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Requirements for Abstraction and Control of TE Networks

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Abstract

This draft provides a set of requirements for abstraction and control of TE networks.

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1. Introduction

This draft provides a set of requirements for Abstraction and Control of TE Networks (ACTN) identified in various use-cases of ACTN. [ACTN-frame] defines the base reference architecture and terminology. [ACTN-PS] provides problem statement and gap analysis.

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 to higher-layer applications and customers, independent of how these resources are managed or controlled, so that these higher-layer entities can dynamically control virtual networks. Control includes creating, modifying, monitoring, and deleting virtual networks.

- Multi-domain and multi-tenant virtual network operations via hierarchical abstraction of TE domains that facilitates multi-administration, multi-vendor, and multi-technology networks as a single virtualized network. This is achieved by presenting the network domain as an abstracted topology to the customers 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 (made on 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 by the network to said customer.

- Provision of a computation scheme and virtual control capability via a data model 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. Sections 3-5 provide the list of ACTN use-cases and the detailed requirement analysis of these use-cases.

2. High-level ACTN 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 controllers (e.g., GMPLS, OpenFlow, PCE, NMS, etc.)

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

2. Requirement 2: Policy Enforcement

   Ability to provide service requirement/policy (between Customer and Network) and mechanism to enforce service level agreement.

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

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

3. Requirement 3: VN Query

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

   - Request Input:

     - VN end-points (CE end)

     - VN Topology Service-specific Multi-Cost Objective Function

     - VN Topology diversity (e.g., VN1 and VN2 must be disjoint)

- VN Topology type: path, graph

- Response includes VN topology

- Exact

- Potential

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

4. Requirement 4: VN Instantiate

Ability to request/confirm VN Instantiation

- VN instance ID

- VN end-points

- VN constraints requirement

- Latency only, B/W guarantee, Latency and B/W guarantee together

- VN diversity

- Node/Link disjoint from other VNs

- VN level diversity (e.g., VN1 and VN2 must be disjoint)

- VN type

- Path (tunnel), Node/Links (graph)

- VN instance ID per service (unique id to identify VNs)

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

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 (Frequency of report)

- Abstraction of Resource Topology reflecting these service-related parameters

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

6. Requirement 6: VN Lifecycle M&O

VN lifecycle management/operation

- Instantiate

- Delete

- Modify

- Update (VN level OAM Monitoring) under policy agreement

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

7. Requirement 7: VN Service Operation

Ability to setup and manage end-2-end service on the VN involving multi-domain, multi-layer, meeting constraints based on SLAs.

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

8. Requirement 8: 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 its parameters

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

9. Requirement 9: Multi-domain & Multi-layer Coordination

Ability to Coordinate multi-domain and multi-layer path computation and setup operation (network)

- E2E path computation across multi-domain (based on abstract topology from each domain)
- The 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].

10. Requirement 10: E2E Path Restoration

Ability to perform E2E Path Restoration Operation

- Intra-domain recovery
- Cross-domain recovery

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

11. Requirement 11: Dynamicity of network control operations

The ACTN interfaces should support dynamicity nature of network control operations. This includes but not limited to the following:

- Real-time VN control (e.g., a 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., ability to query tens of thousands of nodes and connectivity) for time-sensitive applications.

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

12. Requirement 12: VN confidentiality/security

- A VN customer MUST not control other customer's virtual network
- A VN customer MUST not see any routing information (e.g. IGP database, TE database) on other customer's virtual network

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

3. ACTN Use-Cases

Listed below is a set of high-level requirements identified by each of the ACTN use-cases:

- [CHENG] (ACTN Use-cases for Packet Transport Networks in Mobile Backhaul Networks)

  - o Faster End-to-End Enterprise Services Provisioning
  - o Multi-layer coordination in L2/L3 Packet Transport Networks
  - o Optimizing the network resources utilization (supporting various performances monitoring matrix, such as traffic flow statistics, packet delay, delay variation, throughput and packet-loss rate)
  - o Virtual Networks Operations for multi-domain Packet Transport Networks

- [DHODY] (Packet Optical Integration (POI) Use Cases for Abstraction and Control of Transport Networks (ACTN))

  - o Packet Optical Integration to support Traffic Planning, performance Monitoring, automated congestion management and Automatic Network Adjustments
  - o Protection and Restoration Synergy in Packet Optical Multi-layer network.
  - o Service Awareness and Coordination between Multiple Network Domains

- [FANG] (ACTN Use Case for Multi-domain Data Center Interconnect)

  - o Multi-domain Data Center Interconnection to support VM Migration, Global Load Balancing, Disaster Recovery, On-demand Virtual Connection/Circuit Services

o The interfaces between the Data Center Operation and each transport network domain SHOULD support standards-based abstraction with a common information/data model to support the following:
  . Network Query (Pull Model) from the Data Center Operation to each transport network domain to collect potential resource availability (e.g., BW availability, latency range, etc.) between a few data center locations.
  . Network Path Computation Request from the Data Center Operation to each transport network domain to estimate the path availability.
  . Network Virtual Connections/Circuits Request from the Data Center Operation to each transport domain to establish end-to-end virtual connections/circuits (with type, concurrency, duration, SLA.QoS parameters, protection.reroute policy options, policy constraints such as peering preference, etc.).
  . Network Virtual Connections/Circuits Modification Request

- [KLEE] (ACTN Use-case for On-demand E2E Connectivity Services in Multiple Vendor Domain Transport Networks)

o Two-stage path computation capability in a hierarchical control architecture (MDSC-PNC) and a hierarchical composition of integrated network views

o Coordination of signal flow for E2E connections and management.

o Abstraction of:

  . Inter-connection data between domains

  . Customer Endpoint data

  . The multiple levels/granularities of the abstraction of network resource (which is subject to policy and service need).

  . Any physical network constraints (such as SRLG, link distance, etc.) should be reflected in abstraction.

  . Domain preference and local policy (such as preferred peering point(s), preferred route, etc.), Domain network capability (e.g., support of push/pull model).

- [KUMAKI] (ACTN : Use case for Multi Tenant VNO)

  - o On-demand Virtual Network Service Creation
  - o Domain Control Plane/Routing Layer Separation
  - o Independent service Operation for Virtual Services from control of other domains
  - o Multiple service level support for each VN (e.g., bandwidth and latency for each VN service).
  - o VN diversity/survivability should be met in physical network mapping.
  - o VN confidentiality and sharing constraint should be supported.

- [LOPEZ] (ACTN Use-case for Virtual Network Operation for Multiple Domains in a Single Operator Network)

  - o Creation of a global abstraction of network topology: The VNO Coordinator assembles each domain level abstraction of network topology into a global abstraction of the end-to-end network.
  - o End-to-end connection lifecycle management
  - o Invocation of path provisioning request to each domain (including optimization requests)
  - o Invocation of path protection/reroute to the affected domain(s)
  - o End-to-end network monitoring and fault management. This could imply potential KPIs and alarm correlation capabilities.
  - o End-to-end accounting and generation of detailed records for resource usage
  - o End-to-end policy enforcement

- [SHIN] (ACTN Use-case for Mobile Virtual Network Operation for Multiple Domains in a Single Operator Network)

  - o Resource abstraction: operational mechanisms in mobile backhaul network to give the current network usage information for dynamic and elastic applications to be provisioned dynamically with QoS guarantee.

  - o Load balancing or for recovery, the selection of core DC location from edge constitutes a data center selection problem.

  - o Multi-layer routing and optimization, coordination between these two layers.

- [SUZUKI] (Use-case and Requirements for Multi-domain Operation Plane Change)

o Operational state data synchronization between multi-domain controllers

- [XU] (Use Cases and Requirements of Dynamic Service Control based on Performance Monitoring in ACTN Architecture)

  o Dynamic Service Control Policy enforcement and Traffic/SLA Monitoring:
    . Customer service performance monitoring strategy, including the traffic monitoring object (the service need to be monitored)
    . monitoring parameters (e.g., transmitted and received bytes per unit time),
    . traffic monitoring cycle (e.g., 15 minutes, 24 hours),
    . threshold of traffic monitoring (e.g., high and low threshold), etc.

- [XU2] (Requirements of Abstract Alarm Report in ACTN architecture

  o Dynamic abstract alarm report

3.1. Two categories of 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 virtual service coordination function defined in Section 3. 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 virtual network operation function defined in Section 3. 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.

The following table gives an overview of service-specific requirements and network-related requirements respectively for each ACTN use-case and identifies the work in scope of ACTN.

Use-case	Service-specific Requirements	Network-related Requirements	Control Functions/Data Models to be supported
[CHENG]	- E2E service provisioning - Performance monitoring - Resource utilization abstraction	- Multi-layer (L2/L2.5) coordination - VNO for multi-domain transport networks	- Dynamic multi-layer coordination function based on utilization - YANG for utilization abstraction
[DHODY]	- Service awareness/ coordination between P/O.	- POI Performance monitoring - Protection/ Restoration synergy	- Customer's VN survivability policy enforcement for protection/restoration - YANG for Performance Monitoring
[FANG]	- Dynamic VM migration (service), Global load balancing (utilization efficiency), Disaster recovery - Service-aware network query - Service Policy Enforcement	- On-demand virtual circuit request - Network Path Connection request	- Multi-destination service selection policy enforcement function - YANG for Service-aware policy enforcement
[KLEE]		- Two stage path	- Multi-domain

		computation E2E signaling coordination - Abstraction of inter-domain info - Enforcement of network policy (peering, domain preference) - Network capability exchange (pull/push, abstraction level, etc.) - on-demand and long-lived end-to-end service provisioning and monitoring	service policy coordination to network primitives - YANG for Abstraction of peering/ boundary data
[KUMAKI]	- On-demand VN creation - Multi-service level for VN - VN survivability /diversity/confidentiality		- Dynamic VN creation, survivability with security/ confi-dentiality
[LOPEZ]	- E2E accounting and resource usage data - E2E service policy enforcement	- E2E connection management, path provisioning - E2E network monitoring and fault management	- Escalation of performance and fault management data to CNC and the policy enforcement - YANG for performance and fault management

[SHIN]	- Current network resource abstraction Endpoint/DC dynamic selection (for VM migration)	- LB for recovery - Multi-layer routing and optimization coordination	- Multi-layer routing and optimization - VN's dynamic endpoint selection policy.
[SUZUKI]		- Operational Data/State between multi-domain controllers	- Operations DB sync function across controllers - YANG for operational data/state model
[XU]/ [XU2]	- Dynamic service control policy enforcement - Dynamic service control	- Traffic monitoring - SLA monitoring	- Dynamic service control policy enforcement control - YANG for traffic monitoring abstraction, alarm abstraction.

4. 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.

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

4.1. CMI Requirements

Requirement

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

- Configured vs. Discovered
- Trust domain verification (External Entity vs. 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 B/W Map
    - o Latency Map and Available B/W 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 accept)

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

4. VN Topology Abstraction Model (generic network model)
5. VN Topology Abstraction Model (Service-specific model that include customer endpoints)
6. Basic VN Instantiation Request/Confirmation (Between CNC and MDSC: I need 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

7. 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

8. VN lifecycle management/operation
- Create (same as VN instantiate Request)
- Delete
- Modify
- Update (VN level OAM Monitoring) under policy agreement

9. 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

4.2. MPI Requirements

Requirement

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)

- 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 (MSDC operation) Path Setup Operation

- 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)
- 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 (CNC have, for example, multiple endpoints where the source endpoint can send its data to either one of the endpoints)
- When PNC reports domain problem that cannot be resolved at MDSC 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. 6) to the corresponding PNCs.

9. MDSC-PNC policy negotiation is also needed as to how restoration is done across MDSC and PNCs.

10. Generic Abstract Topology Update per changes due to new path setup/connection failure/degradation/restoration
11. Service-specific Abstract Topology Update per changes due to new path setup/connection failure/degradation/restoration
12. Abstraction model of technology-specific topology element

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