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Young Lee
Huawei

Sergio Belotti
Alcatel-Lucent

Dhruv Dhody
Huawei

Daniele Ceccarelli
Ericsson

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Information Model for Abstraction and Control of Transport Networks

draft-leebelotti-actn-info-01.txt

Abstract

This draft provides an information model for abstraction and control of transport networks.

Status of this Memo

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1. Introduction

This draft provides information model for the ACTN interfaces identified in the ACTN architecture and framework document [ACTN-Frame].

The ACTN architecture identified a three-tier control hierarchy as depicted in Figure 1:

- Customer Network Controllers (CNC)
- Multi-Domain Service Coordinator (MDSC)
- Physical Network Controllers (PNC).

```
VPN customer         NW Mobile Customer     ISP NW service Customer
    |                         |                           |
+-------+                 +-------+                   +-------+
| CNC-A |                 | CNC-B |                   | CNC-C |
+-------+                 +-------+                   +-------+
      \                       |                           /
       ----------             | CMI          ------------
                 \            |            /
                  +-----------------------+
                  |         MDSC          |
                  +-----------------------+
                 /            |            \
         --------             | MPI          ------------
        /                     |                           \
+-------+                 +-------+                   +-------+
|  PNC  |                 |  PNC  |                   |  PNC  |
+-------+                 +-------+                   +-------+
```

Figure 1. A Three-tier ACTN control hierarchy

The two interfaces with respect to the MDSC, one north of the MDSC and the other south of the MDSC are referred to as CMI (CNC-MDSC Interface) and MPI (MDSC-PNC Interface), respectively. It is intended to model these two interfaces with one common model.

Section 2 provides a high-level applicability of ACTN based on a number of use-cases listed in the following:

- draft-cheng-actn-ptn-requirements-00 (ACTN Use-cases for Packet Transport Networks in Mobile Backhaul Networks)

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

- draft-fang-actn-multidomain-dci-01 (ACTN Use Case for Multi-domain Data Center Interconnect)

- draft-klee-actn-connectivity-multi-vendor-domains-03 (ACTN Use-case for On-demand E2E Connectivity Services in Multiple Vendor Domain Transport Networks)

- draft-kumaki-actn-multitenant-vno-00 (ACTN : Use case for Multi Tenant VNO)

- draft-lopez-actn-vno-multidomains-01 (ACTN Use-case for Virtual Network Operation for Multiple Domains in a Single Operator Network)

- draft-shin-actn-mvno-multi-domain-00 (ACTN Use-case for Mobile Virtual Network Operation for Multiple Domains in a Single Operator Network)

- draft-xu-actn-perf-dynamic-service-control-02 (Use Cases and Requirements of Dynamic Service Control based on Performance Monitoring in ACTN Architecture)

2. ACTN Applications

This section provides the scope of the ACTN applicability to support the following applications.

- Coordination of Multi-destination Service Requirement/Policy (Section 2.2.1)
- Application Service Policy-aware Network Operation (section 2.2.2)
- Network Function Virtualization Service Enabled Connectivity (2.2.3)
- Dynamic Service Control Policy Enforcement for Performance/Fault Management (Section 2.2.4)
- E2E VN Survivability and Multi-Layer (Packet-Optical) Coordination for Protection/Restoration (Section 2.2.5)

2.1.1. Coordination of Multi-destination Service Requirement/Policy

```
                             +----------------+
                             |       CNC      |
                             |   (Global DC   |
                             |   Operation    |
                             |    Control)    |
                             +--------+-------+
                                      | |  Service Requirement/Policy:
                                      | |  - Endpoint/DC location info
                                      | |  - Endpoint/DC dynamic
                                      | |    selection policy
                                      | |    (for VM migration, DR, LB)
                                      | v
                            +---------+--------+
                            |  Multi-domain    | Service policy-driven
                            |Service Controller| dynamic DC selection
                            +-----+---+---+----+
                                  |   |   |
                                  |   |   |
                 +----------------+   |   +----------------+
                 |                    |                    |
           +-----+-----+       +------+-----+      +------+-----+
           |   PNC for |       |  PNC for   |      |  PNC for   |
           | Transport |       | Transport  |      | Transport  |
           | Network A |       | Network B  |      | network C  |
           +-----------+       +------------+      +------------+
                 |                    |                   |
+---+      ------               ------              ------       +---+
|DC1|--////      \\\\       ////      \\\\      ////      \\\\---+DC4|
+---+ |              |     |              |    |              |  +---+
      |     TN A     +-----+     TN B     +----+      TN C    |
      /              |     |              |    |              |
     / \\\\      ////     / \\\\      ////      \\\\      ////
   +---+   ------        /      ------    \         ------ \
   |DC2|                /                  \                \+---+
   +---+               /                    \                |DC6|
                     +---+                   \ +---+         +---+
                     |DC3|                    \|DC4|
                     +---+                     +---+

                                                DR: Disaster Recovery
                                                LB: Load Balancing
```

Figure 2: Service Policy-driven Data Center Selection

Figure 2 shows how VN service policies from the CNC are incorporated by the MDSC to support multi-destination applications. Multi-

destination applications refer to applications in which the selection of the destination of a network path for a given source needs to be decided dynamically to support such applications.

Data Center selection problems arise for VM mobility, disaster recovery and load balancing cases. VN's service policy plays an important role for virtual network operation. Service policy can be static or dynamic. Dynamic service policy for data center selection may be placed as a result of utilization of data center resources supporting VNs. The MSDC would then incorporate this information to meet the service objective of this application.

2.1.2. Application Service Policy-aware Network Operation

```
                           +----------------+
                           |       CNC      |
                           |   (Global DC   |
                           |   Operation    |
                           |    Control)    |
                           +--------+-------+
                                    | | Application Service Policy
                                    | | - VNF requirement (e.g.
                                    | |   security function, etc.)
                                    | | - Location profile for each VNF
                                    | v
                          +---------+--------+
                          |  Multi-domain    |  Dynamically select the
                          |Service Controller|  network destination to
                          +-----+---+---+----+  meet VNF requirement.
                                |   |   |
                                |   |   |
                +---------------+   |   +----------------+
                |                   |                    |
         +------+-----+        +-----+------+      +------+-----+
         |   PNC for  |        |  PNC for   |      |  PNC for   |
         | Transport  |        | Transport  |      | Transport  |
         | Network A  |        | Network B  |      | network C  |
         |            |        |            |      |            |
         +------------+        +------------+      +------------+
                |                   |                    |
{VNF b}         |                   |                    |  {VNF b,c}
+---+      ------              ------              ------     +---+
|DC1|--////      \\\\       ////      \\\\      ////      \\\\-|DC4|
+---+ |              |     |              |    |              |+---+
     |      TN A      +---+      TN B      +--+      TN C      |
      /              |     |              |    |              |
     / \\\\      ////     / \\\\      ////      \\\\      ////
   +---+   ------        /      ------    \         ------ \
   |DC2|                /                  \               \\+---+
   +---+               /                    \                |DC6|
    {VNF a}          +---+                   +---+           +---+
                     |DC3|                   |DC4|      {VNF a,b,c}
                     +---+                   +---+
            {VNF a, b}                  {VNF a, c}
```

Figure 3: Application Service Policy-aware Network Operation

This scenario is similar to the previous case in that the VN service policy for the application can be met by a set of multiple destinations that provide the required virtual network functions (VNF). Virtual network functions can be, for example, security functions required by the VN application. The VN service policy by the CNC would indicate the locations of a certain VNF that can be fulfilled. This policy information is critical in finding the optimal network path subject to this constraint. As VNFs can be dynamically moved across different DCs, this policy should be dynamically enforced from the CNC to the MDSC and the PNCs.

2.1.3. Network Function Virtualization Service Enabled Connectivity

```
                           +----------------+
                           |       CNC      |
                           |   (Global DC   |
                           |   Operation    |
                           |    Control)    |
                           +--------+-------+
                                    | | Service Policy
                                    | | (e.g., firewall, traffic
                                    | | optimizer)
                                    | |
                                    | v
                          +---------+--------+
                          |  Multi-domain    | Select network
                          |Service Controller| connectivity subject to
                          +-----+---+---+----+ meeting service policy
                                |   |   |
                                |   |   |
                +---------------+   |   +----------------+
                |                   |                    |
         +------+-----+       +-----+------+      +------+-----+
         |   PNC for  |       |  PNC for   |      |  PNC for   |
         | Transport  |       | Transport  |      | Transport  |
         | Network A  |       | Network B  |      | network C  |
         |            |       |            |      |            |
         +------------+       +------------+      +------------+
                |                   |                    |
                |                   |                    |
+---+      ------               ------              ------     +---+
|DC1|--////      \\\\       ////      \\\\      ////      \\\\-|DC4|
+---+ |              |     |              |    |              |+---+
     |      TN A      +---+     TN B       +--+      TN C      |
      /              |     |              |    |              |
     / \\\\      ////     / \\\\      ////      \\\\      ////
   +---+   ------        /      ------    \         ------ \
   |DC2|                /                  \                \\+---+
   +---+               /                    \                 |DC6|
                    +---+                    +---+            +---+
                    |DC3|                    |DC4|
                    +---+                    +---+
```

Figure 4: Network Function Virtualization Service Enabled Connectivity

Network Function Virtualization Services are usually setup between customers' premises and service provider premises and are provided mostly by cloud providers or content delivery providers. The context may include, but not limited to a security function like firewall, a traffic optimizer, the provisioning of storage or computation capacity where the customer does not care whether the service is implemented in a given data center or another.

These services may be hosted virtually by the provider or physically part of the network. This allows the service provider to hide his own resources (both network and data centers) and divert customer requests where most suitable. This is also known as "end points mobility" case and introduces new concepts of traffic and service provisioning and resiliency (e.g., Virtual Machine mobility).

2.1.4. Dynamic Service Control Policy Enforcement for Performance and Fault Management

```
+------------------------------------------------+
|           Customer Network Controller          |
+------------------------------------------------+
1.Traffic|  /|\4.Traffic           | /|\
Monitor& |   |  Monitor            |  | 8.Traffic
Optimize |   |  Result   5.Service |  | modify &
Policy   |   |             modify& |  | optimize
        \|/  |       optimize Req.\|/ | result
+------------------------------------------------+
|         Mult-domain Service Controller         |
+------------------------------------------------+
2. Path  |  /|\3.Traffic           |  |
Monitor  |   | Monitor             |  |7.Path
Request  |   | Result     6.Path   |  | modify &
         |   |            modify&  |  | optimize
        \|/  |       optimize Req.\|/ | result
+------------------------------------------------+
|          Physical Network Controller           |
+------------------------------------------------+
```

Figure 5: Dynamic Service Control for Performance and Fault Management

Figure 5 shows the flow of dynamic service control policy enforcement for performance and fault management initiated by customer per their VN. The feedback loop and filtering mechanism tailored for VNs performed by the MDSC differentiates this ACTN scope from traditional network management paradigm. VN level dynamic OAM data model is a building block to support this capability.

2.1.5. E2E VN Survivability and Multi-Layer (Packet-Optical) Coordination for Protection/Restoration

```
                        +----------------+
                        |   Customer     |
                        |   Network      |
                        |   Controller   |
                        +--------*-------+
                                 *  |     E2E VN Survivability Req.
                                 *  |     - VN Protection/Restoration
                                 *  v        - 1+1, Restoration, etc.
                          +------*-----+   - End Point (EP) info.
                          |            |
                          |    MDSC    | MDSC enforces VN survivability
                          |            | requirement, determining the
                          |            | optimal combination of Packet/
                          +------*-----+ Opticalprotection/restoration,
                                 *       Optical bypass, etc.
                                 *
                                 *
              **********************************************
              *               *             *              *
         +----*-----+    +----*----+   +----*-----+   +----*----+
         |PNC for   |    |PNC for  |   |PNC for   |   |PNC for  |
         |Access N. |    |Packet C.|   |Optical C.|   |Access N.|
         +----*-----+    +----*----+   +----*-----+   +---*-----+
              *             --*---          *             *
              *          ///      \\\       *             *
            --*---      |   Packet   |      *         ----*-
         ///      \\\   |    Core    +------+------///      \\\
        |  Access    +----\\      ///       *     |   Access   |
        |  Network   |      ---+--          *     |   Network  |  +---+
        |\\\      ///          |            *      \\\      ///---+EP6|
        |   +---+-  |          |       -----*         -+---+      +---+
      +-+-+     |   |          +----///      \\\       |   |
      |EP1|     |   +--------------+  Optical   |      |   |  +---+
      +---+     |                  |    Core    +-------+  +--+EP5|
              +-+-+                 \\\      ///              +---+
              |EP2|                    ------ |
              +---+                     |     |
                                     +--++   ++--+
                                     |EP3|   |EP4|
                                     +---+   +---+
```

Figure 6: E2E VN Survivability and Multi-layer Coordination for Protection and Restoration

Figure 6 shows the need for E2E protection/restoration control coordination that involves CNC, MDSC and PNCs to meet the VN survivability requirement. VN survivability requirement and its policy need to be translated into multi-domain and multi-layer network protection and restoration scenarios across different controller types. After an E2E path is setup successfully, the MSDC has a unique role to enforce policy-based flexible VN survivability requirement by coordinating all PNC domains.

As seen in Figure 6, multi-layer (i.e., packet/optical) coordination is a subset of this E2E protection/restoration control operation. The MDSC has a role to play in determining an optimal protection/restoration level based on the customer's VN survivability requirement. For instance, the MDSC needs to interface the PNC for packet core as well as the PNC for optical core and enforce protection/restoration policy as part of the E2E protection/restoration. Neither the PNC for packet core nor the PNC for optical core is in a position to be aware of the E2E path and its protection/restoration situation. This role of the MSDC is unique for this reason. In some cases, the MDSC will have to determine and enforce optical bypass to find a feasible reroute path upon packet core network failure which cannot be resolved the packet core network itself.

To coordinate this operation, the PNCs will need to update its domain level abstract topology upon resource changes due to a network failure or other factors. The MSDC will incorporate all these update to determine if an alternate E2E reroute path is necessary or not based on the changes reported from the PNCs. It will need to update the E2E abstract topology and the affected CN's VN topology in real-time. This refers to dynamic synchronization of topology from Physical topology to abstract topology to VN topology.

MDSC will also need to perform the path restoration signaling to the affected PNCs whenever necessary.

3. ACTN common interfaces information model

This section provides ACTN common interface information model to support primitives between controllers: CNC-MDSC and MDSC-PNC.

The basic primitives are required between the controllers. It is described between a client controller and a server controller. A client-server relationship is recursive between a CNC and a MDSC and between a MDSC and a PNC. In the CMI interface, the client is a CNC

while the server is a MDSC. In the MPI interface, the client is a MDSC and the server is a PNC. At a minimum, the following primitives should be supported:

- Virtual Network (VN) Instantiate/Modify/Delete
- VN Topology Update (Push Model)

```
<VN> ::= <VN Identifier>

         <VN Action>

         <End-Point List>

         <VN Topology Metric>

         <Traffic-Matrix>

         <VN Survivability>

         <VN Status>

         <VN Topology>
```

Where

<VN Identifier> is an identifier that identifies a particular VN.

<VN Action> is an indicator if this <VN> is for (i) instantiate, (ii) modify; (iii) delete. There may be a case where a query of a VN is necessary before an instantiate request. This is subject to further investigation.

```
<End-Point List> ::= (<Interface Identifier>

                     [<Client Capability>])...

                     <Location Service Profile>

                     <End-Point Dynamic Selection Policy>
```

Where

It is assumed that a list of interface identifiers has been known to the server prior to the VN Query message flow.

<Client Capability> ::= <Client Interface Capability>

[<Client Service Policy>]

The Client Capability comprises the client interface capability (e.g., maximum interface bandwidth, etc.) and other Service policy information of the client.

<Client Service Policy> ::= <Customer-Level |

<Network-Level>

Where

<Customer-Level> pertains to end-client service policies which specify the end-client related service/operational policies. Details of this field will be supplied in a later revision.

<Network-Level> pertains to the policies related to multi-domain network operation assumed by the MDSC. For example, domain selection preference in the context of multi-domain networks is a network-level service policy. Details of this field will be supplied in a later version.

<Location Service Profile> describes the End-Point Location's support for certain Virtual Network Functions (VNFs) (e.g., security function, firewall capability, etc.).

<End-Point Dynamic Selection Policy> describes if the End-Point can support load balancing, disaster recovery or VM migration.

<VN Topology Metric> ::= <VN Topology Type>

<VN Topology Cost>

```
                              [<VN Topology Preference>]

                              [<VN Topology Objective Function>]

      Where

      <VN Topology Type> ::= <Path> | <Graph>

      <VN Topology Cost> describes a particular cost associated with
      the VN Topology link/path such as reservable bandwidth,
      maximum link/path capacity, latency, etc.

      <VN Topology Preference> describes if the request is

        .  a single vs. a bulk request,
        .  VN diversity preference (in case of a bulk request,
            whether VNs should be disjoint or not),
        .  SRLG is required in describing link/path topology, or
        .  Others TDB.


      <VN Topology Objective Function> indicates a specific
      objective function for computing a path. This only
      applies when the VN Topology Type is a path vector.





   <Traffic-Matrix> ::= <End-Point List>

                        <Connectivity Type>

                        <Connectivity Metric>

   Where

      <Connectivity Type> ::= <P2P> | <P2MP> | <MP|MP> | <MP|P>

                                 <Multi-destination>



      <Connectivity Matric> ::= <Bandwidth>
```

```
                               [<Latency>]


   <VN Survivability> ::= <VN Protection Level>

                          <VN Survivability Policy>
```

Where

```
      <VN Protection Level> ::= <No Protection> | <1+1> | <1:N> |
                                <restoration>

      <VN Survivability Policy> ::= <Local Reroute Allowed>

                                    [<Domain Preference>]

                                    <Push Allowed>

                                    <Incremental Update>
```

Where

<Local Reroute Allowed> is a delegation policy to the Server to allow or not a local reroute fix upon a failure of the primary LSP.

<Domain Preference> is only applied on the MPI where the MDSC (client) provides a domain preference to each PNC (server).

<Push Allowed> is a policy that allows a server to trigger an updated VN topology upon failure without an explicit request from the client.

<Increment Update> is another policy that triggers an increment update from the server.

<VN Status> is the status indicator whether the VN has been successfully instantiated/modified/deleted in the server network or not in response to <VN Action>.

<VN Topology> describes the resulting VN topology. Details of <VN Topology> are TDB.

4. References

4.1. Informative References

[ACTN-Frame] D. Ceccarelli, et al., "Framework for Abstraction and Control of Transport Networks", draft-ceccarelli-actn-framework, work in progress.

5. Contributors

Contributors' Addresses

Authors' Addresses

Young Lee
Huawei Technologies
5340 Legacy Drive
Plano, TX 75023, USA
Phone: (469)277-5838
Email: leeyoung@huawei.com

Sergio Belotti
Alcatel Lucent
Via Trento, 30
Vimercate, Italy
Email: sergio.belotti@alcatel-lucent.com

Dhruv Dhoddy
Huawei Technologies
Email: dhruv.ietf@gmail.com

Daniele Ceccarelli
Ericsson
Torshamnsgatan,48
Stockholm, Sweden
Email: daniele.ceccarelli@ericsson.com