Frame Relay/ATM PVC Service Interworking Implementation Agreement

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Abstract

This Implementation Agreement provides the functional requirements and configurations across interfaces for service interworking between the Frame Relaying Bearer Service and B-ISDN Permanent Virtual Connection Services.

Frame Relay / ATM PVC Service Interworking Implementation Agreement

1.0 Introduction

1.1 Purpose

This document is an implementation agreement on Permanent Virtual Connection (PVC) service interworking between Frame Relay and Asynchronous Transfer Mode (ATM) technologies. The agreements herein were reached jointly by the Frame Relay and the ATM Forums and are based on the documents referenced in section 2.0. These agreements address the optional parts of these standards, and document agreements reached among vendors and suppliers of frame relay and ATM products and services.

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

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

This document is not applicable to Switched Virtual Connections.

1.2 Scope and Overview

Service interworking applies when a Frame Relay service user interworks with an ATM service user, the ATM service user performs no frame relaying service-specific functions, and the frame relaying service user performs no ATM service-specific functions The optional translation of particular higher layer protocols to satisfy the requirements of end-systems is also specified herein.

Section 3 provides a description of Frame Relay/ATM service interworking. Section 4 describes the Frame Relay/ATM service interworking parameter mappings. Section 5 describes additional FR/ATM interworking aspects including traffic management, PVC management interworking, upper layer user protocol encapsulation, and address resolution. Section 6 describes operations and maintenance aspects.

1.3 Definitions

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.

1.4 Acronyms

AAL	ATM Adaptation Layer
AIS	Alarm Indication Signal
ATM	Asynchronous Transfer Mode
Bc	Committed Burst
Be	Excess Burst
BECN	Backward Explicit Congestion Notification
B-ICI	Broadband Inter Carrier Interface
B-ISDN	Broadband Integrated Services Digital Network
B-TE	BISDN Terminal Equipment
CC	Continuity Check
CDV	Cell Delay Variance
CI	Congestion Indication
CIR	Committed Information Rate
CLP	Cell Loss Priority
CPE	Customer Premises Equipment
CPCS	Common Part Convergence Sub-layer
CPCS-UU	Common Part Convergence Sub-layer User to User
CRC	Cyclic Redundancy Check
C/R	Command/Response bit
CSU	Channel Service Unit
DE	Discard Eligibility
DLCI	Data Link Connection Identifier
DSAP	Destination Service Access Point
DSU	Data Service Unit
DTE	Data Terminal Equipment
DTP	Data Transfer Protocol
DXI	Data Exchange Interface
EA	Address Extension bit
EFCI	Explicit Forward Congestion Indicator
FECN	Forward Explicit Congestion Notification
FFS	For Further Study

FMBS	Frame Mode Bearer Service
FR	Frame Relaying
FRBS	Frame Relaying Bearer Service
FR-SSCS	Frame Relaying - Service Specific Convergence Sub-layer
FRS	Frame Relaying Service
FSBS	Frame Switching Bearer Service
GCRA	Generic Cell Rate Algorithm
IE	Information Element
IETF	Internet Engineering Task Force
ILMI	Interim Local Management Interface
ITU	International Telecommunication Union
ITU-T	ITU Telecommunications Sector
IWF	Interworking Function
LAN	Local Area Network
LAPB	Link Access Procedure Balanced
LIV	Link Integrity Verification
LLC	Lower Layer Compatibility (in the case of ISDN) or Logical Link Control (in the case of LAN)
LP	Loss Priority
MAC	Media Access Control
MBS	Maximum Burst Size
MIB	Management Information Base
NLPID	Network Layer Protocol Identifier
NNI	Network to Network Interface
NPC	Network Parameter Control
NSAPA	Network Service Access Point Address
OAM	Operation, Administration and Maintenance
OUI	Organizationally Unique Identifier
PDU	Protocol Data Unit
PCI	Protocol Control Information
PCR	Peak Cell Rate
PID	Protocol Identifier
PLP	Packet Level Procedures
PSPDN	Packet Switched Public Data Network
PVC	Permanent Virtual Connection
QoS	Quality of Service
RFC	Request for Comments
RDI	Remote Defect Indication
SAP	Service Access Point
SAPI	Service Access Point Identifier
SAR	Segmentation and Reassembly
SCR	Sustainable Cell Rate
SNMP	Simple Network Management Protocol
SDU	Service Data Unit
SSAP	Source Service Access Point

SSCS	Service Specific Convergence Sub-layer
SVC	Switched Virtual Connection
TA	Terminal Adapter
TE	Terminal Equipment
U-Plane	User Plane
UNI	User to Network Interface
UPC	Usage Parameter Control
VC	Virtual Connection
VCC	Virtual Channel Connection
VCI	Virtual Channel Identifier
VPC	Virtual Path Connection
VPI	Virtual Path Identifier
WAN	Wide Area Network

2.0 References

The following is a list of documents upon which this Frame Relay/ATM Interworking Agreement is based:

ANSI T1.606 - Frame Relay Bearer Service - Architectural Framework and Service Description, American National Standards Institute, Inc., 1990.
ANSI T1.606a - "Congestion Management" - Frame Relaying Bearer Service - Architectural Framework and Service Description, American National Standards Institute, Inc., 1991.
ANSI T1.606b - "Network to Network Interface Requirements" - Frame Relaying Bearer Service - Architectural Framework and Service Description, August 1992.
ANSI T1.617 - DSS1 - Signalling Specification for Frame Relay Bearer Service, American National Standards Institute, Inc., 1991.
ANSI T1.617a - Frame Relay Bearer Service for DSS1 (protocol encapsulation and PICS).
ANSI T1.618 - DSS1 - Core Aspects of Frame Protocol for Use with Frame Relay Bearer Service, American National Standards Institute, Inc., 1991.
ANSI T1.633 - Frame Relaying Bearer Service Interworking, 1993.
ATM Forum - B-ICI Specification Document (Version 1.1), September 1994.
ATM Forum - UNI Specification Document (Version 3.1), August 1993.
FRF.1 - Frame Relay User-to-Network Implementation Agreement, January 1992.
FRF.2 - Frame Relay Network-to-Network Interface Phase 1 Implementation Agreement, August 1992.
FRF.3 - Multiprotocol Encapsulation Over Frame Relaying Networks Implementation Agreement, July 1993.
IETF RFC 1483 - Multiprotocol Encapsulation over AAL5, July 1993.
IETF RFC 1490 - Multiprotocol Interconnect over Frame Relay, July 1993.
IETF RFC 1577 - Classical IP and ARP over ATM, M. Laubach, Hewlett-Packard Laboratories, January 1994.
ISO/IEC TR 9577 - Protocol Identification in the Network Layer, October 1990.

ITU-T AAL Type 5, Recommendation Text for Section 6 of I.363, TD-10, SG13 January 1993, Geneva.
ITU-T I.233.1 - Frame Relaying Bearer Services, 1991.
ITU-T I.365.1 - Frame Relaying Service Specific Convergence Sublayer (FR-SSCS), 1993.
ITU-T I.370 - Congestion Management in Frame Relaying Networks, 1991.
ITU-T I.372 - Frame Mode Bearer Service, Network to Network Interface Requirements, 1992.
ITU-T I.555 - Frame Relaying Bearer Service Interworking, November 1993.
ITU-T I.610 - B-ISDN Operations and Maintenance Principles and Maintenance, 1993.
ITU-T Q.922 - ISDN Data Link Layer Specifications for Frame Mode Bearer Services, 1992.
ITU-T Q.933 - DSS1 Signalling Specifications for Frame Mode Basic Call Control, ITU, Geneva, 1992.

3.0 Frame Relay/ATM Service Interworking

Figure 1 illustrates service interworking between Frame Relay and ATM. Service interworking applies when a Frame Relaying service user interworks with an ATM service user, and the ATM service user performs no Frame Relaying specific functions, and Frame Relaying service user performs no ATM service specific functions. All interworking is performed by the interworking function (IWF). Since the ATM terminal (B-CPE) does not support all of the I.233.1 type core service, interworking functions are needed.

This is in contrast to Network Interworking in which the ATM service user performs Frame Relay specific functions in the FR-SSCS within AAL5. In the case of Network Interworking Frame Relay frames are transported over ATM and processed at the FR-SSCS within the B-CPE. This means that the B-CPE must be configured to interoperate with the distant Frame Relay network. In the case of Service Interworking, the B-CPE has no knowledge that the distant device is attached to a Frame Relay network.

Figure 1 does not imply any particular physical location for an IWF. The IWF may be contained within a single device or within multiple devices including the nodal, and or, network management component(s) of the network.

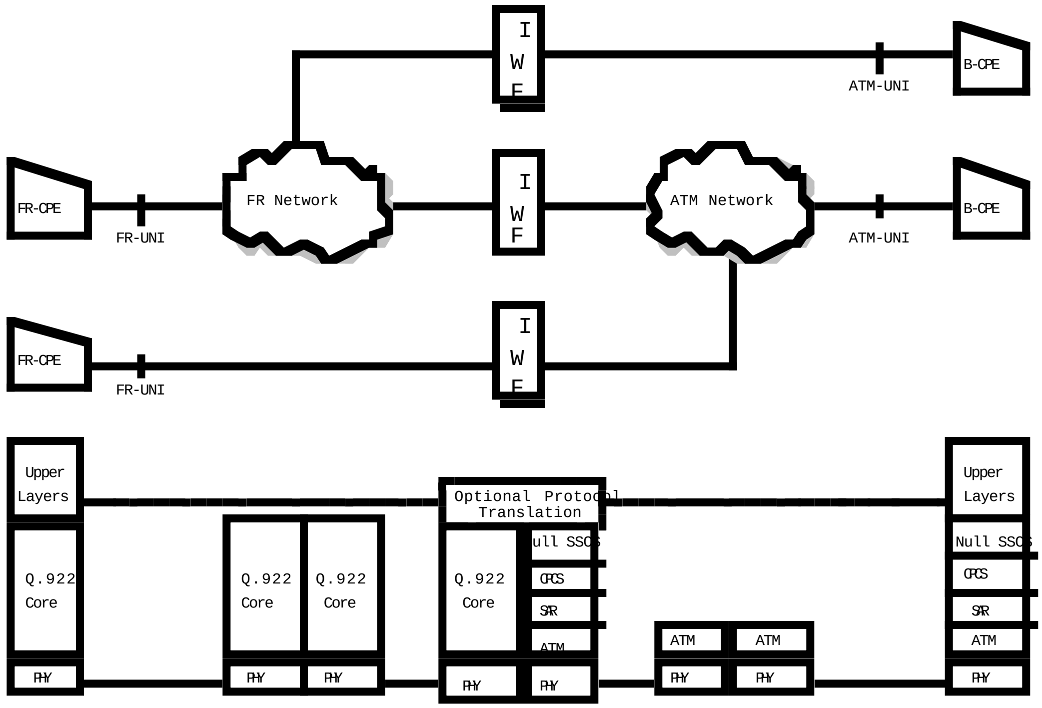

Figure 1: Service Interworking between Frame Relay and ATM Services

4.0 Frame Relay/ATM Service Interworking Parameter Mappings

This section describes FR/ATM Service Interworking where the B-ISDN service user employs the B-ISDN Class C AAL5-based message mode, unassured protocol and interfaces with the network using an ATM UNI interface. The B-CPE uses AAL5 SAR and AAL5 common part convergence sublayer (CPCS) and a null service specific convergence sublayer (SSCS).

B-ISDN Class C, message mode, unassured operation provides some basic functions similar to the Frame Relaying core service, as illustrated in Table 1.

The interworking function can be explained using a protocol stack model described in Figure 1. This protocol stack uses a “null” SSCS for describing the interworking function. Within the interworking function this SSCS provides interfaces using standard primitives to Q.922 DL Core on one side, and to AAL5_CPCS on the other side.

Frame Relay Service	B-ISDN Class C, Message Mode, Unassured	
I.233.1 Core Functions	**ATM Function**	**SAR and CPCS Functions (AAL5)**
Frame delimiting, alignment and transparency		Preservation of CPCS - SDU
Frame muxing / demuxing using the DLCI field	Muxing / demuxing using VPI / VCI	
Inspection of the frame to ensure that it consists of an integral number of octets		
Inspection of the frame to ensure that it is neither too long or too short		
Detection of (but not recovery from) transmission errors		Detection of (but not recovery from) transmission errors
Congestion control forward	Congestion control forward	
Congestion control backward		
Command / Response		CPCS-UU
Congestion control discard eligibility	Cell Loss Priority	

Table 1: Comparison of functions in FR-ATM Service Interworking

4.1 Frame Formatting and Delimiting

In the FR to ATM direction, the FR frame is mapped into an AAL5 PDU; the FR frame's flags, inserted zero bits, and CRC-16 are stripped.

The Q.922 DL Core frame header is removed and some of the fields of the header are mapped into the ATM cell header fields. AAL5 provides message (frame) delineation and 32-bit CRC bit error detection.

In the direction from ATM to FR, the message delineation provided by AAL5 is used to identify frame boundaries, and to permit the insertion of zero bits, CRC-16, and flags. Protocol fields and functions of the ATM AAL5 PDU, received from a B-ISDN Class C User, are translated into the protocol fields and functions of the FR frame.

4.2 Discard Eligibility and Cell Loss Priority Mapping

4.2.1 Frame Relay to ATM Direction

In the Frame Relay to ATM direction, the network provider can select between two modes of operation for loss priority mapping. IWF equipment shall support mode 1 and may optionally support mode 2. When both modes are supported, they are configurable for each virtual connection.

Mode 1: The DE field in the Q.922 core frame shall be mapped to the ATM CLP field of every cell generated by the segmentation process of the AAL5 PDU containing the information of that frame.

Mode 2: The ATM CLP of every ATM cell generated by the segmentation process of the AAL5 PDU containing the information of that frame shall be set to a constant value (either 0 or 1) configured at service subscription time.

4.2.2 ATM to Frame Relay Direction

In the ATM to Frame Relay direction, the network provider can select between two modes of operation for loss priority mapping. IWF equipment shall support mode 1 and optionally mode 2, configurable for each virtual connection.

Mode 1: If one or more cells belonging to a frame has its CLP field set, the IWF shall set the DE field of the Q.922 Core frame.

Mode 2: The DE field of the Q.922 Core frame shall be set to a constant value (either 0 or 1) configured at service subscription time.

4.3 Congestion Indication

4.3.1 Congestion Indication - Forward

4.3.1.1 Frame Relay to ATM Direction

In the FR to ATM direction, the network provider can select between two modes of operation for mapping of forward congestion indication. IWF equipment shall support both of the following two modes, configurable for each virtual connection.

Mode 1: The FECN field in the Q.922 core frame shall be mapped to the ATM EFCI field of every cell generated by the segmentation process of the AAL5 PDU containing the information of that frame. This mode provides congestion indication to the end-points where higher level protocol entities might be involved in traffic control mechanisms. This mode may not be desirable with future reactive congestion control mechanisms of ATM networks.

Mode 2: The FECN field in the Q.922 core frame shall not be mapped to the ATM EFCI field of cells generated by the segmentation process of the AAL5 PDU containing the information of that frame. The EFCI field is always set to 'congestion not experienced'.

In both of the modes above, if there is congestion in the forward direction in the ATM layer within the IWF, then the IWF can set the EFCI field to 'congestion experienced'.

4.3.1.2 ATM to Frame Relay Direction

In the ATM to FR direction, if the EFCI field in the last cell of a segmented frame received is set to ‘congestion experienced’, then the IWF shall set the FECN of the Q.922 Core frame to ‘congestion experienced’.

4.3.2 Congestion Indication - Backward

The BECN field of the Q.922 Core frame has no equivalent protocol field and function in AAL5 Common Part or in ATM.

4.3.2.1 Frame Relay to ATM Direction

In the FR to ATM direction, the IWF shall ignore the BECN of the received Q.922 Core frame. Actions to be taken are for further study.

4.3.2.2 ATM to Frame Relay Direction

In the ATM to FR direction, the IWF shall set the BECN of the Q.922 Core frame to 0.

4.4 Command / Response Field

4.4.1 Frame Relay to ATM Direction

In the FR to ATM direction, the IWF shall map the C/R of the received Q.922 Core frame to the CPCS-UU Least Significant Bit (LSB) of the CPCS PDU. Configuration to block the mapping is for further study.

4.4.2 ATM to Frame Relay Direction

In the ATM to FR direction, the CPCS-UU LSB shall be mapped to the C/R field of the Q.922 Core frame.

4.5 DLCI Field

One-to-one mapping between the DLCIs and VPI/VCIs is used for Service Interworking. The association between FR DLCI and ATM VPI/VCI is made at the time the PVC is provisioned. The association may be arbitrary or systematic.

5.0 Additional FR-ATM Interworking Aspects

5.1 Traffic Management

Appendix A of the ATM Forum B-ICI Specification provides guidelines for conversion of Frame Relay traffic conformance parameters (CIR, Committed Burst Size, Excess Burst Size, Access Rate) to ATM traffic conformance parameters (PCR, CDV, SCR, MBS) using the GCRA (Generic Cell Rate Algorithm) configurations for Frame Relay interworking described in Appendix B, Examples 2a and 2b of the ATM UNI Specification version (3.1).

The ATM traffic conformance parameter determination guidelines from Frame Relay traffic conformance parameters for one-to-one mapping, as described in Appendix A of the ATM Forum B-ICI Specification shall be used by network providers for FR-ATM Service Interworking traffic management. Two methods are provided in the appendix for determination of ATM traffic conformance parameters from Frame Relay traffic conformance parameters. (These two methods also provide for the determination of Frame Relay traffic conformance parameters from ATM traffic conformance parameters.) The first method provides accurate representation of FR traffic parameters in an ATM network. The selection of one of the two methods shall be decided by bilateral agreement between networks.

5.2 PVC Management Interworking

On the Frame Relay side of the IWF, the PVC management procedures are as defined in ITU-T Recommendation Q.933 Annex A (See Figure 2 below). The procedures must be bidirectional to facilitate transport of status indications in both directions. Support of asynchronous status messages is optional.

On the ATM side of the IWF, the PVC management procedures are based on mechanisms provided in the ATM Forum UNI 3.1 and B-ICI 1.1.

The IWF will receive indications from the Frame Relay network and map them to the corresponding ATM indications and then send them to the ATM network. Likewise, the IWF will receive indications from the ATM network and map them to the corresponding Frame Relay indications and then send them to the Frame Relay network.

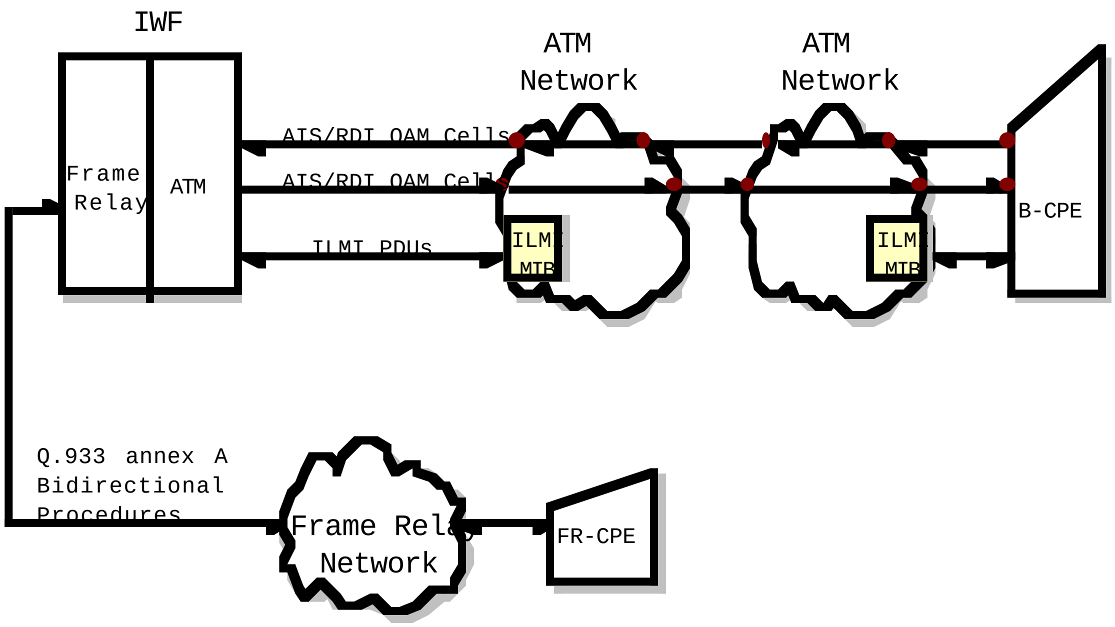

Figure 2: Examples of PVC Management Procedures

5.2.1 Frame Relay PVC Management Procedures

The Frame Relay PVC management procedures are based on periodic polling as defined in Q.933 annex A. (Optionally, procedures for the asynchronous status message as defined in Q.933 annex A are supported.) Bidirectional procedures as defined in section A.4 and its sub-sections apply. Timers and counters used in this process are defined in Q.933 annex A section A.7.

5.2.1.1 Link Integrity Verification

Link Integrity Verification (LIV) performs the function of assuring the link between the IWF and the attached Frame Relay network is operational. The IWF will poll, and respond to polling from, the Frame Relay network and the Frame Relay network will poll, and respond to polling from, the IWF according to the procedures of Q.933 annex A section A.4.2.

If the IWF detects a service affecting condition as defined in Q.933 annex A section A.5, it will map this state to the ATM side of the IWF and begin sending the AIS F5 OAM cell[1] on all configured ATM PVCs corresponding to the PVCs of the Frame Relay link. It is possible that when this event occurs the IWF may already be sending the AIS Fault F5 OAM cell on some ATM PVCs due to other criteria. Other possible criteria are described in section 5.2.1.3.

[1]Ongoing activities in standards bodies which identify fault management cells other than AIS may be adopted by the ATM Forum resulting in modifications to this document.

When the Frame Relay service-affecting condition is cleared, the IWF will stop sending the AIS OAM cells on all ATM PVCs which do not meet other criteria for sending these AIS F5 OAM cells. Other possible criteria are described in section 5.2.1.3.

Whenever the IWF has the need to send the AIS F5 OAM cell, it sends it once per second until the criteria to stop sending it is met.

5.2.1.2 New/Deleted Frame Relay PVCs

When the Frame Relay network indicates to the IWF that a PVC is ‘new’, the IWF takes no action on the corresponding ATM PVC.

When the Frame Relay network indicates to the IWF that a PVC is ‘deleted’ by removing the PVC information element from the full status report (and optionally by the asynchronous status message), the IWF takes no action on the corresponding ATM PVC.

5.2.1.3 Active/Inactive Frame Relay PVCs

The following are criteria for determining ‘inactive’ status:

1. A PVC is not ‘deleted’ from the Frame Relay network and the Frame Relay network explicitly indicates in a full status report (and optionally by the asynchronous status message) that this Frame Relay PVC is ‘inactive’. This maps across the IWF to the corresponding ATM PVC.

2. The LIV indicates that the link from the IWF to the Frame Relay network is down. In this case, the link down indication maps across the IWF to all ATM PVCs.

If either of the above ‘inactive’ criteria are met, then the Frame Relay PVC (or PVCs) is considered inactive. The mapped ‘inactive’ indication results in the sending of the AIS F5 OAM cells by the IWF into the ATM network on the corresponding ATM PVC.

The following are criteria for determining ‘active’ status:

1. When a full status report (or the optional asynchronous status message) indicates a Frame Relay PVC is ‘active’ and LIV indicates that the link to the Frame Relay network is up, then the Frame Relay PVC is considered ‘active’. This maps across the IWF to the corresponding ATM PVC and the action of not sending AIS F5 OAM cells.

5.2.2 ATM PVC Management Procedures

At the IWF, the method of indicating active/inactive status to the Frame Relay network will be limited to mechanisms defined in the ATM Forum UNI 3.1 and B-ICI 1.1.

The ATM PVC management procedures are based on received AIS F5 OAM cells indicating inactive status or ILMI MIB variable values. This status information obtained by the IWF is then mapped to the corresponding Frame Relay status indicators and delivered to the Frame Relay network.

5.2.2.1 Added/Deleted ATM PVCs

When the IWF is configured with an ATM PVC and that PVC is put in service, a ‘new’ indication will be reported by the IWF to the Frame Relay network in a full status report. When an ATM PVC is put out of service or de-configured at the IWF, a ‘delete’ indication will be reported by the IWF to the Frame Relay network in a full status report (or optionally by the asynchronous status message).

5.2.2.2 Active/Inactive ATM PVCs

When the IWF is configured with an ATM PVC and that PVC is put in service, one or both of the following criteria is used for determining ‘inactive’ status:

1. The ATM network explicitly indicates via an AIS or RDI OAM F5 cell that this ATM PVC is down in one or more ATM networks.

2. The ILMI MIB indicates in the variable ‘atmfVccOperStatus’ either ‘localDown’ or ‘end2EndDown’.

If either of the above ‘inactive’ criteria are met or a physical layer alarm is detected by the IWF on its ATM side, then the ATM PVC is considered inactive. The mapped ‘inactive’ indication results in the sending Active bit = 0 in the full status report (and optionally in the asynchronous status message) by the IWF into the Frame Relay network for the corresponding Frame Relay PVC.

When the IWF is configured with an ATM PVC and that PVC is put in service, one or both of the following criteria is used for determining ‘active’ status:

1. There is no AIS OAM cell and no RDI OAM cell from the ATM network for a time interval as defined in ITU-I.610.

2. The ILMI MIB does not indicate in the variable ‘atmfVccOperStatus’ either ‘localDown’ or ‘end2EndDown’.

When both of the above active criteria are used and met, and there is no physical layer alarm detected by the IWF on its ATM side, then the ATM PVC is considered ‘active’. When only one of the above alarm active criteria is used and met, and no physical layer alarm is detected by the IWF on its ATM side, then the ATM PVC is considered ‘active’. The mapped ‘active’ indication results in the sending of Active bit = 1 in the full status report (and optionally in the asynchronous status message) by the IWF into the Frame Relay network for the corresponding Frame Relay PVC.

5.2.2.3 Remote Defect Indication (RDI) Cells

The IWF responds to received AIS cells by sending RDI cells according to procedures specified in I.610.

The IWF may monitor incoming RDI cells for the purpose of statistics collection or alarm indication to a network management system.

5.3 Upper Layer User Protocol Encapsulation

The network provider can configure or provision one of the two modes of operation for each pair of interoperable Frame Relay and ATM PVCs regarding upper layer user protocol encapsulations. One of the following two modes is selected for each PVC at configuration time, in order to achieve end-to-end service interoperability between terminal equipment. Upper layer user protocol encapsulation is optional in the IWF. The IWF may provide one, some, or none of the protocols discussed in this section.

Mode 1: <u>Transparent Mode</u> - When encapsulation methods do not conform to the standards cited in Mode 2 but they are compatible between terminal equipment (e.g., packetized voice), the IWF shall forward the encapsulations unaltered. No mapping nor fragmentation/reassembly shall be performed.

Mode 2: <u>Translation Mode</u> - Encapsulation methods for carrying multiple upper layer user protocols (e.g., LAN to LAN) over a Frame Relay PVC and an ATM PVC conform to the standard FRF.3 and RFC 1483 respectively. The IWF shall perform mapping between the two encapsulations due to the incompatibilities of the two methods. Translation Mode supports the interworking of internetworking (routed and/or bridged) protocols.

5.3.1 Encapsulation Mapping in Translation Mode

Routed or bridged PDUs transferred over FR VCs are encapsulated according to the NLPID method described in FRF.3. For ATM AAL5 PVCs, PDUs are encapsulated according to the LLC method as defined in RFC 1483.

Mapping between encapsulated ATM PDUs and encapsulated Frame Relay PDUs requires examining the incoming ATM AAL5 CPCS-PDU payload header or Frame Relay Q.922 PDU payload header to determine the type, and then overwriting the incoming header with the outgoing header.

The VC-based Multiplexing method described in RFC 1483 is not supported.

In Translation Mode where the IWF is unable to decode the incoming payload headers according to the mapping rules defined in this section (i.e., not recognizable by the IWF), it shall discard the frames.

5.3.1.1 Bridged PDUs

Figure 3 shows the translation between the Frame Relay Q.922 PDU payload header and the ATM AAL5 CPCS-PDU payload header that shall be performed by the IWF. Bridged protocols may include 802.3, 802.4, 802.5, and 802.6.

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This translation applies for 802.3 (PID 0x00-01 or 0x00-07), 802.4 (PID 0x00-02 or 0x0
802.5 (PID 0x00-03 or 0x00-09) and FDDI (PID 0x00-04 or 0x00-0A) bridged PDUs.
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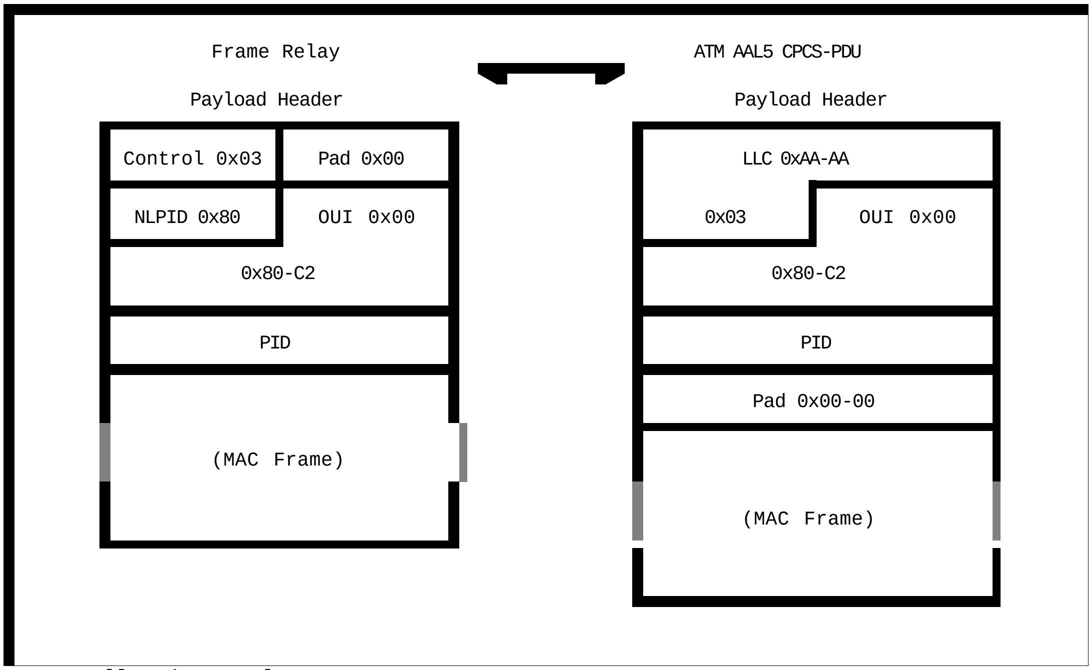


Note: Allowed PID values are 0x00-01, 0x00-02, 0x00-03, 0x00-04, 0x00-07, 0x00-08, 0x00-09, and 0x00-0A.

Figure 3, Part 1: FR/ATM Payload Header Translation for Bridged PDUs

This translation applies for 802.6 (PID 0x00-0B) bridged PDUs.

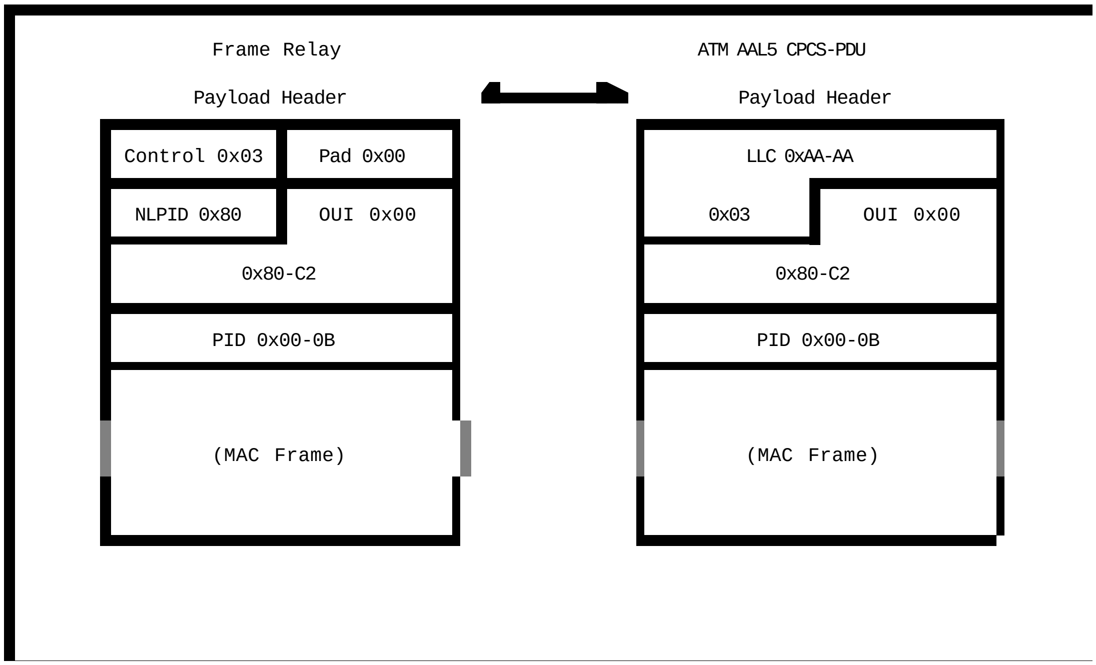


Figure 3, Part 2: FR/ATM Payload Header Translation for Bridged PDUs

This translation applies for BPDU (PID 0x00-0E) and source routed BPDU (PID 0x00-0F).

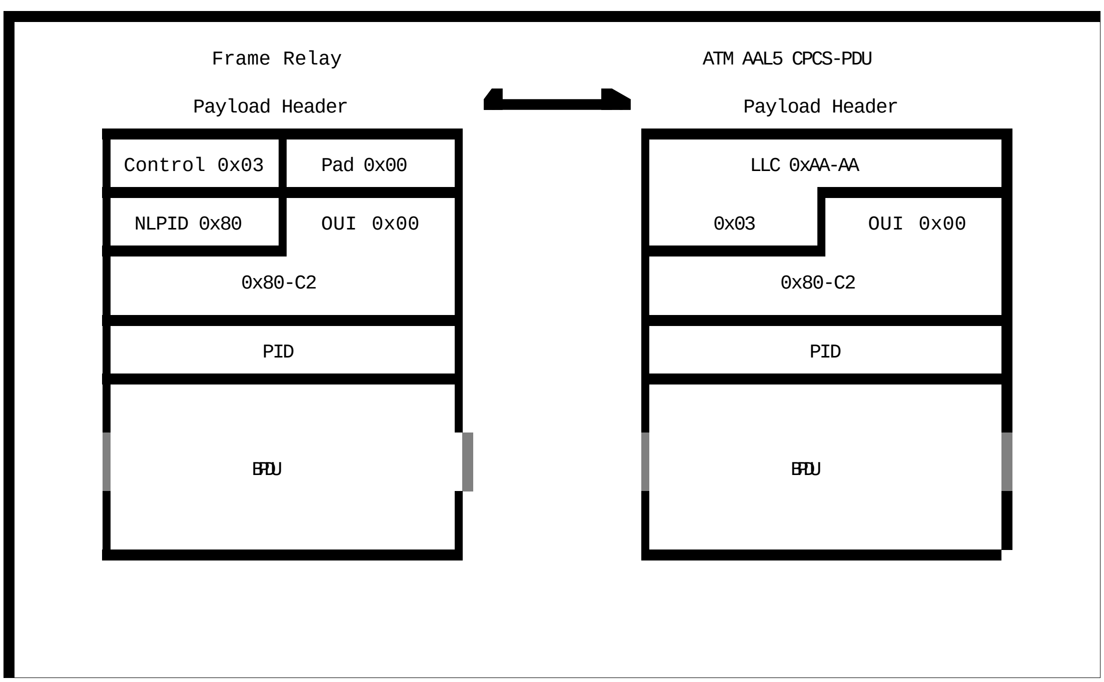


Figure 3, Part 3: FR/ATM Payload Header Translation for Bridged PDUs

5.3.1.2 Routed PDUs

Figure 4 shows the translation between the FR Q.922 PDU payload header and the ATM AAL5 CPCS-PDU payload header that shall be performed by the IWF. Routed protocols may include those shown in parts one through three of Figure 4.

This translation applies for routed IP PDUs.

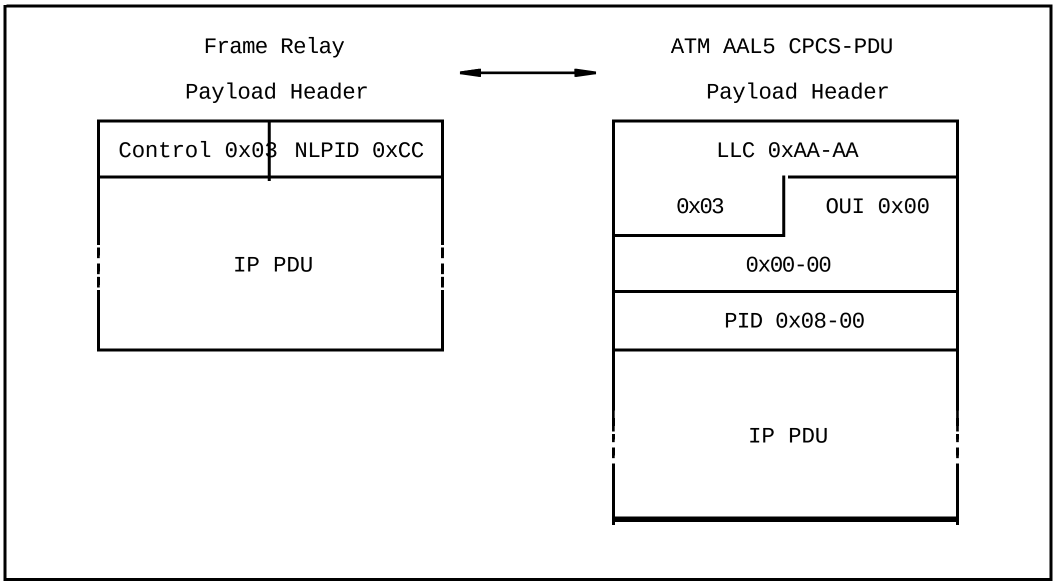
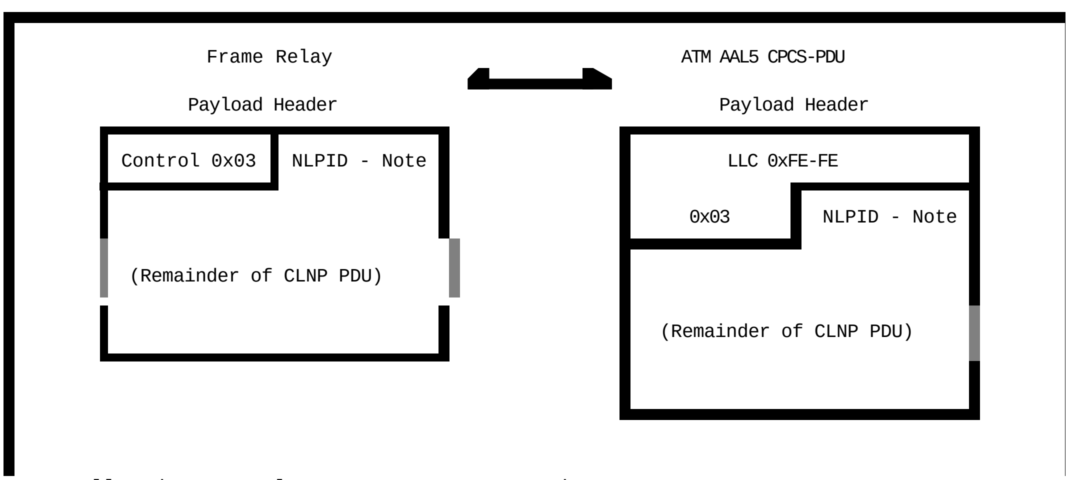


Figure 4, Part 1: FR/ATM Payload Header Translation for Routed IP PDUs

This translation applies for ISO routed PDUs: CLNP (NLPID 0x81), ESIS (NLPID 0x82), a
0x83).



Note: Allowed NLPID values are 0x81, 0x82, and 0x83.

Figure 4, Part 2: FR/ATM Payload Header Translation for Routed OSI PDUs

This translation applies for other routed PDUs.

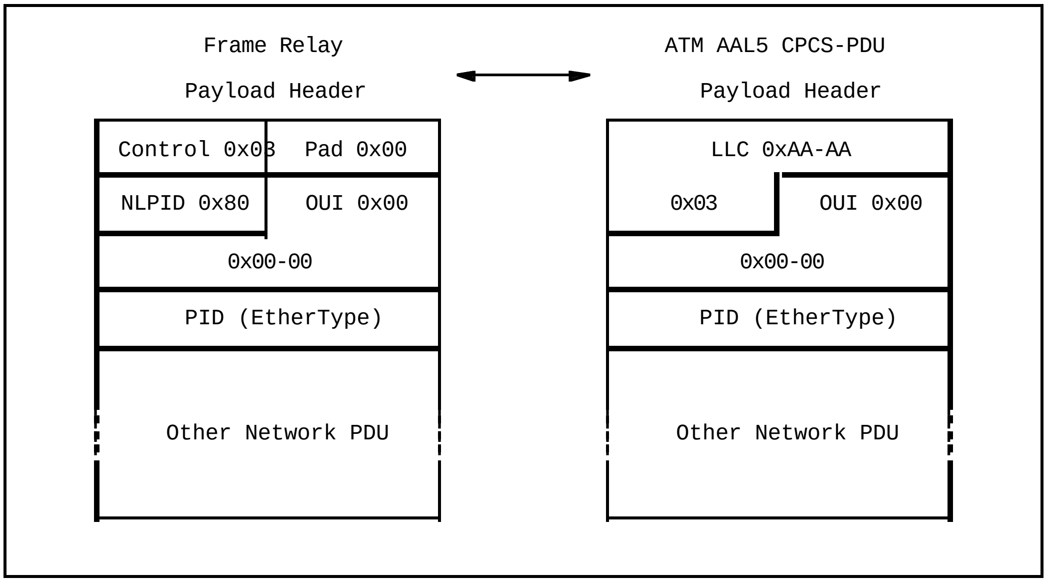
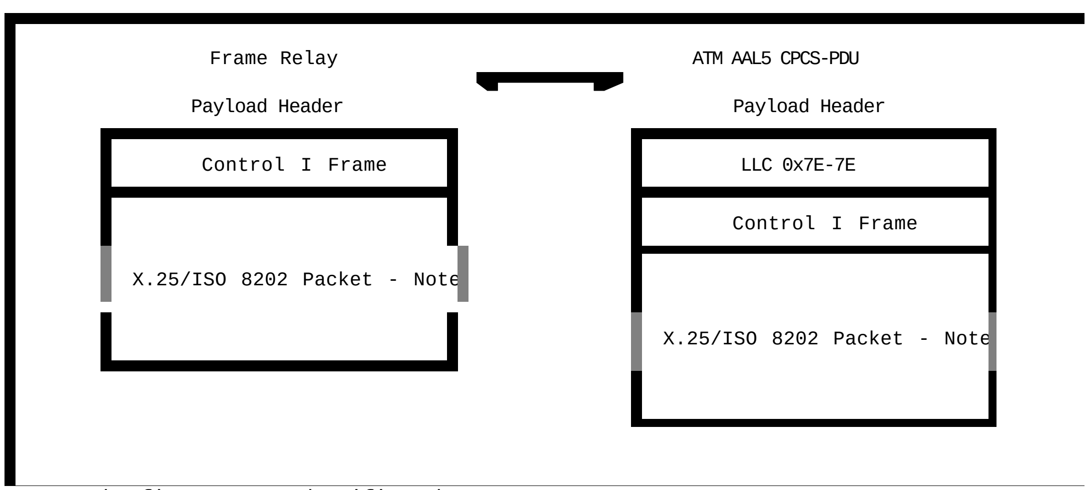


Figure 4, Part 3: FR/ATM Payload Header Translation for other Routed PDUs

5.3.1.3 Connection Oriented Protocols

Figure 5 shows the translation between the Frame Relay Q.922 PDU payload header and the ATM AAL5 CPCS-PDU payload header that shall be performed by the IWF. Connection oriented protocols may include those shown in parts one and two of Figure 5.

This translation applies for X.25/ISO 8208 packets. In the case of Frame Relay, the Q.922 and in the case of ATM it is ISO 8802/2 Type 2. The link layers are terminated mapping of supervisory frames is not shown here.



Note: The first Octet Identifies the NLPID

Figure 5, Part 1: FR/ATM Payload Header Translation for X.25/ISO 8202 Packets

This translation applies for protocols which use the Q.933/Q.2931 NLPID.

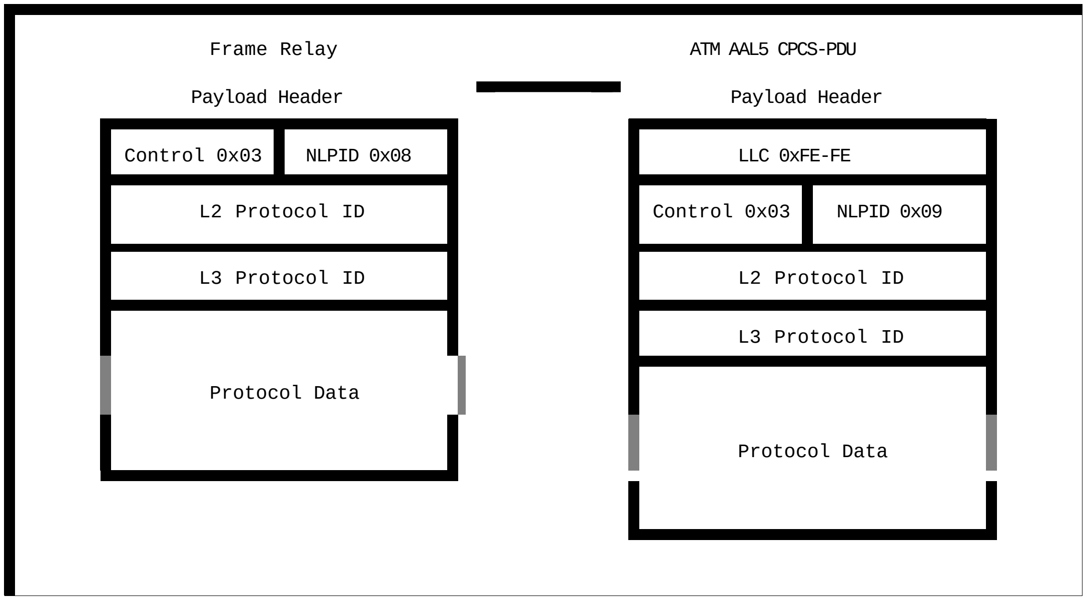


Figure 5, Part 2: FR/ATM Payload Header Translation for protocols which use Q.933/Q.2931

5.3.1.4 Fragmentation and Reassembly

When fragmented packets are received on a Frame Relay PVC by the IWF, reassembly should be performed when forwarding the assembled frame to the ATM PVC. In the reverse direction, fragmentation should be performed on the received CPCS PDU before forwarding them to the Frame Relay PVC if the CPCS PDU is greater than the maximum frame size supported on the Frame Relay PVC. Fragmentation and reassembly support is highly recommended but not mandatory. Details can be found in section F.5.3 of FRF.3 *Multiprotocol Encapsulation Over Frame Relaying Networks Implementation Agreement.*

5.4 Address Resolution

Although ARP was originally intended for IP address resolution, the procedures in this section may also be applicable to other network layer protocols.

Address resolution support, by transforming Address Resolution Protocol (ARP) [RFC 826] and Inverse ARP (InARP) [RFC 1293] between their Frame Relay [RFC 1490] and ATM (the PVC portions of [RFC 1577]) formats, can only be performed when interoperating between PVCs that have been specifically configured to support Translation Mode . The use of these encapsulations allows ARP packets to be recognized and specially handled by the IWF.

The Interworking Function shall contain a mapping table. Each row-wise entry in the mapping table shall contain the following information (see Figure 6):

- Frame Relay Port number on the IWF (P1 in Figure 6)
- Frame Relay DLCI number on the Frame Relay Port (ee in Figure 6)
- ATM Port number on the IWF (P2 in Figure 6)
- ATM VPI/VCI number on the ATM Port (aaa/bbb in Figure 6)

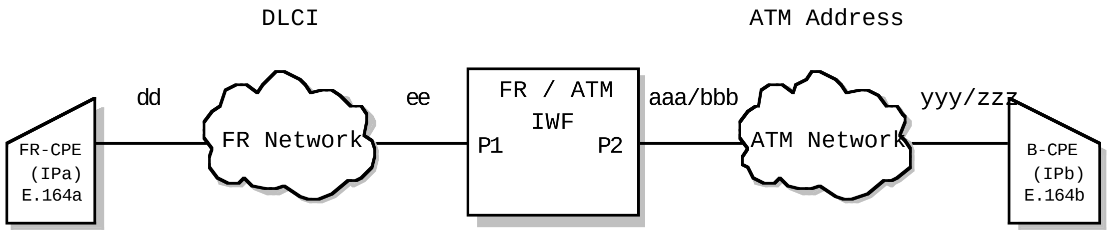


Figure 6: Address Resolution Reference Diagram

The following additional information is desirable to support hybrid PVC/SVC environments:

- Frame Relay Q.933 address, in E.164 format, if known (E.164a in Figure 6)
- ATM Q.2931 address/subaddress tuple, in E.164 and/or NSAP format, if known (E.164b in Figure 6)

Inclusion of the Frame Relay Q.933 address allows future support of Frame Relay SVCs and mapping between Q.933 and Q.2931 addresses. In addition, in mixed PVC/SVC environments the inclusion of this information allows end-systems to optionally choose between existing PVCs and setting up new SVCs to the same destination ATM address. Explicitly providing the above information in the IWF allows easy and straightforward conversion between FR and ATM ARPs, even though they have to be explicitly transformed because of different fields.

The IWF need not keep track of the TE IP addresses; it only needs to know how to convert between the two ARP formats.

Figure 7 illustrates the conversion between Frame Relay and ATM ARPs. The mapping table defined above is used to fill in the corresponding fields when translating between FR and ATM ARPs. There is one exception; if the IWF receives an ATM ARP with opcode 10 (NAK), the ARP packet is discarded, since FR ARP does not support that opcode.

Frame Relay ARP Format

Control 0x03	Pad 0x00
NLPID 0x80	OUI 0x00
0x0000	
PID (0x0806)	
Hardware type (0x000F)	
Protocol type (note 1)	
HLN (note 2)	PLN (note 3)
Opcode (note 4)	
Source Q.922 address (HLN octets) (note 5)	
Source protocol address (PLN octets)	
Target Q.922 address (HLN octets) (note 5)	
Target protocol address (PLN octets)	

ATM ARP Format

LLC 0xAA-AA	
0x03	OUI 0x00
0x0000	
PID (0x0806)	
Hardware type (0x0013)	
Protocol type (note 1)	
SHTL (note 6)	SSTL (note 7)
Opcode (note 4)	
SPLN (note 8)	THTL (note 9)
TSTL (note 10)	TPLN (note 11)
Source ATM number (SHTL octets) (note 12)	
Source ATM subaddress (SSTL octets) (note 13)	
Source protocol address (SPLN octets)	
Target ATM number (THTL octets) (note 12)	
Target ATM subaddress (TSTL octets) (note 13)	
Target protocol address (TPLN octets)	

note 1: Ethertype; IP is x0800
note 2: HLN: Hardware address length: 2 or 4 for Frame Relay
note 3: PLN: Protocol address length: 4 for IP
note 4: ARP Request is 1, ARP Reply is 2,
Reverse ARP Request is 3, Reverse ARP Reply is 4,
Inverse ARP Request is 8, Inverse ARP Reply is 9,
ARP NAK (ATM only) is 10
note 5: C/R, FECN, BECN, and DE bits are set to zero
note 6: SHTL: Type & length of source ATM number (note 14)
note 7: SSTL: Type & length of source ATM subaddress (note 14)
note 8: SPLN: Length of source protocol address: 4 for IP
note 9: THTL: Type & length of target ATM number (note 14)
note 10: TSTL: Type & length of target ATM subaddress (note 14)
note 11: TPLN: Length of target protocol address: 4 for IP
note 12: ATM number (E.164 or ATM Forum NSAPA)
note 13: ATM subaddress (ATM Forum NSAPA)

(continued on next page)

Figure 7, Part 1: ARP Packet Formats

note 14: The encoding of the 8-bit type and length value for SHTL, SSTL, THTL, and TSTL is as follows:

```
MSB   8     7     6     5     4     3     2     1   LSB
    +-----+-----+-----+-----+-----+-----+-----+-----+
    |  0  | 1/0 |      Octet length of address      |
    +-----+-----+-----+-----+-----+-----+-----+-----+
```

Where:

bit.8 (reserved) = 0 (for future use)

bit.7 (type) = 0 ATM Forum NSAPA format
= 1 E.164 format

bit.6-1 (length) = 6 bit unsigned octet length of address
(MSB = bit.6, LSB = bit.1)

The ATM Forum defines three structures for the combined use of number and subaddress:

	ATM Number	ATM Subaddress
Structure 1	ATM Forum NSAPA	null
Structure 2	E.164	null
Structure 3	E.164	ATM Forum NSAPA

Figure 7, Part 2: ARP Packet Formats

6.0 Operations for the Common Part of the AAL Type 5

This Section specifies performance measurements needed to monitor errors for the common part of the AAL Type 5. Figure 8 shows the format of the common part of the AAL Type 5 PDU (I.363). In this Figure, the CPCS-UU is the Common Part Convergence Sublayer - User-to-User indication field. It is used to transfer user-to-user information, and so is not monitored by the network.

CPCS-PDU (Multiple of 48 Bytes)

	User Data	PAD	CPCS-UU	Common Part Indicator	Length	CRC
Bytes	0-65535	0-47	1	1	2	4

Figure 8: Format of the Common Part of the AAL Type 5 PDU (I.363)

The following error conditions may occur at the receiving point:

- Invalid format of Common Part Indicator (CPI) field. The only valid value currently defined for the CPI field is all zeros.

- Length violation. An error occurs when the Length, which is measured in bytes, is not consistent with the length of the CPCS-PDU. If the length of the CPCS-PDU in bytes minus the value of the Length field is not in the range 8-55 (PAD plus the remaining eight octets), the two are not consistent. One exception is when the Length field has a value of zero, which is an indication of a forward abort. This case shall not be counted as a length violation.

- Oversized Received Service Data Unit (SDU): This error condition occurs if a partial or whole CPCS-PDU is received in which the SDU (i.e., User Data) exceeds the maximum allowed length.

- CRC violation.

- If the receiving entity implements a reassembly timer (which is optional, as specified in I.363), then the number of timer expirations shall be counted.

Network equipment at a B-ICI terminating the AAL Type 5 common part shall count the occurrences of the listed errors at the receiving point.

A typical value for a measurement interval could be fifteen minutes, and at least eight hours of history should be kept. The measurement interval and amount of history data will be established by bilateral agreements between carriers.