of a socket address family. This function, when called with a valid family type will return the length that the operating system uses in the specified family's socket address structure.

```
int sctp_getaddrlen(sa_family_t family);
```



## **9. Preprocessor Constants**

For application portability it is desirable to define pre-processor constants for determination if sctp is present and supports various features. The following pre-processor constants should be defined in

a include file, sctp.h.

HAVE\_SCTP - If this constant is defined to 1, then an implementation of SCTP is available.

HAVE\_KERNEL\_SCTP - If this constant is defined to 1, then a kernel SCTP implementation is available through the sockets interface.

HAVE\_SCTP\_PRSCTP - If this constant is defined to 1, then the SCTP implementation supports the partial reliability extension to

SCTP.

HAVE\_SCTP\_ADDIP - If this constant is defined to 1, then the SCTP implementation supports the dynamic address extension to SCTP.

HAVE\_SCTP\_CANSET\_PRIMARY - If this constant is defined to 1, then the

SCTP implementation supports the ability to request setting of

the

remote primary address.

HAVE\_SCTP\_SAT\_NETWORK\_CAPABILITY - If this constant is defined to 1, then the SCTP implementation supports the satellite network extension to SCTP.

HAVE\_SCTP\_MULTIBUF - If this constant is defined to 1, then the SCTP implementation dedicates separate buffer space to each association

on a one-to-many socket. If this constant is defined to 0, then the implementation provides a single block of shared buffer space for a one-to-many socket.

HAVE\_SCTP\_NOCONNECT - If this constant is defined to 1, then the SCTP

implementation supports initiating an association on a one-to-one style socket without the use of connect(), as outlined in [Section 4.1.5](#).

HAVE\_SCTP\_EXT\_RCVINFO - If this constant is defined to 1, then the SCTP implementation supports the use of the extended style sndrcvinfo structure, sctp\_extrcvinfo.

## **10. IANA considerations**

This document contains no IANA considerations.

## **11. Security Considerations**

Many TCP and UDP implementations reserve port numbers below 1024 for privileged users. If the target platform supports privileged users, the SCTP implementation SHOULD restrict the ability to call bind()

or

sctp\_bindx() on these port numbers to privileged users.

Similarly unprivileged users should not be able to set protocol parameters which could result in the congestion control algorithm

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being more aggressive than permitted on the public Internet. These parameters are:

```
struct sctp_rtoinfo
```

If an unprivileged user inherits a one-to-many style socket with open associations on a privileged port, it MAY be permitted to accept new associations, but it SHOULD NOT be permitted to open new associations. This could be relevant for the r\* family of protocols.

## **12. Acknowledgments**

Special acknowledgment is given to Ken Fujita and Jonathan Woods who helped extensively in the early formation of this document.

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## **13. References**

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## **13.2. Informational References**

### **Appendix A. one-to-one style Code Example**

The following code is a simple implementation of an echo server over  
SCTP. The example shows how to use some features of one-to-one  
style

IPv4 SCTP sockets, including:

- o Opening, binding, and listening for new associations on a socket;
- o Enabling ancillary data
- o Enabling notifications
- o Using ancillary data with `sendmsg()` and `recvmsg()`
- o Using `MSG_EOR` to determine if an entire message has been read
- o Handling notifications

```
#include <stdio.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <netinet/in.h>
#include <arpa/inet.h>
#include <stdlib.h>
#include <unistd.h>
#include <netinet/sctp.h>
#include <sys/uio.h>

#define BUFLen 100

static void
handle_event(void *buf)
{
    struct sctp_assoc_change *sac;
    struct sctp_send_failed *ssf;
    struct sctp_paddr_change *spc;
    struct sctp_remote_error *sre;
    union sctp_notification *snp;
    char addrbuf[INET6_ADDRSTRLEN];
    const char *ap;
    struct sockaddr_in *sin;
    struct sockaddr_in6 *sin6;
```



```
    snp = buf;

    switch (snp->sn_header.sn_type) {
    case SCTP_ASSOC_CHANGE:
        sac = &snp->sn_assoc_change;
        printf("^^^ assoc_change: state=%hu, error=%hu, instr=%hu
"
            "outstr=%hu\n", sac->sac_state, sac->sac_error,
            sac->sac_inbound_streams, sac->sac_outbound_streams);
        break;
    case SCTP_SEND_FAILED:
        ssf = &snp->sn_send_failed;
        printf("^^^ sendfailed: len=%hu err=%d\n", ssf-
>ssf_length,
            ssf->ssf_error);
        break;

    case SCTP_PEER_ADDR_CHANGE:
        spc = &snp->sn_paddr_change;
        if (spc->spc_aaddr.ss_family == AF_INET) {
            sin = (struct sockaddr_in *)&spc->spc_aaddr;
            ap = inet_ntop(AF_INET, &sin->sin_addr,
                addrbuf, INET6_ADDRSTRLEN);
        } else {
            sin6 = (struct sockaddr_in6 *)&spc->spc_aaddr;
            ap = inet_ntop(AF_INET6, &sin6->sin6_addr,
                addrbuf, INET6_ADDRSTRLEN);
        }
        printf("^^^ intf_change: %s state=%d, error=%d\n", ap,
            spc->spc_state, spc->spc_error);
        break;
    case SCTP_REMOTE_ERROR:
        sre = &snp->sn_remote_error;
        printf("^^^ remote_error: err=%hu len=%hu\n",
            ntohs(sre->sre_error), ntohs(sre->sre_length));
        break;
    case SCTP_SHUTDOWN_EVENT:
        printf("^^^ shutdown event\n");
        break;
    default:
        printf("unknown type: %hu\n", snp->sn_header.sn_type);
        break;
    };
}

static void *
mysctp_recvmmsg(int fd, struct msghdr *msg, void *buf, size_t
*buflen,
    ssize_t *nrp, size_t cmsglen)
{
    ssize_t nr = 0, nnr = 0;
```



```
    struct iovec iov[1];

    *nrp = 0;
    iov->iov_base = buf;
    iov->iov_len = *buflen;
    msg->msg_iov = iov;
    msg->msg_iovlen = 1;

    for (;;) {
#ifdef MSG_XPG4_2
#define MSG_XPG4_2 0
#endif
        msg->msg_flags = MSG_XPG4_2;
        msg->msg_controllen = cmsglen;

        nnr = recvmsg(fd, msg, 0);
        if (nnr <= 0) {
            /* EOF or error */
            *nrp = nr;
            return (NULL);
        }
        nr += nnr;

        if ((msg->msg_flags & MSG_EOR) != 0) {
            *nrp = nr;
            return (buf);
        }

        /* Realloc the buffer? */
        if (*buflen == (size_t)nr) {
            buf = realloc(buf, *buflen * 2);
            if (buf == 0) {
                fprintf(stderr, "out of memory\n");
                exit(1);
            }
            *buflen *= 2;
        }
        /* Set the next read offset */
        iov->iov_base = (char *)buf + nr;
        iov->iov_len = *buflen - nr;
    }
}

static void
echo(int fd, int socketModeone_to_many)
{
    ssize_t nr;
```



```
struct sctp_sndrcvinfo *sri;
struct msghdr msg[1];
struct cmsghdr *cmsg;
char cbuf[sizeof (*cmsg) + sizeof (*sri)];
char *buf;
size_t buflen;
struct iovec iov[1];
size_t msglen = sizeof (*cmsg) + sizeof (*sri);
/* Allocate the initial data buffer */
buflen = BUFLLEN;
if (!(buf = malloc(BUFLLEN))) {
    fprintf(stderr, "out of memory\n");
    exit(1);
}

/* Set up the msghdr structure for receiving */
memset(msg, 0, sizeof (*msg));
msg->msg_control = cbuf;
msg->msg_controllen = msglen;
msg->msg_flags = 0;
cmsg = (struct cmsghdr *)cbuf;
sri = (struct sctp_sndrcvinfo *)(cmsg + 1);

/* Wait for something to echo */
while (buf = mysctp_recvmmsg(fd, msg,
    buf, &buflen, &nr, msglen)) {

    /* Intercept notifications here */
    if (msg->msg_flags & MSG_NOTIFICATION) {
        handle_event(buf);
        continue;
    }

    iov->iov_base = buf;
    iov->iov_len = nr;
    msg->msg_iov = iov;
    msg->msg_iovlen = 1;

    printf("got %u bytes on stream %hu:\n", nr,
        sri->sinfo_stream);
    write(0, buf, nr);

    /* Echo it back */
    msg->msg_flags = MSG_XPG4_2;
    if (sendmsg(fd, msg, 0) < 0) {
        perror("sendmsg");
        exit(1);
    }
}
```





```
    }

    if (nr < 0) {
        perror("recvmsg");
    }
    if(socketModeone_to_many == 0)
        close(fd);
}

int main()
{
    struct sctp_event_subscribe event;
    int lfd, cfd;
    int onoff = 1;
    struct sockaddr_in sin[1];
    if ((lfd = socket(AF_INET, SOCK_STREAM, IPPROTO_SCTP)) == -1) {
        perror("socket");
        exit(1);
    }

    sin->sin_family = AF_INET;
    sin->sin_port = htons(7);
    sin->sin_addr.s_addr = INADDR_ANY;
    if (bind(lfd, (struct sockaddr *)sin, sizeof (*sin)) == -1) {
        perror("bind");
        exit(1);
    }

    if (listen(lfd, 1) == -1) {
        perror("listen");
        exit(1);
    }

    /* Wait for new associations */
    for (;;) {
        if ((cfd = accept(lfd, NULL, 0)) == -1) {
            perror("accept");
            exit(1);
        }

        /* Enable all events */
        event.sctp_data_io_event = 1;
        event.sctp_association_event = 1;
        event.sctp_address_event = 1;
        event.sctp_send_failure_event = 1;
        event.sctp_peer_error_event = 1;
        event.sctp_shutdown_event = 1;
        event.sctp_partial_delivery_event = 1;
    }
}
```



```
        event.sctp_adaptation_layer_event = 1;
        if (setsockopt(cfd, IPPROTO_SCTP,
                      SctpEvents, &event,
                      sizeof(event)) != 0) {
            perror("setevent failed");
            exit(1);
        }
        /* Echo back any and all data */
        echo(cfd,0);
    }
}
```

### [Appendix B](#). one-to-many style Code Example

The following code is a simple implementation of an echo server over SCTP. The example shows how to use some features of one-to-many style IPv4 SCTP sockets, including:

- o Opening and binding of a socket;
- o Enabling ancillary data
- o Enabling notifications
- o Using ancillary data with `sendmsg()` and `recvmsg()`
- o Using `MSG_EOR` to determine if an entire message has been read
- o Handling notifications

Note most functions defined in [Appendix A](#) are reused in this example.

```
int main()
{
    int fd;
    int idleTime = 2;
    struct sockaddr_in sin[1];
    struct sctp_event_subscribe event;

    if ((fd = socket(AF_INET, SOCK_SEQPACKET, IPPROTO_SCTP)) == -1)
    {
        perror("socket");
        exit(1);
    }

    sin->sin_family = AF_INET;
    sin->sin_port = htons(7);
    sin->sin_addr.s_addr = INADDR_ANY;
    if (bind(fd, (struct sockaddr *)sin, sizeof (*sin)) == -1) {
        perror("bind");
        exit(1);
    }
}
```



```
/* Enable all notifications and events */
event.sctp_data_io_event = 1;
event.sctp_association_event = 1;
event.sctp_address_event = 1;
event.sctp_send_failure_event = 1;
event.sctp_peer_error_event = 1;
event.sctp_shutdown_event = 1;
event.sctp_partial_delivery_event = 1;
event.sctp_adaptation_layer_event = 1;
if (setsockopt(fd, IPPROTO_SCTP,
              Sctp_EVENTS, &event,
              sizeof(event)) != 0) {
    perror("setevent failed");
    exit(1);
}
/* Set associations to auto-close in 2 seconds of
 * inactivity
 */
if (setsockopt(fd, IPPROTO_SCTP, Sctp_AUTOCLOSE,
              &idleTime, 4) < 0) {
    perror("setsockopt Sctp_AUTOCLOSE");
    exit(1);
}

/* Allow new associations to be accepted */
if (listen(fd, 1) < 0) {
    perror("listen");
    exit(1);
}

/* Wait for new associations */
while(1){
    /* Echo back any and all data */
    echo(fd,1);
}
}
```



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