I.366.2 Voice Trunking Format over MPLS Technical Specification

IP/MPLS Forum 5.1.0

IP/MPLS Forum Technical Committee
July 2008

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Revision History

Version	Change	Date
MPLS and Frame Relay Alliance 5.0	Initial version	June 2003
IP/MPLS Forum 5.1	Alignment with ITU-T Y.1452, specification of usage of TDM PW setup TLV's AAL2 option , TDM options and LDP status codes	July 2008

1 Introduction

1.1 Purpose

The purpose of this specification is to define a method for conveying voice trunking, per the format definitions in I.366.2, by 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 transported directly over MPLS (A2oMPLS) provide a very efficient transport mechanism for AAL type 2 CPS-Packets in the MPLS environment.

The purpose of this A2oMPLS – Bearer Transport Specification 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, regardless of the application data that is transported[4,5]. Frame formats and procedures required for this transport are also described.

This specification 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 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 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 Sub layer
CRC	Cyclic Redundancy Check
HEC	Header Error Control
ISDN	Integrated Services Digital Network
LDP	Label Distribution Protocol
LER	Label Edge Router
LI	Length Indicator
HEC	Header Error Control
LSP	Label Switched Path
LSR	Label Switched Router
M	Mandatory
MPLS	Multi-Protocol Label Switching
O	Optional
PSTN	Public Switched Telephone Network
PW	Pseudowire
RSVP	Resource Reservation Protocol
RSVP-TE	RSVP Traffic Engineering
UUI	User-to-User Indication

2 References

2.1 Normative references

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

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

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

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

[5] ITU-T Recommendation Y.1414 – Voice services MPLS network interworking, July 2004

[6] IETF RFC 3985 — Pseudo Wire Emulation Edge-to-Edge (PWE3) Architecture, S. Bryant and P. Pate, March 2005.

2.2 Informative references

[7] IANA Pseudo Wires Name Spaces, http://www.iana.org/assignments/pwe3-parameters

[8] A.Vainshtein, Y.Stein, Control Protocol Extensions for Setup of TDM Pseudowires , Work in progress, <draft-ietf-pwe3-tdm-control-protocol-extensi-07.txt> March 2008,

[9] IETF RFC 4447 Pseudo Wire Setup and Maintenance Using LDP L. Martini et al. April 2006.

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

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

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

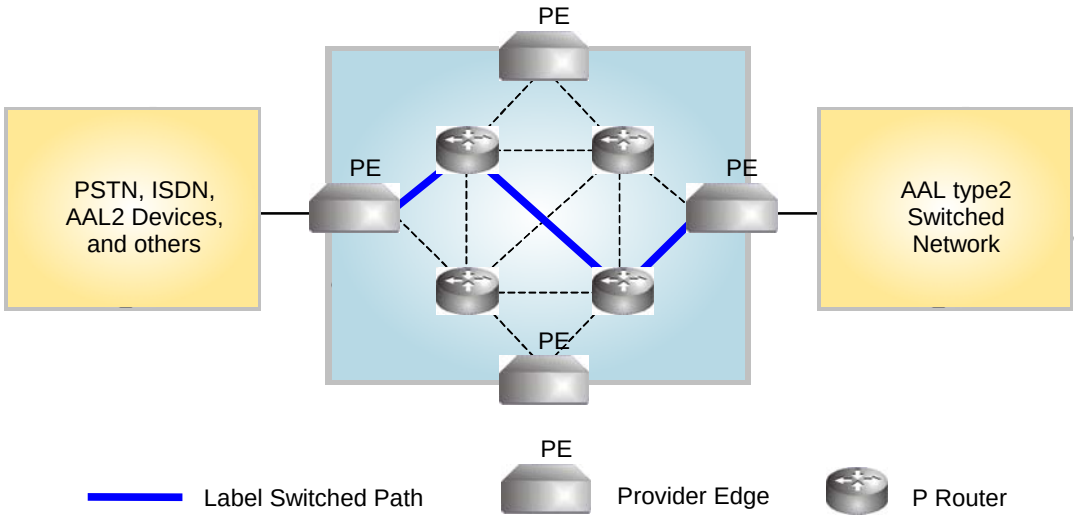
[13] ITU-T Recommendation Y.1452 – Voice Trunking over IP networks, March 2006

[14] ATM Forum specification af-vmoa-0145.001 (2003), *Loop Emulation Service Using AAL2 Rev 1*.

3 Reference Architecture

3.1 General

Figure 3-1 identifies a reference architecture for AAL type 2 over MPLS (A2oMPLS). This MPLS network contains a number of Provider Edge (PE) devices, Provider Routers (P Routers), and Label Switched Paths (LSP).



NOTE1 — This figure does not preclude both networks on the left and the right being "AAL type 2 switched networks", or that both are PSTN, ISDN, AAL2 Devices, and others.

NOTE2 – The PE where AAL2 traffic is encapsulated in MPLS is termed the ingress PE. The PE where AAL2 traffic is decapsulated from MPLS is termed the egress PE.

Figure 3-1 - A2oMPLS Reference Architecture

NOTE — A typical implementation of a PE 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 [10] are not specified in this specification.

It is not the intent of this specification to specify the internal details of MPLS networks, i.e. the signaling required to support A2oMPLS, or the architecture or functions of PEs and P routers. The intent of the reference architecture is to support all possible deployments of A2oMPLS.

The PE in this architecture implements the functions of an end-point 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 PW established between two AAL type 2 nodes existing within a single MPLS domain.

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

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

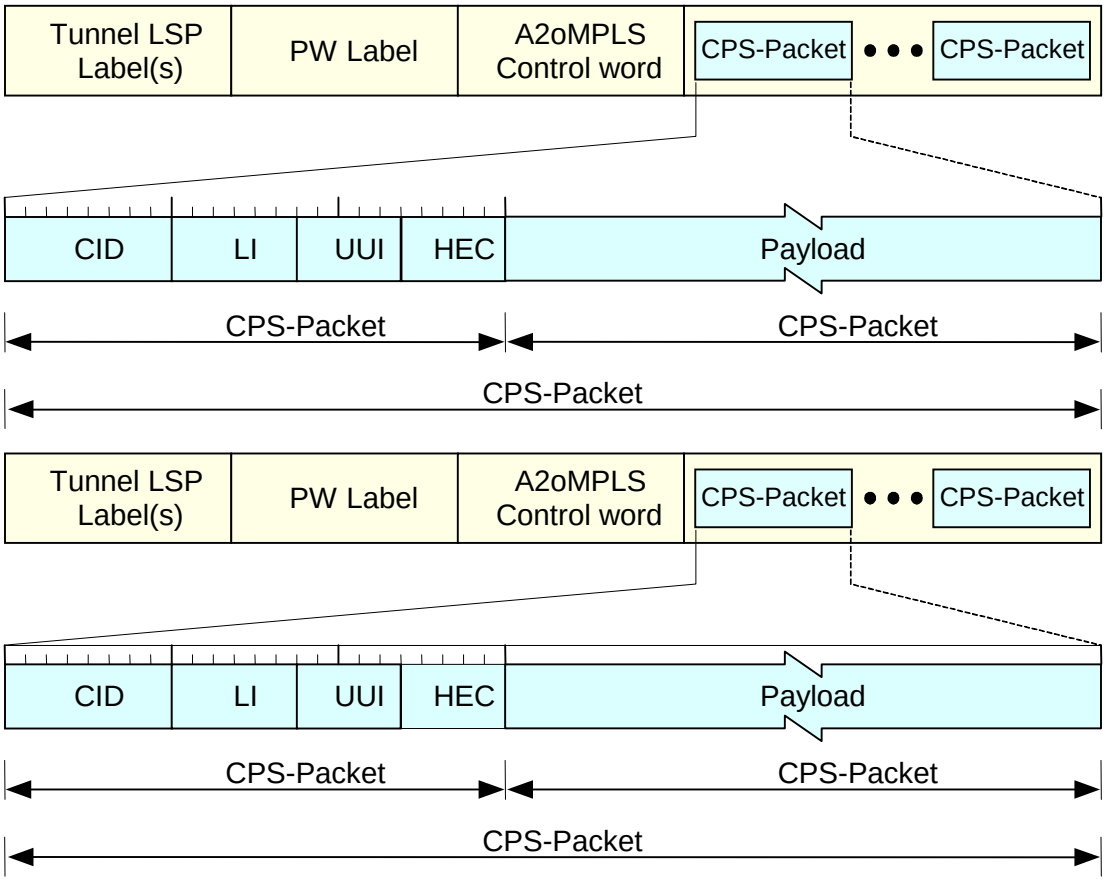
3.2 Multiplexing A2oMPLS connections onto MPLS Label Switched Paths (LSP)

3.2.1 General structure

Multiple A2oMPLS connections may be transported over a Tunnel LSP. Only a single type of A2oMPLS sub-frame (the AAL type 2 CPS-Packet) is defined. 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-Packets over an MPLS LSP is shown in Figure 3-2 . A similar encapsulation is available for IP [13].



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 one or more tunnel labels(see IETF RFC 3032[2]), a PW label (see IETF RFC 3985[6]), 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 CPS-Packets from up to 248 AAL2 connections to be multiplexed within a single PW.

3.2.2 A2oMPLS Control Word (CW) Format

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

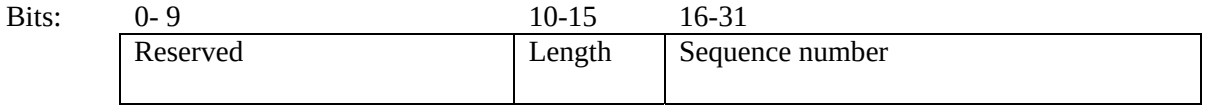


Figure 3-3 - A2oMPLS specific CW

Table 3-1 - A2oMPLS Frame CW Fields

Field	Meaning
Bits 0-9: Reserved	Reserved bits. Set to zero on transmission and ignored on reception.
Length (bits 10 to 15)	As defined in [5] section 8.3.2.
Sequence number (Bit 16 to 31)	As defined in [5] section 8.3.3. Note: the sequence number **Must** be used

3.2.3 Label-stacked structure

Figure 3-4 **LSP structure for multiplexing CPS-Packets** depicts an example A2oMPLS frame structure.

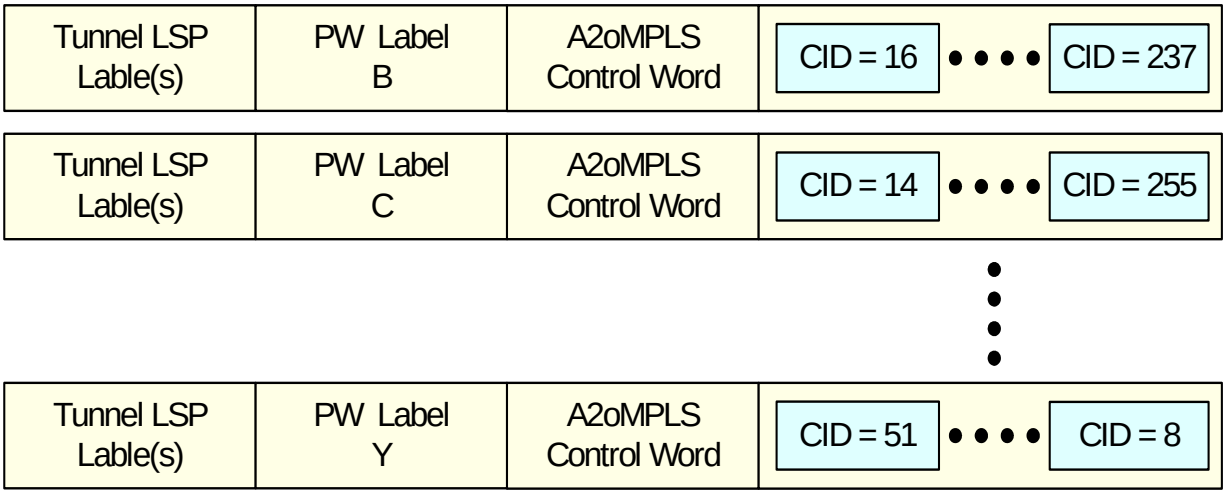


Figure 3-4 LSP structure for multiplexing CPS-Packets

NOTE — A CID that is unique within each PW identifies each A2oMPLS sub frame; that is, CID 16 in PW "B" is a different channel, which is a part of a different A2oMPLS connection from CID 16 in PW "Y"

A2oMPLS sub frames may be transmitted in any order whenever information for a connection is available. For each tunnel LSP, this structure has the potential to convey up to 248 AAL2 Channels multiplied by the number of PWs.

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

1) A pair of tunnel LSPs, (one in each direction) are created, either by manual provisioning or by using an MPLS control protocol.

    a) A PW is established between the PEs through the tunnel LSPs to complete the A2oMPLS connection. The use of the MPLS network is transparent to AAL2 switches, to the PSTN, and to the end-user. The PE provides all mapping and encapsulation functions necessary to ensure that the service provided to the AAL2 switches or to the PSTN is unchanged by the presence of an MPLS transport network.

2. AAL2 connection Identifiers are mapped to CID values on the A2oMPLS connection as follows:

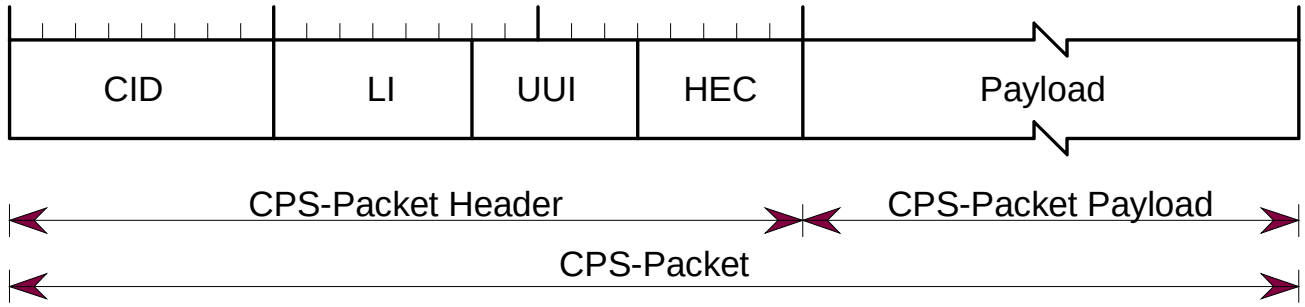
    a) Static configuration of CID value usage. Each CID on each A2oMPLS connection is pre-assigned to an AAL2 connection on the attachment circuit (i.e. there is no need for per-connection signaling);

    or

    b) An invocation of a CID control protocol, such as that defined in [10] or the LDP-based control protocol extension described in section 7.1, to establish bi-directional channels for the AAL2 connections on the attachment circuits.

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 for channel identification shall be used for both directions.

The same CID value may appear multiple times in a single MPLS packet. When this occurs, order shall be maintained.

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). If interworking with voice over DSL (VoDSL) is required, then CID = 8 through CID = 15 are used for special purposes as specified in [14].

All other values are used to identify AAL2 connections. 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 4-1 - Coding of the CID Field

CID value	Use
0	Not used
1	Reserved for Layer Management peer-to-peer procedures
2	Reserved for Signaling
3 through 7	Reserved
8 through 255	Identification of AAL2 connections

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; these procedures are out of the scope of this document.

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 user entities, or between layer management of 2 users/entities ; and
- to distinguish between the A2oMPLS user 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 into 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 HEC computation may be omitted, under the assumption that some layer 2 error protection exists. When the computation is not performed, the HEC field SHOULD be set to zero. The MPLS receiver shall not check the contents of the HEC field to detect errors in the CPS-Packet header.

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

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

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

5.1 A2oMPLS transmitter

The operation of the A2oMPLS transmitter (the ingress PE) 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 state 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 another 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 another CPS-Packet is passed from an A2oMPLS user or from layer management, and the addition of this CPS-Packet 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 procedure defined in [5] section 8.3.3.1 must be used by the ingress PE for a given A2oMPLS service.

5.2 A2oMPLS receiver

The operation of the A2oMPLS receiver (the egress PE) does not need to be modeled as a state machine, as there is just one state.

If a received MPLS frame's Layer 2 checksum is incorrect, the frame is discarded (prior to reaching the A2oMPLS receiver) as the proper recipient cannot be determined. Otherwise the frame is passed to the A2oMPLS receiver and processed as follows:

1) 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.

2) Processing of the sequence number must be implemented as per [5] section 8.3.3.2

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, then Timer_CU must be set to 5 ms or lower in order to guarantee the mechanism of "triple redundancy".

Based upon the line speed, the number of connections supported and maximum MPLS frame size must be calculated. The variation in emission time 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.

7 Operation

[9] defines extensions to LDP [RFC3036] that are required to exchange PW labels for PWs emulating various Layer 2 services (Ethernet, FR, ATM, HDLC etc.). Dynamic setup of A2oMPLS PWs requires both interpretation of the existing information elements of these extensions and exchange of additional information.

A2oMPLS connections MAY be set up using the PWE3 control protocol [9]. The PW type should be set to 0x0018, the value assigned for AAL2 over MPLS.

Additional parameters that are used for A2oMPLS PWs MAY be configured or signaled.

7.1 TDM PW AAL2 Options (0x11 –)

This parameter MUST be present for TDM PW AAL2 mode PWs (PW type 0x0018). It has the following format:

0-7	8-15	16-17	18-31
0x0F	Length	V	Encoding
Maximum Duration			
CID mapping Bases			

Figure 7-1 - Format of the TDM PW AAL2 option parameters

The fields in this parameter are defined as follows:

V defines the Voice Activity Detection capabilities. Its values have the following significance:

0 means that the CID is only switched by signaling
1 means that voice activity detection is employed
3 means that this channel is always active; in particular, this channel may be used for timing recovery.

Encoding specifies native signal processing performed on the payload. When no native signal processing is performed (i.e. G.711 encoding) this field MUST be zero.

Maximum Duration specifies the maximum time allowed for filling an AAL2 PDU, in units of 125 microseconds. For unencoded 64 kbps channels, this numerically equals the maximum number of bytes per PDU, and MUST be less than 64. For other encoding parameters, larger values may be employed.

CID mapping bases is an OPTIONAL parameter; its existence and length are determined by the length field. If the mapping of AAL2 CID values to physical interface and time slot is statically configured, or if AAL2 switching [10] is employed, this parameter MUST NOT appear. When it is present, and the channels belong to N physical interfaces (i.e. N E1s or T1s), it MUST be N bytes in length. Each byte represents a number to be subtracted from the CID to get the timeslot number for each physical interface. For example, if the CID mapping bases parameter consists of the bytes 20 and 60, this signifies that timeslot 1 of trunk 1 corresponds to CID 21 and timeslot 1 of trunk 2 is called 61.

7.2 TDM Options (0x0B)

. “This is an Interface Parameter ID; its format is shown in Fig. 7-2.

0	1-7	0	1	2	3	4-5	6-7

Parameter ID		Length	R	D	F	X	SP	CAS	RSVD-1
0	PT	RSVD-2	FREQ						
SSRC									

Figure 7-2 Format of the TDM Options Interface Parameter

The fields shown in this diagram are used as follows:

Parameter ID	Identifies the TDM PW Options interface parameter(0x0B), value
Length	4, 8 or 12 (see below)
R	The RTP Header Usage bit: if set, indicates that the PW end-point distributing this FEC expects to receive an RTP header in the encapsulation. The RTP header will be used only if both end-points expect to receive it. If this bit is cleared, Length must be set to 4; otherwise it must be either 8 or 12 (see section 8 below). If the peer PW end-point cannot meet this requirement, the Label Mapping message containing the FEC in question must be rejected with the appropriate status code (see Section 8 below).
D	The Dynamic Timestamping Mode bit: if set, indicates that the PW end-point distributing this FEC expects the peer to use Differential timestamping mode in the packets sent to it. If the peer PW end-point cannot meet this requirement, the Label Mapping message containing the FEC in question must be rejected with the appropriate status code (see Section 8 below).
F, X	Reserved for future extensions. Must be cleared when distributed, and must be ignored upon reception
SP	Unused bits. Must be set to 0 by the PW end-point distributing this FEC, and must be ignored by the receiver
CAS	Must be cleared for all types of TDM PWs, except for trunk-specific NxDS0 services with CAS. For these services it encodes the trunk framing as follows: '01' - an E1 trunk '10' - a T1/ESF trunk '11' - a T1 SF trunk
RSVD-1 and RSVD-2	Reserved bits, must be set to 0 by the PW end-point distributing this FEC, and must be ignored by the receiver
PT	Indicates the value of Payload Type in the RTP header expected by the PW end-point distributing this FEC. Value 0 means that Payload Type value checking will not be used for detecting malformed packets
FREQ	Frequency of the timestamping clock in units of 8 kHz
SSRC	Indicates the value of SSRC ID in the RTP header expected by the PW end-point distributing this FEC. Value 0 means that SSRC ID value checking will not be used for detecting misconnections. Alternatively, Length can be set to 8 in this case.

Notes:

This interface parameter may be omitted when RTP is not used and CAS is not present.

A2oMPLS PW encapsulation must either use or not use RTP in **both** directions. However, it is possible to use Differential timestamping mode in just one direction of the PW.

7.3 LDP Status Codes

In addition to the status codes defined in section 5.3 of [9], the following status codes defined in [7] may be used to indicate the reason for failure to establish a TDM PW.

7.3.1 Incompatible bit rate and miss configuration:

(a) In the case of mismatch in the desired usage of RTP header

(b) A20MPLS PWs that do not relay CAS signaling and do not use RTP.

In cases 7.3.1 a above, the user may reconfigure the end-points and attempt to set up the PW once again.

Note that setting of the Control bit to zero must result in an LDP status of “Illegal C-Bit”.

Appendix A Interim Indications (informative)

A.1 Alarms and indication handling

Since A2oMPLS offers interworking of AAL2 across an MPLS network, end-to-end control and alarm surveillance should be supported. When interworking with TDM or ATM networks, the A2oMPLS PE must be able to transfer traffic-affecting alarms and indications, and map them between the networks.

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 F4/F5 - RDI in the ATM environment. This bit is optional, as equivalent functionality can be provided by PW OAM mechanisms such as PW status signaling .

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 If not supported at the transmitter, 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 (A2oMPLS receiver) in a given A2oMPLS service:

- The R bit **must** be set after 1 second when packets are not received on a specific A2oMPLS tunnel, and **must** be cleared when packets are 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 (A2oMPLS transmitter) 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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