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Augmented-by Addition into the IETF-YANG-Library
draft-ietf-netconf-yang-library-augmentedby-02

Abstract

This document augments the ietf-yang-library to provide the augmented-by list. It facilitates the process of obtaining ~~the entireall~~ dependencies between YANG modules, by ~~directly~~ querying the ~~network management~~ server's YANG library.

Discussion Venues

This note is to be removed before publishing as an RFC.
Source for this draft and an issue tracker can be found at
<https://github.com/Zephyre777/draft-lincla-netconf-yang-library-augmentation>.

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1. Introduction

The YANG library [RFC8525] specifies a YANG module that provides module information such as submodule list and deviation list to help a client listing all datastores supported by a network management server and the schema that is used by each of these datastores. ~~utilizes the YANG data modelling language.~~

According to Section 4.2.8 and 5.6.3 in [RFC7950], both augmentations and deviations ~~are~~

~~defining define contents~~ additional nodes internal or external to the module, ~~but applying internally for~~

~~the module, which are are the reverse dependency dependencies~~ of a YANG module. Reverse and dependencies and import as in Section 5.1.1 of RFC 7950 are both crucial informations ~~Teto~~

~~construct the fullunderstand all dependency dependencies~~ of a YANG module, ~~the reverse~~

~~dependency is a crucial information.~~ However, currently it is difficult to obtain the ~~reverse dependency~~ YANG schema tree RFC 8340

without ~~fetching obtaining~~ and

parsing all ~~device YANG~~ modules from a management server. The deviation list defined in YANG

library enables client to obtain the module reverse dependency without having to get and parse all YANG modules. However, the augmentation list is not defined in it.

Since both augmentation and deviation work as YANG module dependencies, it is reasonable to document them the same way in the YANG library. On the other hand, having Having both augmentation and deviation directly available in the YANG library provides an easy and light-weight solution for determining the reverse

~~dependencydependencies.~~

Therefore, this ~~draft document~~ proposes a YANG module that augments the YANG

library, ~~to include the YANG module augmentation information for it.~~

1.1. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

The terminology from [RFC8525] is used in this document

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The terms "client" is used as defined in [RFC6241] for NETCONF and [RFC8040] for RESTCONF. .

2. Motivation

When using a YANG module, it is necessary to make sure that all its dependencies are presented. [RFC7950] identifies four types of dependencies between YANG modules:

- * Import: the "import" statement allows a module or submodule to reference definitions defined in other modules.
- * Include: the "include" statement is used in a module to identify each submodule that belongs to it.
- * Augmentation: the "augment" statement defines the location in the data model hierarchy where additional nodes are inserted.
- * Deviation: the "deviation" statement defines a fragment of a module that the server does not implement.

The import and include are direct dependencies which can be obtained by parsing the YANG module source code, while the augmentation and deviation are reverse dependencies which are defined in another module.

For the reverse dependencies, since they are defined externally, it is not possible to discover them by parsing the YANG module. The current way to discover the reverse dependencies is to query all YANG modules from the server and parse them. This is a lengthy process, which must be repeated for each client that requires these information.

According to the definition of module ietf-yang-library defined in [RFC8525], in the schema content of a module in container yang-library, the deviation is provided to ~~tell this~~describe that a module is deviated by which other modules. If the YANG library ~~can~~could directly report all reverse dependencies, it ~~could~~would provide a much easier and light-weight solution to find module ~~entire~~all ~~dependency~~dependencies, compared to ~~getting-obtaining~~ and parsing all modules.

~~Currently, the YANG library only provides the deviation list, but not the without augmentations.~~ With augmentation being more widely used

and defined, and with use cases ~~arise as the requirement of to~~ automate network management, ~~the augmentations~~ becomes essential information ~~to be learnt by for~~ clients ~~what has been additionally implemented, and for~~

~~it~~ to better understand the device-network management servers module relationships. Thus, the

YANG library should be extended to also provide the augmentation information.

From the perspective of implementation difficulty, it is easy to adapt the device implementation to include augmentation, since augmentation and deviation have similar way of working.

3. Use Cases

As the demand for YANG-based telemetry [RFC8641] arises, there is a need for real-time knowledge of a specific YANG module's dependency list when a specific YANG-Push notification is received.

The alternative for a YANG-Push receiver is to collect and store the entire module set for every single server who could be streaming data. This approach is not always practical due to the following reasons:

* For a YANG-Push ~~collector-receiver~~ => we never know in advance which or

from ~~whom which YANG-Push publisher~~ the ~~telemetry-subscriber YANG~~ content will be received from.

* Querying all the YANG modules is time consuming and overhead => ~~we lose the real-time~~ considering that only a subset of YANG nodes of management server are subscribed.

This section introduces two use cases that reflect the motivation for extending YANG library. One targets solving dependency problems in a data mesh data telemetry system architecture while the other aims at building a data

catalog that makes YANG module information easily accessible.

3.1. Data Mesh ~~Telemetry-Data~~ Architecture

A network analytics architecture that integrates YANG-Push and Kafka is proposed and is continuously growing and gaining influence, refer to the draft: An Architecture for YANG-Push to Apache Kafka

Integration [I-D.ietf-nmop-yang-message-broker-integration]. This

open-source project encompasses contributions such as Support of Versioning in YANG Notifications Subscription

[I-D.ietf-netconf-yang-notifications-versioning] or Support of

Network Observation Timestamping in YANG Notifications

[I-D.

~~netana-netconf-notif-envelope~~

~~netconf-tgraf-yang-push-observation-time~~], among others.

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The purpose of this project is to provide adequate information ~~of-to~~ the

YANG-Push subscription state change notifications so that ~~when it is received,~~ the module and

its ~~dependency-dependencies~~ can be parsed and ~~found-retrieved~~ automatically from the vantage

point. The architecture relies on the information of YANG ~~module and their dependency-dependencies~~ to realize, ~~as one of its main goals is~~ to solve the

problem of missing YANG semantics when ~~data is~~ notifications are ~~transformed or received-indexed~~ in Time

Series Database ~~in the end~~. To solve the problem, a schema registry is introduced to store YANG modules and all their relationships (Direct and reverse dependencies). The schema is obtained by the NETCONF <get-schema> of the subscribed YANG ~~modules~~ schema tree, which is obtained

by parsing the <subscription-started> message of each YANG-Push subscription.

~~The scope of this draft is limited to configured subscriptions as defined in Section 2.5 of [RFC8639], as opposed to dynamic subscription defined in Section 2.4 of [RFC8639]. Configured subscriptions are configured by a YANG client on the YANG server via the supported network protocol. In this scenario, once the subscription is set up, the YANG-Push notification (or event record) is sent over the connections specified by the transport and receiver of the configured subscription. This technique differs from dynamic subscriptions, where the notification messages are sent over the session that has been used to establish the subscription.~~

~~Section 3 of draft [I-D.ietf-nmop-yang-message-broker-integration], defines a separate network orchestrator and data collector in its architecture, which means subscription and data collection are done separately. Therefore, only configured subscription, with which user can configure the subscription from one YANG client and receive the telemetry data in another YANG collector indicated in the subscription, could work with this architecture.~~

~~As a method for massively streaming telemetry data, the UDP-based Transport for configured Subscription defined in draft [I-D.ietf-netconf-udp-notif] (UDP-notif) has been applied in [I-D.ietf-nmop-yang-message-broker-integration] as the transport method and streaming message type. With the same spirit as applying the configured subscription, the UDP-notif has introduced more flexibility into the architecture by defining useful metadata in the message content such as the receiver address, port etc. In this way, at the same time when the Data Mesh architecture is handling massive data, it has the ability to trace the publisher of each message.~~

~~By explaining the above, we have gone back to the beginning of this section, where we explained the schema registry, that contains the YANG modules concerned in each YANG-Push subscription which are obtained by NETCONF <get-schema> operation. UDP-notif has provided the ability to know the publisher of message. Therefore, an~~

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independent process containing multiple <get-schema> operations is
launched after each new YANG-Push subscription module has been known.
However, the complexity ~~still remains~~remains at:

* How ~~we are going to find dependency~~dependencies of ~~the~~-YANG modules
~~are found~~ (so that

the YANG-Push subscription message has the complete ~~set of~~ module
dependencies for its ~~set of subscribed~~ YANG ~~module~~schema tree)?

* How do we conduct <get-schema>?

Currently, the method used for obtaining modules and finding module
dependencies is "get-all-schemas", where the YANG client retrieves
all YANG modules from the network device to enable later the client
can fully understand and utilize all modules and module dependencies
of device. This process is very heavy because in a real situation,
each device may implement hundreds of YANG modules, requiring up to
several minutes to complete, in the worse cases. Besides, the need
of parsing all YANG modules and finding all the dependencies adds a
small extra delay. Applying this method to obtain YANG modules will
make the operation very costly, since after each subscribed module is
learned, "get-all-schemas" needs to be re-performed.

Therefore, considering the ~~telemetry~~-Network Observability real-time
aspects, this extra

delay in collecting (and processing) the dependencies through a get-
all-schemas approach is not ~~ideal~~realistic.

It's more efficient to get dependencies only for the required modules
~~in the telemetry~~.

By using the provided the augmentation information in ietf-yang-
library, the ~~collector~~-YANG-Push receiver can directly obtain the YANG
reverse

dependencies by ~~fetching-obtaining~~ the contents of ~~the~~ YANG library,
saving

collection (and processing time) at the ~~collector~~YANG-Push receiver,
and therefore

helping with the near real-time aspects of ~~the~~-Network Observability
~~and enabling~~ closed loop actions.

3.2. Data Catalog

Finding the YANG modules implemented by a network ~~device~~-management
~~server~~ is paramount

for configuring and monitoring the status of a network. However,
since the inception of YANG the network industry has experienced a
tsunami of YANG modules developed by SDOs, open-source communities,
and network vendors. This heterogeneity of YANG modules, that vary
from one network device model to another, makes the management of a
multi-vendor network a big challenge for operators.

[Martinez-Casanueva2023]

In this regard, a data catalog provides a registry of the datasets exposed by remote data sources for consumers to discover data of interest. Besides the location of the dataset (i.e., the data source), the data catalog registers additional metadata such as the data model (or schema) followed in the dataset or even related terms defined in a business glossary.

Data catalog solutions typically implement collectors that ingest metadata from the data sources themselves ~~and also~~ external metadata

sources. For example, a Kafka Schema Registry is a metadata source that provides metadata about the data models followed by some data stored in a Kafka topic.

In this sense, a YANG-enabled network device can be considered as another kind of data source, which the Data Catalog can pull metadata from. For instance, the data catalog can include a connector that fetches metadata about the YANG modules implemented by the network device. Combining these metadata with other such as the business concept "interface", would enable data consumers to discover which datasets related to the concept "interface" are exposed by the network device.

Network devices that implement YANG library expose metadata about which YANG modules are implemented, and which are only imported. However, what a data consumer needs at the end are the YANG modules implemented by the device, hence, the combination of implemented YANG modules with other YANG modules that might deviate or augment the formers.

Coming back to the example of datasets related to the "interface" concept, say we have a network device that implements the ietf-interfaces module [RFC8343] and the ietf-ip module [RFC8344], where the latter augments the former. For a data catalog to collect these metadata, a connector would retrieve YANG library data from the target device. However, the current version of YANG library would not satisfy the use case as it would tell that the device implements both ietf-interfaces and ietf-ip modules, but will miss the augment dependency between them.

The current workaround ~~to this limitation is to,~~ in combination with the YANG library data, ~~to~~ additionally ~~fetch~~ obtain both YANG modules

and process them to discover that there is an augment dependency. This adds extra burden on the connector, which is forced to combine multiple metadata collection mechanisms. This process could be softened by extending YANG library to also capture augment dependencies, in a similar fashion to deviation dependencies.

4. The "ietf-yang-library-augmentedby" YANG module

This YANG module augments the ietf-yang-library module by adding the augmented-by list in the "yang-library/module-set". The name "augmented-by" indicates the modules by which the current module is being directly augmented. For the definition of "augmented-by", this draft only considers the direct augmentation relationship. The recursive result of augmentation or transitive dependency for module specified along the xpath, are out of the scope of this draft. Section 4.2 has given the implementation instructions.

Note that this module only augments the ietf-yang-library defined in [RFC8525]. At the time of writing this document, most vendors support [RFC7895], a previous revision of the ietf-yang-library YANG module. The module that augments [RFC7895] is provided in the Appendix B.

4.1. Data Model Overview

4.1.1. Tree View

The following is the YANG tree diagram for model ietf-yang-library-augmentedby.

```
module: ietf-yang-library-augmentedby
  augment /yanglib:yang-library/yanglib:module-set/yanglib:module:
    +--ro augmented-by* -> ../../yanglib:module/name
```

4.1.2. Full Tree View

The following is the YANG tree diagram[RFC8340] for the ietf-yang-library with the augmentation defined in module ietf-yang-library-augmentedby, including the RPCs and notifications.

```
module: ietf-yang-library
  +--ro yang-library
  | +--ro module-set* [name]
  | | +--ro name string
  | | +--ro module* [name]
  | | | +--ro name yang:yang-identifier
  | | | +--ro revision? revision-identifier
  | | | +--ro namespace inet:uri
  | | | +--ro location* inet:uri
  | | | +--ro submodule* [name]
  | | | | +--ro name yang:yang-identifier
  | | | | +--ro revision? revision-identifier
  | | | | +--ro location* inet:uri
```

```

| | | +--ro feature*                yang:yang-identifier
| | | +--ro deviation*              -> ../../module/name
| | | +--ro yanglib-aug:augmented-by*
| | |                               -> ../../yanglib:module/name
| | +--ro import-only-module* [name revision]
| |   +--ro name                    yang:yang-identifier
| |   +--ro revision                union
| |   +--ro namespace              inet:uri
| |   +--ro location*              inet:uri
| |   +--ro submodule* [name]
| |     +--ro name                  yang:yang-identifier
| |     +--ro revision?            revision-identifier
| |     +--ro location*            inet:uri
| +--ro schema* [name]
| |   +--ro name                    string
| |   +--ro module-set*            -> ../../module-set/name
| +--ro datastore* [name]
| |   +--ro name                    ds:datastore-ref
| |   +--ro schema                  -> ../../schema/name
| +--ro content-id                 string
x--ro modules-state
  x--ro module-set-id              string
  x--ro module* [name revision]
    x--ro name                      yang:yang-identifier
    x--ro revision                  union
    +--ro schema?                  inet:uri
    x--ro namespace                inet:uri
    x--ro feature*                  yang:yang-identifier
    x--ro deviation* [name revision]
    | x--ro name                    yang:yang-identifier
    | x--ro revision                union
    x--ro conformance-type          enumeration
    x--ro submodule* [name revision]
      x--ro name                    yang:yang-identifier
      x--ro revision                union
      +--ro schema?                inet:uri
notifications:
  +---n yang-library-update
  | +--ro content-id                -> /yang-library/content-id
  x---n yang-library-change
  | x--ro module-set-id            -> /modules-state/module-set-id

```

4.1.3. YANG Module

The YANG module source code of ietf-yang-library-augmentedby in which augmentation to the ietf-yang-library of [RFC8525] is defined.

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<CODE BEGINS> file "ietf-yang-library-augmentedby@2023-10-27.yang"
module ietf-yang-library-augmentedby {
 yang-version 1.1;
 namespace "urn:ietf:params:xml:ns:yang:ietf-yang-library-augmentedby";
 prefix yanglib-aug;
 import ietf-yang-library {
 prefix yanglib;
 reference
 "RFC 8525: YANG Library";
 }
 organization
 "IETF NETCONF (Network Configuration) Working Group";
 contact
 "WG Web: <https://datatracker.ietf.org/wg/netconf/>
 WG List: <mailto:netconf@ietf.org>
 Author: Zhuoyao Lin
 <mailto:zhuoyao.lin1@huawei-parteners.com>
 Benoit Claise
 <mailto:benoit.claise@huawei.com>
 IGNACIO DOMINGUEZ MARTINEZ-CASANUEVA
 <mailto:ignacio.dominguezmartinez@telefonica.com>";
 description
 "This module augments the ietf-yang-library defined in
 [RFC8525] to provide not only the deviation list, but also
 the augmented-by list, in order to give sufficient
 information about the YANG modules reverse dependency. It
 facilitates the process of obtaining the entire
 dependencies of YANG module.
 The key words 'MUST', 'MUST NOT', 'REQUIRED', 'SHALL',
 'SHALL NOT', 'SHOULD', 'SHOULD NOT', 'RECOMMENDED',
 'NOT RECOMMENDED', 'MAY', and 'OPTIONAL' in this document
 are to be interpreted as described in BCP 14 (RFC 2119)
 (RFC 8174) when, and only when, they appear in all
 capitals, as shown here.
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 Relating to IETF Documents
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(<https://trustee.ietf.org/license-info>).

This version of this YANG module is part of RFC XXXX; see the RFC itself for full legal notices. ";

```
revision 2023-10-27 {
  description
    "Added list augmented-by in yang-library/module-set/module to
    make the module store the entire reverse dependency information
    (augmented-by and deviation).";
  reference
    "RFC XXXX: Support of augmentedby in ietf-yang-library";
}
augment "/yanglib:yang-library/yanglib:module-set/yanglib:module" {
  description
    "Augment the augmented-by list from module info with the
    module-augmented-by grouping" ;
  leaf-list augmented-by {
    type leafref {
      path "../..//yanglib:module/yanglib:name";
    }
  }
  description
    "Leaf-list of the augmentation used by this server to
    modify the conformance of the module associated with
    this entry. Note that the same module can be used for
    augmented-by for multiple modules, so the same
    entry MAY appear within multiple 'module' entries.
    This reference MUST NOT (directly or indirectly)
    refer to the module being augmented.
    Robust clients may want to make sure that they handle a
    situation where a module augments itself (directly or
    indirectly) gracefully.";
```

```
  }
}
<CODE ENDS>
```

4.2. Implementation Instructions

4.2.1. The scope of augmented-by

This section defines the scope of augmented-by.

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The "augmented-by" list should only consider those YANG modules that directly augment the YANG module in question in the ietf-yang-library. The "directly augment" is identified by the relationship between the augment module and the target node's parent module that it augments to. Only the direct parent module of the target node is augmented, and the rest of parent modules defined in the schema tree are only indirect dependencies but not augmented modules. (Refer to "Target node" definition in Section 7.17 of [RFC7950])

In the case when a YANG application requires recursive dependency or specific schema tree dependency, the search logic should be implemented by the application itself.

A YANG example with the expected augmented-by result is provided in Section 4.2.2.

4.2.2. An example of YANG module augmented-by result

There are module A, B, C, D and E, which have the following relationships:

- * Module A is the base module with container "foo-a"
- * Module B augments "/a:foo-a" with container "foo-b"
- * Module C augments "/a:foo-a/b:foo-b" with leaf "leaf-c", and it defines a container "foo-c"
- * Module D augments "/c:foo-c" with container "foo-d"
- * Module E augments "/c:foo-c" with containr "foo-e"

The augmented-by result for module A, B and C is the following:

- * Module A is augmented-by: Module B
- * Module B is augmented-by: Module C
- * Module C is augmented-by: Module D, E

Module D, E have no augmented-by result.

5. Implementation Status

Note to the RFC-Editor: Please remove this section before publishing (This follows the template in RFC7942).

5.1. Netopeer2 at IETF119 Hackathon

Zhuoyao Lin did the prototype implementation of the augmented-by list feature of this draft and demonstrated it based on Netopeer2 in IETF 119 Hackathon.

Netopeer2 is a NETCONF server & client implementation developed by CESNET. Source code is here: [NTP17]. The actual feature is implemented by extending the libyang [LY16] and sysrepo [SR16] which are the base libraries for Netopeer2 to support populating the augmented-by list.

5.2. Netopeer2 at IETF120 Hackathon

Zhuoyao Lin did a docker image of netopeer2 that integrates the augmented-by feature in sysrepo and libyang. The result is presented at IETF 120 hackathon.

The source code can be obtained here: [NP24]

5.3. Libyangpush Find-dependency

Zhuoyao Lin did an implementation of find-dependency based on the ietf-yang-library with augmented-by feature in the YANG-Push message parser library libyangpush. The result is presented in IETF 120 hackathon.

The source code can be obtained here: [NP24]

6. Changes

6.1. draft-lincla-netconf-yang-library-augmentation: Changes from 00 to 01

The list name has been updated from "augmentation" to "augmented-by", in order to represent the usage clearly.

The leafref has been changed from absolute path "/yanglib:yang-library/yanglib:module-set/yanglib:module/yanglib:name" to relative path "../../yanglib:module/yanglib:name". The YANG validation in the appendix A shows that this path can work as expected.

Section 5 Implementation and section 6 Changes has been added.

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6.2. draft-lincla-netconf-yang-library-augmentedby version 00
Updated the Use case content in Section 3.1. Add explanation: the scope of use case "Data Mesh Architecture" is limited to configured subscription.
Updated Implementation status content.

6.3. draft-lincla-netconf-yang-library-augmentedby: Changes from 00 to 01
Updated affiliations
Update content of Section 3.1 Data Mesh use case. Explain the limitation of applying get-all-schemas solution under the background of using UDP-notif of configured subscription, and how the feature proposed in the draft can improve the solution.
Full review of document. Nits and refinement of sections.

6.4. draft-lincla-netconf-yang-library-augmentedby: Changes from 01 to 02
Rewrite Section 2 Motivation.
Update Section 6 Changes's subsection title.
Update the Section 7 security consideration and section 8 IANA Considerations.
Added in the appendix the Impact Analysis of ietf-yang-library and proposal for the RFC8525bis draft.

6.5. draft-ietf-netconf-yang-library-augmentedby version 00
Resubmitted the draft name from:
draft-lincla-netconf-yang-library-augmentedby-02
to:
draft-ietf-netconf-yang-library-augmentedby-00

6.6. draft-ietf-netconf-yang-library-augmentedby: Changes from 00 to 01
Correct the yanglint validation invalid example.

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Updated the explanation to the yanglint validation example principle.
Delete Section "ietf-yang-library Impact Analysis, as an evaluation for RFC8525bis". The idea of updating the RFC8525 is paused.

6.7. draft-ietf-netconf-yang-library-augmentedby: Changes from 01 to 02
Update and rephrase the Introduction section.
Add Section 4.2 Implementation Instructions. Address in Section 4.2.1 that the definition of "augmented-by" only consider the direct augment. A YANG example for explaining this purpose has been put into Section 4.2.2.
Draft refinement.
Reference update.

7. Security Considerations
The YANG module specified in this document defines a schema for data that is designed to be accessed via network management protocols such as NETCONF [RFC6241] or RESTCONF [RFC8040]. The lowest NETCONF layer is the secure transport layer, and the mandatory-to-implement secure transport is Secure Shell (SSH) [RFC6242]. The lowest RESTCONF layer is HTTPS, and the mandatory-to-implement secure transport is TLS [RFC8446].
The Network Configuration Access Control Model (NACM) [RFC8341] provides the means to restrict access for particular NETCONF or RESTCONF users to a preconfigured subset of all available NETCONF or RESTCONF protocol operations and content.
The readable node defined in this YANG module may be considered sensitive or vulnerable in some network environments. It is thus important to control read access (e.g., via get, get-config, or notification) to this data node. The following is the explanation to data node's sensitivity/vulnerability:
The "augmented-by" node in this YANG module could reveal all modules that are augmenting one module. It could help attacker identify the relationship between modules and server implementations known bugs. Server vulnerabilities may include but not restricted to: 1. Too many augmented-by records causes buffer overflow. 2. The augmented-by node help identify through the inter-relation of modules how to cause the server to crash or significantly degrade device performance.

8. IANA Considerations

This document registers one URI in the "IETF XML Registry" [RFC3688]. Following the formate in [RFC3688], the following registration has been made.

URI: urn:ietf:params:xml:ns:yang:ietf-yang-library-augmentedby

Registration Contact: The NETCONF WG of the IETF.

XML: N/A, the requested URI is an XML namespace.

This document registers one YANG module in the "YANG Module Names" registry [RFC6020]

name: ietf-yang-library-augmentedby

namespace: urn:ietf:params:xml:ns:yang:ietf-yang-library-augmentedby

prefix: yanglib-aug

reference: [I-D.ietf-netconf-yang-library-augmentedby]

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Appendix A. YANG module validation with yanglint

This section gives a few examples that the user can try themselves with yanglint. This is created to prove the syntax correctness. The examples should be used with YANG modules ietf-yang-library and ietf-yang-library-augmentedby as schemas.

The examples provided are ietf-yang-library 'yang-library' data xml file containing the augmented-by field.

The valid example should pass the validation while the invalid one will not. The difference is that in the invalid example, the module in one module-set has augmented module in another module-set, which is illegal according to the ietf-yang-library definition.

A.1. A valid ietf-yang-library data example

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```
<CODE BEGINS> file "example_valid.xml"
<yang-library xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-library">
  <content-id>1</content-id>
  <module-set>
    <name>ms1</name>
    <module>
      <name>module1</name>
      <revision>2024-02-29</revision>
      <namespace>urn:ietf:params:xml:ns:yang:module1</namespace>
      <augmented-by
        xmlns="urn:ietf:params:xml:ns:yang:
        ietf-yang-library-augmentedby">module2</augmented-by>
      <augmented-by
        xmlns="urn:ietf:params:xml:ns:yang:
        ietf-yang-library-augmentedby">module3</augmented-by>
    </module>
  </module>
  <module>
    <name>module2</name>
    <revision>2024-02-29</revision>
    <namespace>urn:ietf:params:xml:ns:yang:module2</namespace>
  </module>
  <module>
    <name>module3</name>
    <revision>2024-02-29</revision>
    <namespace>urn:ietf:params:xml:ns:yang:module3</namespace>
  </module>
</module-set>
</yang-library>
<modules-state xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-library">
  <module-set-id>0</module-set-id>
</modules-state>
<CODE ENDS>
```

A.2. An invalid ietf-yang-library data example
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```

<CODE BEGINS> file "example_invalid.xml"
<yang-library xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-library">
  <content-id>1</content-id>
  <module-set>
    <name>ms1</name>
    <module>
      <name>module1</name>
      <revision>2024-02-29</revision>
      <namespace>urn:ietf:params:xml:ns:yang:module1</namespace>
      <augmented-by>
        xmlns="urn:ietf:params:xml:ns:yang:
        ietf-yang-library-augmentedby">module3</augmented-by>
      <augmented-by>
        xmlns="urn:ietf:params:xml:ns:yang:
        ietf-yang-library-augmentedby">module2</augmented-by>
    </module>
    <module>
      <name>module3</name>
      <revision>2024-02-29</revision>
      <namespace>urn:ietf:params:xml:ns:yang:module3</namespace>
    </module>
  </module-set>
  <module-set>
    <name>ms2</name>
    <module>
      <name>module2</name>
      <revision>2024-02-29</revision>
      <namespace>urn:ietf:params:xml:ns:yang:module2</namespace>
    </module>
  </module-set>
</yang-library>
<modules-state xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-library">
  <module-set-id>0</module-set-id>
</modules-state>
<CODE ENDS>

```

Appendix B. YANG Module augmenting RFC7895

This section defines the `ietf-yang-library-rfc7895-augmentedby` that augments the `ietf-yang-library` defined in [RFC7895]. The `module-state/module` list of this YANG module version is also defined in the [RFC8525] version though deprecated.

B.1. Tree View for YANG module augmenting RFC7895

The following is the YANG tree diagram for `ietf-yang-library-rfc7895-augmentedby` augmenting RFC7895.


```
module: ietf-yang-library-rfc7895-augmentedby
augment /yanglib:modules-state/yanglib:module:
  x--ro augmentedby* [name revision]
```

```
    +--ro name          -> /yanglib:modules-state/module/name
    +--ro revision      -> /yanglib:modules-state/module/revision
```

B.2. Full Tree View for ietf-yang-library with augmentation to RFC7895

The following is the full YANG tree diagram of ietf-yang-library-rfc7895-augmentedby augmenting ietf-yang-library defined in RFC7895.

```
module: ietf-yang-library
+--ro modules-state
  +--ro module-set-id    string
  +--ro module* [name revision]
    +--ro name          yang:yang-identifier
    +--ro revision      union
    +--ro schema?       inet:uri
    +--ro namespace     inet:uri
    +--ro feature*      yang:yang-identifier
  +--ro deviation* [name revision]
    | +--ro name        yang:yang-identifier
    | +--ro revision    union
    +--ro conformance-type enumeration
  +--ro submodule* [name revision]
    | +--ro name        yang:yang-identifier
    | +--ro revision    union
    | +--ro schema?     inet:uri
  x--ro yanglib-aug:augmented-by* [name revision]
    +--ro yanglib-aug:name
      -> /yanglib:modules-state/module/name
    +--ro yanglib-aug:revision
      -> /yanglib:modules-state/module/revision
```

notifications:

```
+---n yang-library-change
  +--ro module-set-id    -> /modules-state/module-set-id
```

B.3. YANG module augmenting RFC7895

The YANG module that augments the ietf-yang-library RFC7895.

```
<CODE BEGINS>
file "ietf-yang-library-rfc7895-augmentedby@2023-10-27.yang"
module ietf-yang-library-rfc7895-augmentedby {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-yang-library-rfc7895-
augmentedby";
  prefix yanglib-aug;
  import ietf-yang-library {
    prefix yanglib;
    revision-date 2016-06-21;
    reference
      "RFC 7895: YANG Module Library.";
  }
  organization
    "IETF NETCONF (Network Configuration) Working Group";
  contact
    "WG Web: <https://datatracker.ietf.org/wg/netconf/>
    WG List: <mailto:netconf@ietf.org>
    Author: Zhuoyao Lin
      <mailto:zhuoyao.lin1@huawei-partners.com>
    Author: Benoit Claise
      <mailto:benoit.claise@huawei.com>
    Author: IGNACIO DOMINGUEZ MARTINEZ-CASANUEVA
      <mailto:ignacio.dominguezmartinez@telefonica.com>";
  description
    "This document augments the ietf-yang-library to provide the
    augmented-by list. It facilitates the process of obtaining
    the entire dependencies between YANG modules, by directly
    querying the server's YANG module.
    The key words 'MUST', 'MUST NOT', 'REQUIRED', 'SHALL',
    'SHALL NOT', 'SHOULD', 'SHOULD NOT', 'RECOMMENDED',
    'NOT RECOMMENDED', 'MAY', and 'OPTIONAL' in this document
    are to be interpreted as described in BCP 14 (RFC 2119)
    (RFC 8174) when, and only when, they appear in all
    capitals, as shown here.
    Copyright (c) 2022 IETF Trust and the persons identified as
    authors of the code. All rights reserved.
    Redistribution and use in source and binary forms, with or
    without modification, is permitted pursuant to, and subject
    to the license terms contained in, the Revised BSD License
    set forth in Section 4.c of the IETF Trust's Legal Provisions
    Relating to IETF Documents
```

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(<https://trustee.ietf.org/license-info>).
This version of this YANG module is part of RFC XXXX; see the
RFC itself for full legal notices. ";
revision 2023-10-27 {
 description
 "Added list augmentedby in yang-library/modules-state/module to
 make the module store the entire reverse dependency information
 (augmentedby and deviation).";
 reference
 "RFC XXXX: Support of augmentedby in ietf-yang-library
 defined in RFC7895";
}
augment "/yanglib:modules-state/yanglib:module" {
 description
 "Augment the augmentedby from module info with the
 module-augmented-by grouping" ;
 uses yanglib-aug:module-state-augmented-by;
}
/*
 * Groupings
 */
grouping module-state-augmented-by {
 description
 "This grouping defines a list with keys being the module
 name and revision. The list contains the augmented-by list.";
 list augmented-by {
 key "name revision";
 status deprecated;
 description
 "List of YANG augmented-by module names and revisions
 used by this server to modify the conformance of
 the module associated with this entry. Note that
 the same module can be used for augmented-by for
 multiple modules, so the same entry MAY appear
 within multiple 'module' entries.
 The augment module MUST be present in the 'module'
 list, with the same name and revision values.
 The 'conformance-type' value will be 'implement' for
 the augment module.";
 }

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```
leaf name {
  type leafref {
    path "/yanglib:modules-state/yanglib:module/yanglib:name";
  }
  description
    "Identifies a given module in the YANG Library by
    its name.";
}
leaf revision {
  type leafref {
    path "/yanglib:modules-
state/yanglib:module/yanglib:revision";
  }
  description
    "Revision of the module";
}
}
}
}
<CODE ENDS>
```

Contributors

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