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X.25 over SCTP (XOS)
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Status of this Memo

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Abstract

This document is a revision to RFC 1613 [RFC1613] written by James R. Forster, Greg Satz, Gilbert Glick and Bob Day. Since the release of RFC 1613 in May 1994, a new IP transport protocol, Stream Control Transmission Protocol (SCTP) [SCTP], has been released as a Proposed Standard that provides superior services to TCP in some respects, particularly related to OSI or Signalling protocols.

This memo describes the mechanism to allow X.25-PLP to run directly over SCTP over IPv4 or IPv6. It also defines a number of new features that were not provided in RFC 1613, but are now possible due to the superior capabilities provided by SCTP.

The goal of this version is to minimize the number of changes to RFC 1613 as well as ITU-T Rec. X.25 [X.25] or ISO/IEC 8208 [ISO/IEC 8208] while maximizing performance, extending its applicability and protecting the installed base of RFC 1613 users.

1. Introduction

It is sometimes desirable to transport X.25 over IP internets. The X.25 Packet Level requires a reliable link level below it and normally uses LAPB [ISO 7776], [X.222] or LLC2 [802.2]. XOT [RFC1613] describes a method for using a TCP/IP connection as a data link over which X.25 PLP (Packet Layer Protocol) [ISO/IEC 8208] packets can be sent. This memo documents a method of sending X.25 PLP packets over IP internets by encapsulating the X.25 Packet Level in SCTP [SCTP] packets.

SCTP provides a set of reliable sequenced or un-sequenced packets in independent streams. X.25 requires that the layer beneath it provide message semantics, in particular the boundary between packets. SCTP preserves message boundaries and with no need for additional headers. Also, the SCTP PPI field provides a way to identify the version of the protocol.

In contrast, the TCP approach with XOT [RFC1613] does not preserve message boundaries directly, and requires a header field, both to preserve message boundaries as well as to provide a protocol version number.

In general, the normal X.25 protocol packet formats and state transition rules apply to the X.25 layer in XOS. Exceptions to this are noted.

1.1. Scope

1.1.1. Advantages of XOS over XOT

XOS has a number of unique advantages over XOT [RFC1613], as itemized below:

(1) SCTP preserves message boundaries without additional protocol elements (such as the header required by TCP in XOT to recover record boundaries).

(2) SCTP can identify the transported protocol using the Payload Protocol Identifier.

(3) SCTP provides a heartbeat mechanism that detects failure faster than TCP is able. Thus, SCTP associations can be established and left idle awaiting call setups. This, again permits faster call setup.

(4) SCTP detects lost associations and has a quick restart procedure for reestablishing them. TCP can take minutes to reestablish a connection and when confronted with reestablishing 4095 connections, temporary network conditions can be disastrous.

(5) SCTP provides a measure of the quality of service experienced by the SCTP association (smoothed round trip time) that can be used to support X.25 and CONS quality of service parameters and data link resource allocations.

(6) **XOS** only requires one association for per data link and utilizes streams within the SCTP association to provide for independence of flow for individual virtual channels. XOT, on the other hand, requires one TCP connection per virtual channel. Therefore, **XOS** uses less resources per virtual channel and scales better. Also, **XOS** avoids the additional call setup delay associated with establishing a TCP connection.

These and the additional capabilities of SCTP make **XOS** a superior replacement to XOT.

1.1.2. Relationship of XOS to XOT

The XOS protocol described in this memo is not intended as a replacement for XOT [RFC1613], but XOS is intended, where available, as a superior alternative to XOT.

The XOT specification [RFC1613], was used as a template for the initial drafts of this memo. However, RFC 1613 provides sections that are not applicable to XOS, as follows:

(1) The XOT specification [RFC1613], went to some length to describe the interactions between an XOT interface and an X.25 interface on a given host to provide an network relay function. This function, however, has since been standardized as ISO/IEC 10028 [ISO/IEC 10028] and ISO/IEC 10177 [ISO/IEC 10177], and, therefore, does not need to be discussed here. Also, because the X.25 PLP and CONS relay function is a purely nodal function, it has no impact on protocol design.

    Those sections of the XOT specification that spoke to network layer relays and interworking units have been removed from XOS. The procedures of ISO 10177 [ISO/IEC 10028], [ISO/IEC 10177] are as applicable to XOS as they are to LAPB [ISO 7776], [X.222], [ISO 3309], [ISO 4335] or LLC [ISO 8881], [802.2], and the reader is referred to those documents [ISO/IEC 10028], [ISO/IEC 10177].

(2) The XOT specification went to some trouble to remove the distinction between DTE, DCE and DXE as provided for in X.25 and ISO 8208. This was possible because the TCP connection only supported one anonymous virtual channel and Logical Channel Identifier assignment became trivial. Unfortunately, this resulted in modifications to the X.25 engine: removal of the distinction between DTE, DCE and DXE, and the removal of the restart procedures and all messages sent to the null reference.

    XOS reinstates the traditional role of DTE, DCE and DXE as described in X.25 and ISO 8208 and provides for the restart procedure and other procedures on the null reference. **XOS** in this way provides an identical service interface to that of the LAPB or LLC2 data links and does not require any X.25 PLP protocol or procedural modifications whatsoever. Therefore, the passages on the loss of distinction between the role of DTE, DCE and DXE, and the loss of the restart and LCI assignment procedures from the X.25 PLP have been removed.

(3) The XOT specification, because only one virtual channel was supported per TCP connection, and because the LCI assignment procedures were removed, had to specify a non-standard message for use in specifying or establishing Permanent Virtual Circuits. This again required modifications to the X.25 PLP protocol and procedures to support PVCs on XOT.

XOS reinstates the normal static assignment of LCI for PVCs and does not require additional non-standard messages to support PVCs. PVC Setup is, once again, a matter for management systems and the corresponding section from RFC 1613, "PVC Setup", has been removed from this Memo.

1.2. Terminology

This memo uses the following extended terminology:

Virtual Channel — A virtual channel over which an X.25 connection is established using X.25 call setup procedures.

Permanent Virtual Channel — A virtual channel over which an X.25 connection is permanently established without the need for the use of call setup procedures.

1.3. Abbreviations

The following abbreviations are used throughout this memo:

CC — Call Confirm (X.25 message)
DC — Disconnect Confirm (X.25 message)
DCE — Data Control Equipment
DLC — Data Link Connection
DL — Data Link
DLS — Data Link Service
DTE — Data Terminal Equipment
DXE — DTE/DCE
ICMP — Internet Control Managment Protocol
IEC — Inernational Engineering Consortia
IETF — Internet Engineering Task Force
IP — Internet Protocol
ISO — International Organization for Standardization
ITU — International Telecommunications Union
ITU-T — ITU (Telecom Sector)
LAPB — Link Access Protocol (Balanced)
LCI — Logical Channel Identifier
LLC1 — LLC Class 1
LLC2 — LLC Class 2
LLC — Logical Link Control
OOTB — Out Of The Blue
OSI — Open Systems Interconnect
PLP — Packet Layer Protocol
PVC — Permanent Virtual Channel
QOS — Quality of Service

REJ — Reject (X.25 message)
RFC — Request for Comments
RNR — Receiver Not Ready (X.25 message)
RR — Receiver Ready (X.25 message)
SCTP — Stream Control Transmission Protocol
TCP — Transmission Control Protocol
VC — Virtual Channel
XOS — X.25 over SCTP
XOT — X.25 over TCP

2. Conventions

The following language conventions are used in the items of specification in this document:

The key words "**MUST**", "**MUST NOT**", "**REQUIRED**", "**SHALL**", "**SHALL NOT**", "**SHOULD**", "**SHOULD NOT**", "**RECOMMENDED**", "**MAY**", and "**OPTIONAL**" in this document are to be interpreted as described in [RFC2119].

3. Overview

3.1. Relationship Between XOS and X.25

When a networking device (a host, router, etc.) has an X.25 engine (i.e., an X.25 PLP [ISO/IEC 8208] protocol implementation), that engine may be connected to interface(s) running LAPB [ISO 7776], [X.222], [ISO 3309], [ISO 4335], and/or to logical interface(s) running LLC [ISO 8881], [802.2], XOT/TCP/IP [RFC1613] or XOS/SCTP/IP. In general, the XOS layer itself is not at all sensitive to what kind of packets the X.25 engine passes to it. However, to improve interoperability between separate implementations, this document in some cases does specify behaviour for the X.25 engine.

While this document primarily discusses XOS from the perspective of providing X.25 connectivity using XOS, this should not prevent a host from switching X.25 traffic (i.e, connecting an X.25 Virtual Circuit between the local X.25 interfaces of two networking devices). In general, the X.25 PLP is unaware that the data link services are being provided by XOS/SCTP/IP and therefore the standards applicable to network internal layer services [ISO/IEC 10028] and network layer relay and protocol interworking [ISO/IEC 10177] are as applicable to X.25 PLP using XOS and LAPB as they are to X.25 PLP using LLC2 and LAPB.

3.2. Overall Packet Format

The entire encapsulated packet has the format illustrated in *Figure 1*.

RFC convention is that a packet format is represented graphically with the data sent first above the data sent later. This convention is followed in this document, and therefore, while we refer to X.25 being transported over SCTP, we draw the packet format with the X.25 portion of the packet lower on the page than the SCTP portion.

X.25 PLP frames are simply encapsulated in SCTP DATA Chunks in the same manner as normal SCTP user data.

3.3. SCTP Association, Port Number, and Logical Channel Identifiers

A single SCTP stream **MUST** be used for each X.25 virtual circuit. A separate SCTP stream **SHOULD** be used for each X.25 virtual circuit. Each Virtual Circuit (VC) relating to the same Data Link, however, is carried by a stream within a single SCTP association. All connections **MUST** be made to SCTP port number 1998. This port number is an IANA Registered Port Number registered by cisco Systems; cisco has designated it for use by XOT for TCP. This memo recommends the use of the same port number, 1998, for use by XOS for SCTP. See Section 9, "*IANA Considerations* for more information on port number.

The SCTP association **MUST** be created before the virtual circuit can be established. The SCTP association **MAY** be maintained after the last virtual circuit associated with the SCTP association has been cleared or **MAY** be released in accordance with X.25 and ISO 8208 data link procedures. Note that the SCTP association

Figure 1. Overall XOS Packet Format

```
  0                   1                   2                   3
  0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                                                               |
 \                                                               \
 /                          IP Header                            /
 \                                                               \
 |                                                               |
 +---------------------------------------------------------------+
 |                                                               |
 \                                                               \
 /                         SCTP Header                           /
 \                                                               \
 |                                                               |
 +---------------------------------------------------------------+
 |                                                               |
 \                                                               \
 /                       DATA Chunk Header                       /
 \                                                               \
 |                                                               |
 +- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -+
 |                                                               |
 \                                                               \
 /                    X.25 DATA Chunk Payload                    /
 \                                                               \
 |                                                               |
 +---------------------------------------------------------------+
 |                                                               |
 \                                                               \
 /                       DATA Chunk Header                       /
 \                                                               \
 |                                                               |
 +- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -+
 |                                                               |
 \                                                               \
 /                    X.25 DATA Chunk Payload                    /
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```

corresponds to the LAPB [ISO 7776], [X.222], [ISO 3309], [ISO 4335] or LLC2 [ISO 8881], [802.2] link for X.25, and each SCTP stream corresponds to an individual Virtual Circuit (VC) and Logical Channel Identifier (LCI) for X.25 LAPB. The Logical Channel Identifier (LCI) field in the X.25 header maps to the SCTP stream upon which the message is sent.

X.25 and ISO 8208 support the assignment of virtual circuits (VC) and permanent virtual circuits (PVC) to logical channel identifiers in the range from 1-4095 inclusive. Logical channel identifier zero (0) is reserved for data link related messages (e.g., RESTART REQUEST). SCTP provides support for multiple quasi-independent streams of sequenced data records and can negotiate the number of outbound streams (between 1 and 65536) during association establishment. In general, streams in SCTP are used to establish an ordered relationship between packets (all packets transmitted on the same stream with sequenced delivery will be delivered in order), and the stream identifier is not intended to be used to identifying virtual circuits of any kind. For example, there is no requirement on SCTP peers to negotiation the same number of inbound streams as the number of outbound streams; and, there is no requirement to deliver the stream identifier as part of the information associated with received data.

Therefore, the mapping between LCI and SCTP stream number is not an identity relationship (for all but LCI zero (0)). Once a virtual circuit is assigned to an outbound SCTP stream, however, it **SHOULD** remain assigned to that stream for the lifetime of the connection, otherwise, ordered message sequencing will be at risk on the VC. The XOS layer should provide the ability to distribute active VCs over the available outbound streams in as efficient a manner as possible, however, the precise algorithm for doing so is a local matter. One way of accomplishing this is, indeed, by negotiating 4096 outbound streams with the SCTP peer and providing an identity mapping between LCI and SCTP stream number; however, this is not the only (nor most efficient) arrangement possible.

Logical Channel Identifier zero (0), that is the "NULL" virtual circuit, refers to the data link and all contained VC and PVC, and is special in that messages sent on this LCI **MUST** be sent on SCTP stream number zero (0). Messages sent on LCI zero (0) (and SCTP stream zero (0)) **MAY** be sent unordered. No other messages (i.e. messages for LCI other than zero (0)) will be sent on SCTP stream zero (0), unless there is only one outbound stream negotiated (in which case all messages must be sent on stream zero (0)). Which of the other available outbound streams is used for a particular LCI is a local matter; therefore, an XOS receiver **MUST NOT** use the inbound SCTP stream number to discriminate virtual circuits, but **MUST** use the LCI contained in the X.25 header (as is the case for normal X.25 and ISO 8208 operation).

3.4. Service Interfaces

The upper layer service interface to **XOS** protocol functions is provided by the Data Link Provider service interface described in the ITU-T OSI Data Link Service Definition [X.212], and that described for IEEE 802.2 LLC operation [802.2]. The service primitives defined for the data link service are listed in *Table 1*.

Table 1. Data Link Service Primitives

Mode	Service Primitive	Standard
Connectionless	DL-UNIT-DATA request	X.212
	DL-UNIT-DATA indication	X.212
Connection Oriented	DL-CONNECT request	X.212
	DL-CONNECT indication	X.212
	DL-CONNECT response	X.212
	DL-CONNECT confirm	X.212
	DL-DATA request	X.212
	DL-DATA indication	X.212
	DL-RESET request	X.212
	DL-RESET indication	X.212
	DL-RESET response	X.212
	DL-RESET confirm	X.212
	DL-DISCONNECT request	X.212
	DL-DISCONNECT indication	X.212
	DL-CONNECTION-FLOWCONTROL request	ISO 8802-2
	DL-CONNECTION-FLOWCONTROL indication	ISO 8802-2
Acknowledged Connectionless	DL-DATA-ACK request	ISO 8802-2
	DL-DATA-ACK indication	ISO 8802-2
	DL-DATA-ACK-STATUS indication	ISO 8802-2
	DL-REPLY request	ISO 8802-2
	DL-REPLY indication	ISO 8802-2
	DL-REPLY-STATUS indication	ISO 8802-2
	DL-REPLY-UPDATE request	ISO 8802-2
	DL-REPLY-UPDATE-STATUS indication	ISO 8802-2

XOS is primarily concerned with the Connection-Oriented mode service primitives and mapping them onto the SCTP transport interface.

The lower layer service interface providing services to **XOS** protocol function is provided by the SCTP (see Section 10 of RFC 4960) [SCTP]. This service interface can be roughly modelled with the ITU-T OSI Transport Service Definition [X.214], as listed in *Table 2*.

Table 2. SCTP Primitives

SCTP Function	Transport Service Primitive	Standard
SCTP-INITIALIZE	−	−
SCTP-ASSOCIATE	T-CONNECT request	X.214
	T-CONNECT indication	X.214
	T-CONNECT response	X.214
	T-CONNECT confirm	X.214
SCTP-SEND	T-DATA request	X.214
	T-EXDATA request	X.214
	T-UNIT-DATA request	X.214
SCTP-RECEIVE	T-DATA indication	X.214
	T-EXDATA indication	X.214
	T-UNIT-DATA indication	X.214
SCTP-ABORT	T-DISCONNECT request	X.214
	T-DISCONNECT indication	X.214
SCTP-SHUTDOWN	T-RELEASE request	−
	T-RELEASE indication	−
SCTP-RELEASE	−	−

4. XOS Service Definition

The mapping of Data Link Service Definition service primitives to SCTP primitives is straightforward, is listed in *Table 3*, and is detailed in the subsections that follow.

Table 3. Mapping of Service Primitives

DLS Primitive		SCTP Primitive
DL-CONNECT Request	→	SCTP-INITIALIZE
	→	SCTP-ASSOCIATE connect
DL-CONNECT Indication	←	SCTP-ASSOCIATE listen
DL-CONNECT Response	→	SCTP-ASSOCIATE accept
DL-CONNECT Confirm	→	SCTP-ASSOCIATE completes
DL-DATA Request	→	SCTP-SEND
DL-DATA Indication	←	SCTP-RECEIVE
DL-RESET Request	→	SCTP-ABORT
	→	SCTP-ASSOCIATE connect
DL-RESET Indication	←	SCTP-RESTART-INDICATION
DL-RESET Response	→	SCTP-RESTART completes
DL-RESET Confirm	←	SCTP-ASSOCIATE completes
DL-DISCONNECT Request	→	SCTP-ABORT
DL-DISCONNECT Indication	←	SCTP-ABORT or
	←	SCTP-COMMUNICATIONS-LOST-INDICATION

4.1. DL-CONNECT

Upon receipt of an DL-CONNECT Request from the X.25 PLP, XOS will generate an SCTP-INITIALIZE and SCTP-ASSOCIATE primitive to SCTP. The source address parameter from the DL-CONNECT Request will be used as the local port and local eligible address list in the SCTP-INITIALIZE primitive and the destination address parameter from the DL-CONNECT Request will be used as the destination address in the SCTP-ASSOCIATE primitive. The priority parameter from the DL-CONNECT Request is ignored. Once the SCTP ASSOCIATION has formed, XOS will issue a DL-CONNECT Confirm primitive to the X.25 PLP with the source address and destination address parameter corresponding to the SCTP source transport address and SCTP destination transport address.

Upon receipt of an SCTP-ASSOCIATE primitive from SCTP, XOS will issue a DL-CONNECT Indication primitive to the X.25 PLP containing as the source and destination address parameters, the SCTP source and destination transport addresses. Upon receipt of the DL-CONNECT Response primitive from the X.25 PLP, XOS will confirm the SCTP-ASSOCIATE primitive. Upon receipt, the priority parameter is ignored, and when issued, the priority parameter is set to zero. Note that normal LLC [802.2] procedures use the 48-bit MAC address for addresses, however, these 48 bits are normally opaque to the X.25 PLP implementation. Conveniently, an IPv4 Address and Port number is also 48 bits. IPv6 addresses, on the other hand, are much longer.

4.2. DL-DATA

Upon receipt of a DL-DATA Request primitive from the X.25 PLP, XOS will generate an SCTP-SEND primitive with the same data parameter. The “stream id” and “unordered flag” parameter of the SCTP-SEND primitive is determined according to the rules described in the next section of this memo.

Upon receipt of a SCTP-RECEIVE primitive from SCTP, XOS will issue a DL-DATA Indication primitive to the X.25 PLP containing the same data parameter. The source and destination address parameters are derived from the SCTP association to which the SCTP-RECEIVE primitive applies.

4.3. DL-RESET

Upon receipt of an SCTP-RESTART-INDICATION, XOS will issue to the X.25 PLP a DL-RESET Indication primitive and expect a DL-RESET Response form the X.25 PLP. Upon receive of the DL-RESET Response, the SCTP Restart procedure will be completed by XOS.

Upon receipt of a DL-RESET Request primitive from the X.25 PLP, XOS will issue an SCTP-ABORT primitive to SCTP followed immediately by an SCTP-ASSOCIATE primitive for the same pairing of source transport address and destination transport address. XOS should request that SCTP discard all data that has not been delivered at the time of the reset. Once the procedure is complete, XOS will issue the DL-RESET Confirm primitive to the X.25 PLP.

4.4. DL-DISCONNECT

Upon receipt of a DL-DISCONNECT Request from the X.25 PLP, XOS will generate an SCTP-ABORT primitive to SCTP. Upon receipt of an SCTP-ABORT primitive or any of the disconnection indications from SCTP (e.g., SCTP-COMMUNICATIONS-LOST), XOS will issue to the X.25 PLP a DL-DISCONNECT Indication primitive. The reason parameter will be derived from the primitive or indication from SCTP.

5. XOS Packets

For each X.25 packet received from the SCTP connection to be sent out a local interface, an XOS implementation **MUST** set the packet’s logical channel number to that used on the outgoing interface. For the purposes of this RFC, a logical channel number is the 12 bit field confusingly defined by the X.25 Recommendations [X.25] as the high-order 4-bit "logical channel group number" and low-order 8-bit "logical channel number", where the latter phrase is used to refer to both the aggregated 12 bits and the low-order 8 bits.

An XOS implementation **SHOULD** NOT modify the X.25 packet header information received on a local interface to be transmitted over the SCTP association.

An XOS implementation **MUST** modify the X.25 packet header information as required for proper X.25 protocol operation for packets received on an SCTP association to be transmitted over a local interface.

An XOS implementation **MAY** support connection between interfaces that use different flow control modulos. If this feature is supported, XOS **MUST** modify the packet General Format Identifier on all packets received over the SCTP connection to set the proper modulus identifier.

5.1. Transmission of XOS Packets

The XOS layer receives service primitives requires for transmission in the same manner as the data link provider [X.212], [DLPI] for LAPB [ISO 7776], [X.222] or LLC2 [802.2]. The X.25 PLP (DXE) is responsible for resolving LCI assignment conflicts and completing the LCI field of the X.25 header for packets. The packets are then delivered to the XOS layer using the DL-DATA Request primitive. The XOS layer may examine the packet for the content of the LCI assignment, and uses a table to map the LCI from the X.25 header in the message to an SCTP stream number. When the packet is a CC packet establishing a connection, the entry in the mapping table for LCI to SCTP stream is first populated. Once a DC is packet is received, the associated entry in the mapping table for the released virtual circuit may be released (i.e. deleted).

Messages that are for the NULL reference (i.e. that contain zero (0) in the LCI) are always sent on SCTP stream zero (0). Messages with a non-zero LCI are always sent on an SCTP stream other than zero (0), unless stream zero (0) is the only available outbound stream because the maximum number of outbound streams negotiated on association initialization is one (1), or the message is an INTERRUPT or INTERRUPT CONFIRM message. When the message is an INTERRUPT or INTERRUPT CONFIRM message, the XOS layer should select a stream id not used by other messages, or may transmit the message on stream zero (0).

Note: X.25 expects that the flow control restrictions appropriate for expedited data and normal data, for example, CONS mapped onto X.25 in accordance with X.233 [X.233], provide that the expedited data be subject to different flow control restrictions than is normal data. This can be accomplished in SCTP in several ways:

(1) The packets can be sent with the unordered flag set: meaning that INTERRUPT and INTERRUPT CONFIRM packets are permitted to be delivered to the peer user, even when some other packets are missing and ordered packets can not currently be delivered.

(2) The packets can be sent in a separate stream from the stream in which normal data is delivered.

One or both of these procedures can be applied at the same time.

Once the mapping has been performed for a particular message, the message is issued to the SCTP layer with SEND primitive (see RFC 4960, Section 10) the indexed "stream id," the "unordered flag" clear for all non-zero LCI messages with the exception of INTERRUPT and INTERRUPT CONFIRM packets.

5.2. Reception of XOS Packets

Upon receiving data from the SCTP Association using the RECEIVE primitive (see RFC 4960, Section 10), the XOS layer examines the contained X.25 message, extracts the LCI and delivers the message to the indicated X.25 PLP DXE as normal (that is, using the DL-DATA Indication service primitive) [X.212]. The X.25 PLP processes this data no differently that if it were received from LAPB [ISO/IEC 8208], [ISO 7776], [X.222] or LLC2 [ISO 8881], [802.2].

6. XOS Procedures

XOS procedures are modeled after the procedures of the LAPB Data Link [ISO 7776], [X.222]. X.25 PLP procedures are the same as expounded in X.25 and ISO 8208 and are not altered by this memo, except where noted.

6.1. SCTP Association Setup and Clearing

For **XOS**, each SCTP Association corresponds to a data link. Therefore, the SCTP Association follows the same rules for establishment and closing that the LAPB or LLC2 data link exhibits. When the X.25-PLP layer requests that a data link be established, the SCTP-INITIALIZE and SCTP-ASSOCIATE procedures are invoked as described under “*DL-CONNECT*,” above. When the X.25-PLP layer or **XOS** determines that the data link is no longer in use (by virtual circuits), the X.25-PLP requests that the data link be closed with a DL-DISCONNECT Request primitive that results in the SCTP-ABORT or SCTP-SHUTDOWN operation as described under "*DL-DISCONNECT*," above.

6.2. Virtual Circuit Setup and Clearing

Once an SCTP association has been established, the restart procedures described in ISO/IEC 8208 [ISO/IEC 8208] section 4.5 (Determining "DTE" or "DCE" characteristics), are used to determine whether the local DTE acts in DTE or DCE mode for the purpose of logical channel number assignment. This is accomplished using the restart procedure described in that section. This does not preclude and is compatible with a given SCTP peer acting in DCE-only mode (i.e. as a data link entity associated with a private or public packet switched data network).

When establishing virtual and permanent virtual circuits, the normal ITU-T Recommendation X.25 or ISO/IEC 8208 procedures as regards LCI are used by the X.25 PLP layer associated with the XOS peers. Normal message formats and state transitions are used.

To simplify end-to-end flow control, the packet size and window size **SHOULD** always be explicitly sent as facilities in the Call packet, in the fashion of ISO 8208. When included in the Call packet, the packet **MUST** contain both Packet Size and Window Size facilities. The Call Confirm packet **MAY** contain these facilities. The handling of a Call received over an SCTP association that does not encode one or both of the flow control facilities is a local matter--if the XOS accepts such a call, it **MUST** encode the missing flow control facility values that apply to the connection in the returned Call Confirm packet.

Note that the X.25 interface normally have a concept of network default values for packet size and window size. It was thought that when connecting diverse sites over an SCTP/IP network this concept would be difficult to achieve in practise. If there is no network default, then each call must state the packet size and window size. This is the reason for requiring the packet size and window size facilities. It is expected that this can be achieved either by the XOS layer itself, or by configuring the X.25 engine such that there is no network default on the interface.

After receiving or sending a Clear Confirm packet for the last virtual circuit supported by an SCTP association, the SCTP association **MAY** be closed, in accordance with the same procedures for data links as described in ITU-T Recommendation X.25 [X.25] and ISO/IEC 8208 [ISO/IEC 8208].

A packet with an invalid X.25 Packet Type Identifier (PTI) received over the SCTP connection before a Call has been received (i.e., while in the P1 state) **MUST** be silently discarded.

6.3. Interrupt, and Reset Packets

Interrupt, Interrupt Confirm, Reset and Reset Confirm packets are sent over the SCTP association using normal X.25 packet formats and state transitions.

Reset and Reset Confirm packets are sent with the same SCTP stream id as other data packets associated with the VC or PVC by Local Channel Identifier.

Interrupt and Interrupt Confirm packets, on the other hand, are used to implement network expedited data and **SHOULD** be sent either with an SCTP stream id separate from any normal data stream, or on stream id zero (0). Also, Interrupt and Interrupt Confirm packets **MAY** be sent unordered (i.e., with the U bit set ni the SCTP Data Chunk Header).

6.4. Restart, DTE Reject, Diagnostics, and Registration

X.25 packets that have only a local DTE/DXE interface significance (Restart, Restart Confirm, DTE Reject, Diagnostic, Registration Request and Registration Confirmation) **MUST** be sent over the SCTP outbound stream zero (0), and **MAY** be sent unordered (i.e. with the U bit set in the SCTP Data Chunk Header).

7. Reason Codes

This section describes the mapping of specific SCTP error conditions to Data Link Service Definition reset reasons and disconnect reasons.

7.1. Connection Rejection Reasons

As a result of receiving a DL-CONNECT Request from the X.25 PLP, XOS issues an SCTP-INITIALIZE and SCTP-ASSOCIATE primitive to SCTP. When the formation of an SCTP associations fails, SCTP may indicate an error to XOS. This error indication can either be as a result of an SCTP error, or an ICMP error. XOS indicates this connection rejection to X.25 PLP using the DL-DISCONNECT Indication service primitive.

The DL-DISCONNECT Indication primitive, when used for connection rejection, contains a reason parameter that indicates the reason for connection rejection. The connection rejection reason may be one of the following:

- Connection Rejection — Destination Unknown
- Connection Rejection — Destination Unreachable (Permanent)
- Connection Rejection — Destination Unreachable (Transient)
- Connection Rejection — QOS Unavailable (Permanent)
- Connection Rejection — QOS Unavailable (Transient)
- Connection Rejection — Permanent Condition (Permanent)
- Connection Rejection — Transient Condition (Transient)
- Connection Rejection — Unspecified

The **RECOMMENDED** mapping of SCTP and ICMP error codes to Connection Rejection reasons is listed in *Table 4*.

Table 4. SCTP Error mapping to Connection Rejection Reasons

SCTP/ICMP Error	DL-DISCONNECT Indication		
	Origin	**P/T**	**Reason**
ICMP Error: no route to host, redirect.	Provider	−	destination unknown
ICMP Error: protocol unreachable.		P	destination unreachable
ICMP Error: network unreachable, host unreachable, port unreachable.		T	
NO_RESOURCE.		P	QOS unavailable
RES_SHORTAGE.		T	
MISSING_PARM, BAD_CHUNK_TYPE, INVALID_PARM, BAD_PARM, PROTOCOL_VIOLATION, STALE_COOKIE, BAD_ADDRESS, NO_DATA, NEW_ADDR, LAST_ADDR, ILLEGAL_ASCONF.		−	unspecified
USER_INITIATED.	User	P	permanent condition
SHUTDOWN.		T	transient condition
		−	unspecified
SCTP-ABORT, OOTB.	Undefined	−	unspecified

7.2. Disconnect Reasons

Once the data link is in the data transfer state and the SCTP association fails, SCTP may indicate an error to XOS. This error indication can either be as a result of an SCTP error, or an ICMP error. XOS indicates this disconnect to X.25 PLP using the DL-DISCONNECT Indication primitive.

The DL-DISCONNECT Indication primitive, when used for disconnection, contains a reason parameter that indicates the reason for disconnection. The disconnection reason may be one of the following:

- Disconnect — Permanent Condition
- Disconnect — Transient Condition
- Disconnect — Abnormal Condition
- Disconnect — Normal Condition
- Disconnect — Unspecified

The **RECOMMENDED** mapping of SCTP and ICMP error codes to Disconnect reasons is listed in *Table 5*.

Table 5. SCTP Error mapping to Disconnect Reasons

SCTP/ICMP Error	**DL-DISCONNECT Indication**		
	Origin	**P/T**	**Reason**
MISSING_PARM, BAD_CHUNK_TYPE, INVALID_PARM, BAD_PARM, PROTOCOL_VIOLATION, ICMP (Fatal).	Provider	P	permanent condition
INVALID_STR, STALE_COOKIE, NO_RESOURCE, BAD_ADDRESS, NO_DATA, NEW_ADDR, LAST_ADDR, RES_SHORTAGE, ILLEGAL_ASCONF, ICMP (Non-Fatal).		T	transient condition
SCTP-ABORT, OOTB.		−	unspecified
SHUTDOWN.	User	−	normal condition
			abnormal condition
USER_ORIGINATED.			unspecified
	Undefined		

7.3. Reset Reasons

Once the data link is in the data transfer state and the SCTP association restarts, SCTP may indicate an error to XOS. This error indication can either be as a result of an SCTP error, or an ICMP error. XOS indicates this reset to X.25 PLP using the DL-RESET Indication service primitive.

The DL-RESET Indication primitive, when used for reset, contains a reason parameter that indicates the reason for reset. The reset reason may be one of the following:

- Reset — Flow Control
- Reset — Link Error
- Reset — User Resynchronization
- Reset — Unspecified

The **RECOMMENDED** mapping of SCTP and ICMP error codes to Reset reasons is listed in *Table 6*.

Table 6. SCTP Error mapping to Reset Reasons

SCTP Error	**DL-RESET Indication**	
	Origin	**Reason**
SCTP_ECN ICMP Source Quench	Provider	flow control
BAD_CHUNK_TYPE INVALID_STR NO_DATA ILLEGAL_ASCONF		link error
USER_INITIATED and then RESTART	User	resynchronization
RESTART	Undefined	unspecified<1>

Notes for §7

<1> Note that SCTP does not provide a source of an SCTP restart indication. The source could be either the peer SCTP provider or the peer SCTP User. Therfore, the origin is considered to be undefined.

8. Quality of Service

The Data Link Service Definition [X.212] states:

> There are three QOS parameters: throughput, protection, and priority ..., which are of the type that may be selected during DLC establishment. ... Once the DLC is estblished, throughout the lifetime of the DLC, the agreed QOS values are not reselected at any point, and there is no guarantee that the original values will be maintained. The DLS users should also be aware that changes in QOS on a DLC as not explicitly signalled by the DLS provider [X.212].

X.25 LAPB [X.25], ISO Data Link Protocol [ISO 7776], [X.222], and LLC [802.2], all provide for Quality of Service parameters to be determined at the time of establishment of the data link. XOT [RFC1613] (and TCP beneath it) provides no mechanism for Quality of Service. For XOS, on the other hand, SCTP provides several mechanisms to enforce grade of service on an association, as follows:

(1) SCTP protocol parameters provide for the maximum number of path retransmissions, and maximum number of association retransmissions, as well as the maximum retransmission timeout. These parameters can be adjusted to accommodate the maximum transit delay.

(2) The SCTP protocol provides for a maximum lifetime before acknowledgement of data messages submitted for transmission. The lifetime can be affected on an association basis or a per-message basis. This protocol mechanism can also be adjusted to accommodate maximum transit delay.

(3) The SCTP protocol extension for Partial Reliability can be used to adjust the residual error rate for the SCTP association.

Another approach to the management of QOS in the IP network surfaced after the advent of XOT [RFC1613] as the protocol RSVP []. With RSVP, (the procedures of which are also applicable to XOT), a reservation is performed against an RSVP server responsible for admission control of SCTP flows for the attached networks. The RSVP reservation would be made by XOS prior to the establishment of the SCTP association to which the QOS applies.

The following QOS parameters may be supported:

Throughput:–
This is a per-connection value.

Transit Delay:–

Residual Error Rate:–
For SCTP, unless the Partial Reliability extension to SCTP is used, the residual error rate will always be zero (0).<1>

Resilience:–

Protection:–
This is a per-connection value. The protection supported by the SCTP association is a matter for the DLS Provider to determine. When IPSec or TLS is used, the protection value can include passive

monitoring and active attacks. Whether all three values of protection are available when IPSec or TLS is not may depend upon the network providing the SCTP association.

Priority:–
This is a per-connection value. The priority supported by the SCTP association is a matter for the DLS Provider to determine.

Notes for §8

<1> Note that without the Partial Reliability extention, SCTP is always a reliable transport service and the association will fail if SCTP is unable to transport packets to the peer and deliver them in order or out of order within a reasonable (and configurable) time period. This is referred to in the IETF as a "reliable" transport.

9. Security

As with ISO 8208 and ITU-T Rec. X.25 applications, security is not integrated at the data link and network level, but rather, is integrated at layers above the transport layer. Therefore, XOS has no more Security exposure issues that X.25 itself.

On the other hand, by transporting X.25 PLP packets over SCTP over a public internet, their contents are exposed to a much greater degree than if they were transport over a private line service using ISO 8208. It is therefore **RECOMMENDED** that the SCTP implementation used on public internets be capable of operating with IPSec or TLS to protect the payload of the SCTP transport, in this case, the X.25 PLP packets, to at least reduce exposure to the levels of private line service.

10. IANA Considerations

The following IANA considerations are made:

10.1. SCTP Payload Protocol ID

This memo assigns an XOS value for the Payload Protocol Identifier in the SCTP DATA chunk. The following SCTP Payload Protocol Identifier will be registered: XOS "YY"

The SCTP Payload Protocol Identifier value "YY"<1> **SHOULD** be included in each SCTP DATA chunk, to indicates that the SCTP is carrying the XOS protocol. The value zero "0" (unspecified) is also allows but any other values **MUST NOT** be used. This Payload Protocol Identifier is not directly used by SCTP but **MAY** bse used by certain network entities to identify the type of information carried in the DATA chunk.

The User Adaptation peer **MAY** use the Payload Protocol Identifier as a way of determining additional information about the data being presented to it by SCTP. A request will be made to IANA to assign SCTP Payload Protocol IDs.

10.2. SCTP Port Number

IANA has registered TCP Port Number "1998"<2> for XOT [RFC1613]. It is recommended that XOS hosts use this TCP port number also for SCTP for listening for new connections. XOS hosts **MAY** also use statically configured SCTP port numbers instead.

Notes for §10

<1> **EDITOR'S NOTE:–** The value shown as "YY" is to be assigned by IANA and may change in future versions of this document.

<2> **EDITOR'S NOTE:–** The value shown as "1998" is to be assigned by IANA and may change in future versions of this document.

0. Change History

This section provides historical information on the changes made to this draft. This section will be removed from the document when the document is finalized for publication as an RFC.

0.1. Initial Version 0.0

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Change Log

```
$Log: draft-bidulock-tsvwg-xos-00.me,v $
Revision 0.9.2.3  2008-07-01 12:31:04  brian
- updated man pages, drafts, specs, header files

Revision 0.9.2.2  2008-06-18 16:45:23  brian
- widespread updates

Revision 0.9.2.1  2008-05-09 13:45:20  brian
- initial version of draft
```

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[**RFC1613**] "*Cisco Systems X.25 over TCP (XOT)*," **RFC 1613**, The Internet Society (May 1994). *(Status: INFORMATIONAL) (Defines TCP port number 1998.)* <**http://www.ietf.org/rfc/rfc1613.txt**>

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