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PCE support for Maximizing Diversity
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Abstract

The computation of one or a set of Traffic Engineering Label Switched Paths (TE LSPs) in MultiProtocol Label Switching (MPLS) and Generalized MPLS (GMPLS) networks is subject to a set of one or more specific optimization criteria, referred to as objective functions.

In the Path Computation Element (PCE) architecture, a Path Computation Client (PCC) may want a set of services that are required to be diverse (disjointed) from each other. In case when full diversity could not be achieved, it is helpful to maximize diversity as much as possible (or in other words, minimize the common shared resources).

This document defines objective function code types for three new objective functions for this purpose to be applied to a set of synchronized path computation requests.

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1. Introduction

[RFC5440] describes the specifications for the Path Computation Element Communication Protocol (PCEP). PCEP specifies the communication between a Path Computation Client (PCC) and a Path

Computation Element (PCE), or between two PCEs based on the PCE architecture [RFC4655].

Further [RFC5440] describes dependent path computation requests in which case computations cannot be performed independently of each other, and usually used for diverse path computation. [RFC5440] and [RFC6006] describe the use of Synchronization VECtor (SVEC) dependency flags (i.e., Node, Link, or Shared Risk Link Group (SRLG) diverse flags).

In some scenario it may be noted that full diversity cannot be achieved because of topology considerations, deployment considerations, transient network issues etc. In this case it would be helpful to maximize diversity as much as possible (or in other words minimize the common shared resources (Node, Link or SRLG) between a set of paths during path computation).

It is interesting to note that for non synchronized diverse path computation the X bit in Exclude Route Object (XRO) or Explicit Exclusion Route subobject (EXRS) [RFC5521] can be used, where X bit set as 1 indicates that the resource specified SHOULD be excluded from the path computed by the PCE, but MAY be included subject to PCE policy and the absence of a viable path that meets the other constraints and excludes the resource. Thus X bit can be used in a way to maximize diversity (or minimize common shared resources) when full diversity cannot be achieved.

This document defines objective function code types for three new objective functions for this purpose to be applied to a set of synchronized path computation requests.

1.1. Requirements Language

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. Terminology

The terminology is as per [RFC5440].

3. Extension to PCEP

[RFC5541] describes and define Objective function (OF) used in PCEP protocol.

To minimize the common shared resources (Node, Link or SRLG) between a set of paths during path computation three new OF codes are proposed:

MSL

* Name: Minimize the number of shared (common) Links.

* Objective Function Code: TBD

* Description: Find a set of paths such that it passes through the least number of shared (common) links.

MSN

* Name: Minimize the number of shared (common) Nodes.

* Objective Function Code: TBD

* Description: Find a set of paths such that it passes through the least number of shared (common) nodes.

MSS

* Name: Minimize the number of shared (common) SRLG.

* Objective Function Code: TBD

* Description: Find a set of paths such that it share least number of common SRLGs.

4. Other Considerations

4.1. Relationship between SVEC Diversity Flags and OF

[RFC5440] uses SVEC diversity flag for node, link or SRLG to describe the potential disjointness between the set of path computation requests used in PCEP protocol. [I-D.dwpz-pce-domain-diverse] further extends by adding domain-diverse O-bit in SVEC object and a new OF Code for minimizing the number of shared transit domain.

This document defines three new OF codes to maximize diversity as much as possible, in other words, minimize the common shared resources (Node,Link or SRLG) between a set of paths.

It may be interesting to note that the diversity flags in the SVEC object and OF for diversity can be used together. Some example of usage are listed below -

- SVEC object with node-diverse bit=1 - ensure full node-diversity.
- SVEC object with node-diverse bit=1 and OF=MSS - full node diverse with as much as SRLG-diversity as possible.
- SVEC object with domain-diverse bit=1;link diverse bit=1 and OF=MSS - full domain and node diverse path with as much as SRLG-diversity as possible.
- SVEC object with node-diverse bit=1 and OF=MSN - ensure full node-diversity.

4.2. Inter-Domain Considerations

The mechanics for synchronous end to end path computations using Backward-Recursive PCE-Based Computation (BRPC) procedure [RFC5441] described in [RFC6006].

In H-PCE [RFC6805] architecture, the parent PCE is used to compute a multi-domain path based on the domain connectivity information. The parent PCE may be requested to provide a end to end path or only the sequence of domains. Child PCE should be able to request synchronized diverse end to end paths from its parent PCE.

The new objective function described in this document can be used to maximize diversity when full diverse paths cannot be found.

4.3. Domain Diversity

As per [I-D.dwpz-pce-domain-diverse].

4.4. Diversity v/s Optimality

In case of non-synchronized path computation, PCE may be requested to provide an optimal primary path first and then PCC requests for a backup path with exclusion. Note that this approach does not guarantee diversity comparing to disjoint path computations for primary and backup path in a synchronized manner.

A synchronized path computation with diversity flags and/or objective function is used to make sure that both the primary path and the backup path can be computed simultaneously with full diversity or optimized to be as diverse as possible. In the latter case we may sacrifice optimal path for diversity, thus there is a trade-off between the two.

An implementation may further choose to analyze the trade-off i.e. it may send multiple request to PCE asking to optimize based on

diversity as well as say, cost and make an intelligent choice between them.

5. Security Considerations

PCEP security mechanisms are described in [RFC5440] and are used to secure entire PCEP messages. Nothing in this document changes the message flows or introduces any new messages, so the security mechanisms set out in [RFC5440] continue to be applicable.

This document add new OF codes that may optionally be carried on PCEP messages with OF object [RFC5541] and will be automatically secured using the mechanisms described in [RFC5440].

If a PCEP message is vulnerable to attack (for example, because the security mechanisms are not used), then the OF object could be used as part of an attack; however, it is likely that other objects will provide far more significant ways of attacking a PCE or PCC in this case.

6. Manageability Considerations

6.1. Control of Function and Policy

In addition to [RFC5440], the PCC should construct the SVECs to identify and associate diverse SVEC relationships. Considerations for use of objective functions are mentioned in [RFC5541].

6.2. Information and Data Models

The PCEP MIB Module defined in [RFC7420], there are no additional parameters identified in this document.

6.3. Liveness Detection and Monitoring

[RFC5440] provides a sufficient description for this document. There are no additional considerations.

6.4. Verify Correct Operations

[RFC5440] provides a sufficient description for this document. There are no additional considerations.

6.5. Requirements On Other Protocols

[RFC5440] provides a sufficient description for this document. There are no additional considerations.

6.6. Impact On Network Operations

Mechanisms defined in this document do not have any impact on network operations in addition to those already listed in [RFC5440] and [RFC5541].

7. IANA Considerations

As described in Section 3, three new Objective Functions have been defined. IANA has made the following allocations from the PCEP "Objective Function" sub-registry:

Value	Description	Reference
(TBD)	MSL	[This I.D.]
(TBD)	MSN	[This I.D.]
(TBD)	MSS	[This I.D.]

8. Acknowledgments

We would like to thank Adrian Farrel for pointing out the need for this document.

9. References

9.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

[RFC5440] Vasseur, JP. and JL. Le Roux, "Path Computation Element (PCE) Communication Protocol (PCEP)", RFC 5440, March 2009.

[RFC5541] Le Roux, JL., Vasseur, JP., and Y. Lee, "Encoding of Objective Functions in the Path Computation Element Communication Protocol (PCEP)", RFC 5541, June 2009.

9.2. Informative References

[RFC4655] Farrel, A., Vasseur, J., and J. Ash, "A Path Computation Element (PCE)-Based Architecture", RFC 4655, August 2006.

[RFC5441] Vasseur, JP., 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, April 2009.

[RFC5521] Oki, E., Takeda, T., and A. Farrel, "Extensions to the Path Computation Element Communication Protocol (PCEP) for Route Exclusions", RFC 5521, April 2009.

[RFC6006] Zhao, Q., King, D., Verhaeghe, F., Takeda, T., Ali, Z., and J. Meuric, "Extensions to the Path Computation Element Communication Protocol (PCEP) for Point-to-Multipoint Traffic Engineering Label Switched Paths", RFC 6006, September 2010.

[RFC6805] King, D. and A. Farrel, "The Application of the Path Computation Element Architecture to the Determination of a Sequence of Domains in MPLS and GMPLS", RFC 6805, November 2012.

[RFC7420] Koushik, A., Stephan, E., Zhao, Q., King, D., and J. Hardwick, "Path Computation Element Communication Protocol (PCEP) Management Information Base (MIB) Module", RFC 7420, December 2014.

[I-D.dwpz-pce-domain-diverse]
Dhody, D., Wu, Q., Palle, U., and X. Zhang, "PCE support for Domain Diversity", draft-dwpz-pce-domain-diverse-03 (work in progress), April 2015.

Appendix A. Contributor Addresses

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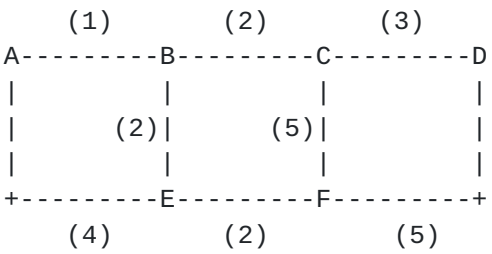
Appendix B. Example

This section illustrate an example based on SRLG.



Node A is Ingress, Node D is Egress. A synchronized path computation requests for SRLG disjoint path may be issued using the SVEC object as described in [RFC5440]. In above topology a full SRLG disjoint paths are not possible because of some topology considerations.

In such scenario, an OF MSS maybe used instead to minimize the number of shared (common) SRLG to get maximum diversity when full diversity may not be possible.

In case of sequential non-synchronized path computation, primary path will be computed first, say the path is (A--B--C--D) with SRLG list (1,2,3). A backup path computation using XRO and SRLG sub-object with X bit (loose) set as 1, can be used to achieve a similar result.

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