Internet Engineering Task Force
Internet-Draft
Intended status: Experimental
Expires: June 23, 2016

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December 21, 2015

"With-config-state" Capability for NETCONF/RESTCONF
draft-wilton-netmod-opstate-yang-02

Abstract

This document proposes a possible alternative solution for handling applied configuration state in YANG as described in draft-openconfig-netmod-opstate-01. The proposed solution, roughly modelled on the with-defaults NETCONF/RESTCONF capability, aims to meet the key requirements set out in draft-ietf-netmod-opstate-reqs-01 without the need for YANG module authors to explicitly duplicate configuration nodes in both configuration and operational containers. This draft does not address the issue of co-location of configuration and operational state for interfaces, nor does it provide a NETCONF mechanism to retrieve operational data separately from configuration data.

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

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This Internet-Draft will expire on June 23, 2016.

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1. Introduction

The NETMOD Operational State Requirements [I-D.ietf-netmod-opstate-reqs] sets out a number of operational requirements and proposed solutions for handling intended and applied config state when using YANG models. This document sets out a possible alternative solution for some of those requirements.

The solution proposed in this document does not require any changes to any existing YANG modules to support intended and applied config state. In particular: the proposed solution does not require the data models to be explicitly modelled with separate configuration and operational containers, and it does not require that all configuration and operational state nodes and leaves to be defined as groupings.

Nor does the proposed solution make explicit use of separate datastores to model intended configuration separately from applied configuration.

Instead, the solution proposed here is a method for generating an

enhanced schema based on any YANG model that is optionally used by network management protocols. This enhanced schema includes up to four data leaves for each configuration node defined in the YANG model. These cover both the intended and applied values, along with an additional reason code and message if the applied configuration does not match the intended configuration.

Although the solution described here is only defined in the context of NETCONF and RESTCONF, it should be possible to extend the same YANG config data encoding mechanism to other protocol schemes used to access YANG data if required.

1.1. Change history

The changes from draft version 00 to 01 is to fix a couple of mistakes in the example YANG module.

The changes from draft version 01 to 02 primarily updates Section 7 to reflect the refinements to the requirements specification. In addition an overview of a YANG Metadata based variant of the original solution is described in Appendix B.

1.2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

The terms 'intended configuration', 'applied configuration' and 'derived state' are defined in NETMOD Operational State Requirements [I-D.ietf-netmod-opstate-reqs].

The following additional terms are used in this document:

operational nodes - this term is colloquially used in this draft to refer to "config false" YANG nodes.

2. Objectives

The aim of this draft is to provide a partial alternative solution to the requirements set out in NETMOD Operational State Requirements

[I-D.ietf-netmod-opstate-reqs]. An explanation of how the specific requirements are addressed is described in Section 7.

3. "With-config-state" encoding scheme

The solution proposed in this document makes use of a new encoding scheme that is used to represent YANG configuration nodes in NETCONF and RESTCONF. An optional parameter, called <with-config-state> and defined below, indicates when this new encoding scheme is used.

When the with-config-state option is used each YANG configuration leaf in the datastore is returned in a different format. Rather than being encoded as an XML or JSON leaf element that holds the configured value, it is instead returned as a node element, with the same name as the YANG config leaf, that contains up to four separate leaf elements. The four leaf elements that the node may contain are 'cfg-intended', 'cfg-applied', 'cfg-status', and 'cfg-status-reason'. Theses leaves are externally addressable through using the full path of the leaf, providing explicit distinct paths for intended

configuration vs applied configuration. These elements are described in more detail in the following sub-sections. Concrete examples of the encoding for NETCONF and RESTCONF requests are given in Appendix A.

3.1. cfg-intended

The cfg-intended leaf represents the intended configuration of the device, and is of the same datatype and holds the same value as the normal YANG data model configuration leaf. The cfg-intended leaf is only present if the associated configuration node exists in the YANG data model.

The cfg-intended leaf is semantically equivalent to the config leaf in the YANG data model that is based on, and hence is logically read/writable. In particular, when the <with-config-state> parameter is used, management requests to modify the configuration may also use the full path to the cfg-intended leaf. The server semantics for writing to the cfg-intended leaf are exactly the same as for writing to the standard YANG config node path - the flexibility is provided as a convenience to the NMS client.

3.2. cfg-applied

The cfg-applied leaf represents the applied configuration, and is of the same datatype as a normal YANG data model configuration leaf. If there is no configuration currently in effect then the cfg-applied leaf is not present.

The cfg-applied leaf is read only.

To give some examples:

If the configuration has been successfully applied then the cfg-applied leaf would exactly match the cfg-intended leaf.

If a new item of configuration is in the process of being applied then the cfg-intended leaf holds the intended configuration value, and the cfg-applied leaf would not be present until the configuration is in effect.

If an existing item of configuration is in the process of being deleted then the cfg-applied leaf would hold the current configuration value, and the cfg-intended leaf would not be present. Once the delete operation has completed, the configuration node element itself would logically be deleted.

If the configuration value of an existing item of configuration is in the process of being changed, then the cfg-intended leaf would hold the new proposed value, and the cfg-applied leaf would hold the existing value that is currently in effect.

3.3. cfg-status

The cfg-status leaf is used, when required, to indicate why the value of the cfg-applied leaf does not match the value of the cfg-intended leaf. It is only present when the values of the cfg-intended and cfg-applied leaves do not match.

The cfg-status leaf is read only.

The cfg-status leaf can take one of following values:

in-progress - the config operation is in the process of being applied.

waiting - the config operation is waiting for other configuration to be applied or hardware to be available before it can be applied. Additional specific information may be provided in the cfg-status-reason leaf.

failed - the config operation failed to be applied. Additional information may be provided in the cfg-status-reason leaf to indicate the reason for the failure.

3.4. cfg-status-reason

The cfg-status-reason leaf may be used to provide additional information as to why the value of the cfg-applied leaf does not match the value of the cfg-intended leaf.

The cfg-status-reason leaf may only be present in the case that the cfg-status leaf is present and is set to either waiting or failed.

The cfg-status-reason leaf is read only.

3.5. Non-leaf config nodes

Non-leaf config nodes require some special handling. In particular, containers with presence and list elements must be considered.

The proposed solution for both types of node is the same. The cfg-intended, cfg-applied, cfg-status, and cfg-status-reason leaf nodes are implicitly added as direct descendants of the presence-container or list element.

Note: There is an open issue that using these leaves directly opens up a potential naming clash between the "cfg-*" names above and existing explicitly defined child nodes in the YANG module definition. There are a few possible ways that this might be addressed:

Making the four "cfg-*" leaves reserved names. I.e. to ensure that they are not used in general YANG modules.

By inserting an implicit node between all child nodes under the container or list element. This would automatically ensure that there can be no naming clash between the defined YANG nodes and the implicitly added "cfg-*" leaves.

By using a reserved namespace for the "cfg-*" leaves to ensure that they cannot clash with any explicitly defined in the YANG module.

4. Retrieval of intended and applied configuration

To make use of the new encoding scheme defined above, this document defines a new parameter, called <with-config-state>, which can be added to specific NETCONF operation request messages, or as a RESTCONF query parameter, to control how retrieval of configuration nodes is treated by the server.

The <with-config-state> parameter is supported for the following NETCONF operations: <get>, <get-config>, <edit-config>, <delete-config>.

The <with-config-state> query parameter is supported for the following RESTCONF operations: GET, PUT, POST, PATCH, DELETE.

Use of the <with-config-state> parameter ensures that all config nodes are always returned using the defined encoding. It also allows servers to explicitly reference the cfg-* leaves in requests and updates.

A server that implements this specification MUST accept the <with-config-state> parameter containing the enumeration for any of the with-config-state modes it supports. The <with-config-state> parameter contains one of the four enumerated values defined in this section.

4.1. all-cfg

When data is retrieved with a <with-config-state> parameter equal to 'all-cfg', all 'cfg-*' nodes are reported using the encoding scheme defined in Section 3.

4.2. intended-cfg-only

When data is retrieved with a <with-config-state> parameter equal to 'intended-cfg', only the 'cfg-intended' leaves are reported using the encoding scheme defined in Section 3. All other 'cfg-*' leaves are omitted.

4.3. applied-cfg-only

When data is retrieved with a <with-config-state> parameter equal to 'applied-cfg-only', only the 'cfg-applied' leaves are reported using the encoding scheme defined in Section 3. All other 'cfg-*' leaves are omitted.

4.4. diff-cfg-only

When data is retrieved with a <with-config-state> parameter equal to 'diff-cfg-only', config nodes are only returned if the value of the cfg-intended leaf does not match the value of the cfg-applied leaf. If the config node is returned then all appropriate 'cfg-*' leaves are returned as per the encoding scheme defined in Section 3.

5. "With-config-state" Capability

5.1. Overview

The :with-config-state capability indicates whether a server supports the with-config-state functionality. For a server that indicates support for the :with-config-state capability it must support at least the 'all-cfg' option. It may also indicate support for the additional with-config-state retrieval modes.

5.2. Dependencies

None

5.3. Capability Identifier

urn:ietf:params:netconf:capability:with-config-state:1.0

The identifer has a paramater: "also-supported". This parameter indicates which additional enumeration values (besides 'all-cfg') the

server will accept for the <with-config-state> parameter in Section 4. The value of the parameter is a comma-separated list of one or more modes that are supported. Possible modes are 'intended-cfg-only', 'applied-cfg-only', 'diff-cfg-only' as defined in Section 4.

6. Suggested layout of data models

Generally, to ensure that operational data and configuration data can be easily related, this draft recommends that configuration and associated operational nodes either be co-located in the same YANG container, or that operational nodes should be placed as descendants nodes of the configuration nodes on which they are related to.

YANG clients should be able to assume that configuration and operational nodes within the same container (and defined in the same namespace) are implicitly related. Likewise any descendant operational nodes are also implicitly related to any parent configuration node.

This draft also supports a variant of the "related-state" statement defined in Operational State Enhancements for YANG, NETCONF, and RESTCONF. [I-D.kwatsen-netmod-opstate], but proposes that the statement be called "related-config" instead and that the same logical two-way binding between a config and operational node should be expressed in the reverse direction. I.e. it should be modelled as an extension statement on an operational node which refers back to the configuration node upon which it depends. Expressing the dependency this way round is anticipated to be much easier to use by model authors, avoiding the perceived likely heavy use of augmentation statements that a 'related-state' statement would probably entail.

7. Addressing the requirements of the NETMOD Operational State Requirements draft

When reading this section, please refer back to NETMOD Operational State Requirements [I-D.ietf-netmod-opstate-reqs] for the definition of those requirements. They are not reproduced here.

7.1. Addressing requirement 1: 'Ability to interact with both intended and applied configuration'

This requirement (and associated subpoints) are met in the following ways:

Requirement 1.A: The applied configuration can be retrieved via making a NETCONF (or management protocol equivalent) <get-config>

request with the 'all-cfg' or 'applied-cfg-only' option of the <with-config-state> parameter.

Requirement 1.B: This would be enforced by the protocol and/or the backing datastore.

Requirement 1.C: The schema encoding scheme proposed in this solution trivially meets this requirement.

Requirement 1.D: Not directly appicable since this is a requirement on the backend server providing the data rather than the encoding schema.

7.2. Addressing requirement 2: Support for both synchronous and asynchronous configuration operations

This requirement (and associated subpoints) are met in the following ways:

Requirement 2.A: This requirement is not addressed by this draft. It is anticipated that this would be solved by protocols specific extentions, and isn't directly concerned with how applied configuration is represented to management clients.

Requirement 2.B: This optional requirement is supported by using either the 'all-cfg' or 'diff-cfg-only' option of the <with-config-state> parameter.

Requirement 2.C: This requirement is not addressed by this draft. This requirement depends on the underlying protocol that is being used to configure the system.

7.3. Addressing requirement 3: Separation of the applied configuration and derived state aspects of operational state; ability to retreive them independently and together

This requirement (and associated subpoints) are met in the following ways:

Requirement 3.A: This requirement is supported via making a NETCONF (or management protocol equivalent) <get-config> request with the 'applied-cfg-only' option of the <with-config-state> parameter.

Requirement 3.B: This requirement is not directly supported by this draft. The proposed protocol extension allows for just the intended config vs applied config nodes to be returned. RESTCONF already supports querying config separately from operational state through use of the 'content' query paremeter. A separate NETCONF protocol

extension would be required to return just the operational nodes without any of the configuration nodes, such as the <get-state> enhancement described in Operational State Enhancements for YANG, NETCONF, and RESTCONF [I-D.kwatsen-netmod-opstate].

Requirement 3.C: This requirement is supported via making a NETCONF (or mgmt protocol equivalent) <get> request with the 'applied-cfg-only' option of the <with-config-state> parameter.

7.4. Addressing requirement 4: Ability to relate configuration with its corresponding operational state

This requirement (and associated subpoints) are met in the following ways:

Requirement 4.A: This requirement is trivially met using the encoding scheme presented in this draft.

Requirement 4.B: This requirement is met using the scheme described in Section 6.

Requirement 4.C: The solution described in requirement 4.B meets this requirement.

7.5. Addressing requirement 5: Ability for distinct modules to leverage a common model-structure

This requirement is not addressed by this draft, it is covered by Network Device YANG Organizational Model [I-D.rtgyangdt-rtgwg-device-model].

7.6. Other benefits of the solution proposed in this draft

In additional to the formal requirements expressed as part of the requirements draft, the solution proposed in this draft also meets the desirable property expressed in the original OpenConfig opstate requirements draft of ensuring that there is a separate unique schema path to both the intended and applied configuration nodes.

8. Acknowledgements

The authors wish to thank Andy Bierman, Einar Nilsen-Nygaard, Neil Ketley, Peyman Owladi and Juergen Schoenwaelder for their helpful comments, ideas and expertise contributing to this draft.

9. IANA Considerations

TBD. This document would at least need to register a new capability identifier URN in the 'Network Configuration Protocol (NETCONF) Capability URNs' registry for the with-config-state optional capability.'".

10. Security Considerations

The proposal in this document does not have any security considerations beyond the existing NETCONF/RESTCONF/YANG security considerations.

11. References

11.1. Normative References

[I-D.ietf-netconf-restconf]
Bierman, A., Bjorklund, M., and K. Watsen, "RESTCONF Protocol", draft-ietf-netconf-restconf-09 (work in progress), December 2015.

[I-D.ietf-netmod-opstate-reqs]
Watsen, K. and T. Nadeau, "NETMOD Operational State Requirements", draft-ietf-netmod-opstate-reqs-01 (work in

progress), December 2015.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <http://www.rfc-editor.org/info/rfc2119>.

[RFC6020] Bjorklund, M., Ed., "YANG - A Data Modeling Language for the Network Configuration Protocol (NETCONF)", RFC 6020, DOI 10.17487/RFC6020, October 2010, <http://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, <http://www.rfc-editor.org/info/rfc6241>.

[RFC6243] Bierman, A. and B. Lengyel, "With-defaults Capability for NETCONF", RFC 6243, DOI 10.17487/RFC6243, June 2011, <http://www.rfc-editor.org/info/rfc6243>.

11.2. Informative References

[I-D.ietf-netmod-yang-metadata]
Lhotka, L., "Defining and Using Metadata with YANG", draft-ietf-netmod-yang-metadata-02 (work in progress), September 2015.

[I-D.kwatsen-netmod-opstate]
Watsen, K., Bierman, A., Bjorklund, M., and J. Schoenwaelder, "Operational State Enhancements for YANG, NETCONF, and RESTCONF", draft-kwatsen-netmod-opstate-00 (work in progress), September 2015.

[I-D.rtgyangdt-rtgwg-device-model]
Lindem, A., Berger, L., Bogdanovic, D., and C. Hopps, "Network Device YANG Organizational Model", draft-rtgyangdt-rtgwg-device-model-01 (work in progress), September 2015.

Appendix A. Encoding examples for NETCONF and RESTCONF

A sample encoding of the <with-config-state> enhancement is described below.

A simple example module is provided to illustrate the subsequent examples. This is not a real module, and is not intended for any real use.


```
module example-interfaces {

  namespace "http://example.com/ns/interfaces";

  prefix exam;

  container interfaces {
    description "Example interfaces group";

    list interface {
      key name;
```

```
        description "Example interface entry";

        leaf name {
          type string {
            length "1 .. max";
          }
          description
            "The administrative name of the interface.";
        }

        leaf mtu {
          type uint32;
          default 1514;
          description
            "The maximum transmission unit (MTU) value assigned to
             this interface.";
        }
      }
    }
  }
```

A.1. NETCONF get-config request using with-config-state with all-cfg option

A get-config request is made for the interfaces subtree using the <with-config-state> enhancement and 'all-cfg' option that returns all config nodes with explicit cfg-intended and cfg-applied leaves, and cfg-status and cfg-status-reason leaves when appropriate.

In this example, at the time of processing the get-config request, the NETCONF server is also asynchronously processing a request to set the MTU leaf to 9000 for 4 interface config nodes.


```
<rpc message-id="101"
     xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get-config>
    <filter type="subtree">
```

```
      <interfaces xmlns="http://example.com/ns/interfaces"/>
    </filter>
    <with-config-state
     xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-with-config-state">
      all-cfg
    </with-config-state>
  </get>
</rpc>
```

The response indicates that at the time of the reply:

The request to set the MTU leaf on eth0/0 to 9000 has completed.

The request to change the MTU leaf on eth0/1 from 2000 to 9000 is in progress.

The request to set the MTU leaf on eth0/2 to 9000 is in progress.

The request to set the MTU leaf on eth1/0 to 9000 is blocked because the necessary hardware is not present.

```
<rpc-reply message-id="101"
           xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <data>
    <interfaces xmlns="http://example.com/ns/interfaces">
      <interface>
        <cfg-intended/>
        <cfg-actual/>
        <name>
          <cfg-intended>eth0/0</cfg-intended>
          <cfg-actual>eth0/0</cfg-actual>
        </name>
        <mtu>
          <cfg-intended>9000</cfg-intended>
          <cfg-actual>9000</cfg-actual>
        </mtu>
      </interface>
      <interface>
        <cfg-intended/>
        <cfg-actual/>
        <name>
          <cfg-intended>eth0/1</cfg-intended>
          <cfg-actual>eth0/1</cfg-actual>
        </name>
```

```
          <mtu>
            <cfg-intended>9000</cfg-intended>
            <cfg-actual>2000</cfg-actual>
            <cfg-status>in-progress</cfg-status>
          </mtu>
        </interface>
        <interface>
          <cfg-intended/>
          <cfg-actual/>
          <name>
            <cfg-intended>eth0/2</cfg-intended>
            <cfg-actual>eth0/2</cfg-actual>
          </name>
          <mtu>
            <cfg-intended>9000</cfg-intended>
            <cfg-status>in-progress</cfg-status>
          </mtu>
        </interface>
        <interface>
          <cfg-intended/>
          <cfg-status>waiting</cfg-status>
          <cfg-status-reason>Linecard 1 is not available
          </cfg-status-reason>
          <name>
            <cfg-intended>eth1/0</cfg-intended>
            <cfg-status>waiting</cfg-status>
            <cfg-status-reason>Linecard 1 is not available
            </cfg-status-reason>
          </name>
          <mtu>
            <cfg-intended>9000</cfg-intended>
            <cfg-status>waiting</cfg-status>
            <cfg-status-reason>Linecard 1 is not available
            </cfg-status-reason>
          </mtu>
        </interface>
      </interfaces>
    </data>
  </rpc-reply>
```

A.2. NETCONF get-config request using with-config-state with diff-cfg-only option

A get-config request is made for the interfaces subtree using the <with-config-state> enhancement and 'diff-cfg-only' option that only returns nodes where the cfg-intended node does not match the cfg-applied node. Appropriate parent nodes are also returned.

As per the previous examples, at the time of processing the get-config request, the NETCONF server is also asynchronously processing a request to set the MTU leaf to 9000 for 4 interface config nodes.

```
<rpc message-id="102"
     xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get-config>
    <filter type="subtree">
      <interfaces xmlns="http://example.com/ns/interfaces"/>
    </filter>
    <with-config-state
     xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-with-config-state">
      diff-cfg-only
    </with-config-state>
  </get>
</rpc>
```

The response indicates that the outstanding configuration requests still to be processed are:

The request to change the MTU leaf on eth0/1 from 2000 to 9000 is in progress.

The request to set the MTU leaf on eth0/2 to 9000 is in progress.

The request to set the MTU leaf on eth1/0 to 9000 is blocked because the necessary hardware is not present.

```
<rpc-reply message-id="102"
           xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <data>
    <interfaces xmlns="http://example.com/ns/interfaces">
      <interface>
        <cfg-intended/>
        <cfg-actual/>
        <name>
          <cfg-intended>eth0/1</cfg-intended>
          <cfg-actual>eth0/1</cfg-actual>
        </name>
        <mtu>
```

```
            <cfg-intended>9000</cfg-intended>
            <cfg-actual>2000</cfg-actual>
            <cfg-status>in-progress</cfg-status>
          </mtu>
        </interface>
        <interface>
          <cfg-intended/>
          <cfg-actual/>
```



```
          <name>
            <cfg-intended>eth0/2</cfg-intended>
            <cfg-actual>eth0/2</cfg-actual>
          </name>
          <mtu>
            <cfg-intended>9000</cfg-intended>
            <cfg-status>in-progress</cfg-status>
          </mtu>
        </interface>
        <interface>
          <cfg-intended/>
          <cfg-status>waiting</cfg-status>
          <cfg-status-reason>Linecard 1 is not available
          </cfg-status-reason>
          <name>
            <cfg-intended>eth1/0</cfg-intended>
            <cfg-status>waiting</cfg-status>
            <cfg-status-reason>Linecard 1 is not available
            </cfg-status-reason>
          </name>
          <mtu>
            <cfg-intended>9000</cfg-intended>
            <cfg-status>waiting</cfg-status>
            <cfg-status-reason>Linecard 1 is not available
            </cfg-status-reason>
          </mtu>
        </interface>
      </interfaces>
    </data>
  </rpc-reply>
```

A.3. NETCONF get-config request using with-config-state with applied-cfg-only option

A get-config request is made for the interfaces subtree using the <with-config-state> enhancement and 'applied-cfg-only' option that only returns the currently applied configuration.

As per the previous examples, At the time of processing the get-config request, the NETCONF server is also asynchronously processing a request to set the MTU leaf to 9000 for 4 interface config nodes.


```
<rpc message-id="103"
     xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <get-config>
    <filter type="subtree">
      <interfaces xmlns="http://example.com/ns/interfaces"/>
    </filter>
    <with-config-state
     xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-with-config-state">
      applied-cfg-only
    </with-config-state>
  </get>
</rpc>
```

The response indicates that the current applied configuration of the selected nodes is:

The MTU leaf of eth0/0 is 9000.

The MTU leaf of eth0/1 is 2000.

Eth0/2 has no MTU leaf applied.

[Implicitly - there is no applied configuration for Eth1/0 since the hardware is not present.]

```
   <rpc-reply message-id="103"
              xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
     <data>
       <interfaces xmlns="http://example.com/ns/interfaces">
         <interface>
           <cfg-actual/>
           <name>
             <cfg-actual>eth0/0</cfg-actual>
           </name>
           <mtu>
             <cfg-actual>9000</cfg-actual>
           </mtu>
         </interface>
         <interface>
           <cfg-actual/>
           <name>
             <cfg-actual>eth0/1</cfg-actual>
           </name>
           <mtu>
```

```
            <cfg-actual>2000</cfg-actual>
          </mtu>
        </interface>
        <interface>
          <cfg-actual/>
          <name>
            <cfg-actual>eth0/2</cfg-actual>
          </name>
        </interface>
      </interfaces>
    </data>
  </rpc-reply>
```

A.4. RESTCONF GET request using with-config-state with all-cfg option (JSON)

An equivalent RESTCONF/JSON example to Appendix A.1 is provided to illustrate the equivalent JSON encoding.

A REST GET request is made for all config data using the <with-config-state> enhancement and 'all-cfg' option that all returns all config nodes with explicit cfg-intended and cfg-applied leaves.

In this example, at the time of processing the GET request, the RESTCONF server is also asynchronously processing a request to set the MTU leaf to 9000 for 4 interface config nodes.


```
GET /restconf/data/example-events:events?content=config&with-config-state=all-c
  HTTP/1.1
Host: example.com
Accept: application/yang.data+json
```

As per Appendix A.1, the response indicates that at the time of the reply:

The request to set the MTU leaf on eth0/0 to 9000 has completed.

The request to change the MTU leaf on eth0/1 from 2000 to 9000 is in progress.

The request to set the MTU leaf on eth0/2 to 9000 is in progress.

The request to set the MTU leaf on eth1/0 to 9000 is blocked because the necessary hardware is not present.

```
HTTP/1.1 200 OK
Date: Mon, 1 Apr 2015 04:01:00 GMT
Server: example-server
Content-Type: application/yang.data+json

{
"example:interfaces": [
  {
    "cfg-intended" = null,
    "cfg-actual" = null,
    "name" : {
      "cfg-intended" = "eth0/0",
      "cfg-actual" = "eth0/0"
    },
    "mtu" : {
      "cfg-intended" = 9000,
      "cfg-actual" = 9000
    },
  },
  {
    "cfg-intended" = null,
    "cfg-actual" = null,
    "name" : {
      "cfg-intended" = "eth0/1",
      "cfg-actual" = "eth0/1"
    },
    "mtu" : {
      "cfg-intended" = 9000,
      "cfg-actual" = 2000,
      "cfg-status" = "in-progress"
```



```
    },
  },
  {
    "cfg-intended" = null,
    "cfg-actual" = null,
```

```
      "name" : {
        "cfg-intended" = "eth0/2",
        "cfg-actual" = "eth0/2"
      },
      "mtu" : {
        "cfg-intended" = 9000,
        "cfg-status" = "in-progress"
      },
    },
    {
      "cfg-intended" = null,
      "cfg-status" = "waiting",
      "cfg-status-reason" = "Linecard 1 is not available",
      "name" : {
        "cfg-intended" = "eth1/0",
        "cfg-status" = "waiting",
        "cfg-status-reason" = "Linecard 1 is not available",
      },
      "mtu" : {
        "cfg-intended" = 9000,
        "cfg-status" = "waiting",
        "cfg-status-reason" = "Linecard 1 is not available",
      },
    },
  ]
  }
```

Appendix B. Alternative meta-data solution using attributes

In addition to the solution written up in the draft, a variant of it has been proposed on the NETMOD WG email alias. The variant, proposed by Andy Bierman, is to broadly encode the 'cfg-intended' vs 'cfg-applied' meta-data using Defining and Using Metadata with YANG [I-D.ietf-netmod-yang-metadata].

Using YANG Metadata certainly has the allure of a cleaner representation of the applied configuration state, particularly when using XML as the encoding where XML attributes can be used to represent the meta-data. This cleaner representation doesn't directly apply to JSON or any other encodings that don't natively support attributes.

B.1. Rough solution outline

To aid discussion, an outline of a possible YANG Metadata based solution follows. Broadly, the solution is similar to the one that has been described in the main body of this draft, and the encoding proposed below would only be used when the client opt in to receive them via an appropriate protocol extension.

Five YANG metadata attribute are defined:

cfg-changing: this attribute has three values ('creating', 'changing', 'deleting') and is only present for configuration nodes that are changing state.

old-value: this attribute holds the currently applied leaf value only for the cases that the cfg-changing attribute has the value 'changing' or 'deleting'. This option is not used for the 'applied-cfg' protocol option described subsequently.

new-value: this attribute holds the intended leaf value only for the cases that the cfg-changing attribute has the value 'creating' or 'changing' and it is only used in conjunction with the 'applied-cfg' protocol option described subsequently.

cfg-status: this attribute holds either the value 'waiting' or 'failed'. It is only used in the case that a configuration change could not be completed for some reason.

failure-reason: this attribute holds a string containing a system provided error message as to why applying the configuration failed. It is only used if the cfg-status reason is 'failed'.

Each of the five YANG metadata attributes above are only used when requried. In particular if a configuration leaf is both intended and applied then no extra YANG metdata attributes are required at all.

The same four protocol options defined previously in the main body of this draft are also supported.

all-cfg: if this option is used then all config nodes are included if they are either intended or applied. The value returned for the config leaf is always the intended value, unless the leaf is being deleted in which case it has no value.

intended-cfg: this option indicates that only the intended configuration nodes are returned. I.e. it excludes any leaves that are applied, but currently in the process of being deleted (and hence have no intended value)

applied-cfg: this option indicates that only the applied configuration nodes are returned. I.e. it excludes any leaves that are intended, but not yet applied. In contrast to the other three options, the value returned for the config leaves are the applied configuration values rather than the intended configuration values provided in all other cases.

diff-cfg: this only includes config nodes that are changing state. I.e. the cfg-changing attribute will be set on all leaves that are returned.

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