Internet Engineering Task Force (IETF)
Request for Comments: 7079
Category: Informational
ISSN: 2070-1721

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November 2013

The Pseudowire (PW) and Virtual Circuit Connectivity Verification (VCCV) Implementation Survey Results

Abstract

The IETF Pseudowire Emulation Edge-to-Edge (PWE3) working group has defined many encapsulations of various layer 1 and layer 2 service-specific PDUs and circuit data. In most of these encapsulations, use of the Pseudowire (PW) Control Word is required. However, there are several encapsulations for which the Control Word is optional, and this optionality has been seen in practice to possibly introduce interoperability concerns between multiple implementations of those encapsulations. This survey of the Pseudowire / Virtual Circuit Connectivity Verification (VCCV) user community was conducted to determine implementation trends and the possibility of always mandating the Control Word.

Status of This Memo

This document is not an Internet Standards Track specification; it is published for informational purposes.

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Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at http://www.rfc-editor.org/info/rfc7079.

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1. Introduction

Most Pseudowire Emulation Edge-to-Edge (PWE3) encapsulations mandate the use of the Control Word (CW) to carry information essential to the emulation, to inhibit Equal-Cost Multipath (ECMP) behavior, and to discriminate Operations, Administration, and Maintenance (OAM) from Pseudowire (PW) packets. However, some encapsulations treat the Control Word as optional. As a result, implementations of the CW, for encapsulations for which it is optional, vary by equipment manufacturer, equipment model, and service provider network. Similarly, Virtual Circuit Connectivity Verification (VCCV) supports three Control Channel (CC) types and multiple Connectivity Verification (CV) types. This flexibility has led to reports of interoperability issues within deployed networks and associated documents to attempt to remedy the situation.

The encapsulations and modes for which the Control Word is currently optional are:

- Ethernet Tagged Mode [RFC4448]
- Ethernet Raw Mode [RFC4448]
- Point-to-Point Protocol (PPP) [RFC4618]
- High-Level Data Link Control (HDLC) [RFC4618]
- Frame Relay Port Mode [RFC4618]
- ATM (N:1 Cell Mode) [RFC4717]

Virtual Circuit Connectivity Verification (VCCV) [RFC5085] defines three Control Channel types for MPLS PWs: Type 1, using the PW Control Word; Type 2, using the Router Alert (RA) Label; and Type 3, using Time to Live (TTL) Expiration (e.g., MPLS PW Label with TTL == 1). While Type 2 (RA Label) is indicated as being "the preferred mode of VCCV operation when the Control Word is not present", RFC 5085 does not indicate a mandatory Control Channel to ensure interoperable implementations. The closest it comes to mandating a control channel is the requirement to support Type 1 (Control Word) whenever the CW is present. As such, the three options yield seven implementation permutations (assuming you have to support at least one Control Channel type to provide VCCV). Due to these permutations, interoperability challenges have been identified by several VCCV users.

In order to assess the best approach to address the observed interoperability issues, the PWE3 working group decided to solicit feedback from the PW and VCCV user community regarding implementation. This document presents the survey questionnaire and the information returned by those in the user community who participated.

1.1. PW/VCCV Survey Overview

Per the direction of the PWE3 working group chairs, a survey was created to sample the nature of implementations of PWs, with specific emphasis on Control Word usage, and VCCV, with emphasis on Control Channel and Control Type usage. The survey consisted of a series of questions based on direction of the WG chairs and the survey opened to the public on November 4, 2010. The survey was conducted using the SurveyMonkey tool, http://www.surveymonkey.com. The survey ran from November 4, 2010 until February 25, 2011 and was repeatedly publicized on the PWE3 email list over that period.

The editors took precautions to ensure the validity of the sample and the data. Specifically, only responses with recognizable non-vendor company-affiliated email addresses were accepted. Unrecognizable or personal email addresses would have been contacted to determine their validity, but none were received. Only one response was received from each responding company. If multiple responses from a company had been received, they would have been contacted to determine whether the responses were duplicative or additive. This, however, did not occur.

1.2. PW/VCCV Survey Form

The PW/VCCV Implementation Survey requested the following information about user implementations (the lists of implementation choices were taken verbatim from the survey):

- Responding Organization. No provisions were made for anonymous responses, as all responses required a valid email address in order to validate the survey response. However, the results herein are reported anonymously, except for an alphabetic list of participating organizations in Section 2.2.

- Of the various encapsulations (and options therein) known at the time, including the WG document, "Encapsulation Methods for Transport of Fibre Channel" (now [RFC6307]), which were implemented by the respondent. These included:

  - Ethernet Tagged Mode - RFC 4448
  - Ethernet Raw Mode - RFC 4448
  - Structure-Agnostic Time Division Multiplexing (TDM) over Packet (SAToP) - RFC 4553
  - PPP - RFC 4618
  - HDLC - RFC 4618
  - Frame Relay (Port Mode) - RFC 4619
  - Frame Relay (1:1 Mode) - RFC 4619
  - ATM (N:1 Mode) - RFC 4717
  - ATM (1:1 Mode) - RFC 4717
  - ATM (AAL5 Service Data Unit (SDU) Mode) - RFC 4717
  - ATM (AAL5 PDU Mode) - RFC 4717
  - Circuit Emulation over Packet (CEP) - RFC 4842
  - Circuit Emulation Service over Packet Switched Network (CESoPSN) - RFC 5086
  - Time Division Multiplexing over IP (TDMoIP) - RFC 5087
  - Fiber Channel (Port Mode) - "Encapsulation Methods for Transport of Fibre Channel" (now RFC 6307)

- Approximately how many PWs of each type were deployed. Respondents could list a number, or for the sake of privacy, could just respond "In-Use" instead.

- For each encapsulation listed above, the respondent could indicate which Control Channel [RFC5085] was in use. (See Section 1 for a discussion of these Control Channels.) The options listed were:

  - Control Word (Type 1)

  - Router Alert Label (Type 2)

  - TTL Expiry (Type 3)

- For each encapsulation listed above, the respondent could indicate which Connectivity Verification types [RFC5085] were in use. The options were:

  - Internet Control Message Protocol (ICMP) Ping

  - Label Switched Path (LSP) Ping

- For each encapsulation type for which the Control Word is optional, the respondents could indicate the encapsulation(s) for which Control Word was supported by the equipment vendor, and whether the CW was also in use in the network. The encapsulations listed were:

  - Ethernet (Tagged Mode)

  - Ethernet (Raw Mode)

  - PPP

  - HDLC

  - Frame Relay (Port Mode)

  - ATM (N:1 Cell Mode)

- Finally, a free-form entry was provided for the respondent to provide feedback regarding PW and VCCV deployments, VCCV interoperability challenges, or the survey or any other network/ vendor details they wished to share.

1.3. PW/VCCV Survey Highlights

There were seventeen responses to the survey that met the validity requirements in Section 1.1. The responding companies are listed below in Section 2.2.

2. Survey Results

2.1. Summary of Results

Prior to this survey, there was considerable speculation about whether the Control Word could always be mandated, with several proposals to do so. However, the survey showed that there was considerable deployment of PWs that did not use the CW. The publication of this survey serves as a reminder of the extent of PWs without the CW in use, and hence a reminder that the CW-less modes cannot be deprecated in the near future.

2.2. Respondents

The following companies, listed here alphabetically as received in the survey responses, participated in the PW/VCCV Implementation Survey. Responses were only solicited from non-vendors (users and service providers), and no vendors responded (although if they had, their response would not have been included). The data provided has been aggregated. No specific company’s response will be detailed herein.

- AboveNet
- AMS-IX
- Bright House Networks
- Cox Communications
- Deutsche Telekom AG
- Easynet Global Services
- France Telecom Orange
- Internet Solution
- MTN South Africa
- OJSC MegaFon
- Superonline
- Telecom New Zealand
- Telstra Corporation

- Time Warner Cable
- Tinet
- Verizon
- Wipro Technologies

2.3. Pseudowire Encapsulations Implemented

The following request was made: "In your network in general, across all products, please indicate which pseudowire encapsulations your company has implemented." Of all responses, the following list shows the percentage of responses for each encapsulation:

- Ethernet Tagged Mode - RFC 4448 = 76.5%
- Ethernet Raw Mode - RFC 4448 = 82.4%
- SAToP - RFC 4553 = 11.8%
- PPP - RFC 4618 = 11.8%
- HDLC - RFC 4618 = 5.9%
- Frame Relay (Port Mode) - RFC 4619 = 17.6%
- Frame Relay (1:1 Mode) - RFC 4619 = 41.2%
- ATM (N:1 Mode) - RFC 4717 = 5.9%
- ATM (1:1 Mode) - RFC 4717 = 17.6%
- ATM (AAL5 SDU Mode) - RFC 4717 = 5.9%
- ATM (AAL5 PDU Mode) - RFC 4717 = 0.0%
- CEP - RFC 4842 = 0.0%
- CESoPSN - RFC 5086 = 11.8%
- TDMoIP - RFC 5087 = 11.8%
- Fiber Channel (Port Mode) - "Encapsulation Methods for Transport of Fibre Channel" (now RFC 6307) = 5.9%

2.4. Number of Pseudowires Deployed

The following question was asked: "Approximately how many pseudowires are deployed of each encapsulation type. Note, this should be the number of pseudowires in service, carrying traffic, or pre-positioned to do so." The following list shows the number of pseudowires in use for each encapsulation:

- Ethernet Tagged Mode = 93,861
- Ethernet Raw Mode = 94,231
- SAToP - RFC 4553 = 20,050
- PPP - RFC 4618 = 500
- HDLC - RFC 4618 = 0
- Frame Relay (Port Mode) - RFC 4619 = 5,002
- Frame Relay (1:1 Mode) - RFC 4619 = 50,959
- ATM (N:1 Mode) - RFC 4717 = 50,000
- ATM (1:1 Mode) - RFC 4717 = 70,103
- ATM (AAL5 SDU Mode) - RFC 4717 = 0
- ATM (AAL5 PDU Mode) - RFC 4717 = 0
- CEP - RFC 4842 = 0
- CESoPSN - RFC 5086 = 21,600
- TDMoIP - RFC 5087 = 20,000
- Fiber Channel (Port Mode) - "Encapsulation Methods for Transport of Fibre Channel" (now RFC 6307) = 0

In the above responses (on several occasions), the response was in the form of "> XXXXX" where the response indicated a number greater than the one provided. Where applicable, the number itself was used in the sums above. For example, ">20K" and "20K+" yielded 20K.

Additionally, the following encapsulations were listed as "In-Use" with no quantity provided:

- Ethernet Raw Mode: 2 Responses
- ATM (AAL5 SDU Mode): 1 Response
- TDMoIP: 1 Response

2.5. VCCV Control Channel in Use

The following instructions were given: "Please indicate which VCCV Control Channel is used for each encapsulation type. Understanding that users may have different networks with varying implementations, for your network in general, please select all which apply." The numbers below indicate the number of responses. The responses were:

- Ethernet Tagged Mode - RFC 4448
  - Control Word (Type 1) = 7
  - Router Alert Label (Type 2) = 3
  - TTL Expiry (Type 3) = 3
- Ethernet Raw Mode - RFC 4448
  - Control Word (Type 1) = 8
  - Router Alert Label (Type 2) = 4
  - TTL Expiry (Type 3) = 4
- SAToP - RFC 4553
  - Control Word (Type 1) = 1
  - Router Alert Label (Type 2) = 0
  - TTL Expiry (Type 3) = 0
- PPP - RFC 4618
  - Control Word (Type 1) = 0
  - Router Alert Label (Type 2) = 0
  - TTL Expiry (Type 3) = 0

- HDLC - RFC 4618
  - Control Word (Type 1) = 0
  - Router Alert Label (Type 2) = 0
  - TTL Expiry (Type 3) = 0
- Frame Relay (Port Mode) - RFC 4619
  - Control Word (Type 1) = 1
  - Router Alert Label (Type 2) = 0
  - TTL Expiry (Type 3) = 0
- Frame Relay (1:1 Mode) - RFC 4619
  - Control Word (Type 1) = 3
  - Router Alert Label (Type 2) = 0
  - TTL Expiry (Type 3) = 2
- ATM (N:1 Mode) - RFC 4717
  - Control Word (Type 1) = 1
  - Router Alert Label (Type 2) = 0
  - TTL Expiry (Type 3) = 0
- ATM (1:1 Mode) - RFC 4717
  - Control Word (Type 1) = 1
  - Router Alert Label (Type 2) = 0
  - TTL Expiry (Type 3) = 1
- ATM (AAL5 SDU Mode) - RFC 4717
  - Control Word (Type 1) = 0
  - Router Alert Label (Type 2) = 1
  - TTL Expiry (Type 3) = 0

- ATM (AAL5 PDU Mode) - RFC 4717
  - Control Word (Type 1) = 0
  - Router Alert Label (Type 2) = 0
  - TTL Expiry (Type 3) = 0
- CEP - RFC 4842
  - Control Word (Type 1) = 0
  - Router Alert Label (Type 2) = 0
  - TTL Expiry (Type 3) = 0
- CESoPSN - RFC 5086
  - Control Word (Type 1) = 0
  - Router Alert Label (Type 2) = 0
  - TTL Expiry (Type 3) = 1
- TDMoIP - RFC 5087
  - Control Word (Type 1) = 0
  - Router Alert Label (Type 2) = 0
  - TTL Expiry (Type 3) = 0
- Fiber Channel (Port Mode) - "Encapsulation Methods for Transport of Fibre Channel" (now RFC 6307)
  - Control Word (Type 1) = 0
  - Router Alert Label (Type 2) = 0
  - TTL Expiry (Type 3) = 0

2.6. VCCV Connectivity Verification Types in Use

The following instructions were given: "Please indicate which VCCV Connectivity Verification types are used in your networks for each encapsulation type." Note that Bidirectional Forwarding Detection (BFD) was not one of the choices. The responses were as follows:

- Ethernet Tagged Mode - RFC 4448
  - ICMP Ping = 5
  - LSP Ping = 11
- Ethernet Raw Mode - RFC 4448
  - ICMP Ping = 6
  - LSP Ping = 11
- SAToP - RFC 4553
  - ICMP Ping = 0
  - LSP Ping = 2
- PPP - RFC 4618
  - ICMP Ping = 0
  - LSP Ping = 0
- HDLC - RFC 4618
  - ICMP Ping = 0
  - LSP Ping = 0
- Frame Relay (Port Mode) - RFC 4619
  - ICMP Ping = 0
  - LSP Ping = 1
- Frame Relay (1:1 Mode) - RFC 4619
  - ICMP Ping = 2
  - LSP Ping = 5

- ATM (N:1 Mode) - RFC 4717
  - ICMP Ping = 0
  - LSP Ping = 1
- ATM (1:1 Mode) - RFC 4717
  - ICMP Ping = 0
  - LSP Ping = 3
- ATM (AAL5 SDU Mode) - RFC 4717
  - ICMP Ping = 0
  - LSP Ping = 1
- ATM (AAL5 PDU Mode) - RFC 4717
  - ICMP Ping = 0
  - LSP Ping = 0
- CEP - RFC 4842
  - ICMP Ping = 0
  - LSP Ping = 0
- CESoPSN - RFC 5086
  - ICMP Ping = 0
  - LSP Ping = 1
- TDMoIP - RFC 5087
  - ICMP Ping = 0
  - LSP Ping = 1
- Fiber Channel (Port Mode) - "Encapsulation Methods for Transport of Fibre Channel" (now RFC 6307)
  - ICMP Ping = 0
  - LSP Ping = 0

2.7. Control Word Support for Encapsulations for Which CW Is Optional

The following instructions were given: "Please indicate your network's support of and use of the Control Word for encapsulations for which the Control Word is optional." The responses were:

- Ethernet (Tagged Mode)
  - Supported by Network/Equipment = 13
  - Used in Network = 6
- Ethernet (Raw Mode)
  - Supported by Network/Equipment = 14
  - Used in Network = 7
- PPP
  - Supported by Network/Equipment = 5
  - Used in Network = 0
- HDLC
  - Supported by Network/Equipment = 4
  - Used in Network = 0
- Frame Relay (Port Mode)
  - Supported by Network/Equipment = 3
  - Used in Network = 1
- ATM (N:1 Cell Mode)
  - Supported by Network/Equipment = 5
  - Used in Network = 1

2.8. Open-Ended Question

Space was provided for user feedback. The following instructions were given: "Please use this space to provide any feedback regarding PW and VCCV deployments, VCCV interoperability challenges, this survey or any network/vendor details you wish to share." Below are the responses, made anonymous. The responses are otherwise provided here verbatim.

1. BFD VCCV Control Channel is not indicated in the survey (may be required for PW redundancy purpose)

2. Using CV is not required at the moment

3. COMPANY has deployed several MPLS network elements, from multiple vendors. COMPANY is seeking a uniform implementation of VCCV Control Channel (CC) capabilities across its various vendor platforms. This will provide COMPANY with significant advantages in reduced operational overheads when handling cross-domain faults. Having a uniform VCCV feature implementation in COMPANY multi-vendor network leads to:

   - Reduced operational cost and complexity

   - Reduced OSS development to coordinate incompatible VCCV implementations.

   - Increased end-end service availability when handing faults.

   In addition, currently some of COMPANY deployed VCCV traffic flows (on some vendor platforms) are not guaranteed to follow those of the customer’s application traffic (a key operational requirement). As a result, the response from the circuit ping cannot faithfully reflect the status of the circuit. This leads to ambiguity regarding the operational status of our networks. An in-band method is highly preferred, with COMPANY having a clear preference for VCCV Circuit Ping using PWE Control Word. This preference is being pursued with each of COMPANY vendors.

4. PW VCCV is very useful tool for finding faults in each PW channel. Without this we can not find fault on a PW channel. PW VCCV using BFD is another better option. Interoperability challenges are with Ethernet OAM mechanism.

5. We are using L2PVPN AToM like-to-like models - ATMoMPLS - EoMPLS ATMoMPLS : This service offered for transporting ATM cells over IP/MPLS core with Edge ATM CE devices including BPX, Ericsson Media Gateway etc. This is purely a Port mode with cell-packing configuration on it to have best performance. QoS marking is done for getting LLQ treatment in the core for these MPLS encapsulated ATM packets. EoMPLS: This service offered for transporting 2G/3G traffic from network such as Node-B to RNC's over IP/MPLS backbone core network. QoS marking is done for getting guaranteed bandwidth treatment in the core for these MPLS encapsulated ATM packets. In addition to basic L2VPN service configuration, these traffic are routed via MPLS TE tunnels with dedicated path and bandwidth defined to avoid bandwidth related congestion.

6. EQUIPMENT MANUFACTURER does not provide options to configure VCCV control-channel and its sub options for LDP based L2Circuits. How can we achieve end-to-end management and fault detection of PW without VCCV in such cases?

7. I'm very interested in this work as we continue to experience interop challenges particularly with newer vendors to the space who are only implementing VCCV via control word. Vendors who have tailed their MPLS OAM set specifically to the cell backhaul space and mandatory CW have been known to fall into this space. That's all I've got.

3. Security Considerations

As this document is an informational report of the PW/VCCV User Implementation Survey results, no protocol security considerations are introduced.

4. Acknowledgements

We would like to thank the chairs of the PWE3 working group for their guidance and review of the survey questions. We would also like to sincerely thank those listed in Section 2.2. who took the time and effort to participate.

5. Informative References

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[RFC4618] Martini, L., Rosen, E., Heron, G., and A. Malis, "Encapsulation Methods for Transport of PPP/High-Level Data Link Control (HDLC) over MPLS Networks", RFC 4618, September 2006.

[RFC4717] Martini, L., Jayakumar, J., Bocci, M., El-Aawar, N., Brayley, J., and G. Koleyni, "Encapsulation Methods for Transport of Asynchronous Transfer Mode (ATM) over MPLS Networks", RFC 4717, December 2006.

[RFC5085] Nadeau, T., Ed. and C. Pignataro, Ed., "Pseudowire Virtual Circuit Connectivity Verification (VCCV): A Control Channel for Pseudowires", December 2007.

[RFC6307] Black, D., Dunbar, L., Roth, M., and R. Solomon, "Encapsulation Methods for Transport of Fibre Channel Traffic over MPLS Networks", RFC 6307, April 2012.

Appendix A. Survey Responses

The detailed responses are included in this appendix. The respondent contact info has been removed.

A.1. Respondent 1

2. In your network in general, across all products, please indicate which pseudowire encapsulations your company has implemented.

   Ethernet Tagged Mode - RFC 4448

3. Approximately how many pseudowires are deployed of each encapsulation type. Note, this should be the number of pseudowires in service, carrying traffic, or pre-positioned to do so. ***Note, please indicate "In-Use" for any PW Encap Types which you are using but cannot provide a number.

   Ethernet Tagged Mode - RFC 4448 - 423

4. Please indicate which VCCV Control Channel is used for each encapsulation type. Understanding that users may have different networks with varying implementations, for your network in general, please select all which apply.

   Ethernet Tagged Mode - RFC 4448: Control Word (Type 1)

5. Please indicate which VCCV Connectivity Verification types are used in your networks for each encapsulation type.

   Ethernet Tagged Mode - RFC 4448: LSP Ping

6. Please indicate your network’s support of and use of the Control Word for encapsulations for which the Control Word is optional.

   Supported by Network/Equipment: Ethernet (Tagged Mode), Ethernet (Raw Mode)

   Used in Network: Ethernet (Tagged Mode), Ethernet (Raw Mode)

7. Please use this space to provide any feedback regarding PW and VCCV deployments, VCCV interoperability challenges, this survey or any network/vendor details you wish to share.

   No Response

A.2. Respondent 2

2. In your network in general, across all products, please indicate which pseudowire encapsulations your company has implemented.

   Ethernet Tagged Mode - RFC 4448

   Ethernet Raw Mode - RFC 4448

   SAToP - RFC 4553

   CESoPSN - RFC 5086

3. Approximately how many pseudowires are deployed of each encapsulation type. Note, this should be the number of pseudowires in service, carrying traffic, or pre-positioned to do so. ***Note, please indicate "In-Use" for any PW Encap Types which you are using but cannot provide a number.

   Ethernet Tagged Mode - RFC 4448 - 5000

   Ethernet Raw Mode - RFC 4448 - 1000

   SAToP - RFC 4553 - 50

   CESoPSN - RFC 5086 - 1600

4. Please indicate which VCCV Control Channel is used for each encapsulation type. Understanding that users may have different networks with varying implementations, for your network in general, please select all which apply.

   Ethernet Tagged Mode - RFC 4448: Control Word (Type 1), Router Alert Label (Type 2), TTL Expiry (Type 3)

   Ethernet Raw Mode - RFC 4448: Control Word (Type 1), Router Alert Label (Type 2), TTL Expiry (Type 3)

   CESoPSN - RFC 5086: TTL Expiry (Type 3)

5. Please indicate which VCCV Connectivity Verification types are used in your networks for each encapsulation type.

   Ethernet Tagged Mode - RFC 4448: ICMP Ping, LSP Ping

   Ethernet Raw Mode - RFC 4448: ICMP Ping, LSP Ping

   SAToP - RFC 4553: LSP Ping

CESoPSN - RFC 5086: LSP Ping

6. Please indicate your network's support of and use of the Control Word for encapsulations for which the Control Word is optional.

   Supported by Network/Equipment: Ethernet (Tagged Mode), Ethernet (Raw Mode)

   Used in Network: No Response

7. Please use this space to provide any feedback regarding PW and VCCV deployments, VCCV interoperability challenges, this survey or any network/vendor details you wish to share.

   I'm very interested in this work as we continue to experience interop challenges particularly with newer vendors to the space who are only implementing VCCV via control word. Vendors who have tailed their MPLS OAM set specifically to the cell backhaul space and mandatory CW have been known to fall into this space. That's all I've got.

A.3. Respondent 3

2. In your network in general, across all products, please indicate which pseudowire encapsulations your company has implemented.

   Ethernet Tagged Mode - RFC 4448

   Ethernet Raw Mode - RFC 4448

   Frame Relay (Port Mode) - RFC 4619

   Frame Relay (1:1 Mode) - RFC 4619

3. Approximately how many pseudowires are deployed of each encapsulation type. Note, this should be the number of pseudowires in service, carrying traffic, or pre-positioned to do so. ***Note, please indicate "In-Use" for any PW Encap Types which you are using but cannot provide a number.

   Ethernet Tagged Mode - RFC 4448 - 800

   Ethernet Raw Mode - RFC 4448 - 50

   Frame Relay (Port Mode) - RFC 4619 - 2

   Frame Relay (1:1 Mode) - RFC 4619 - 2

4. Please indicate which VCCV Control Channel is used for each encapsulation type. Understanding that users may have different networks with varying implementations, for your network in general, please select all which apply.

   No Response

5. Please indicate which VCCV Connectivity Verification types are used in your networks for each encapsulation type.

   No Response

6. Please indicate your network’s support of and use of the Control Word for encapsulations for which the Control Word is optional.

   Supported by Network/Equipment: Ethernet (Tagged Mode), Ethernet (Raw Mode)

   Used in Network: No Response

7. Please use this space to provide any feedback regarding PW and VCCV deployments, VCCV interoperability challenges, this survey or any network/vendor details you wish to share.

   No Response

A.4. Respondent 4

2. In your network in general, across all products, please indicate which pseudowire encapsulations your company has implemented.

   Ethernet Tagged Mode - RFC 4448

   Ethernet Raw Mode - RFC 4448

3. Approximately how many pseudowires are deployed of each encapsulation type. Note, this should be the number of pseudowires in service, carrying traffic, or pre-positioned to do so. ***Note, please indicate "In-Use" for any PW Encap Types which you are using but cannot provide a number.

   Ethernet Tagged Mode - RFC 4448 - 1000

   Ethernet Raw Mode - RFC 4448 - 200

4. Please indicate which VCCV Control Channel is used for each encapsulation type. Understanding that users may have different networks with varying implementations, for your network in general, please select all which apply.

   No Response

5. Please indicate which VCCV Connectivity Verification types are used in your networks for each encapsulation type.

   Ethernet Tagged Mode - RFC 4448: LSP Ping

   Ethernet Raw Mode - RFC 4448: LSP Ping

6. Please indicate your network’s support of and use of the Control Word for encapsulations for which the Control Word is optional.

   Supported by Network/Equipment: Ethernet (Tagged Mode), Ethernet (Raw Mode)

   Used in Network: No Response

7. Please use this space to provide any feedback regarding PW and VCCV deployments, VCCV interoperability challenges, this survey or any network/vendor details you wish to share.

   EQUIPMENT MANUFACTURER does not provide options to configure VCCV control-channel and its sub options for LDP based L2Circuits. How can we achieve end-to-end management and fault detection of PW without VCCV in such cases?

A.5. Respondent 5

2. In your network in general, across all products, please indicate which pseudowire encapsulations your company has implemented.

   Ethernet Tagged Mode - RFC 4448

   Ethernet Raw Mode - RFC 4448

   PPP - RFC 4618

   Frame Relay (Port Mode) - RFC 4619

   Frame Relay (1:1 Mode) - RFC 4619

   Fiber Channel (Port Mode) - "Encapsulation Methods for Transport of Fibre Channel" (now RFC 6307)

3. Approximately how many pseudowires are deployed of each encapsulation type. Note, this should be the number of pseudowires in service, carrying traffic, or pre-positioned to do so. ***Note, please indicate "In-Use" for any PW Encap Types which you are using but cannot provide a number.

   Ethernet Tagged Mode - RFC 4448 - 4000

4. Please indicate which VCCV Control Channel is used for each encapsulation type. Understanding that users may have different networks with varying implementations, for your network in general, please select all which apply.

   Ethernet Tagged Mode - RFC 4448: Control Word (Type 1), Router Alert Label (Type 2)

   Ethernet Raw Mode - RFC 4448: Control Word (Type 1), Router Alert Label (Type 2)

5. Please indicate which VCCV Connectivity Verification types are used in your networks for each encapsulation type.

   Ethernet Tagged Mode - RFC 4448: LSP Ping

6. Please indicate your network’s support of and use of the Control Word for encapsulations for which the Control Word is optional.

   Supported by Network/Equipment: Ethernet (Tagged Mode), Ethernet (Raw Mode)

   Used in Network: Ethernet (Tagged Mode), Ethernet (Raw Mode)

7. Please use this space to provide any feedback regarding PW and VCCV deployments, VCCV interoperability challenges, this survey or any network/vendor details you wish to share.

   No Response

A.6. Respondent 6

2. In your network in general, across all products, please indicate which pseudowire encapsulations your company has implemented.

   Ethernet Tagged Mode - RFC 4448

   Ethernet Raw Mode - RFC 4448

3. Approximately how many pseudowires are deployed of each encapsulation type. Note, this should be the number of pseudowires in service, carrying traffic, or pre-positioned to do so. ***Note, please indicate "In-Use" for any PW Encap Types which you are using but cannot provide a number.

   Ethernet Tagged Mode - RFC 4448 - 1000+

   Ethernet Raw Mode - RFC 4448 - 500

4. Please indicate which VCCV Control Channel is used for each encapsulation type. Understanding that users may have different networks with varying implementations, for your network in general, please select all which apply.

   Ethernet Tagged Mode - RFC 4448: Control Word (Type 1)

   Ethernet Raw Mode - RFC 4448: Control Word (Type 1)

5. Please indicate which VCCV Connectivity Verification types are used in your networks for each encapsulation type.

   Ethernet Tagged Mode - RFC 4448: ICMP Ping, LSP Ping

   Ethernet Raw Mode - RFC 4448: ICMP Ping, LSP Ping

6. Please indicate your network’s support of and use of the Control Word for encapsulations for which the Control Word is optional.

   Supported by Network/Equipment: Ethernet (Tagged Mode), Ethernet (Raw Mode)

   Used in Network: Ethernet (Tagged Mode), Ethernet (Raw Mode)

7. Please use this space to provide any feedback regarding PW and VCCV deployments, VCCV interoperability challenges, this survey or any network/vendor details you wish to share.

   No Response

A.7. Respondent 7

2. In your network in general, across all products, please indicate which pseudowire encapsulations your company has implemented.

   Ethernet Raw Mode - RFC 4448

   ATM (1:1 Mode) - RFC 4717

3. Approximately how many pseudowires are deployed of each encapsulation type. Note, this should be the number of pseudowires in service, carrying traffic, or pre-positioned to do so. ***Note, please indicate "In-Use" for any PW Encap Types which you are using but cannot provide a number.

   Ethernet Raw Mode - RFC 4448 - 20

   ATM (1:1 Mode) - RFC 4717 - 100

4. Please indicate which VCCV Control Channel is used for each encapsulation type. Understanding that users may have different networks with varying implementations, for your network in general, please select all which apply.

   No Response

5. Please indicate which VCCV Connectivity Verification types are used in your networks for each encapsulation type.

   Ethernet Raw Mode - RFC 4448: LSP Ping

   ATM (1:1 Mode) - RFC 4717: LSP Ping

6. Please indicate your network’s support of and use of the Control Word for encapsulations for which the Control Word is optional.

   Supported by Network/Equipment: Ethernet (Tagged Mode), Ethernet (Raw Mode), PPP, HDLC, Frame Relay (Port Mode), ATM (N:1 Cell Mode)

   Used in Network: No Response

7. Please use this space to provide any feedback regarding PW and VCCV deployments, VCCV interoperability challenges, this survey or any network/vendor details you wish to share.

We are using L2PVPN AToM like-to-like models - ATMoMPLS - EoMPLS ATMoMPLS : This service offered for transporting ATM cells over IP/MPLS core with Edge ATM CE devices including BPX, Ericsson Media Gateway etc. This is purely a Port mode with cell-packing configuration on it to have best performance. QoS marking is done for getting LLQ treatment in the core for these MPLS encapsulated ATM packets. EoMPLS: This service offered for transporting 2G/3G traffic from network such as Node-B to RNC's over IP/MPLS backbone core network. QoS marking is done for getting guaranteed bandwidth treatment in the core for these MPLS encapsulated ATM packets. In addition to basic L2VPN service configuration, these traffic are routed via MPLS TE tunnels with dedicated path and bandwidth defined to avoid bandwidth related congestion.

A.8. Respondent 8

2. In your network in general, across all products, please indicate which pseudowire encapsulations your company has implemented.

   Ethernet Raw Mode - RFC 4448

   ATM (AAL5 SDU Mode) - RFC 4717

   TDMoIP - RFC 5087

3. Approximately how many pseudowires are deployed of each encapsulation type. Note, this should be the number of pseudowires in service, carrying traffic, or pre-positioned to do so. ***Note, please indicate "In-Use" for any PW Encap Types which you are using but cannot provide a number.

   Ethernet Raw Mode - RFC 4448 - In-Use

   ATM (AAL5 SDU Mode) - RFC 4717 - In-Use

   TDMoIP - RFC 5087 - In-Use

4. Please indicate which VCCV Control Channel is used for each encapsulation type. Understanding that users may have different networks with varying implementations, for your network in general, please select all which apply.

   Ethernet Raw Mode - RFC 4448: Control Word (Type 1)

   ATM (AAL5 SDU Mode) - RFC 4717: Router Alert Label (Type 2)

5. Please indicate which VCCV Connectivity Verification types are used in your networks for each encapsulation type.

   Ethernet Raw Mode - RFC 4448: LSP Ping

   ATM (AAL5 SDU Mode) - RFC 4717: LSP Ping

   TDMoIP - RFC 5087: LSP Ping

6. Please indicate your network’s support of and use of the Control Word for encapsulations for which the Control Word is optional.

   Supported by Network/Equipment: Ethernet (Raw Mode), ATM (N:1 Cell Mode)

   Used in Network: Ethernet (Raw Mode), ATM (N:1 Cell Mode)

7. Please use this space to provide any feedback regarding PW and VCCV deployments, VCCV interoperability challenges, this survey or any network/vendor details you wish to share.

   PW VCCV is very useful tool for finding faults in each PW channel. Without this we can not find fault on a PW channel. PW VCCV using BFD is another better option. Interoperability challenges are with Ethernet OAM mechanism.

A.9. Respondent 9

2. In your network in general, across all products, please indicate which pseudowire encapsulations your company has implemented.

   Ethernet Tagged Mode - RFC 4448

   Frame Relay (1:1 Mode) - RFC 4619

3. Approximately how many pseudowires are deployed of each encapsulation type. Note, this should be the number of pseudowires in service, carrying traffic, or pre-positioned to do so. ***Note, please indicate "In-Use" for any PW Encap Types which you are using but cannot provide a number.

   Ethernet Tagged Mode - RFC 4448 - 19385

   Frame Relay (1:1 Mode) - RFC 4619 - 15757

4. Please indicate which VCCV Control Channel is used for each encapsulation type. Understanding that users may have different networks with varying implementations, for your network in general, please select all which apply.

   Frame Relay (1:1 Mode) - RFC 4619: Control Word (Type 1)

5. Please indicate which VCCV Connectivity Verification types are used in your networks for each encapsulation type.

   Frame Relay (1:1 Mode) - RFC 4619: LSP Ping

6. Please indicate your network’s support of and use of the Control Word for encapsulations for which the Control Word is optional.

   Supported by Network/Equipment: Ethernet (Tagged Mode), Ethernet (Raw Mode), PPP, HDLC, Frame Relay (Port Mode), ATM (N:1 Cell Mode)

   Used in Network: No Response

7. Please use this space to provide any feedback regarding PW and VCCV deployments, VCCV interoperability challenges, this survey or any network/vendor details you wish to share.

   No Response

A.10. Respondent 10

2. In your network in general, across all products, please indicate which pseudowire encapsulations your company has implemented.

   Ethernet Raw Mode - RFC 4448

3. Approximately how many pseudowires are deployed of each encapsulation type. Note, this should be the number of pseudowires in service, carrying traffic, or pre-positioned to do so. ***Note, please indicate "In-Use" for any PW Encap Types which you are using but cannot provide a number.

   Ethernet Raw Mode - RFC 4448 - 325

4. Please indicate which VCCV Control Channel is used for each encapsulation type. Understanding that users may have different networks with varying implementations, for your network in general, please select all which apply.

   Ethernet Raw Mode - RFC 4448: Control Word (Type 1)

5. Please indicate which VCCV Connectivity Verification types are used in your networks for each encapsulation type.

   Ethernet Raw Mode - RFC 4448: ICMP Ping, LSP Ping

6. Please indicate your network’s support of and use of the Control Word for encapsulations for which the Control Word is optional.

   Supported by Network/Equipment: No Response

   Used in Network: No Response

7. Please use this space to provide any feedback regarding PW and VCCV deployments, VCCV interoperability challenges, this survey or any network/vendor details you wish to share.

   No Response

A.11. Respondent 11

2. In your network in general, across all products, please indicate which pseudowire encapsulations your company has implemented.

   Ethernet Tagged Mode - RFC 4448

   Ethernet Raw Mode - RFC 4448

   PPP - RFC 4618 HDLC - RFC 4618

   Frame Relay (1:1 Mode) - RFC 4619

3. Approximately how many pseudowires are deployed of each encapsulation type. Note, this should be the number of pseudowires in service, carrying traffic, or pre-positioned to do so. ***Note, please indicate "In-Use" for any PW Encap Types which you are using but cannot provide a number.

   Ethernet Tagged Mode - RFC 4448 - 2000

   Ethernet Raw Mode - RFC 4448 - 100

   PPP - RFC 4618 - 500

   Frame Relay (1:1 Mode) - RFC 4619 - 200

4. Please indicate which VCCV Control Channel is used for each encapsulation type. Understanding that users may have different networks with varying implementations, for your network in general, please select all which apply.

   No Response

5. Please indicate which VCCV Connectivity Verification types are used in your networks for each encapsulation type.

   Ethernet Tagged Mode - RFC 4448: ICMP Ping, LSP Ping

   Ethernet Raw Mode - RFC 4448: ICMP Ping, LSP Ping

   Frame Relay (1:1 Mode) - RFC 4619: ICMP Ping, LSP Ping

6. Please indicate your network’s support of and use of the Control Word for encapsulations for which the Control Word is optional.

   Supported by Network/Equipment: Ethernet (Tagged Mode), Ethernet (Raw Mode), PPP, HDLC

   Used in Network: Ethernet (Tagged Mode)

7. Please use this space to provide any feedback regarding PW and VCCV deployments, VCCV interoperability challenges, this survey or any network/vendor details you wish to share.

   No Response

A.12. Respondent 12

2. In your network in general, across all products, please indicate which pseudowire encapsulations your company has implemented.

   Ethernet Raw Mode - RFC 4448

3. Approximately how many pseudowires are deployed of each encapsulation type. Note, this should be the number of pseudowires in service, carrying traffic, or pre-positioned to do so. ***Note, please indicate "In-Use" for any PW Encap Types which you are using but cannot provide a number.

   Ethernet Raw Mode - RFC 4448 - 50000

4. Please indicate which VCCV Control Channel is used for each encapsulation type. Understanding that users may have different networks with varying implementations, for your network in general, please select all which apply.

   Ethernet Raw Mode - RFC 4448: Control Word (Type 1), Router Alert Label (Type 2), TTL Expiry (Type 3)

5. Please indicate which VCCV Connectivity Verification types are used in your networks for each encapsulation type.

   No Response

6. Please indicate your network's support of and use of the Control Word for encapsulations for which the Control Word is optional.

   Supported by Network/Equipment: Ethernet (Tagged Mode), Ethernet (Raw Mode)

   Used in Network: Ethernet (Tagged Mode), Ethernet (Raw Mode)

7. Please use this space to provide any feedback regarding PW and VCCV deployments, VCCV interoperability challenges, this survey or any network/vendor details you wish to share.

   No Response

A.13. Respondent 13

2. In your network in general, across all products, please indicate which pseudowire encapsulations your company has implemented.

   Ethernet Tagged Mode - RFC 4448

   Ethernet Raw Mode - RFC 4448

   Frame Relay (1:1 Mode) - RFC 4619

3. Approximately how many pseudowires are deployed of each encapsulation type. Note, this should be the number of pseudowires in service, carrying traffic, or pre-positioned to do so. ***Note, please indicate "In-Use" for any PW Encap Types which you are using but cannot provide a number.

   Ethernet Tagged Mode - RFC 4448 - 3

   Ethernet Raw Mode - RFC 4448 - 10-20

ATM (1:1 Mode) - RFC 4717 - 3

4. Please indicate which VCCV Control Channel is used for each encapsulation type. Understanding that users may have different networks with varying implementations, for your network in general, please select all which apply.

   Ethernet Tagged Mode - RFC 4448: Control Word (Type 1), TTL Expiry (Type 3)

   Ethernet Raw Mode - RFC 4448: Control Word (Type 1), TTL Expiry (Type 3)

   Frame Relay (1:1 Mode) - RFC 4619: Control Word (Type 1), TTL Expiry (Type 3)

5. Please indicate which VCCV Connectivity Verification types are used in your networks for each encapsulation type.

   Ethernet Tagged Mode - RFC 4448: ICMP Ping, LSP Ping

   Ethernet Raw Mode - RFC 4448: ICMP Ping, LSP Ping

   Frame Relay (1:1 Mode) - RFC 4619: ICMP Ping, LSP Ping

6. Please indicate your network’s support of and use of the Control Word for encapsulations for which the Control Word is optional.

   Supported by Network/Equipment: Ethernet (Tagged Mode), Ethernet (Raw Mode), PPP, HDLC, Frame Relay (Port Mode), ATM (N:1 Cell Mode)

   Used in Network: Ethernet (Tagged Mode), Ethernet (Raw Mode), Frame Relay (Port Mode)

7. Please use this space to provide any feedback regarding PW and VCCV deployments, VCCV interoperability challenges, this survey or any network/vendor details you wish to share.

   No Response

A.14. Respondent 14

2. In your network in general, across all products, please indicate which pseudowire encapsulations your company has implemented.

   Ethernet Tagged Mode - RFC 4448

   Ethernet Raw Mode - RFC 4448

3. Approximately how many pseudowires are deployed of each encapsulation type. Note, this should be the number of pseudowires in service, carrying traffic, or pre-positioned to do so. ***Note, please indicate "In-Use" for any PW Encap Types which you are using but cannot provide a number.

   Ethernet Tagged Mode - RFC 4448 - 150

   Ethernet Raw Mode - RFC 4448 - 100

4. Please indicate which VCCV Control Channel is used for each encapsulation type. Understanding that users may have different networks with varying implementations, for your network in general, please select all which apply.

   Ethernet Tagged Mode - RFC 4448: Control Word (Type 1), Router Alert Label (Type 2)

   Ethernet Raw Mode - RFC 4448: Control Word (Type 1), Router Alert Label (Type 2)

5. Please indicate which VCCV Connectivity Verification types are used in your networks for each encapsulation type.

   Ethernet Tagged Mode - RFC 4448: LSP Ping

   Ethernet Raw Mode - RFC 4448: LSP Ping

6. Please indicate your network’s support of and use of the Control Word for encapsulations for which the Control Word is optional.

   Supported by Network/Equipment: Ethernet (Tagged Mode), Ethernet (Raw Mode), PPP, HDLC, Frame Relay (Port Mode)

   Used in Network: Ethernet (Tagged Mode), Ethernet (Raw Mode)

7. Please use this space to provide any feedback regarding PW and VCCV deployments, VCCV interoperability challenges, this survey or any network/vendor details you wish to share.

   No Response

A.15. Respondent 15

2. In your network in general, across all products, please indicate which pseudowire encapsulations your company has implemented.

   Ethernet Tagged Mode - RFC 4448

   Ethernet Raw Mode - RFC 4448

   Frame Relay (1:1 Mode) - RFC 4619

   ATM (1:1 Mode) - RFC 4717

3. Approximately how many pseudowires are deployed of each encapsulation type. Note, this should be the number of pseudowires in service, carrying traffic, or pre-positioned to do so. ***Note, please indicate "In-Use" for any PW Encap Types which you are using but cannot provide a number.

   Ethernet Tagged Mode - RFC 4448 - 20,000

   Ethernet Raw Mode - RFC 4448 - 1000

   Frame Relay (1:1 Mode) - RFC 4619 - 30,000

   ATM (1:1 Mode) - RFC 4717 - 20,000

4. Please indicate which VCCV Control Channel is used for each encapsulation type. Understanding that users may have different networks with varying implementations, for your network in general, please select all which apply.

   Ethernet Tagged Mode - RFC 4448: TTL Expiry (Type 3)

   Ethernet Raw Mode - RFC 4448: TTL Expiry (Type 3)

   Frame Relay (1:1 Mode) - RFC 4619: TTL Expiry (Type 3)

   ATM (1:1 Mode) - RFC 4717: TTL Expiry (Type 3)

5. Please indicate which VCCV Connectivity Verification types are used in your networks for each encapsulation type.

   Ethernet Tagged Mode - RFC 4448: LSP Ping

   Ethernet Raw Mode - RFC 4448: LSP Ping

   Frame Relay (1:1 Mode) - RFC 4619: LSP Ping

   ATM (1:1 Mode) - RFC 4717: LSP Ping

6. Please indicate your network's support of and use of the Control Word for encapsulations for which the Control Word is optional.

   Supported by Network/Equipment: No Response

   Used in Network: No Response

7. Please use this space to provide any feedback regarding PW and VCCV deployments, VCCV interoperability challenges, this survey or any network/vendor details you wish to share.

   COMPANY has deployed several MPLS network elements, from multiple vendors. COMPANY is seeking a uniform implementation of VCCV Control Channel (CC) capabilities across its various vendor platforms. This will provide COMPANY with significant advantages in reduced operational overheads when handling cross-domain faults. Having a uniform VCCV feature implementation in COMPANY multi-vendor network leads to:

   - Reduced operational cost and complexity
   - Reduced OSS development to coordinate incompatible VCCV implementations.
   - Increased end-end service availability when handing faults.

   In addition, currently some of COMPANY deployed VCCV traffic flows (on some vendor platforms) are not guaranteed to follow those of the customer's application traffic (a key operational requirement). As a result, the response from the circuit ping cannot faithfully reflect the status of the circuit. This leads to ambiguity regarding the operational status of our networks. An in-band method is highly preferred, with COMPANY having a clear preference for VCCV Circuit Ping using PWE Control Word. This preference is being pursued with each of COMPANY vendors.

A.16. Respondent 16

2. In your network in general, across all products, please indicate which pseudowire encapsulations your company has implemented.

   Ethernet Tagged Mode - RFC 4448

   Ethernet Raw Mode - RFC 4448

3. Approximately how many pseudowires are deployed of each encapsulation type. Note, this should be the number of pseudowires in service, carrying traffic, or pre-positioned to do so. ***Note, please indicate "In-Use" for any PW Encap Types which you are using but cannot provide a number.

   Ethernet Tagged Mode - RFC 4448 - 100

   Ethernet Raw Mode - RFC 4448 - 100

4. Please indicate which VCCV Control Channel is used for each encapsulation type. Understanding that users may have different networks with varying implementations, for your network in general, please select all which apply.

   No Response

5. Please indicate which VCCV Connectivity Verification types are used in your networks for each encapsulation type.

   Ethernet Tagged Mode - RFC 4448: ICMP Ping, LSP Ping

   Ethernet Raw Mode - RFC 4448: ICMP Ping, LSP Ping

6. Please indicate your network’s support of and use of the Control Word for encapsulations for which the Control Word is optional.

   Supported by Network/Equipment: Ethernet (Tagged Mode), Ethernet (Raw Mode)

   Used in Network: No Response

7. Please use this space to provide any feedback regarding PW and VCCV deployments, VCCV interoperability challenges, this survey or any network/vendor details you wish to share.

Using CV is not required at the moment

A.17. Respondent 17

2. In your network in general, across all products, please indicate which pseudowire encapsulations your company has implemented.

   Ethernet Tagged Mode - RFC 4448

   SAToP - RFC 4553

   Frame Relay (Port Mode) - RFC 4619

   Frame Relay (1:1 Mode) - RFC 4619

   ATM (N:1 Mode) - RFC 4717

   ATM (1:1 Mode) - RFC 4717

   CESoPSN - RFC 5086

   TDMoIP - RFC 5087

3. Approximately how many pseudowires are deployed of each encapsulation type. Note, this should be the number of pseudowires in service, carrying traffic, or pre-positioned to do so. ***Note, please indicate "In-Use" for any PW Encap Types which you are using but cannot provide a number.

   Ethernet Tagged Mode - RFC 4448 - >40k

   Ethernet Raw Mode - RFC 4448 - In-Use

   SAToP - RFC 4553 - >20k

   Frame Relay (Port Mode) - RFC 4619 - >5k

   Frame Relay (1:1 Mode) - RFC 4619 - >5k

   ATM (N:1 Mode) - RFC 4717 - >50k

   ATM (1:1 Mode) - RFC 4717 - >50k

   CESoPSN - RFC 5086 - >20k

   TDMoIP - RFC 5087 - >20k

4. Please indicate which VCCV Control Channel is used for each encapsulation type. Understanding that users may have different networks with varying implementations, for your network in general, please select all which apply.

   Ethernet Tagged Mode - RFC 4448: Control Word (Type 1)

   SAToP - RFC 4553: Control Word (Type 1)

   Frame Relay (Port Mode) - RFC 4619: Control Word (Type 1)

   Frame Relay (1:1 Mode) - RFC 4619: Control Word (Type 1)

   ATM (N:1 Mode) - RFC 4717: Control Word (Type 1)

   ATM (1:1 Mode) - RFC 4717: Control Word (Type 1)

5. Please indicate which VCCV Connectivity Verification types are used in your networks for each encapsulation type.

   Ethernet Tagged Mode - RFC 4448: LSP Ping

   SAToP - RFC 4553: LSP Ping

   Frame Relay (Port Mode) - RFC 4619: LSP Ping

   Frame Relay (1:1 Mode) - RFC 4619: LSP Ping

   ATM (N:1 Mode) - RFC 4717: LSP Ping

   ATM (1:1 Mode) - RFC 4717: LSP Ping

6. Please indicate your network’s support of and use of the Control Word for encapsulations for which the Control Word is optional.

   Supported by Network/Equipment: ATM (N:1 Cell Mode)

   Used in Network: No Response

7. Please use this space to provide any feedback regarding PW and VCCV deployments, VCCV interoperability challenges, this survey or any network/vendor details you wish to share.

   BFD VCCV Control Channel is not indicated in the survey (may be required for PW redundancy purpose)

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