YANG-Push status overview

INSA de Lyon

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Purpose

Purpose of this slide deck

- Track YANG-push development at IETF
  - Discover gaps to be filled from the current specification
- Overview of YANG-push deployment architecture
  - Track open-source projects development
  - List gaps in YANG-push tools
  - Track integration of YANG into the Kafka schema registry
- Track current issues

YANG-push specification

- RFCs, Ongoing drafts
- Dynamic vs. Configured subscriptions
- Stream vs. Datastore
- Issues on current specification

YANG-push related RFCs

- **RFC6241** – Network Configuration Protocol (NETCONF)
  - Mechanisms to install, manipulate, and delete the configuration of network devices
- **RFC8040** – RESTCONF Protocol
  - HTTP-based protocol using same concepts from NETCONF
- **RFC5277** – NETCONF Event Notifications
  - Message notification delivery service for NETCONF
- **RFC8639** – Subscribed Notifications
  - Subscription-based mechanism to stream YANG-based notifications
- **RFC8641** – YANG-push
  - Solution based on RFC8639 to stream YANG datastores
- **RFC7223** – A YANG Data Model for Interface Management
  - YANG data model for Interface configuration and monitoring

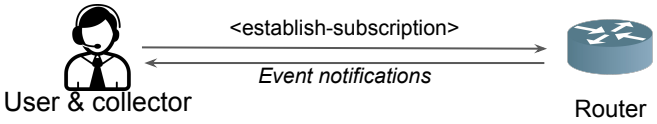
YANG-push related drafts

- draft-ahuang-netconf-notif-yang – YANG model for NETCONF Event Notifications
  - YANG model allowing encoding Netconf notifications in a YANG-based encoding such as JSON or CBOR
- draft-tgraf-netconf-notif-sequencing – Support of Hostname and Sequencing in YANG Notifications
  - Extension to YANG-push header to support Hostname, sequence numbers
- draft-tgraf-yang-push-observation-time – Support of Network Observation Timestamping in YANG Notifications
  - Extension to YANG-push header to support timestamps
- draft-tgraf-netconf-yang-notifications-versioning – Support of Versioning in YANG Notifications Subscription
  - Extension to YANG-push header to support versioning
- draft-ietf-netconf-distributed-notif – Subscription to Distributed Notifications
  - Extension to Subscribed Notifications to allow separating the management node from the Network telemetry collector
- draft-ietf-netconf-udp-notif – UDP-based Transport for Configured Subscriptions
  - UDP-based transport for YANG-push
- draft-ietf-netconf-https-notif – An HTTPS-based Transport for YANG Notifications
  - HTTPS-based transport for YANG-push

YANG-push variants

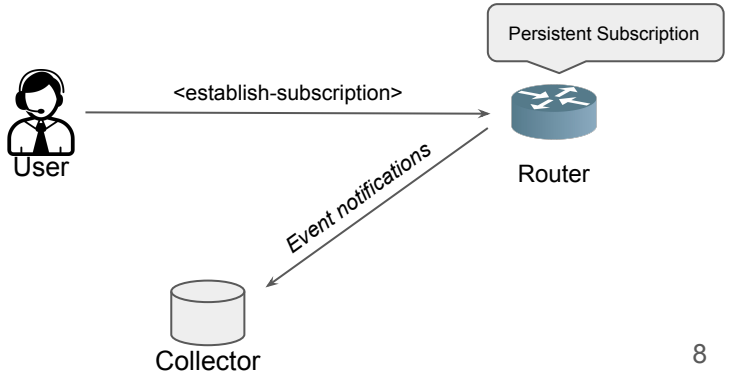
Dynamic Subscriptions (RFC8639 Section 2.4)

- Event Notifications are sent through the same session establishing the subscription
- The subscription and streaming is triggered after the <establish-subscription> RPC



Configured Subscriptions (RFC8639 Section 2.5)

- Event Notifications can be sent through a different session from the session configuring the subscription
- The subscription is persistent across reboots and Notifications can be streamed after start-up once configured through the <establish-subscription> RPC



Subscription configuration: Stream vs. Datastore

Stream (RFC8639)

- [RFC8639] A configuration performed to obtain a flow of events from the publisher
- NIC temperatures
- Netconf events [RFC8639]

```
module: ietf-subscribed-notifications
  +--ro streams
  |  +--ro stream* [name]
  |     +--ro name                          string
  |     +--ro description?                  string
  |     +--ro replay-support?               empty {replay}?
  |     +--ro replay-log-creation-time      ietf-yang-types:date-and-time {replay}?
  |     +--ro replay-log-aged-time?         ietf-yang-types:date-and-time {replay}?
```

```
|  +--:(stream)
|  |  +--rw (stream-filter)?
|  |  |  +--:(by-reference)
|  |  |  |  +--rw stream-filter-name                stream-filter-ref
|  |  |  +--:(within-subscription)
|  |  |     +--rw (filter-spec)?
|  |  |        +--:(stream-subtree-filter)
|  |  |        |  +--rw stream-subtree-filter?       <anydata> {subtree}?
|  |  |        +--:(stream-xpath-filter)
|  |  |           +--rw stream-xpath-filter?         ietf-yang-types:xpath1.0 {xpath}?
|  |  +--rw stream                                   stream-ref
|  |  +--ro replay-start-time?                       ietf-yang-types:date-and-time {replay}?
|  |  +--rw configured-replay?                       empty {configured,replay}?
```

Datastore (RFC8641)

- [RFC8641] A configuration performed to obtain a flow of updates happening on a datastore [RFC8342] of the publisher
- An update to a config <startup>; <candidate>; <running>; <operational>; <intended>

```
|  +--:(ietf-yang-push:datastore)
|     +--rw ietf-yang-push:datastore                identityref
|     +--rw (ietf-yang-push:selection-filter)?
|        +--:(ietf-yang-push:by-reference)
|        |  +--rw ietf-yang-push:selection-filter-ref   selection-filter-ref
|        +--:(ietf-yang-push:within-subscription)
|           +--rw (ietf-yang-push:filter-spec)?
|              +--:(ietf-yang-push:datastore-subtree-filter)
|              |  +--rw ietf-yang-push:datastore-subtree-filter?   <anydata> {sn:subtree}?
|              +--:(ietf-yang-push:datastore-xpath-filter)
|                 +--rw ietf-yang-push:datastore-xpath-filter?   ietf-yang-types:xpath1.0 {sn:xpath}?
```

Specification issues & discussions

1. Issue #1 - To which YANG module is referring an Xpath? (Solved)
2. Issue #2 - Are YANG-push control-plane messages sent over the same session as the data-plane?
3. Issue #3 - In which encoding is the first message when the encoding is changed in a subscription through <modify-subscription> rpc?
4. Issue #4 - No tools found for validating YANG-push JSON encoded messages
5. Issue #5 - How to compile a YANG module (including the YANG-push header and payload) for Kafka messages validation?
6. Issue #6 - YANG-JSON does not define how notifications are encoded, YANG 1.1 defines the notifications in Section 4.1.10

Issue #1: To which YANG module is referring an Xpath?

- /example:root
- /example:root/actors
- /example:root/foo:singers

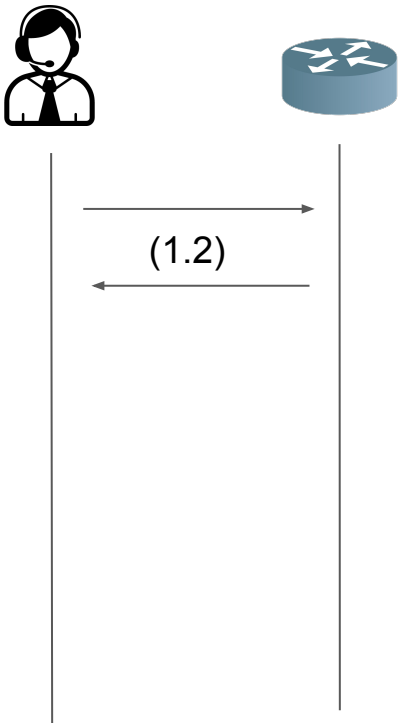
```
<root xmlns:yp="urn:ietf-yang-push" xmlns="urn:example">
        <actors>
                <actor id="1">Christian Bale</actor>
                <actor id="2">Liam Neeson</actor>
                <actor id="3">Michael Caine</actor>
        </actors>
        <foo:singers>
                <foo:singer id="4">Tom Waits</foo:singer>
                <foo:singer id="5">B.B. King</foo:singer>
                <foo:singer id="6">Ray Charles</foo:singer>
        </foo:singers>
</root>
```

“example” is the YANG module name bound to the namespace “urn:example”

Unwritten rule:

- ***An XPath has always the root yang module name***

Issue #1: To which YANG module is referring an Xpath?




```
<rpc-reply message-id="101"
    xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
    <ok/>
</rpc-reply>
```

After 1.2, there is still no reference to the YANG module name

QUESTION

- *Name of the stream == YANG module name?*
- *The datastore name is associated to a YANG module name by default? How can we find this relation?*

ANSWER

Thomas: *we get the YANG module from the XPath*

Issue #1: To which YANG module is referring an Xpath?

- From RFC8641 Section 3.6

*A subscription **must** specify both the selection filters and the datastore[...].*
[...]
*A publisher MUST support **at least one** type of selection filter.*

- YANG Types
  - subtree: anydata
  - xpath: yang:xpath1.0

3.6. Defining the Selection with a Datastore

A subscription must specify both the selection filters and the datastore against which these selection filters will be applied. This information is used to choose and subsequently push data from the publisher's datastore to the receivers.

Only a single selection filter can be applied to a subscription at a time. An RPC request proposing a new selection filter replaces any existing filter. The following selection filter types are included in the YANG-Push data model and may be applied against a datastore:

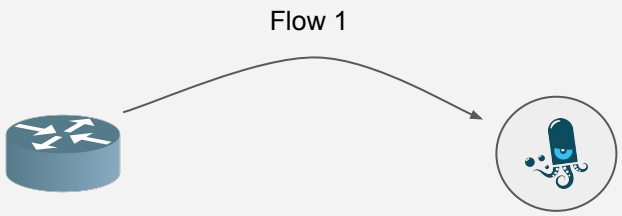
o subtree: A subtree selection filter identifies one or more datastore subtrees. When specified, update records will only come from the datastore nodes of selected datastore subtree(s). The syntax and semantics correspond to those specified in [RFC6241], Section 6.

o xpath: An "xpath" selection filter is an XPath expression that returns a node set. (XPath is a query language for selecting nodes in an XML document; see [XPATH] for details.) When specified, updates will only come from the selected datastore nodes.

These filters are intended to be used as selectors that define which objects are within the scope of a subscription. A publisher MUST support at least one type of selection filter.

We need to assume that the namespace/YANG module name is specified in the Xpath.

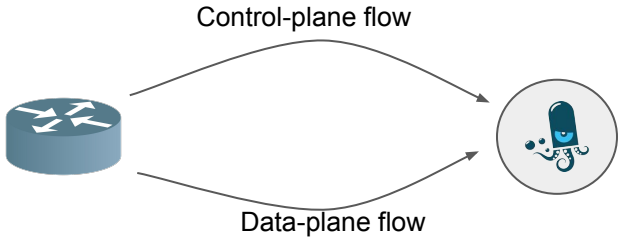
Issue #2 - Are YANG-push control-plane sent in the same session as the data-plane?



Messages sent in “Flow 1”

<subscription-started>
<push-updates>
<subscription-modified>
<push-updates>
<subscription-terminated>

VS



Messages sent in “Control-plane flow”

<subscription-started>
<subscription-modified>
<subscription-terminated>

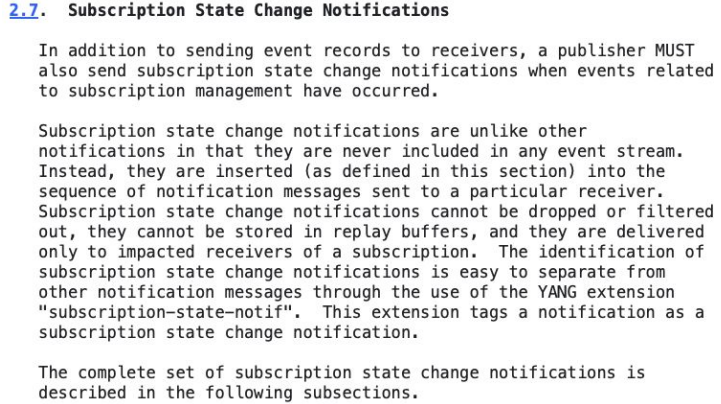
Message sent in “Data-plane flow”

<push-updates>

Issue #2 -
Are YANG-push control-plane notifs sent over the same session as the data-plane notifs?

Reading RFC8639 (1)

1. Section 2.7 (Subscription State Change Notifications)
   - "[...] *they (subscription state change notifications) are inserted* [...] *into the sequence of notification messages sent to a particular receiver.*"
   - I understand that these notifications are part of the same event notification flow.
   - There is no way to separate these flows in the config
     - Though, **dependencies** between subscriptions are allowed (Section 2.3 QoS)



2.7. **Subscription State Change Notifications**

In addition to sending event records to receivers, a publisher MUST also send subscription state change notifications when events related to subscription management have occurred.

Subscription state change notifications are unlike other notifications in that they are never included in any event stream. Instead, they are inserted (as defined in this section) into the sequence of notification messages sent to a particular receiver. Subscription state change notifications cannot be dropped or filtered out, they cannot be stored in replay buffers, and they are delivered only to impacted receivers of a subscription. The identification of subscription state change notifications is easy to separate from other notification messages through the use of the YANG extension "subscription-state-notif". This extension tags a notification as a subscription state change notification.

The complete set of subscription state change notifications is described in the following subsections.

Issue #2 -
Are YANG-push control-plane notifs sent over the same session as the data-plane notifs?

Reading RFC8639 (2)

2. Section 2.5 (Configured Subscription)
   - "[...] *Multiple configured subscriptions MUST be supportable over a single transport session.*"
   - This means multiple subscriptions can send messages over the same notification flow?
   - Use case: 2 subscriptions sending to the same transport UDP-notif

Agree this is not an issue? Yes

Issue #3 - In which encoding is the first message when the encoding is changed in a subscription through <modify-subscription> rpc?

- Since YANG-push control-plane messages and data-plane are in the same flow, when the user modifies the subscription through the RPC `<modify-subscription>` changing the encoding, in which encoding does the collector receives the `<subscription-modified>` notification?
- Other similar corner cases can appear when a subscription is changing. How the collector should manage this changes?

Issue #4 - No tools found for validating YANG-push JSON encoded messages

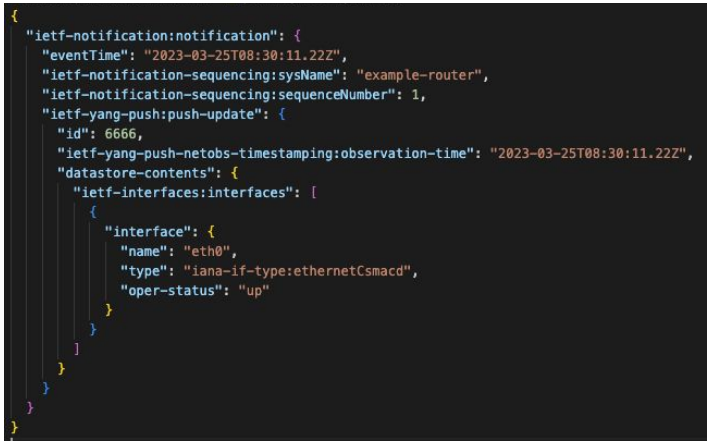
- During Hackathon 117, Ahmed and Alex did not find any tool to validate YANG encoded data against a YANG module
- Validation of YANG-push messages can be done in XML by using yanglint
  - `yanglint -strict –type nc-notif -f xml notification.yang test.xml`
  - By using this command, a Netconf Notification can be validated as defined in RFC5277
  - yanglint only validates the presence of <eventTime> leaf in the XML
  - Does not work with JSON encoding
- ***Note also that the YANG-push notification header is defined as a structure in draft-ahuang-netconf-notif-yang and all YANG-push header augmentations will have to augment this structure***
  - Go to Discuss #5 for more details

Issue #5 - How to compile a YANG module (including the YANG-push header and payload) for Kafka messages validation

- Jean Quilbeuf and Zhouyao Lin implemented a PoC for registering YANG modules in the Kafka schema registry from a Netconf node at the Hackathon 117
- To validate the YANG message in Kafka Schema registry, a single YANG module needs to be compiled including
  - YANG-push header (and header extensions)
  - Payload (for only the XPath of the subscription and including **`augmentations`**)
- Proposed solutions from discussions
  - Compile a YANG module including all headers and payloads and register this metadata YANG module to the schema registry
  - Send only the payload without the YANG-push header to Kafka
  - YANG static mount (not even a draft yet)

Issue #6 - YANG-JSON does not define how notifications are encoded, YANG 1.1 defines the notifications in Section 4.1.10

- YANG 1.1 [RFC7950] defines how a notification should be encoded in Section 4.1.10.
- YANG-JSON [RFC7951] does not define how a YANG notification is encoded in JSON
- Following examples, developers suppose that a notification is encoded as following:



- Should draft-ahuang-netconf-notif-yang fill this gap?

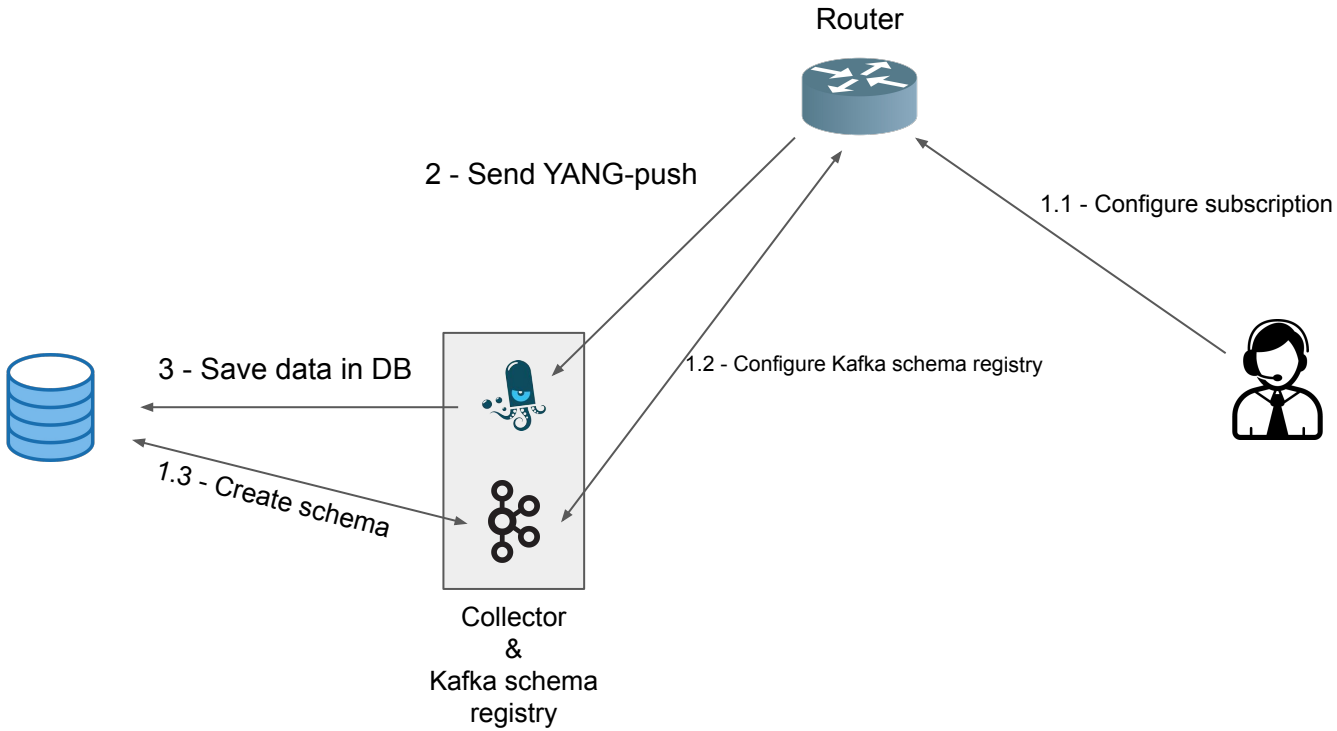
Architecture overview

Focus on integration of Configured Subscriptions

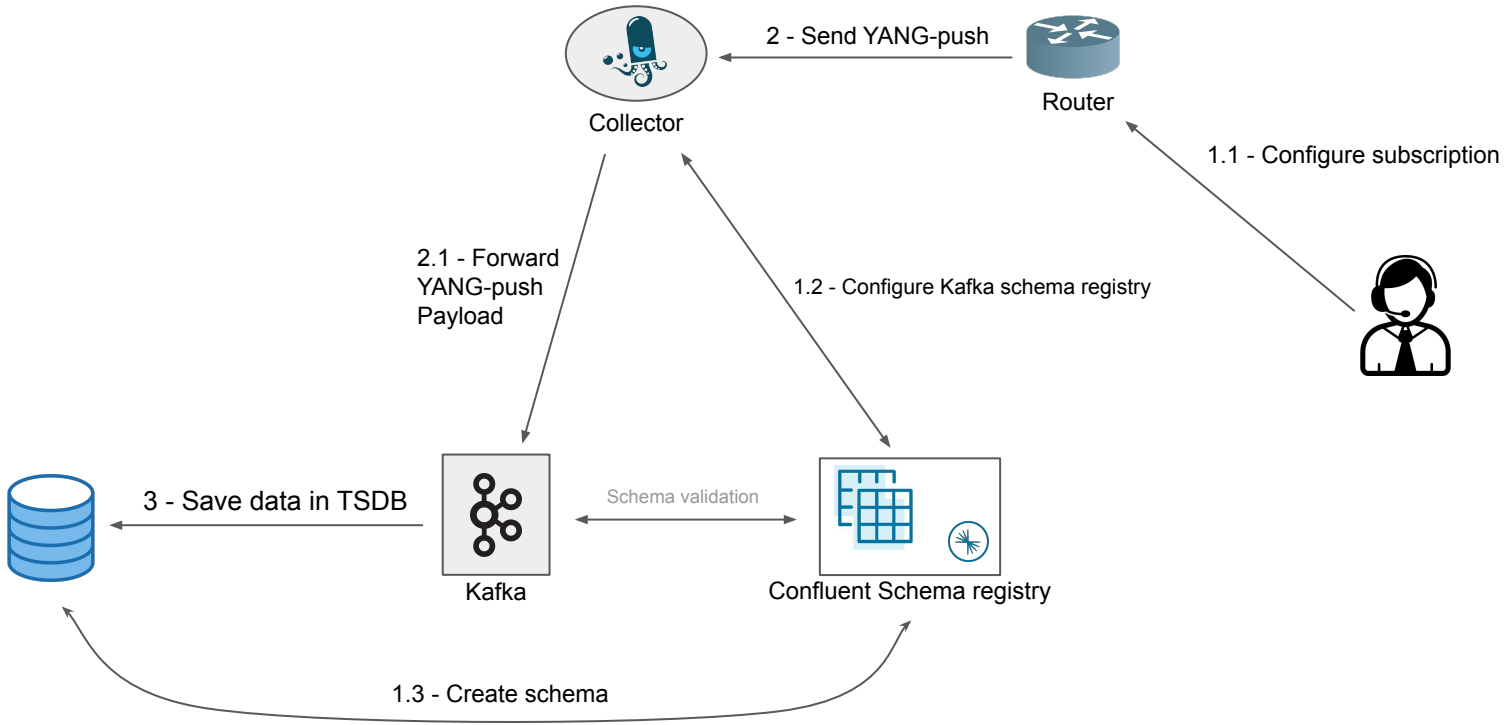
Used tools for demo:

- Kafka
- Kafka schema registry
- pmacct
- TSDB: Druid

High-level Architecture for Configured Subscriptions RFC8639/RFC8641



Implementation-level architecture



Architecture overview

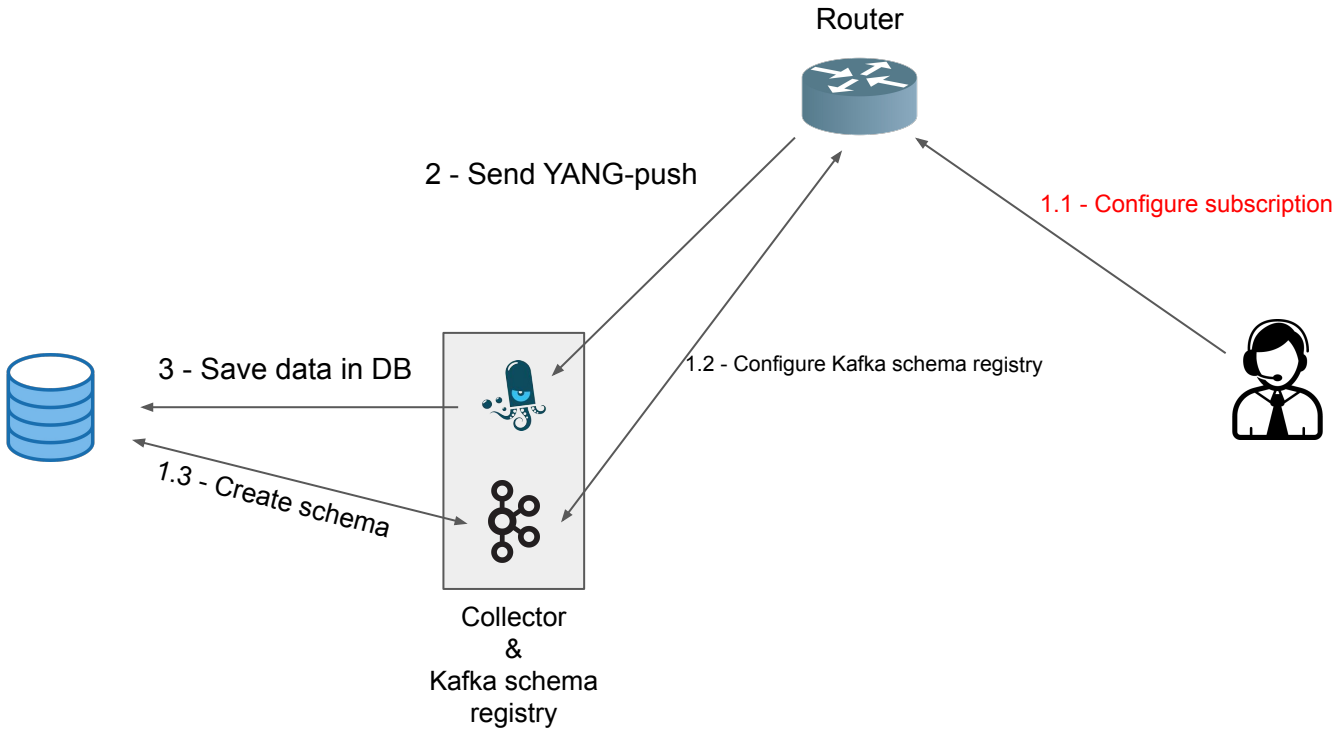
Focus on integration of Configured Subscriptions

Configure subscription (management-plane)

YANG-Push messages (control-plane & data-plane)

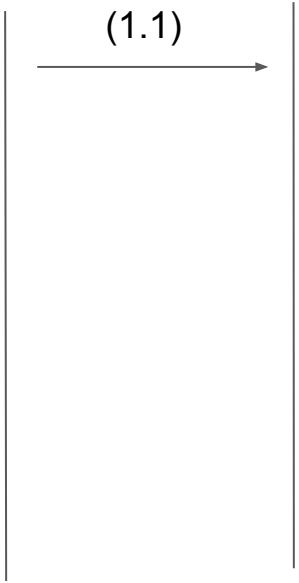
Tracking YANG-push schema changes

Topology for Configured Subscriptions RFC8639/RFC8641



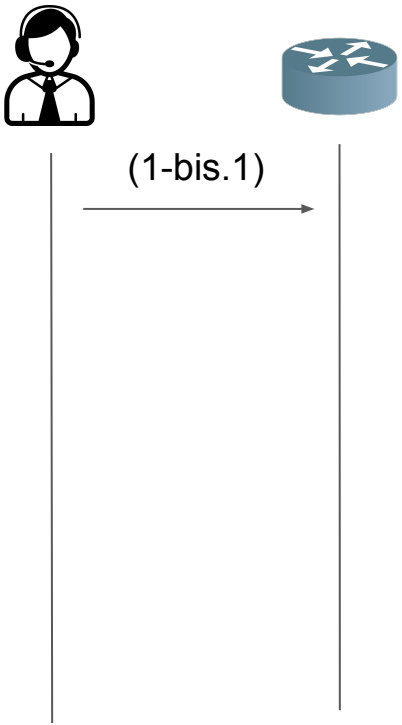
Configure Subscription with RFC8639: Stream

config tree are wrapped in <edit-config> rpc



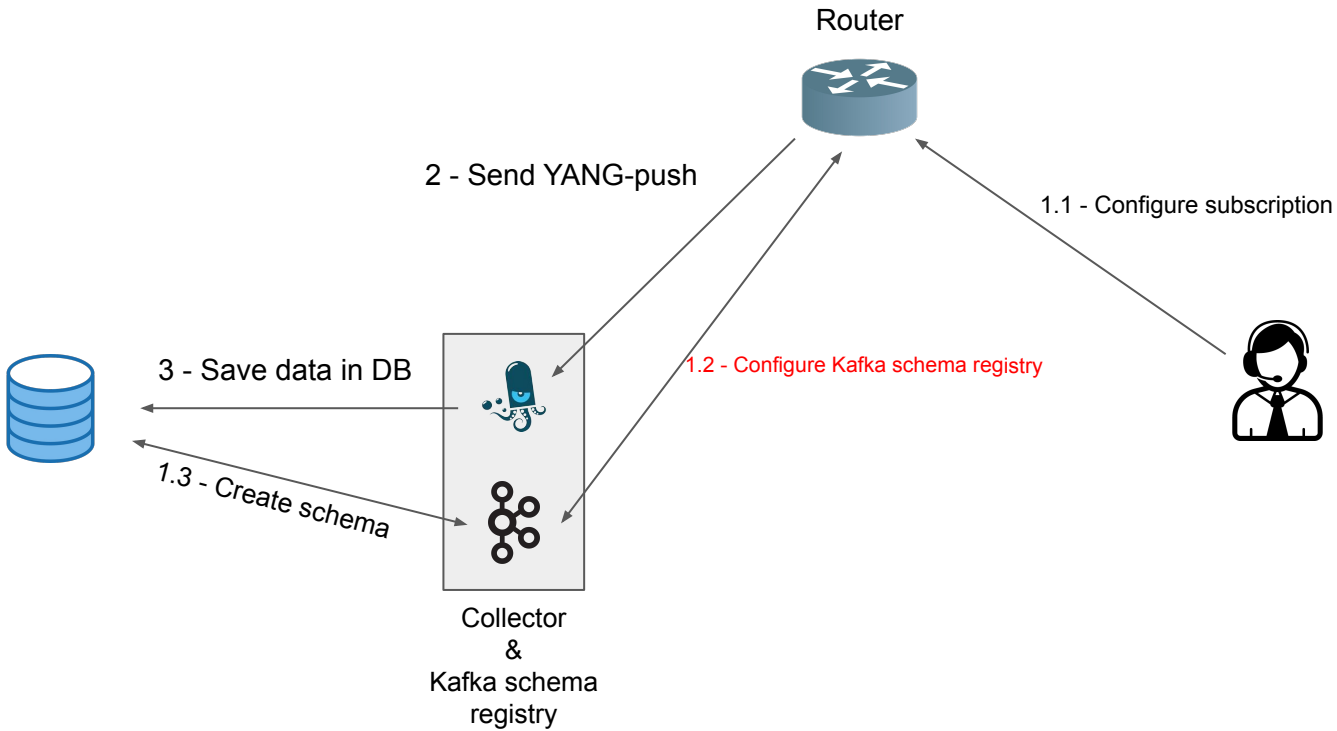

```
<?xml version='1.0' encoding='UTF-8'?>
<config xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <subscriptions xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notifications">
    <subscription>
      <id>6666</id>
      <stream-subtree-filter>some-subtree-filter</stream-subtree-filter>
      <stream>some-stream</stream>
      <transport xmlns:unt="urn:ietf:params:xml:ns:yang:ietf-udp-notif-transport">unt:udp-notif</transport>
      <encoding>encode-json</encoding>
      <receivers>
        <receiver>
          <name>subscription-specific-receiver-def</name>
          <receiver-instance-ref xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notif-receivers">global-udp-notif-receiver-def</receiver-instance-ref>
        </receiver>
      </receivers>
    </subscription>
    <receiver-instances xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notif-receivers">
      <receiver-instance>
        <name>global-udp-notif-receiver-def</name>
        <udp-notif-receiver xmlns="urn:ietf:params:xml:ns:yang:ietf-udp-notif-transport">
          <address>192.0.5.1</address>
          <port>12345</port>
          <enable-segmentation>false</enable-segmentation>
          <max-segment-size/>
        </udp-notif-receiver>
      </receiver-instance>
    </receiver-instances>
  </subscriptions>
</config>
```

Configure Subscription with RFC8641: Datastore



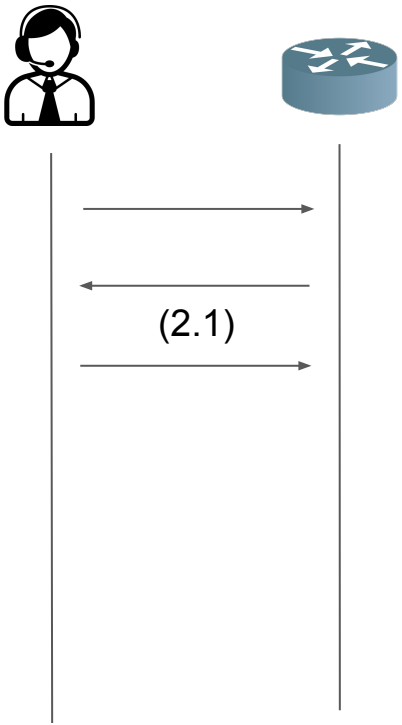

```
<rpc message-id="101"
  xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <edit-config>
    <target>
      <running/>
    </target>
    <config>
      <subscriptions xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notifications">
        <subscription>
          <id>6666</id>
          <datastore xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push"
            xmlns:ds="urn:ietf:params:xml:ns:yang:ietf-datastores">ds:operational</datastore>
          <datastore-xpath-filter xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push"
            xmlns:if="urn:ietf:params:xml:ns:yang:ietf-interfaces">/if:interfaces</datastore-xpath-filter>
          <revision xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push-revision">2018-02-20</revision>
          <transport xmlns:unt="urn:ietf:params:xml:ns:yang:ietf-udp-notif-transport">unt:udp-notif</transport>
          <encoding>encode-json</encoding>
          <receivers>
            <receiver>
              <name>subscription-specific-receiver-def</name>
              <receiver-instance-ref xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notif-receivers">global-udp-notif-receiver-def</receiver-instance-ref>
            </receiver>
          </receivers>
          <periodic xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">
            <period>6000</period>
          </periodic>
        </subscription>
        <receiver-instances xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notif-receivers">
          <receiver-instance>
            <name>global-udp-notif-receiver-def</name>
            <udp-notif-receiver xmlns="urn:ietf:params:xml:ns:yang:ietf-udp-notif-transport">
              <address>192.0.5.1</address>
              <port>12345</port>
              <enable-segmentation>false</enable-segmentation>
              <max-segment-size/>
            </udp-notif-receiver>
          </receiver-instance>
        </receiver-instances>
      </subscriptions>
    </config>
  </edit-config>
</rpc>
```

Topology for Configured Subscriptions RFC8639/RFC8641



Configure Subscription RFC8639/RFC8641

Obtaining available schemas

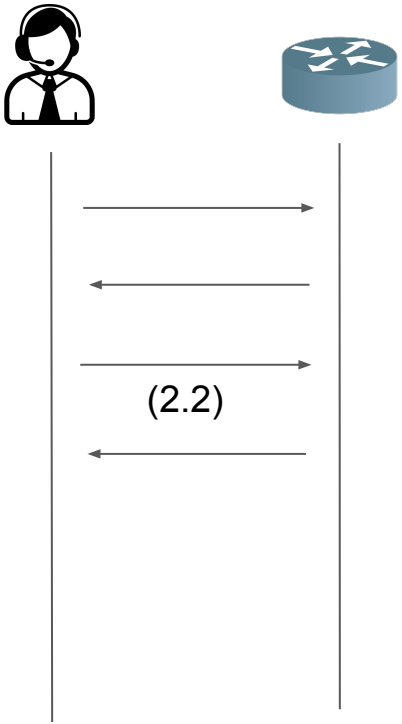


Discovering available YANGs

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

Configure Subscription RFC8639/RFC8641

Obtaining available schemas

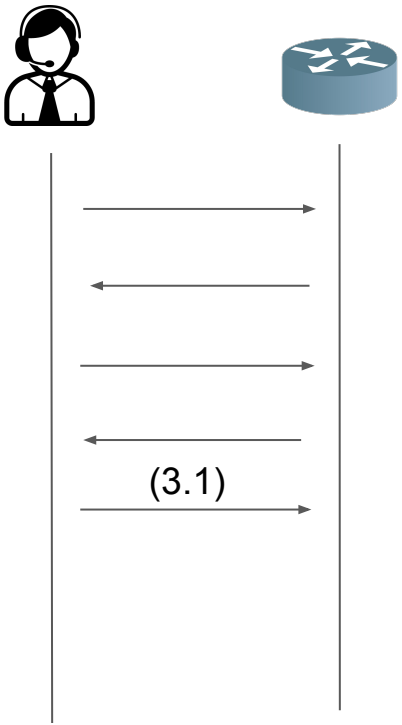


Discovering available YANGs

```
<rpc-reply message-id="101"
  xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <data>
    <netconf-state xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-monitoring">
      <schemas>
        <schema>
          <identifier>foo</identifier>
          <version>2020-10-10</version>
          <format>yang</format>
          <namespace>http://example.com/foo</namespace>
          <location>
            http://example.com/schema/foo@2020-10-10.yang
          </location>
          <location>NETCONF</location>
        </schema>
        <schema>
          <identifier>bar-types</identifier>
          <version>2008-06-01</version>
          <format>yang</format>
          <namespace>http://example.com/bar</namespace>
          <location>
            http://example.com/schema/bar-types@2008-06-01.yang
          </location>
          <location>NETCONF</location>
        </schema>
      </schemas>
    </netconf-state>
  </data>
</rpc-reply>
```

Configure Subscription RFC8639/RFC8641

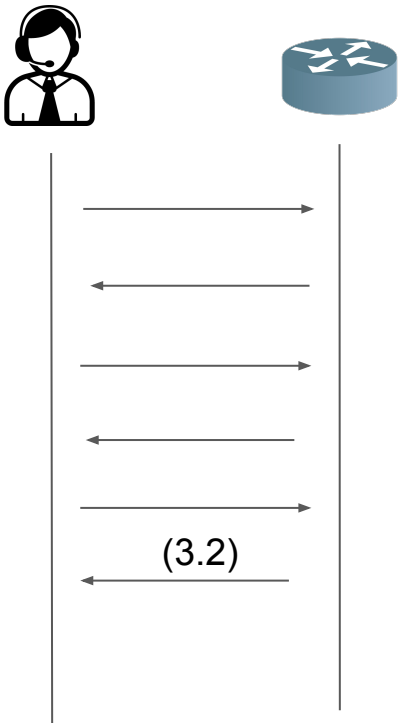
Get schema




```
<rpc message-id="101"
    xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
    <get-schema xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-monitoring">
        <identifier>foo</identifier>
        <version>1.0</version>
        <format>yang</format>
    </get-schema>
</rpc>
```

Configure Subscription RFC8639/RFC8641

Using the schema

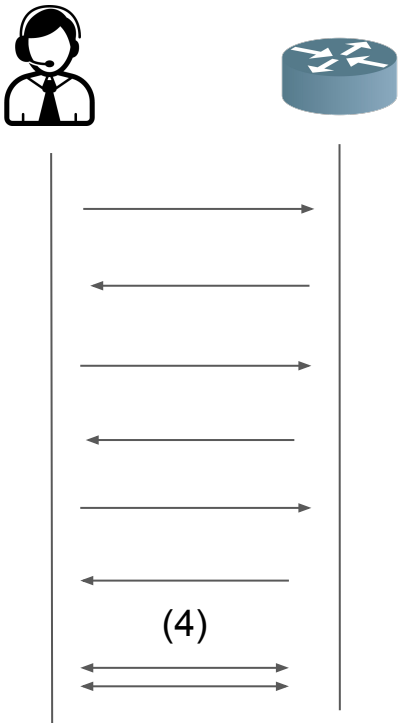



```
<rpc-reply message-id="101"
    xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
    <data xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-monitoring">
        module foo {
        //default format (yang) returned
        //bar version 2020-10-10 yang module
        //contents here ...
        }
    </data>
</rpc-reply>
```

Once got the YANG module and the Xpath
→ Get recursively the imported YANG modules

Configure Subscription RFC8639/RFC8641

Recursively get YANG modules



Get all imported YANG modules

```
<rpc message-id="101"
    xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
    <get-schema xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-monitoring">
        <identifier>foo</identifier>
        <version>1.0</version>
        <format>yang</format>
    </get-schema>
</rpc>
```

```
<rpc-reply message-id="101"
    xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
    <data xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-monitoring">
        module foo {
        //default format (yang) returned
        //bar version 2020-10-10 yang module
        //contents here ...
        }
    </data>
</rpc-reply>
```

Once all the YANG modules (and their Xpath) are obtained
→ Push all these YANG modules to the Schema registry
→ Build one "true" YANG module capturing the actual notification header and message format(s) for the consumer/producer

Architecture overview

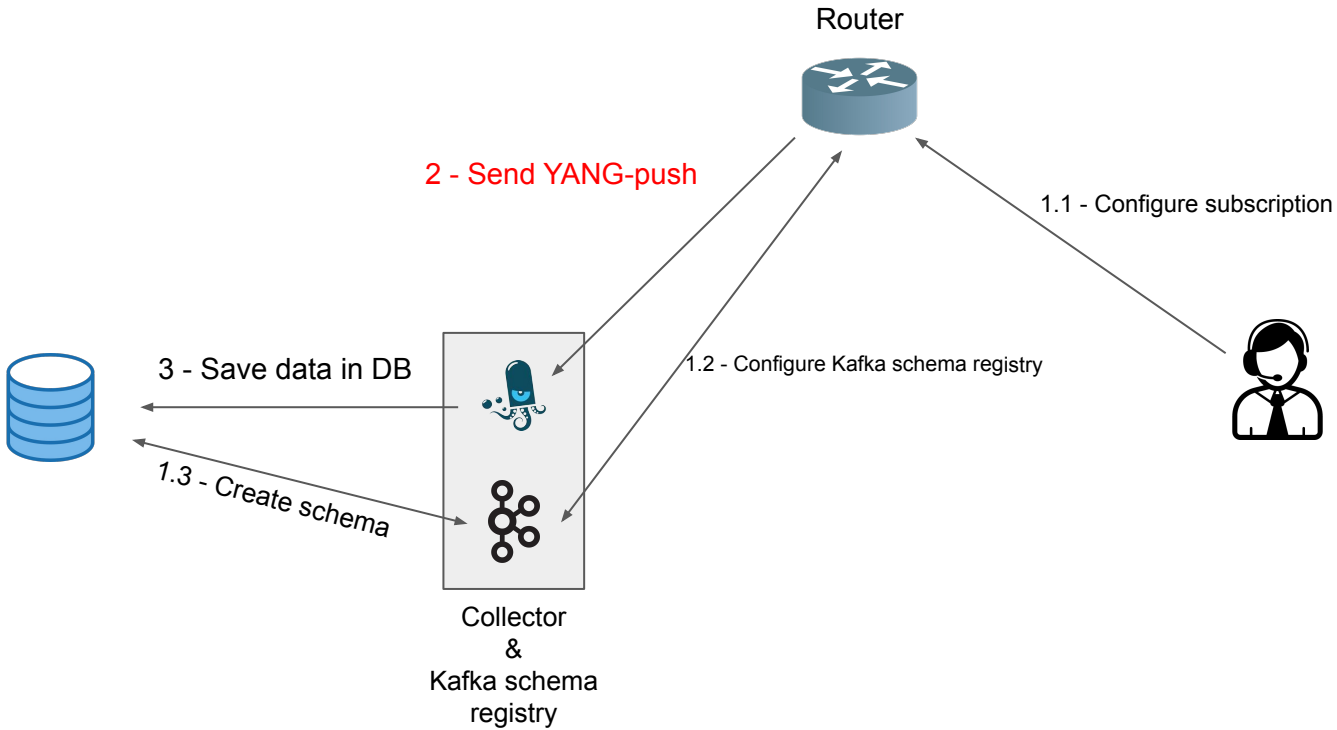
Focus on integration of Configured Subscriptions

Configure subscription (management-plane)

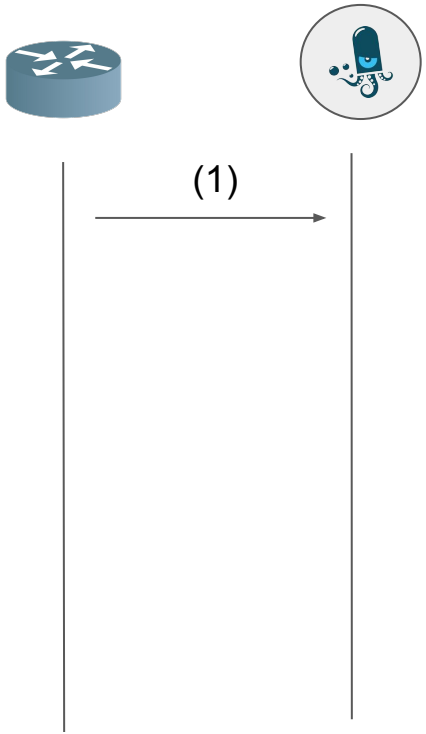
YANG-Push messages (control-plane & data-plane)

Tracking YANG-push schema changes

Topology for Configured Subscriptions RFC8639/RFC8641

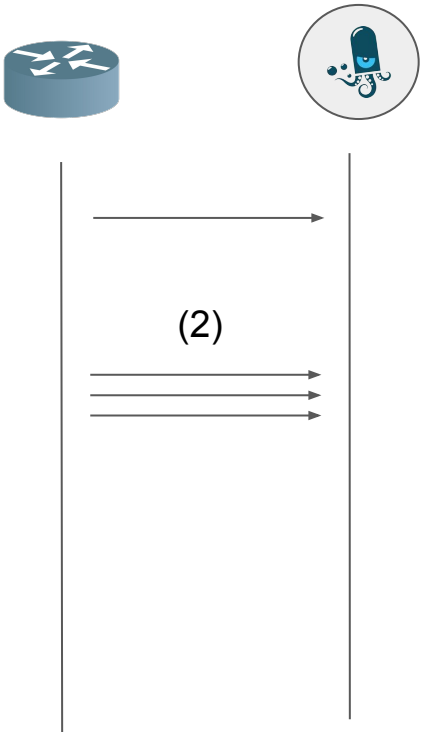


Sending YANG-push to the collector: Subscription started



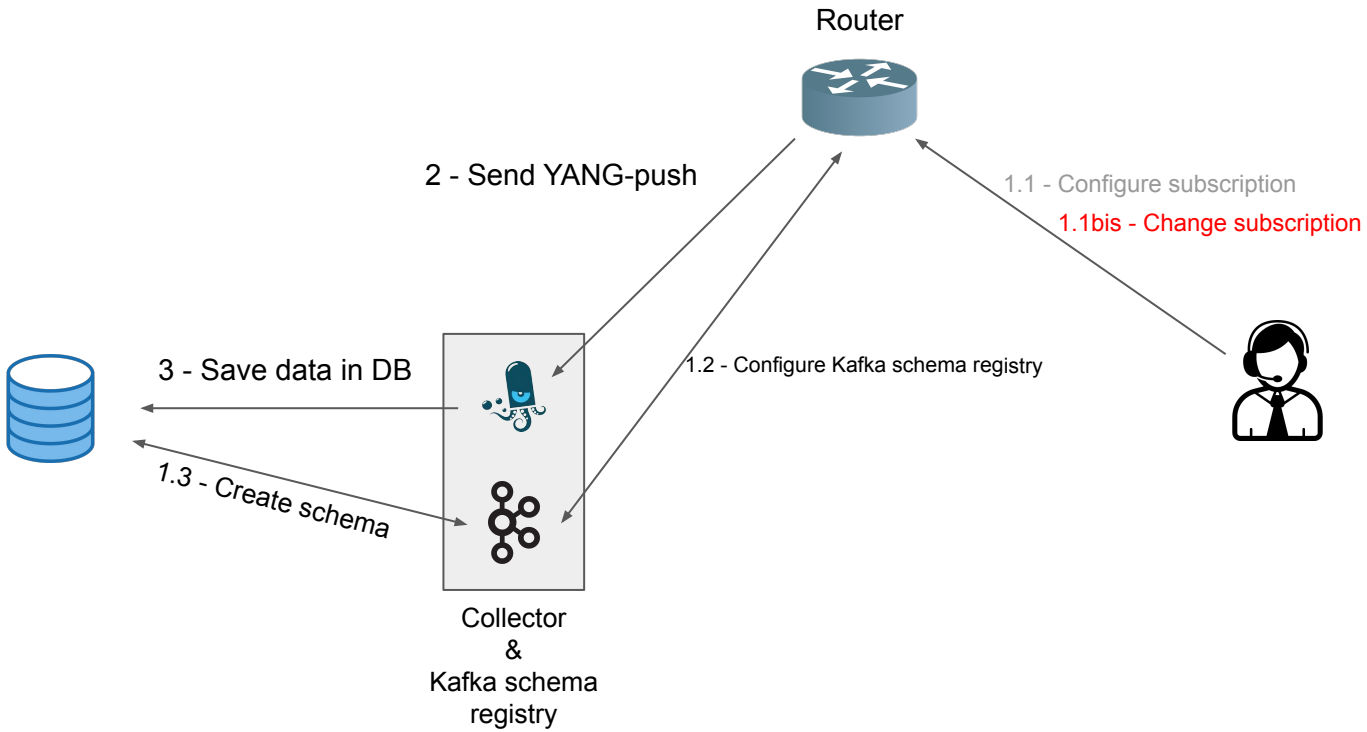

```
{
  "ietf-notification:notification": {
    "eventTime": "2023-03-25T08:30:11.22Z",
    "ietf-subscribed-notification:subscription-started": {
      "id": 1011,
      "target": {
        "ietf-yang-push:datastore": "ds:operational"
      },
      "transport": "ietf-udp-notif-transport:udp-notif",
      "encoding": "encode-json",
      "ietf-yang-push:periodic": {
        "ietf-yang-push:period": 100
      }
    }
  }
}
```

2 - Sending YANG-push to the collector: Updates

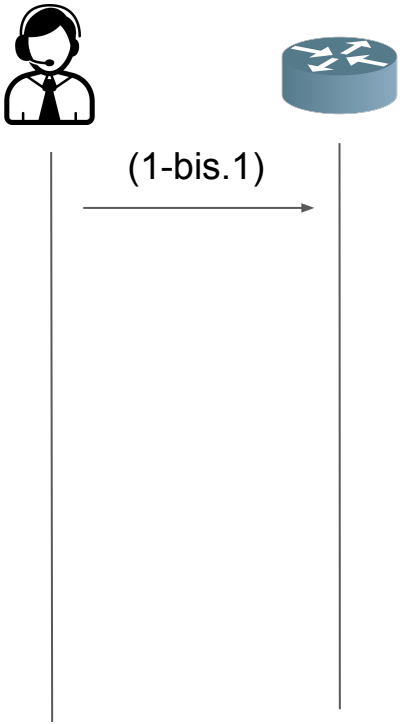



```
{
  "ietf-notification:notification": {
    "eventTime": "2023-03-25T08:30:11.22Z",
    "ietf-yang-push:push-update": {
      "id": 6666,
      "datastore-contents": {
        "ietf-interfaces:interfaces": [
          {
            "interface": {
              "name": "eth0",
              "oper-status": "up"
            }
          }
        ]
      }
    }
  }
}
```

Topology for Configured Subscriptions RFC8639/RFC8641



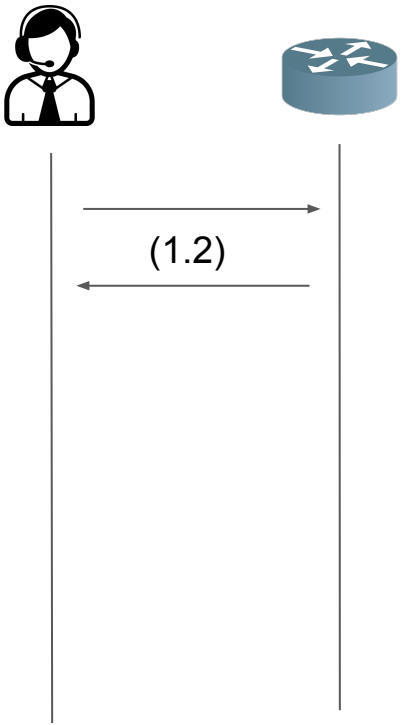
Change Subscription RFC8639/RFC8641 - Router



Example: Change encoding

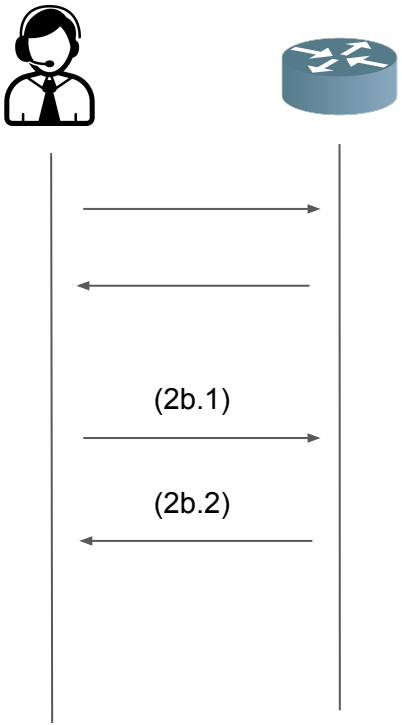
```
<rpc message-id="101"
  xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <edit-config>
    <target>
      <running/>
    </target>
    <config>
      <subscriptions xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notifications">
        <subscription>
          <id>6666</id>
          <datastore xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push"
            xmlns:ds="urn:ietf:params:xml:ns:yang:ietf-datastores">ds:operational</datastore>
          <datastore-xpath-filter xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push"
            xmlns:if="urn:ietf:params:xml:ns:yang:ietf-interfaces">/if:interfaces</datastore-xpath-filter>
          <revision xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push-revision">2018-02-20</revision>
          <transport xmlns:unt="urn:ietf:params:xml:ns:yang:ietf-udp-notif-transport">unt:udp-notif</transport>
          <encoding>encode-xml</encoding>
          <receivers>
            <receiver>
              <name>subscription-specific-receiver-def</name>
              <receiver-instance-ref xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notif-receivers">global-udp-notif-receiver-def</receiver-instance-ref>
            </receiver>
          </receivers>
          <periodic xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">
            <period>6000</period>
          </periodic>
        </subscription>
        <receiver-instances xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notif-receivers">
          <receiver-instance>
            <name>global-udp-notif-receiver-def</name>
            <udp-notif-receiver xmlns="urn:ietf:params:xml:ns:yang:ietf-udp-notif-transport">
              <address>192.0.5.1</address>
              <port>12345</port>
              <enable-segmentation>false</enable-segmentation>
              <max-segment-size/>
            </udp-notif-receiver>
          </receiver-instance>
        </receiver-instances>
      </subscriptions>
    </config>
  </edit-config>
</rpc>
```

Change Subscription RFC8639/RFC8641 - Router




```
<rpc-reply message-id="101"
    xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
    <ok/>
</rpc-reply>
```

Change Subscription RFC8639/RFC8641 - Router

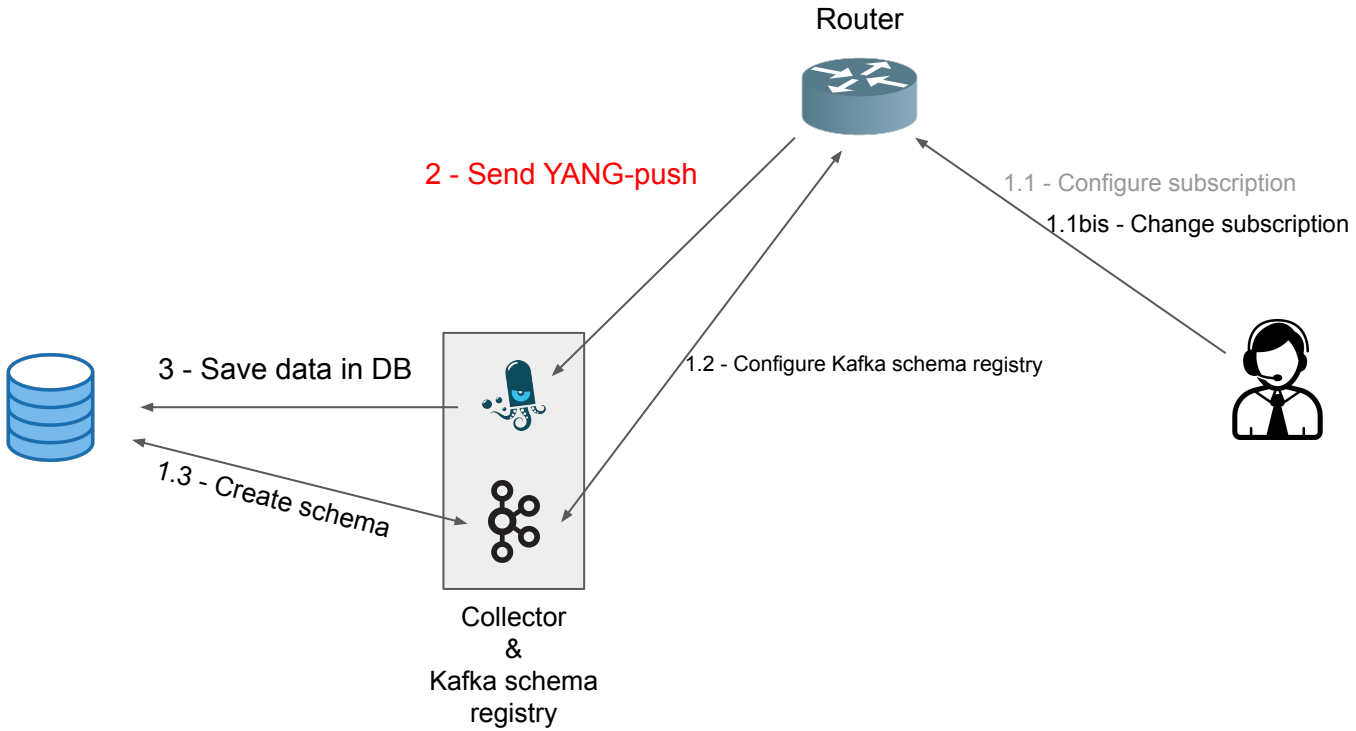



```
<rpc message-id="101"
    xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
    <get-schema xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-monitoring">
        <identifier>foo</identifier>
        <version>1.0</version>
        <format>yang</format>
    </get-schema>
</rpc>
```

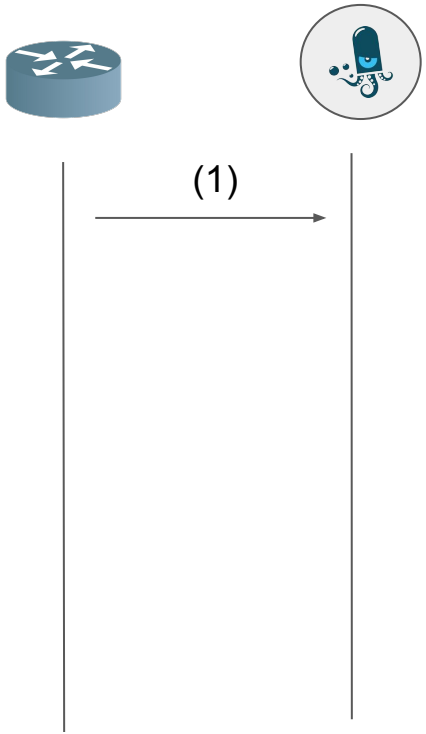
```
<rpc-reply message-id="101"
    xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
    <data xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-monitoring">
        module foo {
        //default format (yang) returned
        //bar version 2020-10-10 yang module
        //contents here ...
        }
    </data>
</rpc-reply>
```

Pushing new YANG module to Schema registry

Topology for Configured Subscriptions RFC8639/RFC8641



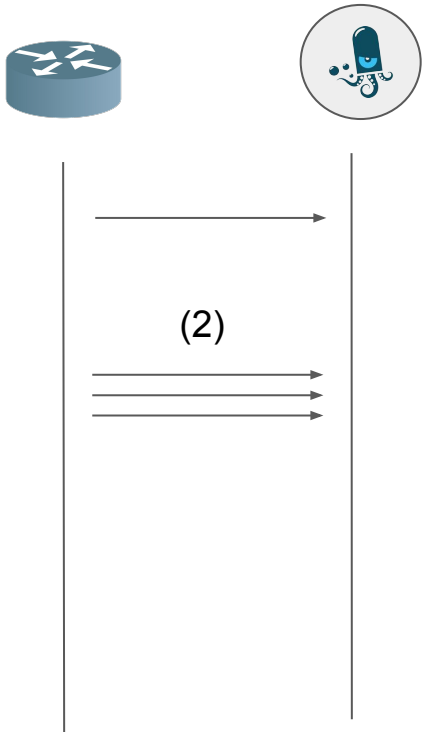
2b - Sending YANG-push to collector




```
{
    "ietf-notification:notification": {
        "eventTime": "2023-03-25T08:30:11.22Z",
        "ietf-subscribed-notification:subscription-modified": {
            "id": 6666,
            "target": {
                "ietf-yang-push:datastore": "ds:operational"
            },
            "transport": "ietf-udp-notif-transport:udp-notif",
            "encoding": "encode-json",
            "ietf-yang-push:periodic": {
                "ietf-yang-push:period": 100
            }
        }
    }
}
```

This first message is in json or in xml when there is a change on the subscription encoding?
Tracked at Issue #3

2 - Sending YANG-push to collector




```
<notification xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
    <eventTime>2022-09-02T10:59:55.32Z</eventTime>
    <push-update xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">
        <id>6666</id>
        <datastore-contents>
            <interfaces xmlns="urn:ietf:params:xml:ns:yang:ietf-interfaces">
                <interface>
                    <name>eth0</name>
                    <oper-status>up</oper-status>
                </interface>
            </interfaces>
        </datastore-contents>
    </push-update>
</notification>
```

Architecture overview

Focus on integration of Configured Subscriptions

Configure subscription (management-plane)

YANG-Push messages (control-plane & data-plane)

Tracking YANG-push schema changes

Tracking YANG model changes from the publisher

How can the collector know about YANG-push subscription changes from the YANG-push flow?

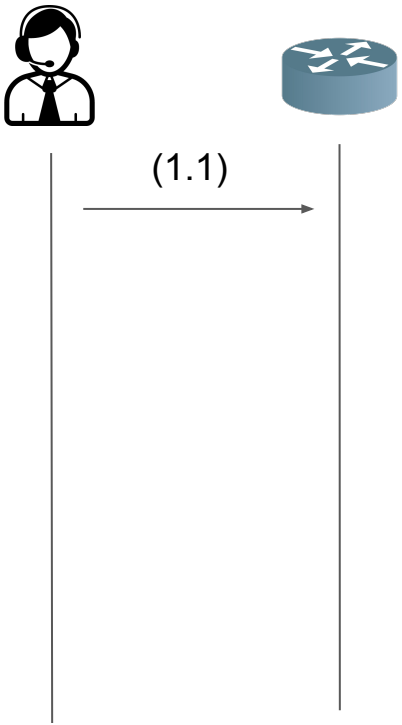
e.g. new version of subscribed YANG module, subscription parameters have changed

Solution: YANG-push subscription to **`/sn:subscription`** container

2 Options:

- Using a periodic subscription to the XPath **`/sn:subscriptions`**
- Using on-change subscription to the Xpath **`/sn:subscriptions`**

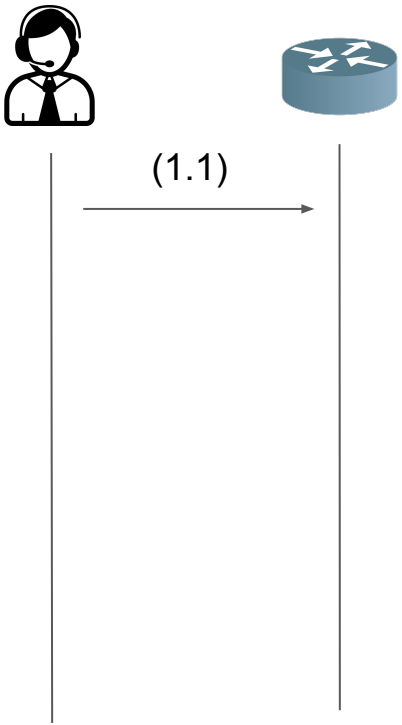
Using a periodic subscription to <subscriptions> container




```
<rpc message-id="101"
  xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <edit-config>
    <target>
      <running/>
    </target>
    <config>
      <subscriptions xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notifications">
        <subscription>
          <id>2222</id>
          <datastore xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">ds:operational</datastore>
          <datastore-xpath-filter xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push"
            xmlns:sn="urn:ietf:params:xml:ns:yang:ietf-subscribed-notifications">/sn:subscriptions</datastore-xpath-filter>
          <transport xmlns:unt="urn:ietf:params:xml:ns:yang:ietf-udp-notif-transport">unt:udp-notif</transport>
          <encoding>encode-xml</encoding>
          <receivers>
            <receiver>
              <name>subscription-specific-receiver-def</name>
              <receiver-instance-ref xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notif-receivers">global-udp-notif-receiver-def</receiver-instance-ref>
            </receiver>
          </receivers>
          <periodic xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">
            <period>30000</period>
          </periodic>
        </subscription>
        <subscription>
          <id>6666</id>
          <datastore xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">ds:operational</datastore>
          <datastore-xpath-filter xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push"
            xmlns:if="urn:ietf:params:xml:ns:yang:ietf-interfaces">/if:interfaces</datastore-xpath-filter>
          <transport xmlns:unt="urn:ietf:params:xml:ns:yang:ietf-udp-notif-transport">unt:udp-notif</transport>
          <encoding>encode-json</encoding>
          <receivers>
            <receiver>
              <name>subscription-specific-receiver-def</name>
              <receiver-instance-ref xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notif-receivers">global-udp-notif-receiver-def</receiver-instance-ref>
            </receiver>
          </receivers>
          <periodic xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">
            <period>6000</period>
          </periodic>
        </subscription>
        <receiver-instances xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notif-receivers">
          <receiver-instance>
            <name>global-udp-notif-receiver-def</name>
            <udp-notif-receiver xmlns="urn:ietf:params:xml:ns:yang:ietf-udp-notif-transport">
              <address>192.0.5.1</address>
              <port>12345</port>
              <enable-segmentation>false</enable-segmentation>
              <max-segment-size/>
            </udp-notif-receiver>
          </receiver-instance>
        </receiver-instances>
      </subscriptions>
    </config>
  </edit-config>
</rpc>
```

See full example in https://github.com/network-analytics/udp-notif-scapy/blob/main/src/resources/xml/subscription/edit-config-yang-push-tracking.xml

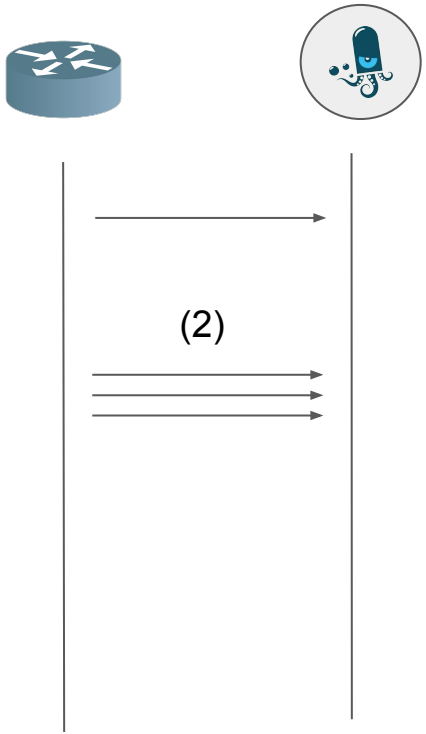
Using a on-change subscription to <subscriptions> container




```
<rpc message-id="101"
  xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <edit-config>
    <target>
      <running/>
    </target>
    <config>
      <subscriptions xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notifications">
        <subscription>
          <id>2222</id>
          <datastore xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">ds:operational</datastore>
          <datastore-xpath-filter xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push"
            xmlns:sn="urn:ietf:params:xml:ns:yang:ietf-subscribed-notifications">/sn:subscriptions</datastore-xpath-filter>
          <transport xmlns:unt="urn:ietf:params:xml:ns:yang:ietf-udp-notif-transport">unt:udp-notif</transport>
          <encoding>encode-xml</encoding>
          <receivers>
            <receiver>
              <name>subscription-specific-receiver-def</name>
              <receiver-instance-ref xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notif-receivers">global-udp-notif-receiver-def</receiver-instance-ref>
            </receiver>
          </receivers>
          <on-change xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">
            <dampening-period>0</dampening-period>
            <sync-on-start>true</sync-on-start>
            <excluded-change>
              <!-- # entries: 0.. -->
            </excluded-change>
          </on-change>
        </subscription>
        <subscription>
          <id>6666</id>
          <datastore xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">ds:operational</datastore>
          <datastore-xpath-filter xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push"
            xmlns:if="urn:ietf:params:xml:ns:yang:ietf-interfaces">/if:interfaces</datastore-xpath-filter>
          <transport xmlns:unt="urn:ietf:params:xml:ns:yang:ietf-udp-notif-transport">unt:udp-notif</transport>
          <encoding>encode-json</encoding>
          <receivers>
            <receiver>
              <name>subscription-specific-receiver-def</name>
              <receiver-instance-ref xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notif-receivers">global-udp-notif-receiver-def</receiver-instance-ref>
            </receiver>
          </receivers>
          <periodic xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">
            <period>6000</period>
          </periodic>
        </subscription>
        <receiver-instances xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notif-receivers">
          <receiver-instance>
            <name>global-udp-notif-receiver-def</name>
            <udp-notif-receiver xmlns="urn:ietf:params:xml:ns:yang:ietf-udp-notif-transport">
              <address>192.0.5.1</address>
              <port>12345</port>
              <enable-segmentation>false</enable-segmentation>
              <max-segment-size/>
            </udp-notif-receiver>
          </receiver-instance>
        </receiver-instances>
      </subscriptions>
    </config>
  </edit-config>
</rpc>
```

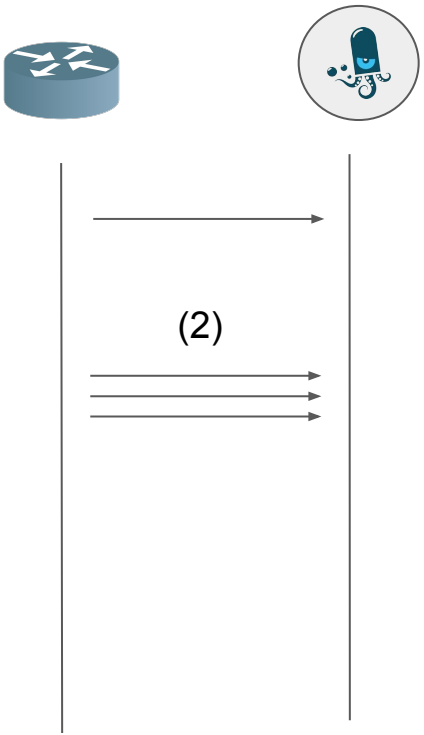
See full example in https://github.com/network-analytics/udp-notif-scapy/blob/main/src/resources/xml/subscription/edit-config-yang-push-tracking-onchange.xml

2 - Sending Telemetry YANG-push to collector



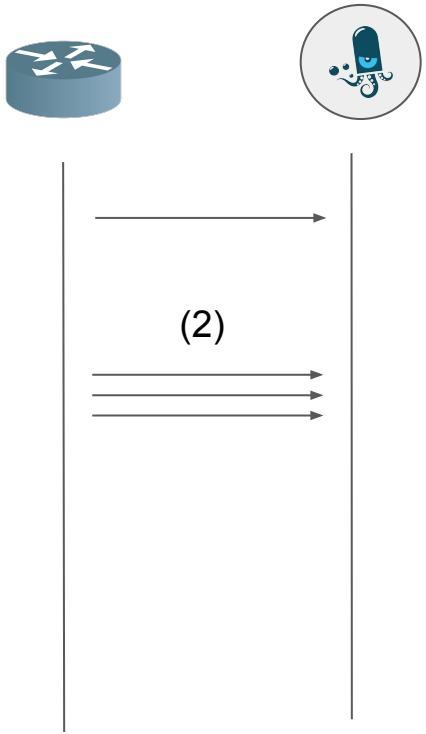

```
{
  "ietf-notification:notification": {
    "eventTime": "2023-03-25T08:30:11.22Z",
    "ietf-yang-push:push-update": {
      "id": 6666,
      "datastore-contents": {
        "ietf-interfaces:interfaces": [
          {
            "interface": {
              "name": "eth0",
              "oper-status": "up"
            }
          }
        ]
      }
    }
  }
}
```

2 - Sending Subscription changes periodically




```
<notification xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
  <eventTime>2022-09-02T10:59:55.32Z</eventTime>
  <push-update xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">
    <id>2222</id>
    <datastore-contents>
      <subscriptions xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notifications">
        <subscription>
          <id>2222</id>
          <datastore xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">ds:operational</datastore>
          <datastore-xpath-filter xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push"
            xmlns:sn="urn:ietf:params:xml:ns:yang:ietf-subscribed-notifications">/sn:subscriptions</datastore-xpath-filter>
          <transport xmlns:unt="urn:ietf:params:xml:ns:yang:ietf-udp-notif-transport">unt:udp-notif</transport>
          <encoding>encode-xml</encoding>
          <receivers>
            <receiver>
              <name>subscription-specific-receiver-def</name>
              <receiver-instance-ref xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notif-receivers">global-udp-notif-receiver-def</receiver-instance-ref>
            </receiver>
          </receivers>
          <periodic xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">
            <period>30000</period>
          </periodic>
        </subscription>
        <subscription>
          <id>6666</id>
          <datastore xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">ds:operational</datastore>
          <datastore-xpath-filter xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push"
            xmlns:if="urn:ietf:params:xml:ns:yang:ietf-interfaces">/if:interfaces</datastore-xpath-filter>
          <transport xmlns:unt="urn:ietf:params:xml:ns:yang:ietf-udp-notif-transport">unt:udp-notif</transport>
          <encoding>encode-json</encoding>
          <receivers>
            <receiver>
              <name>subscription-specific-receiver-def</name>
              <receiver-instance-ref xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notif-receivers">global-udp-notif-receiver-def</receiver-instance-ref>
            </receiver>
          </receivers>
          <periodic xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">
            <period>6000</period>
          </periodic>
        </subscription>
        <receiver-instances xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notif-receivers">
          <receiver-instance>
            <name>global-udp-notif-receiver-def</name>
            <udp-notif-receiver xmlns="urn:ietf:params:xml:ns:yang:ietf-udp-notif-transport">
              <address>192.0.5.1</address>
              <port>12345</port>
              <enable-segmentation>false</enable-segmentation>
              <max-segment-size/>
            </udp-notif-receiver>
          </receiver-instance>
        </receiver-instances>
      </subscriptions>
    </datastore-contents>
  </push-update>
</notification>
```

2 - Sending Subscription change using on-change notifications

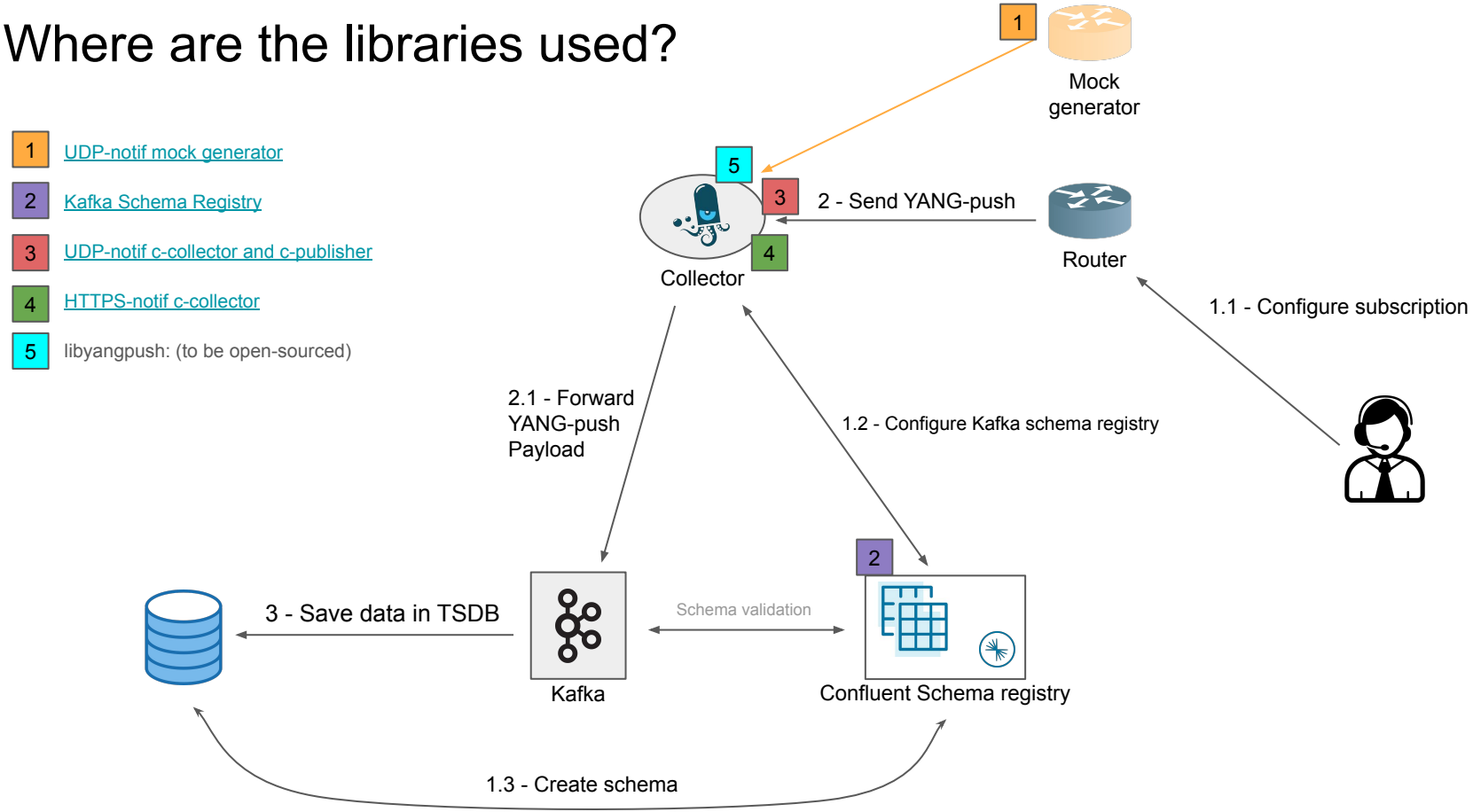



```
<notification xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
  <eventTime>2022-09-02T10:59:55.32Z</eventTime>
  <push-change-update xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">
    <id>2222</id>
    <datastore-changes>
      <yang-patch>
        <patch-id>patch_54</patch-id>
        <comment>Changing encoding to JSON and increasing the period to 10 minutes</comment>
        <edit>
          <edit-id>id_change_1</edit-id>
          <operation>merge</operation>
          <target xmlns:sn="urn:ietf:params:xml:ns:yang:ietf-subscribed-notifications">/sn:subscriptions/subscription[id=2222]</target>
          <value>
            <encoding>encode-json</encoding>
            <periodic xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">
              <period>60000</period>
            </periodic>
          </value>
        </edit>
      </yang-patch>
    </datastore-changes>
  </push-change-update>
</notification>
```

YANG-push Open-source projects

- UDP-notif mock generator: https://github.com/network-analytics/udp-notif-scapy
- Kafka Schema Registry: https://github.com/network-analytics/schema-registry-dev
- UDP-notif c-collector and c-publisher: https://github.com/insa-unyte/udp-notif-c-collector
- HTTPS-notif c-collector: https://github.com/network-analytics/https-notif-c-collector

Where are the libraries used?



YANG-push Open-source projects

- **UDP-notif mock generator:** **https://github.com/network-analytics/udp-notif-scapy**
- Kafka Schema Registry: https://github.com/network-analytics/schema-registry-dev
- UDP-notif c-collector and c-publisher: https://github.com/insa-unyte/udp-notif-c-collector
- HTTPS-notif c-collector: https://github.com/network-analytics/https-notif-c-collector
- libyangpush: (to be open-sourced)

UDP-Notif mock generator

https://github.com/network-analytics/udp-notif-scapy

- Goals
- Current Support
- Planned Support
- Implementation details
  - Used YANG module
  - Implemented JSON messages
  - Implemented XML messages
  - CBOR encoding details

UDP-Notif YANG-push mock generator: Goals

- Mock messages for YANG-push using UDP-Notif transport
  - Data-plane
  - Ctrl-plane
- Support new YANG-push drafts for integration in the global architecture
- Support multiple encodings
  - XML
  - JSON
  - (CBOR)
- Based on Scapy
- MIT License

YANG-push mock generator: Current support

- YANG-push flows
  - Subscription started → Push Updates → Subscription terminated
  - Subscription started → Push Updates → Subscription modified → Push Updates → Subscription terminated
- Supported drafts in YANG-push notifications:
  - draft-ietf-netconf-distributed-notif
  - draft-ahuang-netconf-notif-yang
  - draft-tgraf-netconf-notif-sequencing
  - draft-tgraf-yang-push-observation-time
  - draft-tgraf-netconf-yang-notifications-versioning
  - RFC8639 - Subscribed Notifications
  - RFC8641 - YANG-push
  - RFC7223 - A YANG Data Model for Interface Management
- Transport:
  - UDP-notif (-09): https://datatracker.ietf.org/doc/html/draft-ietf-netconf-udp-notif-09
  - UDP pub channel (-05): https://datatracker.ietf.org/doc/html/draft-ietf-netconf-udp-pub-channel-05
- Encoding
  - YANG-JSON (RFC7951) and XML (RFC7950) supported

YANG-push Scapy mock generator: Planned

- Encoding
  - **RFC7950** YANG 1.1 XML (supported)
  - **RFC7951** YANG-JSON (supported)
  - **RFC9254 YANG-CBOR (ongoing)**

Implementation Details

Used YANG module: ietf-interfaces.yang [RFC8343]

ietf-interfaces@2018-02-20.yang

```
module: ietf-interfaces
  +--rw interfaces
     +--rw interface* [name]
        +--rw name                            string
        +--rw description?                    string
        +--rw type                            identityref
        +--rw enabled?                        boolean
        +--rw link-up-down-trap-enable?       enumeration {if-mib}?
        +--ro admin-status                    enumeration {if-mib}?
        +--ro oper-status                     enumeration
        +--ro last-change?                    yang:date-and-time
        +--ro if-index                        int32 {if-mib}?
        +--ro phys-address?                   yang:phys-address
        +--ro higher-layer-if*                interface-ref
        +--ro lower-layer-if*                 interface-ref
        +--ro speed?                          yang:gauge64
        +--ro statistics
           +--ro discontinuity-time    yang:date-and-time
           +--ro in-octets?            yang:counter64
           +--ro in-unicast-pkts?      yang:counter64
           +--ro in-broadcast-pkts?    yang:counter64
           +--ro in-multicast-pkts?    yang:counter64
           +--ro in-discards?          yang:counter32
           +--ro in-errors?            yang:counter32
           +--ro in-unknown-protos?    yang:counter32
           +--ro out-octets?           yang:counter64
           +--ro out-unicast-pkts?     yang:counter64
           +--ro out-broadcast-pkts?   yang:counter64
           +--ro out-multicast-pkts?   yang:counter64
           +--ro out-discards?         yang:counter32
           +--ro out-errors?           yang:counter32
```

ietf-interfaces@2023-04-30.yang

```
module: ietf-interfaces
  +--rw interfaces
     +--rw interface* [name]
        +--rw name                            string
        +--rw description?                    string
        +--rw mtu                             uint32
        +--rw type                            identityref
        +--rw enabled?                        boolean
        +--rw link-up-down-trap-enable?       enumeration {if-mib}?
        +--ro admin-status                    enumeration {if-mib}?
        +--ro oper-status                     enumeration
        +--ro last-change?                    yang:date-and-time
        +--ro if-index                        int32 {if-mib}?
        +--ro phys-address?                   yang:phys-address
        +--ro higher-layer-if*                interface-ref
        +--ro lower-layer-if*                 interface-ref
        +--ro speed?                          yang:gauge64
        +--ro statistics
           +--ro discontinuity-time    yang:date-and-time
           +--ro in-octets?            yang:counter64
           +--ro in-unicast-pkts?      yang:counter64
           +--ro in-broadcast-pkts?    yang:counter64
           +--ro in-multicast-pkts?    yang:counter64
           +--ro in-discards?          yang:counter32
           +--ro in-errors?            yang:counter32
           +--ro in-unknown-protos?    yang:counter32
           +--ro out-octets?           yang:counter64
           +--ro out-unicast-pkts?     yang:counter64
           +--ro out-broadcast-pkts?   yang:counter64
           +--ro out-multicast-pkts?   yang:counter64
           +--ro out-discards?         yang:counter32
           +--ro out-errors?           yang:counter32
```

New leaf: mtu

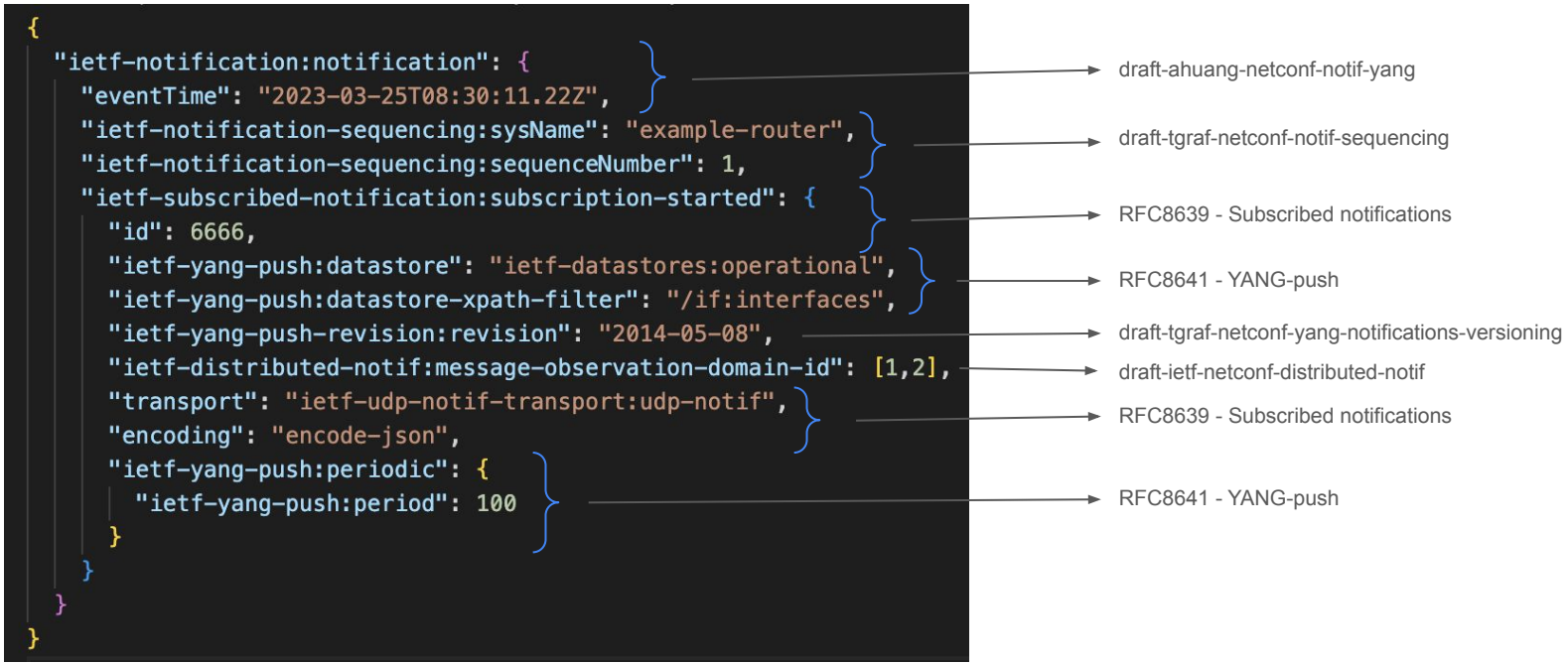
UDP-Notif mock generator

https://github.com/network-analytics/udp-notif-scapy

- Goals
- Current Support
- Planned Support
- Implementation details
  - Used YANG module
  - **Implemented JSON messages**
  - Implemented XML messages
  - CBOR encoding details

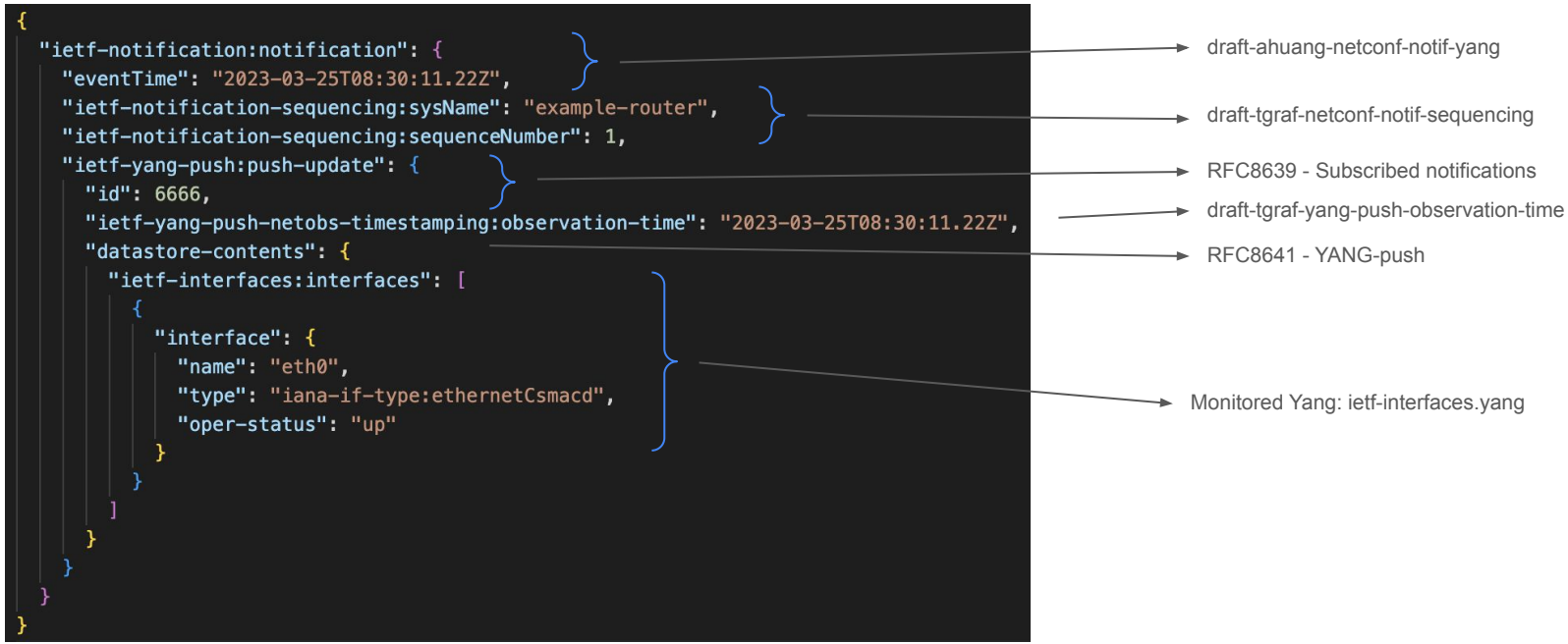
Implementation Details

Implemented JSON messages – <subscription-started>



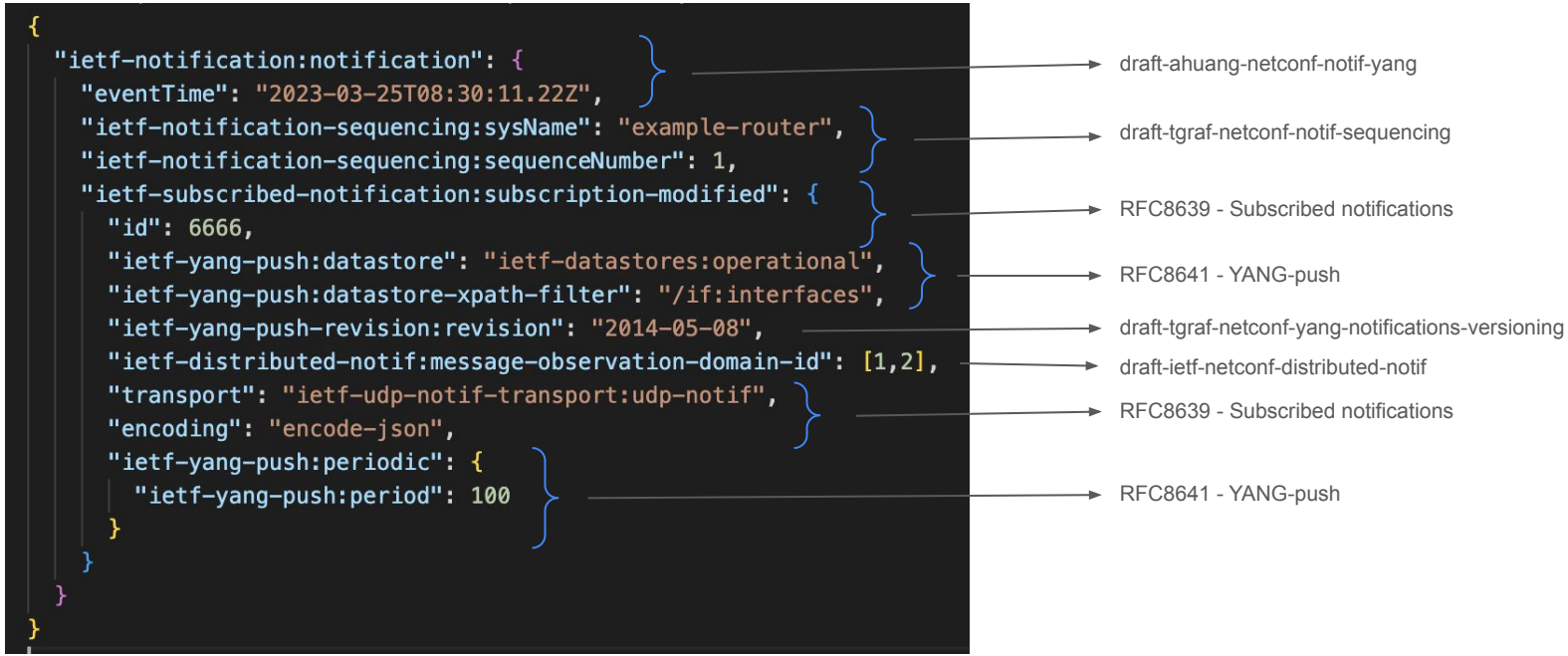
Implementation Details

Implemented JSON messages – <push-update>



Implementation Details

Implemented JSON messages – <subscription-modified>



Implementation Details

Implemented JSON messages – **Updated** <push-update>

Scapy mock generator

https://github.com/network-analytics/udp-notif-scapy

- Goals
- Current Support
- Planned Support
- Implementation details
  - Used YANG module
  - Implemented JSON messages
  - **Implemented XML messages**
  - CBOR encoding details

Implementation Details

Implemented XML messages – <subscription-started>

```
<notification xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
  <eventTime>2022-09-02T10:59:55.32Z</eventTime>
  <sysName xmlns="urn:ietf:params:xml:ns:yang:ietf-notification-sequencing">example-router</sysName>
  <sequenceNumber xmlns="urn:ietf:params:xml:ns:yang:ietf-notification-sequencing">1</sequenceNumber>
  <subscription-started xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notification">
    <id>6666</id>
    <datastore xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push"
      xmlns:ds="urn:ietf:params:xml:ns:yang:ietf-datastores">ds:operational</datastore>
    <datastore-xpath-filter xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push"
      xmlns:if="urn:ietf:params:xml:ns:yang:ietf-interfaces">/if:interfaces</datastore-xpath-filter>
    <revision xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push-revision">2014-05-08</revision>
    <message-observation-domain-id xmlns="urn:ietf:params:xml:ns:yang:ietf-distributed-notif">1</message-observation-domain-id>
    <message-observation-domain-id xmlns="urn:ietf:params:xml:ns:yang:ietf-distributed-notif">2</message-observation-domain-id>
    <transport xmlns:unt="urn:ietf:params:xml:ns:yang:ietf-udp-notif-transport">unt:udp-notif</transport>
    <encoding>encode-xml</encoding>
    <periodic xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">
      <period>100</period>
    </periodic>
  </subscription-started>
</notification>
```

- draft-ahuang-netconf-notif-yang
- draft-tgraf-netconf-notif-sequencing
- RFC8639 - Subscribed notifications
- RFC8641 - YANG-push
- draft-tgraf-netconf-yang-notifications-versioning
- draft-ietf-netconf-distributed-notif
- RFC8639 - Subscribed notifications
- RFC8641 - YANG-push

Implementation Details

Implemented XML messages – <push-update>

```
<notification xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
  <eventTime>2022-09-02T10:59:55.32Z</eventTime>
  <sysName xmlns="urn:ietf:params:xml:ns:yang:ietf-notification-sequencing">example-router</sysName>
  <sequenceNumber xmlns="urn:ietf:params:xml:ns:yang:ietf-notification-sequencing">1</sequenceNumber>
  <push-update xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">
    <id>6666</id>
    <observation-time xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push-netobs-timestamping">
      2022-09-02T10:59:55.32Z
    </observation-time>
    <datastore-contents>
      <interfaces xmlns="urn:ietf:params:xml:ns:yang:ietf-interfaces">
        <interface>
          <name>eth0</name>
          <type xmlns:ianaift="urn:ietf:params:xml:ns:yang:iana-if-type">ianaift:ethernetCsmacd</type>
          <oper-status>up</oper-status>
        </interface>
      </interfaces>
    </datastore-contents>
  </push-update>
</notification>
```

draft-ahuang-netconf-notif-yang

draft-tgraf-netconf-notif-sequencing

RFC8639 - Subscribed notifications

draft-tgraf-yang-push-observation-time

RFC8641 - YANG-push

Monitored Yang: ietf-interfaces.yang

Implementation Details

Implemented XML messages – <subscription-modified>


```
<notification xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
  <eventTime>2022-09-02T10:59:55.32Z</eventTime>
  <sysName xmlns="urn:ietf:params:xml:ns:yang:ietf-notification-sequencing">example-router</sysName>
  <sequenceNumber xmlns="urn:ietf:params:xml:ns:yang:ietf-notification-sequencing">1</sequenceNumber>
  <subscription-modified xmlns="urn:ietf:params:xml:ns:yang:ietf-subscribed-notification">
    <id>6666</id>
    <datastore xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push"
      xmlns:ds="urn:ietf:params:xml:ns:yang:ietf-datastores">ds:operational</datastore>
    <datastore-xpath-filter xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push"
      xmlns:if="urn:ietf:params:xml:ns:yang:ietf-interfaces">/if:interfaces</datastore-xpath-filter>
    <revision xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push-revision">2014-05-08</revision>
    <message-observation-domain-id xmlns="urn:ietf:params:xml:ns:yang:ietf-distributed-notif">1</message-observation-domain-id>
    <message-observation-domain-id xmlns="urn:ietf:params:xml:ns:yang:ietf-distributed-notif">2</message-observation-domain-id>
    <transport xmlns:unt="urn:ietf:params:xml:ns:yang:ietf-udp-notif-transport">unt:udp-notif</transport>
    <encoding>encode-xml</encoding>
    <periodic xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">
      <period>100</period>
    </periodic>
  </subscription-modified>
</notification>
```

Implementation Details

Implemented XML messages – **Updated** <push-update>

```
<notification xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
  <eventTime>2022-09-02T10:59:55.32Z</eventTime>
  <sysName xmlns="urn:ietf:params:xml:ns:yang:ietf-notification-sequencing">example-router</sysName>
  <sequenceNumber xmlns="urn:ietf:params:xml:ns:yang:ietf-notification-sequencing">1</sequenceNumber>
  <push-update xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push">
    <id>6666</id>
    <observation-time xmlns="urn:ietf:params:xml:ns:yang:ietf-yang-push-netobs-timestamping">
      2022-09-02T10:59:55.32Z
    </observation-time>
    <datastore-contents>
      <interfaces xmlns="urn:ietf:params:xml:ns:yang:ietf-interfaces">
        <interface>
          <name>eth0</name>
          <type xmlns:ianaift="urn:ietf:params:xml:ns:yang:iana-if-type">ianaift:ethernetCsmacd</type>
          <oper-status>up</oper-status>
          <mtu>1500</mtu>
        </interface>
      </interfaces>
    </datastore-contents>
  </push-update>
</notification>
```

draft-ahuang-netconf-notif-yang

draft-tgraf-netconf-notif-sequencing

RFC8639 - Subscribed notifications

draft-tgraf-yang-push-observation-time

RFC8641 - YANG-push

Monitored Yang: ietf-interfaces-**02**.yang

Scapy mock generator

https://github.com/network-analytics/udp-notif-scapy

- Goals
- Current Support
- Planned Support
- Implementation details
  - Used YANG module
  - Implemented JSON messages
  - Implemented XML messages
  - **CBOR encoding details**

CBOR encoding details

Dates encoded as:

- Major Type 6; Tag 0: Standard Date/time string as defined in RFC3339
  - `“2023-04-12T23:20:50.52Z”`

YANG-push Open-source projects

- UDP-notif mock generator: https://github.com/network-analytics/udp-notif-scapy
- **Kafka Schema Registry**: **https://github.com/network-analytics/schema-registry-dev**
- UDP-notif c-collector and c-publisher: https://github.com/insa-unyte/udp-notif-c-collector
- HTTPS-notif c-collector: https://github.com/network-analytics/https-notif-c-collector
- libyangpush: (to be open-sourced)

Kafka Schema Registry

YANG integration

https://github.com/network-analytics/schema-registry-dev

- Context
- Goals
- Current Support
- Ongoing Development
- Use-cases to test

Kafka Schema Registry: Context

- Schema registry allows the validation of Kafka messages at the producer and consumer level
- Supports schema versioning and backwards compatibility checks
- Current supported schema encodings:
  - AVRO
  - ProtoBuf
  - JSON Schema

Schema Registry documentation: https://docs.confluent.io/platform/current/schema-registry/fundamentals/index.html

Kafka Schema Registry - YANG integration: Goals

- Use YANG as a schema encoding for validating Kafka messages
- Serialization and Deserialization of YANG encodings
  - YANG-JSON (RFC7951)
  - YANG-CBOR (RFC9254)

Kafka Schema Registry: Current Support

- Registration of YANG module developed by Ahmed Elhassany (Swisscom)
- Schema Registry is capable of
  - Register a new YANG module as a new **`subject`**
  - Validate dependencies from the YANG module before registering the **`subject`**
- Used YANG parsing library: Yangkit (https://github.com/yang-central/yangkit)

Kafka Schema Registry: Ongoing Development

- Serialization and Deserialization of YANG encodings messages
  - YANG-JSON (Ongoing development lead by Alex Huang Feng)
  - YANG-CBOR (WIP)
- Validation of the YANG message using Yangkit

- How can schema registry validate against multiple YANG modules?
- 2 options:
  - (1) Compile a new YANG module combining all related YANG modules into a single YANG
  - (2) Register all IETF raw YANG modules into Yangkit and validate the notification directly against a SchemaContext regrouping all registered modules

Kafka schema registry design

- 2 options:
  - (1) Compile a new YANG module combining all related YANG modules into a single YANG
  - (2) Register all IETF raw YANG modules into Yangkit and validate the notification directly against a SchemaContext regrouping all registered modules

Validating a YANG-encoded message against schema registry

(1) Compile a new YANG module have

Pros

- Yangkit only need to validate the message against **one** YANG module
- Xpath/subtree filter from subscription already computed in the new YANG module

Cons

- Having the same name as the raw yang modules can overlap with already registered YANG modules
  - Multiple YANG modules need to be implemented in the same yang file to align YANG namespaces (To confirm)

(2) Validate message against all RAW IETF modules registered at Yangkit

Pros

- Schema registry registers untransformed YANG modules from the routers

Cons

- If two router send different versions of a YANG module, multiple schema registry need to be instantiated
- The Xpath/subtree filter need to be computed against after the message validation

Kafka schema registry design

- 2 options:
  - (1) Compile a new YANG module combining all related YANG modules into a single YANG
  - (2) Register all IETF raw YANG modules into Yangkit and validate the notification directly against a SchemaContext regrouping all registered modules

Kafka Schema Registry: Use-cases validation @Yangkit

Usecase #1 (Option 2)

YANG module: container with 2 leaves

```
module insa-custom {
  yang-version 1;
  namespace "urn:ietf:params:xml:ns:yang:insa-yang";
  prefix iny;

  contact "alex.huang-feng@insa-lyon.fr";
  organization "INSA Lyon";
  description "insa-custom yang module";

  revision 2019-09-09 {
    description "Initial version.";
  }

  container insa-container {
    config false;
    leaf computer {
      type string;
      description "computer";
    }
    leaf router {
      type uint8;
      description "router";
    }
  }
}
```

Message: valid JSON encoded message

```
{
  "insa-custom:insa-container": {
    "computer": "computer",
    "router": 234
  }
}
```

Is XPath one of the parameters for Schema Registry? ***No***

Kafka Schema Registry: Use-cases validation @Yangkit

Usecase #2 (Option 2)

Register all YANG module

Message: valid JSON encoded message

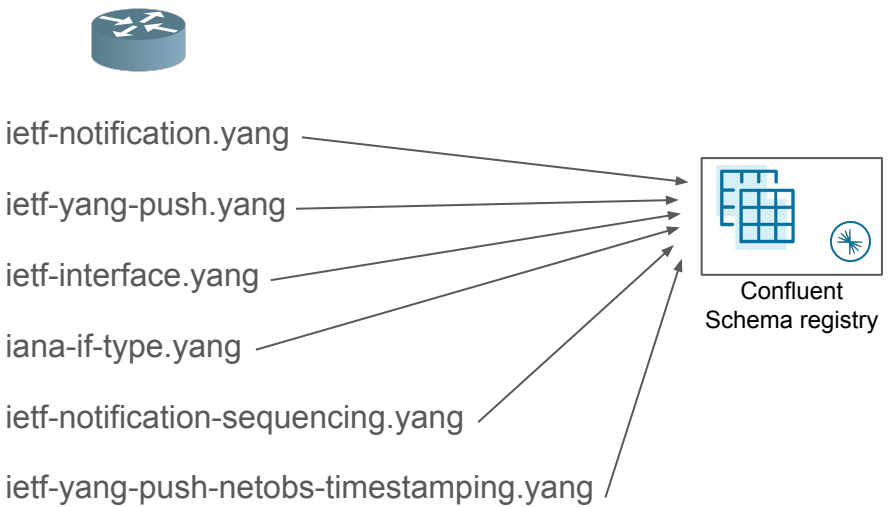
```
{
  "ietf-notification:notification": {
    "eventTime": "2023-03-25T08:30:11.22Z",
    "ietf-yang-push:push-update": {
      "id": 6666,
      "datastore-contents": {
        "ietf-interfaces:interfaces": [
          {
            "interface": {
              "name": "eth0",
              "type": "iana-if-type:ethernetCsmacd",
              "oper-status": "up",
              "mtu": 1500
            }
          }
        ]
      }
    }
  }
}
```

Yangkit validates JSON message from SchemaContext

Kafka Schema Registry: Use-cases validation @Yangkit

Usecase #3 (Option 2)

Register all YANG module



Message: valid JSON encoded message


```
{
  "ietf-notification:notification": {
    "eventTime": "2023-03-25T08:30:11.22Z",
    "ietf-notification-sequencing:sysName": "example-router",
    "ietf-notification-sequencing:sequenceNumber": 1,
    "ietf-yang-push:push-update": {
      "id": 6666,
      "ietf-yang-push-netobs-timestamping:observation-time": "2023-03-25T08:30:11.22Z",
      "datastore-contents": {
        "ietf-interfaces:interfaces": [
          {
            "interface": {
              "name": "eth0",
              "type": "iana-if-type:ethernetCsmacd",
              "oper-status": "up",
              "mtu": 1500
            }
          }
        ]
      }
    }
  }
}
```


Yangkit validates JSON message from SchemaContext

YANG-push Open-source projects

- UDP-notif mock generator: https://github.com/network-analytics/udp-notif-scapy
- Kafka Schema Registry: https://github.com/network-analytics/schema-registry-dev
- **UDP-notif c-collector and c-publisher: https://github.com/insa-unyte/udp-notif-c-collector**
- HTTPS-notif c-collector: https://github.com/network-analytics/https-notif-c-collector
- libyangpush: (to be open-sourced)

UDP-notif
C-collector & C-publisher

https://github.com/insa-unyte/udp-notif-c-collector

- Goals
- Current Support
- Planned Support

UDP-notif C-collector & C-publisher: Goals

- Reference implementation for the collection of UDP-notif messages in C
- Implementation as a library to ease third parties integration
- MIT Licence

UDP-notif C-collector & C-publisher: Current Support

- Serialization and Deserialization of UDP-notif header
- Support of current and legacy protocol:
  - draft-ietf-netconf-udp-notif (06): https://datatracker.ietf.org/doc/draft-ietf-netconf-udp-notif/
  - draft-ietf-netconf-udp-pub-channel (05): https://datatracker.ietf.org/doc/html/draft-ietf-netconf-udp-pub-channel-05
- Segmentation reassembly
- IPv4 and IPv6 supported
- Receive multiple message at once using **`recvmmsg`**
- Socket file descriptor as a parameter
- Monitoring of packet drops by the lib

UDP-notif C-collector & C-publisher: Planned Support

- DTLS1.3 encryption as defined in Section 6

UDP-notif C-collector & C-publisher: Milestones

- First performance tests presented at IETF Hackathon 110
- Library integrated to pmacct

YANG-push Open-source projects

- UDP-notif mock generator: https://github.com/network-analytics/udp-notif-scapy
- Kafka Schema Registry: https://github.com/network-analytics/schema-registry-dev
- UDP-notif c-collector and c-publisher: https://github.com/insa-unyte/udp-notif-c-collector
- **HTTPS-notif c-collector: https://github.com/network-analytics/https-notif-c-collector**
- libyangpush: (to be open-sourced)

HTTPS-notif C-collector

https://github.com/network-analytics/https-notif-c-collector

- Goals
- Current Support

HTTPS-notif C-collector: Goals

- Reference implementation for the collection of HTTPS-notif messages in C
- Implementation as a library to ease third parties integration
- MIT License

HTTPS-notif C-collector: Current Support

- Deserialization of HTTPS-notif header as defined in https://datatracker.ietf.org/doc/draft-ietf-netconf-https-notif/
- IPv4 and IPv6 supported
- HTTPS decoding with **`microhttpd`**

YANG-push Open-source projects

- UDP-notif mock generator: https://github.com/network-analytics/udp-notif-scapy
- Kafka Schema Registry: https://github.com/network-analytics/schema-registry-dev
- UDP-notif c-collector and c-publisher: https://github.com/insa-unyte/udp-notif-c-collector
- HTTPS-notif c-collector: **https://github.com/network-analytics/https-notif-c-collector**
- **libyangpush**: (to be open-sourced)

libyangpush

(to be open-sourced)

Implementation provided by Zhouyao Lin (Huawei)

- Goals
- Current Support
- Milestones

libyangpush: Goals

- Get all the YANG modules involved in a YANG-push subscription using **`datastore-xpath-filter`** / **`datastore-subtree-filter`** field
- Find YANG dependencies for the involved YANG modules
- Generate a registration list for Kafka Schema registry

libyangpush: Current Support

- Parse XML **`push-update`** notification
- Get the datastore-xpath-filter
- Fetch from a NETCONF server the YANG modules
- Register the YANG modules in the Schema Registry
- Cache the retrieved YANG modules

libyangpush: Milestones

- PoC with mock messages was presented in IETF Hackathon 116

We want to thank the following contributors for their invaluable contributions

- Ahmed Elhassany (Swisscom)
- Zhouyao Lin (Huawei)
- Jean Quilbeauf (Huawei)
- Chong Feng (Frank) (Huawei)

References

- YANG-push
  - RFC8639: Subscription to YANG Notifications
  - RFC8641: Subscription to YANG Notifications for Datastore Updates
- Definition of a Datastore:
  - RFC 8342: Network Management Datastore Architecture (NMDA)
- Encoding:
  - RFC7950: The YANG 1.1 Data Modeling Language (for XML)
  - RFC7951: JSON Encoding of Data Modeled with YANG
  - RFC9254: Encoding of Data Modeled with YANG in CBOR
- YANG-push RPCs and notifications in XML:
  - https://github.com/network-analytics/udp-notif-scapy/tree/main/src/resources/xml
- YANG-push notification in JSON:
  - https://github.com/network-analytics/udp-notif-scapy/tree/main/src/resources/json/notifications

Some feedbacks from discussions

- One stream is a set of datastore changes
- If we want to change a subscription, it is better to terminate the subscription and create a new one
- No opinion in “on-change” subscription yet
- Scapy implementation: think about not only changing the version, but changing the xpath we are subscribed to

Do not publish

Backup slides / Old slides

What messages to implement in Scapy (periodic)?

1. <subscription-started> for monitored YANG module (ietf-interfaces.yang)
2. <subscription-started> for monitored YANG-push subscription
3. N messages <push-update> of “ietf-interfaces.yang” messages
4. M messages <push-update> of YANG-push subscription

(simulating here the ietf-interfaces.yang version change)

5. <subscription-modified> for monitored YANG module (ietf-interfaces.yang)
6. N messages <push-update> of new “ietf-interfaces.yang” messages

Assuming we know a reference to the YANG module during the subscription

What messages to implement in Scapy (on-change)?

1. <subscription-started> for monitored YANG module (ietf-interfaces.yang)
2. <subscription-started> for monitored YANG-push subscription
3. N messages <push-update> of “ietf-interfaces.yang” messages

(simulating here the ietf-interfaces.yang version change)

4. <push-change-update> for YANG-push subscription
5. <subscription-modified> for monitored YANG module (ietf-interfaces.yang)
6. N messages <push-update> of new “ietf-interfaces.yang” messages

Assuming we know a reference to the YANG module during the subscription

TODO

- Add libyangpush?
- Add valid example for subtree filter in subscription