

Internet Engineering Task Force (IETF)  
Request for Comments: 8199  
Category: Informational  
ISSN: 2070-1721

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July 2017

## 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.

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## 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.

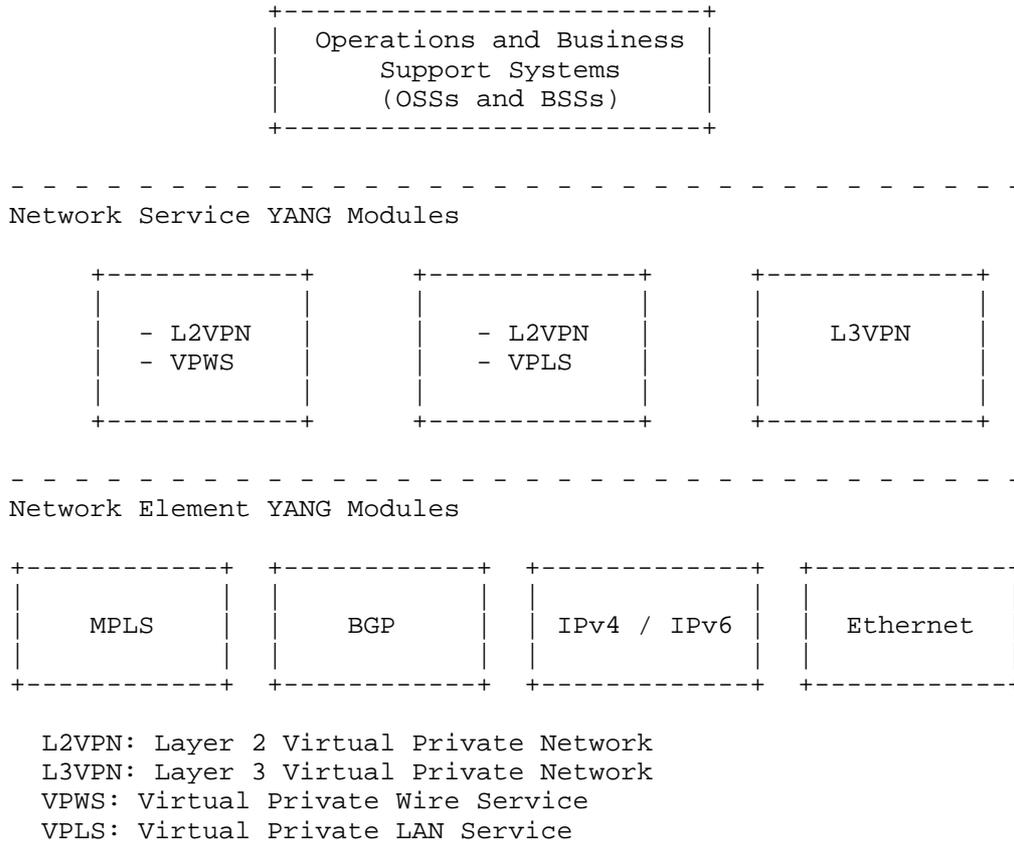


Figure 1: YANG Module Abstraction Layers

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.

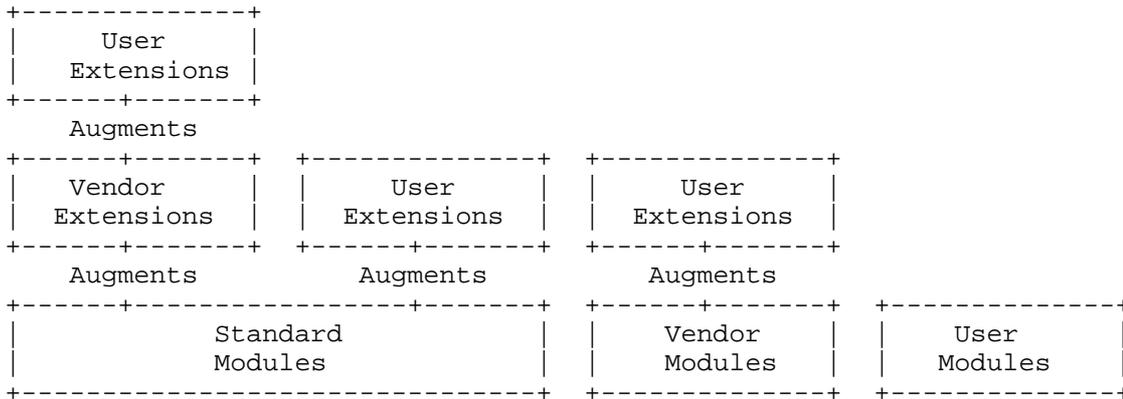


Figure 2: YANG Module Origin Types

### 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.

## Acknowledgements

Thanks to David Ball and Jonathan Hansford for feedback and suggestions.

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