



**Multi-Service Interworking –  
Frame Relay and ATM Service  
Interworking over MPLS**

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# 1 Introduction

## 1.1 Purpose

FRF.8.1 is widely used for Frame Relay (FR) to Asynchronous Transfer Mode (ATM) service interworking over ATM networks<sup>1</sup>. The IETF and ITU-T specify methods for interconnecting homogeneous attachment circuits, i.e. of the same technology, to transport identical native services over pseudo wires (PW) (see references [1], [5], [2], [8], [9]).

This specification provides mechanisms for interconnecting FR and ATM attachment circuits over an MPLS core using pseudo wires. It builds on FRF8.2 [4] and the relevant IETF specifications. In particular, it allows for the interworking of ATM and FR attachment circuits using either cell-based or frame-based encapsulations over MPLS PWs.

## 1.2 Scope

The following defines the scope of the specification:

- FRF 8.2 is used for the Frame Relay to ATM Service Interworking function;
- Only FR and ATM PVCs are supported. SVCs and S-PVCs are for further study;
- Only ATM AAL5 is considered, as per [4] section 4;
- Both one-to-one and many-to-one mapping modes are supported. In one-to-one mode there is a one to one relationship between a FR (or ATM) VC and an MPLS PW. In many-to-one mode, many FR (or ATM) VCs may be carried over each MPLS PW.

## 1.3 Definitions

**Must, Shall, or Mandatory** — the item is an absolute requirement of this specification.

**Should** — the item is desirable.

**May or Optional** — the item is not compulsory and may be followed or ignored according to the needs of the implementer.

## 1.4 Acronyms

AC	Attachment Circuit
ATM	Asynchronous Transfer Mode
B-ICI	Broadband Inter Carrier Interface
CE	Customer Edge
FR	Frame Relay
IETF	Internet Engineering Task Force
IP	Internet Protocol

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<sup>1</sup> FRF8.2 is the current version of this specification, which is backwards compatible with FRF8.1.

LDP	Label Distribution Protocol
LER	Label Edge Router
LSP	Label Switched Path
LSR	Label Switching Router
MPLS	Multi Protocol Label Switching
PDU	Protocol Data Unit
PE	Provider Edge
PVC	Permanent Virtual Circuit
PW	Pseudo Wire
PWE3	PW Emulation Edge-to-Edge
QoS	Quality of Service
SDU	Service Data Unit
SVC	Switched Virtual Circuit
S-PVC	Soft Permanent Virtual Circuit

## 1.5 Normative References

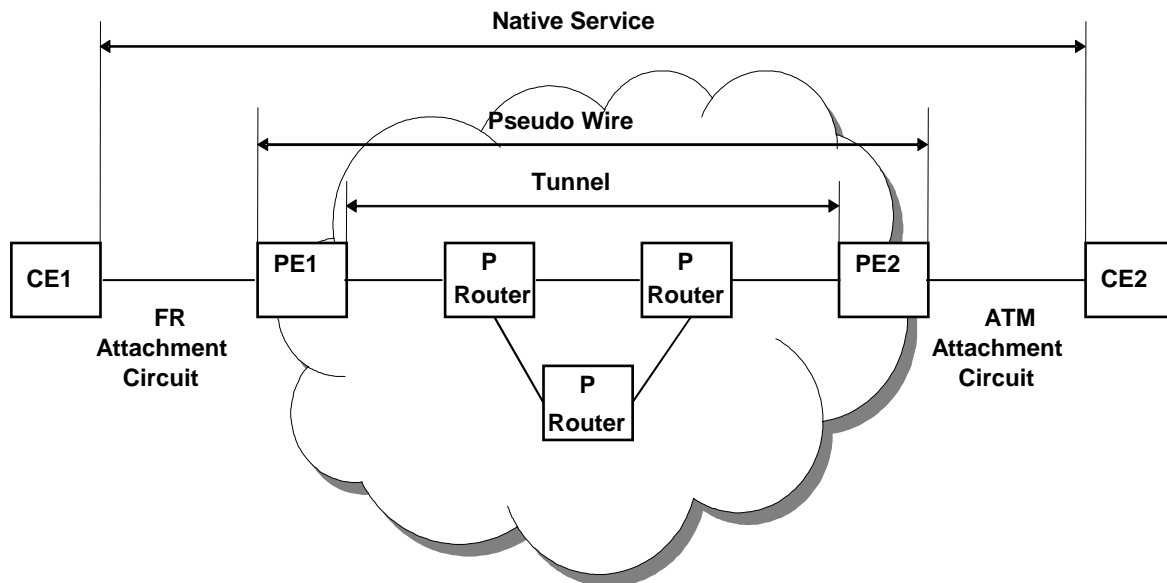
- [1] IETF RFC 3985, “Pseudo Wire Emulation Edge-to-Edge (PWE3) Architecture”, March 2005.
- [2] IETF RFC 4447, “Pseudowire Setup and Maintenance using the Label Distribution Protocol”, April 2006.
- [3] MFA Forum Specification, “Fault Management for Multiservice Interworking over MPLS Version 1.0”, MFA x.0, xxx, 2006
- [4] MPLS/FR Alliance, “Frame Relay/ATM PVC Service Interworking Implementation Agreement (FRF.8.2)”, February 2004.
- [5] ITU-T Recommendation X.84, “Support of frame relay services over MPLS core networks”, March 2004
- [6] ITU-T Recommendation Q.922, “ISDN Data Link Layer Specification for Frame Mode Bearer Services”, February 1992.
- [7] ITU-T Recommendation Q.933, “Signalling specifications for frame mode switched and permanent virtual connection control and status monitoring”, February 2003.
- [8] ITU-T Recommendation Y.1411, “ATM-MPLS network interworking – Cell mode user plane interworking”, February 2003.
- [9] ITU-T Recommendation Y.1412, “ATM-MPLS network interworking – Frame mode user plane interworking”, November 2003.

## 2 Interworking Reference Model

Figure 1 shows the interworking reference model for CE, PE, PW, and Attachment Circuits (ACs). These are defined in [1], and concern homogenous types of ACs over packet-switched networks.

In this specification a heterogeneous Layer 2 circuit with two native services, namely FR and ATM, is considered. It is provided by the attachment circuits between CE1 and PE1, and between CE2 and PE2, respectively. Consistent with [4], this specification specifies a service interworking function (IWF) that allows the Frame Relay service to interwork with the ATM service. The IWF is associated either with the FR AC or with the ATM AC, shown in Figure 1. In the former case, the FR service is interworked to an ATM service, and the PW supports ATM transport. In the latter case, the ATM service is interworked to a FR service, and the PW supports FR transport.

Following both the FRF8.2 and the IETF architecture reference models, the reference model in this specification does not imply any particular physical location for an IWF. As a result, while the IWF can be regarded as an element of a “logical” PE, the IWF may be carried out in external equipment, and the processed data sent to the “physical” PE over one or more physical interfaces. In the remainder of this document, the term “PE” shall be used to mean “logical PE”. The relevant functional modules in a logical PE are described in more detail in Figure 2.



**Figure 1: Interworking Reference Model**

### 2.1 Native Services and Attachment Circuits

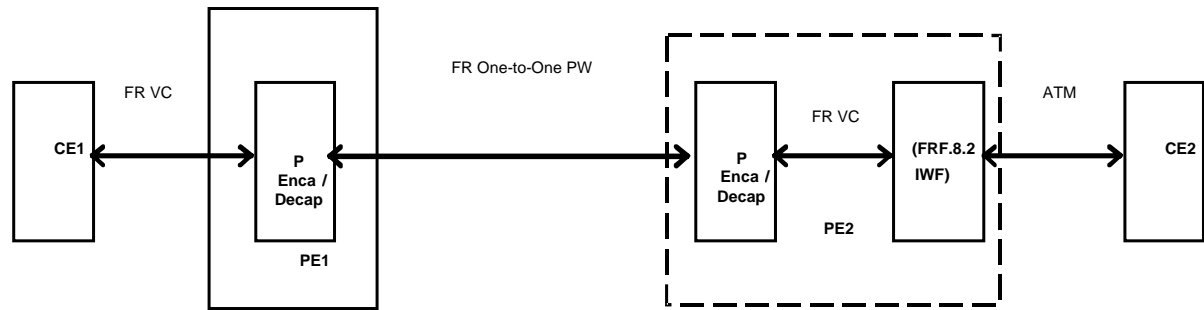
Native Services are defined as the types of service between CE and PE provided by the attachment circuits. Customers subscribe to these services. In this specification, we consider FR and ATM as native services of the attachment circuits.

### 3 FR and ATM Service Interworking over MPLS

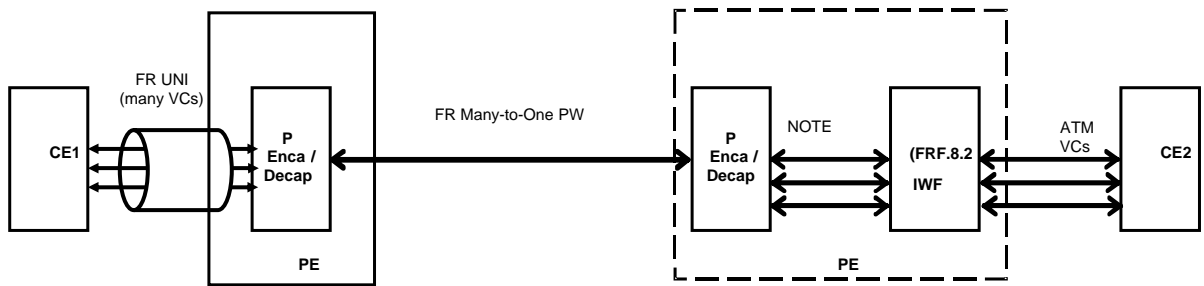
There are two possible locations for the FRF.8.2 IWF: either at PE1 or at PE2, as indicated by the dashed lines in Figures 2 and 3. In the scenarios in Figure 2, the FRF.8.2 IWF is attached to ATM ACs, where ATM traffic is converted to FR traffic. The FR traffic is then carried over MPLS using a FR PW, using either one-to-one mode or many-to-one mode encapsulation, as shown in Figure 2. In the scenarios in Figure 3, the FRF.8.2 IWF is attached directly to FR ACs, where FR traffic is converted to ATM traffic. The ATM traffic is then carried over MPLS via an ATM PW, using either N-to-1 or SDU mode encapsulation, as shown in Figure 3. In all the scenarios the encapsulation over MPLS uses the same procedures specified for homogeneous ATM PWs or FR PWs. Both one-to-one and many-to-one VC mappings are supported.

#### 3.1 Frame Relay PW Encapsulations

The FR PW encapsulation scenarios, supporting the one-to-one and many-to-one VC mappings, are shown in Figure 2(a) and Figure 2 (b) respectively. A description of the FR PW encapsulations is given in [5]. The FR PW encapsulations in Figures 2(a) and 2(b) are referred to as the FR one-to-one and many-to-one encapsulations, respectively.



(a) FRF.8.2 IWF at ATM side using  
Frame Relay One-to-One Encapsulation



(b) FRF.8.1 IWF at ATM side using  
Frame Relay Many-to-One Encapsulation  
(Port Mode)

NOTE: For an external interface, this is a FR UNI. For an internal interface it must consist of all DLCIs associated with the FR UNI (between CE1 and PE1), including DLCI 0. For the internal interface, there is no need to support the Q.922 core aspects.

**Figure 2: FR over PWs Encapsulation Scenarios**

For one-to-one mapping, as shown in Figure 2(a), each VC is mapped to a PW. During defect events, the status information in the LMI for each VC is handled according to section 4 of [3]. In Figure 2(b), in accordance with [5], the CE1 – PE1 interface consists of N PVCs on a FR UNI, where N is equal to the number of PVCs carried over that UNI, including DLCI 0. As a consequence, LMI status messages are carried transparently over the PW between PE1 and the PE with the FRF8.2 IWF. Consistent with the definition given in [5], PE equipment need have no knowledge about which VCs may be contained in the PW.

### 3.1.1 One-to-one encapsulation (Figure 2a)

The interworking scenarios using a FR one-to-one PW include the following constituent elements:

- FR/ATM interworking per [4];
- Data plane, including encapsulation, according to [5], sections 8.2 and 9;
- Management plane and PVC status according to Annex A and [3] section 4. LMI is not carried across the PW and is terminated in the FR-attached PE. Refer to Annex A Section A.2 for procedures for mapping LMI status.

### 3.1.2 Many-to-one encapsulation (Figure 2b)

The interworking scenarios using a FR many-to-one PW include the following constituent elements:

- FR/ATM interworking per [4];
- Data plane, including encapsulation, according to [5], section 12;
- Management plane and PVC status is carried transparently within the PW on DLCI 0. A PW failure is detected through its effect on the management plane and PVC status communicated by the FR LMI (see [4], section 5.2).

## 3.2 ATM PW Encapsulations

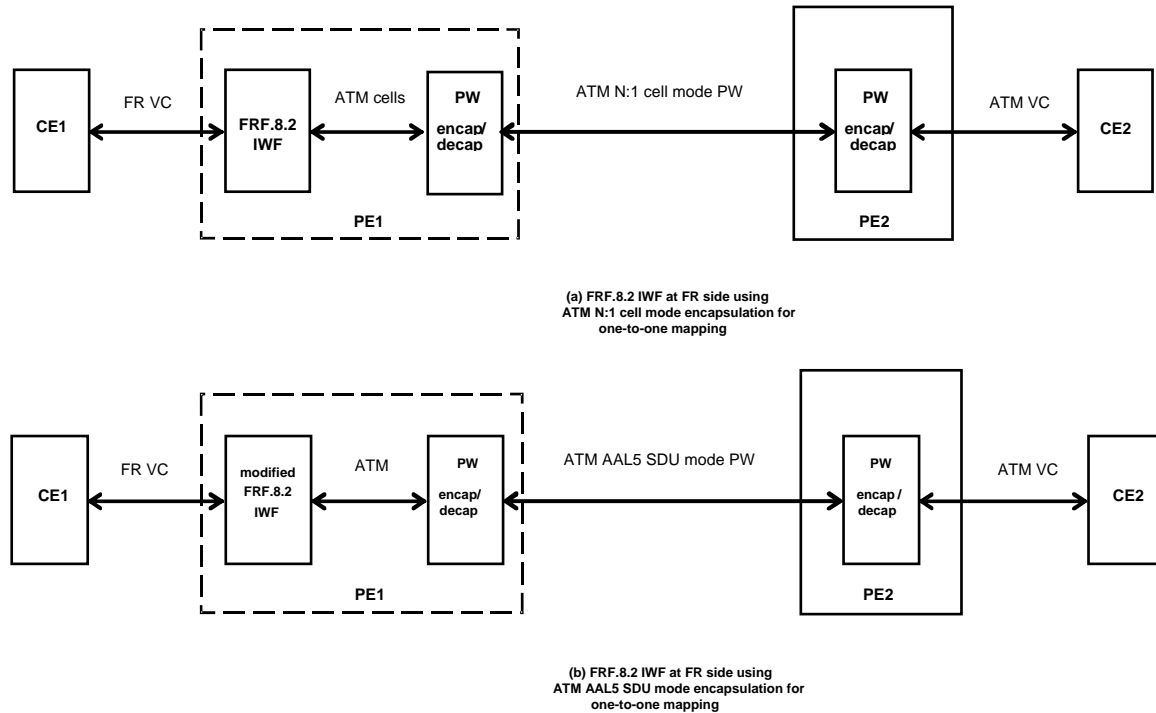
The ATM scenarios supporting one-to-one VC mappings are shown in Figures 3(a) and 3(b). The case of many-to-one mapping using ATM encapsulation is for further study. Descriptions of the ATM PW encapsulations are given in [8] and [9]. The two ATM encapsulations used in this specification are the N-to-one cell mode encapsulation, described in [8], and the AAL5 SDU mode encapsulation, described in [9]. Other encapsulations are for further study. In the scenario in Figure 3(a), where N-to-one cell mode encapsulation is used, management plane information in the form of ATM OAM cells is carried transparently over the PW between PE2 and the PE with the FRF8.2 IWF. In the case of ATM SDU Mode (Figure 3(b)), PW status messaging is the default method for carrying management plane information over the PW.

### 3.2.1 One-to-one mapping with N-to-one cell mode encapsulation (Figure 3a)

These interworking scenarios with ATM encapsulation include the following constituent elements:

- FR/ATM interworking per [4];
- Data plane, including encapsulation, according to [8], sections 7.2 and 9, for N-to-one cell mode encapsulation with one-to-one mapping.
- Management plane and PVC status according to Annex A and [3] section 4, as applicable for the ATM N-to-one mode PW. ILMI is not carried across the PW.





**Figure 3: ATM over PWs Encapsulation Scenarios**

### 3.2.2 One-to-one mapping with AAL5 SDU mode encapsulation (Figure 3b)

These interworking scenarios with ATM encapsulation include the following constituent elements:

- FR/ATM interworking using a modified form of FRF 8.2 [4] (see Note1 below);
- Data plane, including encapsulation, according to [9], sections 7.2 and 9, for AAL5 CPCS-SDU mode encapsulation with one-to-one mapping.
- Management plane and PVC status according to Annex A and [3] section 4 for those portions covering ATM SDU mode PWs. ILMI is not carried across the PW.

Note1: The modified form of FRF 8.2 is similar to the existing FRF 8.2 Implementation Agreement [4], though it will transmit and receive AAL5 SDUs, instead of ATM cells. Annex A to this specification provides a description of the modified FRF 8.2 IWF for the case of ATM SDU mode PWs.

### 3.3 Traffic Management and QoS Considerations

The QoS and traffic parameter mappings between the FR and ATM attachment circuits are described in [4] section 5.1. When a native service is mapped to a PW, the FR or ATM traffic parameters may be mapped to the PW characteristics and traffic parameters of the MPLS tunnel LSPs. Appropriate QoS-based signaling and traffic engineering mechanisms may be applied within the MPLS core to support the QoS requirements defined for the FR and ATM native services. The details of traffic management and QoS for PWs and MPLS Tunnel LSPs within the MPLS core are outside the scope of this specification.

### 3.4 Compliance

This specification describes two modes of deployment in Figure 2 and two modes of deployment in Figure 3. These four modes are as follows:

- one-to-one mapping with FR encapsulation
- many-to-one mapping, using FR port mode, with FR encapsulation
- one-to-one mapping with ATM N:1 cell mode encapsulation
- one-to-one mapping with ATM AAL5 SDU mode encapsulation

All four of these modes are optional. However, for compliance with this specification, a network device must be able to support at least one of the following two modes: one-to-one mapping with ATM N:1 cell mode encapsulation, or one-to-one mapping with ATM AAL5 SDU mode encapsulation. For brevity, the term “mode A” is used to denote the former mode (ATM N:1 cell mode encapsulation) and the term “mode B” is used to denote the latter mode (ATM AAL5 SDU mode encapsulation). Using this terminology, a network device is compliant with this specification if it supports either mode A operation or mode B operation, or both. A network device may in addition support any of the other modes of operation listed above.

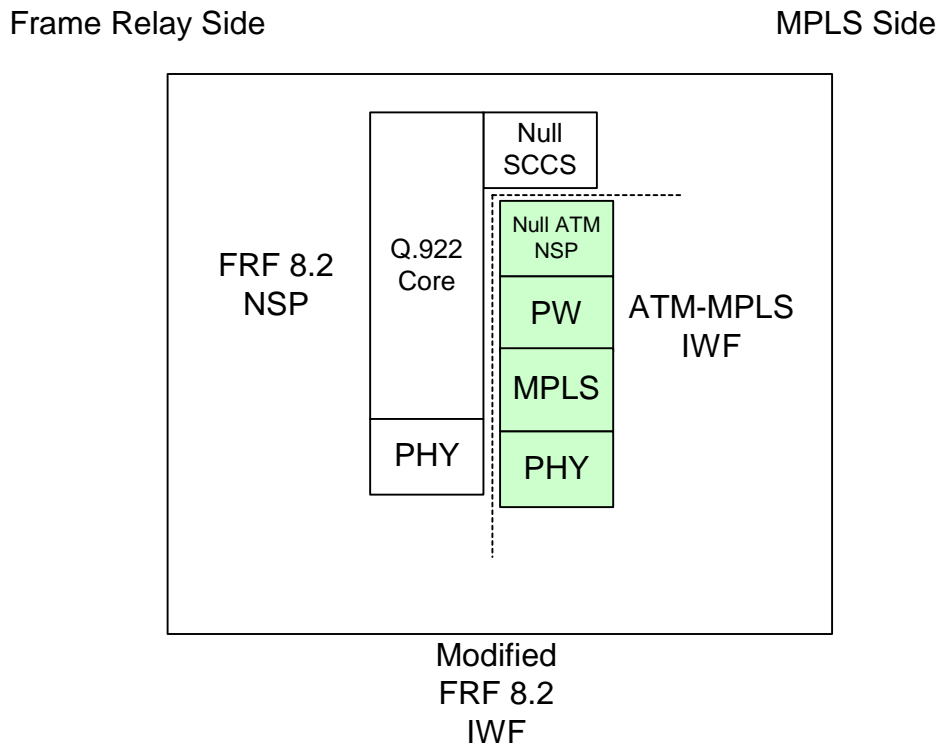
Modes A and B are not interoperable, that is, if a first network device supports only mode A and a second network device supports only mode B, the two devices will not be able to interoperate, since different ATM encapsulations are used in these two modes.

Appendix I to this specification contains some guidance information for network operators with respect to the deployment of mode A or mode B equipment.

## Annex A - Modified FRF 8.2 Interworking Function

This annex describes the modified FRF 8.2 interworking function that is used when an ATM SDU mode pseudo wire interconnects PE1 and PE2. It also describes PVC management procedures for the attachment circuits.

RFC 3985 [1] specifies the functional architecture of a PWE3 PE. This is composed of a native service processing function (NSP) and a PW forwarder.



**Figure A.1 Reference Model for Modified FRF 8.2 IWF PE**

Figure A.1 shows a reference model for the PE containing the modified FRF 8.2 interworking function. There are two functional elements:

- FRF 8.2 NSP
- ATM-MPLS Network Interworking Function

The FRF 8.2 NSP contains the Q.922 core [6] on the Frame Relay side, and the Null SSCS on the ATM side. This passes an ATM SDU to the ATM-MPLS network interworking function. The Null SSCS provides the FR-ATM service interworking function. The primitives produced by the Null SSCS are mapped to the payload and flags of the PW, as shown in Table A.1. This mapping is

bidirectional across the IWF. The SDU mode PW preserves the parameters required for B-ISDN Class C Message Mode Unassured operation.

The ATM-MPLS network IWF performs native service processing for the ATM SDU before encapsulating the SDU in the PW for transport across the MPLS network.

Frame Relay Service	B-ISDN Class C, Message Mode, Unassured over SDU mode PW
I.233.1 Core Functions	ATM SDU mode PW
Frame delimiting, alignment, and transparency	PW length field. Preservation of PW frame order <sup>1</sup>
Frame muxing/demuxing using the DLCI field	Muxing/demuxing using PW label
Inspection of the frame to ensure that it is neither too long or too short	PW fragmentation
Detection of (but not recovery from) transmission errors	Detection of (but not recovery from) transmission errors <sup>1</sup>
Congestion control forward	E bit
Congestion control backward	
Command / Response	U bit
Congestion control discard eligibility	C bit

<sup>1</sup>The PW control word may be used to detect frame misordering by the PSN.

<sup>2</sup>Frame error detection and recovery is a function of the PSN

### Table A.1 Parameter Mappings

#### A.1 Frame Formatting and Delimiting

In the FR to MPLS direction, the FR frame is mapped into a PW frame; the FR frame's flags, inserted zero bits, and CRC-16 are stripped to form an AAL5 SDU, which is then mapped to the PW payload.

The Q.922 DL Core frame header is removed, and some of the fields of the header are mapped into the PW control word flags according to Section 9 of [9]. The PW and MPLS network may provide message (frame) delineation and error detection.

In the MPLS to FR direction, the message delineation provided by the MPLS network and, where necessary, by the length field of the PW is used to identify frame boundaries and permit the insertion of zero bits, CRC-16, and flags. Protocol fields and functions of the PW encapsulation, received from

a B-ISDN Class C User connected via an ATM attachment circuit to the remote PE, are translated into the protocol fields and functions of the FR frame.

ILMI is not carried across an ATM N-to-1 mode or SDU mode pseudo wire, while LMI is not carried across a FR one-to-one mode PW.

## **A.2 PVC Management Interworking**

Defect states and notifications shall be handled by the IWF according to Section 4 of [3]. Other notifications are handled as described in the two subsections following.

### **A.2.1 AC PVC Management Procedures for ATM PWs**

Q.933 Annex A [7] bidirectional procedures are used.

The procedures specified in [4] shall be followed, with the following exceptions:

- ATM SDU Mode PWs: 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 PE containing the IWF should send a PW Status message indicating "forward defect". Forward defect PW status messages are mapped at the ATM attached PE according to Section 4 of [3].
- When the ATM PW, its associated ATM attachment circuit, and the association of the PW and the service interworking function are all provisioned and become operational for the first time from the perspective of the service IWF, the event is treated as equivalent to the provisioning of an ATM VCC in [4].
- When the ATM PW, its associated ATM attachment circuit, and the association of the PW and the service interworking function are deleted, the event is treated as equivalent to deconfiguring an ATM VCC in [4].

### **A.2.2 AC PVC Management Procedures for FR PWs**

The procedures specified in [4] shall be followed. The following exceptions apply in the case of FR one-to-one mode PWs:

- When an ATM PVC is put out of service or de-configured at the service IWF, an indication will be reported by the IWF to the Frame Relay network in a full status report (or optionally by the asynchronous status message) with Active=0. Since LMI is not carried across the FR one-to-one mode PW, the PE containing the IWF should send a PW Status message indicating "forward defect".
- When a FR one-to-one mode PW, its associated FR attachment circuit, and the association of the PW and the service interworking function are all provisioned and become operational for the first time from the perspective of the service IWF, the event is treated as equivalent to the provisioning of a FR VC in [4].
- When the one-to-one mode FR PW, its associated FR attachment circuit, and the association of the PW and the service interworking function are deleted, the event is treated as equivalent to deconfiguring a FR VC in [4].

## Appendix I – Deployment Considerations

The encapsulation mode used for the PW in any interworking scenario will depend upon both the location of the segmentation & reassembly (SAR) function and on the location of the IWF. In the network reference model shown in Figure 1 of [4], the ATM SAR function and the FR-ATM interworking function (IWF) are located in the same network element. In addition, FR-ATM multiservice interworking over MPLS allows the ATM SAR and the FR-ATM IWF to reside in different network elements separated by an MPLS network. If the ATM SAR function and the FR-ATM IWF are located on different PEs at each end of the same PW, then the resulting interworking is termed "modified FRF 8.2".

The possible locations of the SAR and FRF 8.2 IWF functions correspond to the three types of encapsulations described in this specification. These three types are:

1. If both the SAR function and the IWF are located at PE2, which has an ATM AC, then FR encapsulation shall be used, as in Figures 2(a) and 2(b). The protocol reference model for a FR N-to-one mode PW is shown in Figure I.1, and a FR one-to-one mode PW in Figure I.2.
2. If both the SAR function and the IWF function are located at PE1, which has a FR AC, then an ATM N-to-one cell mode PW shall be used, as in Figure 3(a). The protocol reference model for this is shown in Figure I.3.
3. If the SAR function is located at PE2 and the IWF function is located at PE1, then an ATM AAL5 SDU mode PW shall be used, as in Figure 3(b). The protocol reference model for this is shown in Figure I.4.

Case 1 is an appropriate deployment scenario for MPLS transport of the output of an existing implementation of FRF8.2 that uses a frame-based switching fabric.

Case 2 is an appropriate deployment scenario where additional transparency to ATM layer functions is required for the pseudo wires, for example if ATM layer security mechanisms are used. It may also be appropriate for MPLS transport of the output of an existing implementation of FRF 8.2 that uses a cell-based switching fabric.

Case 3 takes advantage of the delineation of higher layer frames in the ATM layer to provide increased bandwidth efficiency compared with the basic cell mapping of Case 2. For example, this encapsulation is more efficient where the frame size is small, and in turn it presents a more appropriate encapsulation when the Frame Relay service is carrying RFC2427-encapsulated IP PDUs.

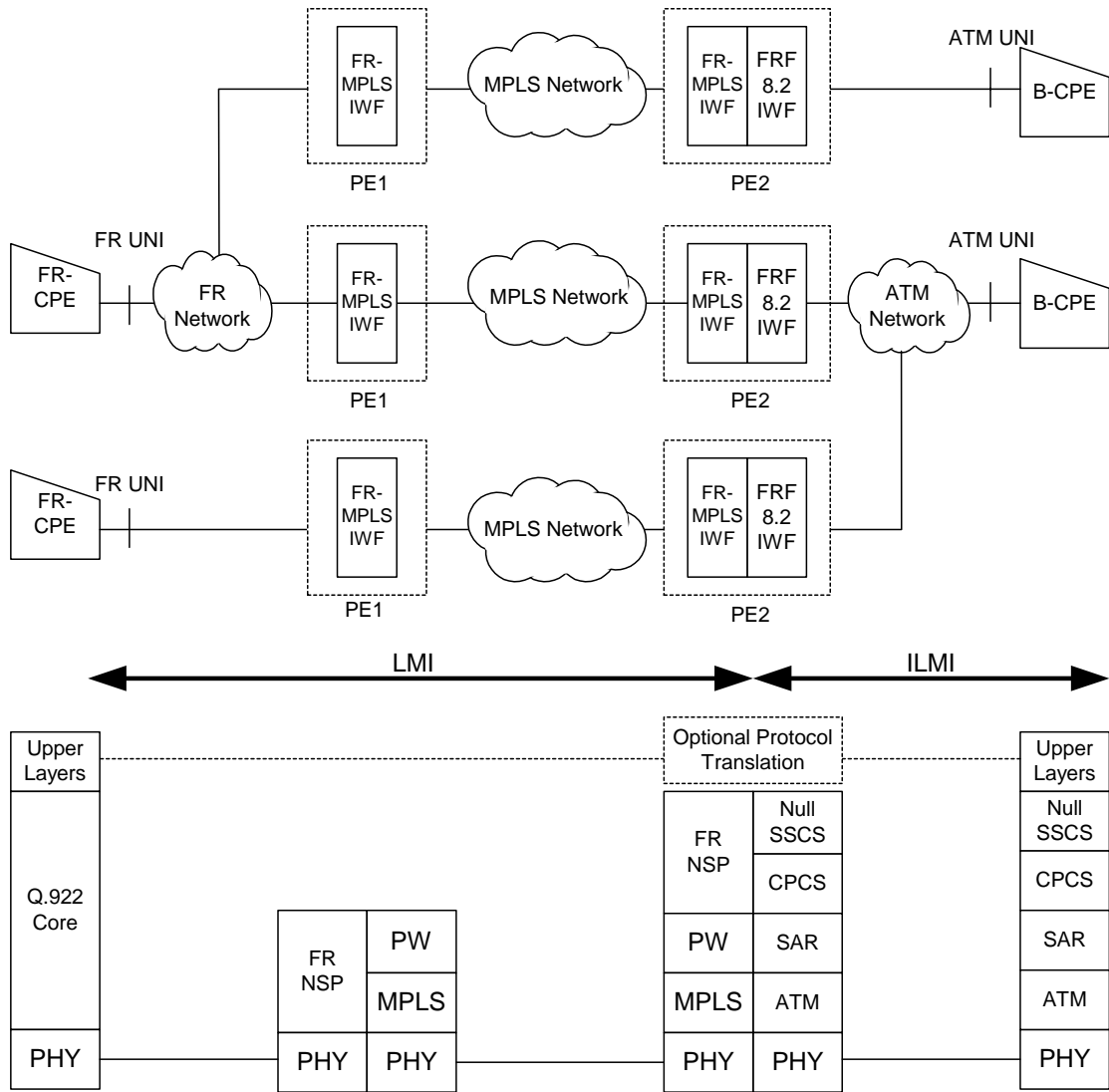


Figure I.1 Protocol Reference Model for N-to-one Mode Frame Relay PW

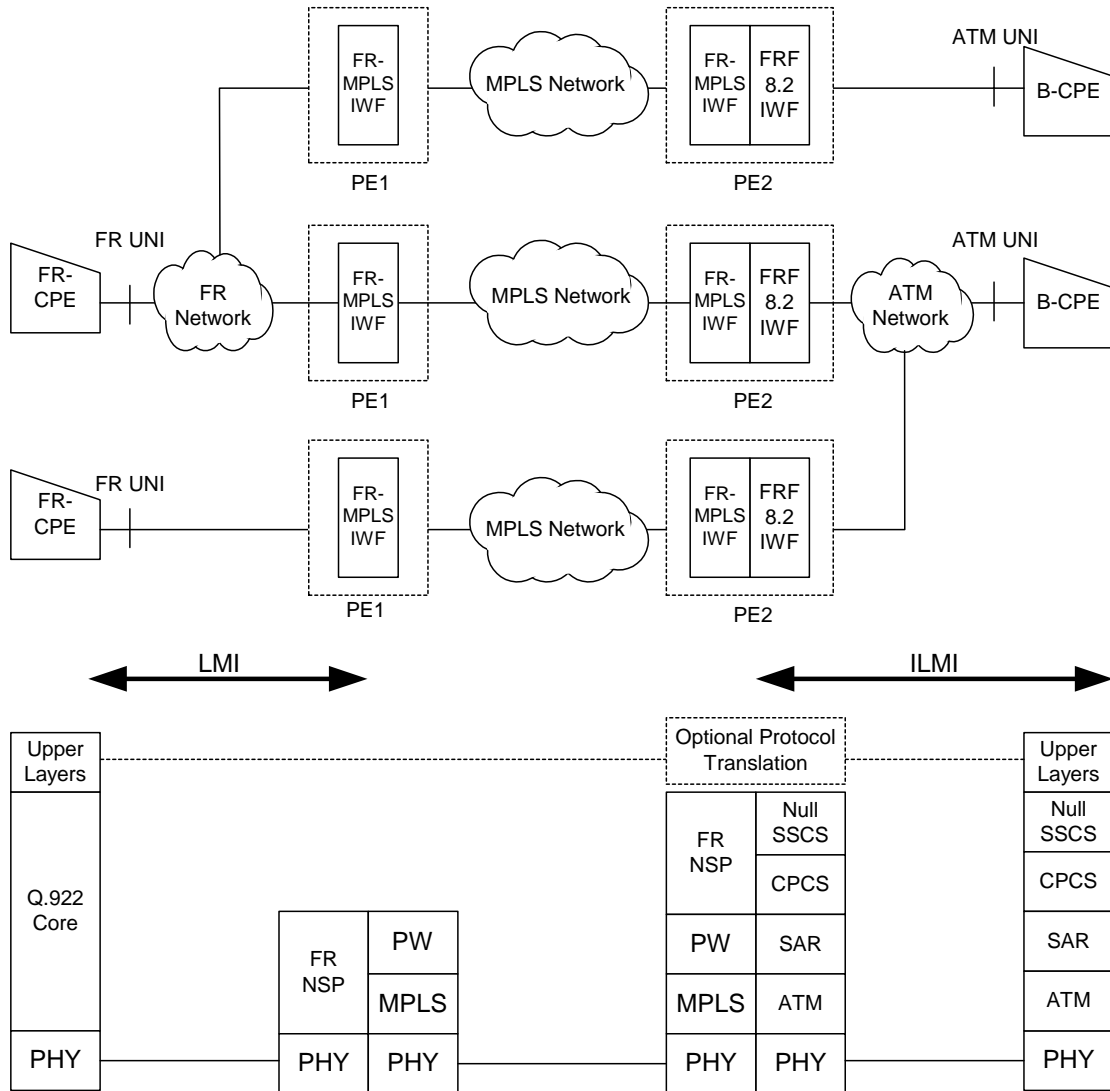


Figure I.2 Protocol Reference Model for One-to-One Mode Frame Relay PW



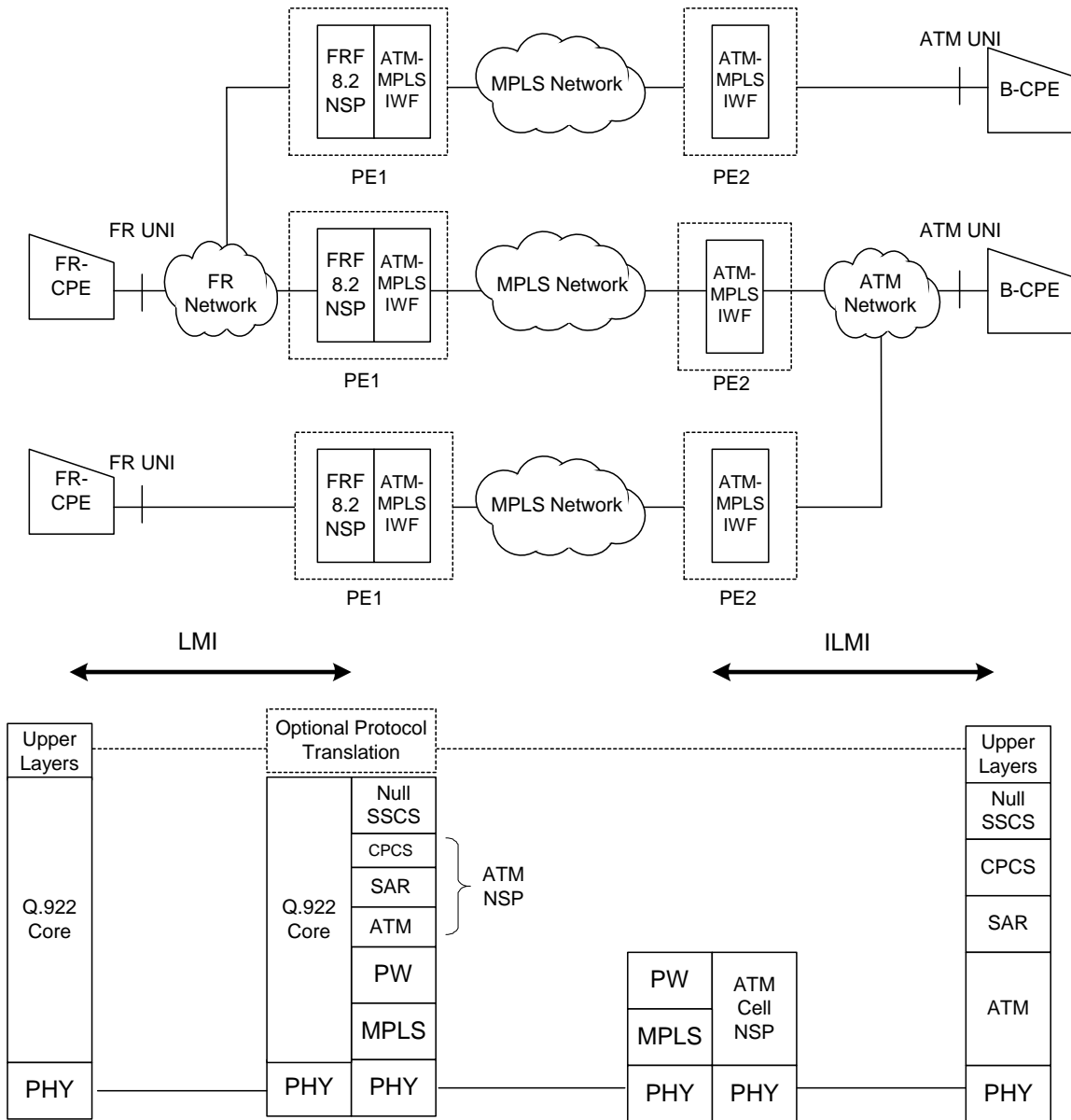
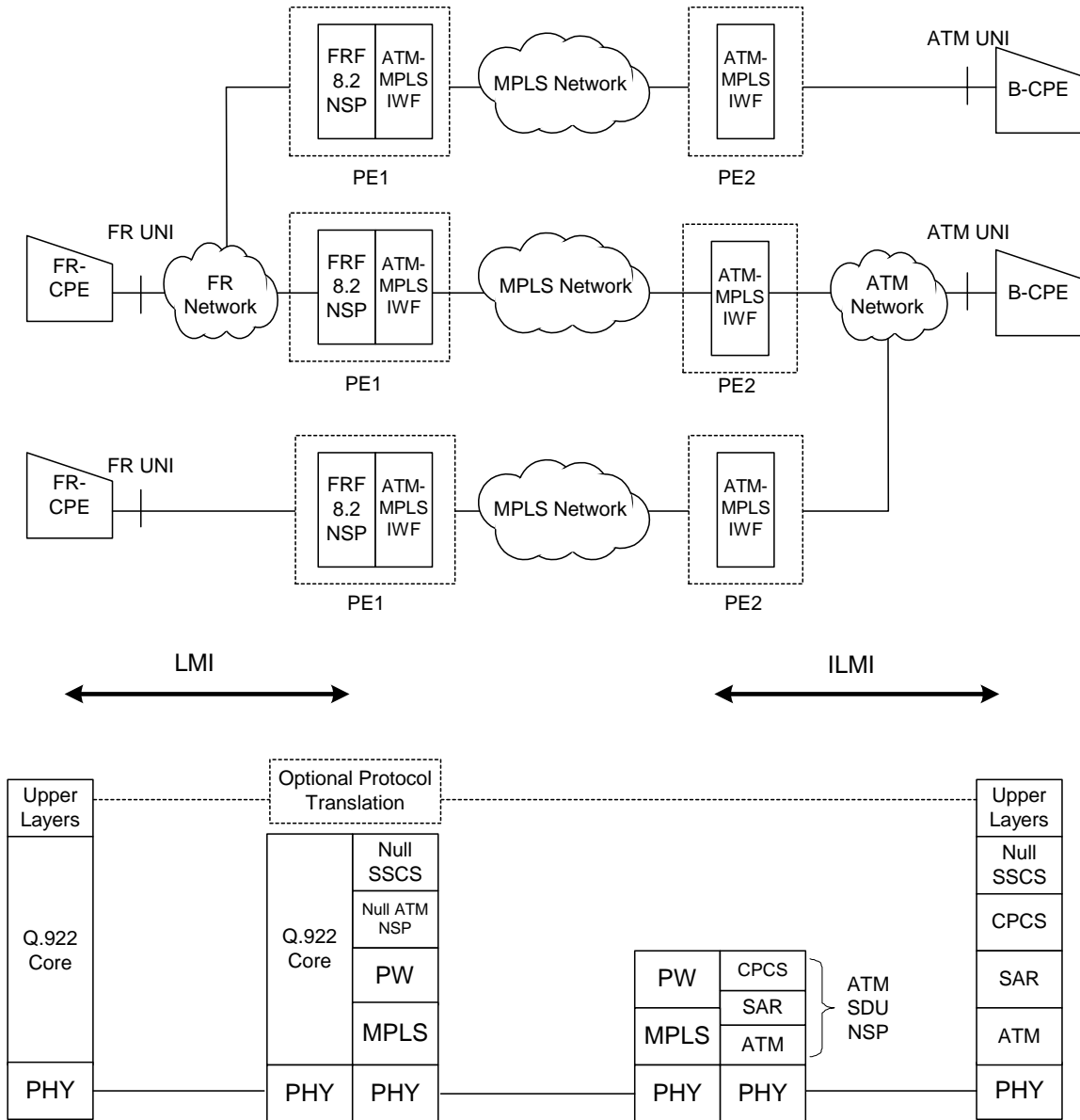


Figure I.3 Protocol Reference Model for ATM N-to-1 PW



**Figure I.4 Protocol Reference Model for ATM SDU PW**

When specifying network equipment to support ATM and Frame Relay interworking over an MPLS network, a network operator should specify the network reference architecture across which the FR to ATM service interworking is to take place, including the location of the SAR function and the IWF. This specification will in turn determine the type of encapsulation to be used for the pseudo wire.

**END OF DOCUMENT**