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ISOCORE

MPLS Interoperability

Path Computation Element Communication Protocol

DRAFT

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Date	Revisions/Changes
3/18/08	**First Draft**
4/11/08	**Changes in section 3.2**
3/10/2010	**updated references**
3/10/2010	**Updated section 4**
9/1/2010	**Minor changes**
08/24/2012	**Minor changes and updated references**

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1 Introduction

This document provides a test plan to validate deployment of the PCEP, Path Computation Element (Communication) Protocol and related technologies. The protocol enables communication between a PCC and a PCE, or between two PCEs. The protocol enables the PCE and PCC to be separated; without it, they must be collocated and considered as one logical unit that serves both functions.

Some test scenarios have been designed for peripheral features of PCEP that some vendors may not plan to implement. It is also understood that some of the systems under test are in beta or even alpha stages in the development process. It is NOT necessary to implement all the functions defined in the test cases in order to participate in the upcoming test activity.

One of the goals of this program is to promote rapid adoption of PCEP technology in products destined for the commercial marketplace. We will support this objective by validating implementations of PCEP in an independent, multi-vendor network infrastructure. The results of the tests will be used to provide input to the IETF which will help correct any discrepancies in the specifications. In the event that problems or issues are discovered, they will be addressed individually between the vendors involved in full confidentiality.

This document is work-in-progress and will be refined and updated based on input from test participants (vendors) and carrier members of Isocore Internetworking lab.

The topologies shown in this document are only preliminary examples. After vendor implementation details have been confirmed, a final topology capable of supporting all tests will be designed and distributed. We expect it will be desirable to configure multiple MPLS TE paths in the final topology.

2 Abbreviations

For more information about the abbreviations used in this document, please see [draft-ietf-pce-pcep].

- PCC – Path Computation Client
- PCE – Path Computation Element
- GMPLS – Generalized Multiprotocol Label Switching
- MPLS TE – Multiprotocol Label Switching Traffic Engineering

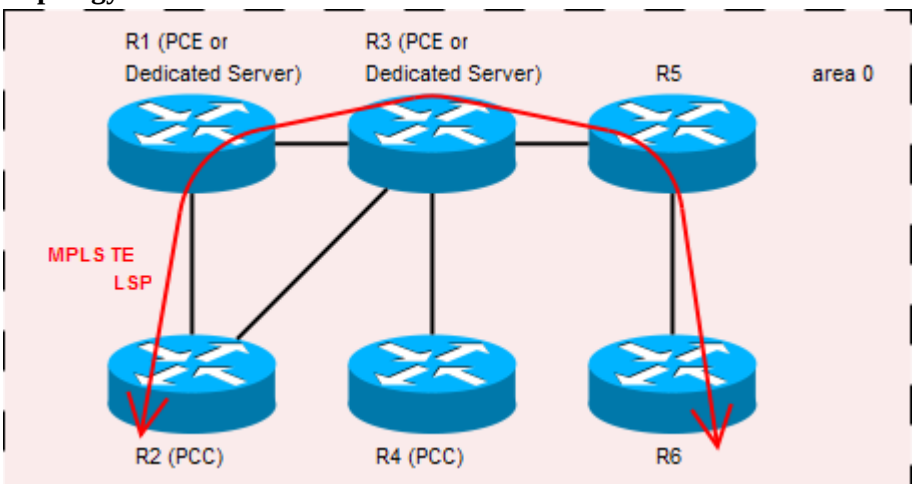
3 PCEP

3.1 Test case: Session Initiation

3.1.1 Configuration A

Purpose: Ensure sessions are correctly initialized and that only one session can be initiated per PCC/PCE or PCE/PCE pair.

Topology:



There may be dedicated servers for PCEs, which are not co-located with routers. In such a scenario, R1 or R3 should be read as dedicated server in the following text.

3.1.1.1 PCC to PCE Communication

Procedure:

1. Build topology. At least 2 routers (R1 and R3) or dedicated servers should be capable of PCE functionality and at least 1 router (R4 or R2) should be capable of PCC functionality. Ensure PCE has enough information to compute path from R2 to R6 (*This test plan assumes OSPF will be used but other routing protocols can be substituted with minor changes. Static routes can be used for some test scenarios).*
2. Configure R3 and R4 (or R2) with PCE and PCC roles respectively (R3 must have enough information to compute path).
3. Establish a PCEP session between R3 and R4 (or R2).
4. Attempt to establish an additional PCEP session between R3 and R4 (or R2).
5. If provided by the implementation, query and observe the following parameters: PCEP Session failure count, amount of time the session has been in active state, number of

corrupted messages, response time, number of requests not replied to, and number of failed computations. Report any anomalies. If an optional error log is maintained, check it for anomalies.

Expected Result: Initial session is successfully established. Attempts to establish additional sessions do not create duplicate PCEP connections between the devices.

3.1.1.2 PCE to PCE Communication

Procedure:

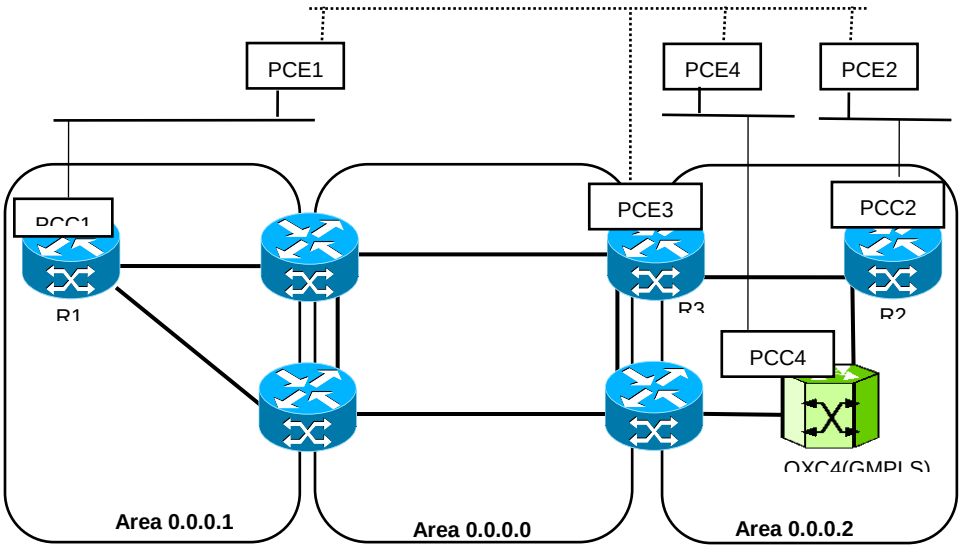
1. Retain topology.
2. Configure R1 with a PCE role.
3. Establish a PCEP session between R1 and R3.
4. Attempt to establish an additional PCEP session between R1 and R3.
5. If provided by the implementation, query and observe the following parameters: PCEP Session failure count, amount of time the session has been in active state, number of corrupted messages, response time, number of requests not replied to, and number of failed computations. Report any anomalies. If an optional error log is maintained, check it for anomalies.

Expected Result: Initial session is correctly established. Attempts to establish additional sessions do not create duplicate PCEP connections between the devices.

3.1.2 Configuration B

Purpose: Ensure sessions are correctly initialized and that only one session can be initiated per PCC/PCE or PCE/PCE pair.

Topology:



3.1.2.1 PCC to PCE Communication

Procedure:

6. Build topology shown covering two PCE models, composite PCE model and external PCE model. At least 1 router (R3) should be capable of PCE functionality and at least 3 routers (R1, R2 and OXC4) should be capable of PCC functionality connecting to PCE server. Ensure PCE has enough information to compute path from each ingress router (*This test plan assumes OSPF will be used but other routing protocols can be substituted with minor changes. Static routes can be used for some test scenarios).*
7. Configure PCC1/PCC2/PCC4 and PCE1/PCE2/PCE4 (PCE1/PCE2/PCE3/PCE4 must have enough information to compute path).
8. Establish a PCEP session between PCC1(R1) and PCE1.
9. Attempt to establish an additional PCEP session between PCC2(R2) and PCE2.
10. Attempt to establish an additional PCEP session between PCC4(OXC4) and PCE4.
11. If provided by the implementation, query and observe the following parameters: PCEP Session failure count, amount of time the session has been in active state, number of corrupted messages, response time, number of requests not replied to, and number of failed computations. Report any anomalies. If an optional error log is maintained, check it for anomalies.

Expected Result: Initial session is successfully established. Attempts to establish additional sessions do not create duplicate PCEP connections between the devices.

3.1.2.2 PCE to PCE Communication

Procedure:

6. Retain topology.
7. Configure R3 with a PCE role.
8. Establish a PCEP session between R3 and PCE1(R1).
9. Attempt to establish an additional PCEP session between R3 and PCE2(R2).
10. If provided by the implementation, query and observe the following parameters: PCEP Session failure count, amount of time the session has been in active state, number of corrupted messages, response time, number of requests not replied to, and number of failed computations. Report any anomalies. If an optional error log is maintained, check it for anomalies.

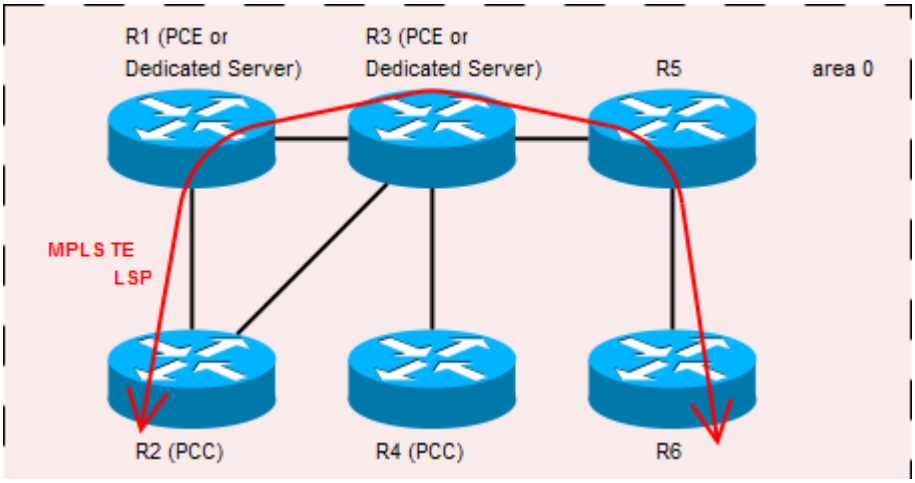
Expected Result: Initial session is correctly established. Attempts to establish additional sessions do not create duplicate PCEP connections between the devices.

3.2 Test case: Path Computation Request and Reply

3.2.1 Configuration A

Purpose: Ensure path computation request communication between a PCE and a PCC with and without provided constraint metrics is reliable and accurate. Ensure device behaviors in situations not specifically addressed by the standard are appropriate.

Topology:



Procedure:

1. Construct the topology shown.
2. Configure PCC (R4 or R2) to send a request to R3 for a path from R2 to R6. No constraint should be specified.
3. Configure PCC (R4 or R2) to send a request to R3 for a path from R2 to R6. A constraint metric should be specified, but such that the PCE (R3) is able to satisfy the request (possible metrics include IGP, TE, and hop count)
4. Configure PCC (R4 or R2) to send a request to R3 for a path from R2 to R6. At least two constraint metrics should be specified such that the PCE (R3) must solve a multi-constraint problem to find and return the path. The constraint problem should be solvable.
5. Configure PCC (R4 or R2) to send a request to R3 for a path from R2 to R6. At least one constraint metric should be specified, but such that the PCE (R3) is *not* able to satisfy the request.
   a. Ensure that the PCC device which requested the path (R4 or R2) handles the failure gracefully.
6. Configure PCC (R4 or R2) to send a request to R3 for a path from R2 to R6 and a path from <> to <>. The path computation requests should be synchronized.
   a. Request two synchronized path computation requests without disjoint requirements.
   b. Request two synchronized path computation requests with disjoint requirements.
7. Configure PCC(R4 or R2) to send a request to R3 for a path from R2 to R6 and a path from <> to <>. The path computation requests should be unsynchronized. The second path request has the “exclude route” constraint. The exclude route is the first path-allocated route.

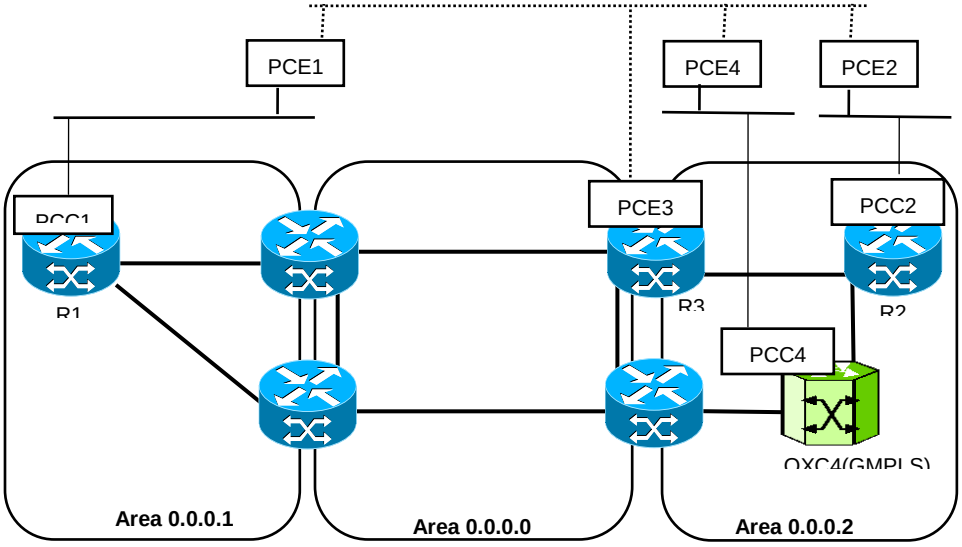
8. Configure R4 to send a request to R3 for diverse path from R2 to R6 with diversity constraint(Node, Link or SRLG). The path computation requests should be synchronized.
9. If provided by the implementation, query and observe the following parameters: PCEP Session failure count, amount of time the session has been in active state, number of corrupted messages, response time, number of requests not replied to, and number of failed computations. Report any anomalies. If an optional error log is maintained, check it for anomalous entries.

Expected Result: PCE router provides a path when it is able to satisfy the request and no path when it is unable to. PCC router is able to interpret the path reply provided by PCE router correctly.

3.2.2 Configuration B

Purpose: Ensure path computation request communication between a PCE and a PCC with and without provided constraint parameters is reliable and accurate. Ensure device behaviors in situations not specifically addressed by the standard are appropriate.

Topology:



Procedure:

1. Construct the topology shown.
2. Configure R1to send a request to PCE1 for a MPLS path from R1 to R2. XRO and bandwidth constraint should be specified.
3. Configure R2 to send a request to PCE2 for a MPLS path from R2 to R1. Link disjoint constraint should be specified for inter-area redundancy paths.
4. Configure R3 to send a request to R1 for a MPLS path from R3 to R1. At least two constraint metrics should be specified such that the PCE (R3) must solve a multi-constraint problem to find and return the path. The constraint problem should be solvable.

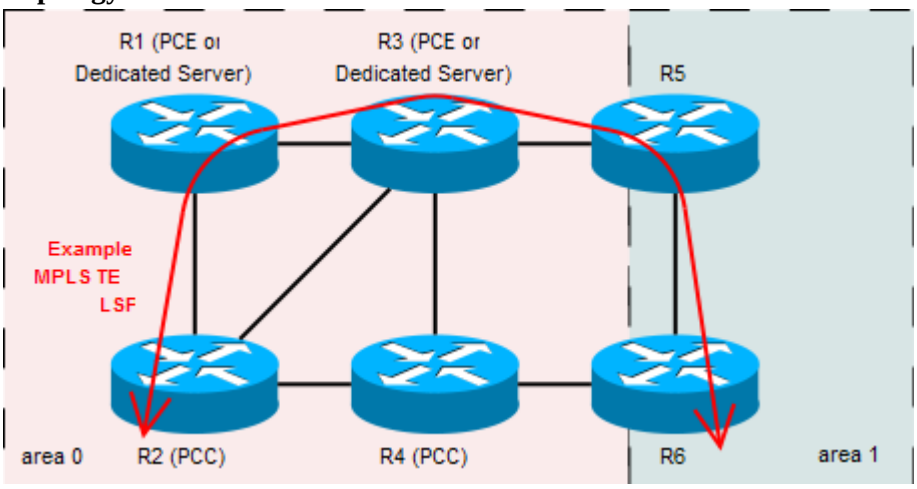
5. Configure R2 to send a request to PCE2 for a GMPLS path from R2 to R1 via OXC4. SRLG Disjoint constraint should be specified. OXC4(PCC4) modifies the GMPLS path controlled by PCE4
6. If provided by the implementation, query and observe the following parameters: PCEP Session failure count, amount of time the session has been in active state, number of corrupted messages, response time, number of requests not replied to, and number of failed computations. Report any anomalies. If an optional error log is maintained, check it for anomalous entries.

3.3 Test case: Inter-area Path Communication

3.3.1 Two Areas

Purpose: Ensure automatic discovery of PCE devices via the extensions to OSPFv2 and v3 defined in RFC5088 is effective. Identify any interoperability issues caused by incomplete implementations (routers which don't support the PCED TLV will silently ignore it, so no verification is required).

Topology:



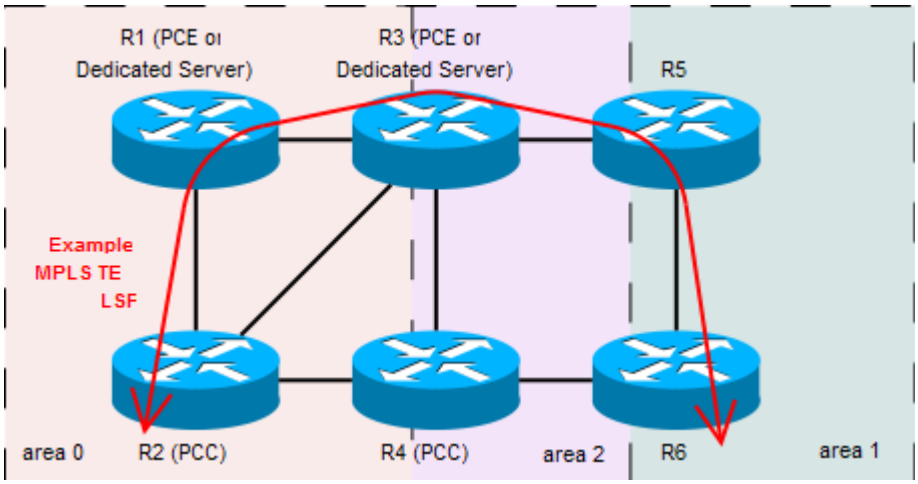
Procedure:

1. Retain topology.
2. Configure PCC (R4 or R2) to send a request to R3 for a path from R2 to R6. No constraint should be specified.
3. Configure PCC (R4 or R2) to send a request to R3 for a path from R2 to R6. A constraint metric should be specified, but such that the PCE (R3) is able to satisfy the request (possible metrics include IGP, TE, and hop count).
4. Configure PCC (R4 or R2) to send a request to R3 for a path from R2 to R6. At least two constraint metrics should be specified such that the PCE (R3) must solve a multi-constraint problem to find and return the path.
5. Configure PCC (R4 or R2) to send a request to R3 for a path from R2 to R6 and a path from <> to <>. The path computation requests should be synchronized. PCE (R3) must return the path route.

6. Configure PCC (R4 or R2) to send a request to R3 for a path from R2 to R6 and a path from <> to <>. The path computation requests should be unsynchronized. The second path request has the exclude route constraint. The exclude route is the first path allocated route. PCE (R3) must return the path route.

3.3.2 Three Areas

Topology:

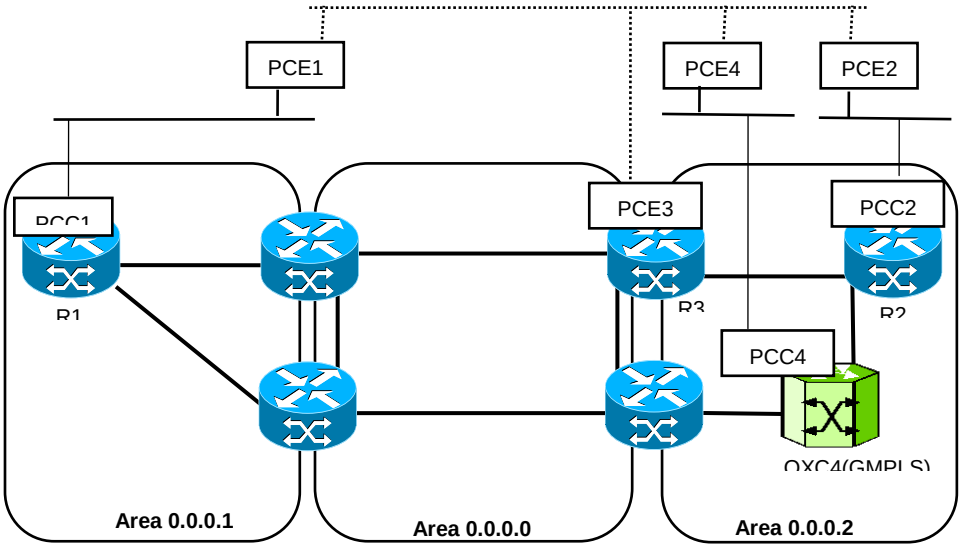


Procedure:

7. Retain topology.
8. Configure PCC (R2) to send a request to R1 for a path from R2 to R6. No constraint should be specified, but PCE (R1) must return the path route by communication between PCE (R3 or R5) with BRPC protocol
9. Configure PCC (R2) to send a request to R1 for a path from R2 to R6. A constraint metric should be specified, but such that the PCE (R1) is able to satisfy the request (possible metrics include IGP, TE, and hop count) by communication between PCE (R3 or R5) with BRPC protocol.
10. Configure PCC (R2) to send a request to R1 for a path from R2 to R6. At least two constraint metrics should be specified such that the PCE (R1) must solve a multi-constraint problem to find and return the path by communication between PCE (R3 or R5) with BRPC protocol. The constraint problem should be solvable.
11. Configure PCC (R2) to send a request to R1 for a path from R2 to R6 and a path from <> to <>. The path computation requests should be synchronized. PCE (R1) must return the path route by communication between PCE (R3 or R5) with BRPC protocol
12. Configure PCC (R2) to send a request to R1 for a path from R2 to R6 and a path from <> to <>. The path computation requests should be unsynchronized. The second path request has the exclude route constraint. The exclude route is the first path allocated route. PCE (R1) must return the path route by communication between PCE (R3 or R5) with BRPC protocol

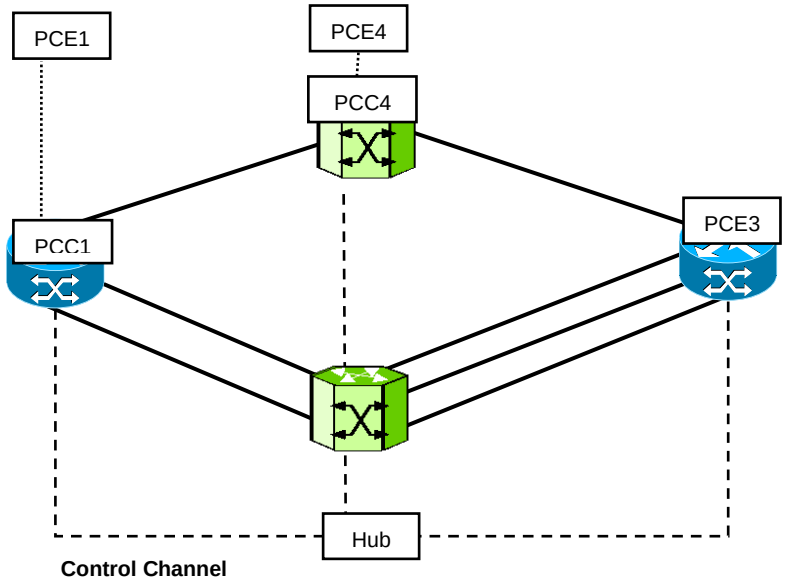
3.3.3 Three Areas, additional PCEs

Topology:



3.4 Test case: GMPLS Path Communication

Topology:



4 PCE Discovery

Purpose: Ensure automatic discovery of PCE devices via the extensions to OSPFv2 and v3 defined in RFC5088 is effective. Identify any interoperability issues caused by incomplete implementations (routers which don't support the PCED TLV will silently ignore it).

Procedure:

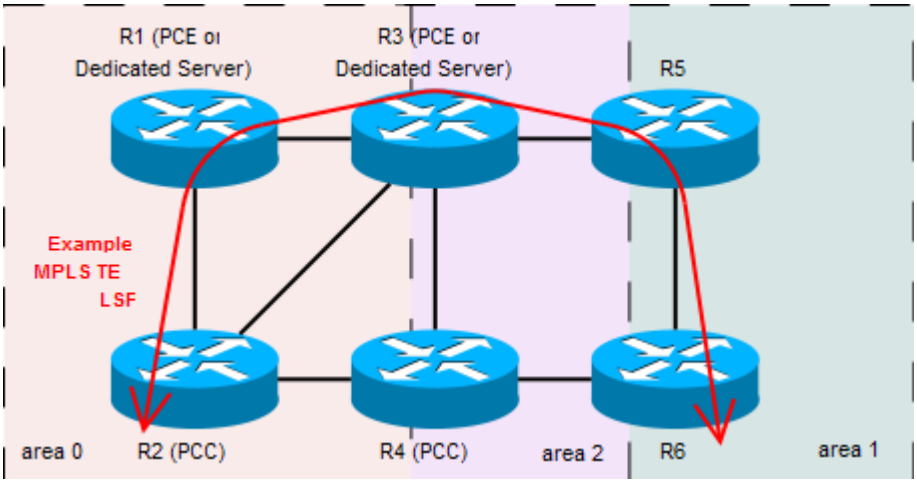
1. Retain topology.
2. Enable PCE discovery on R1, R3, and R4.
3. Verify by observing discovered PCE/PCC devices that discovery was successful.
4. Deactivate PCC/PCE functionality on R1, R3, and R4 in sequence and verify that the status of the devices propagates over PCED by observing the discovered PCE/PCC device list.
5. Observe the PCED MIB (if implemented) and note the number of dropped, corrupt, and rejected information elements.

Expected Result: All routers with PCC/PCE enabled are observed in the device list when PCE discovery is enabled, and routers are removed from the list when PCC/PCE functionality is disabled. Ideally there are no of dropped, corrupt, or rejected information elements detected.

4.1 Test case: Inter-area PCE discovery

Purpose: Ensure automatic discovery of PCE devices via the mechanism defined in RFC4674 is effective.

Topology:



Procedure:

1. Construct topology as shown or similarily. At least one router supporting PCC/PCE should be located in a different area.
2. Enable PCE discovery on R1, R3, and R4.

3. Verify by observing discovered PCE/PCC devices that discovery was successful.
4. Deactivate PCC/PCE functionality on R1, R3, and R4 in sequence and verify that the status of the devices propagates over PCED by observing the discovered PCE/PCC device list.
5. Observe the PCED MIB (if implemented) and note the number of dropped, corrupt, and rejected information elements.

Expected Result: All routers with PCC/PCE enabled are observed in the device list when PCE discovery is enabled, and routers are removed from the list when PCC/PCE functionality is disabled. Ideally there are no of dropped, corrupt, or rejected information elements detected.

Reference Documents

[PCE-DISC-REQ] RFC 4674, "Requirements for Path Computation Element (PCE) Discovery," October 2006	Informative
[PCEP] RFC 5440, "Path Computation Element (PCE) communication Protocol (PCEP) - Version 1," March 2009	Normative
[PCEP-REQ] RFC 4657, "PCE Communication Protocol Generic Requirements," February 2006	Informative
[PCEP-INTER-AREA-REQ] RFC4927, "PCE Communication Protocol (PCECP) Specific Requirements for Inter-Area (G)MPLS Traffic Engineering," June 2007	Informative
[PCEP-INTER-AS-REQ] draft-bitar-zhang-interas-pcecp-reqs-01.txt, "Inter-AS Requirements for the Path Computation Element Communication, " February 2006	Informative
[PCEP-INTER-LAYER-REQ] RFC6457, "PCC-PCE Communication Requirements for Inter-Layer Traffic Engineering," Feb 2010	Informative