I.366.2 Voice Trunking Format over MPLS
Implementation Agreement

MPLS /Frame Relay Alliance 5.0.0

MPLS /Frame Relay Alliance Technical Committee
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Revision History

Version	Change	Date
MPLSF.X.0.0	Initial version	June 2003

1 Introduction

1.1 Purpose

The purpose of this Implementation Agreement (IA) is to define a method for conveying voice trunking per the format definitions in I.366.2 ,using AAL type 2 Common Part Sublayer Packets (CPS-Packets) directly over MPLS without first encapsulating the packets in IP. The typical protocol stack consists of CPS-Packets encapsulated in the MPLS protocol on top of an MPLS transport arrangement such as Frame Relay, ATM, PPP, or Ethernet.

CPS-Packets directly over MPLS (A2oMPLS), provides a very efficient transport mechanism for AAL type 2 CPS-Packets in the MPLS environment and is the subject and purpose of this Implementation Agreement.

The purpose of this A2oMPLS – Bearer Transport Implementation Agreement is to define how an AAL type 2 CPS-Packet is encapsulated directly in the MPLS frame. No definition of an A2oMPLS header format is required as the original AAL type 2 CPS-Packets[1] are aggregated in an MPLS frame without modification.

1.2 Scope and Overview

This specification defines MPLS support for the transport of AAL type 2 CPS-Packets. Frame formats and procedures required for this transport are described in this Implementation Agreement. This specification addresses the transport of any AAL type 2 CPS-Packets regardless of the application data that is transported[4,5].

This Implementation Agreement does not specify signaling protocols, call routing, equipment aspects, performance guidelines, or implementation techniques. In this document, A2oMPLS shall refer only to the arrangement of AAL type 2 CPS-Packets (without IP encapsulation) over MPLS.

1.3 Definitions

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

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.

Notes — outside of Tables and Figures are informative.

1.4 Acronyms and Abbreviations

A2oMPLS	AAL type 2 CPS-Packets (ITU-T I.366.2)over MPLS
AAL	ATM Adaptation Layer
AAL2	AAL type 2
ATM	Asynchronous Transfer Mode
CID	Channel Identifier
CPS	AAL type 2 Common Part Sublayer
CRC	Cyclic Redundancy Check
CR-LDP	Constraint-Based LDP
GW	Gateway
HEC	Header Error Control
ISDN	Integrated Services Digital Network
LDP	Label Distribution Protocol
LER	Label Edge Router
LI	Length Indicator
LSP	Label Switched Path
LSR	Label Switched Router
M	Mandatory
MPLS	Multi-Protocol Label Switching
O	Optional
PSTN	Public Switched Telephone Network
RSVP	Resource Reservation Protocol
RSVP-TE	RSVP Tunnel Extension
UUI	User-to-User Indication

2 References

[1] ITU-T Recommendation I.363.2 — B-ISDN ATM Adaptation layer (AAL) Type 2 specification, Geneva, March 2000.

[2] IETF RFC 3031 — Multiprotocol Label Switching Architecture, E. Rosen et al., January 2001.

[3] IETF RFC 3032 — MPLS Label Stack Encoding, E. Rosen et al., January 2001.

[4] ITU-T Recommendation I.366.1 — Segmentation and Reassembly Service Specific Convergence Sublayer for the AAL type 2, Geneva, June 1998.

[5] ITU-T Recommendation I.366.2 — AAL type 2 service specific convergence sublayer for narrow-band services, Geneva, February 2000.

[6] ITU-T Recommendation Q.2630.2 — AAL type 2 Signaling Protocol (Capability Set 2), Geneva, December 2000.

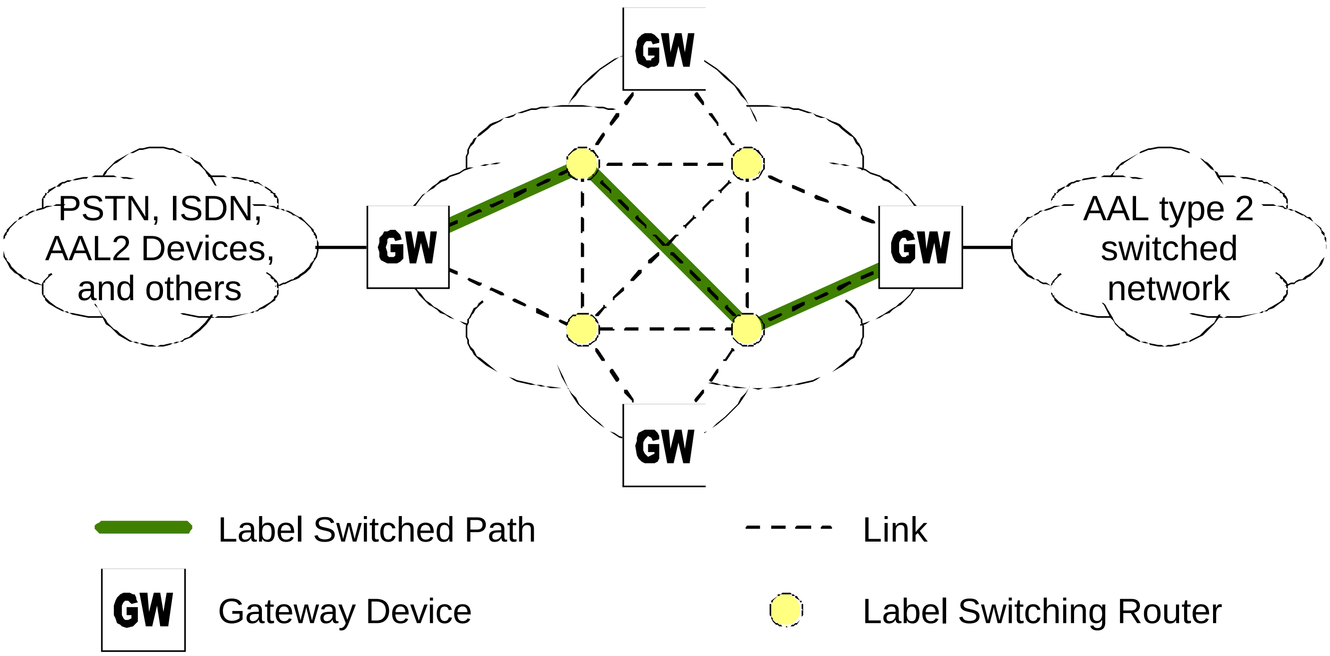
[7] IETF RFC 3212 — Constraint-Based LSP Setup using LDP, B. Jamoussi et al., January 2002.

[8] IETF RFC 3209 — RSVP-TE: Extensions to RSVP for LSP Tunnels, D. Awduche et al, December 2001.

3 Reference Architecture

3.1 General

Figure **3-1** identifies the Reference Architecture for AAL type 2 over MPLS (A2oMPLS). An MPLS network contains a number of Gateway (GW) devices, Label Switching Routers (LSR), and Label Switched Paths (LSP). An example LSP is shown as a solid line in the figure. Gateways may be directly connected to each other or indirectly connected through a number of LSRs (see also ITU-T Recommendation I.363.2[1] and IETF RFC 3031[2]).



NOTE — This figure does not preclude both networks on the left and the right hand side being “AAL type 2 switched networks” or that both are “PSTN, ISDN, AAL2 Devices, and others”.

Figure 3-1 - A2oMPLS Reference Architecture

NOTE — A typical implementation of a Gateway Device would be a line card in, for example, either an AAL type 2 end system or AAL type 2 switch. AAL type 2 end systems or switches[6] are not specified in this Implementation Agreement.

A simple architecture is all that is required in order to understand the application of this Implementation Agreement. It is not the intent of this agreement to specify the internal details of MPLS networks, i.e the signaling required supporting A2oMPLS, or the architecture or functions of gateways and routers. The intent of the reference architecture is to support all possible deployments of A2oMPLS.

The Gateway (GW) contains the functionality of a Label Edge Router (LER) as well as many other functions. In particular, it implements the functions of an endpoint of an AAL type 2 link in an AAL type 2 end-system or an AAL type 2 switch.

This architecture must be capable of supporting many different LSP bearer arrangements to convey AAL type 2 CPS-Packets in an MPLS environment. For example:

a) One arrangement may be an end-to-end LSP established between two AAL type 2 nodes existing within a single MPLS domain.

b) A second arrangement may be an LSP that has been established to support only a portion of the A2oMPLS connection between the end devices.

In the second case, multiple LSPs may need to be concatenated to form an end-to-end connection or perhaps interworking between an LSP and another type of bearer may be required. This second case is for further study.

An MPLS domain might exist between the entry and exit gateway nodes of the service provider's network. LSPs are created between these network gateways to carry A2oMPLS connections in a trunking arrangement.

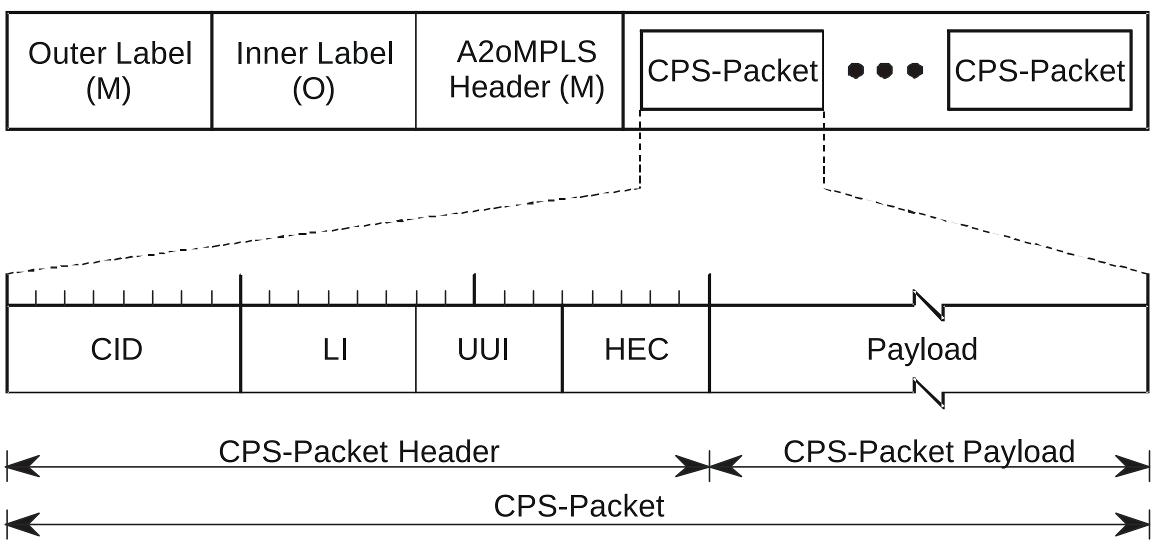
3.2 Multiplexing A2oMPLS connections onto MPLS Label Switched Paths (LSP)

3.2.1 General structure

Multiple A2oMPLS connections may be transported over an LSP. A single type of A2oMPLS sub-frames (the AAL type 2 CPS-Packet) , is defined, it may be transmitted as required. Multiple sub frames may be multiplexed within a single MPLS frame.

An AAL type 2 CPS-Packet contains the information that, — when transmitted — constitutes the traffic that is fundamental to the operation of a connection identified by a Channel Identifier (CID). It may include encoded voice, dialed digits, signaling information, frame mode data, circuit mode data, etc. A2oMPLS sub frames are variable length sub frames where the maximum length of the CPS-Packet payload is either 45 octets (default, required if AAL type 2 switching is performed) or 64 octets.

The MPLS frame structure allowing the multiplexing of CPS-Packet over MPLS calls is shown in Figure **3-2**.



(M)	Mandatory	
(O)	Optional	
CID	Channel Identifier	(8 bits)
LI	Length Indicator	(6 bits)
UUI	User-to-User Indication	(5 bits)
HEC	Header Error Control	(5 bits)

Figure 3-2 - LSP Structure for multiplexing CPS-Packets

A typical A2oMPLS multiplexing structure consists of a mandatory outer label, zero or more inner labels (see IETF RFC 3032[3]), and one or more A2oMPLS sub-frames, each consisting of a 3-octet CPS-Packet Header and variable length CPS-Packet Payload.

The Channel ID (CID) allows up to 248 A2oMPLS connections to be multiplexed within a single LSP. At least one LSP must be created to convey A2oMPLS connections; thus, the use of an outer label is mandatory. As an implementation option, additional inner LSPs may be created using stacked labels.

3.2.2 A2oMPLS Header Format

The A2oMPLS header is shown in Figure **3-3**. Table 1 defines the role of each field.

Bits:	0- 9	10-15	16-31
	Reserved	Length	Sequence number

Figure 3-3 - A2oMPLS specific header

Table 1 - A2oMPLS Frame Header Fields

Field	Meaning
Bits 0-9: Reserved	Reserved bits. Set to zero on transmission and ignored on reception.
Length (bits 10 to 15)	The length field is used to indicate the use of padding to meet minimum transmission unit requirements of layer 2 of the MPLS network. It must be used if the A2oMPLS packet length(including layer 2 overhead) is less then 64 bytes, and must be set to zero if this length exceeds 64bytes.
Sequence number (Bit 16 to 31)	The 16 bits sequence number can be used to guarantee ordered packet delivery. The processing of the sequence number filed is OPTIONAL. The sequence number space is a 16 bit, unsigned circular space. The sequence number value 0 is used to indicate an unsequenced packet.

3.2.3 Single-LSP structure

Figure **3-4** depicts an example A2oMPLS frame structure of a single LSP that is used to convey from one to 248 A2oMPLS connections.

NOTE — A unique CID identifies each A2oMPLS sub–frame, but the sub-frames may be transmitted in any order whenever information for a connection is available.

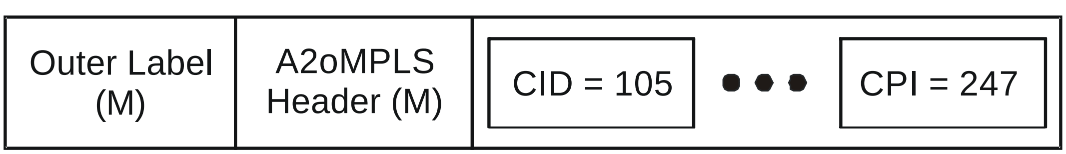


Figure 3-4 - Single-LSP structure for multiplexing CPS-Packets

In order to establish the single-LSP A2oMPLS bearer structure depicted in Figure **3-4** the procedure is as follows:

1. Two associated unidirectional LSPs, one in each direction are created either by manual provisioning or by using an MPLS control protocol (e.g., CR-LDP[7], RSVP-TE[8] ,etc.)

2. As A2oMPLS connections arrive at the LER, a CID value is assigned to the connections (multiplexed) within the LSP. This is accomplished by either:

    a) A priori coordination of CID value usage. In this case each new A2oMPLS connection is assigned to an existing CID (i.e., there is no need for per-connection signaling);

    or

    b) An invocation of the signaling control protocol for CIDs to establish bi-directional channels that are used for the A2oMPLS connection.

    NOTE — Identification or development of a signaling protocol for this purpose is not within the scope of this implementation agreement.

3.2.4 Label-stacked structure

Figure **3-5** depicts an example A2oMPLS frame structure based on label stacked inner LSPs. The outer label is the same while different inner labels are stacked to expand the multiplexing capability of the outer LSP.

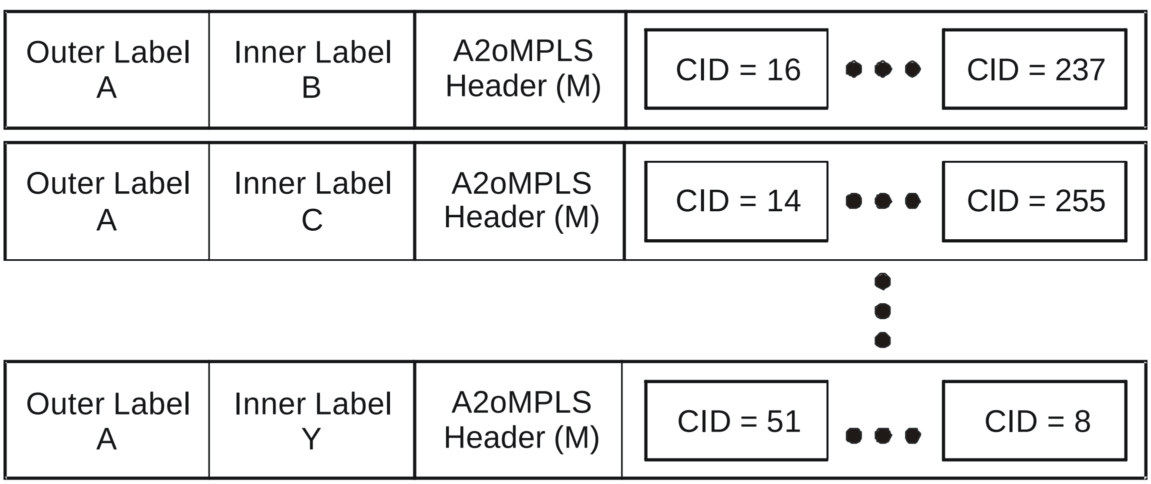


Figure 3-5 - Stacked-LSP structure for multiplexing CPS-Packets

NOTE — A CID that is unique within each inner LSP identifies each A2oMPLS sub frame. That is, CID 16 in LSP “AB” is a different channel, i.e., a different A2oMPLS connection from , CID 16 in LSP “AY”.

Sub frames may be transmitted in any order whenever information for a connection is available. This structure has the potential to convey up to 248 A2oMPLS Channels multiplied by the number of inner LSPs.

In order to establish the stacked-LSP A2oMPLS bearer structure depicted in Figure **3-5** the procedure is as follows:

1) Two associated unidirectional LSPs, one in each direction are created either by manual provisioning or by using an MPLS control protocol (e.g., CR-LDP[7], RSVP-TE[8] ,etc.). These LSPs are termed the outer LSPs.

2. As A2oMPLS connections arrive at the LER, additional LSPs may have to be created (multiplexed) within the outer LSP. This is accomplished by:

    a) A-priori coordination of inner LSP label value usage. In this case each new A2oMPLS connection is assigned to an existing LSP (i.e. there is no need for per-LSP signaling).

    or

b) Repeated invocations of the MPLS control protocol to establish bi-directional inner LSPs that are used for the A2oMPLS connection.

3. As A2oMPLS connections arrive at the LER, a CID value is assigned to the connections (multiplexed) within the inner LSP. This is accomplished by:

   a) A-priori coordination of CID value usage. In this case each new A2oMPLS connection is assigned to an existing CID (i.e. there is no need for per-connection signaling);

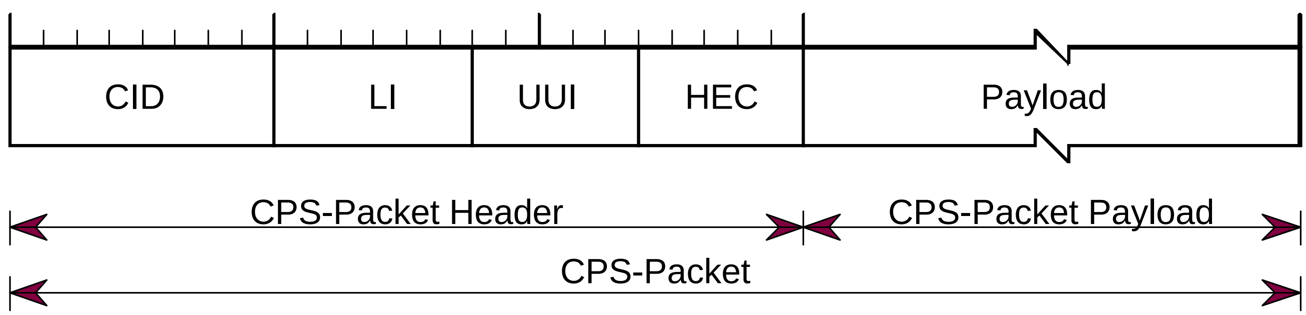
   or

   b) An invocation of a signaling control protocol for CIDs to establish bi-directional channels that are used for the A2oMPLS connection.

   NOTE — Identification or development of a signaling protocol for this purpose is not within the scope of this implementation agreement.

4 Frame Format

The A2oMPLS sub frame has the same structure as the AAL type 2 CPS-Packet [1]. This is shown in Figure **4-1.**



CID	Channel Identifier	(8 bits)
LI	Length Indicator	(6 bits)
UUI	User-to-User Indication	(5 bits)
HEC	Header Error Control	(5 bits)
Payload	User Information	(1 to 45/64 octets)

Figure 4-1 - Format of the AAL type 2 CPS-Packet

The CPS-Packets consists of four fields:

a) Channel Identifier (CID)
The CID value identifies the A2oMPLS user of the channel. The AAL type 2 channel is a bi-directional channel. The same value of channel identification shall be used for both directions.

The value “0” is not used for channel identification because the all zero octet is used (in AAL type 2[1]) for the padding function. The values “1” through “7” are reserved for use by AAL type 2 and are specified in ITU-T Recommendation I.363.2[1] (see Table 4-1).

The values “8” through “255” are used to identify the users of the A2oMPLS; further discrimination between the two types of users, i.e., SSCS and Layer Management, is provided by the UUI field (see item c below).

Table 2 - Coding of the CID Field

CID value	Use
0	Not used
1 2 3 through 7	Reserved for Layer Management peer-to-peer procedures Reserved for Signaling Reserved
8 through 255	Identification of A2oMPLS user entity

b) Length Indicator (LI)
The LI field is binary encoded with a value that is one less than the number of octets in the CPS-Packet Payload. The default maximum length of the CPS-Packet Payload is 45 octets; otherwise, the maximum length can be set to 64 octets.

The maximum length is channel specific, i.e., its value need not be common to all AAL type 2 channels. However, for a given CID value, all CPS-Packet payloads must conform to a common maximum value. This maximum length is set by signaling or management procedures.

When the maximum length is 45 octets, LI values 45 through 63 are not allowed.

c) User-to-User Indication (UUI)
The UUI field serves two purposes:

- to convey specific information transparently between the users, i.e. between A2oMPLS users entities or between Layer Management; and
- to distinguish between the A2oMPLS users entities and layer management of the A2oMPLS.

The 5-bit UUI field provides for 32 code points, “0” through “31”. Code points “0 through “27” are available for A2oMPLS user entities, code points “30” and “31” are available to Layer Management, and code points “28” and “29” are reserved for future standardization by ITU-T[1].

d) Header Error Control (HEC)
In an AAL type 2 environment, the transmitter calculates the remainder of the division (modulo 2), by the generator polynomial $x^5 + x^2 + 1$, of the product of x^5 and the contents of the first 19 bits of the CPS-Packet Header. The coefficients of the remainder polynomial are inserted in the HEC field with the coefficient of the x^4 term in the most significant bit of the HEC field.

In an MPLS environment, this field may not be used as the protection of parts of an MPLS frame — this is completely protected by a layer 2 frame protection (e.g., CRC). The MPLS receiver shall not check the contents of the HEC field to detect errors in the CPS packet header.

5 Procedure of AAL type 2 Common Part Sublayer (CPS)

The multiplexing function in the A2oMPLS sublayer merges several streams of CPS-Packets onto a single MPLS LSP. The method of scheduling the different streams and the possible use of priorities is not specified in this Implementation Agreement.

The A2oMPLS sublayer receives CPS-Packets from one or more A2oMPLS users. It multiplexes and packs these CPS-Packets into MPLS frames. At the A2oMPLS receiver, the CPS-Packets are unpacked and demultiplexed and passed to one of the A2oMPLS users.

5.1 A2oMPLS transmitter

The operation of the A2oMPLS transmitter is modeled as a state machine consisting of the following two states:

IDLE The MPLS frame is empty and the "combined use" Timer_CU is not running.

PART Some CPS-Packets are stored in the MPLS frame and there is room for more; the "combined use" Timer_CU is running.

The A2oMPLS transmitter is defined as follows:

1) When the A2oMPLS transmitter is in state IDLE and a CPS-Packet is passed from an A2oMPLS user or from layer management, a new empty MPLS frame is constructed and the complete CPS-Packet is copied into the new MPLS frame; the "combined use" Timer_CU is started. The state machine proceeds to state PART.

2) When the A2oMPLS transmitter is in state PART and a further CPS-Packet is passed from an A2oMPLS user or from layer management, and the addition of this CPS-Packet does not exceed the maximum permissible length of the MPLS frame, the complete CPS-Packet is copied into the MPLS frame. The "combined use" Timer_CU continues to run unaltered. The state machine remains in state PART.

3) When the A2oMPLS transmitter is in state PART and a further CPS-Packet is passed from an A2oMPLS user or from layer management, and the addition of this CPS-Packer would exceed the maximum permissible length of the MPLS frame, the current MPLS frame is completed with the label stack, the layer 2 frame protection, etc. It is then transmitted on the MPLS LSP. A new empty MPLS frame is constructed and the complete CPS-Packet is copied into the new MPLS frame; the "combined use" Timer_CU is re-started. The state machine remains in state PART.

4) When Timer_CU expires while the process is in state PART, the current MPLS frame is completed with the label stack, the layer 2 frame protection, etc. and is transmitted on the MPLS LSP. The state machine proceeds to state IDLE.

5) Setting the sequence number

   The following procedure MUST be used by the ingress PE if sequencing is desired for a given A2oMPLS service:

   - The initial PDU transmitted on the LSP MUST use sequence number 1.
   - The PE MUST increment the sequence number by one for each subsequent PDU.
   - When the transmit sequence number reaches the maximum 16 bit value (65535) the sequence number MUST wrap to 1.
   - If the ingress PE does not support sequence number processing, then the sequence number filed in the control word MUST be set to 0.

5.2 A2oMPLS receiver

The operation of the A2oMPLS receiver does not need to be modeled as a state machine, there would be just one state.

The A2oMPLS receiver is defined as follows:

1) When a received MPLS frame's checksum is incorrect, the frame is discarded (prior to reaching the A2oMPLS receiver) as the proper recipient cannot be determined.

2) When the A2oMPLS receiver receives a new MPLS frame (with a correct checksum), the CPS-Packet(s) are extracted. The HEC field is ignored. If the UUI field value is "30" or "31", the CPS-Packet is handed to layer management; otherwise, the packet is passed to the appropriate A2oMPLS user.

3) Processing the sequence number

If the egress PE supports receive sequence number processing, then the following procedure MUST be used:

- When A2oMPLS service is initially created, the "expected sequence number" associated with it MUST be initialized to 1. When a PDU is received on the LSP associated with the A2oMPLS service the sequence number must be processed as follows:
- If the sequence number on the packet is 0,then the PDU passes the sequence number check
- Otherwise if the PDU sequence number >= the expected sequence number and the PDU sequence number – the expected sequence number < 32768, the PDU is in order.
- Otherwise if the PDU sequence number < the expected sequence number and the expected sequence number - the PDU sequence number >= 32768, then the PDU is in order
- Otherwise the PDU is out of order.
- If a PDU passes the sequence number check, or is in order then, it can be delivered immediately. If the PDU is in order, then the expected sequenced number MUST be set using the algorithm:
- Expected sequence number = PDU sequence number + 1 mod 2**16 if (expected sequence number = 0) then expected sequence number = 1.
- LSP PDUs that are received out of order MAY be dropped or reordered at the discretion of the egress PE.
- If the egress PE does not support receive sequence number processing, then the sequence number field may be ignored.

6 Configuration Parameters

The interrelation of the maximum MPLS frame size and the "combined use" Timer_CU needs to be considered carefully. For example, if data according to the specifications in ITU-T Recommendation I.366.2 is transported, Timer_CU must be set to 5 ms or lower in order to guarantee the mechanism of the "triple redundancy".

Based on the line speed, the number of connections supported and maximum MPLS frame size must be calculated. The delay variation of an MPLS frame must be less than or equal to 5 ms. While calculating the number of connections and maximum MPLS frame size, consideration must also be given to the end-to-end delay.

Appendix A Interim Indications (informative)

A.1 Alarms and indication handling

Since A2oMPLS offers service interworking of AAL-2 across anMPLS network, end- to- end control and alarm surveillance should be supported. When interworking with TDM or ATM networks, the A2oMPLS gateway MUST be able to transfer traffic affecting alarms and indications and map them between the networks. Support of alarms and indications is critical in order to have a working implementation.

A.1.1 R bit

The R-bit indicates that the source is not receiving packets at its A2oMPLS receiving port.

This indication is important as it reflects the state of the MPLS tunnel. This bit is the equivalent of VC/VP-RDI in the ATM environment. This bit is optional and can be replaced by MPLS OAM.

The R bit is bit 5 in the control word.

The R bit being set indicates that the source is not receiving packets at its A2oMPLS receive port. Note: This bit should always be transmitted. Its use is optional at the receiver when MPLS OAM protocol is supported. The R bit is optional. If not supported it shall be cleared

A.1.1.1 Handling the R bit (receiver)

If the R bit is supported, the following procedure MUST be used by the egress PE in a given A2oMPLS service:

- The R-bit **must** be set after 1 second where packets are not received on a specific A2oMPLS tunnel , and **must** be cleared once packets are once again received.

A.1.1.2 Handling the R bit (sender)

If the R bit is supported, the following procedure MUST be used by the ingress PE in a given A2oMPLS service:

- If the R-bit is set to 1 on a specific A2oMPLS tunnel, then the ingress PE **must** generate an alarm/notification to its network management system.

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