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Requirements for GMPLS applications of PCE

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Abstract

The initial effort of PCE WG is specifically focused on MPLS (Multi-protocol label switching). As a next step, this draft describes

functional requirements for GMPLS (Generalized MPLS) application of PCE (Path computation element).

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](#)].

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[1. Introduction](#)

The initial effort of PCE WG is focused on solving the path computation problem within a domain or over different domains in MPLS networks. As the same case with MPLS, service providers (SPs) have also come up with requirements for path computation in GMPLS networks such as wavelength, TDM-based or Ethernet-based networks as well.

[[RFC4655](#)] and [[RFC4657](#)] discuss the framework and requirements for PCE on both packet MPLS networks and (non-packet switch capable) GMPLS networks. This document complements these documents by providing some considerations of GMPLS applications in the intra-domain and inter-domain networking environments and indicating a set of requirements for the extended definition of series of PCE related protocols.

Note that the requirements for inter-layer traffic engineering described in [PCE-INTER LAYER-REQ] are outside of the scope of this document.

Constraint based shortest path first (CSPF) computation within a domain or over domains for signaling GMPLS Label Switched Paths (LSPs) is more stringent than that of MPLS TE LSPs [[RFC4216](#)], because the additional constraints, e.g., interface switching capability, link encoding, link protection capability and so forth need to be considered to establish GMPLS LSPs [[CSPF](#)]. GMPLS signaling protocol [[RFC3471](#), [RFC3473](#)] is designed taking into account bi-directionality, switching type, encoding type, SRLG, and protection attributes of the TE links spanned by the path, as well as LSP encoding and switching type for the end points, appropriately.

This document provides the investigated results of GMPLS applications of PCE for the support of GMPLS path computation. This document also provides requirements for GMPLS applications of PCE in GMPLS intra-domain and inter-domain environments.

2. Terminology

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 [[RFC2119](#)].

3. GMPLS applications of PCE

3.1. GMPLS network model

Figure 1 depicts a typical network, consisting of several GMPLS domains, assumed in this document. D1, D2, D3 and D4 have multiple inter-domain links, while D5 has only one inter-domain link. These domains follow the definition in [[RFC4726](#)].

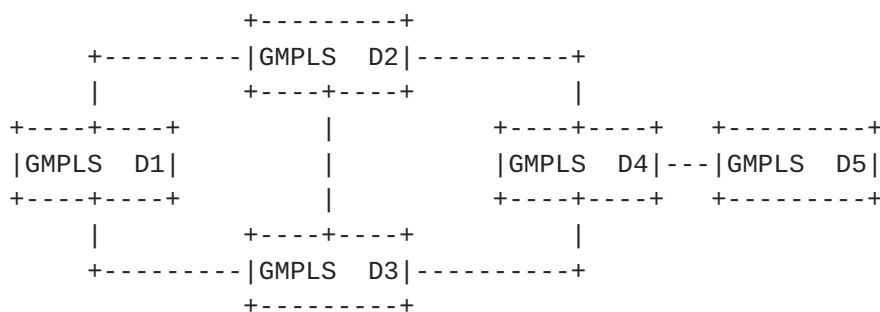


Figure 1: GMPLS Inter-domain network model.

Each domain is configured using various switching and link technologies defined in [[RFC3945](#)] and an end-to-end route needs to respect TE link attributes like switching capability, encoding type, etc., making the problem a bit different from the case of classical (packet) MPLS. In order to route from one GMPLS domain to another GMPLS domain appropriately, each domain manages traffic engineering database (TED) by PCE, and exchanges or provides route information of paths, while concealing its internal topology information.

3.2. Path computation in GMPLS network

[CSPF] describes consideration of GMPLS TE attributes during path computation. Figure 2 depicts a typical GMPLS network, consisting of an ingress link, a transit link as well as an egress link, to investigate a consistent guideline for GMPLS path computation. Each link at each interface has its own switching capability, encoding type and bandwidth.

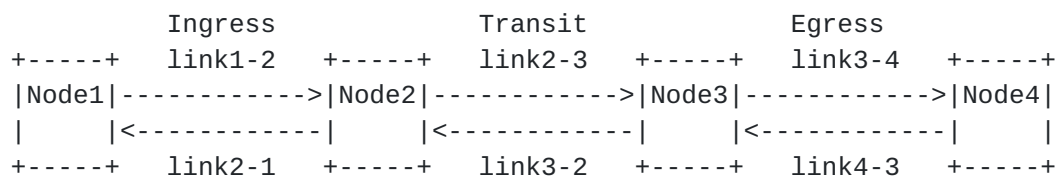


Figure 2: Path computation in GMPLS networks.

For the simplicity in consideration, the below 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 2) must be 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) should be consistent with switching type of a LSP to be created.
- (3) Encoding-types of all transit links should be consistent with encoding type of a LSP to be created.

[CSPF] indicates the possible tables of switching capability, encoding type and bandwidth at the ingress link, transiting links

and the egress link which need to be satisfied with GMPLS path computation of the created LSP.

The non-packet GMPLS networks (e.g., GMPLS-based TDM networks) are usually responsible for transmitting data for the client layer. These GMPLS 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 non-packet networks, for example, GMPLS-based TDM networks, are described in Figure 3. In order to simplify the description, this document just discusses the scenario in SDH networks as an example. The scenarios in SONET or G.709 ODUK layer networks are similar to this scenario.

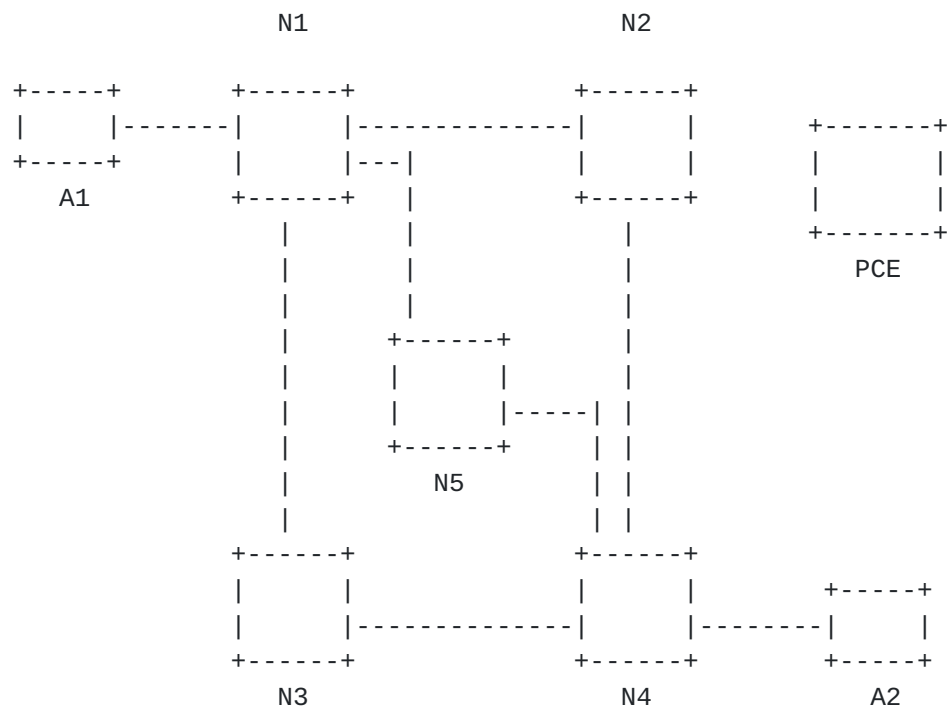


Figure 3: A simple TDM(SDH) network

Figure 3 shows a simple TDM(SDH) network topology, where N1, N2, N3, N4 and N5 are all SDH switches. Assume that one Ethernet service with 100M bandwidth is required from A1 to A2 over this network. The client Ethernet service could be provided by a VC4 connection from

N1 to N4, and it could also be provided by three concatenated VC3 connections (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 connections (one VC4 or three concatenated VC3) could be determined by PCC (e.g., N1 or NMS), but could also be determined by PCE automatically based on policy [[RFC5394](#)]. If it is determined by PCC, 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 message. PCE should consider those parameters during path computation. The route information (co-route or separated-route) should be specified in a PCRep message if path computation is performed successfully.

3.3. Unnumbered Interfaces

GMPLS supports unnumbered interface ID that is defined in [[RFC 3477](#)], which 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 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.

3.4. Asymmetric Bandwidth Path Computation

As per [[RFC5467](#)], GMPLS signaling can be used for setting up an asymmetric bandwidth bidirectional LSP. If a PCE is responsible for the path computation, the PCE should be capable of computing a path for the bidirectional LSP with asymmetric bandwidth. It means that the PCC should be able to indicate the asymmetric bandwidth requirements in forward and reverse directions in the PCReq message.

4. Requirements for GMPLS application of PCE

In this section, we describe requirements for GMPLS applications of PCE in order to establish GMPLS LSP.

4.1. Requirements of Path Computation Request

As for path computation in GMPLS networks as discussed in [section 3](#), the PCE should consider the GMPLS TE attributes appropriately according to tables in [[CSPF](#)] once a PCC or another PCE requests a path computation. Indeed, the path calculation request message from the PCC or the PCE must contain the information specifying appropriate attributes. According to [[RFC5440](#)], [[PCEP-EXT](#)], [PCE-

WSO-REQ] and to RSVP procedures like explicit label control(ELC), the additional attributes introduced are as follows:
[RFC5440]

(1) Switching capability: PSC1-4, L2SC, DCSC [RFC6002], 802_1 PBB-TE [RFC6060], TDM, LSC, FSC

(2) Encoding type: as defined in [RFC4202], [RFC4203], e.g., Ethernet, SONET/SDH, Lambda, etc.

(3) Signal Type: Indicates the type of elementary signal that constitutes the requested LSP. A lot of signal types with different granularity have been defined in SONET/SDH and G.709 ODUk, such as VC11, VC12, VC2, VC3 and VC4 in SDH, and ODU1, ODU2 and ODU3 in G.709 ODUk. See [RFC4606], [RFC4328] and [OSPF-G709] or [RSVP-TE-G709].

(4) Concatenation Type: In SDH/SONET and G.709 ODUk networks, two kinds of concatenation modes are defined: contiguous concatenation which requires co-route for each member signal and requires all the interfaces along the path to support this capability, and virtual concatenation which allows diverse routes for the member signals and only requires the ingress and egress interfaces to support this capability. Note that for the virtual concatenation, it also may specify co-routed or separated-routed. 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) such as wavelength label as defined in [RFC6205].

(7) 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 request: as defined in [RFC5467].

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

4.2. Requirements of Path Computation Reply

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

(1) Concatenation path computation

In the case of concatenation path computation, when a PCE receives the PCReq message specifying the concatenation constraints described in [section 4.1](#), the PCE should compute the path which satisfies the specified concatenation constraints.

For contiguous concatenation path computation, the routes of each member signal must be co-routed 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 which should carry the route information for the response.

For virtual concatenation path computation, only the ingress/egress interfaces need to support virtual concatenation capability and maybe there are 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. In the case that one ERO represents several member signals among the total member signals, the number of member signals along the route of the ERO must be specified.

(2) Wavelength label

In the case that a PCC doesn't specify the wavelength when requesting a wavelength path and the PCE is capable of performing the route and wavelength computation procedure, the PCE should be able to specify the wavelength of the path in a PCRep message.

(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 be capable of indicating which one is working or protection route.

4.3. GMPLS PCE Management

PCE related Management Information Bases must consider extensions to be satisfied with requirements for GMPLS applications. For extensions, [[RFC4802](#)] are defined to manage TE database and may be referred to accommodate GMPLS TE attributes in the PCE.

5. Security consideration

PCE extensions to support GMPLS should be considered under the same security as current PCE work. This extension will not change the underlying security issues.

6. IANA Considerations

This document has no actions for IANA.

7. Acknowledgement

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