Internet Engineering Task Force (IETF)
Request for Comments: 7025
Category: Informational
ISSN: 2070-1721
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September 2013

Requirements for GMPLS Applications of PCE

Abstract

The initial effort of the PCE (Path Computation Element) WG focused mainly on MPLS. As a next step, this document describes functional requirements for GMPLS applications of PCE.

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1. Introduction

The initial effort of the PCE (Path Computation Element) WG focused mainly on solving the path computation problem within a domain or over different domains in MPLS networks. As with MPLS, service providers (SPs) have also come up with requirements for path computation in GMPLS-controlled networks [RFC3945], such as those based on Wavelength Division Multiplexing (WDM), Time Division Multiplexing (TDM), or Ethernet.

[RFC4655] and [RFC4657] discuss the framework and requirements for PCE on both packet MPLS networks and GMPLS-controlled networks. This document complements those RFCs by providing considerations of GMPLS applications in the intradomain and interdomain networking environments and indicating a set of requirements for the extended definition of PCE-related protocols.

Note that the requirements for interlayer and inter-area traffic engineering (TE) described in [RFC6457] and [RFC4927] are outside of the scope of this document.

Constrained Shortest Path First (CSPF) computation within a domain or over domains for signaling GMPLS Label Switched Paths (LSPs) is usually more stringent than that of MPLS TE LSPs [RFC4216], because the additional constraints, e.g., interface switching capability, link encoding, link protection capability, Shared Risk Link Group (SRLG) [RFC4202], and so forth, need to be considered to establish GMPLS LSPs. The GMPLS signaling protocol [RFC3473] is designed taking into account bidirectionality, switching type, encoding type, and protection attributes of the TE links spanned by the path, as well as LSP encoding and switching type of the endpoints, appropriately.

This document provides requirements for GMPLS applications of PCE in support of GMPLS path computation, included are requirements for both intradomain and interdomain environments.

2. GMPLS Applications of PCE

2.1. Path Computation in GMPLS Networks

Figure 1 depicts a model GMPLS network, consisting of an ingress link, a transit link, as well as an egress link. We will use this model to investigate consistent guidelines for GMPLS path computation. Each link at each interface has its own switching capability, encoding type, and bandwidth.

```
          Ingress             Transit             Egress
+-----+   link1-2   +-----+   link2-3   +-----+   link3-4   +-----+
|Node1|------------>|Node2|------------>|Node3|------------>|Node4|
|     |<------------|     |<------------|     |<------------|     |
+-----+   link2-1   +-----+   link3-2   +-----+   link4-3   +-----+
```

Figure 1: Path Computation in GMPLS Networks

For the simplicity in consideration, the following basic assumptions are made when the LSP is created.

(1) Switching capabilities of outgoing links from the ingress and egress nodes (link1-2 and link4-3 in Figure 1) are consistent with each other.

(2) Switching capabilities of all transit links, including incoming links to the ingress and egress nodes (link2-1 and link3-4) are consistent with switching type of an LSP to be created.

(3) Encoding types of all transit links are consistent with the encoding type of an LSP to be created.

GMPLS-controlled networks (e.g., GMPLS-based TDM networks) are usually responsible for transmitting data for the client layer. These GMPLS-controlled networks can provide different types of connections for customer services based on different service bandwidth requests.

The applications and the corresponding additional requirements for applying PCE to GMPLS-based TDM networks are described in this section. In order to simplify the description, this document only discusses the scenario in Synchronous Digital Hierarchy (SDH) networks as an example (see Figure 2). The scenarios in Synchronous Optical Network (SONET) or Optical Transport Network (OTN) are similar.

```
                        N1                    N2
       +-----+       +------+              +------+
       |     |-------|      |--------------|      |       +-------+
       +-----+       |      |---|          |      |       |       |
          A1         +------+   |          +------+       |       |
                        |       |             |           +-------+
                        |       |             |              PCE
                        |       |             |
                        |      +------+       |
                        |      |      |       |
                        |      |      |-----| |
                        |      +------+     | |
                        |         N5        | |
                        |                   | |
                     +------+              +------+
                     |      |              |      |        +-----+
                     |      |--------------|      |--------|     |
                     +------+              +------+        +-----+
                        N3                    N4              A2
```

                   Figure 2: A Simple TDM (SDH) Network

Figure 2 shows a simple TDM (SDH) network topology, where N1, N2, N3, N4, and N5 are all SDH switches; A1 and A2 are client devices (e.g., Ethernet switches). Assume that one Ethernet service with 100 Mbit/s bandwidth is required from A1 to A2 over this network. The client Ethernet service could be provided by a Virtual Container 4 (VC-4) container from N1 to N4; it could also be provided by three concatenated VC-3s (contiguous or virtual concatenation) from N1 to N4.

In this scenario, when the ingress node (e.g., N1) receives a client service transmitting request, the type of containers (one VC-4 or three concatenated VC-3s) could be determined by the PCC (Path Computation Client), e.g., N1 or Network Management System (NMS). However, it could also be determined automatically by the PCE based on policy [RFC5394]. If it is determined by the PCC, then the PCC should be capable of specifying the ingress node and egress node, signal type, the type of the concatenation, and the number of the concatenation in a PCReq (Path Computation Request) message. The PCE should consider those parameters during path computation. The route information (co-routing or diverse routing) should be specified in a PCRep (Path Computation Reply) message if path computation is performed successfully.

As described above, the PCC should be capable of specifying TE attributes defined in the next section, and the PCE should compute a path accordingly.

Where a GMPLS network consists of interdomain (e.g., inter-AS or inter-area) GMPLS-controlled networks, requirements on the path computation follow [RFC5376] and [RFC4726].

2.2. Unnumbered Interface

GMPLS supports unnumbered interface IDs as defined in [RFC3477]; this means that the endpoints of the path may be unnumbered. It should also be possible to request a path consisting of the mixture of numbered links and unnumbered links, or a P2MP (Point-to-Multipoint) path with different types of endpoints. Therefore, the PCC should be capable of indicating the unnumbered interface ID of the endpoints in the PCReq message.

2.3. Asymmetric Bandwidth Path Computation

Per [RFC6387], GMPLS signaling can be used for setting up an asymmetric bandwidth bidirectional LSP. If a PCE is responsible for path computation, it should be capable of computing a path for the bidirectional LSP with asymmetric bandwidth. This means that the PCC should be able to indicate the asymmetric bandwidth requirements in forward and reverse directions in the PCReq message.

3. Requirements for GMPLS Applications of PCE

3.1. Requirements on Path Computation Request

As for path computation in GMPLS-controlled networks as discussed in Section 2, the PCE should appropriately consider the GMPLS TE attributes listed below once a PCC or another PCE requests a path computation. The path calculation request message from the PCC or the PCE must contain the information specifying appropriate attributes. According to [RFC5440], [PCE-WSON-REQ], and RSVP procedures such as explicit label control (ELC), the additional attributes introduced are as follows:

(1) Switching capability/type: as defined in [RFC3471], [RFC4203], and all current and future values.

(2) Encoding type: as defined in [RFC3471], [RFC4203], and all current and future values.

(3) Signal type: as defined in [RFC4606] and all current and future values.

(4) Concatenation type: In SDH/SONET and OTN, two kinds of concatenation modes are defined: contiguous concatenation, which requires co-routing for each member signal and that all the interfaces along the path support this capability, and virtual concatenation, which allows diverse routing for member signals and requires that only the ingress and egress interfaces support this capability. Note that for the virtual concatenation, it may also specify co-routing or diverse routing. See [RFC4606] and [RFC4328] about concatenation information.

(5) Concatenation number: Indicates the number of signals that are requested to be contiguously or virtually concatenated. Also see [RFC4606] and [RFC4328].

(6) Technology-specific label(s): as defined in [RFC4606], [RFC6060], [RFC6002], or [RFC6205].

(7) End-to-End (E2E) path protection type: as defined in [RFC4872], e.g., 1+1 protection, 1:1 protection, (pre-planned) rerouting, etc.

(8) Administrative group: as defined in [RFC3630].

(9) Link protection type: as defined in [RFC4203].

(10) Support for unnumbered interfaces: as defined in [RFC3477].

(11) Support for asymmetric bandwidth requests: as defined in [RFC6387].

(12) Support for explicit label control during the path computation.

(13) Support of label restrictions in the requests/responses, similar to RSVP-TE ERO (Explicit Route Object) and XRO (Exclude Route Object), as defined in [RFC3473] and [RFC4874].

3.2. Requirements on Path Computation Reply

As described above, a PCE should compute the path that satisfies the constraints specified in the PCReq message. Then, the PCE should send a PCRep message, including the computation result, to the PCC. For a Path Computation Reply message (PCRep) in GMPLS networks, there are some additional requirements. The PCEP (PCE communication protocol) PCRep message must be extended to meet the following requirements.

(1) Path computation with concatenation

In the case of path computation involving concatenation, when a PCE receives the PCReq message specifying the concatenation constraints described in Section 3.1, the PCE should compute a path accordingly.

For path computation involving contiguous concatenation, a single route is required, and all the interfaces along the route should support contiguous concatenation capability. Therefore, the PCE should compute a path based on the contiguous concatenation capability of each interface and only one ERO that should carry the route information for the response.

For path computation involving virtual concatenation, only the ingress/egress interfaces need to support virtual concatenation capability, and there may be diverse routes for the different member signals. Therefore, multiple EROs may be needed for the response. Each ERO may represent the route of one or multiple member signals. When one ERO represents multiple member signals, the number must be specified.

(2) Label constraint

In the case that a PCC does not specify the exact label(s) when requesting a label-restricted path and the PCE is capable of performing the route computation and label assignment computation procedure, the PCE needs to be able to specify the label of the path in a PCRep message.

Wavelength restriction is a typical case of label restriction. More generally, label switching and selection constraints may apply in GMPLS-controlled networks, and a PCC may request a PCE to take label constraint into account and return an ERO containing the label or set of labels that fulfill the PCC request.

(3) Roles of the routes

When a PCC specifies the protection type of an LSP, the PCE should compute the working route and the corresponding protection route(s). Therefore, the PCRep should allow to distinguish the working (nominal) and the protection routes. According to these routes, the RSVP-TE procedure appropriately creates both the working and the protection LSPs, for example, with the ASSOCIATION object [RFC6689].

3.3. GMPLS PCE Management

This document does not change any of the management or operational details for networks that utilize PCE. (Please refer to [RFC4655] for manageability considerations for a PCE-based architecture.) However, this document proposes the introduction of several PCEP objects and data for the better integration of PCE with GMPLS networks. Those protocol elements will need to be visible in any management tools that apply to the PCE, PCC, and PCEP. That includes, but is not limited to, adding appropriate objects to existing PCE MIB modules that are used for modeling and monitoring PCEP deployments [PCEP-MIB]. Ideas for what objects are needed may be guided by the relevant GMPLS extensions in GMPLS-TE-STD-MIB [RFC4802].

4. Security Considerations

PCEP extensions to support GMPLS should be considered under the same security as current PCE work, and this extension will not change the underlying security issues. Section 10 of [RFC5440] describes the list of security considerations in PCEP. At the time [RFC5440] was published, TCP Authentication Option (TCP-AO) had not been fully specified for securing the TCP connections that underlie PCEP sessions. TCP-AO [RFC5925] has now been published, and PCEP implementations should fully support TCP-AO according to [RFC6952].

5. Acknowledgement

The authors would like to express thanks to Ramon Casellas, Julien Meuric, Adrian Farrel, Yaron Sheffer, and Shuichi Okamoto for their comments.

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