         Update to the Include Route Object (IRO) Specification
      in the Path Computation Element Communication Protocol (PCEP)

Abstract

   The Path Computation Element Communication Protocol (PCEP) enables
   communications between a Path Computation Client (PCC) and a PCE, or
   between two PCEs. RFC 5440 defines the Include Route Object (IRO) to
   specify network elements to be traversed in the computed path. The
   specification does not specify if the IRO contains an ordered or
   unordered list of subobjects. During recent discussions, it was
   determined that there was a need to define a standard representation
   to ensure interoperability. It was also noted that there is a
   benefit in the handling of an attribute of the IRO's subobject, the L
   bit.

   This document updates RFC 5440 regarding the IRO specification.

Status of This Memo

   This is an Internet Standards Track document.

   This document is a product of the Internet Engineering Task Force
   (IETF). It represents the consensus of the IETF community. It has
   received public review and has been approved for publication by the
   Internet Engineering Steering Group (IESG). Further information on
   Internet Standards is available in Section 2 of RFC 7841.

   Information about the current status of this document, any errata,
   and how to provide feedback on it may be obtained at
   http://www.rfc-editor.org/info/rfc7896.

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1. Introduction

   The Path Computation Element Communication Protocol (PCEP) enables
   communications between a Path Computation Client (PCC) and a PCE, or
   between two PCEs. [RFC5440] defines the Include Route Object (IRO)
   to specify network elements to be traversed in the computed path.
   The specification does not specify if the IRO is an ordered or
   unordered list of subobjects. In addition, it defines the L bit as
   having no meaning within an IRO.

   [RFC5441] describes the use of an IRO to indicate the sequence of
   domains to be traversed during inter-domain path computation.

   During recent discussions, it was determined that there was a need to
   define a standard representation to ensure interoperability.

   This document updates the IRO specifications in Section 7.12 of
   [RFC5440].

2. Update in the IRO Specification

   Section 7.12 of [RFC5440] describes the IRO as an optional object
   used to specify a set of network elements to be traversed in the
   computed path. It states that the L bit in the subobject has no
   meaning within an IRO. It does not mention if the IRO contains an
   ordered or unordered list of subobjects.

2.1. Update to RFC 5440

   The IRO specification is updated to remove the last line in the
   Section 7.12 of [RFC5440], which states:

       "The L bit of such sub-object has no meaning within an IRO."

   Further, Section 7.12 of [RFC5440] is updated to add the following
   two statements at the end of the first paragraph.

   - The content of an IRO is an ordered list of subobjects
      representing a series of abstract nodes (refer to Section 4.3.2 of
      [RFC3209]).

   - The L bit of an IRO subobject is set based on the loose or strict
      hop property of the subobject; it is set if the subobject
      represents a loose hop. If the bit is not set, the subobject
      represents a strict hop. The interpretation of the L bit is as
      per Section 4.3.3.1 of [RFC3209].

3. Operational Considerations

   Because of the lack of clarity in [RFC5440], it is possible to
   encounter implementations that always interpret the IRO subobjects as
   loose. When these implementations interwork with an implementation
   conforming to this document, the following impact might be seen:

   o If a non-conforming (to this document) PCC sends an IRO to a
      conforming (to this document) PCE, then the PCE may unexpectedly
      fail to find a path (since the PCC may think of the IRO subobjects
      as loose hops, but the PCE interprets them as strict hops).

   o If a conforming PCC sends an IRO containing strict hops to a non-
      conforming PCE, then the PCE may erroneously return a path that
      does not comply with the requested strict hops (since the PCE
      interprets them all as loose hops). The PCC may check the
      returned path and find the issue, or it may end up using an
      incorrect path.

4. Security Considerations

   This update in the IRO specification does not introduce any new
   security considerations, apart from those mentioned in [RFC5440].
   Clarification in the supported IRO ordering or Loose hop bit handling
   will not have any negative security impact.

   It is worth noting that PCEP operates over TCP. An analysis of the
   security issues for routing protocols that use TCP (including PCEP)
   is provided in [RFC6952].

5. References

5.1. Normative References

   [RFC3209] Awduche, D., Berger, L., Gan, D., Li, T., Srinivasan, V.,
              and G. Swallow, "RSVP-TE: Extensions to RSVP for LSP
              Tunnels", RFC 3209, DOI 10.17487/RFC3209, December 2001,
              <http://www.rfc-editor.org/info/rfc3209>.

   [RFC5440] Vasseur, JP., Ed. and JL. Le Roux, Ed., "Path Computation
              Element (PCE) Communication Protocol (PCEP)", RFC 5440,
              DOI 10.17487/RFC5440, March 2009,
              <http://www.rfc-editor.org/info/rfc5440>.

5.2. Informative References

   [RFC5441] Vasseur, JP., Ed., Zhang, R., Bitar, N., and JL. Le Roux,
              "A Backward-Recursive PCE-Based Computation (BRPC)
              Procedure to Compute Shortest Constrained Inter-Domain
              Traffic Engineering Label Switched Paths", RFC 5441,
              DOI 10.17487/RFC5441, April 2009,
              <http://www.rfc-editor.org/info/rfc5441>.

   [RFC6952] Jethanandani, M., Patel, K., and L. Zheng, "Analysis of
              BGP, LDP, PCEP, and MSDP Issues According to the Keying
              and Authentication for Routing Protocols (KARP) Design
              Guide", RFC 6952, DOI 10.17487/RFC6952, May 2013,
              <http://www.rfc-editor.org/info/rfc6952>.

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