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# Layer Two Tunneling Protocol version 3 - Setup of Time-Division Multiplexing (TDM) Pseudowires

## Abstract

This document defines extensions to the Layer Two Tunneling Protocol version 3 (L2TPv3) for support of structure-agnostic and structure-aware (Circuit Emulation Service over Packet Switched Network (CESoPSN) style) Time-Division Multiplexing (TDM) pseudowires. Support of structure-aware (Time-Division Multiplexing over IP (TDMoIP) style) pseudowires over L2TPv3 is left for further study.

## Status of This Memo

This document specifies an Internet standards track protocol for the Internet community, and requests discussion and suggestions for improvements. Please refer to the current edition of the "Internet Official Protocol Standards" (STD 1) for the standardization state and status of this protocol. Distribution of this memo is unlimited.

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Table of Contents



## 1. Introduction

This document defines extensions to the Layer Two Tunneling Protocol Version 3 (L2TPv3) for support of structure-agnostic [RFC4553] and structure-aware (CESoPSN style, see [RFC5086]) Time-Division Multiplexing (TDM) pseudowires. Structure-agnostic encapsulation of TDM bit-streams over L2TPv3 is described in [RFC4553], Figure 2b; Circuit Emulation Service over Packet Switched Networks (CESoPSN), structure-aware encapsulation is described in [RFC5086], Figures 1c (TDM data packets) and 4a (CE application signaling packets). However, the order of the CESoPSN Control Word (CW) and RTP header (if it is used) MUST match between the TDM data and CE signaling packets.

Setup of structure-aware TDM pseudowires using the encapsulations described in [RFC5087] has been left for further study.

Setup and maintenance of TDM pseudowires (PWs) in MPLS networks using LDP is described in [RFC5287].

### 1.1. Conventions Used in This Document

In this document, we refer to the "control plane" as meaning the packets that contain control information (via Attribute-Value Pairs (AVPs)) and the mechanism that handles these packets. We also refer to the "data plane" as meaning the packets that contain transported user data.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

## 2. L2TPv3 Extensions

The L2TPv3 Control Connection is responsible for 3 main operations:

1. Establishment and validation of a pseudowire (PW) session.

2. Ending (tearing down) of a pseudowire session.

3. Transferring of End Point status.

Tearing down of the session for a TDM pseudowire is performed following the L2TPv3 tear-down operations as described in Section 3.4.3 of [RFC3931].

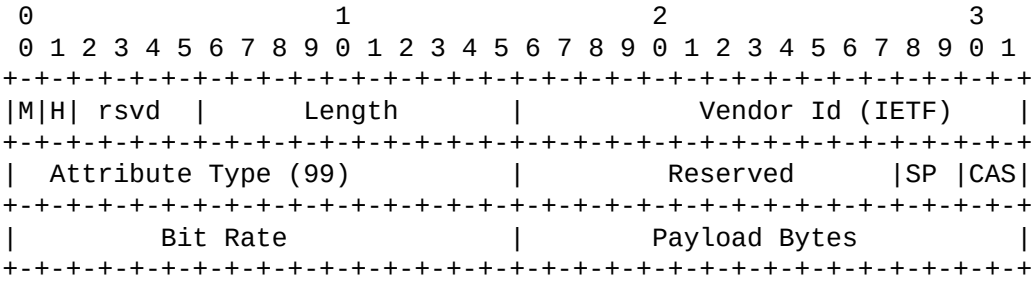
[RFC5086] and [RFC4553] describe how to transfer the Attachment Circuit (AC) status via the data plane. Therefore, the Set-Link-Info (SLI) message described in [RFC3931] SHOULD NOT be used for conveying this status for the PWs in question.

[RFC3931] specifies that the Circuit Status Attribute-Value Pair (AVP) MUST be present in the ICRQ/ICRP (Incoming-Call-Request / Incoming-Call-Reply) messages. It also specifies that the N bit in this AVP should be set during the PW setup, even if the specific AC does not provide any way to convey the "new AC" indication. Accordingly, the Circuit Status AVP for the PWs in question, when used in the ICRQ/ICRP messages, MUST always have both N and A bits set.

The next sections describe the extensions to L2TPv3 for establishment and validation of TDM pseudowire sessions.

There are two new AVPs for the Session Management messages. One AVP describes the TDM pseudowire attributes. The second AVP describes the RTP attributes for this TDM pseudowire.

## 2.1. TDM PW Attribute-Value Pair (AVP) (ICRQ, OCRQ)




This AVP MAY be hidden (the H bit MAY be 0 or 1). The M bit for this AVP SHOULD be set to 0. The Length (before hiding) of this AVP is 12.

The Bit Rate field contains the value that represents the bit rate of the local AC in the units of 64 Kbit/s, encoded as an unsigned 16-bit integer. Its usage for all types of TDM PWs employs the following semantics:

1) For structure-agnostic emulation, this parameter MUST be set to one of the following values (see [RFC4553]):

   a) Structure-agnostic E1 emulation - 32

   b) Structure-agnostic T1 emulation:

      i) MUST be set to 24 for the basic mode

      ii) MUST be set to 25 for the "Octet-aligned T1" mode

   c) Structure-agnostic E3 emulation - 535

   d) Structure-agnostic T3 emulation - 699

2) For CESoPSN PWs, this parameter MUST be set to the number of DS0 channels in the corresponding attachment circuit.

Note: For structure-agnostic T1 emulation, the values 24 and 25 do not reflect the exact bit rate and are used for convenience only.

Note: The semantics of the Bit Rate field defined above are consistent with those of the CEP/TDM Bit-Rate interface parameter as defined in [RFC5287].

The Payload Bytes field contains the value representing the number of TDM payload bytes in the PW packet and is used with the following semantics:

1) For structure-agnostic emulation, any value of the Payload Bytes can be specified.

2) For CESoPSN PWs:

   a) The specified value MUST be an integer multiple of the number of DS0 channels in the corresponding attachment circuit.

   b) In addition to that, for trunk-specific NxDS0 with Channel-Associated Signaling (CAS), the number of the trunk frames per multiframe fragment (value resulting from the Payload Bytes divided by the number of DS0 channels) MUST be an integer divisor of the number of frames per corresponding trunk multiframe.

The Reserved bits MUST be set to 0 on transmission and MUST be ignored on reception.

The SP bits define support for the CESoPSN-application signaling packets (see [RFC5086]) and MUST be used as follows:

1) Set to '01' for the CESoPSN PWs carrying TDM data packets and expecting CE application signaling packets in a separate PW.

2) Set to '10' for a PW carrying CE application signaling packets with the data packets in a separate PW.

3) Set to '11' for a CESoPSN PW carrying both TDM data and signaling packets.

4) Set to '00' for Structure-Agnostic Time-Division Multiplexing over Packet (SAToP) PWs and for CESoPSN PWs not using separate signaling packets.

The CAS bits define the trunk type for trunk-specific CESoPSN services with CAS. These bits MUST be set to:

1) For trunk-specific CESoPSN with CAS:

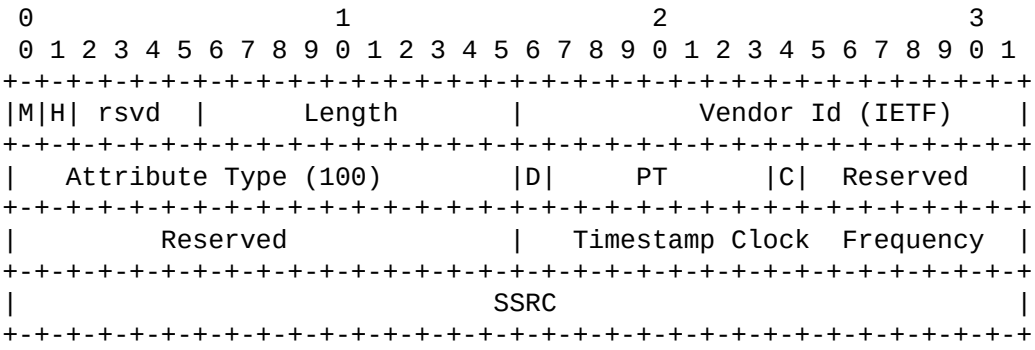
   a) '01' in the case of an E1 trunk

   b) '10' in the case of a T1/ESF trunk

   c) '11' in the case of a T1/SF trunk

2) '00' for all the other TDM pseudowire types

## 2.2. RTP Attribute-Value Pair (AVP) (ICRQ, OCRQ, ICRP, OCRP)




Presence of this AVP indicates that the RTP header is used in the TDM pseudowire encapsulation. Use or non-use of the RTP header MUST match for the two directions of a TDM PW. This AVP MAY be hidden (the H bit MAY be 0 or 1). The M bit for this AVP SHOULD be set to 0. The Length (before hiding) of this AVP is 16.

The D bit indicates the timestamping mode (absolute or differential) in the RTP header. These modes are described in, e.g., Section 4.3.2 of [RFC4553]. If the D bit is set to 1, then the differential timestamping mode is used; otherwise, the absolute timestamping mode is used. Timestamping modes can be used independently for the two directions of a TDM PW.

The C bit indicates the ordering of the RTP header and the Control Word as following:

- If the C bit is set to 1, the RTP header appears after the Control Word in the data channel of the TDM pseudowire. This mode is described in [RFC4553] and [RFC5086] as SAToP/CESoPSN encapsulation over IPv4/IPv6 PSN with L2TPv3 demultiplexing, respectively.

- If the C bit is set to 0, the RTP header appears before the Control Word. This mode is described as the old mode of the SAToP/CESoPSN encapsulation over L2TPv3 in Appendix A of [RFC4553] and Appendix C of [RFC5086], respectively.

PT is the payload type expected in the RTP header. A value of 0 indicates that the receiver shall not check payload type to detect malformed packets.

Timestamp Clock Frequency is the clock frequency used for timestamping in units of 8 KHz.

SSRC indicates the expected value of the synchronization source (SSRC) ID in the RTP header. A 0 in this field means that the SSRC ID will not be used for detecting misconnections. Since L2TP provides an alternative security mechanism using cookies, if the cookie length is larger than 0, the SSRC SHOULD be 0.

## 2.3. Changes in the Control Connection Management AVPs

Control Connections that support TDM PWs MUST add the appropriate PW Type value(s) to the list in the Pseudowire Capabilities List AVP. The valid values are listed in the next section.

## 2.4. Changes in the Session Management AVPs

PW Type AVP should be set to one of the following values:

1. Structure-agnostic emulation [RFC4553] of:

   a. E1 circuits - 0x0011

   b. T1 (DS1) circuits - 0x0012

   c. E3 circuits - 0x0013

   d. T3 (DS3) circuits - 0x0014

2. Structure-aware emulation [RFC5086] of:

   a. CESoPSN basic mode - 0x0015

   b. Trunk-specific CESoPSN service with CAS - 0x0017

TDM pseudowires use their own Control Word. Therefore, the L2-Specific Sublayer AVP MUST either be omitted or set to 0.

TDM pseudowires use their own sequencing. Therefore, the Data Sequencing AVP MUST either be omitted or set to 0.

Note: The Control Word (CW) used in the SAToP and CESoPSN encapsulations over L2TPv3 effectively represents a dedicated L2-Specific Sublayer.

# 3. Creation of the TDM Pseudowire Session

When an L2TP Control Connection Endpoint (LCCE) wants to open a Session for a TDM PW, it MUST include the TDM PW AVP (in any case) and the RTP AVP (if and only if the RTP header is used) in the ICRQ or OCRQ (Outgoing-Call-Request) message. The LCCE peer must validate

the TDM PW AVP and make sure it can meet the requirements derived from the RTP AVP (if it exists). If the peer agrees with the TDM AVP, it will send an appropriate ICRP or OCRP (Outgoing-Call-Reply) message with the matching RTP AVP (if needed). The initiator needs to validate that it can supply the requirements derived from the received RTP AVP.

The two peers MUST agree on the values in the TDM PW AVP:

1. Bit Rate values MUST be equal on both sides. If they are different, the connection will be rejected with Result Code 30 and Error Code 1.

2. In the case of trunk-specific CESoPSN with CAS, the trunk type (as encoded in the CAS bits of the TDM AVP) MUST be the same for the two sides. Otherwise, the connection will be rejected with Result Code 30 and Error Code 2.

3. If one side does not support the Payload Bytes value proposed by the other one, the connection will be rejected with Result Code 30 and Error Code 3.

4. If one side cannot send the RTP header as requested by the other side, the connection will be rejected with Result Code 30 and Error Code 4.

5. If one side can send the RTP header but not with the requested timestamp clock frequency, the connection will be rejected with Result Code 30 and Error Code 5.

If CE signaling for a CESoPSN basic PW is transported in a separate PW instance, then the two PW instances:

1. MUST use the same PW type.

2. MUST use the same values in all the fields of the TDM AVP excluding the SP field, which must be set to ’01’ for the TDM data PW and to ’10’ for the PW carrying CE application signaling.

3. MUST both either use or not use the RTP header (and, accordingly, include or not include the RTP AVP).

## 4. IANA Considerations

IANA assigned the following values according to this document:

New L2TPv3 Pseudowire Types:

```
    0x0011 - Structure-agnostic E1 circuit
    0x0012 - Structure-agnostic T1 (DS1) circuit
    0x0013 - Structure-agnostic E3 circuit
    0x0014 - Structure-agnostic T3 (DS3) circuit
    0x0015 - CESoPSN basic mode
    0x0017 - CESoPSN TDM with CAS
```

Note that the values listed match the values defined in [RFC4446] for the MPLS Pseudowire Types.

New Attribute-Value Pair IDs:

```
     99 - TDM Pseudowire AVP
    100 - RTP AVP
```

New Result Codes for the CDN message:

```
   30 - Result Code to indicate connection was refused because of TDM
        PW parameters.  The Error Code indicates the problem.
```

New TDM PW specific Error Codes, to be used with 30 Result Code for the CDN message:

This is a new registry for IANA to maintain within the Result Code AVP (Attribute Type 1) Values. Additional values may be assigned by Expert Review [RFC5226].

```
   0 - Reserved.
   1 - Bit Rate values disagree.
   2 - Different trunk types in the case of trunk-specific CESoPSN
       with CAS.
   3 - Requested payload size too big or too small.
   4 - RTP header cannot be generated.
   5 - Requested timestamp clock frequency cannot be generated.
```

## 5. Congestion Control

The congestion considerations from [RFC4553] and [RFC5086] apply respectively to the structure-agnostic and CESoPSN modes of this specification.

## 6. Security Considerations

This document specifies only the L2TPv3-based control plane for setup of TDM PWs. Within this scope, there are no additional security considerations in addition to those discussed in [RFC3931].

Common data plane security considerations for the TDM PWs have been discussed in some detail in both [RFC4553] and [RFC5086]. On top of these, the L2TPv3-based data plane provides additional security mechanisms based on the usage of cookies.

## 7. Acknowledgements

The authors want to thank Carlos Pignataro, Ignacio Goyret, and Yaakov Stein for careful review and useful suggestions.

## 8. References

### 8.1. Normative References

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[RFC5086] Vainshtein, A., Ed., Sasson, I., Metz, E., Frost, T., and P. Pate, "Structure-Aware Time Division Multiplexed (TDM) Circuit Emulation Service over Packet Switched Network (CESoPSN)", RFC 5086, December 2007.

### 8.2. Informative References

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[RFC5087] Y(J). Stein, Shashoua, R., Insler, R., and M. Anavi, "Time Division Multiplexing over IP (TDMoIP)", RFC 5087, December 2007.

[RFC5226] Narten, T. and H. Alvestrand, "Guidelines for Writing an IANA Considerations Section in RFCs", BCP 26, RFC 5226, May 2008.

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