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PCEP Requirements for WSON Routing and Wavelength Assignment

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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 PCEP extensions in support of
   optical impairments will be addressed in a separate document.

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   This Internet-Draft will expire on February 13, 2009.

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 [RFC2119].

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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)-controlled 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 communication 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 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].

2. WSON RWA Processes & Architecture

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

```
   +------------------+
   |  +-------+  +--+  |     +-------+    +--+       +-------+    +---+
   |  |   R   |  |WA|  |     |   R   |--->|WA|       |   R   |--->|DWA|
   |  +-------+  +--+  |     +-------+    +--+       +-------+    +---+
   |   Combined       |      Separate Processes     Separate Processes
   |   Processes      |                             WA performed in a
   +------------------+                             distributed manner
        (a)                         (b)                    (b')
```
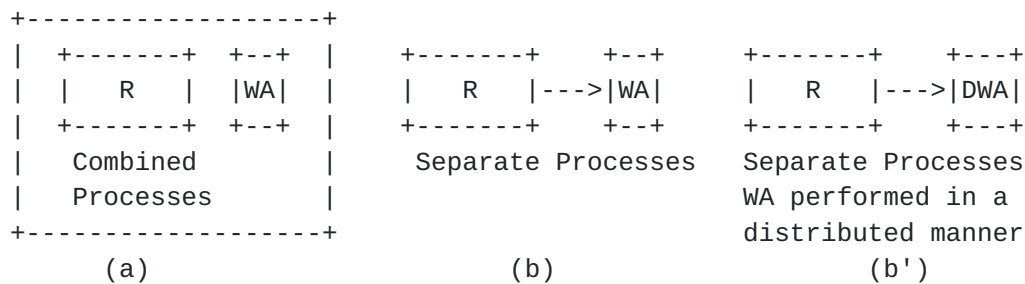
Figure 1. RWA process alternatives

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

(a)   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.

(b)   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.

(b') 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 is a
      particular case of R+WA and it should be covered by GMPLS PCEP
      extensions and does not present new WSON-specific
      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
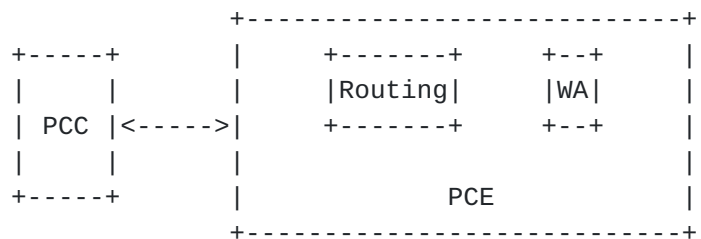are specified in this document.

```
                      +----------------------------+
          +-----+     |     +-------+     +--+     |
          |     |     |     |Routing|     |WA|     |
          | PCC |<----->|     +-------+     +--+     |
          |     |     |                            |
          +-----+     |           PCE              |
                      +----------------------------+
```

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:

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

   (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.

3.2. RWA Processing

(a)   When the request is a RWA path computation type, the request
      MUST further include the wavelength assignment options. At the
      minimum, the following option 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 a 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, or 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 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 request. Bulk path request is an ability to request a number
      of simultaneous RWA path requests.

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

3.4. RWA Path Re-optimization Request/Reply

1. For a re-optimization request, the request MUST provide both the
   path and current wavelength to be re-optimized and MAY 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 the wavelength and the path to
        change

2. The corresponding response to the re-optimized request MUST
   provide the re-optimized path and wavelengths even when the
   request asked for the path or the wavelength to remain unchanged.

3. In case that the new path (i.e., other than the current path) is
   not found, the response MUST include why the path is not found
   (e.g., network disconnected, wavelength not found, or 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 label or label set.

Note that the requester (e.g., PCC) is not required to furnish any
range restrictions. This restriction may for example come from the
tuning ability of a laser transmitter, any optical element, or a
policy-based restriction.

3.6. Wavelength Assignment Preference

1. A RWA computation type request MAY include the requester
   preference for, e.g., random assignment, descending order,
   ascending order, etc. A response SHOULD follow the requestor
   preference unless it conflicts with operator's policy.

2. 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 single transponder (e.g., 1+1 link disjoint paths).

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.

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 source and at destination.

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

   o Modulation Type List

   o 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 Routing and Wavelength Assignment (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:

   o 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:

   o The support for WSON RWA.

   o 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, 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].

4.3. 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].

4.4. 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]

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

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].

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.

6. IANA Considerations

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

7. Acknowledgments

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   contents of this draft.

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

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