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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 specified by the operators. [ACTN-frame] defines the base reference architecture and terminology.

ACTN refers to the set of virtual network service 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.

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 achieved 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.

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. All these requirements are specified by operators that are interested in implementing ACTN.

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 and necessary for coherent/seamless for the virtual network operation function. These requirements are related to multi-domain and multi-layer signaling, routing, protection/restoration and re-optimization/re-grooming, etc.

Each requirement specified in Sections 2.1 and 2.2 is derived from ACTN use-cases: [CHENG], [DHODY], [FANG], [KLEE], [KUMAKI], [LOPEZ], [SHIN], [XU], [XU2], and [SUZUKI].

2.1. Service-Specific Requirements

1. Requirement 1: Virtual Network Service (VNS) creation

Customer MUST be able to request/instantiate the VNS to the network within the confines of mutual agreement between customer and network operator and network operator's capability. A VNS is the service

agreement between a customer and provider to provide a VN [ACTN-Frame]. There are different types of VNS in terms of the VN types the customer is allowed to operate (e.g., a VN type can be simply a set of edge-to-edge links, or it can comprise of virtual nodes and virtual links, etc.). The customer MUST be able to express VNS policy that captures Service Level Agreements (SLA) associated with virtual network service (e.g., Endpoint selection policy, routing policy, time-related policy, etc.)

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

2. Requirement 2: Virtual Network Service Query

Customer SHOULD be able to request VNS Query ("Can you give me these VN(s)?") that includes the following parameters:

- VN type: various VN types defined by the customer (e.g., path, graph, etc.)
- VN end-points (Customer Edge interface information)
- VN Topology Service-specific Objective Functions (e.g., maximum bandwidth, minimum latency, minimum hops, etc. and any combination of them).
- VN constraints requirement (e.g., Maximum Latency threshold, Minimum Bandwidth, etc.)

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

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

Customer MUST be able to instantiate VNS that includes various VNS related parameters:

- VN type: various VN types defined by the customer (e.g., Type 1, Type 2, etc. See [ACTN-Frame] for the definition of VN Type 1 and Type 2).
- VN end-points (Customer Edge interface information)
- VN Topology Service-specific Objective Functions (e.g., maximum bandwidth, minimum latency, minimum hops, etc. and any combination of them).
- VN constraints requirement (e.g., Maximum Latency threshold, Minimum Bandwidth, etc.)

- VN Topology diversity when there are multiple instances of VNS (e.g., VN1 and VN2 must be disjoint; Node/link disjoint from other VNs)

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

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

Customer MUST be able to perform the following VNS operations:

- VNS Delete: Customer MUST be able to delete VNS.
- VNS Modify: Customer MUST be able to modify VNS related parameters during the lifecycle of the instantiated VNS.

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

5. Requirement 5: VNS Isolation

Customer's VN should be able to use arbitrary network topology, routing, or forwarding functions as well as customized control mechanisms independent of the underlying physical network and of other coexisting virtual networks. Other customers' VNS operation MUST not impact a particular customer's VNS network operation.

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

6. Requirement 6: Multi-Destination Coordination

Customer MUST be able to define and convey service/preference requirements for multi-destination applications (e.g., set of candidate sources/destinations, thresholds for load balancing, disaster recovery policy, etc.)

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

7. Requirement 7: VNS Performance Monitoring

The customer MUST be able to define performance monitoring parameters and its associated policy such as frequency of report, abstraction/aggregation level of performance data (e.g., VN level, tunnel level, etc.) with dynamic feedback loop from the network.

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

8. Requirement 8: VNS Confidentiality and Security Requirements

The following confidentiality/security requirements MUST be supported in all interfaces:

- Securing the request and control of resources, confidentially of the information, and availability of function.
- Trust domain verification (external entity versus internal entity)
- Encrypting data that flow between components, especially when they are implemented at remote nodes, regardless if these are external or internal network interfaces.

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

2.2. Network-Related Requirements

1. Requirement 1: Virtual Network Service Coordination

Network MUST be able to support the following VNS operations:

- VNS Delete: Upon customer's VNS deletion request, network MUST be able to delete VNS.
- VNS Modify: Upon customer's VNS modification request, network MUST be able to modify VNS related parameters during the lifecycle of the instantiated VNS.
- VNS Update: Upon customer's VNS performance monitoring setup, the network MUST be able to support VNS level Operations, Administration and Management (OAM) Monitoring under policy agreement.

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

2. Requirement 2: Topology Abstraction Capability

The network MUST be capable of managing its networks based on the principle of topology abstraction to be able to scale multi-layer, multi-domain networks.

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

3. Requirement 3: Multi-Domain & Multi-layer Coordination

Network coordination for multi-domain and multi-layer path computation and path setup operation MUST be provided:

- 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].

4. Requirement 4: End-to-End Path Restoration

End-to-end Path Restoration Operations MUST be provided with seamless coordination between domain-level recovery schemes and cross-domain recovery schemes.

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

5. Requirement 5: Dynamicity of virtual network control operations

Dynamic virtual network control operations MUST be supported. This includes, but is not limited to, the following:

- Real-time VNS 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 VNS 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].

3. References

3.1. Normative References

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