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       Packet Optical Integration (POI) Use Cases for Abstraction and Control
                        of Transport Networks (ACTN)
                      draft-dhody-actn-poi-use-case-03

Abstract

   This document describes the Abstraction and Control of Transport
   Networks (ACTN) use cases related to Packet and Optical Integration
   (POI), that may be potentially deployed in various transport networks
   and apply to different applications.

Status of This Memo

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   material or to cite them other than as "work in progress."

   This Internet-Draft will expire on April 17, 2015.

Table of Contents

1. **Introduction**

   Network operators build and operate multi-layered multi-domain
   networks and these domains may be technology, administrative or
   vendor specific (vendor islands). Interoperability for dealing with
   different domains is a perpetual problem for operators. Due to these
   issues, new service introduction, often requiring connections that
   traverse multiple domains, need significant planning, and several
   manual operations to interface different vendor equipment and
   technology accross IP and Optical layers.

   The aim of Abstraction and Control of Transport Networks (ACTN) is to
   facilitate virtual network operation, creation of a virtualized
   environment allowing operators to view and control multi-subnet
   multi-technology networks into a single virtualized network. This
   will accelerate rapid service deployment of new services, including
   more dynamic and elastic services, and improve overall network
   operations and scaling of existing services.

[ACTN-FWK] describes a business model of ACTN, comprising of
customers, service providers and network providers. This separates
the network operations on physical network from the business needs
(based on virtual network). It further describes the architecture
model for ACTN including the entities (Customer Network
Controller(CNC), Virtual Network Controller(VNC), and Physical
Network Controller(PNC)) thier interfaces.

Discussion with operators has highlighted a need for virtual network
operation based on the abstraction of underlying technology and
vendor domains. This would be used for a variety of key use cases,
including:

o Physical network infrastructure providers who want to build
   virtual network operations infrastructure via standards-based
   interfaces that facilitates automation and operation of multiple
   virtual networks for both internal and external trust domains.

o Data Center operators that need to lease facility from a number of
   physical network infrastructure providers to offer their global
   data center applications and services. As they face multi-domain
   and diverse transport technology, interoperability based on
   standard-based abstraction will enable dynamic and flexible
   applications and services.

The transport networks are in an unique position to embrace the
concepts of software defined networking (SDN) because of the existing
separation in control and forwarding plane via GMPLS/ASON. The path
computation element (PCE) [RFC4655] and its stateful extension
[STATEFUL-PCE] can further provide a central control over the
resources. Also [STATEFUL-PCE-INITIATED] provides capability to
initiate and delete LSP dynamically. ACTN is focused on building
over the existing blocks by adding programmability, access and
control over abstract virtual topologies. [ACTN-PROBLEM] and
[ACTN-FWK] provide detailed information regarding this work. This
document focuses on the Packet and Optical Integration (POI) use
cases of ACTN. We refer to POI as packet over any connection-
oriented transport technologies such as MPLS-TE, MPLS-TP, OTN or
WSON.

It is preferable to coordinate network resource control and
utilization rather than controlling and optimizing resources at each
network layer (packet and optical transport network) independently.
This facilitates network efficiency and network automation.

In a multi-layer network via client and server networking roles,
Label Switched Paths (LSPs) in a server (lower) layer are used to
carry client (higher) layer LSPs across the server (lower) layer

network. POI in a distributed control plane environment may be
achieved by some of the existing mechanism as specified in [RFC4208]
and [RFC5623]. This document explores the POI use cases of ACTN to
help provide programmable network services like orchestration, access
to abstract topology and control over the resources.

Increasingly there is a need for packet and optical transport
networks to work together to provide accelerated services. Transport
networks can provide useful information to the packet network
allowing it to make intelligent decisions and control its allocated
resources.

1.1. POI Scenario

This section explores some typical scenario for packet and optical
integration (POI). These include, but not limited to, a single
administrative domain as well as Carriers-of-Carrier case.

Figure 1 shows a single administrative domain comprising of both
Packet and Optical transport networks. A POI coordinator would help
build and operate a multi-layered multi-domain allowing operators to
view and control a single virtualized network.

```
                             +------------+
             +------------------+   POI     |
             |                  |Orchestrator|
             |                  +-----+------+ (VNC)
          +-v---+                     |
          |     |                     |
          +-----+                +--v--+
          Packet                 |     |
          Control                +-----+
          (PNC)            Optical Control (PNC)
       +------------+ +--------------------------+ +--------------+
       |            | |                          | |              |
       | +-+        | | +-+                +-+   | | +-+    +-+    |
       | |R|        |***|O|                |O|********|R|    |R|    |
       | +-+  +-+   |*| +-+     +-+        +-+   | | +-+    +-+    |
       |      |R|*****|          |O|                | |              |
       |      +-+*****|          +-+                | |              |
       |   +-+        |*|    +-+        +-+    +-+ | |    +-+        |
       |   |R|        |*****|O|        |O|    |O|********|R|        |
       |   +-+        | |    +-+        +-+    +-+ | |    +-+        |
       |            | |                          | |              |
       +------------+ +--------------------------+ +--------------+
          Packet            Optical Transport          Packet
          Network                Network               Network
```

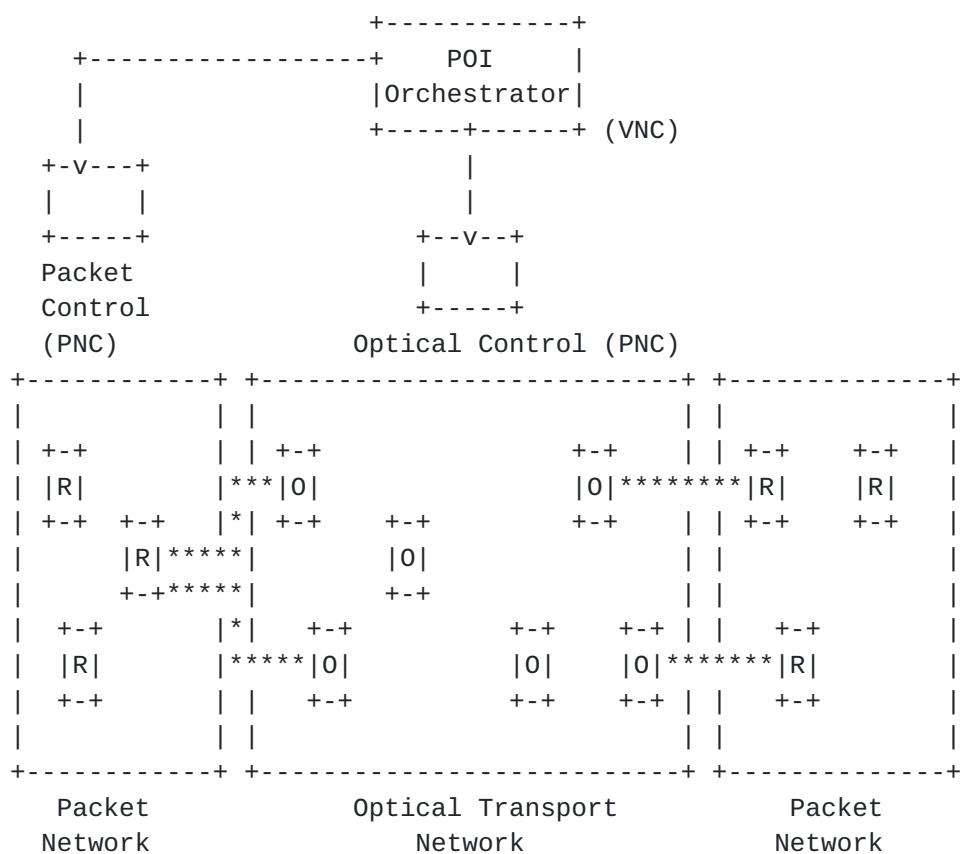   Figure 1: POI for single adminstration

   Figure 2 shows a Carriers-of-Carrier case, where an optical transport
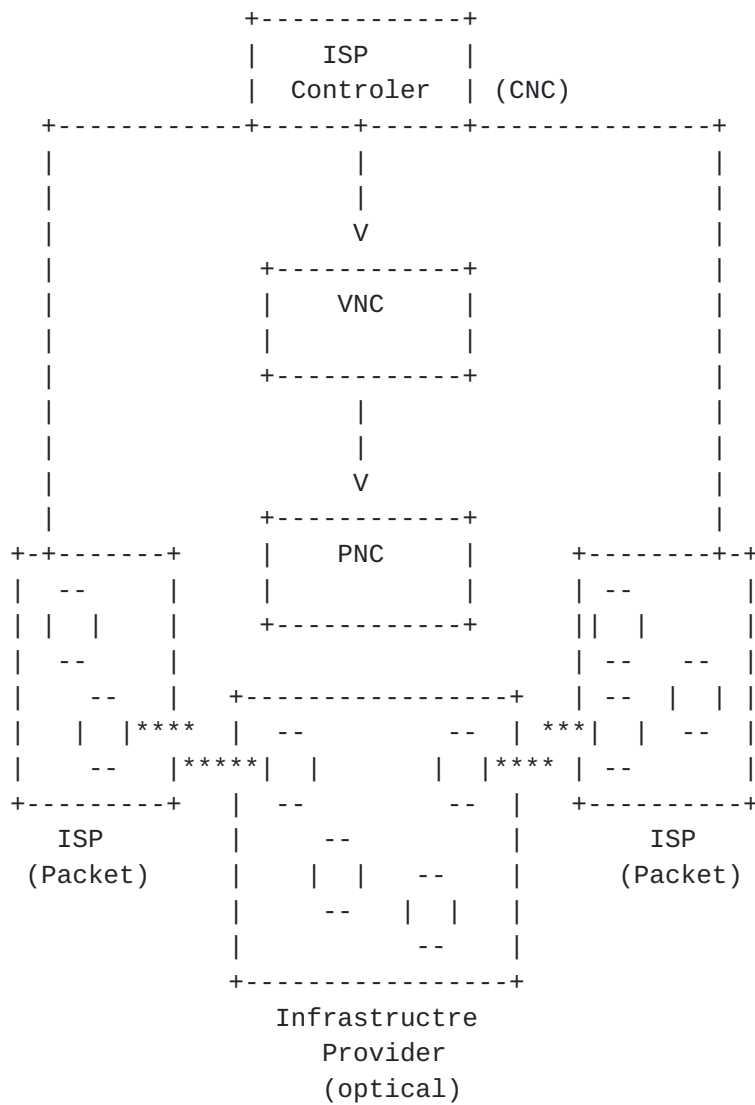   infrastructure provider provides ACTN service to the ISP.

```
                          +-------------+
                          |    ISP      |
                          | Controler   | (CNC)
          +-----------+------+------+--------------+
          |                  |                     |
          |                  |                     |
          |                  V                     |
          |            +------------+              |
          |            |    VNC     |              |
          |            |            |              |
          |            +------------+              |
          |                  |                     |
          |                  |                     |
          |                  V                     |
          |            +------------+              |
    +-+-------+        |    PNC     |        +--------+-+
    |   --    |        |            |        | --       |
    | |   |   |        +------------+        || |       |
    |   --    |                              | --    -- |
    |     --  |  +----------------+    | --   | | |
    |   | |****  |  --         -- | ***|  |  -- |
    |     --  |*****|   |        |   |****  | --       |
    +---------+     | --         -- |      +----------+
       ISP          |    --          |        ISP
     (Packet)       |   | |  --      |      (Packet)
                    |     --  | |   |
                    |      -- | |   |
                    |         --    |
                    +----------------+
                       Infrastructre
                         Provider
                        (optical)
```

                 Figure 2: POI for Carriers-of-Carrier

[2](#). Terminology

   The following terms are as defined in [ACTN-FWK]:

   o CNC:Customer Network Controller

   o PNC:Physical Network Controller

   o VNC:Virtual Network Controller

   The following terminology is used in this document.

   ACTN: Abstraction and Control of Transport Networks.

PCE: Path Computation Element. An entity (component, application,
or network node) that is capable of computing a network path or
route based on a network graph and applying computational
constraints.

POI: Packet and Optical Integration

VNTM: Virtual Network Topology Manager

3. Packet Optical Integration

Connections (or tunnels) formed across the optical transport network,
can be used as virtual TE links in the packet network. The
relationship is reduced to determining which tunnels to set up, how
to trigger them, how to route them, and what capacity to assign them.
As the demands in the packet network vary, these tunnels may need to
be modified.

One possible way to envision POI is via considering packet network as
customer i.e. an entity in packet network - (maybe a Path Computation
Element (PCE), Virtual Network Topology Manager (VNTM) [RFC5623],
Controller etc..) should be aware of the abstract topology of the
optical transport network. This entity is the customer network
controller (CNC) as per [ACTN-FWK] which interacts with Virtual
Network Controller (VNC). This is shown in Figure 2. Another way
would be to consider Packet and Optical transport networks as domains
and a POI coordinator (VNC) to help build and operate a multi-layered
multi-domain network allowing operators to view and control a single
virtualized network as shown in Figure 1.

In either case, the abstract topology may consist of established
tunnels in optical transport network or ones that can be created on
demand. The level of abstraction is dependent on various management,
security and policy considerations. This abstract topology
information in the packet network can be utilized in various cases,
as detailed in the following sections.

3.1. Traffic Planning, Monitoring and Automatic Network Adjustments

Currently there is a schism between network planning for packet and
optical transport networks. Sometimes these networks are
administered, operated and planned independently even when they are a
part of a single trusted domain. Any change in traffic requirements
requires long business process to make changes in the network. In
dynamic networks this is no longer acceptable.

A unified Packet+Optical traffic planning tool can be developed which
uses the traffic demand matrix to plan the optical transport network.

Further based on traffic demand changes, historical data, traffic
prediction and monitoring, changes should be made to the optical
transport network. An access to abstract topology of the optical
transport network based on established and potential (on-demand)
tunnels in optical transport network can provide mechanism to handle
this.

Further optical bypass may be established automatically to offload
the continuous changing traffic to optical transport network allowing
streamlined business process between packet and optical transport
networks.

3.1.1. Automated Congestion Management

Congestion management and synergized network optimization for packet
and optical transport networks can eliminate the need for overbooking
of optical transport networks as dumb pipes. Application could be
written that provide automated congestion management and network
optimization. Automated congestion management recognizes prolonged
congestion in the network and works with the controllers to add
bandwidth at an optical transport layer, to alleviate the congestion,
or make changes in the packet layer to reroute traffic around the
congestion.

For such applications there is a clear need for an abstract network
topology of optical transport layer, further there is also a need for
a synergy of cost and SLA across optical and packet networks.

3.2. Protection and Restoration Synergy

The protection and restoration are usually handled individually in
Packet and optical layer. There is a need for synergy and optimized
handling of protection of resources across layers. A lot more
resources in the optical transport network are booked for backup then
actually required since there is a lack of coordination between
packet and optical layers. The access to abstract graph of optical
transport network with information pertaining to backup path
information can help the packet network to handle protection, shared
risk, fault restoration in an optimized way. Informing the packet
network about both working and protection path which are either
already established, or potential path can be useful.

A significant improvements in overall network availability that can
be achieved by using optical transport shared-risk link group (SRLG)
information to guide packet network decisions; for example, to avoid
or minimize common SRLGs for the main (working) path and the loop
free alternative or traffic engineered fast reroute (LFA/TE FRR)
back-up path. Shared risk information need to be synergized between

the packet and optical. A mechanism to provide abstracted SRLG
information can help the packet network consider this information
while handling protection and restoration.

3.3. Service Awareness

In certain networks like financial information network (stock/
commodity trading) and enterprises using cloud based applications,
Latency (delay), Latency-Variation (jitter), Packet Loss and
Bandwidth Utilization are associated with the SLA. These SLAs must
be synergized across packet and optical transport networks. Network
optimization evaluates network resource usage at all layers and
recommends or executes service path changes while ensuring SLA
compliance. It thus makes more effective use of the network, and
relieves current or potential congestion.

The main economic benefits of ACTN arise from its ability to maintain
the SLA of the services at reduced overall network cost considering
both packet and optical transport network. Operational benefits of
the ACTN also stem from greater flexibility in handling dynamic
traffic such as demand uncertainty or variations over time, or
optimization based on cost or latency, or improved handling of
catastrophic failures.

3.4. Coordination between Multiple Network Domains

In some deployments, optical transport network may further be divided
into multiple domains, an abstracted topology comprising of multiple
optical domains MAY be provided to the packet network. A Seamless
aggregation and orchestration across multiple optical transport
domains is achieved via the VNC, a great help in such deployments.

Another interesting deployment involves multiple packet network
domains. There exist scenarios where the topology provided to the
packet network domains may be different based on the initial demand
matrix as well as, management, security and policy considerations.

The ACTN framework as described in [ACTN-FWK] should support the
aggregation and orchestration across network domains and layers.

Further Figure 3 shows a multi-domain scenario where multiple PNC
(each controlling a packet or optical domain) and a VNC coordinating
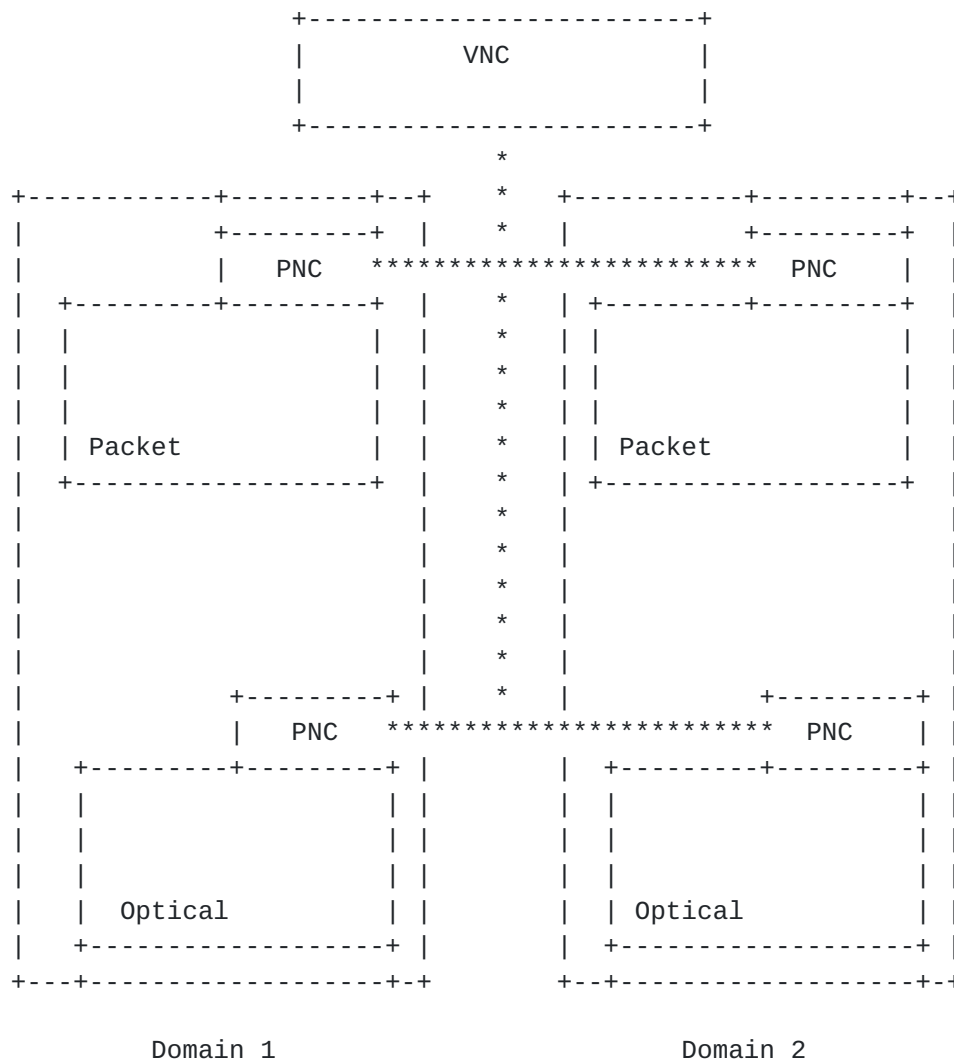among them and providing a consolidated view.

```
                    +-------------------------+
                    |           VNC           |
                    |                         |
                    +-------------------------+
                                 *
    +------------+---------+--+   *   +-----------+---------+--+
    |         +---------+  |   *   |         +---------+  |
    |         |   PNC  *************************  PNC   |  |
    |  +---------+---------+  |   *   | +---------+---------+  |
    |  |         |        | |   *   | |         |        |  |
    |  |         |        | |   *   | |         |        |  |
    |  |         |        | |   *   | |         |        |  |
    |  | Packet           | |   *   | | Packet           |  |
    |  +------------------+ |   *   | +------------------+  |
    |                      |   *   |                     |
    |                      |   *   |                     |
    |                      |   *   |                     |
    |                      |   *   |                     |
    |                      |   *   |                     |
    |         +---------+  |   *   |         +---------+  |
    |         |   PNC  *************************  PNC   |  |
    |  +---------+---------+  |   |  +---------+---------+  |
    |  |        |         | |  |  |  |        |         |  |
    |  |        |         | |  |  |  |        |         |  |
    |  |        |         | |  |  |  |        |         |  |
    |  | Optical          | |  |  |  | Optical          |  |
    |  +------------------+ |  |  |  +------------------+  |
    +---+------------------+-+  +--+------------------+-+

            Domain 1                       Domain 2
```

            Figure 3: Coordination between Multiple Network Domains

[4]. Typical Workflow

   Consider a two-layer network where the higher-layer network is a
   packet-based IP/MPLS or GMPLS network and the lower-layer network is
   a GMPLS-controlled optical network both under a common administrative
   control.

   The PNC in both layers are under a common VNC that coordinates
   between the two layers. And this multi-layer network is used to
   interconnect DCs, where the DC controller (customer network
   controller - CNC) takes charge as shown in Figure 4.

```
                                                    Data Center
                                            ***** Controller
                ------------------------------------*CNC*-------------
                |                                   *****            |
                |                                    |  Multi-layer  |
                |                                    v   Coordinator |
                |                                   *****            |
                |                                   *VNC*--          |
    Data        |                                   *****  |        |
    Center      |                                          |        |
    +----+      |                                   *****  | +----+ |
    | DC1|<-                                        *PNC*<- | DC3|<-
    +----+      |                                   *****  | +----+ |
      .....|..                                      Packet | ....   |
    +----+  | .   +--------------------------------+ | .+----+ |
    | DC2|<- .. /R          R            R      R..../...|..| DC4|<-
    +----+      /          R          R           /    | +----+
      ........./....R    .   R    .      R   R../.....|.....
          +--------------------------------+    |
    Packet          .    .    .    .    .    .        |
    Layer           .    .    .    .    .    .        |
                    .    .    .    .    .    . *****  |
                    .    .    .    .    .    . *PNC*<-
                    .    .    .    .    .    . ***** Optical
            +--------------------------------+
           / O     . O . O  .      O    O   /
          /          O   .    O  O           /
    Optical  / O    O         O          O    O  /
    Layer    +--------------------------------+
```
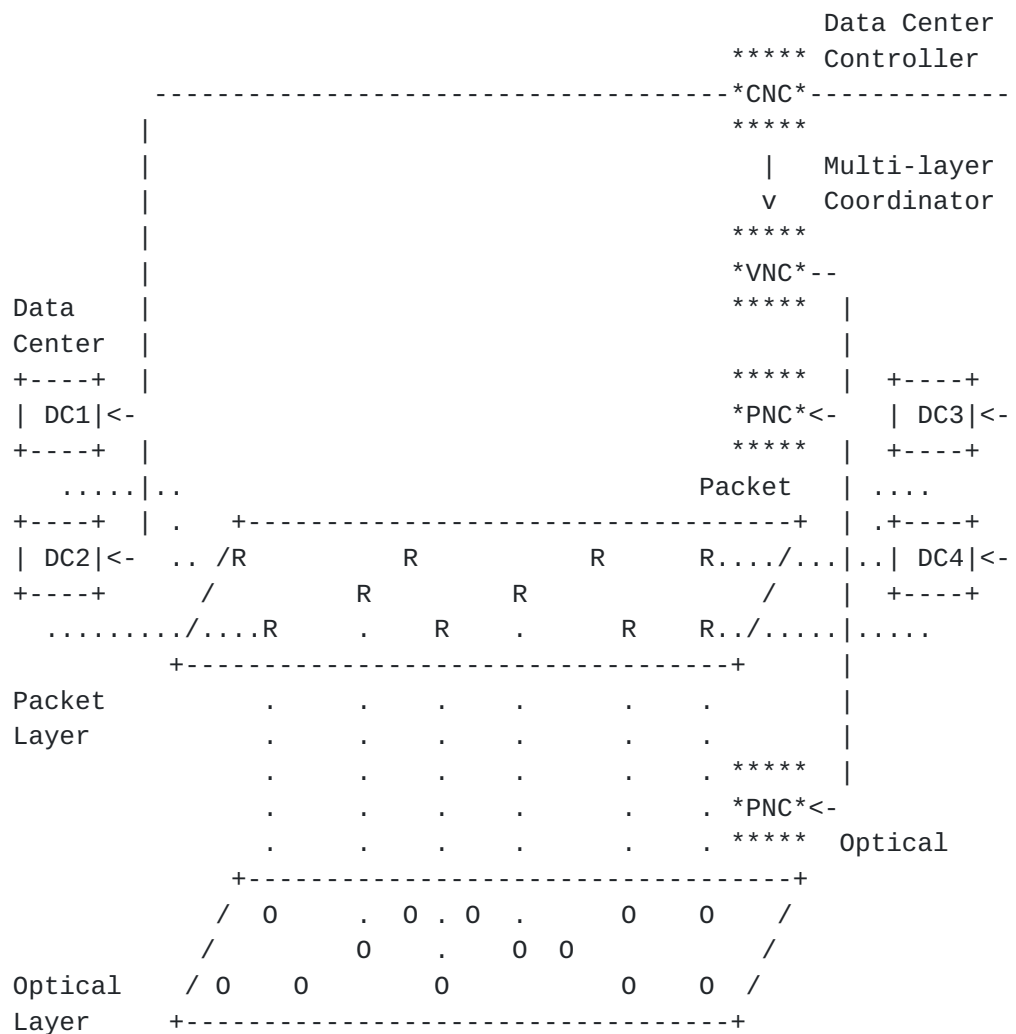
                      Figure 4: Typical Workflow

   Data centre controller (as Customer Network Controller) interfaces
   the data centre application stratum, it understands multiple DC
   application requirements and their service needs. DC Controller
   provides its traffic demand matrix that describes bandwidth
   requirements and other optional QoS parameters (e.g., latency,
   diversity requirement, etc.) for each pair of inter-DC connections.
   The VNC (multi-layer coordinator) sits between the DC controller (CNC
   - the one issuing connectivity requests) and the physical network
   controllers (the one managing the resources). In this case each
   layer has its own PNC managing the resources in each layer with VNC
   acting as a multi-layer coordinator. The PNC is in charge of
   configuring the network elements, monitoring the physical topology of
   the network and passing it, either raw or abstracted, to the VNC.

VNC with the help of PNC(s) coordinates network resource control and utilization facilitating network efficiency and network automation. The VNC are also responsible for the abstract topology and the level of abstraction, which facilitate various DC usecases like VM Migrations, global load balancing among geographically distributed DCs, Business continuity and disaster recovery etc using the ACTN framework in an elastic and dynamic and way, improving overall network operations and scaling.

Based on the Data centre controller's (acting as CNC) requests for virtual network paths, the VNC mediates with the PNCs and maps these 'virtual' request to inter-layer coordinated path computation and provisioning requests in the 'physical' domain to the PNC. Thus VNC acts as a multi-layer coordinator both in respect to multi-layer end to end optimized path computation as well as multi-layer signaling and provisioning. The path computation and abstract topology creation would be based on the guidelines set by the CNC including the optimization criteria, traffic profile, policy etc.

In case the PNC could not fulfill the desired request from VNC and indirectly from DC controller, there should be a feedback loop to the VNC so that suitable actions including path recalculation and signaling, negotiation of parameters and attributes with DC controller etc can be undertaken. Thus VNC effectively arbitrate between the customers (DC) and the existing network (PNC) in this example.

5. Security Considerations

TBD.

6. IANA Considerations

None, this is an informational document.

7. Acknowledgments

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8.1. Normative References

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Appendix A. Contributor Addresses

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