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Matt Holdrege  
Ascend Communications

The Reliable Signaling Gateway Control Protocol (RSGCP)  
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#### Abstract

This memo describes the Control Protocol used between a Network Access Server (NAS) and a Signaling Gateway (SG). The requirements of this protocol are Call Control, Circuit Maintenance and Resource Management. This protocol must be reliable in nature and support redundant links between the NAS and SG. It's important to note that the NAS could be handling either packetized voice or data for access to the Internet.

#### Introduction

A need has arisen to better integrate Internet access and the Public Switched Telephone Network (PSTN). To accomplish this daunting task, several new techniques are being developed. One such technique is to establish communications between the main PSTN signaling network, known as Signaling System 7 (SS7) and dial-in internet NAS's. This allows multiple NAS access ports to collectively appear as a virtual resource of a PSTN switch. Another way to look at it is that the NAS's appear as a egress PSTN switch to an ingress PSTN switch.

The communication between the NAS and SS7 is facilitated by the SG. The SG has two fundamental interfaces. One is to the SS7 network speaking standard SS7 protocols as defined in the ITU-T Q.700 series.

The other interface is TCP/IP speaking to the SG's defined NAS population. This document describes the protocol that is carried between the SG and the NAS.

Since there is no existing protocol that fits the requirements completely, a new protocol will be derived from the ITU-T protocol Q.931. Q.931 is a very reliable protocol that has been used for years mainly as an ISDN call control protocol. Q.931 has well defined procedures and a message set that is extensible to allow additional functionality to be added easily. Additionally, Q.931 has already been incorporated into NAS's minimizing the modifications required to implement the new Control Protocol.

Due to the requirement for reliability and redundancy, a lower layer protocol is defined which is similar in nature to Q.921 or the link layer protocol.

It is assumed that the implementer has access to the Q.931 protocol specification as well as an understanding of SS7 messages.

## **2.0 Bearer Services**

### **Bearer Services and Interface Configuration**

#### **Bearer Services**

Four (4) bearer services are supported in the Control Protocol:

1. Circuit Mode, 64-kbps, 8-khz structured, Speech
2. Circuit Mode, 64-kbps, 8-khz structured, 3.1-khz, Audio
3. Circuit Mode, 64-kbps, 8-khz structured, Unrestricted Digital Transmission-Rate Adapted from 56-kbps
4. Circuit Mode, 64-kbps, 8-khz structure, Unrestricted Digital Transmission

Circuit Mode, 64-kbps, 8-khz structured, Speech The speech present at the inter-machine trunk is coded by the standardized Mu-law or a-law pulse code modulation (PCM) technique specified by CCITT Recommendation G.711.

Circuit Mode, 64-kbps, 8-khz structured, 3.1-khz, Audio The 3.1-khz audio signal present at the inter-machine trunk is coded by the standardized Mu-law or a-law PCM technique specified by CCITT Recommendation G.711.

Circuit Mode, 64-kbps, 8-khz structured, Unrestricted Digital Transmission-Rate Adapted from 56-kbps An information transfer rate of 56-kbps over a B channel is possible by rate adapting the user data rate of 56-kbps to 64-kbps. The transmitting side shall set bit eight (8) of each byte on the B-channel to a binary one, while the other bits are populated from the 56 kbps data stream. Conversely, the receiving side shall ignore the eighth bit of each byte.

Circuit Mode, 64-kbps, 8-khz structured, Unrestricted Digital  
Transmission This bearer service is used to originate and terminate  
circuit-mode data calls at 64-kbps.

Interface Configuration The Control Protocol is considered non-facility associated signaling, where the signaling for specific B-channels occur over a different physical facility. The bearer channels are carried over inter machine trunks which are connected between NAS units and central office exchanges. The control channel is carried over an IP network.

### [3.1](#) Format and Coding

#### [3.2.1](#) Message Structure

This section defines the messages the SG and NAS use for call processing, maintenance, and management. These messages are based on the ITU-T Recommendation Q.931 message set, and in most cases are simply specific codings of standard Q.931 messages. However, because the requirements of the SG based systems differ from those of ISDN access for which the Q.931 message set was developed, some messages described in this section are extensions of standard Q.931 messages. The Control Protocol message set consists of:

Message	Value
CONNect	0x07
CONNect ACKnowledge	0x0f
CONTInuity	0x11
CONTInuity ACKnowledge	0x13
DISConnect	0x45
REGistration	0x1f
REGistration ACKnowledge	0x17
RELease	0x4d
RELease COMplete	0x5a
REStart	0x46
REStart ACKnowledge	0x4e
SERVice	0x0f
SERVice ACKnowledge	0x07
SETUP	0x05
STATus	0x7d
STATus ENQuiry	0x73
LOGon	0x7f

Of the above messages, most are standardized in ITU-T Q.931. A few are added to meet the requirements of this protocol. They are:

CONTInuity  
CONTInuity ACKnowledge  
REGistration  
REGistration ACKnowledge  
SERVice

SERVice ACKnowledge  
LOGon

#### 3.2.1.1 CONTinuity

Holdrege

[Page 3]

The Continuity message shall be formatted as shown:

Information Element	Direction	Inclusion Condition	Length
Protocol Discriminator	NAS -> SG	Mandatory	1
Call Reference	NAS -> SG	Mandatory	5
Message Type	NAS -> SG	Mandatory	1
Channel Identification	NAS -> SG	Mandatory	8
Continuity Indicator	NAS -> SG	Mandatory	3

The Continuity message is used by the NAS to indicate the outcome of a continuity test.

#### **3.2.1.2 CONTinuity ACKnowledge**

Information Element	Direction	Inclusion Condition	Length
Protocol Discriminator	SG -> NAS	Mandatory	1
Call Reference	SG -> NAS	Mandatory	5
Message Type	SG -> NAS	Mandatory	1
Channel Identification	SG -> NAS	Mandatory	8

The Continuity Acknowledge message is used by the SG to acknowledge the receipt of a Continuity message from the NAS.

#### **3.2.1.3 REGistration**

The Registration message shall be formatted as shown below:

Information Element	Direction	Inclusion Cond.	Length
Protocol Discriminator	NAS -> SG	Mandatory	1
Call Reference	NAS -> SG	Mandatory	5
Message Type	NAS -> SG	Mandatory	1
Resource	NAS -> SG	Mandatory	3-5
Channel Identification	NAS -> SG	Optional	7+
Channel State ID	NAS -> SG	Optional	7+

The Registration message is sent by the NAS to register associated trunk and user port resources. For each Resource information element that specifies a trunk resource, there must be a corresponding Channel State Identification information element, immediately



following. If no trunk resources are specified in the Resource information element, the Channel Identification State information element may be omitted. When the NAS detects both links fail between the SG, if at least one link comes back up again, it will send the Registration message to inform the Gateway the available resources. The protocol discriminator of the Registration message is 0x43 (Maintenance Protocol Discriminator).

#### **3.2.1.4 REGISTRATION ACKNOWLEDGE**

The Registration Acknowledge message shall be formatted as shown below:

Information Element	Direction	Inclusion Cond.	Length
Protocol Discriminators	SG -> NAS	Mandatory	1
Call Reference	SG -> NAS	Mandatory	5
Message Type	SG -> NAS	Mandatory	1

The Registration Acknowledge message is sent by the SG to acknowledge confirmation of a resource registration. For each Resource information element that specifies a trunk resource, there must be a corresponding Channel State Identification information element, immediately following. The Registration Acknowledge message is not part of the basic Q.931 message set. The protocol discriminator of the Registration Ack is 0x43 (Maintenance Protocol Discriminator).

#### **3.2.1.5 SERVICE**

The Service message shall be formatted as shown below:

Information Element	Direction	Inclusion Cond.	Length
Protocol Discriminator	BOTH	Mandatory	1
Call Reference	BOTH	Mandatory	5
Message Type	BOTH	Mandatory	1
Resource	BOTH	Mandatory	3
Channel Identification	BOTH	Mandatory	7+

The Service message is sent by the SG to request a change in channel status and by the NAS to indicate a change in channel status.

#### **3.2.1.6 SERVICE ACKNOWLEDGE**

The Service ACKnowledge message shall be formatted as shown below:

Information Element	Direction	Inclusion Cond.	Length
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Protocol Discriminator	BOTH	Mandatory	1
Call Reference	BOTH	Mandatory	5
Message Type	BOTH	Mandatory	1
Resource	BOTH	Mandatory	3
Channel Identification	BOTH	Mandatory	7+

The Service Acknowledge message is sent by either the SG or the NAS to indicate that the state of the specified channel has been changed. The Change Status and Channel Identification IE's should be equivalent to the corresponding values sent in the Service Message.

### [3.2.1.7](#) **LOGon**

The Logon message shall be formatted as shown below:

Information Element	Direction	Inclusion Cond.	Length
Protocol Discriminator	NAS -> SG	Mandatory	1
Call Reference	NAS -> SG	Mandatory	5
Message Type	NAS -> SG	Mandatory	1

When the NAS cold restarts, it will send a LOGon message to notify the SG. Then the NAS will send REGistration messages to inform the SG of the available resources. The Protocol Discriminator of the Logon message is 0x43 (Maintenance Protocol Discriminator).

### Details

Information Elements are defined in ITU-T Q.931 and are not re-defined here for brevity.

Timers are defined in ITU-T Q.931 and are not re-defined here for brevity.

## [4.](#) **Basic Call Control**

This section describes the basic call control capabilities required for processing calls in the SG based NAS system.

### [4.1](#) **Call Scenarios**

#### [4.1.1](#) **Network Initiated Call Origination**

##### [4.1.1.1](#) **IAM Initiated with No COT Required**

This scenario describes the signaling that proceeds when a call is initiated by the reception of an IAM from the SS7 network and a continuity test is not required.

- \* When the SG receives a IAM from the SS7 network, the Nature of Connection indicators shall be examined to determine if COT is required on the specified circuit. If COT is not required, the SG shall send a SETUP message to the NAS.
- \* Once the NAS has determined that the call can be completed and the specified channel has been connected to the called party, it shall send a CONNECT message to the SG. The NAS shall start timer T313 when the CONNECT message is sent.
- \* Upon receipt of the CONNECT message, the SG shall send a CONNECT ACKNOWLEDGE message to the NAS and an ANM message out to the SS7 network.
- \* Upon receipt of the CONNECT ACKNOWLEDGE message, the NAS shall stop timer T313.

#### **4.1.1.2 IAM Initiated with COT Required**

This scenario describes the signaling that proceeds when a call is initiated by the reception of an IAM from the SS7 network and a continuity test is required.

- \* When the SG receives a IAM from the SS7 network, the Nature of Connection indicators shall be examined to determine if COT is required on the specified circuit. If COT is required, the SG shall send a SERVICE message to the NAS indicating that the specified circuit should be placed in a loopback mode, and start timer Tserv.
- \* When the NAS receives the SERVICE message indicating the specified circuit should be placed in loopback mode, the circuit shall be marked as busy, placed in a loopback mode, and a SERVICE ACKNOWLEDGE message indicating the circuit was successfully placed in a loopback mode, shall be sent to the SG.
- \* When the SG receives the SERVICE ACKNOWLEDGE message indicating the circuit was successfully placed in a loopback mode, timer Tserv shall be stopped.
- \* When the SG receives a COT message from the SS7 network indicating the continuity test was successful, the SG shall send a SETUP message to the NAS.
- \* Once the NAS has determined that the call can be completed and the specified channel has been connected to the called party, it shall send a CONNECT message to the SG. The NAS shall start timer T313 when the CONNECT message is sent.
- \* Upon receipt of the CONNECT message, the SG shall send a CONNECT

ACKNOWLEDGE message to the NAS and an ANM message out to the SS7 network.

\* Upon receipt of the CONNECT ACKNOWLEDGE message, the NAS shall stop timer T313.

#### **4.1.1.3 IAM Initiated with COT on Previous Circuit Required**

This scenario describes the signaling that proceeds when a call is initiated by the reception of an IAM from the SS7 network that specifies a continuity test on a previous circuit is required.

- \* When the SG receives a IAM from the SS7 network, the Nature of Connection indicators shall be examined to determine if COT is required on the specified circuit, or on a previous circuit. If COT is required on a previous circuit, the SG shall send a SETUP message out to the control link.

- \* Once the NAS has determined that the call can be completed and the specified channel has been connected to the called party, it shall send a CONNECT message to the SG. The NAS shall start timer T313 when the CONNECT message is sent.

- \* Upon receipt of the CONNECT message, the SG shall send a CONNECT ACKNOWLEDGE message to the NAS.

- \* Upon receipt of the CONNECT ACKNOWLEDGE message, the NAS shall stop timer T313.

- \* When the SG receives a COT message from the SS7 network indicating the continuity test was successful, the SG shall send a ANM message out to the SS7 network.

#### **4.1.2 Call Clearing**

##### **4.1.2.1 Network Initiated Call Clearing**

This scenario describes the signaling that proceeds when a call clearing is initiated by the SS7 network.

- \* Call clearing is initiated by the SS7 network when a REL is received by the SG from the SS7 network. When the SG receives a REL from the SS7 network, a DISCONNECT message with a Cause Value of 16, "normal clearing", is sent to the NAS.

- \* When the NAS receives a DISCONNECT message the associated circuit shall be disconnected, a RELEASE shall be sent to the SG, and timer T308 shall be initiated.

- \* When the SG receives the RELEASE message, a RELEASE COMPLETE shall be sent to the NAS and a RLC shall be sent out to the SS7 network.

- \* When the NAS receives the RELEASE COMPLETE message timer T308 shall be stopped, the channel shall be released, and the call reference shall be released.

4.1.2.2 NAS Initiated Call Clearing This scenario describes the signaling that proceeds when a call clearing is initiated by the NAS.

\* When the NAS detects that an active call has been terminated by the



local subscriber, the NAS shall disconnect the associated circuit, send a DISCONNECT message to the SG, and initiate timer T305.

\* When the SG receives a DISCONNECT from the NAS, a RELEASE message shall be sent to the NAS, and a RLS message shall be sent out to the SS7 network.

\* When the NAS receives the RELEASE message timer T305 shall be stopped, the circuit shall be released, the call reference shall be released, and a RELEASE COMPLETE shall be sent to the SG.

\* When the NAS receives the RELEASE COMPLETE message timer T308 shall be stopped, the B-channel shall be release, and the call reference shall be released.

#### **4.1.3 Call Failures and CCR**

\* message timer Tserv shall be stopped and a RLC shall be sent out to the SS7 network.

##### **4.1.3.1 IAM Initiated with COT on Previous Circuit Failed**

This scenario describes the signaling that proceeds when a call is initiated by the reception of an IAM from the SS7 network that specifies a continuity test on a previous circuit is required and consequently the continuity test fails.

\* When the SG receives a IAM from the SS7 network, the Nature of Connection indicators shall be examined to determine if COT is required on the specified circuit, or on a previous circuit. If COT is required on a previous circuit, the SG shall send a SETUP message out to the control link.

\* Once the NAS has determined that the call can be completed and the specified channel has been connected to the called party, it shall send a CONNECT message to the SG. The NAS shall start timer T313 when the CONNECT message is sent.

\* Upon receipt of the CONNECT message, the SG shall send a CONNECT ACKNOWLEDGE message to the NAS.

\* Upon receipt of the CONNECT ACKNOWLEDGE message, the NAS shall stop timer T313.

\* When the SG receives a REL message from the SS7 network, which indicates the continuity test failed, a DISCONNECT message with a Cause Value of 16, "normal clearing", is sent to the NAS.

\* When the NAS receives a DISCONNECT message the associated circuit

shall be disconnected, a RELEASE shall be sent to the SG, and timer T308 shall be initiated.

\* When the SG receives the RELEASE message, a RELEASE COMPLETE shall be sent to the NAS and a RLC shall be sent out to the SS7 network.

\* When the NAS receives the RELEASE COMPLETE message timer T308 shall be stopped, the channel shall be released, and the call reference shall be released.

#### **4.1.4 Resource Registration**

##### **4.1.4.1 Registration**

This scenario describes the message flow that proceeds when a NAS unit registers the available hardware interfaces.

\* When the NAS detects that a resource has changed operational states, a REGistration message is sent to the SG and Timer T350 shall be initiated.

\* When the SG receives the REGistration message, the indicated resource states are updated and a REGistration ACKnowledgement is sent to the NAS. The Resource information elements in the REGistration ACKnowledgement must be identical to those received in the original REGistration message.

\* When the NAS receives the REGistration ACKnowledge message, timer T350 shall be stopped.

##### **4.1.4.2 Registration - T350 Timeout**

This scenario describes the message flow that proceeds when a timeout of Timer T350 occurs after the NAS has initiated registration of the available hardware interfaces. It is important to note that the NAS should continue to re-send the REGistration message and restart Timer T350 until a corresponding REGistration ACKnowledge is received.

\* When the NAS detects that a resource has changed operational states, a REGistration message is sent to the SG and Timer T350 shall be initiated.

\* When Timer T350 expires on the NAS, the NAS shall re-send the REGistration message and restart timer T350.

\* When the SG receives the REGistration message, the indicated resource states are updated and a REGistration ACKnowledgement is sent to the NAS. The Resource information elements in the REGistration ACKnowledgement must be identical to those received in the original REGistration message.

\* When the NAS receives the REGistration ACKnowledge message, timer T350 shall be stopped.

##### **4.1.4.3 SG Initiated Restart**

This scenario describes the message flow that proceeds when a Restart Request primitive is received by the SG Control Protocol from the call control.

\* When the SG Control Protocol receives a Restart Request primitive from the call control, a REStart message is sent to the NAS and timer T317 is initiated.

\* When the NAS receives a REStart message from the SG Control Protocol, the specified device shall be restarted and a REStart ACKnowledgment shall be sent to the SG.

\* When the SG Control Protocol receives a REStart ACKnowledgment from the NAS, timer T317 shall be stopped.

#### **4.1.4.4 NAS Initiated Restart**

This scenario describes the message flow that proceeds when a REStart message is received by the SG Control Protocol from the NAS, as shown in figure Figure 28 - NAS Initiated Restart.

\* If the NAS determines that a restart of a single DS0, an entire DS1/E1, or the entire NAS system is necessary, a RESTART message shall be sent to the SG and timer T317 shall be initiated.

\* When the SG Control Protocol receives a REStart message from the NAS, a Restart Indication primitive shall be sent to the call control and a REStart ACKnowledgment shall be sent to the NAS.

\* When the NAS receives a REStart ACKnowledgment from the SG, timer T317 shall be stopped, and the associated equipment shall be restarted.

## **4.2 Detailed Procedures**

This section provides detailed information that describes the operation of the SG Control Protocol. A call progresses through different states as various events occur, and this section describes how the SG and NAS should process calls in each state. The table below shows the call states that apply to the SG Control Protocol.

State Name	Value
Null	0
Call Initiated	1
Call Present	6
Connect Request	8
Active	10
Disconnect Request	11
Disconnect Indication	12
Release Request	19

## **5.0 Redundancy**

For redundancy support, the SG and the NAS are connected via two independent links, a primary link (D1) and a secondary link (D2). The D1 and D2 entities on the NAS will attempt to establish sessions with their peers on the SG. When a session is established or lost, the Data Link Layer Entity (DLLE) will notify the Link Selection Control

(LS) entity.

The LS entity selects an available link (based on the reports from D1 and D2) and directs all NMI messages to that link. When an active link fails or is administratively declared inactive, the LS entity looks for an alternate link.

In general, the NAS Messaging Interface (NMI) is unaware of the link selection mechanism. As far as the NMI is concerned, there is a single pipe between the Gateway and the NAS. Therefore, the queue of outgoing messages (including those that are still unacknowledged) must be shared between the two D1 and D2 entities.

The message exchange between the Gateway and the NAS will use TCP over IP. The TCP port to be used should be user settable.

The usual physical connection between the Gateway and the NAS will be Ethernet. Transmission of IP over Ethernet follows the usual rules. Other physical connections are possible.

All numbers should be in binary, encoded in Network Byte Order (Big Endian).

Sequence numbers follow the rules defined in [RFC 1982](#) ("Serial Number Arithmetic").

The procedures have been designed assuming that the Gateway will listen for TCP connections, while the NAS will initiate the TCP connections.

Piggy-back acknowledgments are allowed and encouraged. Acknowledgments should not be delayed excessively.

## **[5.1](#) Formats**

### **[5.1.1](#) NMI packet format**

The NMI packets are transported using the TCP protocol over IP. The IP and TCP protocols are standard and are not defined in this document. Refer to [RFC791](#) and [RFC793](#) for further details.

The NMI header is defined below. The Information field is optional and it is used to carry NMI messages.

### **[5.1.2](#) NMI header format**

The NMI header is four bytes long.

7 6 5 4 3 2 1 0

```

      +--+--+--+--+--+--+--+
0 |      N(r)
      +--+--+--+--+--+--+--+
1 |      N(s)
      +--+--+--+--+--+--+--+

```



```

2 | 0 0 0 0 0 0
   +-+--+--+--+--+
3 | Info Field Lng

```

The N(r) field carries the received sequence number. The N(s) field carries the send sequence number. These numbers are used to detect duplicated data packets when using multiple links. Duplicate data packets can occur on the receiver when the sender switches from one active link to another.

The information field length indicates the length in bytes of the information field following the NMI header, if any. If the information field is not present, the length field is set to zero. The field is encoded in big-endian format.

### **5.1.3 Packet types**

Depending on the presence of the information field, there are two kinds of packets: Information packets and ACK packets.

#### **5.1.3.1 Information (I) packet**

The function of the Information (I) packet is to transfer sequentially numbered NMI messages. In this case, the header is followed by an information field containing the NMI message.

I packets may also be used to acknowledge previously received I packets numbered up to and including N(r) - 1. This function is commonly referred to "piggy-back acknowledge".

#### **5.1.3.2 Acknowledge (ACK) packet**

The function of the Acknowledge (ACK) packet is to acknowledge previously received I packets numbered up to and including N(r) - 1.

## **5.2 Recommended system parameters**

### **5.2.1 Maximum number of outstanding data packets - k**

The maximum number (k) of sequentially numbered data packets that may be outstanding (that is, unacknowledged) at any given time should not exceed 63.

### **5.2.2 Maximum number of received data packets pending acknowledgement - m**

The maximum number (m) of sequentially numbered data packets received pending acknowledgement at any given time must be smaller or equal to

the value of  $k$ .

### **5.2.3 ACK delay timer - T1**

The ACK delay timer (T1) specifies the maximum time that an

acknowledge response can be delayed after correctly receiving an I packet.

#### **5.2.4 Transmission timeout timer - T2**

The transmission timeout timer (T2) specifies the maximum time that an end point should wait for an acknowledgement.

#### **5.2.5 Persistent error timer - T3**

The transmission timeout timer (T3) specifies the maximum time that the Link Selection layer will wait for a link to establish. When this timer expires, the LS layer will indicate the error with an L2-ERROR indication. When the error condition is removed (i.e., a TCP session is established), another L2-ERROR indication will be issued with a "no error" indication.

### **5.3 Variables and sequence numbers**

#### **5.3.1 Sequence numbers**

Each NMI message is sequentially numbered. The sequence numbers cycle through the range 1 through 255. The number following 255 is 1, the number before 1 is 255. The value 0 has special meaning.

Arithmetic operations on state variables representing sequence numbers are affected by the fact that 0 is a forbidden value.

#### **5.3.2 Link selection (LS) layer**

##### **5.3.2.1 Active link - L(a)**

L(a) denotes an identifier associated with the currently selected link. Valid values are system dependent. In UNIX systems, this value could be the TCP socket number.

##### **5.3.2.2 Inactive link - L(i)**

L(i) denotes an identifier associated with the other link. Valid values are system dependent. In UNIX systems, this value could be the TCP socket number.

##### **5.3.2.3 Send state variable - V(s)**

V(s) denotes the sequence number of the next NMI message to be transmitted. V(s) can take on the value 1 through 255. The value of V(s) will be incremented by 1 with each successive NMI message transmission, and will not exceed V(a) by more than the maximum number of outstanding data packets k. The value of k (send window

size) must be in the range 1 less than or equal to  $k$  less than or equal to 63.

#### [5.3.2.4](#) Acknowledge state variable - $V(a)$

V(a) identifies the last NMI message that has been acknowledged by its peer [ $V(a) - 1$  equals  $N(s)$  of the last acknowledged NMI message]. V(a) can take on the value 1 through 255. The value of V(a) will be updated by the valid N(r) values received from the peer. A valid N(r) value is one that is in the range V(a) less than or equal to N(r) less than or equal to V(s).

#### **5.3.2.5 Receive state variable - V(r)**

V(r) denotes the sequence number of the next in-sequence NMI message expected to be received. V(r) can take on the value 0 through 255. The value of V(r) will be incremented by one with the receipt of an error-free, in-sequence NMI message whose N(s) equals V(r).

When the value of V(r) is 0, it will match any received N(s) exactly. This is used during sequence synchronization.

#### **5.3.2.6 Receive packets pending acknowledgement counter - RP**

RP denotes the count of received packets that are pending acknowledgement. RP can take on the value 0 through  $m - 1$ . The value of RP will be incremented by one with the receipt of an error-free, in-sequence NMI message whose N(s) equals V(r). It is reset to 0 when a packet is transmitted (either an I packet or an ACK packet).

### **5.3.3 Data link (DL) layer**

#### **5.3.3.1 Send sequence number - N(s)**

All packets carry N(s), the send sequence number of transmitted NMI messages. At the time that a packet is designated for transmission, the value of N(s) is set equal to V(s). The valid range is 1 through 255.

#### **5.3.3.2 Receive sequence number - N(r)**

All packets carry N(r), the expected send sequence number of the next received NMI message. At the time that a packet is designated for transmission, the value of N(r) is set equal to V(r). N(r) indicates that the DLLE transmitting the N(r) has correctly received all data packets numbered up to and including  $N(r) - 1$ .

A valid N(r) value is one that is in the range V(a) less than or equal to N(r) less than or equal to V(s).

The valid range of values is 0 through 255. The value 0 indicates that the sender of the packet needs to synchronize sequence numbers.

### **5.4 Primitives**

### [5.4.1](#) NP <-> LS primitives

#### [5.4.1.1](#) L2-START

Holdrege

[Page 15]

The L2-START primitive is used to request the establishing of a redundant session.

#### [5.4.1.2](#) L2-STOP

The L2-STOP primitive is used to request the release of an established redundant session. All pending outgoing data will be delivered before the session is released.

#### [5.4.1.3](#) L2-ABORT

The L2-ABORT primitive is used to request the immediate release of an established session. All pending outgoing data is discarded.

#### [5.4.1.4](#) L2-DATA

The L2-DATA primitives are used to request and indicate NMI messages which are to be transmitted, or have been received, by the data link layer.

#### [5.4.1.5](#) L2-ERROR

The L2-ERROR primitive is used to indicate when an error condition has occurred. Some of the possible conditions include:

Loss of communication with peer.

Persistent loss of communication with peer.

Error condition removed.

### [5.4.2](#) LS <-> DL primitives

#### [5.4.2.1](#) DL-ESTABLISH

The DL-ESTABLISH primitives are used to request and confirm the outcome of procedures for establishing a TCP session.

#### [5.4.2.2](#) DL-RELEASE

The DL-RELEASE primitives are used to request, indicate and confirm the release of an established TCP session.

#### [5.4.2.3](#) DL-ACTIVE

The DL-ACTIVE primitives are used to request, indicate and confirm the outcome of procedures for activating a link.

#### [5.4.2.4](#) DL-DATA

The DL-DATA primitives are used to request and indicate NMI messages which are to be transmitted, or have been received, by the data link layer.



#### **5.4.2.5 DL-ERROR**

The DL-ERROR primitive is used to indicate when an error has occurred.

#### **5.4.3 DL <-> DA primitives**

##### **5.4.3.1 DD-SYNC**

The DD-SYNC primitive is used to request and indicate the synchronization of a data link.

##### **5.4.3.2 DD-LOSS**

The DD-LOSS primitive is used to indicate that a data link is no longer available. The TCP session should be closed and reestablished. Some of possible reasons include:

Loss of TCP connection (such as reception of an RST or FIN flag).

Timeout while waiting for an acknowledge after sending an I packet.

Reception of an invalid N(r).

Reception of an invalid N(s).

##### **5.4.3.3 DD-DATA**

The DD-DATA primitives are used to request and indicate NMI messages which are to be transmitted, or have been received, by the data link layer.

#### **5.4.4 TCP primitives**

##### **5.4.4.1 TCP-CONNECT**

The TCP-CONNECT primitives are used to request and confirm establishing a TCP session.

##### **5.4.4.2 TCP-CLOSE**

The TCP-CLOSE primitives are used to request and indicate the release of an established TCP session.

##### **5.4.4.3 TCP-ABORT**

The TCP-ABORT primitives is used to request the immediate release of a TCP session.

## **6. State transition tables**

## [6.1](#) State machines overview

### [6.1.1](#) Layer 2 - Link selection state machine (LS)

Holdrege

[Page 17]

The link selection (LS) layer implements redundant data delivery, link management and selection for both data links. The following is a list of the Link Selection layer states:

State	Name	Comments
0	Inactive	NMI layer 2 is disabled.
1	Selecting	Layer 2 starting. Waiting for DL-ESTABLISH.
2	Active	Layer 2 active: a link is active and data transfer is possible.
3	Restarting	Layer 2 restarting with new parameters. Waiting for both links to be released. Any pending data will be sent before the active link is released.
4	Stopping	Layer 2 stopping. Waiting for both links to be released.
5	Stopping-restart	Layer 2 stopping and restarting. Waiting for both links to be released before the new parameters are effected.

#### **6.1.2 Link control state machine (LC)**

Each redundant link is controlled by a 'Link Control State Machine'. The following is a list of the Link Control states:

State	Name	Comments
0	Inactive	
1	Unavailable	Link establishment in progress.
2	Available	Link established and ready.
3	Pending	Link established and ready. Synchronization activation pattern received.
4	Active	Link active. Data transfer occurs on this link.
5	Stopping	Active link stopping. Waiting for all pending outgoing data to be delivered.
6	Closing	Active link closing. Waiting for TCP confirmation of link closed.

7	Releasing	Inactive link closing. Waiting for TCP confirmation of link closed.
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### **6.1.3 Link state machine - active mode (LA)**

The following is a list of the link states while in active mode. A link is said to be in active mode if it is the currently selected link. A link that is in the active mode is enabled for data transfer.

State	Name	Comments
0	Idle	Link control state is one of the following: INACTIVE, UNAVAILABLE, AVAILABLE, RELEASING and CLOSING.
1	Sync sent	Active link, synchronization request sent. Waiting for synchronization response.
2	Established	Active link, no data to send and no acknowledge pending.
3	Acknowledge	Active link, data has been received but a pending acknowledgement has not been sent.
4	Data sent	Active link, data sent but not acknowledged.
5	Data sent, acknowledge pending	Active link, data sent but not acknowledged and data has been received but an acknowledgement has not been sent.

## **7. Security Considerations**

SS7 is a critical network component in the PSTN and must be protected at all costs. This is taken into consideration in all current SS7 networks. Signaling gateways are designed also to protect the SS7 network and should employ thoughtful thresholds to make sure a NAS or malicious intermediate entity cannot adversely affect the SS7 network or any SS7 connected nodes.

Also, it is recommended but not required that the TCP/IP link from the NAS to the SG be protected by IPsec AH and ESP. In the case that the physical network between the NAS and SG is private, such security techniques are optional. In the case that the IP backbone used is shared with other applications and/or nodes, IPsec security is strongly recommended. This is to prevent Denial of Service attacks, and false message attacks which cannot be prevented by SG thresholds.

## **8. Acronyms**

ANM	Answer Message
SG	Signaling SG
CCR	Continuity Check Request

COT                      Continuity

CPE                      Customer Premises Equipment

CRM	Circuit Reservation Message
IAM	Initial Address Message
ICD	Interface Control Document
IE	Information Element
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ISP	Internet Service Provider
ISUP	ISDN User Part
MTP	Message Transfer Part
PCM	Pulse Code Modulation
PSTN	Public Switched Telephone Network
SPCS	Stored Program Control System
SS7	Signaling System Number 7
UL	Upper Layer

## **10. Authors Address**

Matt Holdrege  
1701 Harbor Bay Pkwy  
Alameda, CA 94502  
510-747-2711  
matt@ascend.com

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