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ACTN Use-case for Mobile Virtual Network Operation for Multiple Domains in a Single Operator Network

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Abstract

This document provides a use-case that addresses the need for virtual network operation for mobile operators, which is facilitated by the application of network abstraction. These abstractions shall create a virtual network operation environment supporting mobile operators in viewing, managing and operating multi-domains of many dimensions (e.g., radio access, backhaul transport, mobile DC edge, mobile DC core, packet/optical transport for DC interconnect, etc.) as a single virtualized network.

This use-case considers the application of these abstractions and the need for the associated operational mechanisms within the network of a single operator.

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1. Introduction

Mobile network operators build and operate their network using multiple domains in different dimensions. From a network domain/technology point of view, mobile services/applications traverse many different domains such as radio access, backhaul transport, mobile DC edge, packet/optical backbone transport for DC interconnect, mobile DC core, etc. Due to this diversity of technology domains (e.g., radio, packet, optical, etc.) and the complex organizational boundaries for operations (e.g., access, backhaul, core transport, data center, etc.), the efficient operation of the services/applications spanning several of these domains has been a challenge for mobile operators.

In addition, multi-vendor issue adds another dimension of complexity. Both interoperability and operational concerns at the control and data planes have increased operational complexity and the OpEx.

Moreover, the widespread deployment of middle boxes (e.g. edge cache, firewall etc.) inside the DC edge and core edge will be achieved due to tightly-coupled interaction with higher layer protocols and transport control protocols (i.e. GMPLS, RSVP, etc.)

With the aforementioned situations, the introduction of new services and applications, often requiring connections that traverse multiple domains, necessitates significant planning, and several manual operations to interface different administrative zones, vendor equipment and transport technology.

This document provides a use-case that addresses the need for facilitating the application of virtual network abstractions to mobile network operators. These abstractions shall create a virtualized network operation environment supporting mobile operators in viewing and controlling multi-domains of many dimensions (e.g., radio access, backhaul transport, mobile DC edge, mobile DC core, packet/optical transport for DC interconnect, etc.) as a single virtualized network. This use-case considers the application of these abstractions within the network of a single operator.

This use-case is a part of the overarching work, called Abstraction and Control of Transport Networks (ACTN). The goal of ACTN is to facilitate virtual network operation by:

. The creation of a virtualized environment allowing operators to view the abstraction of the underlying multi-admin, multi-vendor, multi-technology networks and

. The operation and control/management of these multiple networks as 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.

Related documents are the ACTN-framework [ACTN-Frame] and the problem statement [ACTN-PS].

2. Operational Challenges and Issues in Mobile Operator's Multi-domain Networks

Figure 1 depicts an illustrative example for mobile operator's multi-domain networks.

```
                                         +--------------+
                                         |   Internet   |
                                         |   Core       |
                                         |   Network    |
                                         |   Domain 6   |
                                         |  (Vendor G)  |
                                         +--------------+
                                                *
  +----------+  +----------+  +----------+  +--------------+  +----------+
  |          |  |          |  |          |  | +----------+ |  |          |
  |          |  |          |  |          |  | | Packet   | |  |          |
  |          |  |          |  |          |  | | Network  | |  |          |
  |          |  |          |  |          |  | |(Vendor E)| |  |          |
  | Radio    |  | Transport|  | Mobile   |  | +----------+ |  | Mobile   |
  | Access   |  | Network  |  | Edge DC  |  |      *       |  | Core DC  |
  | Network  |**| Domain 2 |**| Domain 3 |**| +----------+ |**| Domain 5 |
  | Domain 1 |  |(Vendor B)|  |(Vendor C)|  | | Optical  | |  |(Vendor F)|
  |(Vendor A)|  |          |  |          |  | | Transport| |  |          |
  |          |  |          |  |          |  | | Network  | |  |          |
  |          |  |          |  |          |  | |(Vendor D)| |  |          |
  |          |  |          |  |          |  | +----------+ |  |          |
  |          |  |          |  |          |  |   Domain 4   |  |          |
  +----------+  +----------+  +----------+  +--------------+  +----------+
```

Figure 1: Multi-domains in Mobile Operator's Network

It consists of six domains:

1. Radio Access Network Domain

2. Mobile Backhaul Transport Network Domain

3. Mobile Edge Data Center Network Domain

4. Core Packet/Optical Transport Network Domain for Data Center interconnect (this domain typically consists of multi-layer)

5. Mobile Core Data Center Network Domain

6. Internet Core Network Domain

Mobile data application may find its servers hosted by the Mobile Edge DC (Domain 3) while some other applications hosted by servers in the Mobile Core DC (Domain 5). For the former case, the connectivity starts from a RAN edge and terminates at a Mobile Edge Data Center. For the latter case, the connectivity is extended beyond the Mobile Edge Data Center and traverses the Mobile Backhaul Transport Network domain and the Core Transport Network domain.

There are several issues that are relevant in the ACTN context:

1. Transport from RAN to Mobile Edge DC

From RAN to mobile edge DC, there is mobile backhaul transport network that provides connectivity between a client data device and one of the edge nodes in the Mobile Edge DC Domain. The backhaul transport networks provide tunnels for data transport for mobile applications. These tunnels are typically provisioned statically. This mobile backhaul transport network can be a resource bottle neck. Operators typically overprovision this backhaul network to accommodate unpredicted serge of data traffic.

Resource abstraction is one of the missing operational mechanisms in mobile backhaul network. Resource abstraction will give the current network usage information to the operators and will help dynamic and elastic applications be provisioned dynamically with QoS guarantee.

2. Transport from Mobile Edge DC to Mobile Core DC

From Mobile Edge DC domain to Mobile Core DC domain, there is core transport network that provides connectivity between edges to core. As Mobile Core DC servers may be geographically spread for load balancing or for recovery, the selection of core DC location from edge constitutes a data center selection problem.

To support dynamic and flexible connection setup for applications that are of dynamic nature with flexible bandwidth, network resource abstraction is needed to facilitate this operation.

3. Transport from Mobile Edge DC to Internet Core Network

From Mobile Edge DC domain to Internet Core Network, there is also core transport network that provides connectivity between edges to Internet core for Local traffic breakout (e.g. LIPA and SIPTO). As Mobile Edge DC servers may be geographically spread at the network edge side for load balancing, the selection of traffic from edge to Internet core is required to be controlled. See [3GPP TR 23.859] for related discussion.

4. Multi-layer Integration/Coordination (aka., POI)

Within the core transport network domain, there is also a multi-layer issue between packet networks and optical transport networks. To support multi-layer routing and optimization, coordination between these two layers are necessary. Network abstraction of both packet and optical networks will be very useful to support different applications flexibly and efficiently. See [ACTN-POI] for related discussion.

5. End-to-end tunnel/transport operations/management from RAN to Mobile Core DCN:

As there are multiple transport domains (namely, Mobile backhaul and Core transport networks) involved for an end-to-end connectivity within an operator's network, the coordination between these domains are crucial for operation. Static provisioning with stitching tunnels are inadequate for many applications/services requiring strict QoS such as a guaranteed bandwidth and latency.

In the current network environments, these two domains are not well coordinated due to various reasons including the lack of a global resource view, a domain administrative boundary, and the differences in transport technology and vendor equipment.

In summary, due to complexity in mobile operator's network in terms of heterogeneous transport technology, organizational boundaries between domains, multi-vendor issues and others, facilitating connectivity that traverse the aforementioned multi-domains is not readily achieved.

Each domain control establishing other domain control in a peer to peer level creates permutation issues for the end-to-end control. Besides, these domain controls are optimized for its local operation and in most cases not suited for controlling the end-to-end connectivity services.

Moreover, the path computation for any end-to-end connection would need abstraction of network resources and ways to find an optimal path that meets the connection's service requirements. This would require knowledge of network abstraction and topology for all domains through which a connection traverses.

For mobile networks, signaling is a complex issue as it involves not only a session control but also a connection control. The coordination between the session control and the connection control has to be worked out for a seamless operation.

From a network connectivity management perspective, it would require a mechanism to disseminate any connectivity issues from the local domain to the other domains whenever the local domain cannot resolve a connectivity issues.

3. Virtual Network Operations for Mobile Operators' Networks

Based on the issues discussed in the previous section in regard to the operations for mobile multi-domain networks, there is a need to support a coordination that facilitates virtual network operation, the creation of a virtualized environment allowing operators to view the underlying radio access network, backhaul transport network, mobile DC edge, mobile DC core, packet/optical transport network for DC interconnect networks and their operation and management as a single, virtualized network.

The basic premise of this virtual network operation is to create a hierarchy of operations in which to separate virtual network operations from physical network operations. This helps operators build virtual network operations infrastructure on top of physical network operations. Figure 2 shows a hierarchical structure of operations.

```
                    +----------------------+
                    |    MVNO Coordinator  |
                    +----------------------+
                                |
                                | VNO-I
      .-------------------------------------------------------.
      |             |            |             |             |
+----------+  +----------+  +----------+  +----------+  +---------+
|    RAN   |  |  Mobile  |  |  Mobile  |  |   Core   |  | Mobile  |
|          |  | Backhaul |  | Edge DCN |  |    TN    |  | Core DCN|
|  Control |  |  Control |  |  Control |  | Control  |  | Control |
+----------+  +----------+  +----------+  +----------+  +---------+
```

Figure 2. Mobile VN Operation Hierarchy

Figure 2 shows operations hierarchy based on Figure 1. The two main ideas are:

1. Domain control/management entities (e.g., RAN Control, Mobile Backhaul Network Control, Mobile Edge Data Center Network Control, Core Transport Network Control, Mobile Core Data Center Network Control) are kept intact to continue its domain operations with its technology choice and policy, etc. As discussed before domain

control/management entities can be a form of various types (e.g., SDN-controller, NMS/EMS, Control Plane, or a combination of these entities, etc.) that is responsible for domain-specific network operations.

2. The VNO Coordinator establishes a standard-based API (which is termed as the Virtual Network Operations Interface (VNO-I) in Figure 2) with each of the domain control/management entities. The VNO coordination takes place via the VNO-I's.

4. References

[ACTN-Frame] D. Ceccarelli, L. Fang, Y. Lee and D. Lopez, "Framework for Abstraction and Control of Transport Networks," draft-ceccarelli-actn-framework, work in progress.

[ACTN-PS] Y. Lee, D. King, M. Boucadair, and R. Jing, "Problem Statement for the Abstraction and Control of Transport Networks," draft-leeking-actn-problem-statement, work in progress.

[ACTN-POI] D. Dhody, et. al., "Packet Optical Integration (POI) Use Cases for Abstraction and Control of Transport Networks (ACTN)," draft-dhody-actn-poi-use-case, work in progress.

[3GPP TR 23.859] Local IP access (LIPA) mobility and Selected IP Traffic Offload (SIPTO) at the local network.

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