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Overlay Network - Path Computation Approaches
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Abstract

This document discusses various path computations approaches which are applicable to overlay networks [framework doc ref]. It discusses how the customer edge nodes uses the information advertised by the provider network to compute a path between two customer edge nodes or how it can request the provider network to compute a path and setup an end-2-end LSP.

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1 Introduction

This document attempts to describe possible ways to advertise information required for customer network CE nodes to compute a path for LSPs between two points in two customer network islands connected by a provider network, so as to adhere a set of constraints in provider network without knowledge of the detailed provider network topology. These constraints could be, but not limited to, diversity, latency, jitter, skew etc. Connectivity between customer network islands is presumed to be an "overlay" over provider network.

1.1 Terminology

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 [RFC2119].

2. Network Configuration

Multi-layer, multi-domain network typically involve overlay boundaries, where routing information sharing is restricted in nature. These are typically administrative boundaries coupled with technology boundaries.

Overlay network boundaries can be envisioned on two axes.

a. Technology Boundary : This typically involves different types of switching technologies i.e. Packet, OTN, DWDM. These technologies are also known as client or server technologies. Client technologies are typically enabled by Packet, OTN switching, while server technologies are enabled by OTN, DWDM technologies.

b. Administrative Boundary: This boundaries are enforced by administrative contracts that bars exchange of routing information for operational reasons, hence creating a need for special mechanism that facilitates circuit provisioning in such environment.

Customer and Provider domains are the examples of distinct administrative domains.

Intersecting a and b will give us following unique network configurations

UseCase i : Tech boundary coincides with administrative boundary
UseCase ii : Tech boundary is part of provider domain
UseCase iii : stacking of UNI interfaces in provider domain.

following section discuss these usecases in more detail.

3. Network Configuration Usecases

In this section, ONI, overlay network interface terminology is used to indicate the administrative boundary that imposes restriction on routing information exchange.Client layer is assumed to be using packet/OTN technologies while server layer could be Packet,OTN, DWDM etc. the technology transition could be in customer or provider network.

C is referred to as customer network node and P is referred to as provider network node. CE is referred to as Customer Edge and PE is referred to as Provider edge.

3.1 ONI is located between CE-PE nodes.

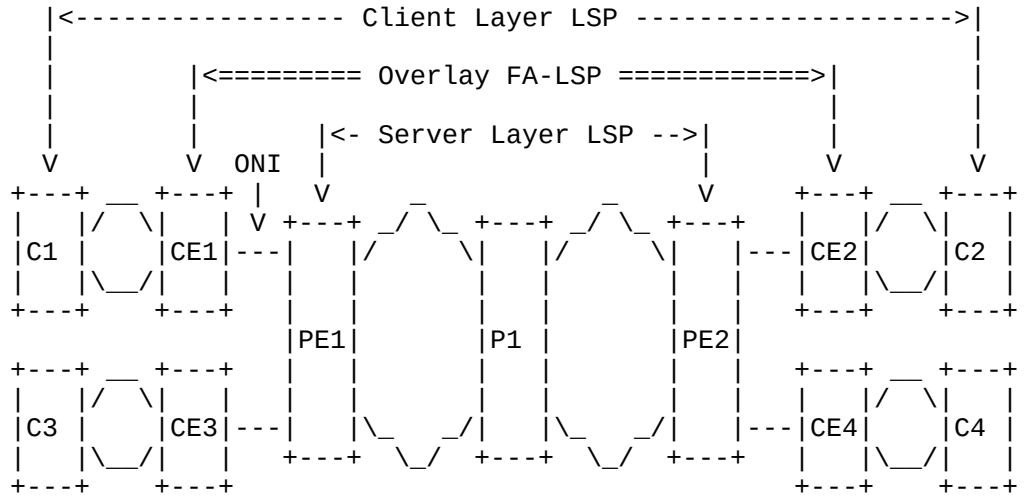


Figure. 1

Here server layer is assumed to be OTN/DWDM. There are couple of scenarios possible here :

i. CE-PE link could be Packet Link, so layer transition from Packet to OTN/DWDM will happen in PE node ii. CE-PE link could be OTN/DWDM link, so layer transition from packet to OTN/DWDM will happen in CE node

3.2 ONI is located between CE and PE nodes.

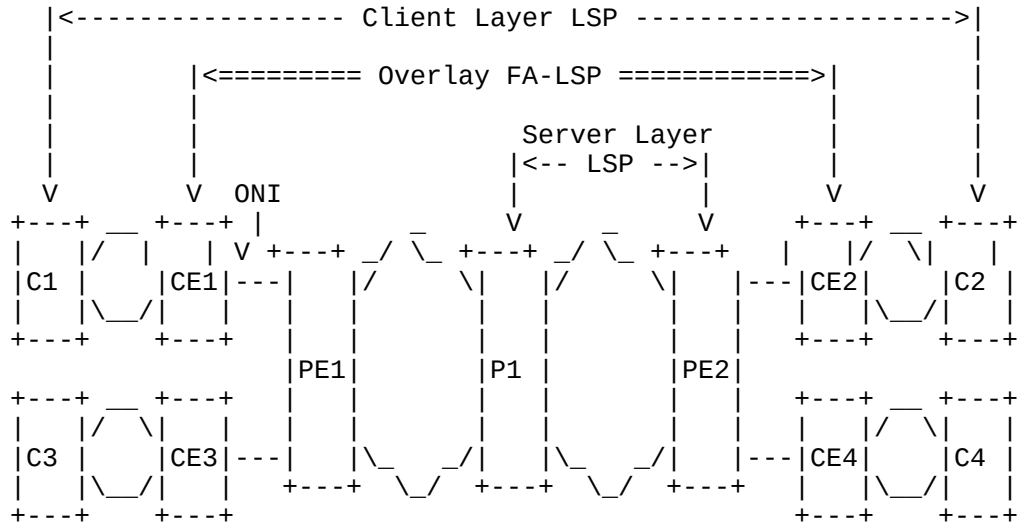
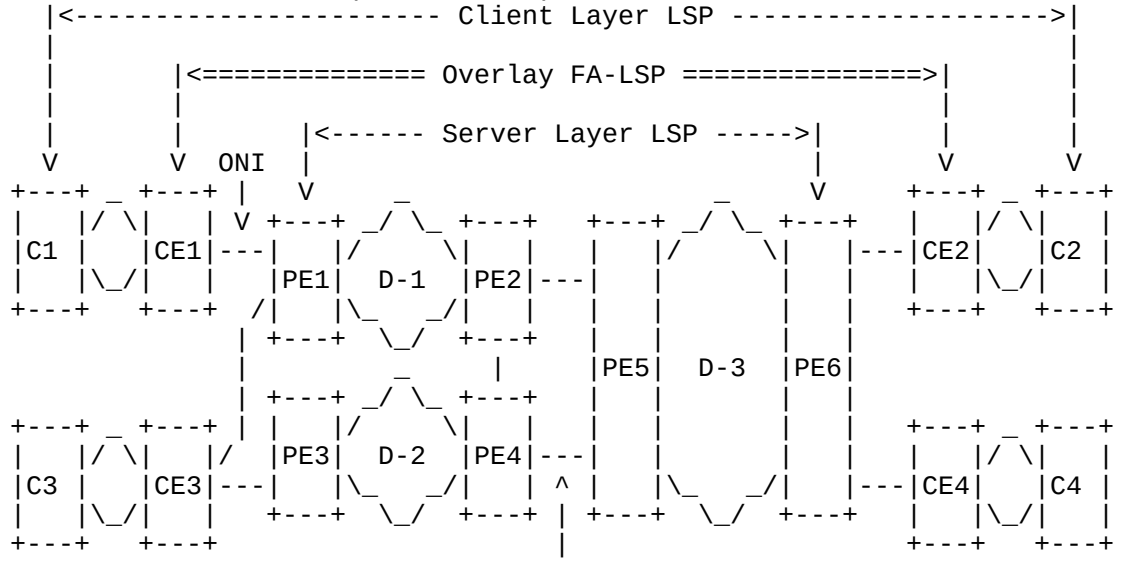


Figure. 2 In Figure 2, the Packet switching continues from cutomer to provider network and transitions to OTN/DWDM at P1. This kind of configuration is possible in multi-party client and server network, where the provider operates multi-layer network and provide services to its customers.

3.3 Nested ONIs

This is multi-layer network having ONIs between CE and PE, and also between PE and PE (PE2/4 - PE5)



ONI
Figure. 3

Because of multiple server layer technologies, it is possible that a layer closer to packet layer is digital (OTN), which is supported by pure optical layer (DWDM) to achieve better aggregation and improved restoration and protection capabilities.

In this configuration it is assumed that digital layer is playing dual role of customer to provider of optical layer and provider to customer that operates packet layer. In figure 3, domains D-1 and D-2 can be assumed to be digital layer, which is interfacing with packet layer through ONI between PE and CE. Digital domains D-1 and D-2 are also interfacing with optical D-3, again through ONI. If OTN and DWDM multi-layer network belongs to same IGP, then this becomes a multi-layer path-computation and signaling case, and it is out of scope of this document.

4. Path Computation Use-cases

In case of overlay networks it is required to compute a path between the customer edge nodes for the overlay FA-LSP as shown in the figure 4.

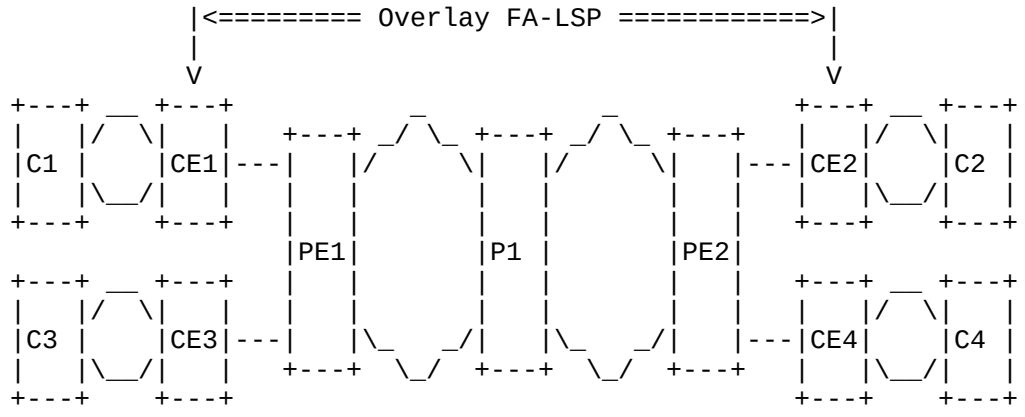


Figure. 4

The typical path computation use-cases are the following:

1. Point-to-point overlay path.
2. Multiple point-to-point diverse overlay paths sharing common LSP head and tail ends.

3. Multiple point-to-point diverse overlay paths that do not share common LSP head and tail ends.
4. Point-to-multipoint overlay paths.
5. Overlay paths over multi-domain (i.e. Multi-area or multi-AS) provider networks.

The typical TE constraints are:
1. Bandwidth or resource (this is technology specific).
2. Include or exclude nodes/links/SRLG or paths identified by path-keys.
3. Latency, jitter, max-hop requirements.
4. Optimization options - minimize cost, minimize latency etc.

5. Path Computation Approaches

There are three path computation approaches
1. Virtual-topology approach
2. PCE approach
3. Hybrid approach - combined virtual topology and PCE approach

5.1 Virtual Topology Approach

This path computation approach uses a virtual topology that is advertised by the provider network by the customer edge nodes.

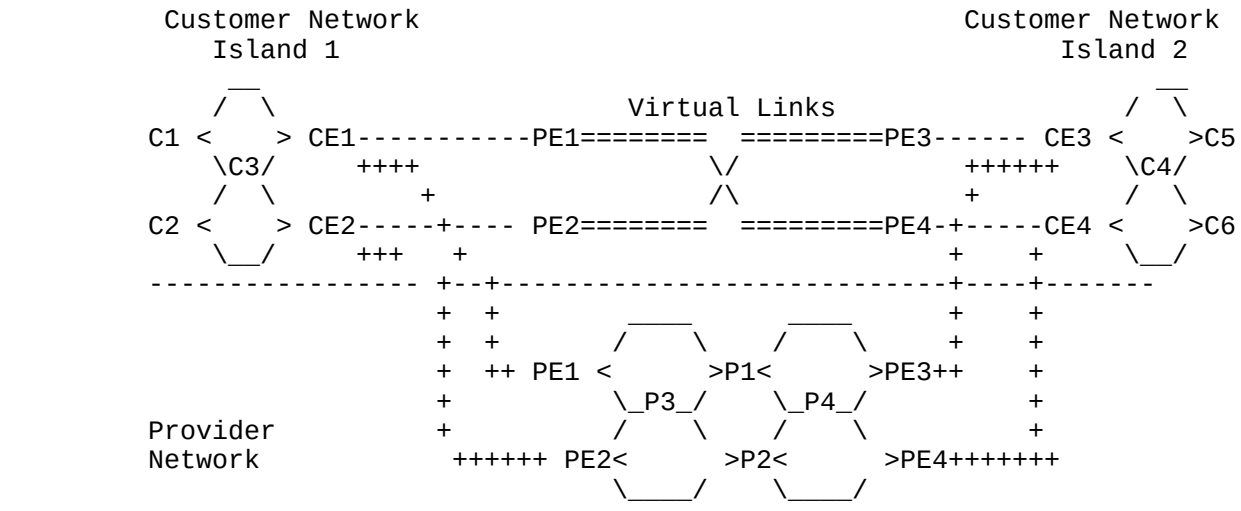


Figure. 5

In Figure 5, Provider Network has 4 interconnected rings supports full node diversity to connect any 2 Provider Edge Nodes.

PE1, PE2, PE3, PE4 are provider edge nodes.
P1, P2, P3, P4 are internal provider Network nodes, that must not be known to the customer network.

Customer Network has two islands connected by provider network.
C1, C2, C3, C4, C5, C6 are internal customer network nodes.
CE1, CE2, CE3, CE4 are customer network edge nodes connected to provider network edge nodes PE1, PE2, PE3, PE4.

Virtual Link Set : Virtual Link set is defined as set of one or more virtual links between any two provider edge nodes. The virtual links in the virtual link set, when realized may take different paths within provider domain, having different SRLGs and other TE metrics.

Above example topology has following Virtual Link Sets
a/ [PE1, PE2]
b/ [PE1, PE3]
c/ [PE1, PE4]
d/ [PE2, PE3]

e/ [PE2, PE4]
f/ [PE3, PE4]

The PEs in provider network do full peering with its attached CEs for virtual topology. So provider network virtual Links along with its SRLG IDs and other TE metrics are advertised into customer network.

Customer network internal Nodes C1..C6 can see provider network virtual TE Links and can compute paths between two points in customer network islands across provider network satisfying required diversity and TE metrics.

5.2 PCE Approach

An alternative approach for a CE node to obtain a path to another remote CE node would be by making a request to a provider network PCE. This approach requires either provider network PE nodes to advertise the PCE's IP address to CE nodes or CE Nodes should be configured with Provider Network PCE IP address. CE nodes needs to advertise the TE link-state of the CE-PE interface. This allows the PCE to build the overlay network topology link-state data-base.

In Figure. 1 above, the example depicted shows the provider network with a single IGP area and the provider network PCE has visibility to the detailed topology and TE information representing the server layer forwarding plane plus the CE-PE interface link-states that have been learned from the CE nodes. The server layer topology in addition to the CE-PE interface link-states constitutes the overlay network topology.

Figure. 2 above shows the case in which the provider network is a multi-layer network and the server layer boundary does not coincide with the provider network boundary. Again, the provider network PCE can have visibility to a single IGP area as described for MLN or alternatively there could be multiple IGP instances as described in [RFC6107], one instance for the overlay network and another instance for the server layer.

Figure. 3 above shows a multi-area or multi-AS provider network (generalized as a multi-domain provider network in this document). For multi-domain networks a hierarchical PCE could be deployed and the IP address of the hierarchical PCE is advertised to the CE nodes. The hierarchical PCE could maintain a multi-domain virtual topology instead of detailed topology of each domain.

In all three cases the head-end CE node is assumed to be aware of the address in the remote CE node for which the path is to be computed.

The exact manner by which this knowledge becomes available is beyond the scope of this document. The head-end CE node then makes a request to the provider network PCE with the remote address and the required set of TE constraints that need to be satisfied by the computed path.

In each case of the provider networks PCE uses the overlay network topology to compute the path. In case of the provider network example shown in Figure. 4 the hierarchical PCE computes the domain-level or inter-domain path first and then computes the intra-domain paths. The exact mechanism could be using the BRPC procedure in order to compute optimal intra-domain paths.

Once the computation is complete the PCE responds back with the path. The path generated by the PCE is expected to contain both real and virtual links and nodes. In case there is a need to maintain confidentiality with respect to the details of the provider network topology from the customer network then the response can include a path-key. In case there is a need to compute diverse paths one of two approaches could be followed - simultaneous computation approach in which case the response will have multiple paths or path-keys or the request could include the exclude hops or exclude path-key.

In the example below the procedure of computing a set of diverse paths using the PCE approach is explained.

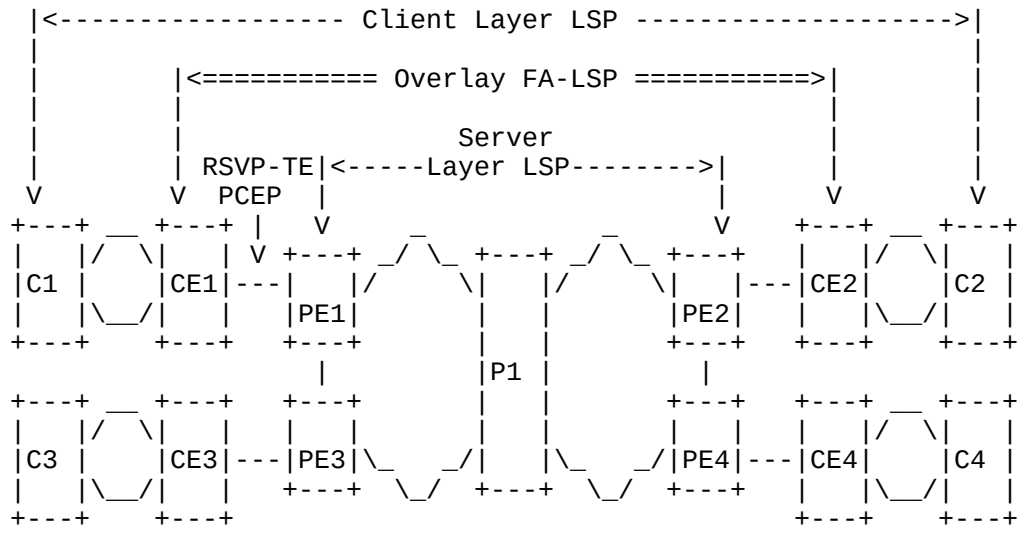


Figure. 6

Step-1: CE1 requests computation of diverse paths between PE1-PE2 and PE3-PE4.

Step-2: PE1 responds with 2 sets of EROs or 2 path-keys.

Step-3: CE1 initiates signaling of LSP PE1-PE2 with ERO or path-key.

Step-4: ERO or path-key is transferred to CE3.

Step-5: CE3 initiates signaling of LSP PE3-PE4 with ERO or path-key.

This approach uses a single computation for a pair of diverse paths. An alternative approach is by computing diverse paths separately as follows:

Step-1: CE1 requests computation of a path between PE1-PE2.

Step-2: PE1 responds with a set of EROs or a path-key.

Step-3: CE1 initiates signaling of LSP PE1-PE2 with ERO or path-key.

Step-4: PE1-PE2 path ERO or path-key is transferred to CE3.

Step-5: CE3 request computation of a path between PE3-PE4 with XRO(= PE1-PE2 ERO or path-key).

Step-6: PE3 responds with a set of EROs or path-key.

Step-7: CE3 initiates signaling of LSP PE3-PE4 with ERO or path-key.

5.3 Hybrid Approach

In the absence of a hierarchical PCE for a multi-domain provider network, it is possible a CE node learns of multiple PCE IP addresses from multiple PE nodes. This is possible in case each PE node lies in separate areas or ASs and with PCEs deployed per-area or per-AS. In such a situation it will be necessary for the CE node to pick one of the PCEs to send the path computation request. One way to select the appropriate PCE would be to advertise a virtual-topology associated with each PCE IP address to provide sufficient information for the CE node to determine whether a path to the remote CE address can be computed by the specific PCE.

In Figure. 4 above, CE3 has a dual-homed connectivity with the multi-domain provider network (i.e. CE3 to D-1 and D-2 via PE1 and PE3

respectively). In the absence of a hierarchical PCE, PE1 can advertise a virtual topology with connectivity to a set of CE nodes. Similarly PE3 advertises a virtual topology with connectivity to another set of CE nodes. This can happen in cases when there is no available bandwidth to a specific CE node via a specific domain. CE3 can determine using the virtual topologies which PCE should it send the path computation request.

6. CE-PE / PE-PE Interface

The CE-PE or PE-PE interface requires a routing interface in order to be able to exchange topology information and a path-computation interface in order to be able to send path computation requests and responses. For signaling the overlay LSP a signaling interface is requried as well.

7 Security Considerations

TBD

8 IANA Considerations

TBD

9 References

9.1 Normative References

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