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YANG Module Classification
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Abstract

The YANG data modeling language is currently being considered for a wide variety of applications throughout the networking industry at large. Many standards-defining 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.

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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], [RFC7950] and NETCONF protocol [RFC6241] for configuration management purposes, especially in new working group charters [Writable-MIB-Module-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, including many standards development organizations, 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:

- The layering of modules based on their abstraction levels
- The type of module 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. The authors acknowledge that the classification boundaries are at times blurry, but believe that this document should provide a robust starting point as the YANG community gains further experience with designing and deploying modules. To be more explicit, the authors believe that the classification criteria will change over time.

A number of module types have created substantial discussion during the development of this document including those concerned with topologies. Topology modules are useful both on the Network Element level (e.g. link-state database content) as well as 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:

- First, a common taxonomy helps with the different standards development organizations and industry consortia discussions, whose goals are determined in their respective areas of work.
- Second, operators might look at the YANG module classification type 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, an L2VPN YANG module might be a Network Service YANG module, ready to be used as a service model by 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.
- And thirdly, this taxonomy would help equipment vendors (whether physical or virtual), controller vendors, orchestrator vendors to

explain to their customers the relationship between the different YANG modules they support in their products. See Figure 1.

1.1. Terminology

[RFC7950] specifies:

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

- 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 on, or well-defined best practices around the development of YANG modules. For the purpose of this document we assume that both approaches (bottom-up and top-down) will be used as they both provide benefits that appeal to different groups.

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

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

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

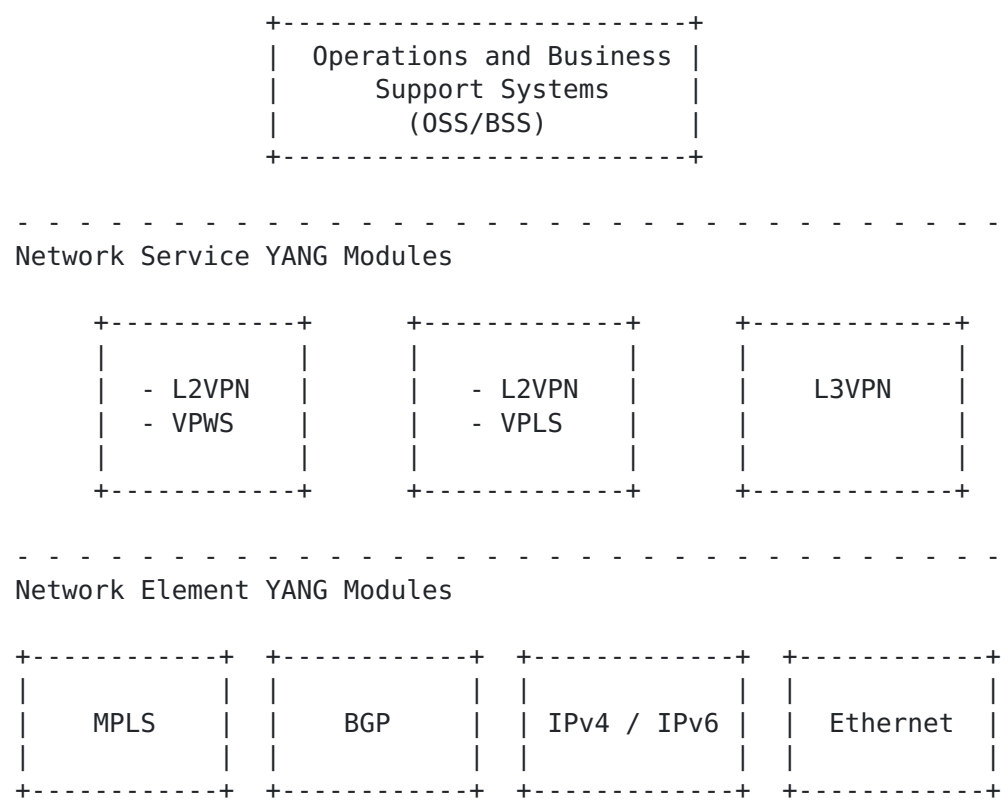

Figure 1: YANG Module Layers

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 for e.g. routing or switching protocols requires teams that include developers with experience of 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 developing e.g. 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 with details depending on how the network operator chooses to realize the service. For the purpose of this document we will use the term "orchestrator" to describe a system implementing such a process.

Network Service YANG Modules define service models to be consumed by external systems. External systems can be provisioning systems, service orchestrators, Operations Support Systems, Business Support Systems and applications exposed to network service consumers, being either internal network operations peole or extarnal 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 speed at the expense of reusability.

The component-based approach captures device-centric features (e.g. the definition of a 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 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 e.g. UNI-interface definitions independent of the underlying transport network (e.g. MEF UNI interface or MPLS interface). The monolithic

approach would assume a specific set of transport technologies and interface definitions.

Another example for a network service model is [RFC8049]. Although it provides information that can be used to achieve customer service service level agreement, which is more then network service module classification describes in this document, it provides an abstract model for Layer 3 IP VPN service configuration which is a good network service model. This module includes e.g. 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 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 [I-D.ietf-ospf-yang], and firewall rules definitions [I-D.ietf-netmod-acl-model].

Although the [RFC7950], [RFC7950] doesn't explain the relationship of the terms '(YANG) data model' and '(YANG) module', the authors understand there is a 1:1 relationship between a data model and a YANG module, but a data model may also be expressed using a collection of YANG modules (and submodules). The 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: Module Types

This document suggests classifying YANG module 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 types of modules.

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

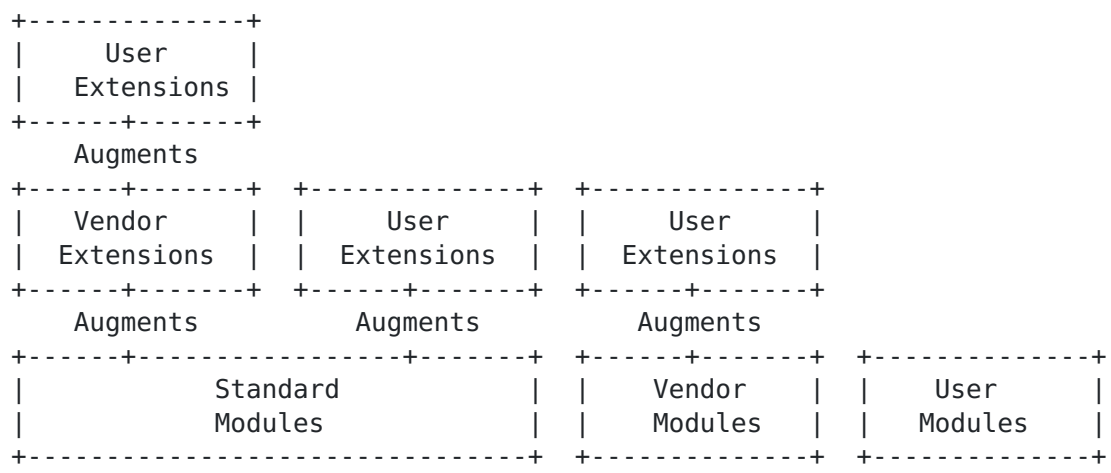

Figure 2: YANG Module Types

3.1. Standard YANG Modules

Standard YANG Modules are published by standards-defining organizations (SDOs). While there is no formal definition of what construes an SDO, a common feature is that they publish specifications along specific processes with content that reflects some sort of membership consensus. The specifications are developed for wide use among the membership or for audiences beyond that.

The lifecycle of these modules is driven by the editing cycle of the specification and not tied to a specific implementation.

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

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 opensource projects. The intent of these modules range 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 lifecycle of these modules are generally aligned with the release cycle 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 augmented 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 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 has no IANA actions.

6. Acknowledgements

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

7. Change log [RFC Editor: Please remove]

version 00: Renamed and small fixes based on WG feedback.

version 01: Language fixes, collapsing of vendor data models and extensions, and the introduction of user data models and extensions.

version 02: Updated the YANG Module Catalog section, terminology alignment (YANG data model versus YANG module), explain better the distinction between the Network Element and Service YANG data models even if sometimes there are grey areas, editorial pass. Changed the use of the term 'model' to 'module' to be better aligned with RFC6020.

version 06: updates based on comments from Adrian Farrel about YANG Data Model for L3VPN Service Delivery.

8. References

8.1. Normative References

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8.2. Informative References

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[Writable-MIB-Module-IESG-Statement]
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