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

Most Pseudowire Emulation Edge-to-Edge (PWE3) encapsulations mandate the use of the Control Word (CW) in order to better emulate the services for which the encapsulations have been defined. 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 drafts to attempt to remedy the situation. This survey of the PW/VCCV user community was conducted to determine implementation trends. The survey and results is presented herein.

Requirements Language

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].

Status of this Memo

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1. Introduction

The PWE3 working group has defined many encapsulations of various Layer
1 and Layer 2 links. Within these encapsulations, there are often

several modes of encapsulation which have differing requirements in order to fully emulate the service. As such, the use of the PWE3 Control Word is mandated in many of the encapsulations, but not all. This can present interoperability issues related to A) Control Word use and B) VCCV Control Channel negotiation in mixed implementation environments.

The encapsulations and modes for which the Control Word is currently optional are: [RFC5085] defines three Control Channel types for MPLS PW's: Type 1, using the Pseudowire Control Word, Type 2, using the Router Alert Label, and Type 3, using 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 control word 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 permuations, interoperability challenges have been identified by several VCCV users.

* Ethernet Tagged Mode

* Ethernet Raw Mode

* PPP

* HDLC

* Frame Relay Port Mode

* ATM (N:1 Cell Mode)

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 and the information returned by 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 Pseudowires, 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 URL for the survey (now closed) was http://www.surveymonkey.com/pwe3/. The survey ran from November 4, 2010 until February 25, 2011.

The PW/VCCV Implementation Survey requested the following information about user implementations:
- Responding Organziation. No provisions were made for anonymity. All responses required a valid email address in order to validate the survey response.
- Of the various encapsulations (and options therein) known at the time, including the WG draft for Fiber Channel), which were implemented b the respondent. These included:

    *Ethernet Tagged Mode - RFC 4448

    *Ethernet Raw Mode - RFC 4448

    *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 SDU Mode) - RFC 4717

    *ATM (AAL5 PDU Mode) - RFC 4717

    *CEP - RFC 4842

    *CESoPSN - RFC 5086

    *TDMoIP - RFC 5087

    *Fiber Channel (Port Mode) - draft-ietf-pwe3-fc-encap

- Approximately how many Pseudowires 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 indicated which Control Channel was in use. 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 were in use. The options were:

        *ICMP Ping

        *LSP Ping

- For each encapsulation type for which the use of the Control Word is
optional, the respondents could indicated the encaps for which Control
Word was supported by the equipment used and whether it was in use in
the network. The encaps listed were:

        *Ethernet (Tagged Mode)

        *Ethernet (Raw Mode)

        *PPP

        *HDLC

        *Frame Relay (Port Mode)

        *ATM (N:1 Cell Mode)

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

1.3. **PW/VCCV Survey Highlights**

There were 17 valid responses to the survey. The following companies
responded.

2. **Survey Results**

2.1. **Respondents**

The following companies participated in the PW/VCCV Implementation
Survey. The data provided has been aggregated. No specific company's
reponse will be detailed herein.

        *Time Warner Cable

        *Bright House Networks

        *Tinet

        *AboveNet

*Telecom New Zealand

        *Cox Communications

        *MTN South Africa

        *Wipro Technologies

        *Verizon

        *AMS-IX

        *Superonline

        *Deutsche Telekom AG

        *Internet Solution

        *Easynet Global Services

        *Telstra Corporation

        *OJSC MegaFon

        *France Telecom Orange

2.2. Pseudowire Encapsulations Implemented

The following question was asked: "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 = 77.8%

        *Ethernet Raw Mode - RFC 4448 = 77.8%

        *SAToP - RFC 4553 = 11.1%

        *PPP - RFC 4618 = 11.1%

        *HDLC - RFC 4618 = 5.6%

        *Frame Relay (Port Mode) - RFC 4619 = 16.7%

        *Frame Relay (1:1 Mode) - RFC 4619 = 44.4%

        *ATM (N:1 Mode) - RFC 4717 = 5.6%

        *ATM (1:1 Mode) - RFC 4717 = 22.2%

*ATM (AAL5 SDU Mode) - RFC 4717 = 5.6%

    *ATM (AAL5 PDU Mode) - RFC 4717 = 0.0%

    *CEP - RFC 4842 = 0.0%

    *CESoPSN - RFC 5086 = 11.1%

    *TDMoIP - RFC 5087 = 11.1%

    *Fiber Channel (Port Mode) - draft-ietf-pwe3-fc-encap = 5.6%

2.3. 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 psudowires 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) - draft-ietf-pwe3-fc-encap = 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 encaps were listed as "In-Use" with no quantity provided:

   *Ethernet Raw Mode: 2 Responses

   *ATM (AAL5 SDU Mode): 1 Response

   *TDMoIP: 1 Response

2.4. 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) - draft-ietf-pwe3-fc-encap

       -Control Word (Type 1) = 0

       -Router Alert Label (Type 2) = 0

       -TTL Expiry (Type 3) = 0

2.5. 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 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) - draft-ietf-pwe3-fc-encap

        -ICMP Ping = 0

        -LSP Ping = 0

2.6. Control Word Support for Encaps 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

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        -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
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2.7. 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.

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. Introperbility challences 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 a report of the PW/VCCV User Implementation Survey results, no security considerations are introduced.

4. Acknowledgements

I would like to thank the chairs of the PWE3 Working Group for their guidance and review of the Survey questions. I would also like to sincerly thank those who took the time and effort to participate.

5. References

5.1. Normative References

| [RFC2119] | Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997. |

5.2. Informative References

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

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