Network Working Group
Internet Draft
Intended status: Informational
Expires: October 2012

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April 23, 2012

# PCEP Requirements for WSON Routing and Wavelength Assignment

draft-ietf-pce-wson-routing-wavelength-07.txt

## Status of this Memo

Abstract

This memo provides application-specific requirements for the Path Computation Element communication Protocol (PCEP) for the support of Wavelength Switched Optical Networks (WSON). 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 Optical impairments will be addressed in a separate document.

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 0.

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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 (LSP) in Multiprotocol Label Switching Traffic Engineering (MPLS-TE) and Generalized MPLS (GMPLS) networks 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, and may be within an optical switching element, a Network Management System (NMS) or Operational Support System (OSS), or may be an independent network server.

The PCE communications Protocol (PCEP) is the communication protocol used between PCC and PCE, and 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 (WSON). 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 case, the lightpath is said to satisfy the wavelength-continuity constraint. Two lightpaths that share a common fiber link can not 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 route from origin to destination. It is, however, to be noted that wavelength converters may be limited due to their relatively high cost, 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 computation.

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].

### 1.1. WSON RWA Processes

In [RFC6163] three alternative process architectures were given for performing routing and wavelength assignment. These are shown schematically in Figure 1.

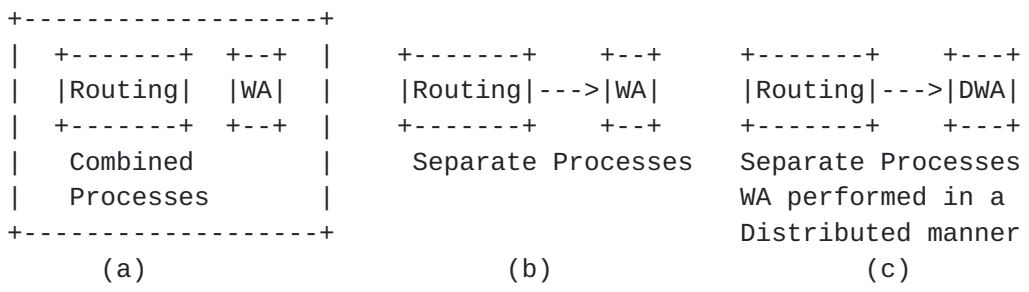


Figure 1 RWA process alternatives.

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

1. Combined Processes (R&WA) - Here path selection and wavelength assignment are performed as a single process. The requirements for PCC-PCE interaction with such a combined RWA process PCE is addressed in this document.

2. Routing separate from Wavelength Assignment (R+WA) - Here 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.

3. Routing and distributed Wavelength Assignment (R+DWA) - Here a standard path computation (unaware of detailed wavelength availability) takes place, then wavelength assignment is performed along this path in a distributed manner via signaling (RSVP-TE). This alternative should be covered by existing or emerging GMPLS PCEP extensions and does not present new WSON specific requirements.

## 2. WSON PCE Architectures and Requirements

In the previous section various process architectures for implementing RWA have been reviewed. Figure 2 shows one typical PCE based implementation, which is referred to as 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.

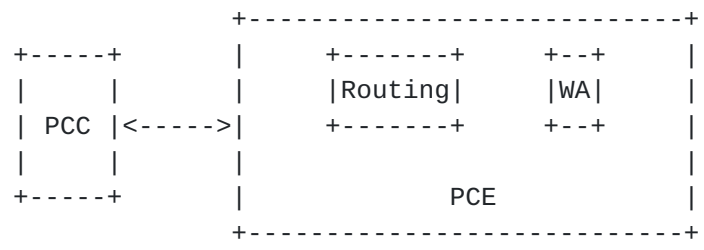


Figure 2 Combined Process (R&WA) architecture

### 2.1. RWA PCC to PCE Interface

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

#### 2.1.1. RWA Computation Type and Wavelength Assignment Option

1. The PCReq Message MUST include the path computation type. This can be:

   (i) Both Routing and Wavelength Assignment (RWA), or

   (ii) Routing only.

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

2. When the PCReq Message is RWA path computation type, the PCReq Message MUST further include the wavelength assignment options. At the minimum, the following option should be supported:

   (i) Explicit Label Control (ELC) [RFC4003]

   (ii) Non-Explicit labels in the form of Label Sets (This will allow Distributed WA at a node level where each node would select the wavelength from the Label Sets)

3. The PCRep Message MUST include the route, wavelengths assigned to the route and indication of which wavelength assignment option has been applied (ELC or Label Sets).

4. In the case where a valid path is not found, the PCRep Message MUST include why the path is not found (e.g., no route, wavelength not found, optical quality check failed, etc.)

#### 2.1.2. Bulk RWA path request/reply

1. The PCReq Message MUST be able to specify an option for bulk RWA path request. Bulk path request is an ability to request a number of simultaneous RWA path requests.

2. The PCRep Message MUST include the route, wavelength assigned to the route for each RWA path request specified in the original bulk PCReq Message.

#### 2.1.3. An RWA path re-optimization request/reply

1. For a re-optimization request, the PCReq Message MUST provide the path to be re-optimized and include the following options:

   a. Re-optimize the path keeping the same wavelength(s)

   b. Re-optimize wavelength(s) keeping the same path

   c. Re-optimize allowing both wavelength and the path to change

2. The corresponding PCRep Message for the re-optimized request MUST provide the Re-optimized path and wavelengths.

3. In case that the path is not found, the PCRep Message MUST include why the path is not found (e.g., no route, wavelength not found, both route and wavelength not found, etc.)

#### 2.1.4. Wavelength Range Constraint

For any PCReq Message that is associated with a request for wavelength assignment the requester (PCC) MUST be able to specify a restriction on the wavelengths to be used.

Note that the requestor (PCC) is NOT required to furnish any range restrictions. This restriction is to be interpreted by the PCE as a constraint on the tuning ability of the origination laser transmitter.

#### 2.1.5. Wavelength Policy Constraint

The PCReq Message May include specific operator's policy information for WA (E.g., random assignment, descending order, ascending order, etc.)

The PCReq Message SHOULD be able to request, when requesting a 1+1 connection (e.g. link disjoint paths), that both paths use the same wavelength.

Note that this is extremely useful in the case of protection with single transponder. Now, there is no way to specify such constraint.

The PCReq Message SHOULD be able to request, when performing 3R, that wavelength may change or not.

#### 2.1.6. Signal Processing Capability Restriction

The PCReq Message MUST be able to specify restrictions for signal compatibility either on the endpoint or any given link. The following signal processing capability should be supported at a minimum:

- Modulation Type List
- FEC Type List

## 3. Manageability Considerations

Manageability of WSON Routing and Wavelength Assignment (RWA) with PCE must address the following considerations:

### 3.1. 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.

### 3.2. Information and Data Models, e.g. MIB module

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

### 3.3. Liveness Detection and Monitoring

Mechanisms defined in this document do not imply any new liveness detection and monitoring requirements in addition to those already listed in section 8.3 of [RFC5440].

### 3.4. Verifying Correct Operation

Mechanisms defined in this document do not imply any new verification requirements in addition to those already listed in section 8.4 of [RFC5440]

### 3.5. Requirements on Other Protocols and Functional Components

The PCE Discovery mechanisms ([RFC5089] and [RFC5088]) may be used to advertise WSON RWA path computation capabilities to PCCs.

### 3.6. Impact on Network Operation

Mechanisms defined in this document do not imply any new network operation requirements in addition to those already listed in section 8.6 of [RFC5440].

## 4. 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.

## 5. IANA Considerations

This informational document does not make any requests for IANA action.

## 6. Acknowledgments

The authors would like to thank Adrian Farrel for many helpful comments that greatly improved the contents of this draft.

This document was prepared using 2-Word-v2.0.template.dot.

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## Acknowledgment

Funding for the RFC Editor function is currently provided by the Internet Society.