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        Requirements for Abstraction and Control of Transport Networks

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Abstract

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

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1. Introduction

   This draft provides a set of requirements for 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.

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)

  - Computes E2E path across multi-domain (based on abstract
    topology from each domain)

  - Determines the domain sequence

  - Request path signaling to each domain controller

  - Find alternative path 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

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          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-
          endnetwork.
        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 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	service policy coordination to network primitives
		- 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	- YANG for Abstraction of peering/ boundary data
[KUMAKI]	- On-demand VN creation - Multi- service level for VN - VN survivability /diversity/con fidentiality		- 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

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[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.
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[SUZUKI]		- Operational Data/State between multi-domain controllers	- Operations DB sync function across controllers - YANG for operational data/state model
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[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 Interface 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

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   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 (MDSC-PNC Interface)

    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

5. References

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