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An Architecture for Data Model Driven Network Management: the Network Virtualization Case
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Abstract

Data Model driven network management can be used at various phases of service and network management life cycle such as service instantiation, service provision, optimization, monitoring, and diagnostic. Also, it can be designed to provide closed-loop control for the sake of agile service creation, delivery and maintenance.

This document describes an architecture for data model driven network management with a sample applicability case: network virtualization environments.

Status of This Memo

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1. Introduction

As observed in [I-D.arkko-arch-virtualization], many IETF discussions earlier in the summer of 2017 started from a top-down view of new virtualization technologies, but they were often unable to explain the necessary delta to the wealth of existing IETF technologies in this space. Therefore, [I-D.arkko-arch-virtualization] considered a bottom-up approach to provide an overview of existing technologies which is aiming at identifying areas for further development.

For years, the IETF has been driving the industry transition from an overloaded Software Defined Networking (SDN) buzzword to focus on specific areas such as data modeling-driven management. [RFC7149] provides a first tentative to rationalize that space by identifying concrete technical domains that need to be considered:

- Techniques for the dynamic discovery of network topology, devices, and capabilities, along with relevant information and data models that are meant to precisely document such topology, devices, and their capabilities.

- Techniques for exposing network services [RFC8309] and their characteristics.

- Techniques used by service-requirement-derived dynamic resource allocation and policy enforcement schemes, so that networks can be programmed accordingly.

- Dynamic feedback mechanisms that are meant to assess how efficiently a given policy (or a set thereof) is enforced from a service fulfillment and assurance perspective.

Models are key for each of these technical items.

In the later development, , as described in [RFC8199], YANG module developers have taken both top-down and bottom-up approaches to develop modules and establish mapping between network technology and customer requirements on the top or abstracting common construct from various network technologies. At the time of writing this document (2018), we see the large number of data models including configuration models and service models developed or under development in IETF covering much of networking protocols and techniques. In addition, how these models work together to fully configure a device, or manage a set of devices involved in a service aren't developed yet in IETF.

This document takes both bottom up approach and top down approach to provide a framework that discusses the architecture for data model

driven network management, with a focus on network virtualization environment.

This document also describes specific YANG modules needed to realize connectivity services and investigates how top down built model (e.g., customer-facing data models) interact with bottom up built model (network resource-facing data models) in the context of service delivery and assurance.

2. Architectural Concepts

2.1. Data Models: Layering and Representation

As described in [RFC8199], layering of modules allows for better reusability of lower-layer modules by higher-level modules while limiting duplication of features across layers.

The IETF has developed large number of network level and device level modules and service level module. Different service level modules may rely on the same set of network level or device level modules. Service level modules follow top down approach and are mostly customer-facing models providing a common model construct for higher level network services, which can be further mapped to network technology-specific models at lower layer.

Network level modules mostly follow bottom up approach and are mostly network resource-facing model and describe various aspects of a network infrastructure, including devices and their subsystems, and relevant protocols operating at the link and network layers across multiple devices (e.g., Network topology and TE Tunnel modules).

Device level modules follow bottom up approach and are mostly technology-specific modules used to realize a service.

2.2. Service and Network Resources Exposure:

Service level model defines a service ordered by a customer from an operator. The service can be built from a combination of network elements and protocols configuration which also include various aspects of the underlying network infrastructure, including functions/devices and their subsystems, and relevant protocols operating at the link and network layers across multiple device.

2.3. Service Element Configuration Model Composition

To provide service agility (including network management automation), lower level technology-specific models need to be assembled together to provision each involved network function/device and operate the

network based on service requirements described in the service level model.

IETF RTGWG working group has already been tasked to define service elements configuration model composition mechanism and develop several composition model such as network instance model, logical network element model and device model.

These models can be used to setup and administrate both virtualized system and physical system.

2.4. A Catalog for YANG Modules

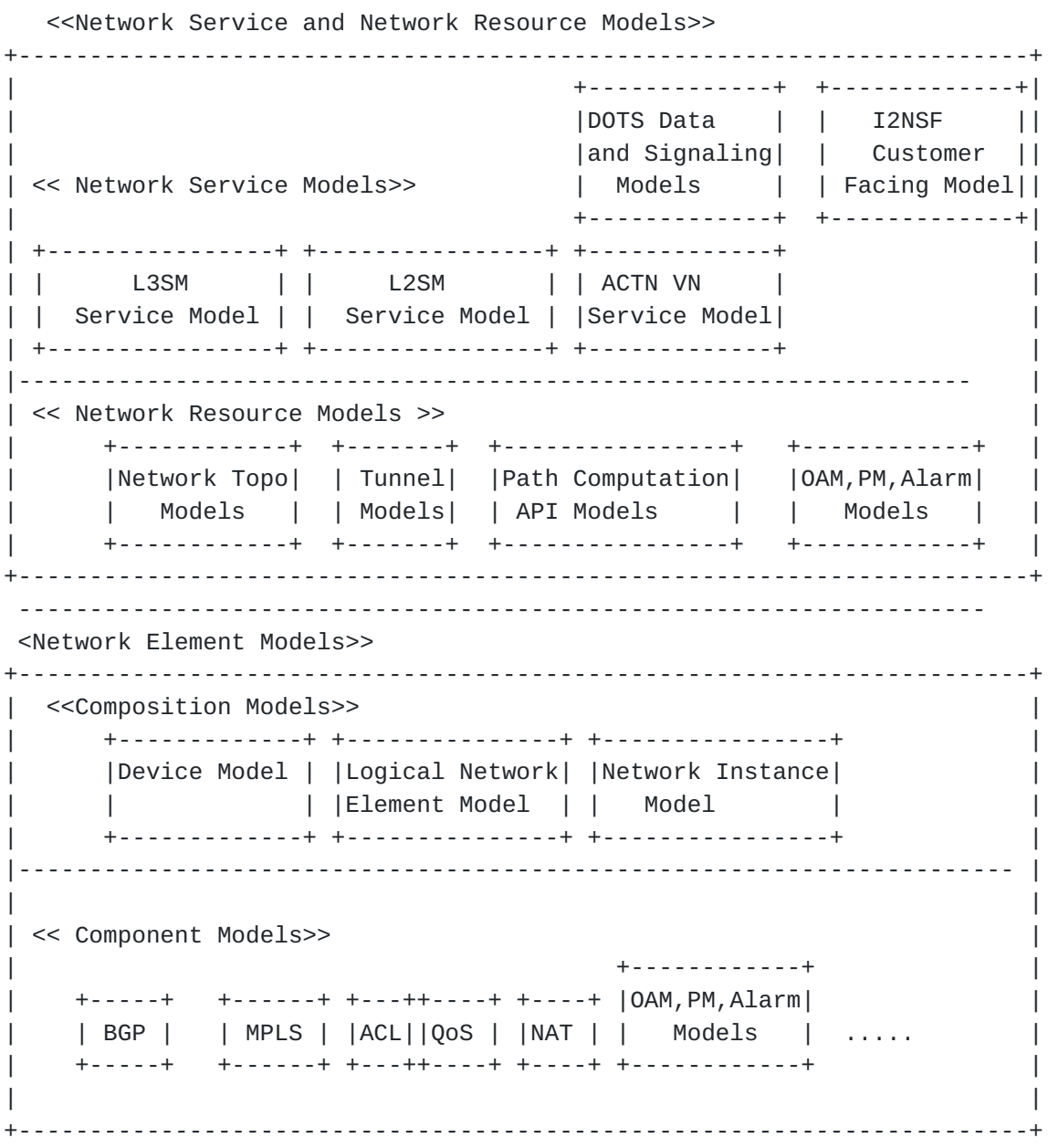
The idea of a catalog is similar to service catalogs in traditional IT environments. Service catalogs serve as a software-based registries of available services with information needed to discover and invoke available services.

The IETF has already tasked to develop a YANG catalog which can be used to manage not only IETF defined modules, but also non-IETF defined ones [I-D.clacla-netmod-model-catalog].

The YANG catalog allows to align IETF work with other SDOs work and prevent duplicated building blocks being developed. It also encourages reusability of common building blocks.

The YANG catalog allows both YANG developers and operators to discover the more mature YANG modules that may be used to automate services operations .

3. IETF YANG Modules: An Overview



3.1. Network Service and Resource Models

Service and Network Resource Exposure modules define what the "service"/"resource" is. These modules can be classified into two categories:

- Network Service Models
- Network Resource Models

3.1.1. Network Service Models: Definition and Samples

As described in [RFC8309], the service is some form of connectivity between customer sites and the Internet or between customer sites across the network operator's network and across the Internet.

For example,

- L3SM model [RFC8299] defines the L3VPN service ordered by a the customer from a network operator.

- L2SM model [I-D.ietf-l2sm-l2vpn-service-model] defines the L2VPN service ordered by a the customer from a network operator.

- L1CSM model [I-D.ietf-ccamp-l1csm-yang]defines a YANG data model for Layer 1 Connectivity Service Model (L1CSM).

- ACTN model [I-D. ietf-teas-actn-vn-yang] defines YANG data model for the Abstraction and Control of Traffic Engineered (TE) networks (ACTN) Virtual Network Service (VNS) operation. Unlike L3SM model, ACTN model can also be used as operator facing model, e.g., establish interconnection between L3VPN sites across multiple ASs.

- TE service mapping model [I-D.lee-teas-te-service-mapping-yang] a YANG data model to map service model (e.g., L3SM) and Traffic Engineering model (e.g., TE Tunnel or ACTN VN model). This model is applicable to the operation's need for a seamless control and management of their VPN services with TE tunnel support.

- Composite VPN model [I-D.chen-opsawg-composite-vpn-dm] the YANG data model of the composite VPN for operators to provision, optimize, monitor and diagnose the end to end PE-based VPN services across multiple autonomous systems (ASes). The model from this document are limited to multiple ASes within one service provider. Ulike L3SM model, Composite VPN model is operator facing model.

The IETF is currently defining three other customer-facing modules: ietf-dots-signal-channel [I-D.ietf-dots-signal-channel] and ietf-dots-data-channel [I-D.ietf-dots-data-channel] and I2NSF Consumer-Facing Interface YANG module [I-D.jeong-i2nsf-consumer-facing-interface-dm]. The first two modules are meant to be used by clients to signal DDoS attacks or to request installing filters for the sake of DDoS mitigation. Those modules do not intervene directly in the configuration of underlying network devices. The third module is required for enabling different

users of a given I2NSF system to define, manage, and monitor security policies for specific flows within an administrative domain.

3.1.2. Network Resource Models

Figure 1 shows a set of resource-facing network YANG modules:

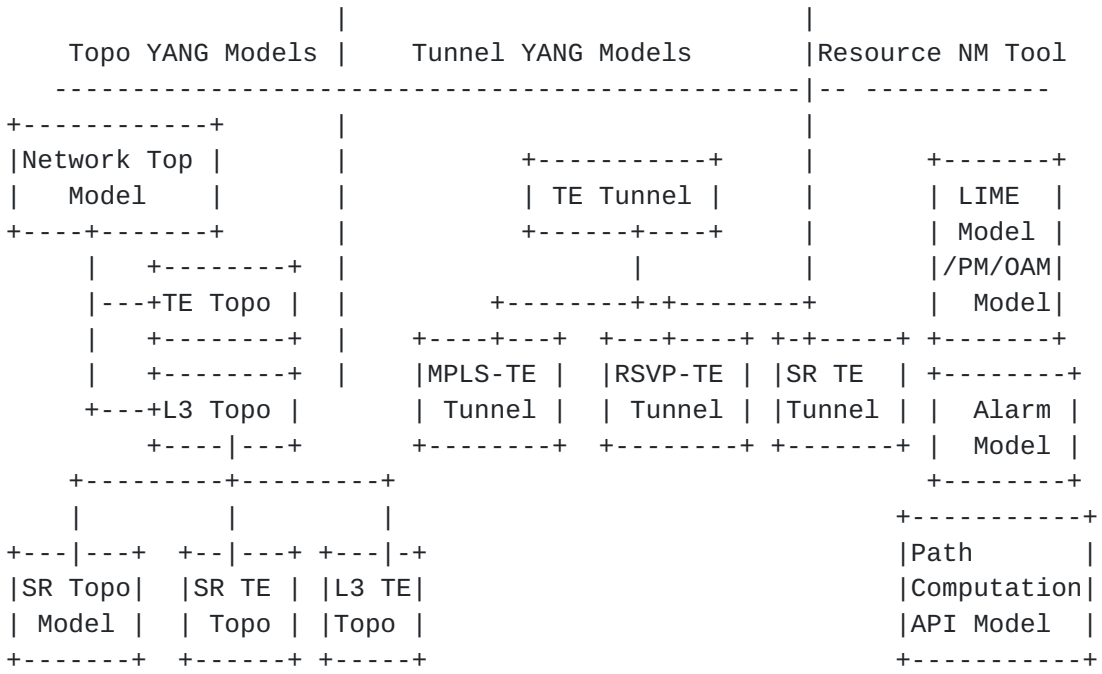


Figure 1: Sample Resource Facing Network Models

Topology YANG Models:

- Network Topology Models: [I.D-ietf-i2rs-yang-network-topo] defines base model for network topology and inventories. Network topology data include link resource, node resource and terminate-point resource.

- TE Topology Models: [I.D-ietf-teas-yang-te-topo] defines a data model for representing and manipulating TE Topologies.

  This module is extended from network topology model defined in [I.D-ietf-i2rs-yang-network-topo] with TE topologies specifics. This model contains technology agnostic TE Topology building blocks that can be augmented and used by other technology-specific TE Topology models.

- L3 Topology Models

[I.D-ietf-i2rs-yang-l3-topology] defines a data model for representing and manipulating L3 Topologies. This model is extended from the network topology model defined in [I.D-ietf-i2rs-yang-network-topo] with L3 topologies specifics.

- L2 Topology Models

  [I.D-ietf-i2rs-yang-l2-topology] defines a data model for representing and manipulating L2 Topologies. This model is extended from the network topology model defined in [I.D-ietf-i2rs-yang-network-topo] with L2 topologies specifics.

- L3 TE Topology Models

  When traffic engineering is enabled on a layer 3 network topology, there will be a corresponding TE topology. [I.D-liu-teas-yang-l3-te-topo] defines data models for layer 3 traffic engineering topologies. Two data models are defined, one is layer 3 TE topology model, the other is packet switching TE topology model. Layer 3 TE topology model is extended from Layer 3 topology model. Packet switching TE topology model is extended from TE topology model.

- SR TE Topology Models

  [I-D.liu-teas-yang-sr-te-topo] defines a YANG module for Segment Routing (SR) topology and Segment Routing (SR) traffic engineering (TE) topology. Two models are defined, one is SR topology model, the other is SR TE topology model, SR topology model is extended from L3 Topology model. SR TE topology model is extended from both SR Topology model and L3 TE topology model.

- SF Aware TE Topology YANG Model

  [I-D. ietf-teas-sf-aware-topo-model] defines a YANG data model for TE network topologies that are network service and function aware.

- Optical Transport Topology Models:

  OTN Transport Topology Model: [I-D.ietf-ccamp-otn-topo-yang]defines a YANG data model to describe the topologies of an Optical Transport Network (OTN).

  WSON Transport Topology Model: [I-D.ietf-ccamp-wson-yang] defines a YANG data model for the routing and wavelength assignment (RWA) Traffic Engineering (TE) topology in wavelength switched optical networks (WSONs).

Flex-Grid Transport Topology Model: [I-D.ietf-ccamp-flexigrid-yang]defines a YANG model for flexi-grid objects in the dynamic optical network, including the nodes, transponders and links between them, as well as how such links interconnect nodes and transponders.

Tunnel YANG Models:

- TE Tunnel Model

  [I.D-ietf-teas-yang-te] defines a YANG module for the configuration and management of TE interfaces, tunnels and LSPs.

- SR TE Tunnel Model

  [I.D-ietf-teas-yang-te] augments the TE generic and MPLS-TE model(s) and defines a YANG module for Segment Routing (SR) TE specific data.

- MPLS TE Model

  [I.D-ietf-teas-yang-te] augments the TE generic and MPLS-TE model(s) and defines a YANG module for MPLS TE configurations, state, RPC and notifications.

- RSVP-TE MPLS Model

  [I.D-ietf-teas-yang-rsvp-te] augments the RSVP-TE generic module with parameters to configure and manage signaling of MPLS RSVP-TE LSPs.

- Optical Transport Tunnel Models:

  * Flexigrid Media Channel Tunnel Models: [I-D.ccamp-flexigrid-media-channel-yang] defines a YANG model for the flexi-grid media-channel. This YANG module defines the whole path from a source transponder or node to the destination through a number of intermediate nodes in the flexi-grid network.

  * WSON Tunnel Model: [I-D.ccamp-wson-tunnel-model] defines a YANG data model for WSON tunnel model.

  * OTN Tunnel Model: [I-D. ietf-ccamp-otn-tunnel-model]defines a YANG data model for OTN tunnel Model.

Resource NM Tool Models:

- Path Computation API Model

[I.D-ietf-teas-path-computation] yang model for a stateless RPC which complements the stateful solution defined in [I.D-ietf-teas-yang-te].

- OAM Models

  [I.D-ietf-lime-yang-connectionless-oam] defines a base YANG module for the management of OAM protocols that use Connectionless Communications. [I.D-ietf-lime-yang-connectionless-oam-methods] defines a retrieval method YANG module for connectionless OAM protocols. [I.D-ietf-lime-yang-connection-oriented-oam-model] defines a base YANG module for connection oriented OAM protocols. These three models can be used to provide consistent reporting, configuration and representation.

- PM Models

- Alarm Models

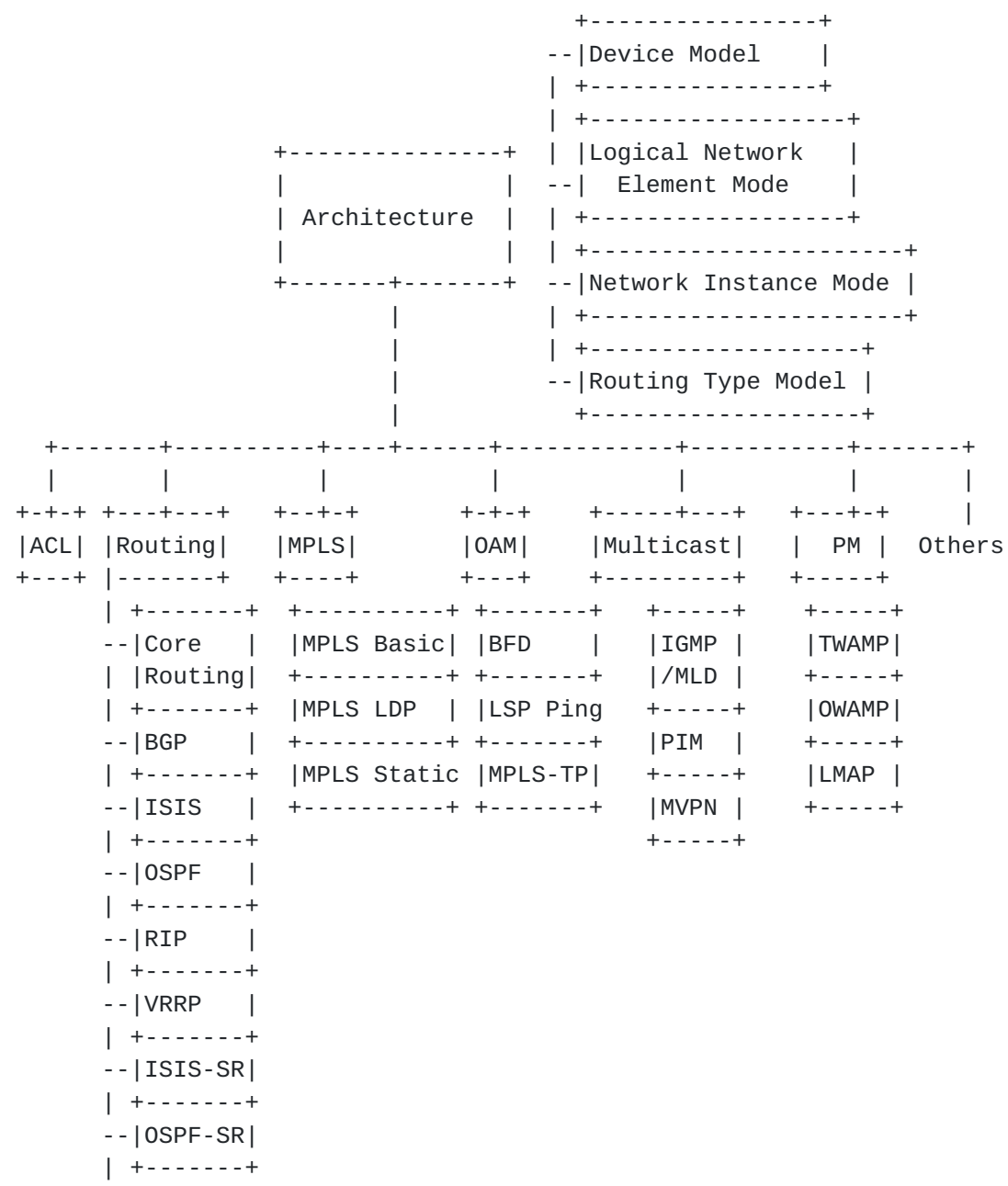
  Alarm monitoring is a fundamental part of monitoring the network. Raw alarms from devices do not always tell the status of the network services or necessarily point to the root cause. [I.D-ietf-ccamp-alarm-module]defines a YANG module for alarm management.

- Generic Policy Model

  The Simplified Use of Policy Abstractions (SUPA) policy-based management framework [RFC8328] defines base YANG data models to encode policy. These models point to device-, technology-, and service-specific YANG data models developed elsewhere. Policy rules within an operator's environment can be used to express high-level, possibly network-wide, policies to a network management function (within a controller, an orchestrator, or a network element). The network management function can then control the configuration and/or monitoring of network elements and services. This document describes the SUPA basic framework, its elements, and interfaces.

3.2. Network Element Models

Network Element models are used to describe how a service can be implemented by activating and tweaking a set of functions (enabled in one or multiple devices) that are involved in the service delivery.



3.2.1. Model Composition

- Device Model

  [I.D-ietf-rtgwg-device-model] presents an approach for organizing YANG models in a comprehensive logical structure that may be used to configure and operate network devices.The structure is itself represented as an example YANG model, with all of the related component models logically organized in a way that is operationally intuitive, but this model is not expected to be implemented.

- Logical Network Element Model

  [I.D-ietf-rtgwg-lne-model] defines a logical network element module which can be used to manage the logical resource partitioning that may be present on a network device. Examples of common industry terms for logical resource partitioning are Logical Systems or Logical Routers.

- Network Instance Model

  [I.D-ietf-rtgwg-ni-model] defines a network instance module. This module can be used to manage the virtual resource partitioning that may be present on a network device. Examples of common industry terms for virtual resource partitioning are Virtual Routing and Forwarding (VRF) instances and Virtual Switch Instances (VSIs).

3.2.1.1. Schema Mount

Modularity and extensibility were among the leading design principles of the YANG data modeling language. As a result, the same YANG module can be combined with various sets of other modules and thus form a data model that is tailored to meet the requirements of a specific use case. [I-D.ietf-netmod-schema-mount] defines a mechanism, denoted schema mount, that allows for mounting one data model consisting of any number of YANG modules at a specified location of another (parent) schema.

That capability does not cover design time.

3.2.2. Protocol/Function Configuration Models

BGP: [I-D.mks-idr-bgp-yang-model] defines a YANG module for configuring and managing BGP, including protocol, policy, and operational aspects based on data center, carrier and content provider operational requirements.

MPLS: [I-D.ietf-mpls-base-yang] defines a base model for MPLS which serves as a base framework for configuring and managing an MPLS switching subsystem. It is expected that other MPLS technology YANG models (e.g. MPLS LSP Static, LDP or RSVP-TE models) will augment the MPLS base YANG model.

QoS: [I-D.asechoud-netmod-diffserv-model] describes a YANG model of Differentiated Services for configuration and operations.

ACL: Access Control List (ACL) is one of the basic elements used to configure device forwarding behavior. It is used in many networking technologies such as Policy Based Routing, Firewalls etc. [I.D-ietf-netmod-acl-model] describes a data model of Access Control List (ACL) basic building blocks.

NAT: For the sake of network automation and the need for programming Network Address Translation (NAT) function in particular, a data model for configuring and managing the NAT is essential. [I.D-ietf-opsawg-nat-yang] defines a YANG module for the NAT function.

Multicast: [I-D.ietf-pim-yang] defines a YANG module that can be used to configure and manage Protocol Independent Multicast (PIM) devices. [I-D.ietf-pim-igmp-mld-yang] defines a YANG module that can be used to configure and manage Internet Group Management Protocol (IGMP) and Multicast Listener Discovery (MLD) devices.

Microwave: [I-D. ietf-ccamp-mw-yang] defines a YANG data model for control and management of the radio link interfaces, and their connectivity to packet(typically Ethernet) interfaces in a microwave/millimeter wave node.

EVPN: [I-D.ietf-bess-evpn-yang] defines a YANG data model for Ethernet VPN services.The model is agnostic of the underlay. It apply to MPLS as well as to VxLAN encapsulation. The model is also agnostic of the services including E-LAN, E-LINE and E-TREE services. This document mainly focuses on EVPN and Ethernet-Segment instance framework.

L3VPN: [I-D.ietf-bess-l3vpn-yang] defines a YANG model that can be used to configure and manage BGP L3VPNs [RFC4364]. It contains VRF sepcific parameters as well as BGP specific parameters applicable for L3VPNs.

L2VPN: [I-D.ietf-bess-l2vpn-yang] defines a YANG data model for MPLS based Layer 2 VPN services (L2VPN) [RFC4664] and includes switching between the local attachment circuits. The L2VPN model covers point-to-point VPWS and Multipoint VPLS services. These services use signaling of Pseudowires across MPLS networks using LDP [RFC8077][RFC4762] or BGP[RFC4761].

Routing Policy: [I-D.ietf-rtgwg-policy-model] defines a YANG data model for configuring and managing routing policies in a

vendor-neutral way and based on actual operational practice. The model provides a generic policy framework which can be augmented with protocol-specific policy configuration.

BFD: [I-D.ietf-bfd-yang]defines a YANG data model that can be used to configure and manage Bidirectional Forwarding Detection (BFD) [RFC5880]. BFD is a network protocol which is used for liveness detection of arbitrary paths between systems.

4. Architecture Overview

The architectural considerations and conclusions described in the previous section lead to the architecture described in this section and illustrated in Figure 2.

The interfaces and interactions shown in the figure and labeled (a) through (j) are further described in Section 5.1.

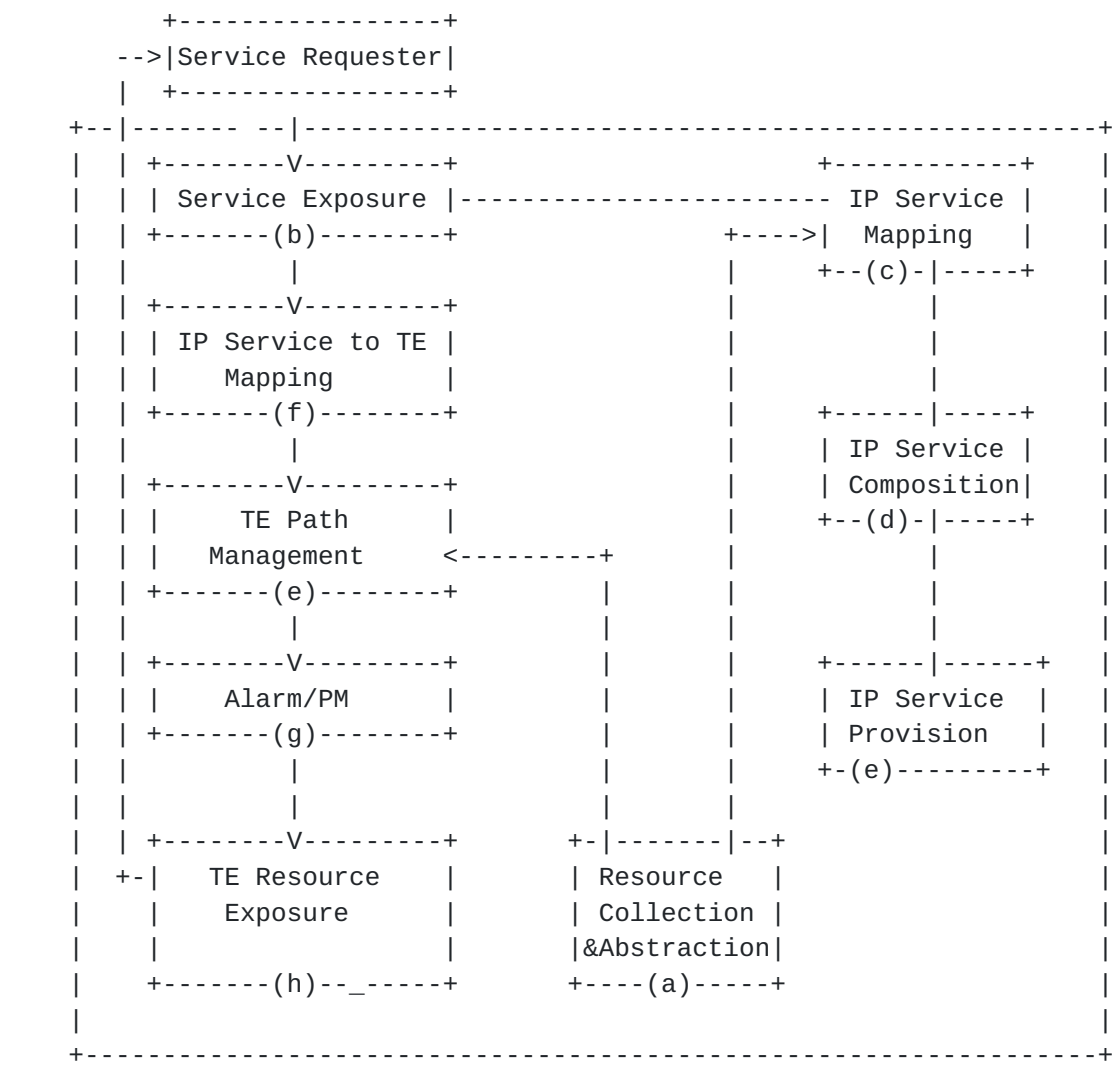


Figure 2: Data Model Driven Management

4.1. End-to-End Service Delivery and Service Assurance Procedure

4.1.1. Resource Collection and Abstraction (a)

Network Resource such as links, nodes, or terminate-point resources can be collected from the network and aggregated or abstracted to the management system. Periodic fetching of data is not an adequate solution for applications requiring frequent or prompt updates of network resource. Applying polling-based solutions to retrieve network resource also imposes a load on networks, devices, and applications.These limitations can be addressed by including generic object subscription mechanisms within network elements.

These resources can be modelled using network topology model, L3 topology model, L2 topology model, TE topology model, L3 TE topology model, SR TE topology models at different layers.

In some cases, there may have multiple overlay topologies built on top of the same underlay topology, and the underlay topology can be also built from one or more lower layer underlay topology.

In some cases, there may have multiple overlay topologies built on top of the same underlay topology, and the underlay topology can be also built from one or more lower layer underlay topology. The network resources and management objects in these multi-layer topologies are not recommended to be exposed to customers who (will) order the service from the management system, instead it will be exposed to the management system for IP service mapping and TE path Management.

The abstract view is likely to be technology-agnostic.

4.1.2. Service Exposure & Abstraction (b)

Service exposure & abstraction is used to capture services offered to customers.

Service abstraction can be used by a customer to request a service (ordering and order handling). One typical example is that a customer can use L3SM service model to request L3VPN service by providing the abstract technical characterization of the intended service. Such L3VPN service describes various aspects of network infrastructure, including devices and their subsystems, and relevant protocols operating at the link and network layers across multiple device. The L3SM service model can be used to interact with the network infrastructure, e.g., configure sites, decide QoS parameters to be applied to each network access within a site, select PEs, CEs, etc.

Service catalogs can be created to expose the various services and the information needed to invoke/order a given service.

YANG modules can be grouped into various service bundles; each service bundle is corresponding to a set of YANG modules that have been released or published. Then, a mapping can be established between service abstraction and service bundles at higher layer and between service bundle and a set of YANG modules at lower layer.

4.1.3. IP Service Mapping (c)

Service abstraction starts with high-level abstractions exposing the business capabilities or capturing customer requirements. Then, it needs to maps them to resource abstraction and specific network technologies.

Therefore, the interaction between service abstraction and resource abstraction or between overlay and underlay is required. For example, in the L3SM service model, we describe VPN service topology including sites relationship, e.g., hub and spoke and any to any, single homed, dual-homed, multi-homed relation between PEs and CEs, but we don't know how this service topology can be mapped into underlying network topology. For detailed interaction, please refer to Section 4.1.7

In addition, there is a need to decide on a mapping between service abstraction and underlying specific network technologies. Take L3SM service model as an example, to realize L3VPN service, we need to map L3SM service view defined in Service model into detailed configuration view defined by specific configuration models for network elements, these configuration models include:

- VRF definition, including VPN Policy expression
- Physical Interface
- IP layer (IPv4, IPv6).
- QoS features such as classification, profiles, etc.
- Routing protocols: support of configuration of all protocols listed in the document, as well as routing policies associated with those protocols.
- Multicast Support
- NAT

4.1.4. IP Service Composition (d)

These detailed configuration models are further assembled together into service bundle using, e.g., device model, logical network element model or network instance model defined in [I.D-ietf-rtgwg-device-model] [I.D-ietf-rtgwg-lne-model] [I.D-ietf-rtgwg-ni-model] provide the association between an interface and its associated LNE and NI and populate into appropriate devices(e.g., PE and CE).

4.1.5. IP Service Provision (e)

IP Service Provision is used to provision service or network infrastructure using various configuration models, e.g., use service element models such as BGP, ACL, QoS, Interface model, Network instance models to configure PE and CE device within the site. BGP Policy model is used to establish VPN membership between sites and VPN Service Topology. Traditionally, "push" service element configuration model one by one to the network device and provide association between an interface and each service element configuration model is not efficient.

To automate configuration of the service elements, we first assemble all related service elements models into logical network element model defined in [I.D-ietf-rtgwg-lne-model] and then establish association with an interface and a set of service elements.

In addition, IP Service Provision can be used to setup tunnels between sites and setup tunnels between PE and CE within the site when tunnels related configuration parameters can be generated from service abstraction.However when tunnels related configuration parameters can not be generated from service abstraction, IP Service to TE Mapping procedure is required.

4.1.6. IP Service to TE Mapping (e)

In L3SM Service Model, the management system will have to determine where to connect each site-network-access of a particular site to the provider network (e.g., PE, aggregation switch). L3SM Service model proposes parameters and constraints that can influence the meshing of the site-network-access.

Nodes used to connect a site may be captured in relevant clauses of a service exposure model (e.g., Customer Nodes Map [RFC7297]).

When Site location is determined, PE and CE device location will be selected. Then we can replace parameters and constraints that can influence the meshing of the site-network-access with specified PE and CE device information associated with site- network-access and generate resource facing VN Overlay Resource model.One example of resource facing VN Overlay Resource model is ACTN VN Service Model.

This VN Overlay Resource model can be used to calculate node and link resource to Meet service requirements based on Network Topology models collected at step (a).

4.1.7. Path Management (f)

Path Management includes Path computation and Path setup. For example, we can translate L3SM service model into resource facing VN Overlay Resource Model, with selected PE and CE in each site, we can calculate point to point or multipoint end to end path between sites based on VPN Overlay Resource Model.

After identifying node and link resources required to meet service requirements, the mapping between overlay topology and underlay topology can be set, e.g., establish an association between VPN service topology defined in customer facing model and underlying network topology defined in I2RS network topology model (e.g., one overlay node is supported by multiple underlay nodes, one overlay link is supported by multiple underlay nodes)and generate end to end VN topology model.

4.1.8. Performance Measurement and Alarm Telemetry (g)

Once the mapping between overlay and underlay has been setup, PM and Warning information per link based on end to end VN topology can be collected and report to the management system.

Performance metrics can be collected before instantiating a service, too.

4.1.9. TE Resource Exposure (h)

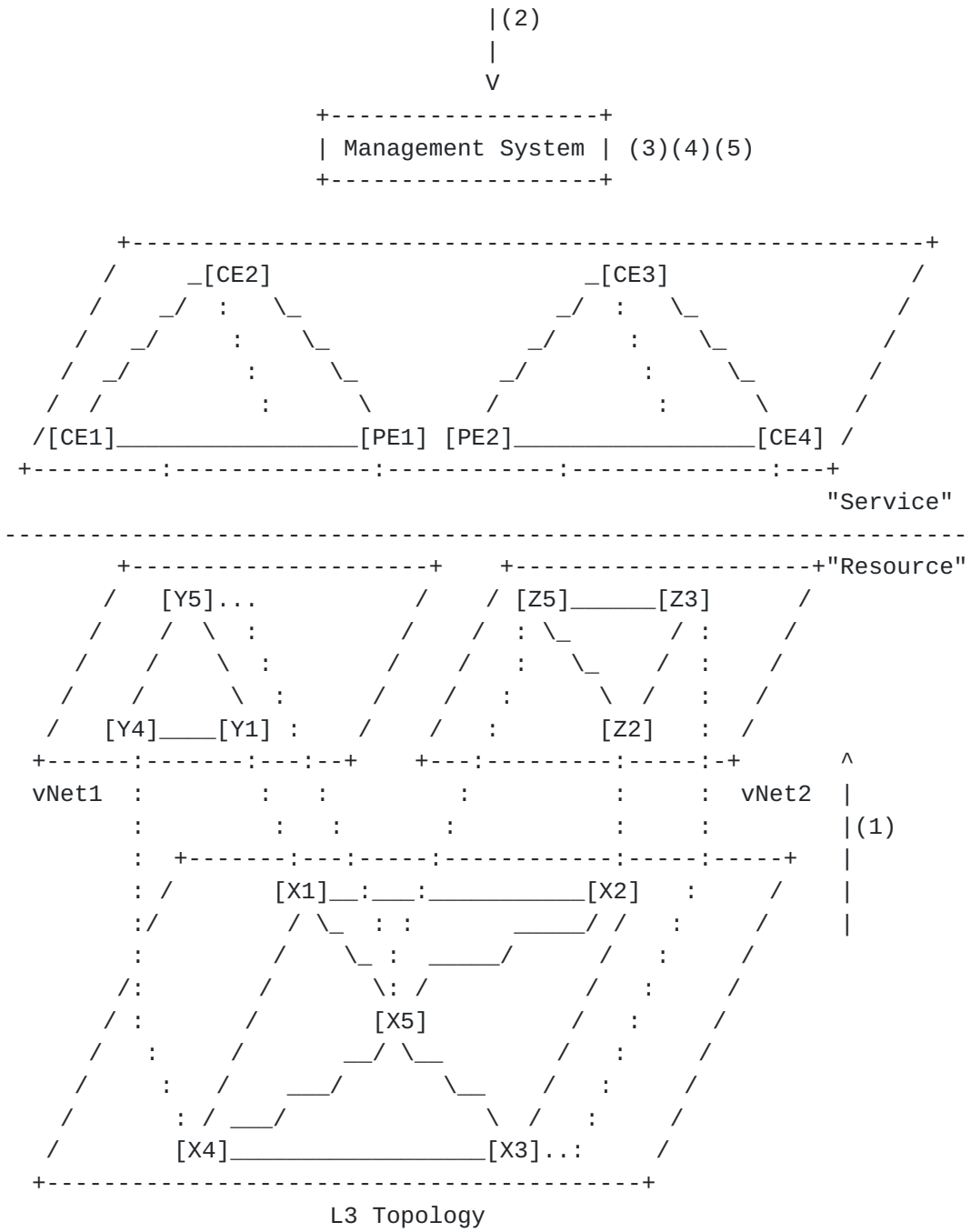
When tunnels related configuration parameters can not be generated from service abstraction, IP Service to TE Mapping procedure can be used to generate TE Resource Exposure view, this TE reource Exposure view can be modeled as resource facing VN model which is translated and instantiated from L3SM model and manage TE resource based on path management information and PM and alarm telemetry information.

Operators may use this dedicated TE resource Exposure view to dynamically capture the overall network status and topology to:

- Perform all the requested recovery operations upon detecting network failures affecting the network service.
- Adjust resource distribution and update to end to end Service topology models
- Provide resource scheduling to better guarantee services for customers and to improve the efficiency of network resource usage.

5. Model usage in network virtualization environment: Sample Examples

5.1. Network Topology Resource Pre-Provision



L3 Topology

The following steps are performed to deliver the service within model driven management architecture proposed in this document:

- Pre-provision multiple (virtualized) overlay networks on top of the same basic network infrastructure and establish resource pool for each overlay network.

- Request to create two sites based on L3SM Service model with each having one network access connectivity:

  Site A: Network-Access A, Bandwidth=20M, for class "foo", guaranteed-bw-percent = 10, One-Way-Delay=70 msec

  Site B: Network-Access B, Bandwidth=30M, for class "foo1", guaranteed-bw-percent = 15, One-Way-Delay=60 msec

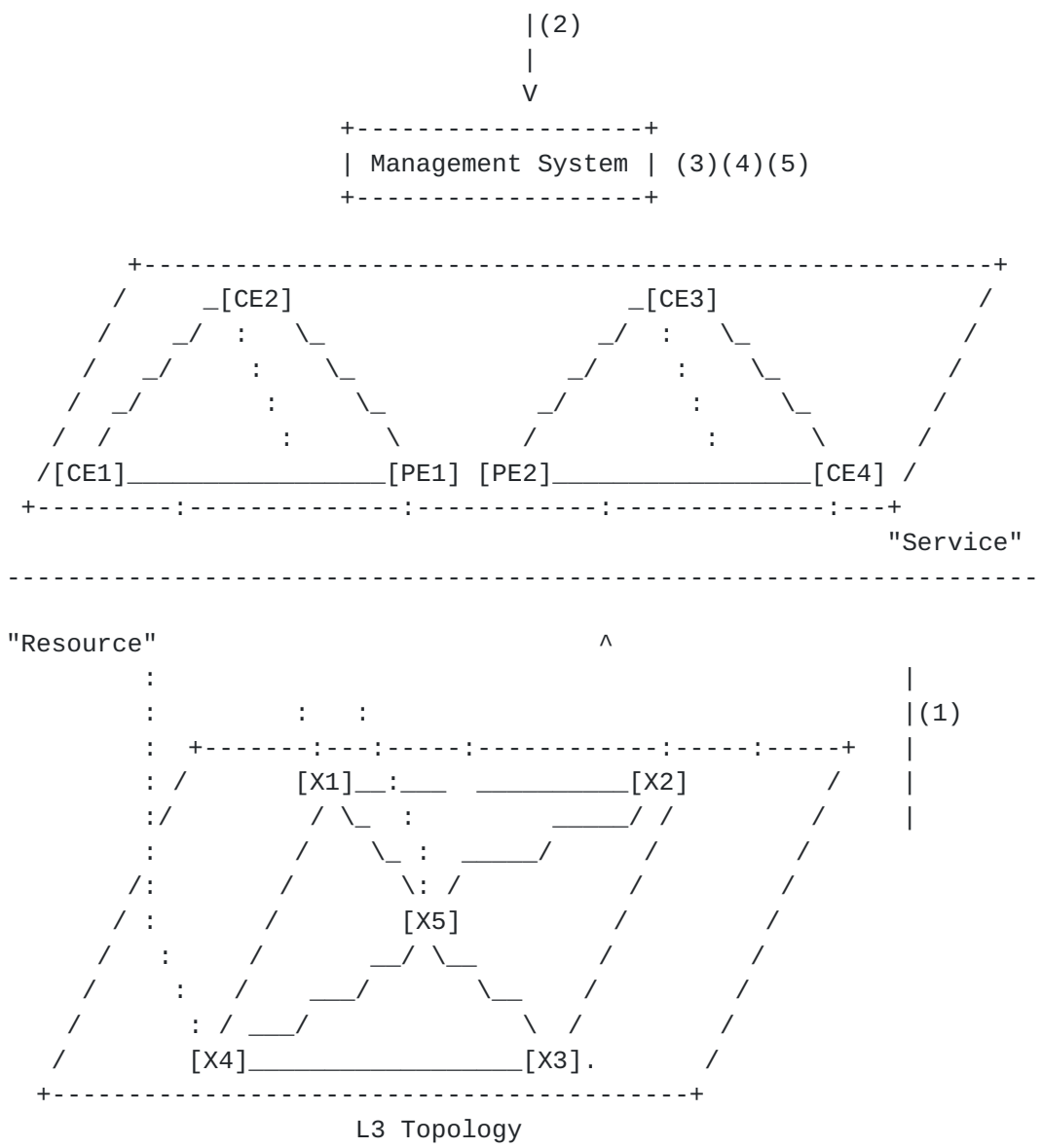
- Select appropriate virtualized overlay networks topology based on Service Type and service requirements defined in L3SM service model.

- Translate L3SM service model into resource facing VN Network Model, based on selected virtualized overlay network topology and PE and CE info in the generated resource facing VN network model, calculate node resource, link resource corresponding to connectivity between sites or connectivity between PE and CE within a Site.

- Setup tunnels between sites and tunnels between PE and CE within a Site and map them into the selected (virtualized) overlay topology and establish resource facing VN topology model.

  The source facing VN topology model and corresponding Tunnel model can be used to notify all the parameter changes and event related to VN topology or Tunnel. These information can be further used to adjust network resource distributing in the network.

5.2. On Demand Network Topology Resource Creation



L3 Topology

The following steps are performed to deliver the service within model driven management architecture proposed in this document:

- Establish resources pool for basic network infrastructure.

- Request to create two sites based on L3SM Service model with each having one network access connectivity:

  Site A: Network-Access A, Bandwidth=20M, for class "foo", guaranteed-bw-percent = 10, One-Way-Delay=70 msec

  Site B: Network-Access B, Bandwidth=30M, for class "foo1", guaranteed-bw-percent = 15, One-Way-Delay=60 msec

- Create a new service topology based on Service Type and service requirements (e.g., Slice Service Type, Slice location, Number of Slices, QoS requirements corresponding to network connectivity within a Slice) defined in L3SM service model.

- Translate L3SM service model into resource facing VN Network Model, based on generated resource facing VN network model, calculate node resource, link resource corresponding to connectivity between sites or connectivity between PE and CE within Site in the service topology.

- Setup tunnels between sites and tunnel between PE and CE within Site and map them into basic network infrastructure and establish resource facing VN topology model. The source facing VN topology model and corresponding Tunnel model can be used to notify all the parameter changes and event related to VN topology or Tunnel. These information can be further used to adjust network resource distribution within the network.

6. Security Considerations

Security considerations specific to each of the technologies and protocols listed in the document are discussed in the specification documents of each of these techniques.

(Potential) security considerations specific to this document are listed below:

- Create forwarding loops by mis-configuring the underlying network.

- Leak sensitive information: special care should be considered when translating between the various layers introduced in the document.

- ...tbc

7. IANA Considerations

There are no IANA requests or assignments included in this document.

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