                         Service Models Explained

Abstract

   The IETF has produced many modules in the YANG modeling language.
   The majority of these modules are used to construct data models to
   model devices or monolithic functions.

   A small number of YANG modules have been defined to model services
   (for example, the Layer 3 Virtual Private Network Service Model
   (L3SM) produced by the L3SM working group and documented in RFC
   8049).

   This document describes service models as used within the IETF and
   also shows where a service model might fit into a software-defined
   networking architecture. Note that service models do not make any
   assumption of how a service is actually engineered and delivered for
   a customer; details of how network protocols and devices are
   engineered to deliver a service are captured in other modules that
   are not exposed through the interface between the customer and the
   provider.

Status of This Memo

Copyright Notice

Table of Contents

1. Introduction

   In recent years, the number of modules written in the YANG modeling
   language [RFC6020] for configuration and monitoring has blossomed.
   Many of these are used for device-level configuration (for example,
   [RFC7223]) or for control of monolithic functions or protocol
   instances (for example, [RFC7407]).

   [RFC7950] makes a distinction between a "data model", which it
   defines as describing how data is represented and accessed, and a
   "YANG module", which defines hierarchies of schema nodes to make a
   self-contained and compilable block of definitions and inclusions.
   YANG structures data models into modules for ease of use.

   Within the context of Software-Defined Networking (SDN) [RFC7149]
   [RFC7426], YANG data modules may be used on the interface between a
   controller and network devices, as well as between network
   orchestrators and controllers. There may also be a hierarchy of such
   components with super controllers, domain controllers, and device
   controllers all exchanging information and instructions using YANG
   modules.

   There has been interest in using YANG to define and document data
   models that describe services in a portable way that is independent
   of which network operator uses the model, for example, the Layer 3
   Virtual Private Network Service Model (L3SM) [RFC8049]. Such models
   may be used in manual and even paper-driven service request processes
   with a gradual transition to IT-based mechanisms. Ultimately, they
   could be used in online, software-driven dynamic systems and may be
   used as part of an SDN system.

   This document explains the scope and purpose of service models within
   the IETF (and is limited to within the scope of the IETF) and
   describes how a service model can be used by a network operator.
   Equally, this document clarifies what a service model is not and
   dispels some common misconceptions.

   The document also shows where a service model might fit into an SDN
   architecture, but it is important to note that a service model does
   not require or preclude the use of SDN. Note that service models do
   not make any assumption of how a service is actually engineered and
   delivered to a customer; details of how network protocols and devices
   are engineered to deliver a service are captured in other modules
   that are not exposed through the interface between the customer and
   the provider.

In summary, a service model is a formal representation of the data
elements that describe a network service as that service is described
to or requested by a customer of a network operator. Details
included in the service model include a description of the service as
experienced by the customer, but not features of how that service is
delivered or realized by the service provider.

Other work on classifying YANG modules has been done in [RFC8199].
That document provides an important reference for this document and
also uses the term "service module". In this document, Section 6.1
provides a comparison between these two uses of the same terminology.

2. Terms and Concepts

Readers should familiarize themselves with the description and
classification of YANG modules provided in [RFC8199].

The following terms are used in this document:

Network Operator: This term is used to refer to the company that
    owns and operates one or more networks that provide Internet
    connectivity services and/or other services.

Customer: This term refers to someone who purchases a service
    (including connectivity) from a network operator. In the context
    of this document, a customer is usually a company that runs their
    own network or computing platforms and wishes to connect to the
    Internet or between sites. Such a customer may operate an
    enterprise network or a data center. Sometimes this term may also
    be used to refer to the individual in such a company who contracts
    to buy services from a network operator. A customer as described
    here is a separate commercial operation from the network operator,
    but some companies may operate with internal customers so that,
    for example, an IP/MPLS packet network may be the customer of an
    optical transport network.

   Service: A network operator delivers one or more services to a
      customer. A service in the context of this document (sometimes
      called a Network 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. However,
      a distinction should be drawn between the parameters that describe
      a service as included in a customer service model (see the
      definition of this term, below) and a Service Level Agreement
      (SLA), as discussed in Sections 5 and 7.2.

      A service may be limited to simple connectivity (such as IP-based
      Internet access), may be a tunnel (such as a virtual circuit), or
      may involve more complex connectivity (such as in a multisite
      virtual private network). Services may be further enhanced by
      additional functions providing security, load balancing,
      accounting, and so forth. Additionally, services usually include
      guarantees of quality, throughput, and fault reporting.

      This document makes a distinction between a service as delivered
      to a customer (that is, the service as discussed on the interface
      between a customer and the network operator) and the service as
      realized within the network (as described in [RFC8199]). This
      distinction is discussed further in Section 6.

      Readers may also refer to [RFC7297] for an example of how an IP
      connectivity service may be characterized.

   Data Model: The information model (IM) and data model (DM) concepts
      are described in [RFC3444]. That document defines a data model by
      contrasting it with the definition of an IM as follows:

         The main purpose of an IM is to model managed objects at a
         conceptual level, independent of any specific implementations
         or protocols used to transport the data. The degree of
         specificity (or detail) of the abstractions defined in the IM
         depends on the modeling needs of its designers. In order to
         make the overall design as clear as possible, an IM should hide
         all protocol and implementation details. Another important
         characteristic of an IM is that it defines relationships
         between managed objects.

         DMs, conversely, are defined at a lower level of abstraction
         and include many details. They are intended for implementors
         and include protocol-specific constructs.

      As mentioned in Section 1, this document also uses the terms "data
      model" and "YANG module" as defined in [RFC7950].

   Service Model: A service model is a specific type of data model. It
      describes a service and the parameters of the service in a
      portable way that can be used uniformly and independent of the
      equipment and operating environment. The service model may be
      divided into the two following categories:

      Customer Service Model: A customer service model is used to
         describe a service as offered or delivered to a customer by a
         network operator as shown in Figure 1. It can be used by a
         human (via a user interface such as a GUI, web form, or
         Command-Line Interface (CLI)) or by software to configure or
         request a service and may equally be consumed by a human (such
         as via an order fulfillment system) or by a software component.
         Such models are sometimes referred to simply as "service
         models" [RFC8049]. A customer service model is expressed in a
         YANG module as a core set of parameters that are common across
         network operators: additional features that are specific to the
         offerings of individual network operators would be defined in
         extensions or augmentations of the module. Except where
         specific technology details are directly pertinent to the
         customer (such as encapsulations or mechanisms applied on
         access links), customer service models are technology agnostic
         so that the customer does not have influence over or knowledge
         of how the network operator engineers the service.

         An example of where such details are relevant to the customer
         is when they describe the behavior or interactions on the
         interface between the equipment at the customer site (often
         referred to as the Customer Edge or CE equipment) and the
         equipment at the network operator's site (usually referred to
         as the Provider Edge or PE equipment).

      Service Delivery Model: A service delivery model is used by a
         network operator to define and manage how a service is
         engineered in the network. It can be used by a human operator
         (such as via a management station) or by a software tool to
         instruct network components. The YANG modules that encode such
         models are sometimes referred to as "network service YANG
         modules" [RFC8199] and are consumed by "external systems" such
         as an Operations Support System (OSS). A service delivery
         module is expressed as a core set of parameters that are common
         across a network type and technology: additional features that
         are specific to the configuration of individual vendor
         equipment or proprietary protocols would be defined in
         extensions or augmentations of the module. Service delivery
         modules include technology-specific modules.

The distinction between a customer service model and a service
delivery model needs to be clarified. The modules that encode a
customer service model are not used to directly configure network
devices, protocols, or functions: it is not something that is sent
to network devices (i.e., routers or switches) for processing.
Equally, the modules that encode a customer service model do not
describe how a network operator realizes and delivers the service
described by the module. This distinction is discussed further in
later sections.

3. Using Service Models

As already indicated, customer service models are used on the
interface between customers and network operators. This is shown in
Figure 1.

The language in which a customer service model is described is a
choice for whoever specifies the model. The IETF uses the YANG data
modeling language defined in [RFC6020].

The encoding and communication protocol used to exchange a customer
service model between the customer and network operator is specific
to deployment and implementation. The IETF has standardized the
NETCONF protocol [RFC6241] and the RESTCONF protocol [RFC8040] for
interactions "on the wire" between software components with data
encoded in XML or JSON. However, co-located software components
might use an internal API, while systems with more direct human
interactions might use web pages or even paper forms. Where direct
human interaction comes into play, interface interactions may be
realized via business practices that may introduce some margin of
error, thus raising the priority for automated, deterministic
interfaces.

```
                                    Customer
        --------------        Service Model      ----------------------
       |              |    <------------------>  |                      |
       |   Customer   |                          |   Network Operator   |
       |              |                          |                      |
        --------------                            ----------------------
```

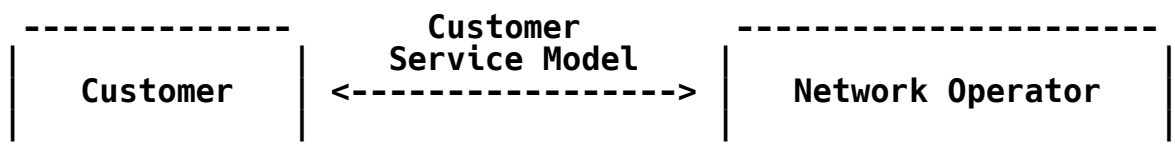   Figure 1: The Customer Service Models Used on the Interface between
                    Customers and Network Operators

How a network operator processes a customer's service request when
described with a customer service model depends on the commercial and
operational tools, processes, and policies used by the network
operator. These may vary considerably from one network operator to
another.

However, the intent is that the network operator maps the service request into configuration and operational parameters that control one or more networks to deliver the requested services. That means that the network operator (or software run by the network operator) takes the information in the customer service model and determines how to deliver the service by enabling and configuring network protocols and devices. They may achieve this by constructing service delivery models and passing them to network orchestrators or controllers. The use of standard customer service models eases service delivery by means of automation.

3.1. Practical Considerations

The practicality of customer service models has been repeatedly debated. It has been suggested that network operators have radically different business models and widely diverse commercial offerings, which makes a common customer service model impractical. However, L3SM [RFC8049] results from the consensus of multiple individuals working at network operators and offers a common core of service options that can be augmented according to the needs of individual network operators.

It has also been suggested that there should be a single, base customer service module, and that details of individual services should be offered as extensions or augmentations of this. It is quite possible that a number of service parameters (such as the identity and postal address of a customer) will be common, and it would be a mistake to define them multiple times (once in each customer service model). However, the distinction between a 'module' and a 'model' should be considered at this point: modules are how the data for models is logically broken out and documented, especially for reuse in multiple models.

4. Service Models in an SDN Context

In an SDN system, the management of network resources and protocols is performed by software systems that determine how best to utilize the network. Figure 2 shows a sample architectural view of an SDN system where network elements are programmed by a component called an "SDN controller" (or "controller" for short) and where controllers are instructed by an orchestrator that has a wider view of the whole of, or part of, a network. The internal organization of an SDN control plane is specific to deployment.

```
                     ------------------
                    |                  |
                    |   Orchestrator   |
                    |.----------------.|
                   .  .       :       .  .
                  .    .      :      .    .
                 .      .     :     .      .
         -----------    -----------    -----------
        |           |  |           |  |           |
        | Controller|  | Controller|  | Controller|
        |           |  |           |  |           |
         -----------    -----------    -----------
          :              .       .              :
          :             .         .             :
          :            .           .            :
      ---------    ---------   ---------    ---------
     | Network |  | Network | | Network |  | Network |
     | Element |  | Element | | Element |  | Element |
      ---------    ---------   ---------    ---------
```
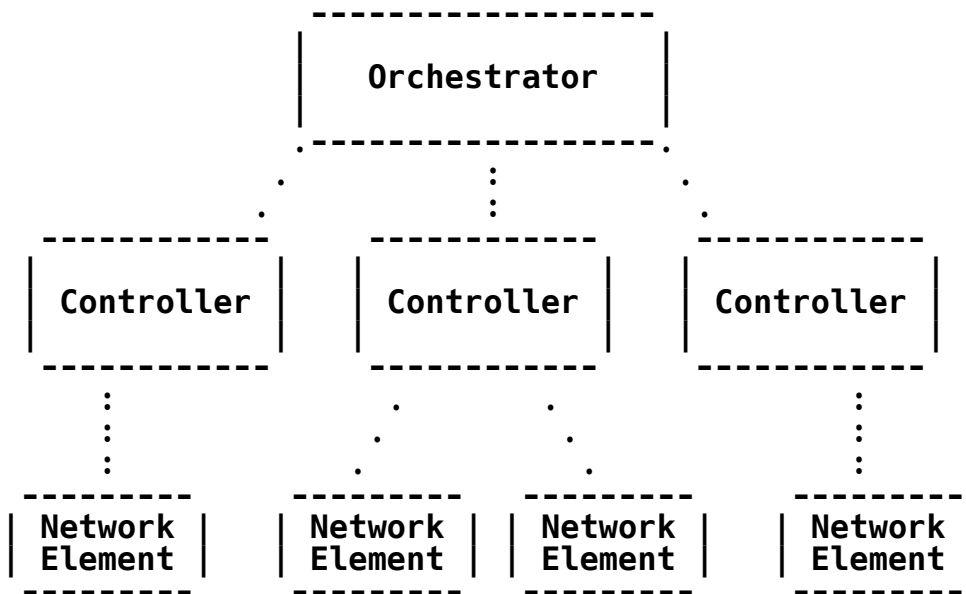
Figure 2: A Sample SDN Architecture

A customer's service request is (or should be) technology agnostic.
That is, a customer is unaware of the technology that the network
operator has available to deliver the service, so the customer does
not make requests specific to the underlying technology but is
limited to making requests specific to the service that is to be
delivered. The orchestrator must map the service request to its
view, and this mapping may include a choice of which networks and
technologies to use depending on which service features have been
requested.

One implementation option to achieve this mapping is to split the
orchestration function between a "Service Orchestrator" and a
"Network Orchestrator" as shown in Figure 3.

```
                                   Customer
                                    Service
               ------------------    Model    ----------
              |                  |  <-------->|          |
              |     Service      |            | Customer |
              |   Orchestrator   |    (a)     |          |
              |                  |             ----------
               ------------------
                 .           .
                 .           .          (b)    ----------
               . (b)           .        ......|Application|
                 .               .         :  |  BSS/OSS  |
                 .                 .        :   ----------
               .   Service Delivery  .      :
                 .       Model         .     :
               ------------------    ------------------
              |                  |  |                  |
              |     Network      |  |     Network      |
              |   Orchestrator   |  |   Orchestrator   |
              |                  |  |                  |
               .----------------.    .----------------.
              .          :          :                  .
             .           : Network Configuration :      .
            .            :        Model           :      .
      -----------   -----------   -----------   -----------
     |           | |           | |           | |           |
     |Controller | |Controller | |Controller | |Controller |
     |           | |           | |           | |           |
      -----------   -----------   -----------   -----------
         :             .     .          Device  :           :
         :            .       .     Configuration :         :
         :           .         .        Model   :           :
      ---------   ---------   ---------   ---------   ---------
     | Network | | Network | | Network | | Network | | Network |
     | Element | | Element | | Element | | Element | | Element |
      ---------   ---------   ---------   ---------   ---------
```
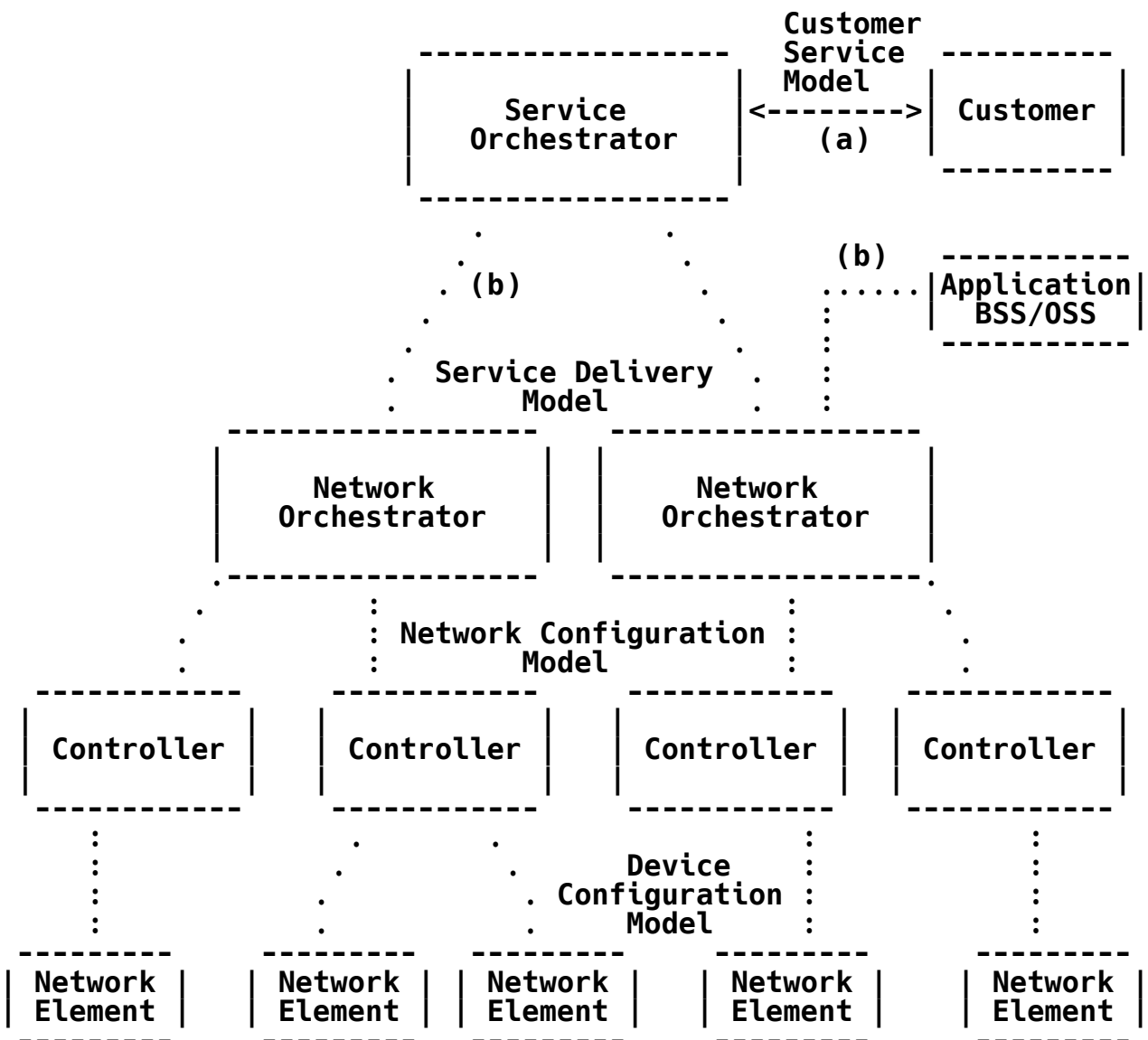
        Figure 3: An Example SDN Architecture with a Service Orchestrator

   Figure 3 also shows where different data models might be applied
   within the architecture. The device configuration models are used by
   a controller to set parameters on an individual network element. The
   network configuration models are used by a network orchestrator to
   instruct controllers (which may each be responsible for multiple
   network elements) how to configure parts of a network.

The following examples illustrate the split between control
components that expose a "service interface" that is present in many
figures that show extended SDN architectures:

o Figure 1 of [RFC7426] shows a separation of the "Application
   Plane", the "Network Services Abstraction Layer (NSAL)", and the
   "Control Plane". It marks the "Service Interface" as situated
   between the NSAL and the control plane.

o Figure 1 of [RFC7491] shows an interface between an "Application
   Service Coordinator" and an "Application-Based Network Operations
   Controller".

o Figure 1 of [RFC8199] shows an interface from an OSS or a Business
   Support System (BSS) that is expressed in "Network Service YANG
   Modules".

This can all lead to some confusion around the definition of a
"service interface" and a "service model". Some previous literature
considers the interface northbound of the network orchestrator
(labeled "(b)" in Figure 3) to be a "service interface" used by an
application, but the service described at this interface is network
centric and is aware of many features, such as topology, technology,
and operator policy. Thus, we make a distinction between this type
of service interface and the more abstract service interface (labeled
"(a)" in Figure 3) where the service is described by a service model
and the interaction is between the customer and network operator.
Further discussion of this point is provided in Section 5.

5. Possible Causes of Confusion

In discussing service models, there are several possible causes of
confusion:

o The services we are discussing are connectivity services provided
   by network operators to customers; the services are achieved by
   manipulating the network resources of the operator's network.
   This is a completely different thing to "Foo as a Service" (for
   example, Storage as a Service (SaaS)) where a service provider
   offers reachability to a value-added service that is provided at
   some location in the network using other resources (compute,
   storage, ...) that are not part of the network itself. The
   confusion arises not only because of the use of the word "service"
   in both cases, but also because network operators may offer both
   types of service to their customers.

o Network operation is normally out of scope in the discussion of
   services between a network operator and a customer. That means
   that the customer service model does not reveal to the customer
   anything about how the network operator delivers the service, nor
   does the model expose details of technology or network resources
   used to provide the service (all of these details could, in any
   case, be considered security vulnerabilities). For example, in
   the simple case of point-to-point virtual link connectivity
   provided by a network tunnel (such as an MPLS pseudowire), the
   network operator does not expose the path through the network that
   the tunnel follows. Of course, this does not preclude the network
   operator from taking guidance from the customer (such as to avoid
   routing traffic through a particular country) or from disclosing
   specific details (such as might be revealed by a route trace), but
   these are not standard features of the service as described in the
   customer service model.

o The network operator may use further data models (service delivery
   models) that help to describe how the service is realized in the
   network. These models might be used on the interface between the
   service orchestrator and the network orchestrator, as shown in
   Figure 3, and might include many of the pieces of information from
   the customer service model alongside protocol parameters and
   device configuration information. [RFC8199] also terms these data
   models as "service models" and encodes them as "Network Service
   YANG Modules"; a comparison is provided in Section 6.1. It is
   important that the service orchestrator be able to map from a
   customer service model to these service delivery models, but they
   are not the same thing.

o Commercial terms (such as "cost per byte", "cost per minute", and
   "scoped by quality and type of service", as well as terms related
   to payment) are generally not a good subject for standardization.
   It is possible that some network operators will enhance standard
   customer service models to include commercial information, but the
   way this is done is likely to vary widely between network
   operators. Thus, this feature is out of scope for standardized
   customer service models.

o SLAs have a high degree of overlap with the definition of services
   present in customer service models. Requests for specific
   bandwidth, for example, might be present in a customer service
   model, and agreement to deliver a service is a commitment to the
   description of the service in the customer service model.
   However, SLAs typically include a number of fine-grained details
   about how services are allowed to vary, by how much, and how
   often. SLAs are also linked to commercial terms with penalties
   and so forth and thus are also not good topics for

standardization. As with commercial terms, it is expected that
some network operators will enhance standard customer service
models to include SLA parameters either using their own work or
depending on material from standards bodies that specialize in
this topic, but this feature is out of scope for the IETF's
customer service models.

If a network operator chooses to express an SLA using a data
model, that model might be referenced as an extension or an
augmentation of the customer service model.
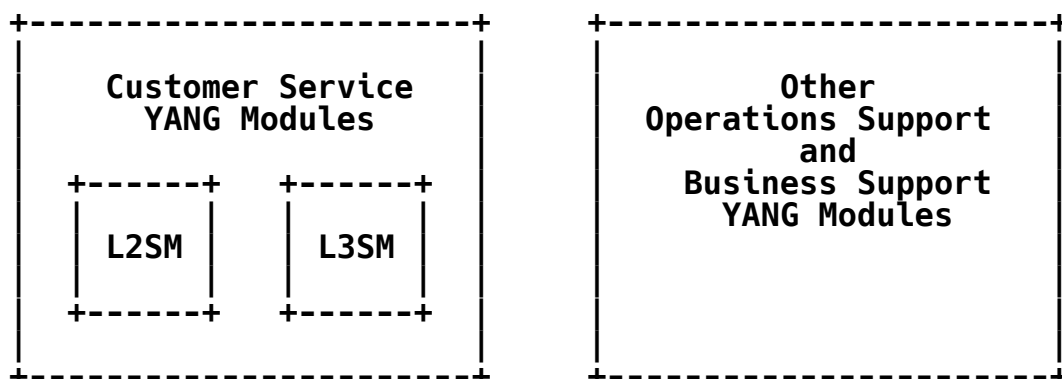
6. Comparison with Other Work

Other work has classified YANG modules, produced parallel
architectures, and developed a range of YANG modules. This section
briefly examines that other work and shows how it fits with the
description of service models introduced in this document.

6.1. Comparison with Network Service Models

As previously noted, [RFC8199] provides a classification of YANG
modules. It introduces the term "Network Service YANG Module" to
identify the type of module used to "describe the configuration,
state data, operations, and notifications of abstract representations
of services implemented on one or multiple network elements." These
modules are used to construct the service delivery models as
described in this document; that is, they are the modules used on the
interface between the service orchestrator or OSS/BSS and the network
orchestrator, as shown in Figure 3.

Figure 1 of [RFC8199] can be modified to make this more clear and to
include an additional example of a Network Service YANG module, as
shown in Figure 4. As can be seen, the highest classification of
modules collects those that are used to deliver operations support
and business support. These might be consumed by an Operations
Support System (OSS) or a Business Support System (BSS), and a
service orchestrator may form part of an OSS/BSS or may be a separate
component. This highest layer in the figure is divided into the
customer service modules that are used to describe services to a
customer as discussed in this document, and other modules that
describe further OSS/BSS functions such as billing and SLAs.
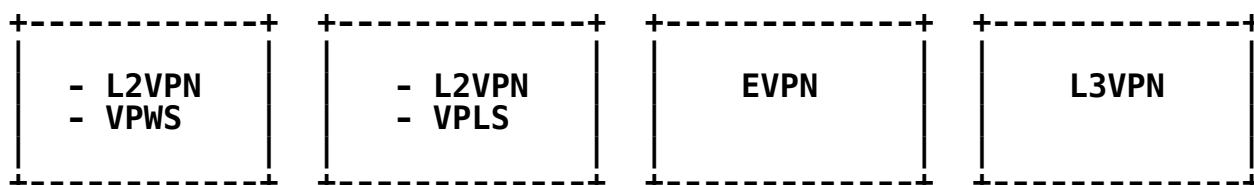
```
 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
   Operations Support and Business Support YANG Modules

   +-----------------------+       +-----------------------+
   |                       |       |                       |
   |    Customer Service   |       |         Other         |
   |      YANG Modules     |       |  Operations Support   |
   |                       |       |          and          |
   |   +------+  +------+  |       |    Business Support   |
   |   |      |  |      |  |       |     YANG Modules      |
   |   | L2SM |  | L3SM |  |       |                       |
   |   |      |  |      |  |       |                       |
   |   +------+  +------+  |       |                       |
   |                       |       |                       |
   +-----------------------+       +-----------------------+


 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
   Network Service YANG Modules

   +------------+   +------------+   +------------+   +------------+
   |            |   |            |   |            |   |            |
   |  - L2VPN   |   |  - L2VPN   |   |    EVPN    |   |   L3VPN    |
   |  - VPWS    |   |  - VPLS    |   |            |   |            |
   |            |   |            |   |            |   |            |
   +------------+   +------------+   +------------+   +------------+


 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
   Network Element YANG Modules

   +------------+   +------------+   +------------+   +------------+
   |            |   |            |   |            |   |            |
   |    MPLS    |   |     BGP    |   | IPv4 / IPv6|   |  Ethernet  |
   |            |   |            |   |            |   |            |
   +------------+   +------------+   +------------+   +------------+

   Key:
      EVPN: Ethernet Virtual Private Network
      L2SM: Layer 2 Virtual Private Network Service Model
      L2VPN: Layer 2 Virtual Private Network
      L3SM: Layer 3 Virtual Private Network Service Model
      L3VPN: Layer 3 Virtual Private Network
      VPLS: Virtual Private LAN Service
      VPWS: Virtual Private Wire Service
```
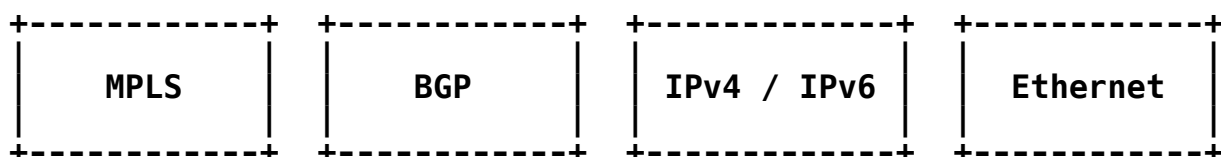
Figure 4: YANG Module Abstraction Layers Showing
Customer Service Modules

6.2. Service Delivery and Network Element Model Work

   A number of IETF working groups are developing YANG modules related
   to services. These models focus on how the network operator
   configures the network through protocols and devices to deliver a
   service. Some of these models are classified as network service
   delivery models (also called service delivery models or network
   configuration models depending on the level at which they are
   pitched), while others have details that are related to specific
   element configuration and so are classed as network element models
   (also called device models).

   A sample set of these models is listed here:

   o [BGP-L3VPN-YANG] defines a YANG module that can be used to
      configure and manage BGP L3VPNs.

   o [L2VPN-YANG] documents a data model that is expected to be used by
      the management tools run by the network operators in order to
      manage and monitor the network resources that they use to deliver
      L2VPN services.

   o [EVPN-YANG] defines YANG modules for delivering an Ethernet VPN
      service.

6.3. Customer Service Model Work

   Several initiatives within the IETF are developing customer service
   models. The L3SM presents the L3VPN service, as described by a
   network operator, to a customer. Figure 5, which is reproduced from
   [RFC8049], shows that the L3SM is a customer service model as
   described in this document.

```
L3VPN-SVC  |
  MODEL    |
           |
    +-------------------+      +-----+
    |   Orchestration   | < --- > | OSS |
    +-------------------+      +-----+
         |           |
    +----------------+   |
    | Config manager |   |
    +----------------+   |
         |           |
         | Netconf/CLI ...
         |           |
    +----------------------------------------------+
                      Network
```
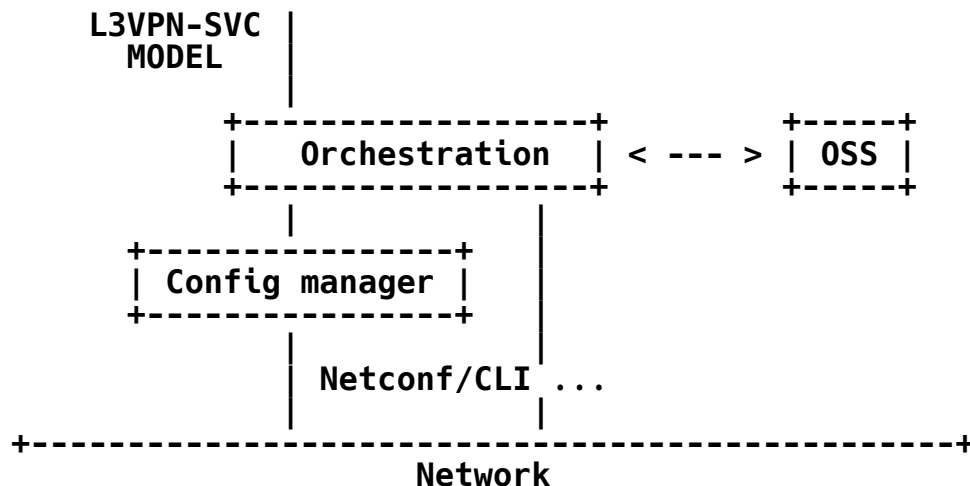
             Figure 5: The L3SM Service Architecture

   A Layer 2 VPN Service Model (L2SM) is defined in [L2VPN-SERVICE].
   That model's usage is described as in Figure 6, which is a
   reproduction of Figure 5 from that document. As can be seen, the
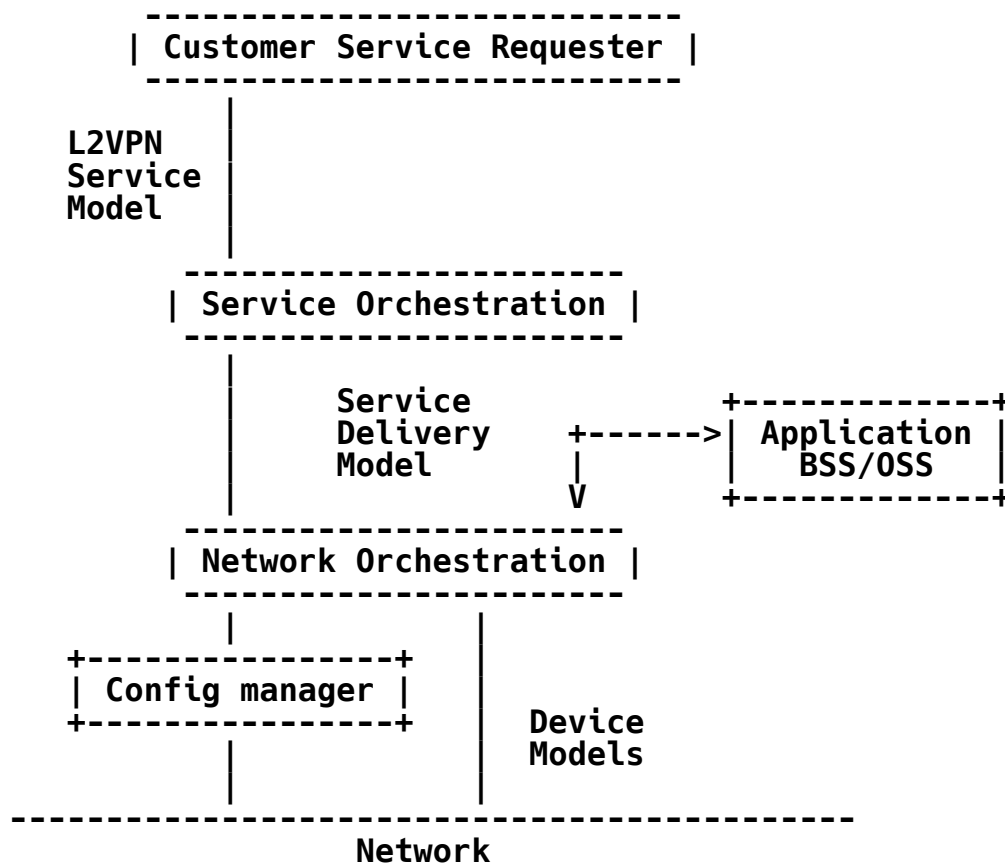   L2SM is a customer service model as described in this document.

```
              ------------------------------
             | Customer Service Requester |
              ------------------------------
                        |
  L2VPN                 |
  Service               |
  Model                 |
                        |
                        |
              ------------------------
             | Service Orchestration |
              ------------------------
                 |
                 |       Service                +-------------+
                 |       Delivery    +------>| Application |
                 |       Model       |       |   BSS/OSS   |
                 |                   |       +-------------+
                 |                   V
              ------------------------
             | Network Orchestration |
              ------------------------
                 |            |
       +-----------------+    |
       | Config manager  |    |
       +-----------------+    |
                 |            |    Device
                 |            |    Models
                 |            |
       ---------------------------------------------
                      Network
```

Figure 6: The L2SM Service Architecture

6.4. The MEF Architecture

The MEF Forum (MEF) has developed an architecture for network
management and operation. It is documented as the Lifecycle Service
Orchestration (LSO) Reference Architecture and is illustrated in
Figure 2 of [MEF-55].

The work of the MEF embraces all aspects of Lifecycle Service
Orchestration, including billing, SLAs, order management, and
lifecycle management. The IETF's work on service models is typically
smaller and offers a simple, self-contained service YANG module.
This does not invalidate either approach: it only observes that they
are different approaches.

7. Further Concepts

   This section introduces a few further, more advanced concepts.

7.1. Technology Agnostic

   Service models should generally be technology agnostic. That is to
   say, the customer should not care how the service is provided so long
   as the service is delivered.

   However, some technologies reach to the customer site and impact the
   type of service delivered. Such features do need to be described in
   the service model.

   Two examples are as follows:

   o The data passed between customer equipment and network operator
      equipment will be encapsulated in a specific way, and that data-
      plane type forms part of the service.

   o Protocols that are run between customer equipment and network
      operator equipment (for example, Operations, Administration, and
      Maintenance (OAM) protocols, protocols for discovery, or protocols
      for exchanging routing information) need to be selected and
      configured as part of the service description.

7.2. Relationship to Policy

   Policy appears as a crucial function in many places during network
   orchestration. A service orchestrator will, for example, apply the
   network operator's policies to determine how to provide a service for
   a particular customer (possibly considering commercial terms).
   However, the policies within a service model are limited to those
   over which a customer has direct influence and that are acted on by
   the network operator.

   The policies that express desired behavior of services on occurrence
   of specific events are close to SLA definitions: they should only be
   included in the base service model where they are common offerings of
   all network operators. Policies that describe which person working
   for a customer may request or modify services (that is,
   authorization) are close to commercial terms: they, too, should only
   be included in the base service model where they are common offerings
   of all network operators.

   As with commercial terms and SLAs discussed in Section 5, it is
   expected that some network operators will enhance standard customer
   service models to include policy parameters either using their own

   work or depending on specific policy models built in the IETF or
   other standards bodies.

   Nevertheless, policy is so important that all service models should
   be designed to be easily extensible to allow policy components to be
   added and associated with services as needed.

7.3. Operator-Specific Features

   When work on the L3SM was started, there was some doubt as to whether
   network operators would be able to agree on a common description of
   the services that they offer to their customers because, in a
   competitive environment, each markets the services in a different way
   with different additional features. However, the working group was
   able to agree on a core set of features that multiple network
   operators were willing to consider as "common". They also understood
   that, should an individual network operator want to describe
   additional features (operator-specific features), they could do so by
   extending or augmenting the L3SM model.

   Thus, when a basic description of a core service is agreed upon and
   documented in a service model, it is important that that model be
   easily extended or augmented by each network operator so that the
   standardized model can be used in a common way and only the operator-
   specific features be varied from one environment to another.

7.4. Supporting Multiple Services

   Network operators will, in general, offer many different services to
   their customers. Each would normally be the subject of a separate
   service model.

   Whether each service model is handled by a specialized service
   orchestrator that is able to provide tuned behavior for a specific
   service, or whether all service models are handled by a single
   service orchestrator, is an implementation and deployment choice.

   It is expected that, over time, certain elements of the service
   models will be seen to repeat in each model. An example of such an
   element is the postal address of the customer.

   It is anticipated that, while access to such information from each
   service model is important, the data will be described in its own
   module and may form part of the service model either by inclusion or
   by index.

8. Security Considerations

   The interface between customer and service provider is a commercial
   interface, and it needs to be subject to appropriate confidentiality.
   Additionally, knowledge of what services are provided to a customer
   or delivered by a network operator may supply information that can be
   used in a variety of security attacks. The service model itself will
   expose security-related parameters for the specific service where the
   related function is available to the customer.

   Clearly, the ability to modify information exchanges between customer
   and network operator may result in bogus requests, unwarranted
   billing, and false expectations. Furthermore, in an automated
   system, modifications to service requests or the injection of bogus
   requests may lead to attacks on the network and delivery of customer
   traffic to the wrong place.

   Therefore, it is important that the protocol interface used to
   exchange service request information between customer and network
   operator is subject to authorization, authentication, and encryption.
   Clearly, the level of abstraction provided by a service model
   protects the operator from unwarranted visibility into their network,
   and additional protection is provided by the fact that how the
   service is delivered is entirely up to the operator.

   Equally, all external interfaces, such as any of those between the
   functional components in Figure 3, need to be correctly secured.
   This document discusses modeling the information, not how it is
   exchanged.

9. Manageability Considerations

   This whole document discusses issues related to network management
   and control.

   It is important to observe that automated service provisioning
   resulting from use of a customer service model may result in rapid
   and significant changes in traffic load within a network and that
   that might have an effect on other services carried in a network.

   It is expected, therefore, that a service-orchestration component has
   awareness of other service commitments, that the network-
   orchestration component will not commit network resources to fulfill
   a service unless doing so is appropriate, and that a feedback loop
   will be provided to report on degradation of the network that will
   impact the service.

The operational state of a service does not form part of a customer
service model. However, it is likely that a network operator may
want to report some state information about various components of the
service and that could be achieved through extensions to the core
service model, just as SLA extensions could be made as described in
Section 5.

10. IANA Considerations

This document does not require any IANA actions.

11. References

11.1. Normative References

[RFC3444] Pras, A. and J. Schoenwaelder, "On the Difference between
           Information Models and Data Models", RFC 3444,
           DOI 10.17487/RFC3444, January 2003,
           <https://www.rfc-editor.org/info/rfc3444>.

[RFC8199] Bogdanovic, D., Claise, B., and C. Moberg, "YANG Module
           Classification", RFC 8199, DOI 10.17487/RFC8199, July
           2017, <https://www.rfc-editor.org/info/rfc8199>.

11.2. Informative References

[BGP-L3VPN-YANG]
           Jain, D., Patel, K., Brissette, P., Li, Z., Zhuang, S.,
           Liu, X., Haas, J., Esale, S., and B. Wen, "Yang Data Model
           for BGP/MPLS L3 VPNs", Work in Progress, draft-dhjain-
           bess-bgp-l3vpn-yang-02, August 2016.

[EVPN-YANG]
           Brissette, P., Sajassi, A., Shah, H., Li, Z.,
           Tiruveedhula, K., Hussain, I., and J. Rabadan, "Yang Data
           Model for EVPN", Work in Progress, draft-ietf-bess-evpn-
           yang-03, October 2017.

[L2VPN-SERVICE]
           Wen, B., Fioccola, G., Xie, C., and L. Jalil, "A YANG Data
           Model for L2VPN Service Delivery", Work in Progress,
           draft-ietf-l2sm-l2vpn-service-model-04, October 2017.

[L2VPN-YANG]
           Shah, H., Brissette, P., Chen, I., Hussain, I., Wen, B.,
           and K. Tiruveedhula, "YANG Data Model for MPLS-based
           L2VPN", Work in Progress, draft-ietf-bess-l2vpn-yang-07,
           October 2017.

   [MEF-55]   MEF Forum, "Lifecycle Service Orchestration (LSO):
               Reference Architecture and Framework", Service Operations
               Specification MEF 55, March 2016.

   [RFC6020]   Bjorklund, M., Ed., "YANG - A Data Modeling Language for
               the Network Configuration Protocol (NETCONF)", RFC 6020,
               DOI 10.17487/RFC6020, October 2010,
               <https://www.rfc-editor.org/info/rfc6020>.

   [RFC6241]   Enns, R., Ed., Bjorklund, M., Ed., Schoenwaelder, J., Ed.,
               and A. Bierman, Ed., "Network Configuration Protocol
               (NETCONF)", RFC 6241, DOI 10.17487/RFC6241, June 2011,
               <https://www.rfc-editor.org/info/rfc6241>.

   [RFC7149]   Boucadair, M. and C. Jacquenet, "Software-Defined
               Networking: A Perspective from within a Service Provider
               Environment", RFC 7149, DOI 10.17487/RFC7149, March 2014,
               <https://www.rfc-editor.org/info/rfc7149>.

   [RFC7223]   Bjorklund, M., "A YANG Data Model for Interface
               Management", RFC 7223, DOI 10.17487/RFC7223, May 2014,
               <https://www.rfc-editor.org/info/rfc7223>.

   [RFC7297]   Boucadair, M., Jacquenet, C., and N. Wang, "IP
               Connectivity Provisioning Profile (CPP)", RFC 7297,
               DOI 10.17487/RFC7297, July 2014,
               <https://www.rfc-editor.org/info/rfc7297>.

   [RFC7407]   Bjorklund, M. and J. Schoenwaelder, "A YANG Data Model for
               SNMP Configuration", RFC 7407, DOI 10.17487/RFC7407,
               December 2014, <https://www.rfc-editor.org/info/rfc7407>.

   [RFC7426]   Haleplidis, E., Ed., Pentikousis, K., Ed., Denazis, S.,
               Hadi Salim, J., Meyer, D., and O. Koufopavlou, "Software-
               Defined Networking (SDN): Layers and Architecture
               Terminology", RFC 7426, DOI 10.17487/RFC7426, January
               2015, <https://www.rfc-editor.org/info/rfc7426>.

   [RFC7491]   King, D. and A. Farrel, "A PCE-Based Architecture for
               Application-Based Network Operations", RFC 7491,
               DOI 10.17487/RFC7491, March 2015,
               <https://www.rfc-editor.org/info/rfc7491>.

   [RFC7950]   Bjorklund, M., Ed., "The YANG 1.1 Data Modeling Language",
               RFC 7950, DOI 10.17487/RFC7950, August 2016,
               <https://www.rfc-editor.org/info/rfc7950>.

   [RFC8040] Bierman, A., Bjorklund, M., and K. Watsen, "RESTCONF
              Protocol", RFC 8040, DOI 10.17487/RFC8040, January 2017,
              <https://www.rfc-editor.org/info/rfc8040>.

   [RFC8049] Litkowski, S., Tomotaki, L., and K. Ogaki, "YANG Data
              Model for L3VPN Service Delivery", RFC 8049,
              DOI 10.17487/RFC8049, February 2017,
              <https://www.rfc-editor.org/info/rfc8049>.

Acknowledgements

Authors' Addresses

   Qin Wu
   Huawei Technologies

   Email: bill.wu@huawei.com

   Will Liu
   Huawei Technologies

   Email: liushucheng@huawei.com

   Adrian Farrel
   Juniper Networks

   Email: afarrel@juniper.net