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Requirements for Abstraction and Control of TE Networks

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Abstract

This document provides a set of requirements for abstraction and control of Traffic Engineering networks to facilitate virtual network operation via the creation of a single virtualized network or a seamless service. This supports operators in viewing and controlling different domains (at any dimension: applied technology, administrative zones, or vendor-specific technology islands) as a single virtualized network.

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1. Introduction

This document provides a set of requirements for Abstraction and Control of Traffic Engineering (TE) Networks (ACTN) identified in various use-cases. [ACTN-frame] defines the base reference architecture and terminology.

ACTN refers to the set of virtual network operations needed to orchestrate, control and manage large-scale multi-domain TE networks so as to facilitate network programmability, automation, efficient resource sharing, and end-to-end virtual service aware connectivity and network function virtualization services.

These operations are summarized as follows:

- Abstraction and coordination of underlying network resources independent of how these resources are managed or controlled, so that higher-layer entities can dynamically control virtual networks based on those resources. Control includes creating, modifying, monitoring, and deleting virtual networks.

- Collation of the resources from multiple TE networks (multiple technologies, equipment from multiple vendors, under the control of multiple administrations) through a process of hierarchical abstraction to present a customer with a single virtual network. This is chieved by presenting the network domain as an abstracted topology to the customer via open and programmable interfaces. Hierarchical abstraction allows for the recursion of controllers in a customer-provider relationship.

- Orchestration of end-to-end virtual network services and applications via allocation of network resources to meet specific service, application and customer requirements.

- Adaptation of customer requests (to control virtual resources) to the physical network resources performing the necessary mapping, translation, isolation and, policy that allows conveying, managing and enforcing customer policies with respect to the services and the network of the customer.

- Provision via a data model of a computation scheme and virtual control capability to customers who request virtual network

services. Note that these customers could, themselves, be service providers.

ACTN solutions will build on, and extend, existing TE constructs and TE mechanisms wherever possible and appropriate. Support for controller-based approaches is specifically included in the possible solution set.

Section 2 provides high-level ACTN requirements. Section 3 provides ACTN interface requirements.

2. High-level ACTN requirements

This section provides a summary of use-cases in terms of two categories: (i) service-specific requirements; (ii) network-related requirements.

Service-specific requirements listed below are uniquely applied to the work scope of ACTN. Service-specific requirements are related to the virtual service coordination function. These requirements are related to customer's VNs in terms of service policy associated with VNs such as service performance objectives, VN endpoint location information for certain required service specific functions (e.g., security and others), VN survivability requirement, or dynamic service control policy, etc.

Network-related requirements are related to the virtual network operation function. These requirements are related to multi-domain and multi-layer signaling, routing, protection/restoration and synergy, re-optimization/re-grooming, etc. These requirements are not inherently unique for the scope of ACTN but some of these requirements are in scope of ACTN, especially for coherent/seamless operation aspect of multiple controller hierarchy.

2.1. Service-Specific Requirements

1. Requirement 1: Policy Enforcement

Ability to provide service requirement/policy (between Customer and Network) and mechanism to enforce Service Level Agreements (SLA).

- Endpoint selection policy, routing policy, time-related policy, etc.

Reference: [KLEE], [LOPEZ], [SHIN], [DHODY], [FANG].

2. Requirement 2: Virtual Network (VN) Query

Ability to request/respond VN Query ("Can you give me these VN(s)?")

Request Input:

- VN end-points (Customer Edge equipment)
- VN Topology Service-specific Multi-Cost Objective Function
- VN constraints requirement
    - o Latency only, bandwidth guarantee, joint latency and bandwidth guarantee
- VN Topology diversity (e.g., VN1 and VN2 must be disjoint; Node/link disjoint from other VNs)
- VN Topology type: path, graph

Response includes VN topology:

- Exact
- Potential

Reference: [KUMAKI], [FANG], [CHENG].

3. Requirement 3: VN Instantiation ("Please create a VN for me")

Ability to request/confirm VN Instantiation

Request Input:

- VN instance ID
- VN end-points (Customer Edge equipment)
- VN Topology Service-specific Multi-Cost Objective Function
- VN constraints requirement
    - o Latency only, bandwidth guarantee, joint latency and bandwidth guarantee
- VN Topology diversity (e.g., VN1 and VN2 must be disjoint; Node/link disjoint from other VNs)
- VN Topology type: path, graph

Response includes VN topology:

- Exact
- Potential

Reference: [KUMAKI], [FANG], [CHENG].

4. Requirement 4: VN Lifecycle Management & Operation (M&O)

Ability to do the following VN operations:

- Delete
- Modify
- Update (VN level Operations, Administration and Management (OAM) Monitoring) under policy agreement

Reference: [FANG], [KUMAKI], [LOPEZ].

5. Requirement 5: VN Service Operation

Ability to set up and manage end-to-end services on the VN involving multi-domain and multi-layer operations of the underlying network while meeting constraints based on SLAs.

Reference: [LOPEZ], [KUMAKI], [CHENG], [DHODY], [FANG], [KLEE].

6. Requirement 6: VN Confidentiality/Security

- A VN customer must not be able to control another customer's virtual network
- A VN customer must not see any routing information (e.g. IGP database, TE database) relating to another customer's virtual network

Reference: [KUMAKI], [FANG], [LOPEZ]

7. Requirement 7: Multi-Destination Coordination

Coordination of multi-destination service requirement/policy to support dynamic applications such as VM migration, disaster recovery, load balancing, etc.

- Service-policy primitives and their parameters

Reference: [FANG], [LOPEZ], [SHIN].

2.2. Network-Related Requirements

1. Requirement 1: Single Virtualized Network Topology

Ability to build virtual network operation infrastructure based on multi-layer, multi-domain topology abstracted from multiple physical network control mechanisms (e.g., GMPLS, OpenFlow, PCE, NMS, etc.)

Reference: [KLEE], [LOPEZ], [DHODY], [CHENG].

2. Requirement 2: Multi-Domain & Multi-layer Coordination

Ability to coordinate multi-domain and multi-layer path computation and path setup operation

- End-to-end path computation across multi-domain networks (based on abstract topology from each domain)
- Domain sequence determination
- Request for path signaling to each domain controller
- Alternative path computation if any of the domain controllers cannot find its domain path

Reference: [CHENG], [DHODY], [KLEE], [LOPEZ], [SHIN], [SUZUKI].

3. Requirement 3: End-to-End Path Restoration

Ability to perform end-to-end Path Restoration Operations

- Intra-domain recovery
- Cross-domain recovery

Reference: [CHENG], [KLEE], [DHODY], [LOPEZ], [SHIN].

4. Requirement 4: Dynamicity of network control operations

The ACTN interfaces should support dynamic network control operations. This includes, but is not limited to, the following:

- Real-time VN control (e.g., fast recovery/reroute upon network failure).
- Fast convergence of abstracted topologies upon changes due to failure or reconfiguration across the network domain view, the multi-domain network view and the customer view.
- Large-scale VN operation (e.g., the ability to query tens of thousands of nodes, and to examine tens of thousands of connectivity requests) for time-sensitive applications.

Reference: [SHIN], [XU], [XU2], [KLEE], [KUMAKI], [SUZUKI].

5. Requirement 5: Dynamic VN Control

Dynamic/On-demand VN Modification/Confirmation with feedback loop to the customer

- Traffic monitoring and control policies sent to the network
- Network states based traffic optimization policies
- Utilization Monitoring (including frequency of reporting)
- Abstraction of Resource Topology reflecting service-related parameters

Reference: [XU], [XU2], [DHODY], [CHENG]

3. ACTN Interfaces Requirements

This section provides detailed ACTN interface requirements for the two interfaces that are within the ACTN scope based on [ACTN-Frame] and the use-cases referenced in this document.

The ACTN architecture described in [ACTN-Frame] comprises three functional components:

- CNC: Customer Network Controller

- MDSC: Multi Domain Service Coordinator
- PNC: Physical Network Controller

The architecture gives rise to two interfaces between components:

- CMI: CNC-MDSC Interface
- MPI: MDSC-PNC Interface

3.1. CMI Requirements

1. Security/Policy Negotiation ("Who are you?") between CNC and MDSC

   - Trust domain verification (External Entity versus Internal Service Department)
   - Push/Pull support (for policy)

2. VN Topology Query ("Can you give me VN?") from CNC to MDSC

   - VN end-points (CE end)
   - VN Topology Service-specific Multi-Cost Objective Function
     - o Latency Map
     - o Available Bandwidth Map
     - o Latency Map and Available Bandwidth Map together
     - o Other types
   - VN Topology diversity
     - o Node/Link disjoint from other VNs
     - o VN Topology level diversity (e.g., VN1 and VN2 must be disjoint)
   - VN Topology type
     - o Path vector (tunnel)
     - o Node/Links (graph)

3. VN Topology Query Response from MDSC to CNC: "Here's the VN Topology that can be given to you if you request it"

   - For VN Topology,
     - o This is what can be reserved for you
     - o This is what is available beyond what you asked for (potential)

4. Basic VN Instantiation Request/Confirmation between CNC and MDSC: "I need a VN for my service, please instantiate my VN"

- VN instance ID
- VN end-points
- VN service requirement
  - o Latency only
  - o B/W guarantee
  - o Latency and B/W guarantee together
- VN diversity
  - o Node/Link disjoint from other VNs
- VN level diversity (e.g., VN1 and VN2 must be disjoint)
- VN type
  - o Path vector (tunnel)
  - o Node/Links (graph)
- VN instance ID per service (unique id to identify VNs)
- If failed to instantiate the requested VN, say why

5. Dynamic/On-demand VN Instantiation/Modification and Confirmation with feedback loop (This is to be differentiated from Basic VN Instantiation)

   - Performance/Fault Monitoring
   - Utilization Monitoring (Frequency of report)
   - Abstraction of Resource Topology reflecting these service-related parameters
   - Dynamic Policy enforcement

6. VN lifecycle management/operation

   - Create (same as VN instantiate Request)
   - Delete
   - Modify
   - Update (VN level OAM Monitoring) under policy agreement

7. Coordination of multi-destination service requirement/policy to support dynamic applications such as VM migration, disaster recovery, load balancing, etc.

   - Service-policy primitives and its parameters

3.2. MPI Requirements

1. Security/Policy negotiation ("Who are you?")

   - Exchange of key, etc.
   - Domain preference + local policy exchange
   - Push/Pull support
   - Preferred peering points
   - Preferred route
   - Reroute policy
   - End-point mobility (for multi-destination)

2. Topology Query /Response (Pull Model from MDSC to PNC: "Please give me your domain topology")

   - TED Abstraction level negotiation
   - Abstract topology (per policy)
     - o Node/Link metrics
     - o Node/Link Type (Border/Gateway, etc.)
     - o All TE metrics (SRLG, etc.)
     - o Topology Metrics (latency, B/W available, etc.)

3. Topology Update (Push Model from PNC to MDSC: "The topology has been updated")

   - Under policy agreement, topology changes to be pushed to MDSC from PNC

4. VN Path Computation Request (From MDSC to PNC: "Please give me a path in your domain")

   - VN Instance ID (Note: this is passed from CNC to MDSC)
   - End-point information
   - CE ends
   - Border points (if applicable)
   - All other PCE request info (PCEP)

5. VN Path Computation Reply ("Here's the path info per your Request")

- Path level abstraction
- LSP DB
- LSP ID
- VN ID

6. Coordination of multi-domain Centralized Signaling Path Setup Operation (From MDSC to PNC: "Please give me your domain path if you can; otherwise, let me know if that is not possible."

   - MSDC computes E2E path across multi-domain (based on abstract topology from each PNC)
   - MDSC determines the domain sequence
   - MDSC request path signaling to each PNC (domain)
   - MDSC finds alternative path if any of the PNCs cannot find its domain path
     o PNC will crankback to MDSC if it cannot find its domain path
     o PNC will confirm to MDSC if it finds its domain path

7. Path Restoration Operation after an E2E path is setup successfully, some domain had a failure that cannot be restored by the PNC domain (From PNC to MDSC: "My domain path failed and I cannot restore it."; From MDSC to PNC: "OK. Please set up a new domain path with this ingress/egress nodes."

   - The problem PNC will send this notification with changed abstract topology (computed after resource changes due to failure/other factors)
   - MDSC will find an alternate E2E path based on the changes reported from PNC. 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 perform the path restoration signaling to the affected PNCs.

8. Coordination of Multi-destination service restoration operation: the CNC may have, for example, multiple endpoints where the source can send its data to either one of the endpoints. (From PNC to MDSC, "I lost my connectivity to the

endpoint. Please help to find alternative endpoint."; From MDSC to PNC, "Please use this alternative endpoint.")

- When PNC reports domain problem that cannot be resolved at PNC level because of there is no network restoration path to a given destination, then MDSC has customers' profile in which to find the customer has "multi-destination" application.
- Under policy A, MDSC will be allowed to reroute the customer traffic to one of the pre-negotiated destinations and proceed with restoration of this particular customer's traffic.
- Under policy B, CNC may reroute on its VN topology level and push this to MDSC and MDSC maps this into its abstract topology and proceed with restoration of this customer's traffic.
- In either case, the MDSC will proceed its restoration operation (as explained in Req. 7) to the corresponding PNCs.

9. MDSC-PNC policy negotiation is also needed as to how restoration is done across MDSC and PNCs. (From MDSC to PNC: "Please resolve at your domain for restoration of LSP."

10. Generic Abstract Topology Update per changes due to new path setup/connection failure/degradation/restoration (From PNC to MDSC: "Here's an updated topology")

11. Service-specific Abstract Topology Update per changes due to new path setup/connection failure/degradation/restoration (From PNC to MDSC: "Here's an updated service-specific topology")

4. References

4.1. Normative References

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