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Path Computation Element Communication Protocol (PCEP) Requirements for Wavelength Switched Optical Network (WSON) Routing and Wavelength Assignment

Abstract

This memo provides application-specific requirements for the Path Computation Element Communication Protocol (PCEP) for the support of Wavelength Switched Optical Networks (WSONs). Lightpath provisioning in WSONs requires a Routing and Wavelength Assignment (RWA) process. From a path computation perspective, wavelength assignment is the process of determining which wavelength can be used on each hop of a path and forms an additional routing constraint to optical light path computation. Requirements for PCEP extensions in support of optical impairments will be addressed in a separate document.

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1. Introduction

[RFC4655] defines the PCE-based architecture and explains how a Path Computation Element (PCE) may compute Label Switched Paths (LSPs) in networks controlled by Multiprotocol Label Switching Traffic Engineering (MPLS-TE) and Generalized MPLS (GMPLS) at the request of Path Computation Clients (PCCs). A PCC is shown to be any network component that makes such a request and may be, for instance, an optical switching element within a Wavelength Division Multiplexing (WDM) network. The PCE itself can be located anywhere within the network; it may be within an optical switching element, a Network Management System (NMS), or an Operational Support System (OSS), or it may be an independent network server.

The Path Computation Element Communication Protocol (PCEP) is the communication protocol used between a PCC and PCE; it may also be used between cooperating PCEs. [RFC4657] sets out the common protocol requirements for PCEP. Additional application-specific requirements for PCEP are deferred to separate documents.

This document provides a set of application-specific PCEP requirements for support of path computation in Wavelength Switched Optical Networks (WSONs). WSON refers to WDM-based optical networks in which switching is performed selectively based on the wavelength of an optical signal.

The path in WSON is referred to as a lightpath. A lightpath may span multiple fiber links, and the path should be assigned a wavelength for each link.

A transparent optical network is made up of optical devices that can switch but not convert from one wavelength to another. In a transparent optical network, a lightpath operates on the same wavelength across all fiber links that it traverses. In such cases, the lightpath is said to satisfy the wavelength-continuity constraint. Two lightpaths that share a common fiber link cannot be assigned the same wavelength. To do otherwise would result in both signals interfering with each other. Note that advanced additional multiplexing techniques such as polarization-based multiplexing are not addressed in this document since the physical-layer aspects are not currently standardized. Therefore, assigning the proper wavelength on a lightpath is an essential requirement in the optical path computation process.

When a switching node has the ability to perform wavelength conversion, the wavelength-continuity constraint can be relaxed, and a lightpath may use different wavelengths on different links along its path from origin to destination. It is, however, to be noted

that wavelength converters may be limited for cost reasons, while the number of WDM channels that can be supported in a fiber is also limited. As a WSON can be composed of network nodes that cannot perform wavelength conversion, nodes with limited wavelength conversion, and nodes with full wavelength conversion abilities, wavelength assignment is an additional routing constraint to be considered in all lightpath computations.

In this document, we first review the processes for Routing and Wavelength Assignment (RWA) used when wavelength continuity constraints are present and then specify requirements for PCEP to support RWA. Requirements for optical impairments will be addressed in a separate document.

The remainder of this document uses terminology from [RFC4655].

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].

2. WSON RWA Processes and Architecture

In [RFC6163], three alternative process architectures were given for performing routing and wavelength assignment. These are shown schematically in Figure 1, where R stands for Routing, WA for Wavelength Assignment, and DWA for Distributed Wavelength Assignment.

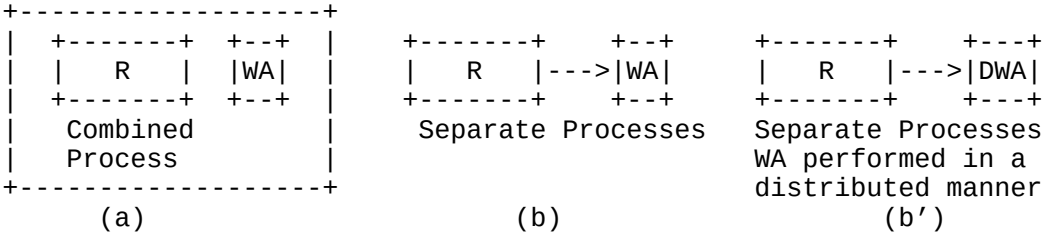

Figure 1: RWA Process Alternatives

These alternatives have the following properties and impact on PCEP requirements in this document.

(a) Combined Process (R&WA)

Path selection and wavelength assignment are performed as a single process. The requirements for PCC-PCE interaction with a PCE implementing such a combined RWA process are addressed in this document.

(b) Routing Separate from Wavelength Assignment (R+WA)

The routing process furnishes one or more potential paths to the wavelength assignment process that then performs final path selection and wavelength assignment. The requirements for PCE-PCE interaction with one PCE implementing the routing process and another implementing the wavelength assignment process are not addressed in this document.

(b') Routing and Distributed Wavelength Assignment (R+DWA)

A standard path computation (unaware of detailed wavelength availability) takes place, and then wavelength assignment is performed along this path in a distributed manner via signaling (RSVP-TE). This alternative is a particular case of R+WA and should be covered by GMPLS PCEP extensions; it does not present new WSON-specific requirements.

The various process architectures for implementing RWA have been reviewed above. Figure 2 shows one typical PCE-based implementation, which is referred to as the Combined Process (R&WA). With this architecture, the two processes of routing and wavelength assignment are accessed via a single PCE. This architecture is the base architecture from which the requirements are specified in this document.

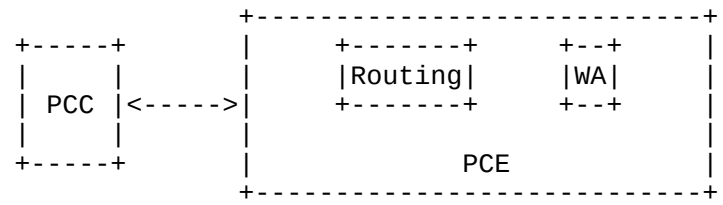

Figure 2: Combined Process (R&WA) Architecture

3. Requirements

The requirements for the PCC-to-PCE interface of Figure 2 are specified in this section.

3.1. Path Computation Type Option

A PCEP request MAY include the path computation type. This can be:

(a) Both RWA, or

(b) Routing only.

This requirement is needed to differentiate between the currently supported routing with distributed wavelength assignment option and combined RWA. For the distributed wavelength assignment option, wavelength assignment will be performed at each node of the route.

3.2. RWA Processing

As discussed in Section 2, various RWA processing options should be supported in a PCEP request/reply.

(a) When the request is an RWA path computation type, the request MUST further include the wavelength assignment options. At minimum, the following options should be supported:

  (i) Explicit Label Control (ELC) [RFC3473]

  (ii) A set of recommended labels for each hop. The PCC can select the label based on local policy.

  Note that option (ii) may also be used in R+WA or R+DWA.

(b) In case of an RWA computation type, the response MUST include the wavelength(s) assigned to the path and an indication of which label assignment option has been applied (ELC or label set).

(c) In the case where a valid path is not found, the response MUST include why the path is not found (e.g., network disconnected, wavelength not found, both, etc.). Note that 'wavelength not found' may include several sub-cases such as wavelength continuity not met, unsupported FEC/Modulation type, etc.

3.3. Bulk RWA Path Request/Reply

Sending simultaneous path requests for "routing only" computation is supported by the PCEP specification [RFC5440]. To remain consistent, the following requirements are added.

(a) A PCEP request MUST be able to specify an option for bulk RWA path requests. A bulk path request provides an ability to request a number of simultaneous RWA path requests.

(b) The PCEP response MUST include the path and the assigned wavelength for each RWA path request specified in the original bulk request.

3.4. RWA Path Reoptimization Request/Reply

This section provides a number of requirements concerning RWA path reoptimization processing in PCEP.

(a) For a reoptimization request, the request MUST provide both the path and current wavelength to be reoptimized and MAY include the following options:

  (i) Reoptimize the path keeping the same wavelength(s)

  (ii) Reoptimize wavelength(s) keeping the same path

  (iii) Reoptimize allowing both the wavelength and the path to change

(b) The corresponding response to the reoptimized request MUST provide the reoptimized path and wavelengths even when the request asked for the path or the wavelength to remain unchanged.

(c) In the case that the new path is not found, the response MUST include why the path is not found (e.g., network disconnected, wavelength not found, both, etc.). Note that 'wavelength not found' may include several sub-cases such as wavelength continuity not met, unsupported FEC/Modulation type, etc.

3.5. Wavelength Range Constraint

For any RWA computation type request, the requester (PCC) MUST be allowed to specify a restriction on the wavelengths to be used. The requester MAY use this option to restrict the assigned wavelength for explicit labels or label sets. This restriction may, for example, come from the tuning ability of a laser transmitter, any optical element, or a policy-based restriction.

Note that the requester (e.g., PCC) is not required to furnish any range restrictions.

3.6. Wavelength Assignment Preference

In a network with wavelength conversion capabilities (e.g., sparse 3R regenerators), a request SHOULD be able to indicate whether a single, continuous wavelength should be allocated or not. In other words, the requesting PCC SHOULD be able to specify the precedence of wavelength continuity even if wavelength conversion is available.

(a) An RWA computation type request MAY include the requester preference for random assignment, descending order, ascending order, etc. A response SHOULD follow the requester preference unless it conflicts with the operator's policy.

(b) A request for two or more paths MUST allow the requester to include an option constraining the paths to have the same wavelength(s) assigned. This is useful in the case of protection with a single transponder (e.g., 1+1 link disjoint paths).

3.7. Signal-Processing Capability Restriction

Signal-processing compatibility is an important constraint for optical path computation. The signal type for an end-to-end optical path must match at the source and at the destination.

The PCC MUST be allowed to specify the signal type at the endpoints (i.e., at the source and at the destination). The following signal-processing capabilities should be supported at a minimum:

- Modulation Type List
- FEC Type List

The PCC MUST also be allowed to state whether transit modification is acceptable for the above signal-processing capabilities.

4. Manageability Considerations

Manageability of WSON RWA with PCE must address the following considerations.

4.1. Control of Function and Policy

In addition to the parameters already listed in Section 8.1 of [RFC5440], a PCEP implementation SHOULD allow configuring the following PCEP session parameters on a PCC:

- The ability to send a WSON RWA request.

In addition to the parameters already listed in Section 8.1 of [RFC5440], a PCEP implementation SHOULD allow configuring the following PCEP session parameters on a PCE:

- The support for WSON RWA.

- The maximum number of bulk path requests associated with WSON RWA per request message.

These parameters may be configured as default parameters for any PCEP session the PCEP speaker participates in, or may apply to a specific session with a given PCEP peer or a specific group of sessions with a specific group of PCEP peers.

4.2. Information and Data Models

As this document only concerns the requirements to support WSON RWA, no additional MIB module is defined in this document. However, the corresponding solution document will list the information that should be added to the PCE MIB module defined in [RFC7420].

4.3. Liveness Detection and Monitoring

This document does not define any new mechanisms that imply any new liveness detection and monitoring requirements in addition to those already listed in Section 8.3 of [RFC5440].

4.4. Verifying Correct Operation

This document does not define any new mechanisms that imply any new verification requirements in addition to those already listed in Section 8.4 of [RFC5440]

4.5. Requirements on Other Protocols and Functional Components

If PCE discovery mechanisms ([RFC5089] and [RFC5088]) were to be extended for technology-specific capabilities, advertising WSON RWA path computation capability should be considered.

4.6. Impact on Network Operation

This document does not define any new mechanisms that imply any new network operation requirements in addition to those already listed in Section 8.6 of [RFC5440].

5. Security Considerations

This document has no requirement for a change to the security models within PCEP [RFC5440]. However, the additional information distributed in order to address the RWA problem represents a disclosure of network capabilities that an operator may wish to keep private. Consideration should be given to securing this information.

Solutions that address the requirements in this document need to verify that existing PCEP security mechanisms adequately protect the additional network capabilities and must include new mechanisms as necessary.

6. References

6.1. Normative References

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