

PCE Working Group
Internet Draft
Intended status: Informational

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Expires: April 21 2014

October 18, 2013

Application-oriented Stateful PCE Architecture and Use-cases for
Transport Networks

draft-lee-pce-app-oriented-arch-00.txt

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Abstract

This draft presents an application-oriented stateful PCE architecture for transport networks. Under this architecture, several use cases are described.

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

With the emerging applications requiring large bandwidth and dynamic provisioning, such as Data Center Interconnection(DCI), cloud bursting and so on, the traditional transport network architecture is limited as it only provides "dumb pipe" services. These services lack the flexibility for operation and management. In order to support the demands, including large bandwidth, low service latency as well as dynamic and flexible resource allocation, transport networks may need to be enhanced architecturally such that it could be aware of application requirements in a dynamic fashion. The Path Computation Elements (PCE) architecture and the corresponding protocol extensions provide a mechanism that enables path computation for transport network. As specified in [RFC4655], a PCE supports the request for path computation issued by a Path

Computation Client (PCC). When the PCC is external to the PCE, a communication protocol, i.e., PCE Protocol (PCEP), is required to support the path computation request/reply process. Furthermore, extensions to PCEP are proposed in [PCE-S] , [PCE-I], and [PCE-S-GMPLS] to enable stateful control over networks including transport networks.

This draft provides an application-oriented stateful PCE architecture for transport networks. In particular, this architecture introduces transport network controller (TNC) component in which transport PCE plays a central role. Given the high demands from applications, an interface between the transport network controller and the application client controller is also introduced to enable the communication function between these entities. The application client controller is a special type of PCC with respect to PCE capability within the transport network controller. This interface and its communication mechanism between the application client controller and the transport network controller enables operation of the transport network with more flexibility. Specifically, in a larger-scale transport network with multiple layers or multiple domains, the communication mechanism between different PCEs and the application client controllers is very important to satisfy the request from the application stratum. Current PCEP can provide communication between PCE and PCCs, and further extensions to PCEP may be desirable to cooperate with new types of PCCs such as application client controllers.

2. 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 [RFC2119].

3. Architecture and Key Features

In this draft, a PCE-centric architecture which supports application-oriented transport network is defined. The architecture is illustrated in Figure 1. The functions of each architectural component are described. And then interfaces between the stateful PCE and the other functional blocks in the transport network are defined.

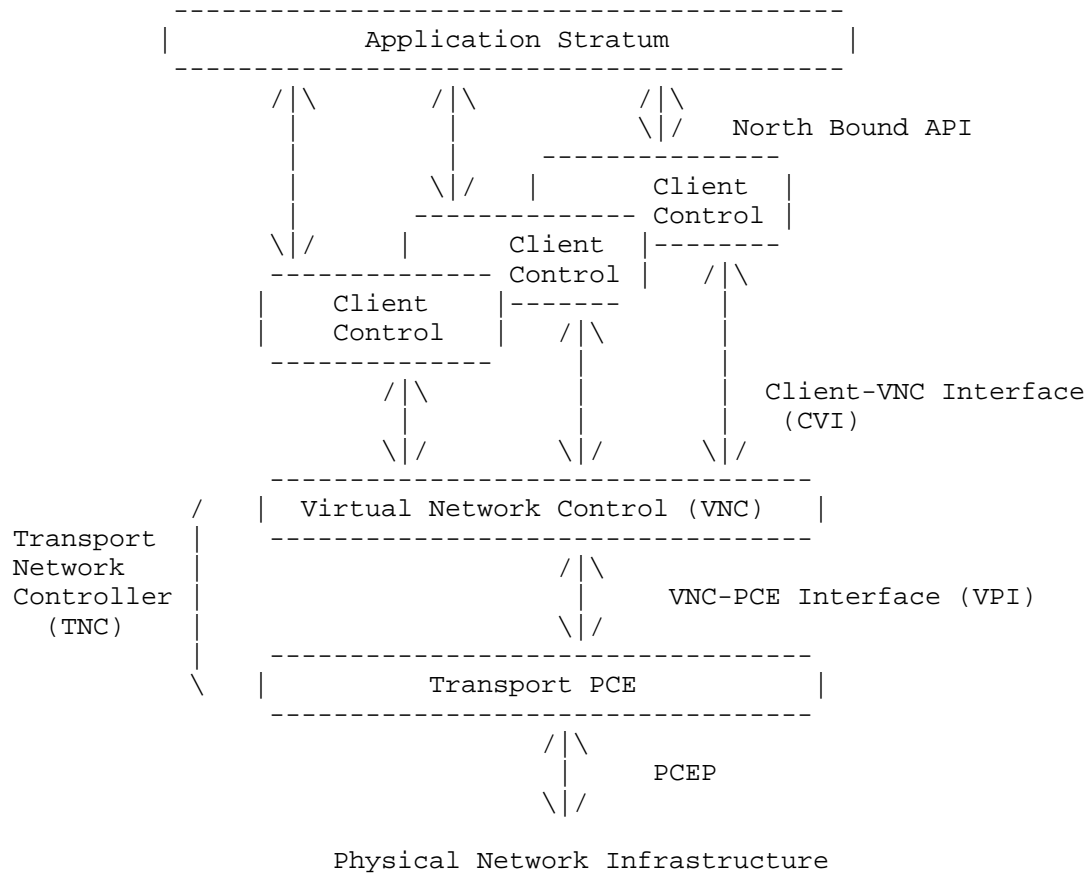


Figure 1: Application-oriented PCE Architecture for Transport Network

Transport Network Controller (TNC) in Figure 1 is the core of the application-oriented PCE architecture for transport network. It is built around the Transport PCE and provides additional functions that facilitate multi-layer control, virtual network service control and other functionalities such as topology abstraction via the Virtual Network Control (VNC) block. The VNC interfaces can be different types of client controllers, such as packet network

controllers, data center provider controllers, enterprise network controllers, virtual service provider controllers, etc. The VNC provides network control function virtualization to the PCE and to the clients via the VNC-PCE Interface (VPI) and the Client-VNC Interface (CVI), respectively. The VNC allows the clients (via their client controllers) to program their client-defined virtual network services (VNS) over the CVI. The VNC also provides abstract network topology for each client based on the network resources allocated to the client. In order to facilitate this capability, the VNC needs to communicate with the PCE via the VPI interface. The VPI can be an internal interface from an implementation standpoint. In this draft, it is assumed an external entity from the PCE. The VNC is a PCC to the PCE.

The VNC provides control plane function virtualization over programmable interfaces such as virtual network path computation and optimization, topology abstraction hiding details of physical topology while supporting service-specific objectives the clients demand, maintaining virtual network service instances and the states, policy enforcement for virtual network services. See [NCFV] for details of control function virtualization concept. With this evolutionary architecture built on top of transport PCE, a number of challenging use-cases can be supported. Transport PCE is a stateful PCE and supports all the generic stateful PCE functions as described in [PCE-S] and [PCE-S-GMPLS].

The CVI is an external interface with respect to the transport network controller (TNC). Client controller is an external client. Figure 1 shows that there are multiple client controls which are independent to each other and that each client supports various business applications over its NB API. There are layered client-server relationships in this architecture. As various applications are clients to client control, client control itself is also a client to virtual network control; likewise, virtual network control is also a client to physical network control. This layered relationship is important in protocol definition work on NB API, CVI and VPI interfaces as this allows third-party software developers to program client control and virtual network control functions in such a way to create, modify and delete virtual network services.

4. Use-cases

This section provides a number of use-cases to which the architecture discussed in Section 3 is applied.

4.1. Dynamic Data Center Network Interconnection

In the context of multiple data center networks where there is a need to move large data dynamically from one location to other location(s), data center network controller is a type of client controller that coordinates with the virtual network controller (VNC). This coordination across data center client controller and the VNC allows multiple instances of inter data center connections need for different applications.

For each application, the VNC keeps the instance and creates an abstracted network topology based on the network resources allocated to a particular application. The data center client controller has the view of this abstracted network topology and is given a full control of how to use the allocated virtual resources.

The topology abstraction created by the VNC for the client is based on the transport PCE's real network resource information and is needed to be filtered via the VNC's filtering mechanism based on contract, policy and security.

The VNC interlays client control's request for inter data center connection and converts into a PC request to the PCE. Then a PCE instantiates a network path via its provisioning mechanism described in [PCE-I].

4.2. Packet-Optical Integration (POI)

Client controller can also be a router network controller that needs transport network interconnections. The router network controller can request different connection services from the transport network based on different QoS needs.

Note that this POI use-case is different from multi-layer PCE work [RFC5623] in that it allows more flexible interactions and more granular level of abstracted network topologies than tunnel-based virtual network topology.

4.3. Virtual Network Service (VNS)

Virtual Network Service is instantiated by the client control via the CVI. As client control directly interfaces the application stratum, it understands multiple application requirements and their service needs. It is assumed that client control and VNC have the common knowledge on the end-point interfaces based on their business negotiation prior to service instantiation. End-point interfaces refer to client-network physical interfaces that connect client

premise equipment to network provider equipment. The different level of topology abstractions can be provided by the VNC topology abstraction engine based on physical topology base maintained by the PNC.

The level of topology abstraction is expressed in terms of the number of virtual network elements (VNEs) and virtual links (VLs). As different client has different control/application needs, abstracted topologies for a certain client can show much less degree of abstraction. The level of topology abstraction is determined by the policy (e.g., the granularity level) placed for the client and/or the path computation results by the PNC's PCE. The finer granularity the abstraction topology is, the more control is given to the client control. For instance, if the client is a third-party virtual service broker/provider, then it would desire much more sophisticated control of virtual network resources to support differing application needs. On the other hand, if the client were only to support simple tunnel services to its application, then abstracted topology for such client is a simple abstracted topology with a set of end-point tunnels.

4.4. Time-based Scheduling

Transport services with time constraints are another highly-demanded task in the network. In this scenario, a client controller can request to reserve some bandwidth for future use. This 'time-based' service needs to be considered together with the traffic Engineering Database (TED) and Label Switched Path Database (LSPD). PCE will compute the scheduled network resource for this 'time-based' service, and reserve such resources for future use.

In this scenario, the LSPD contains two categories of LSP information, current LSP in use and scheduled LSP. These two groups of LSP can be included in a single LSPD or two separate ones, with internal interface to PCE. PCEP should also be extended to include the scheduled information for service requests, such as proposed in [Time-based]. With these extensions, the PCC (for example, application stratum) can generate the path computation request.

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7. Acknowledgment

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