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PCEP Extension for Distribution of Link-State and TE Information for Optical Networks

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Abstract

In order to compute and provide optimal paths, Path Computation Elements (PCEs) require an accurate and timely Traffic Engineering Database (TED). Traditionally this Link State and TE information has been obtained from a link state routing protocol (supporting traffic engineering extensions).

An existing experimental document extends the Path Computation Element Communication Protocol (PCEP) with Link-State and Traffic Engineering (TE) Information. This document provides further experimental extensions to collect Link-State and TE information for optical networks.

Status of this Memo

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Table of Contents

1. Introduction

[PCEP-LS] describes an experimental mechanism by which Link State (LS) and Traffic Engineering (TE) information can be collected from packet networks and shared through the Path Computation Element Communication Protocol (PCEP) with a Path Computation Element (PCE). This approach is called PCEP-LS and uses a new PCEP message format.

Problems in the optical networks, such as Optical Transport Networks (OTN), is becoming worse due to the growth of the network scalability. Such growths are also challenging the requirement of memory/storage on each equipment. The introduction of a PCEP-based LS helps solving the problem, with equally capability and functionalities.

This document describes an experimental extension to PCEP-LS for use in optical networks, and explains how encodings defined in [PCEP-LS] can be used in the optical network contexts.

1.1. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

2. Applicability

There are three main applicabilities of the mechanism described in this document:

- Case 1: There is IGP running in optical network but there is a need to collect LS and TE resource information at a PCE from individual or specific optical nodes more frequently of more rapidly than the IGP allows.

    o A PCE may receive full information or an incremental update (as opposed to the entire TE information of the node/link).

- Case 2: There is no IGP running in the optical network and there is a need to collect link-state and TE resource information from the optical nodes for use by the PCE.

- Case 3: There is a need to share abstract optical link-state and TE information from child PCE to a parent PCE in a hierarchical PCE (H-PCE) system per [RFC6805] and [RFC8751]. Alternatively, this requirement may exist between a Physical Network Controller (PNC) and a Multi-Domain Service Coordinator (MDSC) in the Abstraction and Control of TE Networks (ACTN) architecture [RFC8453].

  Note: The applicability for Case 3 may arise as a consequence of Case 1 and Case 2. When TE information changes occur in the optical network, this may also affect abstracted TE information and thus needs to be updated to the parent PCE/MSDC from each child PCE/PNC.

3. Requirements for PCEP Extension

The key requirements associated with link-state and TE information distribution are identified for PCEP and listed in Section 4 of [PCEP-LS]. These new functions introduced to PCEP to support distribution of link-state (and TE) information are described in Section 5 of [PCEP-LS]. Details of PCEP messages and related Objects/TLVs are specified in Sections 8 and 9 of [PCEP-LS]. The key requirements and new functions specified in [PCEP-LS] are equally applicable to optical networks.

Besides the generic requirements specified in [PCEP-LS], optical specific features also need to be considered. As a connection-based network, there are specific parameters such as reachability table, optical latency, wavelength consistency, and some other parameters that need to be included during the topology collection. Without these restrictions, the path computation may be inaccurate or infeasible for deployment, therefore these information MUST be included in the PCEP.

The procedure for using the optical parameters is described in following sections.

3.1. Reachable Source-Destination

The reachable source-destination node pair indicates that there are some OCh paths between two nodes. The reachability is restricted by impairment, wavelength consistency and so on. This information is necessary at the PCE to ensure that the path computed between source node and destination node is feasible. In this scenario, the PCE is responsible for computing how many OCh paths are available to set up connections between source and destination node. Moreover, if a set of optical wavelengths is indicated in the path computation request, the PCE also determines whether a wavelength from the set of preselected optical wavelengths is available for the source-destination pair connection.

To enable the PCE to complete the above functions, the reachable relationship and OMS link information need to be reported to the PCE. Once the PCE detects that any wavelength is available, the corresponding OMS link is marked as a candidate link in the optical network, which can then be used for path computation in the future.

Moreover, in a hierarchical PCE architecture, the information above needs to be reported from child PCE to parent PCE, which acts as a service coordinator.

3.2. Optical Latency

It is the usual case that the PCC indicates the latency when requesting the path computation. In optical networks the latency is a very sensitive parameter and there is stricter requirement on latency. Given the number of OCh paths between source-destination nodes, the PCE also need to determine how many OCh path satisfy the indicated latency threshold.

There is usually an algorithm running on the PCE to guarantee the performance of the computed path. During the computation, the delay factor may be converted into a kind of link weight. After the algorithm provides the candidate paths between the source and destination nodes, the PCE selects the best path by computing the total path propagation delay.

Optical PCEs contain optimization algorithms, e.g., shortest path algorithm, to select the best-performing path.

4. PCEP-LS Extensions for Optical Networks

This section provides the additional PCEP-LS extensions necessary to support optical networks. All Objects/TLVs defined in [PCEP-LS] are applicable to optical networks.

4.1. Node Attributes TLV

The Node-Attributed TLV is defined in Section 9.3.9.1 of [PCEP-LS]. This TLV is applicable for LS Node Object-Type as defined in [PCEP-LS].

This TLV contains a number of Sub-TLVs. [PCEP-LS] defines that any Node-Attribute defined for BGP-LS [BGP-LS] can be used as a Sub-TLV of the PCEP Node-Attribute TLV. BGP-LS does not support optical networks, so the Node-Attribute Sub-TLVs shown below are defined in this document for use in PCEP-LS for optical networks.

TBD1 The Connectivity Matrix Sub-TLV is used as defined in [RFC7579].

TBD2 The Resource Block Information Sub-TLV is used as defined in [RFC7688].

TBD3 The Resource Block Accessibility Sub-TLV is used as defined in [RFC7688].

TBD4 The Resource Block Wavelength Constraint Sub-TLV is used as defined in [RFC7688].

TBD5 The Resource Block Pool State Sub-TLV is used as defined in [RFC7688].

TBD6 The Resource Block Shared Access Wavelength Availability Sub-TLV is used as defined in [RFC7688].

4.2. Link Attributes TLV

The Link-Attributes TLV is defined in Section 9.3.9.2 of [PCEP-LS]. This TLV is applicable for the LS Link Object-Type as defined in [PCEP-LS].

This TLV contains a number of Sub-TLVs. [PCEP-LS] defines that any Node-Attribute defined for BGP-LS [BGP-LS] can be used as a Sub-TLV of the PCEP Link-Attribute TLV. BGP-LS does not support optical networks, so the Link-Attribute Sub-TLVs shown below are defined in this document for use in PCEP-LS for optical networks.

TBD7 The ISCD Sub-TLV is used to describe the Interface Switching Capability Descriptor as defined in [RFC4203].

TBD8 The OTN-TDM SCSI Sub-TLV is used to describe the Optical Transport Network Time Division Multiplexing Switching Capability Specific Information as defined in [RFC4203] and [RFC7138].

TBD9 The WSON-LSC SCSI Sub-TLV is used to describe the Wavelength Switched Optical Network Lambda Switch Capable Switching Capability Specific Information as defined in [RFC4203] and [RFC7688].

TBD10 The Flexi-grid SCSI Sub-TLV is used to describe the Flexi-grid Switching Capability Specific Information as defined in [RFC8363].

TBD11 The Port Label Restriction Sub-TLV is used as defined in [RFC7579], [RFC7580], and [RFC8363].

4.3. PCEP-LS for Optical Network Extension

This section provides additional PCEP-LS extension necessary to support the optical network parameters discussed in Sections 3.1 and 3.2.

Collection of link state and TE information is necessary before the path computation processing can be done. The procedure can be divided into: 1) link state collection by receiving the corresponding topology information in periodically; 2) path computation on the PCE, triggered by receiving a path computation request message from a PCC, and completed by transmitting a path computation reply with the path computation result, per [RFC4655].

For OTN networks, maximum bandwidth available may be per ODU 0/1/2/3 switching level or aggregated across all ODU switching levels (i.e., ODUj/k).

For Wavelength Switched Optical Networks (WSON) , Routing and Wavelength Assignment (RWA) information collected from Network Elements (Nes) would be utilized to compute light paths. The list of information collected can be found in [RFC7688]. More specifically, the maximum bandwidth available may be per lambda/frequency level

(OCh) or aggregated across all lambda/frequency levels. Per OCh level abstraction gives more detailed data to the P-PCE at the expense of more information processing. Either the OCh-level or the aggregated level abstraction in the RWA constraint (i.e., wavelength continuity) needs to be taken into account by the PCE during path computation. Resource Block Accessibility (i.e., wavelength conversion information) in [RFC7688] needs to be taken into account in order to guarantee the reliability of optical path computation.

5. Security Considerations

This document extends PCEP for LS (and TE) distribution in optical networks by including a set of Sub-TLVs to be carried in existing TLVs of existing messages. Procedures and protocol extensions defined in this document do not affect the overall PCEP security model (see [RFC5440] and [RFC8253]). The PCE implementation SHOULD provide mechanisms to prevent strains created by network flaps and amount of LS (and TE) information as defined in [PCEP-LS]. Thus, any mechanism used for securing the transmission of other PCEP message SHOULD be applied here as well. As a general precaution, it is RECOMMENDED that these PCEP extensions only be activated on authenticated and encrypted sessions belonging to the same administrative authority.

6. IANA Considerations

This document requests IANA actions to allocate code points for the protocol elements defined in this document.

6.1. PCEP-LS Sub-TLV Type Indicators

PCEP-LS] requests IANA to create a registry of "PCEP-LS Sub-TLV Type Indicators". IANA is requested to make the following allocations from this registry using the range 1 to 255.

Sub-TLV	Meaning
TBD1	Connectivity Matrix
TBD2	Resource Block Information
TBD3	Resource Block Accessibility
TBD4	Resource Block Wavelength Constraint
TBD5	Resource Block Pool State
TBD6	Resource Block Shared Access Wavelength Available
TBD7	ISCD
TBD8	OTN-TDM SCSI

	TBD9	WSON-LSC SCSI
	TBD10	Flexi-grid SCSI
	TBD11	Port Label Restriction

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