                        YANG Module Classification

Abstract

   The YANG data modeling language is currently being considered for a
   wide variety of applications throughout the networking industry at
   large.  Many standards development organizations (SDOs), open-source
   software projects, vendors, and users are using YANG to develop and
   publish YANG modules for a wide variety of applications.  At the same
   time, there is currently no well-known terminology to categorize
   various types of YANG modules.

   A consistent terminology would help with the categorization of YANG
   modules, assist in the analysis of the YANG data modeling efforts in
   the IETF and other organizations, and bring clarity to the YANG-
   related discussions between the different groups.

   This document describes a set of concepts and associated terms to
   support consistent classification of YANG modules.

Status of This Memo

   This document is not an Internet Standards Track specification; it is
   published for informational purposes.

   This document is a product of the Internet Engineering Task Force
   (IETF).  It represents the consensus of the IETF community.  It has
   received public review and has been approved for publication by the
   Internet Engineering Steering Group (IESG).  Not all documents
   approved by the IESG are a candidate for any level of Internet
   Standard; see Section 2 of RFC 7841.

   Information about the current status of this document, any errata,
   and how to provide feedback on it may be obtained at
   http://www.rfc-editor.org/info/rfc8199.

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Table of Contents

1.  Introduction

   The Internet Engineering Steering Group (IESG) has been actively
   encouraging IETF working groups to use the YANG data modeling
   language [RFC7950] and the Network Configuration Protocol (NETCONF)
   [RFC6241] for configuration management purposes, especially in new
   working group charters [IESG-Statement].

   YANG is also gaining wide acceptance as the de facto standard data
   modeling language in the broader industry.  This extends beyond the
   IETF to include many SDOs, industry consortia, ad hoc groups, open-
   source projects, vendors, and end users.

There are currently no clear guidelines on how to classify the
layering of YANG modules according to abstraction or how to classify
modules along the continuum spanning formal standards publications,
vendor-specific modules, and modules provided by end users.

This document presents a set of concepts and terms to form a useful
taxonomy for consistent classification of YANG modules in two
dimensions:

o  The layering of modules based on their abstraction levels

o  The module origin type based on the nature and intent of the
   content

The intent of this document is to provide a taxonomy to simplify
human communication around YANG modules.  While the classification
boundaries are at times blurry, this document should provide a robust
starting point as the YANG community gains further experience with
designing and deploying modules.  To be more explicit, it is expected
that the classification criteria will change over time.

A number of modules, for example, modules concerned with topologies,
created substantial discussion during the development of this
document.  Topology modules are useful both on the network element
level (e.g., link-state database content) and on the network service
level (e.g., network-wide, configured topologies).  In the end, it is
the module developer that classifies the module according to the
initial intent of the module content.

This document should provide benefits to multiple audiences:

o  First, a common taxonomy helps with discussions among SDOs and
   industry consortia; the goals of such discussions are determined
   by the respective areas of work.

o  Second, operators might look at the YANG module abstraction layers
   to understand which Network Service YANG Modules and Network
   Element YANG Modules are available for their service composition.
   It is difficult to determine the module type without inspecting
   the YANG module itself.  The YANG module name might provide some
   useful information but is not a definite answer.  For example, a
   Layer 2 Virtual Private Network (L2VPN) YANG module might be a
   Network Service YANG Module, ready to be used as a service model
   by a network operator.  Alternatively, it might be a Network
   Element YANG Module that contains the L2VPN data definitions
   required to be configured on a single device.

   o  Third, this taxonomy will help equipment vendors (whether physical
      or virtual), controller vendors, and orchestrator vendors to
      explain to their customers the relationship between the different
      YANG modules they support in their products.

1.1.  Terminology

   [RFC7950] specifies:

   o  data model: A data model describes how data is represented and
      accessed.

   o  module: A YANG module defines hierarchies of schema nodes.  With
      its definitions and the definitions it imports or includes from
      elsewhere, a module is self-contained and "compilable".

2.  First Dimension: YANG Module Abstraction Layers

   Module developers have taken two approaches to developing YANG
   modules: top-down and bottom-up.  The top-down approach starts with
   high-level abstractions modeling business or customer requirements
   and maps them to specific networking technologies.  The bottom-up
   approach starts with fundamental networking technologies and maps
   them into more abstract constructs.

   There are currently no specific requirements or well-defined best
   practices for the development of YANG modules.  This document
   considers both bottom-up and top-down approaches as they are both
   used and they each provide benefits that appeal to different groups.

   For layering purposes, this document suggests the classification of
   YANG modules into two distinct abstraction layers:

   o  Network Element YANG Modules describe the configuration, state
      data, operations, and notifications of specific device-centric
      technologies or features.

   o  Network Service YANG Modules describe the configuration, state
      data, operations, and notifications of abstract representations of
      services implemented on one or multiple network elements.

```
                  +--------------------------+
                  |  Operations and Business |
                  |       Support Systems    |
                  |      (OSSs and BSSs)     |
                  +--------------------------+


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


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


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


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

        L2VPN: Layer 2 Virtual Private Network
        L3VPN: Layer 3 Virtual Private Network
        VPWS: Virtual Private Wire Service
        VPLS: Virtual Private LAN Service
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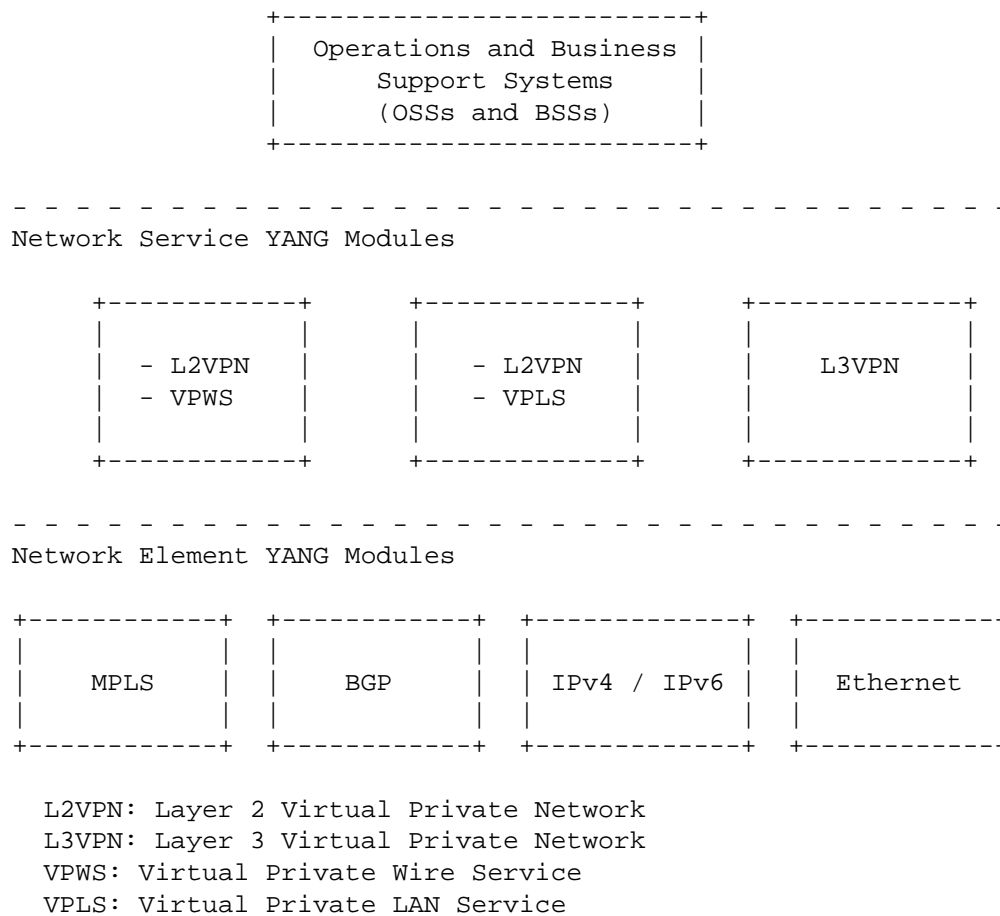
              Figure 1: YANG Module Abstraction Layers

   Figure 1 illustrates the application of YANG modules at different
   layers of abstraction.  Layering of modules allows for reusability of
   existing lower-layer modules by higher-level modules while limiting
   duplication of features across layers.

   For module developers, per-layer modeling allows for separation of
   concern across editing teams focusing on specific areas.

   As an example, experience from the IETF shows that creating useful
   Network Element YANG Modules (e.g., for routing or switching
   protocols) requires teams that include developers with experience
   implementing those protocols.

On the other hand, Network Service YANG Modules are best developed by
network operators experienced in defining network services for
consumption by programmers, e.g., those developing flow-through
provisioning systems or self-service portals.

2.1.  Network Service YANG Modules

Network Service YANG Modules describe the characteristics of a
service, as agreed upon with consumers of that service.  That is, a
service module does not expose the detailed configuration parameters
of all participating network elements and features but describes an
abstract model that allows instances of the service to be decomposed
into instance data according to the Network Element YANG Modules of
the participating network elements.  The service-to-element
decomposition is a separate process; the details depend on how the
network operator chooses to realize the service.  For the purpose of
this document, the term "orchestrator" is used to describe a system
implementing such a process.

External systems can be provisioning systems, service orchestrators,
Operations Support Systems, Business Support Systems, and
applications exposed to network service consumers (either internal
network operations people or external customers).  These modules are
commonly designed, developed, and deployed by network infrastructure
teams.

YANG allows for different design patterns to describe network
services, ranging from monolithic to component-based approaches.

The monolithic approach captures the entire service in a single
module and does not put focus on reusability of internal data
definitions and groupings.  The monolithic approach has the
advantages of single-purpose development, including development speed
at the expense of reusability.

The component-based approach captures device-centric features (e.g.,
VPN Routing and Forwarding (VRF), routing protocols, or packet
filtering) in a vendor-independent manner.  The components are
designed for reuse across many service modules.  The set of
components required for a specific service is then composed into the
higher-level service.  The component-based approach has the
advantages of modular development, including a higher degree of
reusability at the expense of initial development speed.

As an example, an L2VPN service can be built on many different types
of transport network technologies, including, e.g., MPLS or Carrier
Ethernet.  A component-based approach would allow for reuse of User-
Network Interface (UNI) definitions, such as the MEF UNI interface or

MPLS interface, independent of the underlying transport network.  The
monolithic approach would assume a specific set of transport
technologies and interface definitions.

An example of a Network Service YANG Module is in [RFC8049].  It
provides an abstract model for Layer 3 IP VPN service configuration.
This module includes the concept of a 'site-network-access' to
represent bearer and connection parameters.  An orchestrator receives
operations on service instances according to the service module and
decomposes the data into configuration data according to specific
Network Element YANG Modules to configure the participating network
elements to the service.  In the case of the L3VPN module, this would
include translating the 'site-network-access' parameters to the
appropriate parameters in the Network Element YANG Module implemented
on the constituent elements.

## 2.2.  Network Element YANG Modules

Network Element YANG Modules describe the characteristics of a
network device as defined by the vendor of that device.  The modules
are commonly structured around features of the device, e.g.,
interface configuration [RFC7223], OSPF configuration [OSPF-YANG],
and access control list (ACL) configuration [ACL-YANG].

The Network Element YANG Module provides a coherent data model
representation of the software environment consisting of the
operating system and applications running on the device.  The
decomposition, ordering, and execution of changes to the operating
system and application configuration is the task of the agent that
implements the module.

## 3.  Second Dimension: YANG Module Origin Types

This document suggests classifying YANG module origin types as
Standard YANG Modules, Vendor-Specific YANG Modules and Extensions,
or User-Specific YANG Modules and Extensions.

The suggested classification applies to both Network Element YANG
Modules and Network Service YANG Modules.

It is to be expected that real-world implementations of both Network
Service YANG Modules and Network Element YANG Modules will include a
mix of all three module origin types.

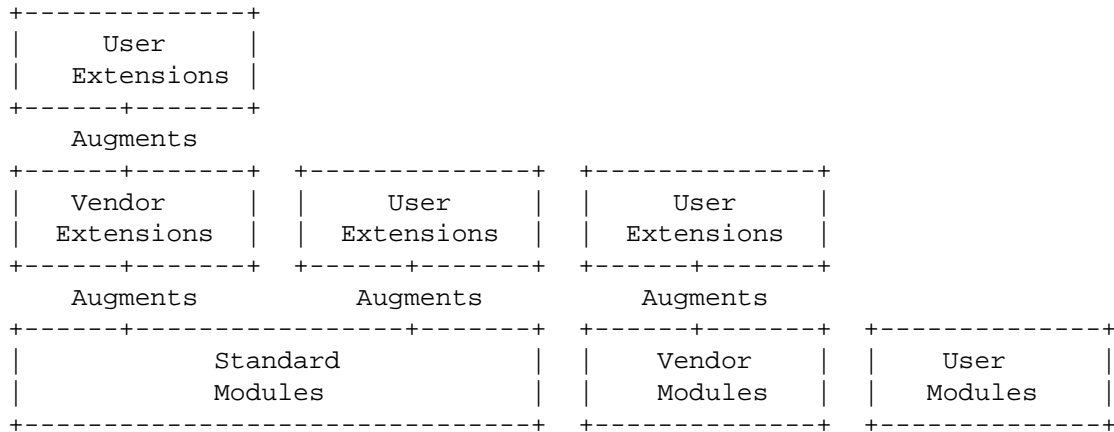Figure 2 illustrates the relationship between the three types of
modules.

```
+--------------+
|     User     |
|  Extensions  |
+------+-------+
    Augments
+------+-------+  +--------------+  +--------------+
|    Vendor    |  |     User     |  |     User     |
|  Extensions  |  |  Extensions  |  |  Extensions  |
+------+-------+  +------+-------+  +------+-------+
    Augments         Augments         Augments
+------+---------------+-------+  +------+-------+  +--------------+
|            Standard          |  |    Vendor    |  |     User     |
|            Modules           |  |    Modules   |  |    Modules   |
+------------------------------+  +--------------+  +--------------+
```

Figure 2: YANG Module Origin Types

## 3.1.  Standard YANG Modules

Standard YANG Modules are published by SDOs.  Most SDOs create
specifications according to a formal process in order to produce a
standard that is useful for their constituencies.

The lifecycles of these modules are driven by the editing cycles of
the specifications and not tied to a specific implementation.

Examples of SDOs in the networking industry are the IETF and the
IEEE.

## 3.2.  Vendor-Specific YANG Modules and Extensions

Vendor-Specific YANG Modules are developed by organizations with the
intent to support a specific set of implementations under control of
that organization, for example, vendors of virtual or physical
equipment, industry consortia, and open-source projects.  The intent
of these modules ranges from providing openly published YANG modules
that may eventually be contributed back to or adopted by an SDO to
strictly internal YANG modules not intended for external consumption.

The lifecycles of these modules are generally aligned with the
release cycles of the product or open-source software project
deliverables.

It is worth noting that there is an increasing amount of interaction
between open-source projects and SDOs in the networking industry.
This includes open-source projects implementing published standards
as well as open-source projects contributing content to SDO
processes.

Vendors also develop vendor-specific extensions to standard modules
using YANG constructs for extending data definitions of previously
published modules.  This is done using the 'augment' statement that
allows locally defined data trees to be added into locations in
externally defined data trees.

Vendors use this to extend standard modules to cover the full scope
of features in implementations, which commonly is broader than that
covered by the standard module.

3.3.  User-Specific YANG Modules and Extensions

User-Specific YANG Modules are developed by organizations that
operate YANG-based infrastructure including devices and
orchestrators, for example, network administrators in enterprises or
at service providers.  The intent of these modules is to express the
specific needs for a certain implementation, above and beyond what is
provided by vendors.

This module type obviously requires the infrastructure to support the
introduction of user-provided modules and extensions.  This would
include the ability to describe the service-to-network decomposition
in orchestrators and the module-to-configuration decomposition in
devices.

The lifecycles of these modules are generally aligned with the change
cadence of the infrastructure.

4.  Security Considerations

This document doesn't have any Security Considerations.

5.  IANA Considerations

This document does not require any IANA actions.

6.  References

6.1.  Normative References

   [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,
              <http://www.rfc-editor.org/info/rfc6241>.

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

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

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

6.2.  Informative References

   [ACL-YANG]
              Bogdanovic, D., Jethanandani, M., Huang, L., Agarwal, S.,
              and D. Blair, "Network Access Control List (ACL) YANG Data
              Model", Work in Progress, draft-ietf-netmod-acl-model-11,
              June 2017.

   [IESG-Statement]
              "Writable MIB Module IESG Statement",
              <https://www.ietf.org/iesg/statement/
              writable-mib-module.html>.

   [OSPF-YANG]
              Yeung, D., Qu, Y., Zhang, Z., Chen, I., and A. Lindem,
              "Yang Data Model for OSPF Protocol", Work in Progress,
              draft-ietf-ospf-yang-08, July 2017.

Authors' Addresses

   Dean Bogdanovic
   Volta Networks, Inc.

   Email: dean@voltanet.io


   Benoit Claise
   Cisco Systems, Inc.
   De Kleetlaan 6a b1
   1831 Diegem
   Belgium

   Phone: +32 2 704 5622
   Email: bclaise@cisco.com


   Carl Moberg
   Cisco Systems, Inc.

   Email: camoberg@cisco.com