

Network Working Group
Internet-Draft
Intended status: Standards Track

E. Oki
UEC Tokyo
Tomonori Takeda
NTT
J-L Le Roux
France Telecom
A. Farrel
Juniper Networks
Fatai Zhang
Huawei
January 24, 2014

Expires: July 24, 2014

Extensions to the Path Computation Element communication Protocol
(PCEP) for Inter-Layer MPLS and GMPLS Traffic Engineering

[draft-ietf-pce-inter-layer-ext-08.txt](#)

Status of this Memo

This Internet-Draft is submitted to IETF in full conformance with the provisions of [BCP 78](#) and [BCP 79](#).

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF), its areas, and its working groups. Note that other groups may also distribute working documents as Internet-Drafts.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

The list of current Internet-Drafts can be accessed at <http://www.ietf.org/ietf/1id-abstracts.txt>.

The list of Internet-Draft Shadow Directories can be accessed at <http://www.ietf.org/shadow.html>.

This Internet-Draft will expire on July 24, 2014.

Abstract

<E. Oki>

Expires July 2013

[Page 1]

[draft-ietf-pce-inter-layer-ext-08.txt](#)

January 2014

The Path Computation Element (PCE) provides path computation functions in support of traffic engineering in Multiprotocol Label Switching (MPLS) and Generalized MPLS (GMPLS) networks.

MPLS and GMPLS networks may be constructed from layered service networks. It is advantageous for overall network efficiency to provide end-to-end traffic engineering across multiple network layers through a process called inter-layer traffic engineering. PCE is a candidate solution for such requirements.

The PCE communication Protocol (PCEP) is designed as a communication protocol between Path Computation Clients (PCCs) and PCEs. This document presents PCEP extensions for inter-layer traffic engineering.

Conventions used in this document

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](#)].

Table of Contents

1.	Introduction	3
2.	Overview of PCE-Based Inter-Layer Path Computation	3
3.	Protocol Extensions	4
	3.1. INTER-LAYER Object.....	4
	3.2. SWITCH-LAYER Object	7
	3.3. REQ-ADAP-CAP Object	8
	3.4. New Metric Types.....	9
	3.5. ERO sub-object	10
4.	Procedures	10
	4.1. Path Computation Request	10
	4.2. Path Computation Reply	11
5.	Updated Format of PCEP Messages	12
6.	Manageability Considerations	13
7.	IANA Considerations	13
	7.1. New PCEP Objects.....	13
	7.2. New Registry for INTER-LAYER Object Flags	14
	7.3. METRIC Type	15
8.	Security Considerations	15
9.	Acknowledgments	15
10.	References	15
	10.1. Normative References	15
	10.2. Informative References	16
11.	Authors' Addresses	16

1. Introduction

The Path Computation Element (PCE) defined in [[RFC4655](#)] is an entity that is capable of computing a network path or route based on a network graph, and applying computational constraints. A Path Computation Client (PCC) may make requests to a PCE for paths to be computed.

A network may comprise multiple layers. These layers may represent separations of technologies (e.g., packet switch capable (PSC), time division multiplex (TDM), lambda switch capable (LSC)) [[RFC3945](#)], separation of data plane switching granularity levels (e.g., PSC-1 and PSC-2, or VC4 and VC12) [[RFC5212](#)], or a distinction between client and server networking roles (e.g., commercial or administrative separation of client and server networks). In this multi-layer network, Label Switched Paths (LSPs) in lower layers are used to carry higher-layer LSPs. The network topology formed by lower-layer LSPs and advertised as traffic engineering links (TE links) in the higher layer is called a Virtual Network Topology (VNT) [[RFC5212](#)].

It is important to optimize network resource utilization globally, i.e., taking into account all layers, rather than optimizing resource utilization at each layer independently. This allows better network efficiency to be achieved. This is what we call inter-layer traffic engineering. This includes mechanisms allowing the computation of end-to-end paths across layers (known as inter-layer path computation), and mechanisms for control and management of the VNT by setting up and releasing LSPs in the lower layers [[RFC5212](#)].

PCE can provide a suitable mechanism for resolving inter-layer path computation issues. The framework for applying the PCE-based path computation architecture to inter-layer traffic engineering is described in [[RFC5623](#)].

The PCE communication protocol (PCEP) is designed as a communication protocol between PCCs and PCEs and is defined in [[RFC5440](#)]. A set of requirements for PCEP extensions to support inter-layer traffic engineering is described in [[RFC6457](#)].

This document presents PCEP extensions for inter-layer traffic engineering that satisfy the requirements described in [[RFC6457](#)].

2. Overview of PCE-Based Inter-Layer Path Computation

[[RFC4206](#)] defines a way to signal a higher-layer LSP which has an explicit route that includes hops traversed by LSPs in lower layers.

The computation of end-to-end paths across layers is called Inter-Layer Path Computation.

A Label Switching Router (LSR) in the higher-layer might not have information on the lower-layer topology, particularly in an overlay or augmented model [[RFC3945](#)], and hence may not be able to compute an end-to-end path across layers.

PCE-based inter-layer path computation consists of using one or more PCEs to compute an end-to-end path across layers. This could be achieved by relying on a single PCE that has topology information about multiple layers and can directly compute an end-to-end path across layers considering the topology of all of the layers. Alternatively, the inter-layer path computation could be performed using multiple cooperating PCEs where each PCE has information about the topology of one or more layers (but not all layers) and where the PCEs collaborate to compute an end-to-end path.

As described in [[RFC5339](#)], a hybrid nodes may advertise a single TE link with multiple switching capabilities. Those TE links exist at the layer/region boarder normally. In this case, PCE needs to be capable of specifying the server layer path information when the server layer path information is required to be returned to the PCC.

[RFC5623] describes models for inter-layer path computation in more detail.

[3.](#) Protocol Extensions

This section describes PCEP extensions for inter-layer path computation. Three new objects are defined: the INTER-LAYER object, the SWITCH-LAYER object, the REQ-ADAP-CAP object and SERVER-INDICATION. Also, two new metric types are defined.

[3.1.](#) INTER-LAYER Object

The INTER-LAYER object is optional and can be used in PCReq and PCRep messages.

In a PCReq message, the INTER-LAYER object indicates whether inter-layer path computation is allowed, the type of path to be computed, and whether triggered signaling (hierarchical LSPs per [[RFC4206](#)] or stitched LSPs per [[RFC5150](#)] depending on physical network technologies) is allowed. When the INTER-LAYER object is absent from a PCReq message, the receiving PCE MUST process as though inter-layer path computation had been explicitly disallowed (I-bit set to zero - see below).

In a PCRep message, the INTER-LAYER object indicates whether inter-

layer path computation has been performed, the type of path that has been computed, and whether triggered signaling is used.

When a PCReq message includes more than one request, an INTER-LAYER object is used per request. When a PCRep message includes more than one path per request that is responded to, an INTER-LAYER object is used per path.

INTER-LAYER Object-Class is to be assigned by IANA (recommended value=18)

INTER-LAYER Object-Type is to be assigned by IANA (recommended value=1)

The format of the INTER-LAYER object body is as follows:

```

      0               1               2               3
      0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|      Reserved                                                    T|M|I|
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

I flag (1 bit): The I flag is used by a PCC in a PCReq message to indicate to a PCE whether an inter-layer path is allowed. When the I flag is set (one), the PCE MAY perform inter-layer path computation and return an inter-layer path. When the flag is clear (zero), the path that is returned MUST NOT be an inter-layer path.

The I flag is used by a PCE in a PCRep message to indicate to a PCC whether the path returned is an inter-layer path. When the I flag is set (one), the path is an inter-layer path. When it is clear (zero), the path is contained within a single layer either because inter-layer path computation was not performed or because a mono-layer path (without any virtual TE link and without any loose hop that spans the lower-layer network) was found notwithstanding the use of inter-layer path computation.

M flag (1 bit): The M flag is used by a PCC in a PCReq message to indicate to a PCE whether mono-layer path or multi-layer path is requested. When the M flag is set (one), multi-layer path is requested. When it is clear (zero), mono-layer path is requested.

The M flag is used by a PCE in a PCRep message to indicate to a PCC whether mono-layer path or multi-layer path is returned. When M flag

is set (one), multi-layer path is returned. When M flag is set (zero), mono-layer path is returned.

If the I flag is clear (zero), the M flag has no meaning and MUST be ignored.

[RFC6457] describes two sub-options for mono-layer path.

- A mono-layer path that is specified by strict hops. The path may include virtual TE links.
- A mono-layer path that includes loose hops that span the lower-layer network.

The choice of this sub-option can be specified by the use of O flag in the RP object specified in [\[RFC5440\]](#).

T flag (1 bit): The T flag is used by a PCC in a PCReq message to indicate to a PCE whether triggered signaling is allowed. When the T flag is set (one), triggered signaling is allowed. When it is clear (zero), triggered signaling is not allowed.

The T flag is used by a PCE in a PCRep message to indicate to a PCC whether triggered signaling is required to support the returned path. When the T flag is set (one), triggered signaling is required. When it is clear (zero), triggered signaling is not required.

Note that triggered signaling is used to support hierarchical [\[RFC4206\]](#) or stitched [\[RFC5150\]](#) LSPs according to the physical attributes of the network layers.

If the I flag is clear (zero), the T flag has no meaning and MUST be ignored.

Note that the I flag and M flag differ in the following ways. - When the I flag is clear (zero), virtual TE links must not be used in path computation. In addition, loose hops that span the lower-layer network must not be specified. Only regular TE links from the same layer may be used.

- When the I flag is set (one), the M flag is clear (zero), and the T flag is set (one), virtual TE links are allowed in path computation. In addition, when the O flag of the RP object is set, loose hops that span the lower-layer network may be specified. This will initiate lower-layer LSP setup, thus inter-layer path is setup even though the path computation result from a PCE to a PCC include hops from the same layer only.

- However, when the I flag is set (one), the M flag is clear (zero), and the T flag is clear (zero), since triggered signaling is not allowed, virtual TE links must not be used in path computation. In

addition, loose hops that span the lower-layer network must not be specified. Therefore, this is equivalent to the I flag being clear (zero).

Reserved bits of the INTER-LAYER object SHOULD be transmitted as zero and SHOULD be ignored on receipt. A PCE that forwards a path computation request to other PCEs SHOULD preserve the settings of reserved bits in the PCReq messages it sends and in the PCRep messages it forwards to PCCs.

3.2. SWITCH-LAYER Object

The SWITCH-LAYER object is optional on a PCReq message and specifies switching layers in which a path MUST, or MUST NOT, be established. A switching layer is expressed as a switching type and encoding type.

When a SWITCH-LAYER object is used on a PCReq it is interpreted in the context of the INTER-LAYER object on the same message. If no INTER-LAYER object is present, the PCE MUST process the SWITCH-LAYER object as though inter-layer path computation had been explicitly disallowed. In such a case, the SWITCH-LAYER object MUST NOT have more than one LSP Encoding Type and Switching Type with the I flag set.

The SWITCH-LAYER object is optional on a PCRep message, where it is used with the NO-PATH object in the case of unsuccessful path computation to indicate the set of constraints that could not be satisfied.

SWITCH-LAYER Object-Class is to be assigned by IANA (recommended value=19)

SWITCH-LAYER Object-Type is to be assigned by IANA (recommended value=1)

The format of the SWITCH-LAYER object body is as follows:

[illegible]

```

| . |
// . //
| . |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
| LSP Enc. Type | Switching Type | Reserved | I |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

```

Each row indicates a switching type and encoding type that must or must not be used for specified layer(s) in the computed path.

The format is based on [[RFC3471](#)], and has equivalent semantics.

LSP Encoding Type (8 bits): see [[RFC3471](#)] for a description of parameters.

Switching Type (8 bits): see [[RFC3471](#)] for a description of parameters.

I flag (1 bit): the I flag indicates whether a layer with the specified switching type and encoding type must or must not be used by the computed path. When the I flag is set (one), the computed path **MUST** traverse a layer with the specified switching type and encoding type. When the I flag is clear (zero), the computed path **MUST NOT** enter or traverse any layer with the specified switching type and encoding type.

When a combination of switching type and encoding type is not included in SWITCH-LAYER object, the computed path **MAY** traverse a layer with that combination of switching type and encoding type.

A PCC may want to specify only a Switching Type and not an LSP Encoding Type. In this case, the LSP Encoding Type is set to zero.

[3.3. REQ-ADAP-CAP Object](#)

The REQ-ADAP-CAP object is optional and is used to specify a requested adaptation capability for both ends of the lower layer LSP. The REQ-ADAP-CAP object is used in a PCReq message for inter-PCE communication, where the PCE that is responsible for computing higher layer paths acts as a PCC to request a path computation from a PCE that is responsible for computing lower layer paths.

The REQ-ADAP-CAP object is used in a PCRep message in case of unsuccessful path computation (in this case, the PCRep message also contains a NO-PATH object, and the REQ-ADAP-CAP object is used to indicate the set of constraints that could not be satisfied).

The REQ-ADAP-CAP object **MAY** be used in a PCReq message in a mono-

layer network to specify a requested adaptation capability for both ends of the LSP. In this case, it MAY be carried without INTER-LAYER Object.

REQ-ADAP-CAP Object-Class is to be assigned by IANA (recommended value=20)

REQ-ADAP-CAP Object-Type is to be assigned by IANA (recommended value=1)

The format of the REQ-ADAP-CAP object body is as follows:

```

      0               1               2               3
    0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+
| Switching Cap |   Encoding   | Reserved |
+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+--+

```

The format is based on [\[RFC6001\]](#) and has equivalent semantics as the IACD Upper SC and Lower SC.

Switching Capability (8 bits): see [\[RFC4203\]](#) for a description of parameters.

Encoding (8 bits): see [\[RFC3471\]](#) for a description of parameters.

A PCC may want to specify a Switching Capability, but not an Encoding. In this case, the Encoding MUST be set zero.

[3.4.](#) New Metric Types

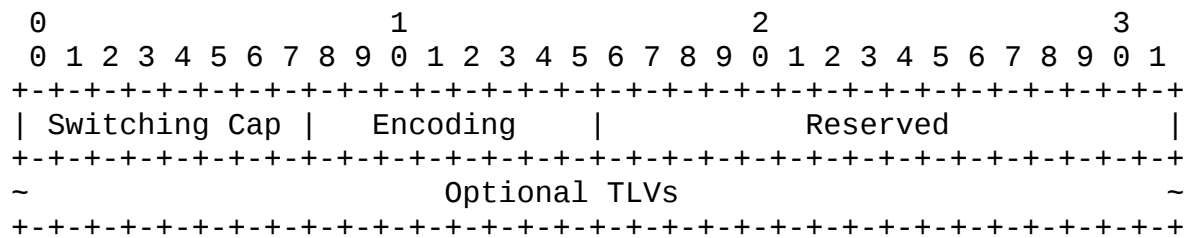
Two new metric types are defined for the METRIC object in PCEP.

Type 11 (suggested value, to be assigned by IANA): Number of adaptations on a path.

Type 12 (suggested value, to be assigned by IANA): Number of layers to be involved on a path.

[3.5.](#) SERVER-INDICATION object

The SERVER-INDICATION is optional and is used to indicate that path information included in the ERO is server layer information and specify the characteristics of the server layer, e.g. the switching capability and encoding of the server layer path.



The type of SERVER-INDICATION object is to be assigned by IANA.

Switching Capability (8 bits): see [[RFC4203](#)] for a description of parameters.

Encoding (8 bits): see [[RFC3471](#)] for a description of parameters.

Optional TLVs: Optional TLVs may be included within the object to specify more specific server layer path information (e.g., traffic parameters).

4. Procedures

4.1. Path Computation Request

A PCC requests or allows inter-layer path computation in a PCReq message by including the INTER-LAYER object with the I flag set. The INTER-LAYER object indicates whether inter-layer path computation is allowed, which path type is requested, and whether triggered signaling is allowed.

The SWITCH-LAYER object, which MUST NOT be present unless the INTER-LAYER object is also present, is optionally used to specify the switching types and encoding types that define layers that must, or must not, be used in the computed path. When the SWITCH-LAYER object is used with the INTER-LAYER object I flag clear (zero), inter-layer path computation is not allowed, but constraints specified in the

SWITCH-LAYER object apply. Example usage includes path computation in a single layer GMPLS network.

The REQ-ADAP-CAP object is optionally used to specify the interface switching capability of both ends of the lower layer LSP. The REQ-ADAP-CAP object is used in inter-PCE communication, where the PCE that is responsible for computing higher layer paths makes a request as a PCC to a PCE that is responsible for computing lower layer paths. Alternatively, the REQ-ADAP-CAP object may be used in the NMS-VNTM

model, where the VNTM makes a request as a PCC to a PCE that is responsible for computing lower-layer paths.

The METRIC object is optionally used to specify metric types to be optimized or bounded. When metric type 11 (TBC by IANA) is used, it indicates that path computation MUST minimize or bound the number of adaptations on a path. When metric type 12 (TBC by IANA) is used, it indicates that path computation MUST minimize or bound the number of layers to be involved on a path.

Furthermore, in order to allow different objective functions to be applied within different network layers, multiple OF objects MAY be present. In such a case, the first OF object specifies an objective function for the higher-layer network, and subsequent OF objects specify objection functions of the subsequent lower-layer networks.

4.2. Path Computation Reply

In the case of successful path computation, the requested PCE replies to the requesting PCC for the inter-layer path computation result in a PCRep message that MAY include the INTER-LAYER object. When the INTER-LAYER object is included in a PCRep message, the I flag, M flag, and T flag indicate semantics of the path as described in [Section 3.1](#). Furthermore, when the C flag of the METRIC object in a PCReq is set, the METRIC object MUST be included in the PCRep to provide the computed metric value, as specified in [\[RFC5440\]](#).

PCE MAY specify the server layer path information in the ERO. In this case, the requested PCE replies a PCRep message that includes at least two sets of ERO information in the path-list, one is for the client layer path information, and another one is the server layer path information. When SERVER-INDICATION is included in a PCRep message, it indicates that the path in the ERO is the server layer path information. The server layer path specified in the ERO could be loose or strict. On receiving the replied path, the PCC (e.g. NMS, ingress node) can trigger the signaling to setup the LSPs according to the computed paths.

In the case of unsuccessful path computation, the PCRep message also contains a NO-PATH object, and the SWITCH-TYPE object and/or the REQ-ADAP-CAP MAY be used to indicate the set of constraints that could not be satisfied.

5. Updated Format of PCEP Messages

Message formats in this section, as those in [\[RFC5440\]](#) are presented using Backus-Naur Format as specified in [\[RFC5511\]](#).

The format of the PCReq message is updated as follows:

```
<PCReq Message> ::= <Common Header>
                    [<SVEC-list>]
                    <request-list>
```

where:

```
<svec-list> ::= <SVEC>
                [<svec-list>]

<request-list> ::= <request> [<request-list>]

<request> ::= <RP>
              <END-POINTS>
              [<of-list>]
              [<LSPA>]
              [<BANDWIDTH>]
              [<metric-list>]
              [<RRO> [<BANDWIDTH>]]
              [<IRO>]
              [<LOAD-BALANCING>]
              [<INTER-LAYER> [<SWITCH-LAYER>]]
              [<REQ-ADAP-CAP>]
```

where:

```
<of-list> ::= <OF> [<of-list>]
<metric-list> ::= <METRIC> [<metric-list>]
```

The format of the PCRep message is updated as follows:

```
<PCRep Message> ::= <Common Header>
                    <response-list>
```

where:

```
<response-list> ::= <response> [<response-list>]

<response> ::= <RP>
               [<NO-PATH>]
               [<attribute-list>]
               [<path-list>]

<path-list> ::= <path> [<path-list>]

<path> ::= <ERO> <attribute-list>
```

where:

```
<attribute-list> ::= [<of-list>]
                    [<LSPA>]
```

[<BANDWIDTH>]
[<metric-list>]
[<IRO>]
[<INTER-LAYER>]
[<SWITCH-LAYER>]
[<REQ-ADAP-CAP>]
[<SERVER-INDICATION>]

<of-list>::=<OF>[<of-list>]
<metric-list>::=<METRIC>[<metric-list>]

6. Manageability Considerations

Manageability of inter-layer traffic engineering with PCE must address the following consideration for [section 5.1](#).

- need for a MIB module for control and monitoring
- need for built-in diagnostic tools
- configuration implication for the protocol

7. IANA Considerations

7.1. New PCEP Objects

Four new objects: INTER-LAYER object, SWITCH-LAYER object, REQ-ADAP-CAP and SERVER-INDICATION object.

INTER-LAYER Object-Class is to be assigned by IANA (recommended value=18)

INTER-LAYER Object-Type is to be assigned by IANA (recommended value=1)

SWITCH-LAYER Object-Class is to be assigned by IANA (recommended value=19)

SWITCH-LAYER Object-Type is to be assigned by IANA (recommended value=1)

REQ-ADAP-CAP Object-Class is to be assigned by IANA (recommended value=20)

REQ-ADAP-CAP Object-Type is to be assigned by IANA (recommended value=1)

SERVER-INDICATION Object-Class is to be assigned by IANA (recommended value=21)

SERVER-INDICATION Object-Type is to be assigned by IANA (recommended value=1)

7.2. New Registry for INTER-LAYER Object Flags

IANA is requested to create a registry to manage the Flag field of the INTER-Layer object.

New bit numbers may be allocated only by an IETF Consensus action. Each bit should be tracked with the following qualities:

- o Bit number (counting from bit 0 as the most significant bit)
- o Capability Description
- o Defining RFC

Several bits are defined for the INTER-LAYER object flag fields in this document. The following values have been assigned:

Bit Number	Description	Reference
29	T flag	this document
30	M flag	this document
31	I flag	this document

E. Oki

Expires July 2013

[Page 14]

[draft-ietf-pce-inter-layer-ext-08.txt](#)

January 2014

7.3. METRIC Type

Two new metric types are defined in this document for the METRIC object (specified in [[RFC5440](#)]). The IANA is requested to make the following allocation (suggested value):

- Type 11 : Number of adaptations on a path
- Type 12 : Number of layers on a path

8. Security Considerations

Inter-layer traffic engineering with PCE may raise new security issues when PCE-PCE communication is done between different layer networks for inter-layer path computation. Security issues may also exist when a single PCE is granted full visibility of TE information that applies to multiple layers.

Path-Key-based mechanism defined in [[RFC5520](#)] MAY be applied to address the topology confidentiality between different layers.

9. Acknowledgments

The authors would like to thank Cyril Margaria for his valuable comments.

10. References

10.1. Normative References

- [RFC2119] S. Bradner, "Key words for use in RFCs to indicate requirements levels", [RFC 2119](#), March 1997.
- [RFC3471] L. Burger, "Generalized Multi-Protocol Label Switching (GMPLS)", [RFC 3471](#), January 2003.
- [RFC3945] E. Mannie, "Generalized Multi-Protocol Label Switching Architecture", [RFC 3945](#), October 2004.
- [RFC4203] K. Kompella and Y. Rekhter, "OSPF Extensions in Support of Generalized Multi-Protocol Label Switching (GMPLS)", [RFC 4203](#), October 2005.

E. Oki

Expires July 2013

[Page 15]

[draft-ietf-pce-inter-layer-ext-08.txt](#)

January 2014

- [RFC4206] K. Kompella, and Y. Rekhter, "Label Switched Paths (LSP) Hierarchy with Generalized Multi-Protocol Label Switching (GMPLS) Traffic Engineering (TE)", [RFC 4206](#), October 2005.
- [RFC5440] JP. Vasseur et al, "Path Computation Element (PCE) Communication Protocol (PCEP)" [RFC 5440](#), March 2009.
- [RFC6457] E. Oki et al., "PCC-PCE Communication Requirements for Inter-Layer Traffic Engineering", [RFC6457](#), December 2011.
- [RFC5623] E. Oki et al., "Framework for PCE-Based Inter-Layer MPLS and GMPLS Traffic Engineering", September 2009.
- [RFC5339] JL. Le Roux et al, "Evaluation of Existing GMPLS Protocols against Multi-Layer and Multi-Region Networks (MLN/MRN)", [RFC5339](#), September 2008.

10.2. Informative References

- [RFC4655] A. Farrel, JP. Vasseur and J. Ash, "A Path Computation Element (PCE)-Based Architecture", [RFC 4655](#), September 2006.
- [RFC5212] K. Shiimoto et al., "Requirements for GMPLS-based multi-region and multi-layer networks (MRN/MLN)", [RFC 5212](#), July

2008.

- [RFC6001] D. Papadimitriou et al., "Generalized Multi-Protocol Label Switching (GMPLS) Protocol Extensions for Multi-Layer and Multi-Region Networks (MLN/MRN)", [RFC6001](#), October 2010.
- [RFC5150] A. Ayyangar et al., "Label Switched Path Stitching with Generalized Multiprotocol Label Switching Traffic Engineering (GMPLS TE)", [RFC 5150](#), February 2008.
- [RFC5511] Farrel, A., "Reduced Backus-Naur Form (RBNF) A Syntax Used in Various Protocol Specifications", April 2009.

11. Authors' Addresses

Eiji Oki
University of Electro-Communications
Tokyo
Japan
Email: oki@ice.uec.ac.jp

E. Oki

Expires July 2013

[Page 16]

[draft-ietf-pce-inter-layer-ext-08.txt](#)

January 2014

Tomonori Takeda
NTT
3-9-11 Midori-cho,
Musashino-shi, Tokyo 180-8585, Japan
Email: takeda.tomonori@lab.ntt.co.jp

Jean-Louis Le Roux
France Telecom R&D,
Av Pierre Marzin,
22300 Lannion, France
Email: julien.meuric@orange.com

Adrian Farrel
Juniper Networks
Email: adrian@olddog.co.uk

Fatai Zhang
Huawei Technologies Co., Ltd.
F3-5-B R&D Center, Huawei Base,
Bantian, Longgang District
Shenzhen 518129 P.R.China

Phone: +86-755-28972912
Email: zhangfatai@huawei.com

Intellectual Property

The IETF Trust takes no position regarding the validity or scope of any Intellectual Property Rights or other rights that might be claimed to pertain to the implementation or use of the technology described in any IETF Document or the extent to which any license under such rights might or might not be available; nor does it represent that it has made any independent effort to identify any such rights.

Copies of Intellectual Property disclosures made to the IETF Secretariat and any assurances of licenses to be made available, or the result of an attempt made to obtain a general license or

E. Oki

Expires July 2013

[Page 17]

[draft-ietf-pce-inter-layer-ext-08.txt](#)

January 2014

permission for the use of such proprietary rights by implementers or users of this specification can be obtained from the IETF on-line IPR repository at <http://www.ietf.org/ipr>

The IETF invites any interested party to bring to its attention any copyrights, patents or patent applications, or other proprietary rights that may cover technology that may be required to implement any standard or specification contained in an IETF Document. Please address the information to the IETF at ietf-ipr@ietf.org.

The definitive version of an IETF Document is that published by, or under the auspices of, the IETF. Versions of IETF Documents that are published by third parties, including those that are translated into other languages, should not be considered to be definitive versions of IETF Documents. The definitive version of these Legal Provisions is that published by, or under the auspices of, the IETF. Versions of these Legal Provisions that are published by third parties, including those that are translated into other languages, should not be considered to be definitive versions of these Legal Provisions.

For the avoidance of doubt, each Contributor to the IETF Standards Process licenses each Contribution that he or she makes as part of the IETF Standards Process to the IETF Trust pursuant to the provisions of [RFC 5378](#). No language to the contrary, or terms, conditions or rights that differ from or are inconsistent with the rights and licenses granted under [RFC 5378](#), shall have any effect and shall be null and void, whether published or posted by such Contributor, or included with or in such Contribution.

Disclaimer of Validity

All IETF Documents and the information contained therein are provided on an "AS IS" basis and THE CONTRIBUTOR, THE ORGANIZATION HE/SHE REPRESENTS OR IS SPONSORED BY (IF ANY), THE INTERNET SOCIETY, THE IETF TRUST AND THE INTERNET ENGINEERING TASK FORCE DISCLAIM ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY WARRANTY THAT THE USE OF THE INFORMATION THEREIN WILL NOT INFRINGE ANY RIGHTS OR ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

Full Copyright Statement

Copyright (c) 2010 IETF Trust and the persons identified as the document authors. All rights reserved.

E. Oki

Expires July 2013

[Page 18]

[draft-ietf-pce-inter-layer-ext-08.txt](#)

January 2014

This document is subject to [BCP 78](#) and the IETF Trust's Legal Provisions Relating to IETF Documents (<http://trustee.ietf.org/license-info>) in effect on the date of publication of this document. Please review these documents carefully, as they describe your rights and restrictions with respect to this document. Code Components extracted from this document must include Simplified BSD License text as described in [Section 4.e](#) of the Trust Legal Provisions and are provided without warranty as described in the Simplified BSD License.

E. Oki

Expires July 2013

[Page 19]