Software Defined Networking Initiatives in Carrier Networks

: Orchid One

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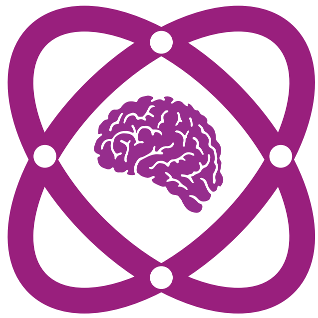
The intent of this document is to look at the approach to Software Defined Networking and its applicability in the carrier environments.

The SDN initiative started with the necessity that arose from data center space where there are several servers depending on the size of the data center, switches and routers. There could be hundreds or thousands of these elements depending on the size of the data center in either the top-of-rack or end-of-row configurations. Provisioning and managing these devices individually is a daunting task especially when equipment is moved or layout changes are made.



SDN defined a new way of building and managing these networks by separating the "brains", the control function from the "muscles", the forwarding of the data plane, thereby ensuring control of the thousands of devices from a single point of control. The controller, also called the SDN controller, presents an abstract and centralized view of the network. The network administrators, via the controller, can make the decisions on how the forwarding plane of the switches/routers will handle the traffic and push these rules to the data plane or the hardware to control the flow of packets through the network. SDN uses the openflow protocol to enable the communications between the SDN controller and the data plane.

Based on the concept of the separation of control plane from data plane is another protocol called the Path Computation Element Protocol. This protocol was standardized by the IETF in 2005 and presents ways of incorporating the MPLS-TE and RSVP-TE into path determination. We look at the pros and cons of the PCEP versus the Openflow and it can be seen that PCEP is more aligned with the service provider requirements.

The application of the SDN concept in the carrier environment takes a different shape and the requirements are different. Note that the SDN in its conceptual form was already embraced by the next generation switching infrastructure where the media gateway controllers represent the "brains" of the network while the media gateways represent the packet-forwarding plane, which is dynamically controlled by the controller on a per session basis.

The document describes the applicability of the SDN in carrier networks and our view on how Cataleya Orchid One platform can work with SDN in bringing significant value to the service provider networks.

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SDN Openflow vs Path Computing Element Protocol

Openflow concept started in the academic community with a view to simplify the network configuration, provisioning and management. The concept is very new and has yet to mature with several essential extensions still needed to be worked out. On the other hand the PCE architecture was standardised in 2005 and is a mature standard as it comes to working with MPLS/TE networks. The following table shows a comparison of the two protocols.

SDN Openflow

- Academic work now getting standardised in the Open Networking Foundation recently aims at completely taking over the control plane from the network, leaving the network dumb
- General control principles is a top down approach – SDN controller to switch.
- Requires a mass upgrade of the network infrastructure.
- Revolutionary protocol – as in the previous point.
- IT friendly - Currently data center friendly and most activities geared towards managing IT infrastructures.
- A lot of work ahead in terms of addressing discovery, path determination, MPLS networks etc.
- Significant work needed to make Openflow work for service provider networks – Orchid One to SDN controller peering is beyond the scope of definition as proper SDN control of MPLS-TE is not yet formally defined.

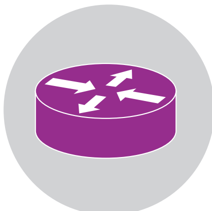
Path computing element protocol

- Work was standardised by the IETF in 2005 and is a visibility and control protocol that works with MPLS – RFC 4655, 4657, 4674, 4927, 5088, 5089, 5376, 5394, 5440, 5441, 5455, 5520, 5521.
- Partially removes the control plane (from the provider edge or head end routers only).
- General control is from switch/router to PCE server. Router/switch requests for the best path from the PCE.
- Requires upgrade only on the provider edge routers and the other routers in the network need not be upgraded.
- Evolutionary protocol – removes only the path computing function from the network and centralises this.
- Service provider friendly – PCE requires only the "head end" routers to be upgraded and not the entire service providers network routers.
- PCE architecture and protocols are already standardized and works with MPLS-TE/RSVP-TE
- Integrating PCE into service provider networks and enhancing PCE to accommodate for the enhanced end-end QoS / dynamic bandwidth reservation can be accomplished more easily. Orchid One interface to PCE is much more practical in the near term.

The openflow approach would entail a tightly coupled interface between the Orchid One controller and the SDN controller where in the SDN controller gets the information needed to setup or update the flow tables from the Orchid One controller. This means the east-west interface between the SDN controller and its peers (e.g. Orchid One controller or other SDN controllers) needs to be defined which this is not currently defined.

On the other hand, with the PCE architecture, the Orchid One controller need not interface with the PCE entities as the PCE architecture works in a stand-alone fashion. PCE architecture is geared towards service provider network implementations where best possible paths need to be made available based on end to end QoS requirements and bandwidths reserved for VoIP, video and collaboration scenarios which are QoS sensitive.

Innovation in the PCE architecture can be independently controlled with minimal interface between the Orchid One controller and the PCE. There may be enhanced DSCP or other layer 3 markings that can be leveraged by the Orchid One to indicate the need for additional services from the PCE entities.



Overall, it seems that the PCE architecture provides a service provider friendly proposition that works with MPLS networks, requiring upgrades on only a few routers in the service provider networks. Service providers have already rolled out their MPLS networks in preparation for the IPX roll out and it will be impractical to expect them to do a mass upgrade of their network to support the SDN initiatives, unless it delivers significant value.

PCE architecture

The Path Computing Element architecture is shown in the following diagram. The PCE application works with a Traffic Engineering DB to provide with the optimum path through the MPLS network based on the QoS requirements. The request for the best path comes from the head end router that interfaces with the PCE server. This head end router is upgraded with the PCE client that requests for the route from the PCE server. The rest of the nodes in the MPLS network work as normal and do not require a PCE upgrade.

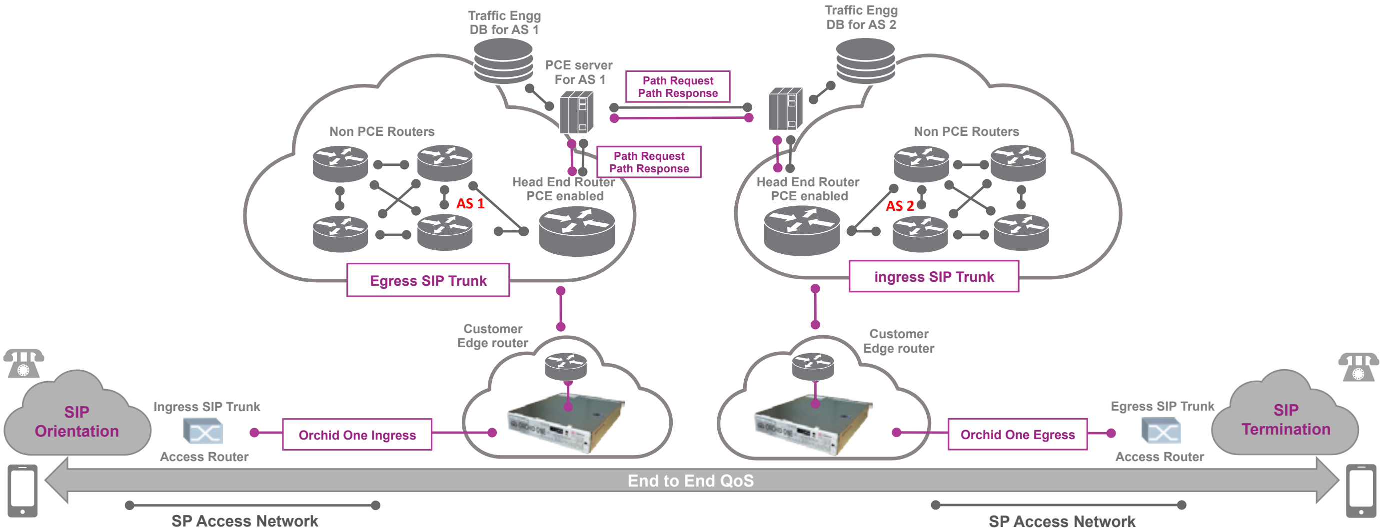


Figure1 End to End Qos with PCE

The above diagram shows a scenario where there are multiple autonomous systems networks and each AS network has a PCE server with a traffic-engineering database. There could be multiple PCE servers within an AS network. Path computation starts when the customer edge router sends a request to the head-end router. This request contains the specifics of the source/destination addresses, QoS and bandwidth requirements. The PCE server may in turn consult with the other PCE servers during this path computation process. Once the PCE server receives the response from other PCE servers, if present, the PCE server returns the path with the Explicit Route Object that specifies the hops along the path. This ERO is sent from the head-end router to each router in the path. The ERO is identical to the ERO used in RSVP-TE and the intermediate routers would know how to process this without any PCE related software.

The PCE process can be extended as necessary to accommodate any requirements based on the end-to-end service level QoS requirement.

> “This is one of the areas of innovation that the industry is looking at and when these developments are in place, we should be able to see data plane development kit (DPDK) handle significantly more voice traffic.”

Openflow architecture

In the Openflow architecture, the Orchid One peers with the SDN controllers thereby indicating to the SDN controllers of the bandwidth and QoS requirements so that the SDN controller can apply the necessary flow tables to the openflow enabled routers to forward the packets based on the requested QoS profiles. The following diagram shows an openflow architecture and the necessary interactions to communicate the quality needs of the service provider SIP session to the SDN controller.

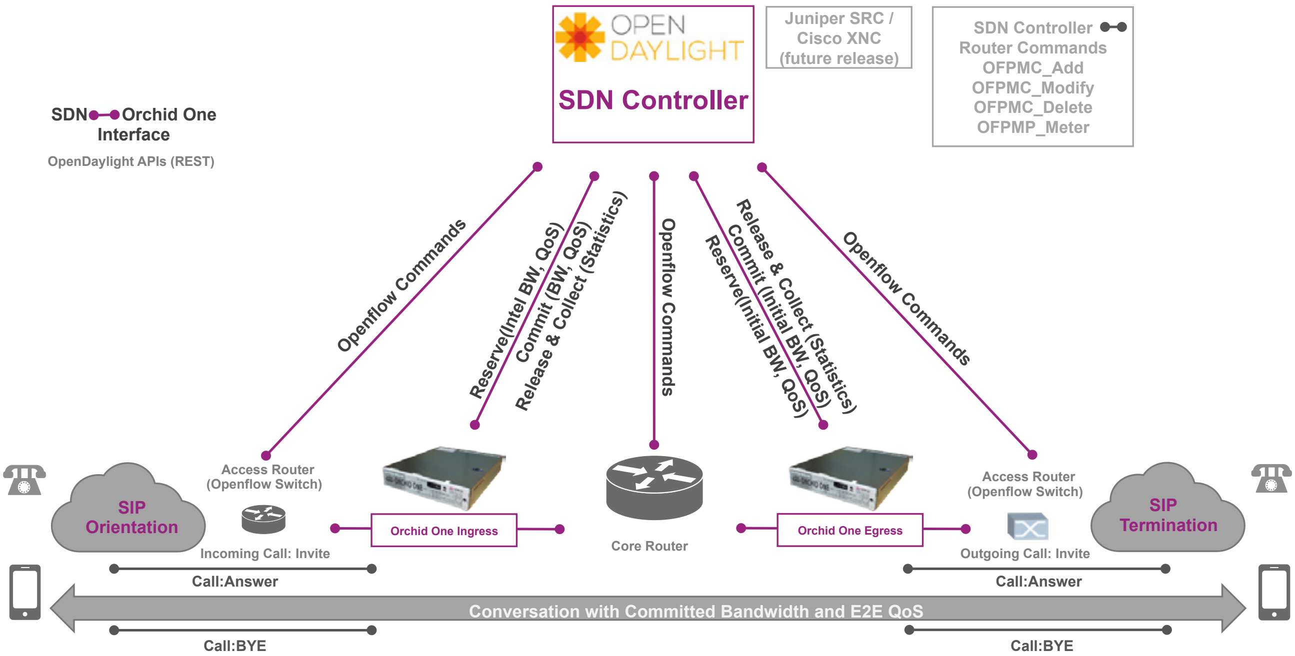


Figure2 Openflow architecture for end-to-end QoS

In this case, the Orchid One determines the type of session (voice or video), bandwidth requirements (based on voice/video codecs), priorities etc. and communicates this to the SDN controller. The SDN controller can invoke the appropriate flow tables and leverage the MPLS-TE features (LSP tunnels) for bandwidth reservation for different priority levels, auto-route of IP traffic via the tunnels as necessary, auto-bandwidth of tunnels reservations, traffic type control per tunnel and load balancing of traffic flows via the tunnels over physical IP links.

The bandwidth reservation may be done on a call-by-call basis, or tie different call profiles to appropriate tunnels and have these TE profiles active over a period of time. These flow tables may be active so long as the Orchid One is provisioned within customer zones with the specific QoS requirements.

Cataleya SDN proposition

There are two approaches presented in the earlier sections. Both the approaches are equivalent in terms of managing and directing the MPLS network to perform traffic engineering functions as dictated by the needs of the service provider voice and video sessions.

The PCE approach impacts the service providers' MPLS network minimally by requiring the PCE upgrades to the head-end routers only. Cataleya will liaise with the PCE work group (PCE WG), review the current functionality provided by the PCE based architecture for compliance with the requirements of the real time sessions establishment with specific QoS needs and document the gaps for the PCE WG.

The WG validates the requirements for extensions to existing routing and signaling protocols in support of the PCE architecture and the signaling of inter-domain paths (e.g. RSVP-TE). Once validated, the necessary extensions are produced in collaboration with the Working Groups responsible for the protocols.

The openflow approach is still in its infancy in terms of application to the service provider markets. There needs to be the east-west protocols defined for the SDN controller to interface with other SDN controllers in different autonomous systems and with the Orchid One platform. The scale, capacity and security requirements for these peering interfaces need to be determined and pushed through the standardization process. It will take time to sift through these requirements and establish these standards.

In the meantime, PCE is mature and in place that is more service provider friendly and Cataleya will adopt the PCE architecture for the initial proof of concept.

Cataleya will also keep on top of the developments in the openflow standardisation process and drive the requirements to make openflow applicable to the service provider market segment.

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About Cataleya

Cataleya is a leader in IP networking innovation, with a strong track record in developing and deploying next generation carrier grade switching systems, pushing the envelope in an all IP paradigm.

Cataleya is headquartered in Singapore with its own technology development team in Silicon Valley and a wholly owned subsidiary of Epsilon Global Communications.

Cataleya is another outstanding result of Epsilon's innovation DNA and reflects a strong service provider influence in the design and functionality of its technology. A new approach to new challenges has led to a product of unparalleled performance, simplicity to operate and reduced cost of ownership.

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