

# **End-to-End Multilink Frame Relay Implementation Agreement**

**FRF.15**

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# 1 Introduction

## 1.1 Purpose

This document specifies the procedures and frame format to be used by customer premise equipment (CPE) to offer an aggregated virtual circuit (AVC) service. AVC service allows Frame relay CPE to use multiple virtual circuits (VCs) for transport of a single stream of sequenced frames. AVC service provides the following benefits:

- additional bandwidth to an application by supporting distribution of data traffic over multiple underlying VCs
- increased transport resiliency through distribution of traffic over multiple VCs
- order preserving service for application traffic

The agreements herein were reached in the Frame Relay Forum and are based on the documents referenced in Section 1.4. This document may be submitted to different bodies involved in ratification of implementation agreements and conformance testing to facilitate multi-vendor interoperability, and to different standards bodies for inclusion in international standards.

## 1.2 Terminology

**Must, Shall, or Mandatory** - the item is an absolute requirement of this implementation agreement (IA).

**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 implementer.

**Not Applicable** - the item is outside the scope of this IA.

**Aggregated Virtual Circuit** – a virtual circuit that is formed by aggregating one or more independent virtual circuits.

**Constituent Virtual Circuit** – Independent virtual circuits that are members of the same AVC.

## 1.3 Acronym List

AVC - Aggregated Virtual Circuit  
BECN- Backward Explicit Congestion Notification  
CIR – Committed Information Rate  
CPE – Customer Premise Equipment  
CVC – Constituent Virtual Circuit  
DCE - Data Communications Equipment  
DLCI - Data Link Connection Identifier  
DTE - Data Terminal Equipment  
FCS - Frame Check Sequence  
FECN – Forward Explicit Congestion Notification  
FR - Frame Relay  
IA - Implementation Agreement  
MFR – Multilink Frame Relay  
NLPID - Network Layer Protocol Identifier  
NNI - Network-to-Network Interface

PPP - Point-to-Point Protocol  
PVC - Permanent Virtual Circuit  
UI - Unnumbered Information  
UNI - User-to-Network Interface  
VC - Virtual Circuit

## 1.4 Relevant Standards

The End-to-End Multilink Frame Relay IA is based on the following standards and IAs:

- [1] ANSI T.617, DSS1- Signalling Specification for Frame Relay Bearer Service, American National Standards Institute, Inc. 1991.
- [2] FRF.3.1, R. Cherukuri (ed.), Multiprotocol Encapsulation Implementation Agreement, June 22, 1995.
- [3] RFC 2427, C. Brown, A. Malis, Multiprotocol Interconnect over Frame Relay, September 1998.
- [4] FRF.12, Frame Relay Fragmentation Implementation Agreement, December 1997.
- [5] FRF.1.1, User-to-Network Implementation Agreement (UNI), January 19, 1996.
- [6] FRF.14 Physical Layer Interface Implementation Agreement, December 1998
- [7] Multilink Frame Relay UNI/NNI Implementation Agreement.
- [8] Recommendation Q.922 ISDN Data Link Layer Specification for Frame Mode Bearer Services, ITU, Geneva, 1993.

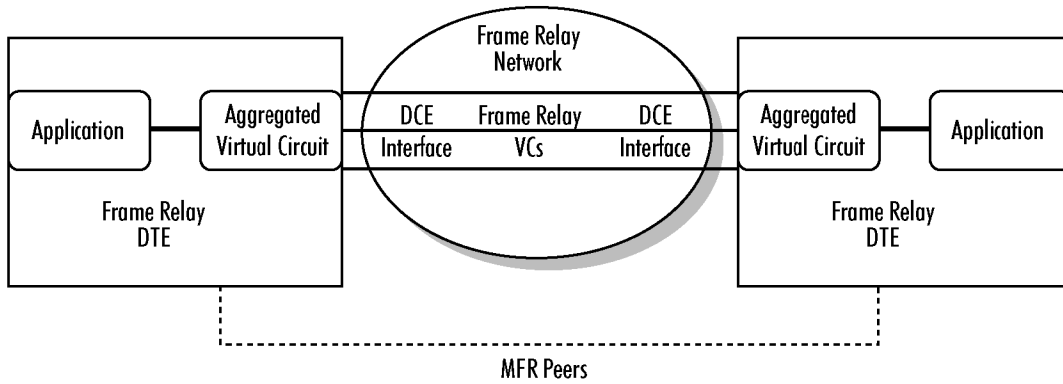
## 2 Reference Model

### 2.1 Overview

End-to-End Multilink Frame Relay (MFR) specifies a method for peer DTEs to aggregate a stream of frames over multiple independent VCs. The combined virtual circuits form a single AVC. Applications operate over an AVC as they would over a single virtual circuit.

A stream of frames may lose its original sequence as it traverses multiple VCs between two endpoints. In-order delivery of frames is a guaranteed property of Frame relay service and MFR must preserve this property. This requirement is accomplished by marking each frame with a sequence number and using this number for resequencing at the destination.

Figure 1 illustrates the logical position of the AVC with respect to an application and frame relay service. This functionality is logically positioned between the DTE application and the frame relay interface. Peer multilink functions communicate with each other over frame relay networks.



**Figure 1 End-to-End Reference Diagram**

## 2.2 Protocol Stack

The goal of End-to-End MFR is to use existing frame relay services to create an AVC by multiplexing a number of independent virtual circuits. The aggregation takes place at VC data transfer level only. Therefore, this functionality shall be implemented in the communicating DTEs and is completely transparent to intervening Frame relay network(s).

The protocol layers at which End-to-End MFR resides are displayed in Figure 2. The End-to-End MFR functionality resides between the VCs and the application protocols using frame relay. Each AVC uses multiple VCs but is completely independent of the physical layer.

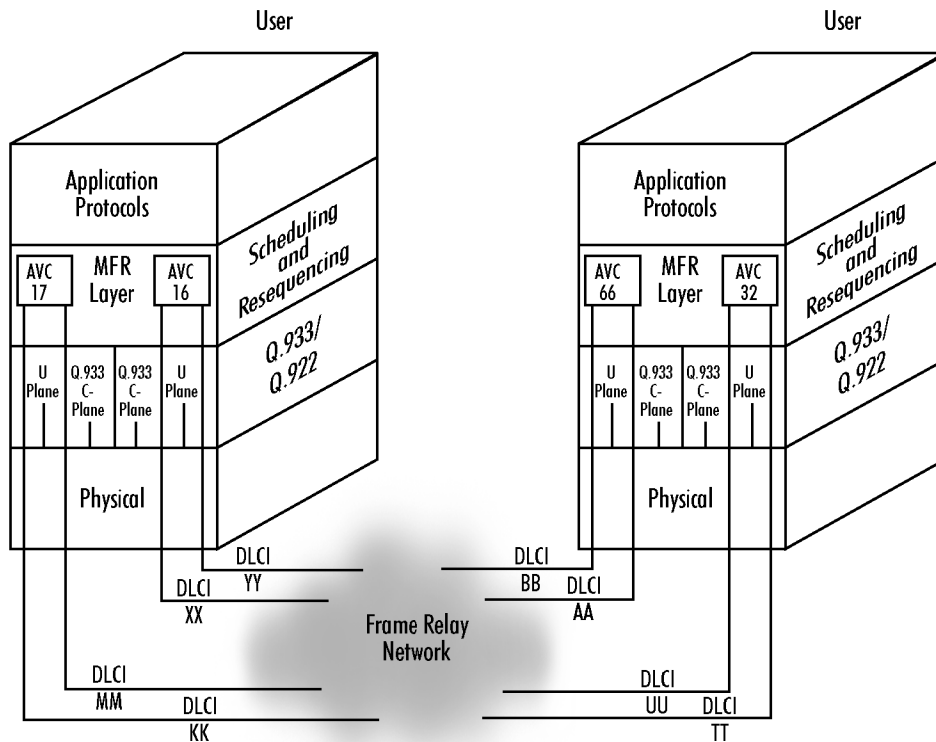


Figure 2 Protocol Diagram for End-to-End MFR

The method described in this IA is intended for use with PVC frame transfer; the data transfer phase of SVCs is for further study.

## 2.3 Relationship to Other Implementation Agreements

### 2.3.1 UNI/NNI Multilink

UNI/NNI MFR described in Multilink Frame Relay UNI/NNI Implementation Agreement [6] differs from the implementation described in this document. End-to-End MFR provides logical bandwidth aggregation using multiple virtual connections. UNI/NNI MFR provides a single logical link by multiplexing multiple physical interfaces.

End-to-End MFR is implemented at the CPE only and is transparent to intervening networks. UNI/NNI MFR is implemented over a set of physical frame relay interfaces between two logically adjacent devices, at least one of which is a DCE.

### 2.3.2 Fragmentation

The MFR End-to-End frame structure uses the End-to-End fragmentation header format defined in FRF.12[4]. Fragmentation utilizing FRF.12[4] End-to-End procedures may optionally be supported for MFR information transfer with the following functional extensions:

- Fragments of a frame may be transmitted over different constituent VCs (CVCs).
- The frame reassembly procedures accept fragments of a frame from any CVC within an AVC.

## 3 End-to-End Multilink Frame Format

End-to-End MFR frames conform to the End-to-End frame relay fragmentation format defined in FRF.12[4]. An example of an End-to-End MFR frame with a two-octet DLCI is shown in Figure 3.

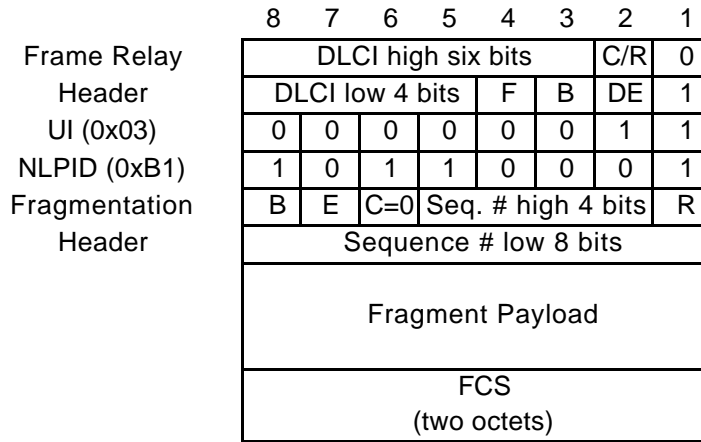


Figure 3 Frame Format

The use of the Sequence Field, the (B)eginning-bit and the (E)nding-bit complies with FRF.12[4]. The sequence counter is maintained separately for each AVC.

## 4 Procedures

Preservation of frame sequence over the data transfer path is accomplished by inserting the sequencing field into each frame before frame transmission. At the receiving end, frames are resequenced to their original order in accordance with the sequence field. The sequence field is then removed and the frame is forwarded.

The status and traffic management indications of the multiple CVCs are to be aggregated for presentation to the higher layer. Section 4.2.2 presents rules for combining the status indications of the CVCs.

### 4.1 Configuration and Provisioning

Configuration of AVCs and the assignment of CVCs to them may be accomplished by means of vendor-specific network management. It is not a requirement that an MFR allow CVCs to be dynamically added to or deleted from an AVC. Automatic addition and deletion of CVCs from an AVC by means of the procedures specified in Annex A of [7] is for further study.



## **4.2 Activation/Deactivation of CVC**

### **4.2.1 Data Link Control Management Interface**

There are no mandatory data link control protocol procedures defined for End-to-End MFR. Each CVC is independently governed by standard VC signaling defined in [1] and [8].

Any CVC that has a status of active as determined by standard data link management procedures shall be eligible for frame transport as part of the AVC.

### **4.2.2 Status Reporting for AVC**

End-to-End MFR configuration is transparent to the frame relay switching equipment. Standard frame relay signaling is applied to each constituent link independently. At layer 3 the status indications of the CVCs of an AVC are aggregated into a single status. The status aggregation procedure can be configured in one of three modes:

Mode 1: (default) The status shall be active for an AVC if the status of any CVC is active. The status of the AVC shall be inactive if the status of every CVC is inactive.

Mode 2: (optional) The status shall be active for an AVC if the status of every CVCs is active. The status of the AVC shall be inactive if the status of any CVC is inactive.

Mode 3: (optional) users may mutually agree to certain operating requirements for activating and deactivating the AVC. Operating requirements to be considered are:

- minimum number of active CVCs
- available CIR on each CVC
- total aggregated CIR available to the AVC

The communicating DTEs should mutually agree on the aggregation procedure to be used.

## **4.3 Frame Transmission**

### **4.3.1 Procedures**

The information transfer procedure is accomplished as follows. Frames from the AVC are sequenced for distribution over multiple CVCs. A separate sequence counter is maintained for each AVC.

### **4.3.2 Selection of CVCs for Data Transport**

The sender may send frames associated with an AVC over any of its active constituent links. The choice of which active CVCs to use for transmission is implementation dependent. However, the receiving CPE must accept frames over all active CVCs.

The active status of each CVC is controlled by standard data link control management procedures and indicated by the A-bit.

## **4.4 Frame Reception**

### **4.4.1 Frame Procedures**

Incoming received frames from CVCs are reordered for sequential delivery to the AVC. The frame distribution and reassembly procedure follows the procedure defined in FRF.12[4].

### **4.4.2 Frame Resequencing Procedures**

The reassembly procedure is defined in FRF.12[4]; however, because frames may be received out of order, frame loss detection procedures are required. Frame loss detection procedures are implementation specific. Two general algorithms are presented in the Annex A of this document. Algorithms other than those described in Annex A may also be used without violating this implementation agreement.

## **4.5 Frame Relay Service for AVC**

Frame relay services are applied independently to each CVC. Therefore, the frame relay service that is available to the AVC is derived indirectly from all of its CVCs. Traffic management, such as processing of DE, FECN and BECN, must be operated independently at each CVC.

## **Annex A ( informative ): Frame Loss Detection**

The frame reassembly procedure used by this implementation agreement is defined in FRF.12[4]; however, because frames may be received out of order, the receiving end of an AVC must detect loss of frames. After the receiving end declares a frame to be lost:

frames sequenced behind the lost frame will no longer be buffered but rather be forwarded to the destination application.

a frame that arrives after having been declared lost must be discarded.

The algorithm used for determining that a frame is lost is implementation specific.

Two general methods are discussed below. Each has advantages and disadvantages. These two approaches may be used separately, together, or not at all depending on the design decisions facing a particular implementation.

### **Timer-Based Frame Loss Detection**

This class of frame loss detection causes a frame to be declared lost when it is not received within a specified time interval.

A timer is initiated when a frame is received with a sequence number value more than one increment greater than that of any frame that has been received on the same AVC.

Expiration of the timer results in a frame(s) being considered lost. This timing function is terminated by arrival of the expected frame(s).

The minimum interval used to detect frame loss is usually influenced by the time required to transmit a frame with the maximum frame size over the slowest link.

This method may cause frames to be prematurely declared lost, but it has the advantage of providing an upper bound for the buffering required.

### **VC-Based Frame Loss Detection**

A frame can reasonably be declared lost when on each CVC within the AVC, a frame with a greater sequence number has been received.

This method guarantees that a frame is not prematurely declared lost but does not provide an upper bound for the amount of buffering needed to support an AVC.