1.0 Introduction

1.1 Purpose

This document is a frame relay permanent virtual connection (PVC) network-to-network interface (NNI) implementation agreement. The agreements herein were reached in the Frame Relay Forum, and are based on the relevant frame relay standards referenced in Section 2.0. They address the optional parts of these standards, and document agreements reached among vendors/suppliers of frame relay network products and services regarding the options to be implemented.

The default NNI PVC management procedures are as defined in Q.933 Annex A bidirectional procedures. Refer to Section 4.0, Application of Bidirectional Procedures for Use at the Network-to-Network Interface, of this implementation agreement. The event driven procedures contained herein may optionally be supported by bilateral agreement. Refer to Section 5.0, Application of Event Driven Procedures at the Network-to-Network Interface, of this implementation agreement.

Except as noted, these agreements will form the basis of conformance test suites produced by the Frame Relay Forum.

This document may be submitted to different bodies involved in ratification of implementation agreements and conformance testing to facilitate multi-vendor interoperability.

Annex 1 of this document (Event Driven Procedures), is included due to its unavailability elsewhere. When it has been separately published as an ITU recommendation, this document will be reissued with Annex 1 replaced by a reference to the ITU recommendation. No substantive changes are expected. However, if substantive, noninteroperable changes are made to the event driven procedures, then at the time this document is reissued, it will require reballoting with a change to the revision number.

1.2 Definitions

- Network-to-Network Interface (NNI) - the Network-to-Network Interface is concerned with the transfer of C-Plane and U-Plane information between two network nodes belonging to two different frame relay networks.
- Must, Shall, or Mandatory - the item is an absolute requirement of this implementation agreement.
- Should - the item is highly desirable.
- May or Optional - the item is not compulsory, and may be followed or ignored according to the needs of the implementor.
- Not Applicable - the item is outside the scope of this implementation agreement.
- PVC segment - A PVC in a single network which is a component of a multi-network PVC.
- Multi-network PVC - A concatenation of two or more PVC segments.

2.0 Relevant Standards

The following is a list of standards and implementation agreements on which this frame relay NNI implementation agreement is based:

1. ANSI T1.403 - Carrier to Customer Installation DS1 Metallic Interface, 1989.
2. ANSI T1.107a - Digital hierarchy - supplement to formats specifications (DS3 format applications), 1990.
3. ANSI/TIA/EIA-612-1993, Electrical Characteristics for an Interface at Data Signaling Rates up to 52 Mbit/s.
4. ANSI/TIA/EIA/-613-1993, High Speed Serial Interface for Data Terminal Equipment and Data Circuit-Terminating Equipment.
5. CCITT Recommendation I.233.1 - Frame Relay Bearer Services, 1991.
6. CCITT Recommendation I.370 - Congestion Management for the ISDN Frame Relaying Bearer Service, 1991.
7. CCITT Recommendation I.372 - Frame Relaying Bearer Service Network-to-Network Interface Requirements, 1992.
8. CCITT Recommendation Q.922, ISDN Data Link Layer Specification for Frame Mode Bearer Services, 1991.
9. CCITT Recommendation G.703 - Physical/electrical characteristics of hierarchical digital interfaces, 1988.
10. CCITT Recommendation G.704 - Synchronous Frame Structures used at Primary and Secondary Hierarchical Levels
11. CCITT Recommendation E.164 / I.331 - Numbering Plan for the ISDN era.
12. CCITT Recommendation V.36 - Modems for synchronous data transmission using 60-108 kHz group band circuits.
13. CCITT Recommendation V.37 - Synchronous data transmission at a data signalling rate higher than 72 kbit/s using 60-108 kHz group band circuits.
14. CCITT Recommendation X.121 - International Numbering Plan for Public Data Networks, 1993.
15. ITU-T Recommendation Q.933, DSS1 Signalling Specification for Frame Mode Basic Call Control, ITU, Geneva, 1995.
16. ITU-T Recommendation Draft Q.frnni 1 - Frame Relay Services Network-to-Network Signalling Protocol For PVC Monitoring, 1994 (attached Annex A).
17. ITU-T I.555 - Interworking between FMBS and Other Services, 1993.
18. Frame Relay Forum - Frame Relay User-to-Network Implementation Agreement, Document Number FRF.1, 1992.
19. Frame Relay Forum - Frame Relay/ATM Network Interworking Implementation Agreement FRF.5, 1994.
20. Frame Relay Forum FRF.5, Frame Relay/ATM Network Interworking Implementation Agreement, August, 1994.

3.0 Implementation Agreements

3.1 Physical Layer Interface Guidelines

The recommended physical layer network-to-network interfaces (NNI) supported by frame relay network equipment are based on American National Standards and ITU-T / CCITT (International Telegraph and Telephone Consultative Committee) Recommendations. This section provides a description of the recommended physical layer interfaces that may be supported by frame relay network equipment. This section is not intended to be used for frame relay conformance testing. Interfaces other than those listed below may be used where appropriate (e.g., ISDN, etc.). If the recommended interfaces are used, they should be implemented as follows:

3.1.1 DS1 Interface (1544 kbit/s)

ANSI T1.403-1989 Carrier to Customer Installation DS1 Metallic Interface:

This specification will be followed, with the following exceptions:

1. **Section 2.2 - Other Publications:** The reference to CCITT, Red Book Q.921 Recommendation is replaced by "CCITT, Blue Book, Volume VI - Fascicle VI.10, Recommendation Q.921, Digital Subscriber Signalling System No 1 (DSS1), Data Link Layer".
2. **Section 5.3.1 - Transmission Rate:** The rate variation up to +/- 200 bit/s is not applicable**.**
3. **Section 6.1 - Framing Format General:** The Superframe (SF) format is not applicable.
4. **Section 6.3 - Superframe Format:** This section is not applicable.
5. **Section 7. - Clear Channel Capability:** The text in this section is replaced by the following: To provide DS1 Clear Channel capability (CCC), a DS1 signal with unconstrained information bits is altered to meet the pulse density requirement of 5.6. The method used to provide DS1 CCC is B8ZS. This method shall be used in both directions of transmission.
6. **Section 8. - Maintenance:** The mention of SF format and the associated note 4 is not applicable.
7. **Section 8.1 - Yellow Alarm:** Item 1 of the list (Superframe format) and associate note 5 are not applicable. In the same section; item 3 of the list, is applicable to ESF only.
8. **Section 8.3.1.1 - Line Loopback Using the SF Format:** This section, including note 6, is not applicable.
9. **Section 8.4.3.3 - Format of Message-Oriented Performance Report:** The sentence before last: "Throughput of the data link may be reduced to less than 4 kbit/s in some cases" is not applicable.
10. **Section 8.4.5 - Special Carrier Applications:** Item 3 of the list and note 12 are not applicable.
11. **Table 2 - Superframe Format:** This table is not applicable.
12. **Table 3 - Extended Superframe Format:** The portion of the table "Signaling Bit Use Options" and notes related to Option T, Option 2, Option 4, and Option 16 are not applicable.

In addition to ANSI T1.403, portions of CCITT Recommendations G.703 and G.704 relating to 1544 kbit/s interface are used. Exceptions to Recommendations G.703 and G.704 are listed below:

CCITT Recommendation G.703

The sections related to the 1544 kbit/s interface in this Recommendation apply with the following exception:

- **Section 2.5:** The current text is replaced by: 'The B8ZS code shall be used because connecting line systems require suitable signal content to guarantee adequate timing information.'

CCITT Recommendation G.704

The sections related to the 1544 kbit/s interface in this Recommendation apply with the following exceptions:

1. **Section 2.1.3 - Allocation of the F-bit:** The current text is to be replaced by: 'Table 1/G.704 provides the recommended F-bits allocation.'
2. **Table 1/G.704:** In the column 'For character signal', all instances of '1-7' are replaced by '1-8' (related bits are: 966, 2124, 3282 and 4440).
    a. The column 'For signalling' is not applicable.
    b. The column 'Signalling channel designation' is not applicable.
3. **Table 2/G.704:** The table is not applicable.
4. **Section 2.1.3.1.1 - Multiframe alignment signal:** The section starting with '...as well as to identify.' to the end of the sentence is not applicable.
5. **Section 2.1.3.1.3 - 4 kbit/s data link, third paragraph:** The entire paragraph is replaced by: 'The idle data link pattern is the HDLC flag bit pattern (01111110).'
6. **Section 2.1.3.2 - Method: twelve-frame multiframe:** This section is not applicable.
7. **Section 3.1.2 - Use of 64 kbit/s channel time slots:** This section is not applicable.
8. **Section 3.1.3 - Signalling:** All sections under 3.1.3 are not applicable.
9. **Section 3.2 - Interface at 1544 kbit/s carrying 32 kbit/s channel time slots:** All sections under 3.2 are not applicable.
10. **Section 3.3 - Interface at 1544 kbit/s carrying n * 64 kbit/s:** This section is not applicable.

3.1.2 CCITT Recommendation G.703 (2048 kbit/s)

Applicable sections of this specification are:

1. **Introduction:** except those references which are to 1544 kbit/s
2. **Section 6:** Interface at 2048 kbit/s
3. **Annex A:** Definition of codes
4. **Annex B:** Specification of the overvoltage protection requirement

In addition, when the 75 ohm interface is implemented, the transmit BNC connector shall be labeled TFC OUT and the receive BNC connector shall be labeled TFC IN.

3.1.3 CCITT Recommendation G.704 (2048 kbit/s)

Applicable sections of this specification are:

1. **General**
2. **Section 2.3:** Basic frame structure at 2048 kbit/s
3. **Section 5:** Characteristics of frame structures carrying channels at various bit rates in 2048 kbit/s interfaces
4. **Annex A.3:** CRC-4 procedure for interface at 2048 kbit/s

Note that **Section 1. General** specifies the electrical interface characteristics to be G.703.

3.1.4 DS3 Interface (44.736 Mbps)

ANSI T1.107a - 1990, Digital Hierarchy - Formats Specifications:

Applicable sections of this standard are:

1. **Section 8.0, Interface rate:** The sentence states the nominal bit rate.
2. **Section 8.1, DS3 frame structure:** All of 8.1 and its subsections.
3. **Section 8.2, DS3 Application:** M23 multiplex - 7 DS2 Channels: All of section 8.2.
4. **Section 8.4, Asynchronous DS3 C-bit Parity:** All of 8.4 and its subsections except that section 8.4.7, PMDL is optional.
5. **DS3 C-bit Parity - Unchannelized Application:** For further study.

3.1.5 E3 Interface (34.368 Mbps)

CCITT Recommendation G.703 - 1988 (34.368 Mbps)

Applicable sections of this specification are:

1. **Section 8:** Interface at 34.368 Mbps
2. **Annex A:** Definition of codes
3. **Annex B:** Specification of the overvoltage protection requirement

In addition the transmit BNC connector shall be labeled TFC OUT and the receive BNC connector shall be labeled TFC IN.

3.1.6 Transmission over ATM

As described in section 3.0 and Figure 1 of the Frame Relay/ATM Network Interworking Implementation Agreement FRF.5, two frame relay networks can be connected over an ATM network. This is listed in reference configuration 4, A2 to B2 (section 3.0 of FRF.5).

3.1.7 High Speed Serial Interface (HSSI)

The standard ANSI/TIA/EIA-613-1993 High Speed Serial Interface for DTE and DCE, together with ANSI/TIA/EIA-612-1993, Electrical Characteristics for an Interface at Data Signaling Rates up to 52 Mbit/s, provides for a general purpose DTE-DCE interface for data rates up to a maximum of 52 Mbit/s employing bit-serial data over balanced interchange circuits.

Applicable sections of this specification are:

1. **Section 3** of ANSI/TIA/EIA-613, Signal Characteristics (which references ANSI/TIA/EIA-612), shall apply.
2. **Section 5** of ANSI/TIA/EIA-613, Functional Description Of Interchange Circuits, shall apply with the exception of the following interchange circuits and subsections.

Table 1:

Circuit Number	Contact Pair	Circuit Name	Associated Section
107	3 & 28	DCE Ready	5.3.4
108/2	8 & 33	DTE Ready	5.3.5
143	10 & 35	Loopback A	5.3.6
144	12 & 37	Loopback B	5.3.6
142	24 & 49	Test Mode	5.3.7

3. **Section 4.1** of ANSI/TIA/EIA-613, 50-Position Interface Connector, in its entirety, shall apply.
4. **Section 4.2** of ANSI/TIA/EIA-613, Connector Contact Assignments, shall apply with the following exceptions:
   - 107 does not apply
   - 108 / 2 does not apply
   - 143 does not apply
   - 144 does not apply
   - 142 does not apply

3.1.8 CCITT V.36 / V.37 (1988) Interface (2-to-10 Mbps)

CCITT recommendations V.36 and V.37 specify the same connector (ISO 4902), pin assignments, electrical characteristics, and interchange circuit functions. Therefore, only the V.37 text is referenced below. Applicable sections of V.37 are:

1. **Section 13.1, List of interchange circuits:** Support of the following balanced interchange circuits is required. Note 4 is not applicable.
   - 103 Transmitted data
   - 104 Received data
   - 113 Transmitter signal element timing (DTE source)
   - 114 Transmitter signal element timing (DCE source)
   - 115 Receiver signal element timing (DCE source)
2. **Section 13.2, Electrical Characteristics:** The following text is applies:
   - Use of electrical characteristics conforming to Recommendation V.11 is required.
3. **Connector:** Section 13.2 specifies the 37-pin-D ISO 4902 connector. ISO 2110 amendment 1, 1991, specifies the 25-pin-D connector and the mapping of V.36/V.37 ISO 4902 pins to ISO 2110 pins. The mapping of pins is shown in Table B.1 of ISO 2110 amendment 1 (page 2). The 37-pin-D connector shall not be used. The following summarizes the pin assignments of the V.36/V.37 interface using the required 25-pin-D connector:
   - 103a - pin 2, 103b - pin 14
   - 104a - pin 3, 104b - pin 16
   - 113a - pin 24, 113b - pin 11

- 114a - pin 15, 114b - pin 12
- 115a - pin 17, 115b - pin 9

3.2 Data Transfer

This section is intended to be used for Frame Relay conformance testing. Implementations for the Frame Relay NNI U-plane shall be based on CCITT Q.922 Annex A. Implementation agreements on the optional parts of Q.922 Annex A are as follows:

3.2.1 Interframe Time Fill

Interframe time fill shall be accomplished by transmitting one or more contiguous HDLC flags with the bit pattern 01111110 when the data link layer has no frames to send. All equipment shall be able to receive, as a minimum, consecutive frames separated by 1 flag.

3.2.2 Frame Relay Information Field (Q.922 Annex A §A.2.5 & §A.5.1)

A maximum frame relay information field size of 1600 octets shall be supported by networks. In addition, maximum information field sizes less than or greater than 1600 octets may be agreed to between networks by bilateral agreement during PVC provisioning.

3.2.3 Address Field Variables

This section applies when using bidirectional procedures. When using event driven procedures, the address field is as defined in Section 5.

Note: On a given NNI, the address field and DLCI described below shall be configured as either 2 octets or 4 octets but not both.

- *Length of Address Field (Q.922 Annex A §A.3.3.1)*

  An address field of 2 octets shall be supported as the default. All frames using an address field of 2 octets must have the EA bit set to 0 in the first octet of the address field and the EA bit set to 1 in the second octet of the address field.

  The 3 octet address format is outside the scope of this implementation agreement.

  An address field of 4 octets may optionally be supported. All frames using an address field of 4 octets must have the EA bit set to 0 in the first, second and third octet of the address field and the EA bit set to 1 in the fourth octet of the address field.

- *Data Link Connection Identifier (DLCI) (Q.922 Annex A §A.3.3.6)*

  The 2 octet address format shall be supported with DLCI values as defined in Table 1 (for 10 bit DLCIs) of Q.922.

  The 4 octet address format may optionally be supported with DLCI values as defined in Table 1 of Q.922. When the D/C bit is set to 1, the DLCI is 17 bits in length. When the D/C bit is set to 0, the DLCI is 23 bits in length.

- *DLCI on the D-channel (Q.922 Annex A §A.3.3.6)*

  The descriptions in Q.922 Table 1 and §3.3.6 related to DLCI assignment on the D-channel are not applicable to PVCs.

- *DLCI or DL-CORE Control Indicator (D/C) (Q.922 Annex A §A.3.3.7)*

  This section is applicable to an address field of 4 octets. Use of the DL-CORE control bits is for further study.

Note: Other address structure variables (i.e., the command/response (C/R), discard eligibility indicator (DE), forward explicit congestion notification (FECN), and backward explicit congestion notification (BECN) bits) and their usage are as specified in Q. 922 Annex A.

3.2.4 Congestion Management

Congestion management and control is described in CCITT I.370. The mandatory procedures of this recommendation shall be implemented.

Additional congestion management principles applicable to the network-to-network interface are as follows:

> Each network should generate forward explicit congestion notification (FECN), backward explicit congestion notification (BECN), and support rate enforcement using the DE indicator in accordance with CCITT I.370.
>
> Each network is responsible for protecting itself against congestion scenarios at the network-to-network interface (e.g., a given network should not rely solely on the prior network's setting of the DE bit).
>
> Under normal operating conditions, every effort should be made not to discard Bc committed data at the NNI. One method to assure this, is to limit the sum of the subscribed CIRs (egress from the network) of all PVCs on a given NNI to be less than the NNI access rate.
>
> The committed information rate (CIR), committed burst size (Bc), and excess burst size (Be) values are administratively coordinated at the network-to-network interface. To provide a consistent service along the multi-network PVC, the same CIR value should be configured on all PVC segments (see section 4.1 for definitions of multi-network PVC and PVC segment). CIR, Bc, and Be may be uniquely defined in both the forward and backward directions.
>
> The access rate (AR) of all NNIs involved in a multi-network PVC do not have to be equal. The access rate at one NNI may be substantially higher than at another NNI. Therefore, continuous input of Be frames at one NNI may lead to persistent congestion of the network buffers at another NNI, and a substantial amount of the input Be data may be discarded.

The relationships of CIR, Bc and Be are illustrated in Table 1/I.372. These constraints shall apply to selection of parameters at the NNI.

3.2.5 Consolidated Link Layer Management (CLLM) Message (Q.922 Annex A §A.7)

Use of the CLLM message is outside the scope of this implementation agreement.

3.3 Control (Signalling) Procedures

3.3.1 Permanent Virtual Connection (PVC) Procedures

The default NNI PVC management procedures are as defined in Q.933 Annex A bidirectional procedures. Refer to Section 4.0, Application of Bidirectional Procedures for Use at the Network-to-Network Interface, of this implementation agreement. The event driven procedures contained herein may optionally be supported by bilateral agreement. Refer to Section 5.0, Application of Event Driven Procedures at the Network-to-Network Interface, of this implementation agreement.

3.3.2 Switched Virtual Connection (SVC) Procedures

Procedures for SVCs are not applicable to this implementation agreement.

3.4 Network Performance Parameters

Frame relay quality of service refers to service performance from the end-user standpoint. Network performance, when considered between two user-to-network interfaces, is closely tied to, and directly impacts the quality of service. Network performance parameters apply at different interfaces in the network. For a multi-network frame relay service, the values of performance parameters at the network-to-network interface contribute to the service performance from the end-user standpoint.

The performance parameters applicable to frame relay network-to-network service include those specified in Annex A of CCITT Recommendation I.233.1.

3.5 PVC Parameter Coordination

The parameter values that shall be administratively coordinated at the network-to-network interface include maximum frame size per PVC segment, originating DLCI and terminating DLCI of a PVC segment, and CIR in each direction per PVC segment. Additional parameters that should be coordinated include Bc and Be in each direction per PVC segment.

4.0 Application of Bidirectional Procedures for Use at the NNI

This section defines the unique network-to-network interface and user-to-network interactions when the bidirectional procedures are implemented at the NNI. Specific scenarios of how the PVC status information element status bits shall be interpreted in a multi-network environment are described. These scenarios include:

- addition of a multi-network PVC
- deletion of a multi-network PVC
- failure and restoration of a multi-network PVC

4.1 Bidirectional network procedures and multi-network PVCs

When a permanent virtual connection (PVC) between two users involves more than one network, the portion of the PVC provided by each network is termed a “PVC segment”. A multi-network PVC is a concatenation of two or more PVC segments. This is depicted in the Figure 1 below.

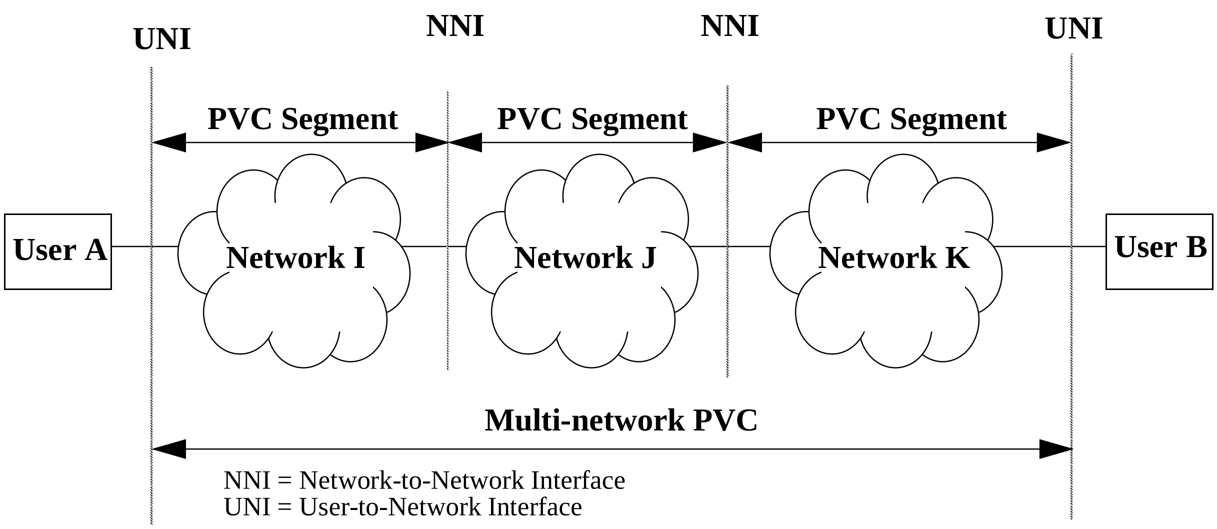

Figure 1
Multi-network PVC

The bidirectional network procedures shall be used to communicate status between networks. Each network at the network-to-network interface shall support both user side procedures and network side procedures simultaneously. In effect, there are two distinct user-to-network procedures taking place where each side of the NNI supports both user side and network side procedures concurrently. This is depicted in the Figure 2 below:

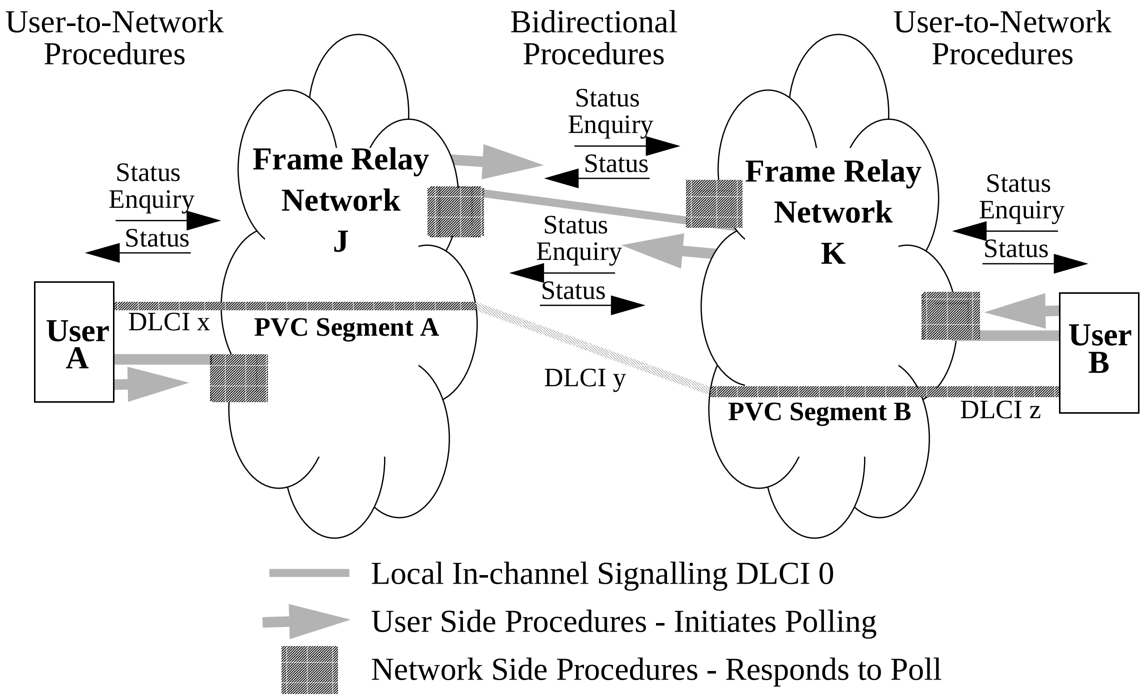

Figure 2
NNI Bidirectional Procedures

4.2 Polling requirements of network-to-network interfaces

Two sets of sequence numbers and local in-channel signalling parameters are administered for the network-to-network interface as shown below; see Table 2 for parameter ranges and default values.

- user side procedures - T391, N391, N392, and N393
- network side procedures - T392, N392, and N393

Table 2 summarizes the acceptable values when using bidirectional procedures at the NNI. The default values in Table 2 should be used as the actual system parameter values. Parameter values other than the default values are a subscription time option. Procedures for starting and stopping T391 and T392 are described in Q.933 Annex A.

Name	Range	Default	Units	Definition
N391	1-255	6	Polling Cycles	Full status (status of all PVCs) polling cycles.
N392	1-10[1]	3	Errors	Number of errors during N393 monitored events which cause the channel/user side procedures to be declared inactive. This number may also be used by the user side procedures as the number of errors during N393 monitored events which cause the network side procedures to be declared inactive.
N393	1-10[2]	4	Events	Monitored events count.
T391	5-30	10	Seconds	Link integrity verification polling timer.
T392	5-30[3]	15	Seconds	Timer for verification of polling cycle.

[1] N392 should be less than or equal to N393.

[2] If N393 is set to a value much less than N391, then the link could go in and out of an error condition without the user side procedures or network side procedures being notified.

[3] T392 should be set greater than T391.

Table 2
NNI system parameters

Both networks are required to initiate status enquiry messages based on T391. A full status report is requested each N391 (default 6) polling cycles. Both networks shall have the same values for T391, T392, N392, and N393 for both user side procedures and network side procedures; N391 is not required to have the same value in both networks.

PVC status information from full status reports and optionally from single PVC asynchronous status reports shall be propagated towards the user-to-network interface (UNI) of the multi-network PVC. The PVC status information element active bit state signaled at the NNI is independent of the PVC status information element active bit state signaled in the other direction at the same NNI.

In addition, when a PVC segment's active/inactive status has changed, or a PVC segment has been newly added or deleted, the network should respond to any poll (i.e., status enquiry) with a full status report. Alternatively, the network may generate a single PVC asynchronous status report to convey the PVC segment's status change.

4.3 Initial NNI status

The NNI access channel shall be considered non-operational when the user side procedures or network side procedures are first activated.

- The NNI access channel should be considered non-operational until N393 consecutive valid polling cycles occur.
- As an alternative, if the first polling cycle constitutes a valid exchange of sequence numbers, then the respective NNI access channel shall be considered operational. If the first polling cycle results in an error, then the respective NNI shall be considered non-operational until N393 consecutive valid polling cycles occur.

4.4 Multi-network PVC active status criteria

The network shall report a multi-network PVC as "active" (i.e., active bit =1) at the UNI only if all the following criteria are met:

1. All PVC segments are configured.

2. Link integrity verification is successful at all UNIs and NNIs that are associated with the multi-network PVC (N393 consecutive valid polling cycles, or as defined in Section 4.3 above).
3. All UNIs and NNIs associated with the multi-network PVC are operational (i.e., no service affecting conditions).
4. All PVC segments within the multi-network PVC are operational (i.e., no service affecting conditions).
5. The remote user equipment, when supporting bidirectional procedures at the UNI, reports that the PVC is active by setting the active bit = 1 in a PVC status information element.

Whenever these criteria are not fully met, the active bit indication propagated toward the UNIs shall be set to 0.

Only a network with a PVC terminating at a UNI may set the active bit to 1 towards the remote UNI (considered the “target UNI”). Each succeeding network along the multi-network PVC may either pass the active bit unchanged or set the active bit to 0. If any PVC segment is not active along the multi-network PVC, an inactive status is propagated (when possible) to the target UNI.

See Sections 4.5 - 4.10 for further details.

4.5 Adding a multi-network PVC

Since a multi-network PVC consists of a number of PVC segments, each managed by a different network, all PVC segments in a multi-network PVC cannot be added simultaneously. The PVCs can be thought as being added one at a time in an arbitrary order.

The presence or absence of a PVC status information element in a full status report at either the user-to-network interface or at the network-to-network interface indicates only the presence or absence of a particular PVC segment within the multi-network PVC.

As each PVC segment is added to a multi-network PVC, the network-to-network interface(s) and the user device (if applicable) are notified that the PVC segment has been added (i.e., new bit set to 1). The active status in a multi-network PVC is set according to the criteria given in section 4.4 and propagated towards the target UNI.

See Section 4.10.3 for an example of adding a multi-network PVC.

4.6 Deleting a multi-network PVC

Since a multi-network PVC consists of a number of concatenated PVC segments each managed by a different network, the PVC segments in a multi-network PVC cannot be deleted simultaneously. The PVC segments can be thought of as being deleted one at a time in an arbitrary order.

A multi-network PVC is considered to be deleted when the PVC status information element in the full status report has been deleted at every associated UNI and NNI.

The presence or absence of the PVC status information element at either the user-to-network interface or the network-to-network interface indicates only the presence or absence of a particular PVC segment within the multi-network PVC. As a PVC segment is deleted from a multi-network PVC, the adjacent network-to-network interface(s) and/or adjacent user device (if applicable) are notified by the deletion of the PVC status information element that its associated PVC segment has been deleted.

An inactive status is propagated towards the target UNI whenever the deletion of a PVC segment is detected at the NNI.

See Section 4.10.4 for an example of deleting a multi-network PVC.

4.7 Response to UNI failure

When a network detects that the user-to-network interface is inoperative, it notifies users of the multi-network PVCs associated with the failed UNI that the multi-network PVCs are inactive. The PVC status changes are propagated through the adjacent network(s) to the remote users.

See Section 4.10.5 for an example of response to UNI failure.

4.8 Response to PVC segment failure

When a network determines that a PVC segment has become inoperative, it notifies the adjacent network(s) and/or UNI that the multi-network PVC is inactive. The PVC status change is propagated through the adjacent network(s) to the remote user(s).

See Section 4.10.6 for an example of PVC segment failure.

4.9 Response to NNI failure

When a network detects that a network-to-network interface is inoperative, each network notifies users of the PVCs associated with the NNI that the multi-network PVCs are inactive. The PVC status changes are propagated through the adjacent network(s) to the remote users.

See Section 4.10.7 for an example of response to NNI failure.

4.10 Examples of multi-network PVC status signalling

This section provides examples of multi-network permanent virtual connection (PVC) status signalling at the user-to-network interface (UNI) and network-to-network interface (NNI). It contains examples of multi-network PVC status signalling in the following scenarios:

- adding a multi-network PVC (See Section 4.10.3)
- deleting a multi-network PVC (See Section 4.10.4)
- UNI failure & restoration (See Section 4.10.5)
- PVC segment failure & restoration (See Section 4.10.6)
- NNI failure & restoration (See Section 4.10.7)

4.10.1 Generic example comments

Status enquiry/status report exchanges occur at all UNIs and NNIs to indicate that the interface is operational. The status enquiry/status report exchanges are shown only when a change in link integrity verification state occurs or when multi-network PVC status signalling is affected. The PVC status information elements are only shown when the associated PVC segment has a status change.

The flows throughout this section show only the use of full status reports to signal a change in multi-network PVCs. Alternatively, the single PVC asynchronous status reports may be used to convey multi-network PVC active and inactive status changes.

All examples deal with the following multi-network PVC consisting of two PVC segments and as illustrated below in Figure 3:

- PVC segment in Network I interfaces to User A with DLCI 16 and Network J with DLCI 32.
- PVC segment in Network J interfaces to Network I with DLCI 32 and User B with DLCI 48.

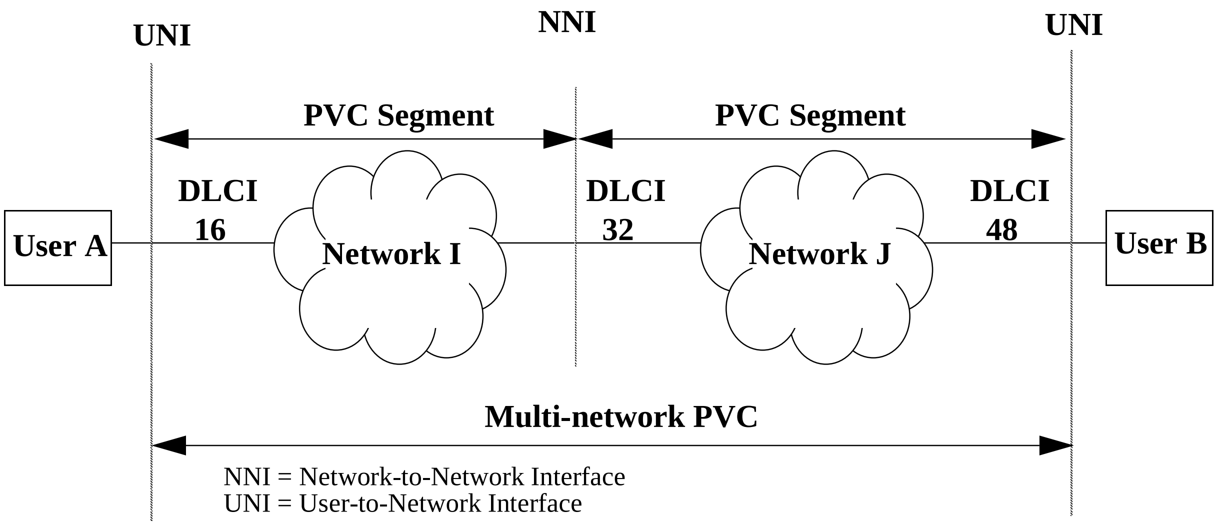

Figure 3
Example Multi-network PVC

Note that the default values of 3 errors for N392 and 4 monitored events for N393 are used throughout the examples.

4.10.2 Nomenclature

Notation	Meaning
SE	This is the status enquiry message as described in Q.933 Annex A, Section A.1.2. The request for a full status report need not be present.
S	This is the link integrity verification status report as described in Q.933 Annex A, Section A.1.1.
FS(16,N,I)	This is a full status report as described in Q.933 Annex A, Section A.1.1. A full status report request is not necessary for a full status report response. In this case, DLCI 16 reported the status of “new” and “inactive” for the PVC segment.
FS()	This is a full status report as described in Q.933 Annex A, Section A.1.1. A full status report request is not necessary for a full status report response. In this case, the PVC segment of interest is not present (e.g., no longer configured).
I->J	This indicates the status generated by Network I as seen by Network J.
A_{16}-I-J_{32}	This designates a PVC segment from User A through Network I to Network J. At the User A to Network I UNI, DLCI 16 is used. At the Network I to Network J NNI, DLCI 32 is used.
C	The “C” status for a particular PVC segment indicates that the PVC is configured and the PVC status information element is present in the full status report.
Not C	The “Not C” status for a particular PVC segment indicates that the PVC is not configured and the PVC status information element is not present in the full status report.
N	The “N” status for a particular PVC segment indicates that the “new” bit is set to 1 in the PVC status information element at the indicated interface. (The absence of an “N” in the diagrams indicates that the “new” bit is set to 0.)
A	The “A” status for a particular PVC segment indicates that the “active” bit is set to 1 in the PVC status information element at the indicated interface.
I	The “I” status for a particular PVC segment indicates that the “active” bit is set to 0 in the PVC status information element at the indicated interface.
ChanI	The “ChanI” indicates that the channel is inactive at the UNI or NNI due to link integrity verification failure, or other network determined UNI or NNI service affecting condition (e.g., data set signals down).

4.10.3 Example of adding a multi-network PVC

When configuring a multi-network PVC, each PVC segment must be added through its associated network management system. Figure 4 shows the addition of the multi-network PVC:

- Network I to User A using DLCI 16
- Network I to Network J using DLCI 32
- Network J to User B using DLCI 48

Simultaneous configuration of both PVC segments in the multi-network PVC is virtually impossible. After the PVC segment is configured in Network I and before the PVC segment in Network J is configured, Network I may detect that the PVC segment in Network J is not present and informs User A with a full status report indicating that the PVC segment is inactive. Note that the PVC segment has been configured locally and is therefore present (on the user interface to User A) but inactive because it is not configured on the remote network (Network J). As far as User B is concerned, the entire multi-network PVC has not been configured until the PVC segment is configured on its local network (Network J).

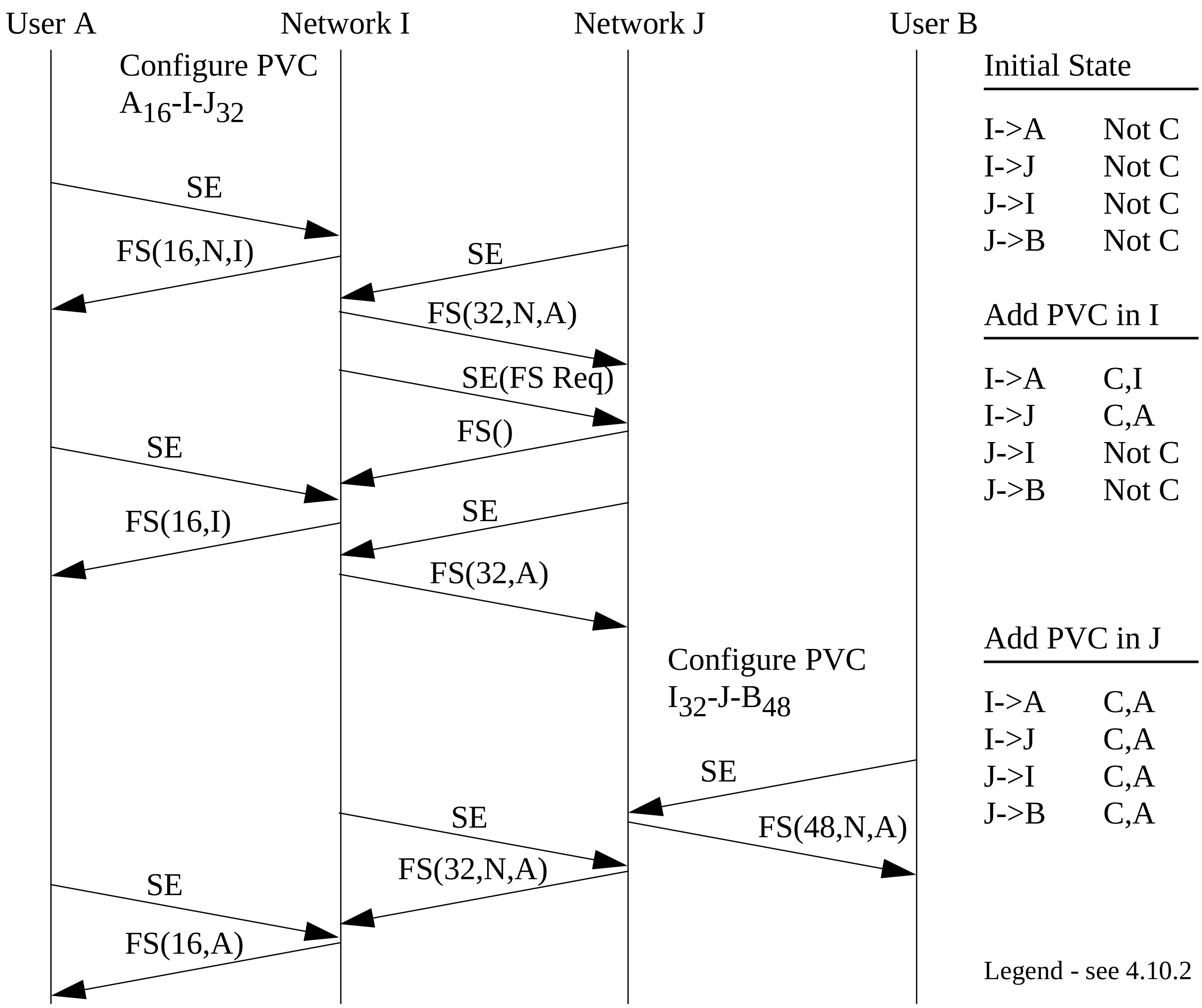

Figure 4
Configuration of a multi-network PVC

4.10.4 Example of deleting a multi-network PVC

When deleting a multi-network PVC, each PVC segment must be deleted through its associated network management system. Figure 5 shows the deletion of the multi-network PVC:

- Network I to User A using DLCI 16
- Network I to Network J using DLCI 32
- Network J to User B using DLCI 48

Simultaneous deletion of both PVC segments in the multi-network PVC is virtually impossible. User A receives a full status report with DLCI 16 deleted (absent) from Network I. After the PVC segment is deleted in Network I and before the PVC segment in Network J is deleted, Network J detects that the PVC segment in Network I is not present and informs User B with a full status report indicating that the PVC segment is inactive. Note that the PVC segment on Network J has not been deleted locally and is therefore present (on the user interface to User B) but inactive because it is not configured on the remote network (Network I). As far as User B is concerned, the multi-network PVC is not deleted until the PVC segment is deleted on its local network (Network J).

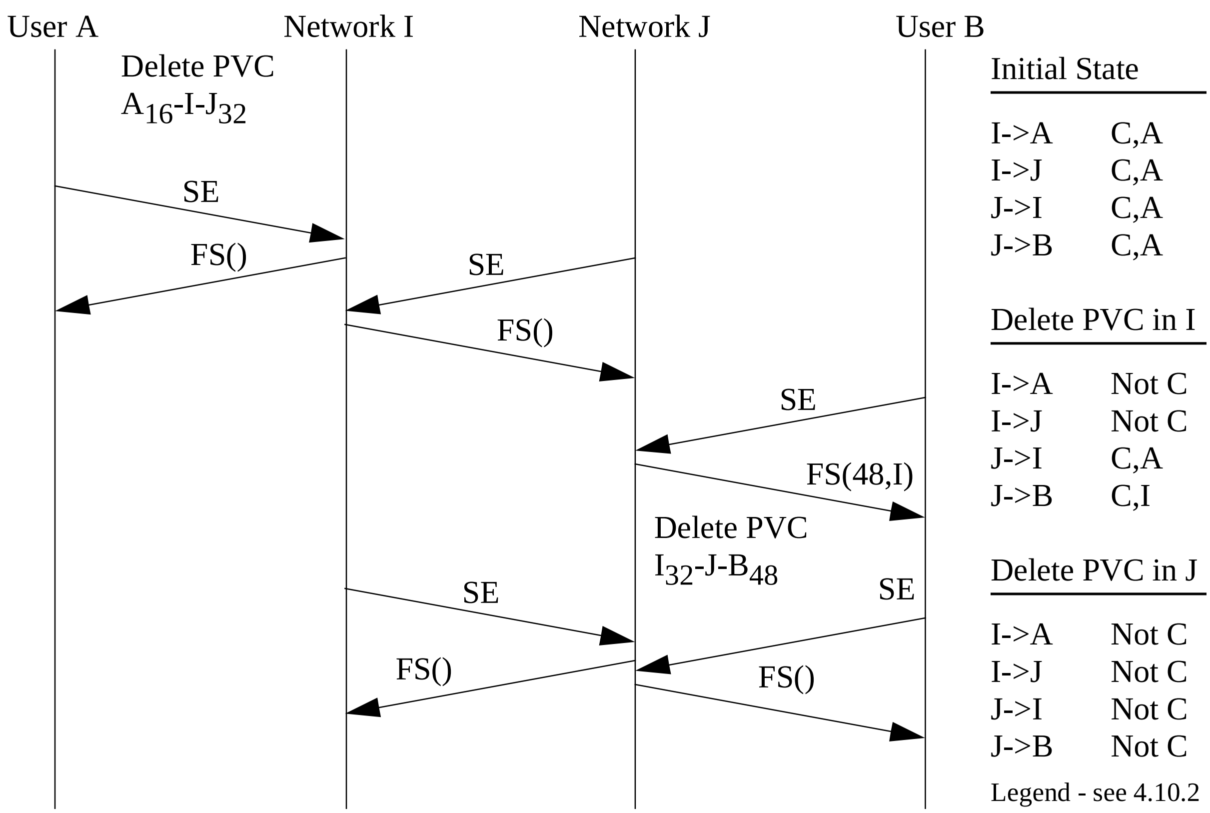

Figure 5
Deletion of a multi-network PVC

4.10.5 Example of UNI failure and restoration

Figure 6 shows the detection of an inactive channel (UNI channel) between User A and Network I (N393 valid polling cycles have not occurred). Network I notifies Network J that DLCI 32 is inactive. The inactive indication is forwarded to the PVC endpoint (User B) on Network J. The active/inactive indication from Network I to Network J is independent of the active/inactive indication from Network J to Network I. In Figure 6 the active bit is still set to 1 in the PVC Status Information Element for DLCI 32 in the full status reports sent from Network J to Network I.

Figure 6 also shows the detection of an active channel (UNI restoration) between User A and Network I. Network I notifies Network J that DLCI 32 is active. The active indication is forwarded to the PVC endpoint (User B) on Network J. The active/inactive indication from Network I to Network J is independent of the active/inactive indication from Network J to Network I.

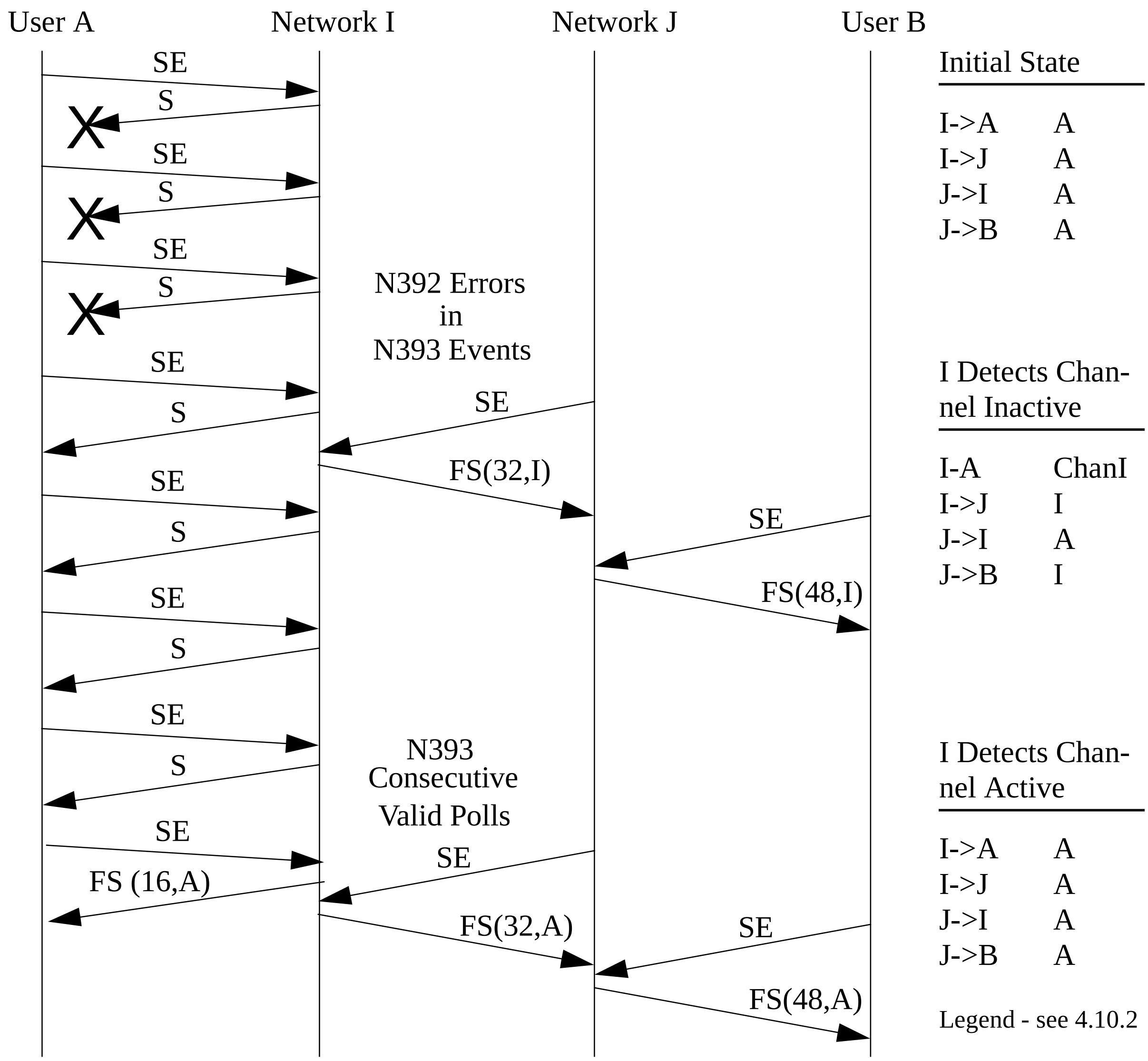

Figure 6
UNI failure and restoration

4.10.6 Example of PVC segment failure and restoration

Figure 7 shows the failure of a PVC segment in Network I. Network I notifies Network J that DLCI 32 is inactive. The inactive indication is forwarded to the PVC endpoint (User B) on Network J. The active/inactive indication from Network I to Network J is independent of the active/inactive indication from Network J to Network I. In Figure 7 the active bit is still set to 1 in the PVC status information element for DLCI 32 in the full status reports sent from Network J to Network I.

Figure 7 also shows the notification of a PVC segment becoming operational in Network I. Network I notifies Network J that DLCI 32 is active. The active indication is forwarded to the PVC endpoint (User B) on Network J. The active/inactive indication from Network I to Network J is independent of the active/inactive indication from Network J to Network I.

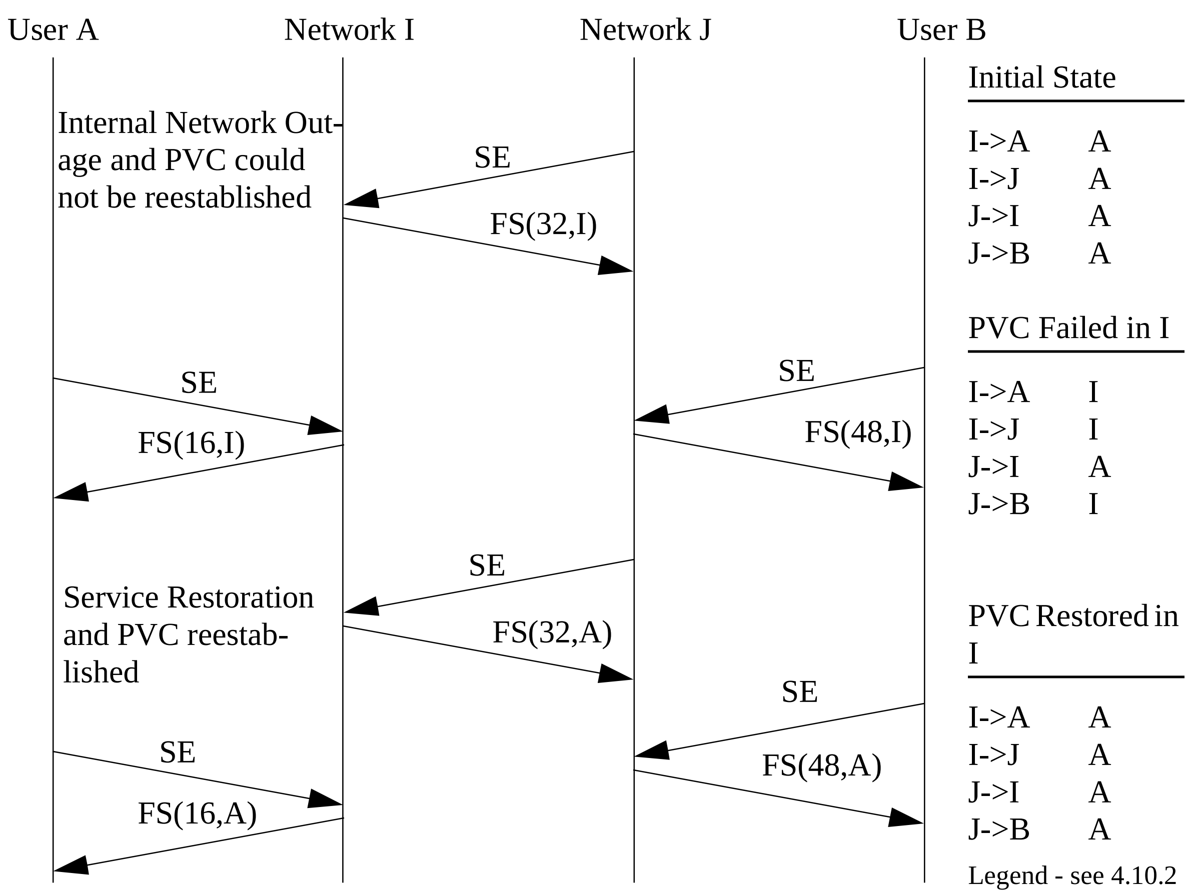

Figure 7
PVC segment failure and restoration

4.10.7 Example of NNI failure and restoration

Figure 8 shows the detection of an inactive channel (NNI failure) between Network I and Network J. Network I notifies the User A that DLCI 16 is inactive. Network J notifies the User B that DLCI 48 is inactive.

Figure 8 also shows the detection of an active channel (after N393 valid polling cycles) between Network I and Network J. Network I notifies the User A that DLCI 16 is active. Network J notifies the User B that DLCI 48 is active.

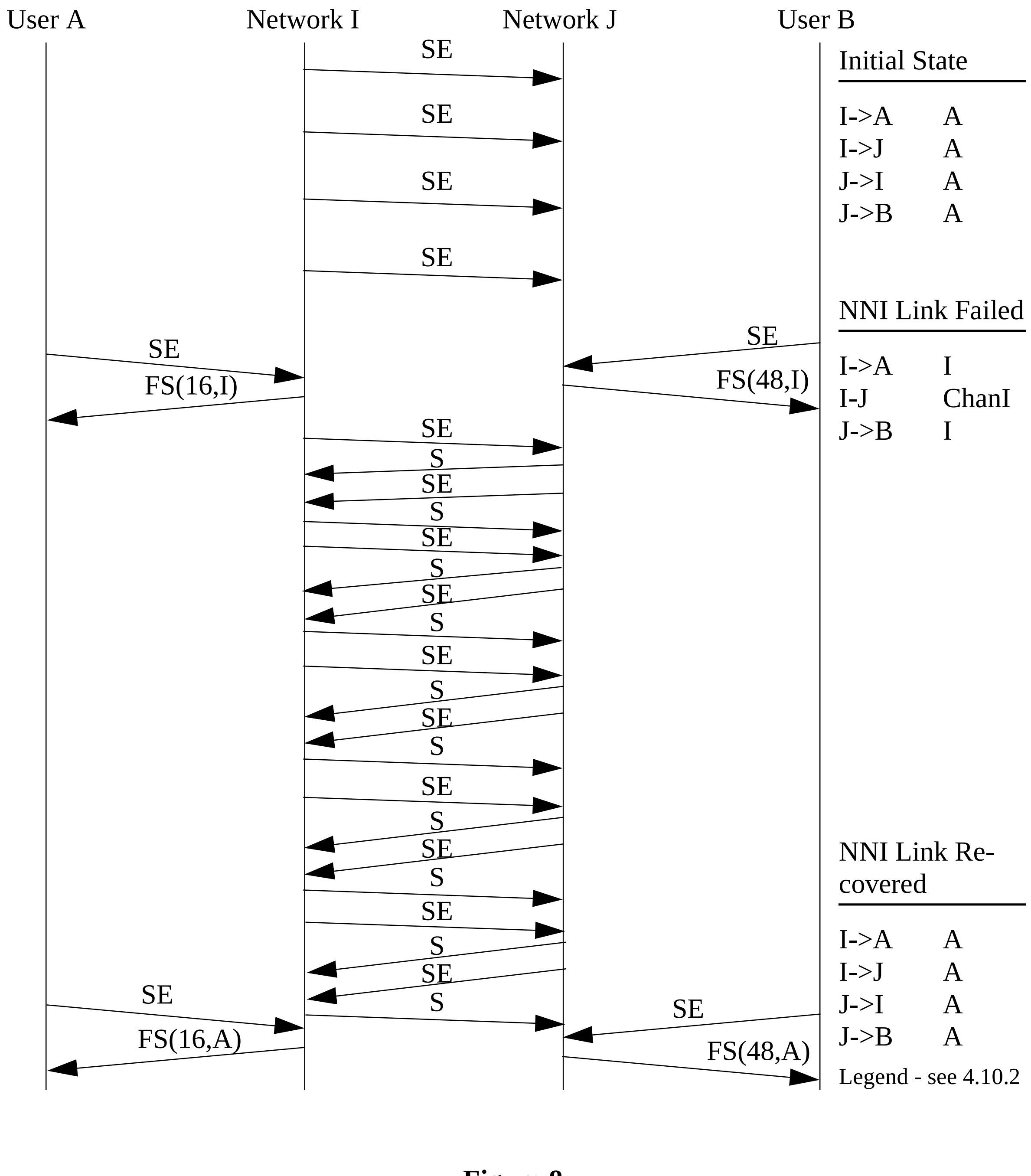

Figure 8
NNI failure and restoration

5.0 Application of Event Driven Procedures at the NNI

This section describes event driven procedures which are an alternative to the bidirectional procedures described in section 4.0. These procedures may be used by bilateral agreement between two networks, when the networks choose to have the associated benefits. Key functional differences provided by event driven procedures are:

- No polling for status. Status changes are immediately and reliably conveyed when they occur.
- No full status reports are sent. Status reports are only sent for PVCs that have status changes.
- Support of greater numbers of DLCIs. The quantity of DLCIs are not limited by a full status report maximum frame length as is the case with bidirectional procedures.
- Provides reporting of additional diagnostic information to help determine why a PVC or multi-network PVC is inactive and in which network a failure occurred.
- No special procedures are necessary to ensure that a new bit of 1 is not lost since the LAPF procedures ensure the reliability of data transferred on the signalling link.

The following sub-sections provide highlights of the event driven procedures.

Note: Implementors should be aware that the Event Driven Procedures do not provide reliable message exchange between peer Layer 3 entities. STATUS messages are discarded without detection when Q.933 protocol errors occur. STATUS messages may be lost without detection between the Q.922 and Q.933 entities due to the following types of NNI equipment problems: Q.933 task aborts, memory parity errors, buffer overflow, etc.

The Event Driven Procedures can potentially send a large number of STATUS messages after a Q.922 reset. Priority should be given to Q.933 SVC messages to avoid timing problems with any coexisting Q.933 entities.

5.1 Address Field Variables

Note: On a given NNI, the address field and DLCI described below shall be configured as either 2 octets or 4 octets but not both.

- *Length of Address Field Q.922 Annex A §A.3.3.1)*

  An address field of 4 octets shall be supported and is preferred as it provides increased capacity. All frames using an address field of 4 octets must have the EA bit set to 0 in the first, second and third octet of the address field and the EA bit set to 1 in the fourth octet of the address field.

  The 2 octet address format is also supported. All frames using an address field of 2 octets must have the EA bit set to 0 in the first octet of the address field and the EA bit set to 1 in the second octet of the address field.

  The 3 octet address format is not supported.

- *Data Link Connection Identifier (DLCI) (Q.922 Annex A §A.3.3.6)*

  The 4 octet address format is preferred and shall be supported with DLCI values as defined in Table 1 of Q.922. When the D/C bit is set to 1, the DLCI is 17 bits in length. When the D/C bit is set to 0, the DLCI is 23 bits in length.

  The 2 octet address format shall be supported with DLCI values as defined in Figure 1 (for 10 bit DLCIs) of Q.922.

- *DLCI on the D-channel (Q.922 Annex A §A.3.3.6)*

  The descriptions in Q.922 Table 1 and §3.3.6 related to DLCI assignment on the D-channel are not applicable to PVCs.

- *DLCI or DL-CORE Control Indicator (D/C) (Q.922 Annex A §A.3.3.7)*

  This section is applicable to an address field of 4 octets. Use of the DL-CORE control bits is for further study.

Note: Other address structure variables (i.e., the command/response (C/R), discard eligibility indicator (DE), forward explicit congestion notification (FECN), and backward explicit congestion notification (BECN) bits) and their usage are as specified in Q. 922 Annex A.

5.2 Permanent Virtual Connection (PVC) Procedures

Networks shall implement ITU Draft Q.frnni 1, 1994 procedures for managing PVCs (attached, Annex A).

The event driven procedures of Q.frnni1 operate in the LAPF assured mode. This means that status messages which incur errors are retransmitted by the LAPF layer. Event driven means that no status message is sent until there is a change in status of a PVC. When a change occurs, the new status sent is that of only the PVC which has had a change in status.

5.2.1 PVC Status Information Element

The PVC status information element indicates New, Active, Delete, Country Code, and Network ID.

5.2.1.1 New Bit

The new bit has similar functionality to that of Q.933 annex A but with one enhancement. This enhancement is that the new bit received at the NNI is always passed to the destination interface. This assures that if a network deletes and adds a PVC (re-using the DLCI value) in a transit network, the user will be informed.

Additionally, whenever a network informs an adjacent network that a PVC is “New,” the adjacent network responds with the status (active = 0/1 or deleted) of the corresponding PVC.

5.2.1.2 Active Bit

The Active bit has the same functionality as in Q.933 annex A.

5.2.1.3 Delete Bit

The Delete bit has similar functionality to that of Q.933 annex A but with an additional enhancement. Here, the delete bit has assured delivery.

5.2.1.4 Country Code and National Network Identifier

The country code and national network ID provide diagnostic capability and are included with PVC status messages indicating “inactive.” These fields are inserted by the network where the status change is first noted and are passed from network to network. A network switch or monitor may track this information for the purpose of diagnosing where a malfunction may have occurred. The country code is the standard E.164 or X.121 code assigned by ITU-T to each country and the national network ID is administered within each country.

5.2.1.5 Inactive Reason

While the country code and national network ID indicate where a malfunction occurred, the inactive reason indicates why it occurred. For example, the physical link to the adjacent network may have broken, or a PVC may have been removed from the network.

Like the country code and national network ID, the inactive reason is inserted by the network where the status change is first noted and is then passed from network to network.

5.3 Interactions With SVC Signaling

Implementors should recognize that use of the event driven procedures with SVC signaling procedures requires coordinated control of the data link for DLCI zero. For example, both sets of procedures require notification of LAPF link establishment, release and restart, and must coordinate such functions as initial LAPF link establishment or link re-establishment following a link failure.

Appendix 1: Handling of physical layer loopback conditions when using frame relay PVC bi-directional procedures

(informative)

A. Recommended procedures for equipment that can detect loopback at the physical layer:

Frame relay equipment that can detect physical layer loopback conditions should internally remove the interface from service during a physical layer loopback condition. It is strongly recommended that the equipment declare a service affecting condition at the frame relay interface for the duration of the loopback condition.

B. Recommended procedures for equipment that cannot detect loopback at the physical layer:

Frame relay equipment that cannot detect loopback at the physical layer may do the following sequence number processing at the frame relay layer to handle a loopback condition.

One property of the Q.933 Annex A bidirectional procedures is its capability to operate on a transaction basis. The send sequence number has an initial value of zero but it can be incremented by any value from 1 to 255 inclusive. This property can be exploited advantageously to detect accidental loopback.

Note: The frame relay procedures cannot detect that the loopback is occurring at the physical layer. They only detect that there is a loopback condition somewhere on the interface.

The equipment suspects a loopback condition exists if the send sequence number on a message received by a procedure is equal to the send sequence count of the opposite procedure, (i.e. if the send sequence number of a received STATUS is equal to the send sequence count of the equipment's network procedures, or if the send sequence number of a received STATUS ENQUIRY is equal to the send sequence count of the equipment's user procedures). A message meeting this condition is discarded. The equipment then attempts to confirm the loopback condition.

Note: Both devices on an interface starting with the same send sequence number produces an initial false loopback condition. It is strongly recommended that the send sequence counts for the user and network procedures of both devices be initialized to unique values. This significantly reduces the probability of an initial false loopback condition.

The procedure that suspects a loopback condition confirms it by incrementing its send sequence count by a value that may be fixed or randomly generated (as opposed to incrementing by one) before it sends the next message, (i.e. If the user procedures suspect loopback, the send sequence number of the next STATUS ENQUIRY is incremented by this value. If the network procedures suspect loopback, the send sequence number of the STATUS response is incremented by this value.) A bilateral agreement should be reached to ensure that both devices on the interface do not use the same fixed value or same random number. If the next message received by the procedure opposite the one suspecting the loopback condition contains a send sequence number that matches the incremented send sequence count, the loopback condition is confirmed. The message with the matching send sequence number is discarded.

Once the loopback condition is confirmed, each message received that meets the loopback condition is discarded. This results in a service affecting condition until the loopback condition is cleared.

The equipment detects that the loopback has been cleared when it receives N392 consecutive messages where the send sequence number of the received message does not match the send sequence count of the opposite procedures. At this point it goes back to incrementing by one.

Annex 1: Event Driven Procedures

(Normative)