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NETCONF Event Notifications
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Abstract

This document defines mechanisms which provide an asynchronous message notification delivery service for the NETCONF protocol. This is an optional capability built on top of the base NETCONF definition. This document defines the capabilities, operations, transport mappings, and data models necessary to support this service.

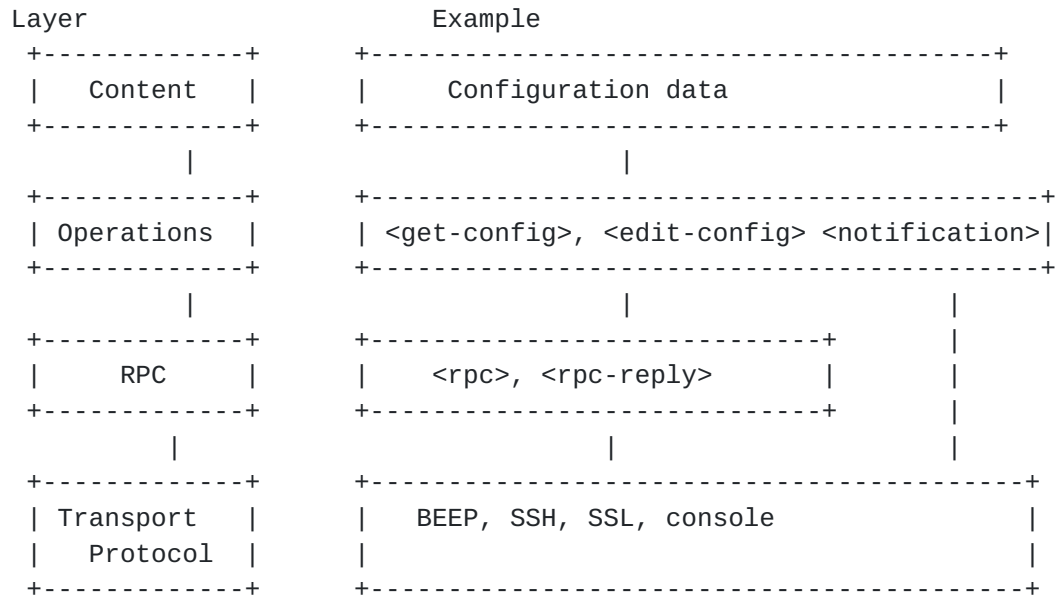
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1. Introduction

[NETCONF] can be conceptually partitioned into four layers:



This document defines mechanisms which provide an asynchronous message notification delivery service for the [NETCONF] protocol. This is an optional capability built on top of the base NETCONF definition. This memo defines the capabilities, operations, transport mappings, and data models necessary to support this service.

Figure 1

1.1. Definition of Terms

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 [RFC2119].

Element: An [XML] Element.

Managed Object: A collection of one of more Elements that define an abstract thing of interest.

Subscription: A concept related to the delivery of notifications (if any to send) involving destination and selection of notifications. It is bound to the lifetime of a session.

Operation: This term is used to refer to NETCONF protocol operations. Specifically within this document, operation refers to NETCONF protocol operations defined in support of NETCONF notifications.

1.2. Event Notifications in NETCONF

An event is something that happens which may be of interest - a configuration change, a fault, a change in status, crossing a threshold, or an external input to the system, for example. Often this results in an asynchronous message, sometimes referred to as a notification or event notification, being sent out to interested parties to notify them that this event has occurred.

This memo defines a mechanism whereby the NETCONF client indicates interest in receiving event notifications from a NETCONF server by creating a subscription to receive event notifications. The NETCONF server replies to indicate whether the subscription request was successful and, if it was successful, begins sending the event notifications to the NETCONF client as the events occur within the system. These event notifications will continue to be sent until either the NETCONF session is terminated or some event, outside the scope of this specification, causes the subscription to terminate. The event notification subscription allows a number of options to enable the NETCONF client to specify which events are of interest. These are specified when the subscription is created.

An NETCONF server is not required to process RPC requests on the session associated with the subscription until the notification stream is done. A capability may be advertised to announce that a server is able to process RPCs while a notification stream is active on a session.

1.3. Motivation

The motivation for this work is to enable the sending of asynchronous messages that are consistent with the data model (content) and security model used within a Netconf implementation.

1.4. Requirements

The following requirements have been addressed by the solution:

- o Initial release should ensure it supports notification in support of configuration operations
- o Data content must not preclude the use of the same data model as used in configuration

- o solution should support a reasonable message size limit (syslog and SNMP are rather constrained in terms of message sizes)
- o solution should provide reliable delivery of notifications
- o solution should provide a subscription mechanism (A NETCONF server does not send notifications before asked to do so and the NETCONF client initiates the flow of notifications)
- o solution should provide a filtering mechanism within the Netconf server
- o solution should send sufficient information in a notification so that it can be analyzed independent of the transport mechanism (data content fully describes a notification; protocol information is not needed to understand a notification)
- o solution should support replay of locally logged notifications

2. Notification-Related Operations

2.1. Subscribing to receive Event Notifications

The event notification subscription is initiated by the NETCONF client and responded to by the NETCONF server. When the event notification subscription is created, the events of interest are specified.

Content for an event notification subscription can be selected by applying user-specified filters.

2.1.1. <create-subscription>

Description:

This operation initiates an event notification subscription which will send asynchronous event notifications to the initiator of the command until the NETCONF session terminates or some event, outside the scope of this specification, causes the subscription to terminate.

Parameters:

Streams:

An optional parameter that indicates which stream(s) of events are of interest. If not present, then events in the default NETCONF stream will be sent.

Filter:

An optional parameter that indicates which subset of all possible events are of interest. The format of this parameter is the same as that of the filter parameter in the NETCONF protocol operations. If not present, all events not precluded by other parameters will be sent.

Named Profile:

An optional parameter that points to a separately defined filter profile. The contents of the profile are specified in the provided [XML Schema]. If not present, no additional filtering will be applied. Note that changes to the profile after the subscription has been created will have no effect.

Start Time:

A parameter used with the optional replay capability to signals that this is a replay subscription and that the replay should start at the time specified. If start time is not present, this is not a replay subscription. Stop time for replay is implicitly defined to be the time the create-subscription command was received by the Netconf server.

Positive Response:

If the NETCONF server can satisfy the request, the server sends an <ok> element.

Negative Response:

An <rpc-error> element is included within the <rpc-reply> if the request cannot be completed for any reason. Subscription requests will fail if a filter with invalid syntax is provided or if the name of a non-existent profile or stream is provided.

2.1.2. Filter Dependencies

When multiple filters are specified (in-line Filter, Named Profiles), they are applied collectively (i.e. logical AND operation). That is, event notifications must pass all specified filters in order to be sent to the subscriber.

2.2. Sending Event Notifications

Once the subscription has been set up, the NETCONF server sends the event notifications asynchronously along the connection.

2.2.1. <notification>**Description:**

An event notification is sent to the initiator of a <create-subscription> command asynchronously when an event of interest (i.e. meeting the specified filtering criteria) to them has occurred. An event notification is a complete XML document. Note that <notification> is not an RPC method but rather the top level element identifying the one way message as a notification.

Parameters:

Data:

Contains notification-specific tagged content.

Response:

No response. Not applicable.

2.3. Terminating the Subscription

Closing of the event notification subscription is done by terminating the Netconf session (<kill-session>) or via some action outside the scope of this specification.

3. Supporting Concepts

3.1. Capabilities Exchange

The ability to process and send event notifications is advertised during the capability exchange between the NETCONF client and server.

"urn:ietf:params:xml:ns:netconf:capability:notification:1.0"

For Example

```
<hello xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <capabilities>
    <capability>
      urn:ietf:params:xml:ns:netconf:base:1.0
    </capability>
    <capability>
      urn:ietf:params:xml:ns:netconf:capability:startup:1.0
    </capability>
    <capability>
      urn:ietf:params:xml:ns:netconf:capability:notification:1.0
    </capability>
  </capabilities>
  <session-id>4</session-id>
</hello>
```

3.2. Event Streams

An event stream is defined herein as a set of event notifications matching some forwarding criteria.

System components generate event notifications which are passed to a central component for classification and distribution. The central component inspects each event notification and matches the event notification against the set of stream definitions. When a match occurs, the event notification is considered to be a member of that event stream. An event notification may be part of multiple event streams.

When a NETCONF client subscribes to a given event stream, user-defined filters, if applicable, are applied to the event stream and matching event notifications are forwarded to the NETCONF server for distribution to subscribed NETCONF clients.


```

+----+
| c1 |---+          available streams
+----+ | +-----+
+----+ | |central |-> stream 1
| c2 | +--->|event  |-> stream 2   filter +-----+
+----+ | |processor|-> netconf stream --->|netconf|
...    | |         |-> stream n           |server | see
System | +-----+                               +-----+ below
Components| |                                     //
...      | |                                     //
+----+   | | (-----)
| cn |---+ | (notification)
+----+   +-----> ( logging )
                ( service )
                (-----)

                +-----+ +-----+
                |netconf|<--->|netconf|
-> |server |   |client |
                +-----+ +-----+

```

[3.2.1.](#) Event Stream Definition

Event streams are predefined on the managed device. The configuration of event streams is outside the scope of this document. However, it is envisioned that event streams are either pre-established by the vendor (pre-configured) or user configurable (e.g. part of the device's configuration) or both. Device vendors may allow event stream configuration via NETCONF protocol (i.e. edit-config operation)

[3.2.2.](#) Event Stream Content Format

The contents of all event streams made available to a NETCONF client (i.e. the notification sent by the NETCONF server) must be encoded in XML.

[3.2.3.](#) Default Event Stream

A NETCONF server implementation supporting the notification capability must support the "NETCONF" notification event stream. This stream contains all NETCONF XML event notifications supported by the NETCONF server. The definition of the event notification and their contents for this event stream is outside the scope of this document.

3.2.4. Event Stream Sources

With the exception of the default event stream (NETCONF notifications) specification of additional event stream sources (e.g. SNMP, syslog, etc.) is outside the scope of this document. NETCONF server implementations may leverage any desired event stream source in the creation of supported event streams.

3.2.5. Event Stream Discovery

A NETCONF client retrieves the list of supported event streams from a NETCONF server using the <get> RPC request.

3.2.5.1. Name Retrieval using <get> operation

The list of available event streams is retrieved by requesting the <eventStreams> subtree via a <get> operation. Available event streams for the requesting session are returned in the reply containing <name> and <description> elements, where <name> element is mandatory and its value is unique [Editor's Note: should we then define it as a key?]. The returned list must only include the names of those event streams for which the NETCONF session has sufficient privileges. The NETCONF session privileges are determined via access control mechanisms which are beyond the scope of this document. An empty reply is returned if there are no available event streams.

Retrieving available event stream list using <get> operation:

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

  <get>
    <filter type="subtree">
      <top xmlns="urn:ietf:params:xml:ns:netmod:base:1.0">
        <eventStreams/>
      </top>
    </filter>
  </get>
</rpc>

<rpc-reply message-id="101"
  xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <data>
    <top xmlns="urn:ietf:params:xml:ns:netmod:base:1.0">
      <eventStreams>
        <stream>
          <name>NETCONF</name>
          <description>Default netconf event stream
          </description>
        </stream>
        <stream>
          <name>snmp</name>
          <description>SNMP notifications</description>
        </stream>
        <stream>
          <name>syslog-critical</name>
          <description>Critical and higher severity
          </description>
        </stream>
      </eventStreams>
    </top>
  </data>
</rpc-reply>
```

3.2.5.2. Device Supported Event Streams (System)

The list of all event streams configured on a device may be retrieved over a NETCONF session with sufficient privileges (e.g. administrator). The information is retrieved by requesting the <eventStreams> subtree via a <get> operation.

3.2.5.3. Stream Retrieval Schema

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
  xmlns:netconf="urn:ietf:params:xml:ns:netconf:base:1.0"
  elementFormDefault="qualified"
  attributeFormDefault="unqualified">
  <xs:annotation>
    <xs:documentation xml:lang="en">
      Schema for event streams
    </xs:documentation>
  </xs:annotation>
  <xs:appinfo>
    <nm:identity
      xmlns:nm="urn:ietf:params:xml:ns:netmod:base:1.0">
      <nm:Name>
        NetconfNotificationSchema
      </nm:Name>
      <nm:LastUpdated>
        2006-09-06T09:30:47-05:00
      </nm:LastUpdated>
      <nm:Organization>IETF
      </nm:Organization>
      <nm:Description>
        A schema that can be used to learn about current
        event streams.
      </nm:Description>
    </nm:identity>
  </xs:appinfo>
</xs:annotation>

  <xs:import namespace="http://www.w3.org/XML/1998/namespace"
    schemaLocation="http://www.w3.org/2001/xml.xsd"/>
  <xs:import namespace="urn:ietf:params:xml:ns:netconf:base:1.0"
    schemaLocation="./draft-ietf-netconf-prot-12.xsd"/>

  <xs:element name="eventStreams">
    <xs:annotation>
      <xs:documentation>
        The list of event streams supported by the system.
        When a query is issued, the returned set of streams is
        determined based on user privileges
      </xs:documentation>
    </xs:annotation>
    <xs:complexType>
      <xs:sequence maxOccurs="unbounded">
```



```
<xs:element name="stream">
  <xs:annotation>
    <xs:documentation>
      Stream name and description
    </xs:documentation>
  </xs:annotation>
  <xs:complexType>
    <xs:sequence>
      <xs:element name="name" type="xs:string"/>
      <xs:element name="description" type="xs:string"/>
    </xs:sequence>
  </xs:complexType>
</xs:element>
</xs:sequence>
</xs:complexType>
</xs:element>
</xs:schema>
```

3.2.6. Event Stream Subscription

A NETCONF client may request from the NETCONF server the list of available event streams to this session and then issue a <create-subscription> request with the desired event stream name. Omitting the event stream name from the <create-subscription> request results in subscription to the default NETCONF event stream.

3.2.6.1. Filtering Event Stream Contents

The set of event notifications delivered in an event stream may be further refined by applying a user-specified filter at subscription creation time (<create-subscription>). This is a transient filter associated with the event notification subscription and does not modify the event stream configuration.

3.2.6.2. Subscription to Multiple Event Streams

Multiple event streams may be configured on a device and a NETCONF client may subscribe to one or more of the available event streams.

3.3. Subscriptions not Configuration Data

While it is possible to retrieve information about subscriptions via a get operation, subscriptions are not stored configuration. They are non-persistent state information. In this respect, they are comparable to NETCONF sessions.

Named profiles, if used, are considered configuration data.

3.4. Querying Subscription Properties

The following Schema can be used to retrieve information about active event notification subscriptions

```
<xs:schema
  xmlns:xs="http://www.w3.org/2001/XMLSchema"
  xmlns:ns="urn:ietf:params:xml:ns:netconf:subscription:1.0"
  targetNamespace="urn:ietf:params:xml:ns:netconf:subscription:1.0"
  xmlns:netconf="urn:ietf:params:xml:ns:netconf:base:1.0"
  xmlns:ncEvent="urn:ietf:params:xml:ns:netconf:notification:1.0"
  xmlns:nm="urn:ietf:params:xml:ns:netconf:appInfo:1.0"
  elementFormDefault="qualified" attributeFormDefault="unqualified"
  xml:lang="en">
  <xs:annotation>
    <xs:documentation xml:lang="en">
      Schema for reporting on Event Subscriptions
    </xs:documentation>
    <xs:appinfo>
      <nm:identity
        xmlns:nm="urn:ietf:params:xml:ns:netmod:base:1.0">
        <nm:Name>NetconfNotificationSchema</nm:Name>
        <nm:LastUpdated>2006-09-13T09:30:47-05:00
        </nm:LastUpdated>
        <nm:Organization>IETF</nm:Organization>
        <nm:Description>
          A schema that can be used to learn about current
          NETCONF Event subscriptions and creating named
          profiles
        </nm:Description>
        </nm:identity>
      </xs:appinfo>
    </xs:annotation>

    <xs:import namespace="http://www.w3.org/XML/1998/namespace"
      schemaLocation="http://www.w3.org/2001/xml.xsd"/>
    <xs:import
      namespace="urn:ietf:params:xml:ns:netconf:notification:1.0"
      schemaLocation=
        "urn:ietf:params:xml:ns:netconf:notification:1.0"/>
    <xs:import namespace="urn:ietf:params:xml:ns:netconf:base:1.0"
      schemaLocation="urn:ietf:params:xml:ns:netconf:base:1.0"/>

    <!-- Associations -->

    <xs:element name="associatedNamedProfile" type="xs:string"/>
```



```
<xs:element name="relationships">
  <xs:keyref name="subscriptionToNamedProfile"
    refer="nsub:namedProfileKey">
    <xs:selector xpath="//netconfSubscription"/>
    <xs:field xpath="nsub:associatedNamedProfile"/>
  </xs:keyref>

  <!-- Keys -->

  <xs:key name="namedProfileKey">
    <xs:selector xpath="//namedProfile"/>
    <xs:field xpath="name"/>
  </xs:key>
</xs:element>

<xs:element name="netconfSubscription">
  <xs:annotation>
    <xs:appinfo>
      <nm:minAccess><read/></nm:minAccess>
      <nm:maxAccess><read/></nm:maxAccess>
    </xs:appinfo>
  </xs:annotation>
  <xs:complexType>
    <xs:sequence >

      <xs:element name="session-id"
        type="netconf:SessionId" >
        <xs:annotation>
          <xs:documentation xml:lang="en">
            The session id associated with this
            subscription.
          </xs:documentation>
        </xs:annotation>
      </xs:element>

      <xs:element name="streams"
        type="ncEvent:StreamsList" minOccurs="0">
        <xs:annotation>
          <xs:documentation xml:lang="en">
            A list of event streams associated with this
            subscription.
          </xs:documentation>
        </xs:annotation>
      </xs:element>

      <xs:element name="filter"
        type="netconf:filterInlineType" minOccurs="0">
        <xs:annotation>
```



```
<xs:documentation xml:lang="en">
  The filters associated with this subscription.
</xs:documentation>
</xs:annotation>
</xs:element>

<xs:element ref="nsub:associatedNamedProfile"
              minOccurs="0">
  <xs:annotation>
    <xs:documentation xml:lang="en">
      The named profile associated with this
      subscription. Note that the contents of the
      named profile may have changed since it was
      last applied.
    </xs:documentation>
  </xs:annotation>
</xs:element>

<xs:element name="lastModified"
              type="xs:dateTime" >
  <xs:annotation>
    <xs:documentation xml:lang="en">
      The last time this subscription was modified. If
      it has not been modified since creation, this is
      the time of subscription creation.
    </xs:documentation>
  </xs:annotation>
</xs:element>

<xs:element name="messagesSent"
              type="xs:unsignedInt" minOccurs="0">
  <xs:annotation>
    <xs:documentation xml:lang="en">
      A count of event notifications sent along
      this connection since the subscription was
      created.
    </xs:documentation>
  </xs:annotation>
</xs:element>

<xs:element name="key">
  <xs:key name="uniqueSubscription">
    <xs:selector xpath="./subscription"/>
    <xs:field xpath="session-id"/>
  </xs:key>
</xs:element>
```



```
        </xs:sequence>
      </xs:complexType>
    </xs:element>

    <xs:element name="netconfSubscriptions">
      <xs:complexType>
        <xs:sequence>
          <xs:element ref="nsub:netconfSubscription"
            minOccurs="0"
            maxOccurs="unbounded" />
        </xs:sequence>
      </xs:complexType>
    </xs:element>

    <xs:element name="namedProfile">
      <xs:annotation>
        <xs:appinfo>
          <nm:minAccess><read/></nm:minAccess>
          <nm:maxAccess><read/> <write/> <create/> <delete/>
          </nm:maxAccess>
        </xs:appinfo>
      </xs:annotation>
      <xs:complexType>
        <xs:sequence>

          <xs:element name="name"/>

          <xs:element name="streams"
            type="ncEvent:streamsList" minOccurs="0">
            <xs:annotation>
              <xs:documentation xml:lang="en">
                The event streams associated with this named
                profile.
              </xs:documentation>
            </xs:annotation>
          </xs:element>

          <xs:element name="filter"
            type="netconf:filterInlineType" minOccurs="0">
            <xs:annotation>
              <xs:documentation xml:lang="en">
                The filters associated with this named
                profile.
              </xs:documentation>
            </xs:annotation>
          </xs:element>

          <xs:element name="lastModified" type="xs:dateTime">
```



```

<xs:annotation>
  <xs:documentation>
    The timestamp of the last modification to this
    named Profile. Note that modification of the
    profile does not cause an immediate update
    to all applicable subscription. Therefore,
    this time should be compared with the last
    modified time associated with the
    subscription. If this time is earlier, then
    the subscription is using the exact set of
    parameters associated with this named profile.
    If this time is later, then the subscription
    is using an earlier version of this named
    profile and the exact parameters may not
    match.
  </xs:documentation>
  <xs:appinfo>
    <nm:minAccess><read/></nm:minAccess>
    <nm:maxAccess><read/> </nm:maxAccess>
  </xs:appinfo>
</xs:annotation>
</xs:element>
</xs:sequence>
</xs:complexType>
</xs:element>

<xs:element name="namedProfiles">
  <xs:complexType>
    <xs:sequence>
      <xs:element ref="nsub:namedProfile" minOccurs="0"
        maxOccurs="unbounded" />
    </xs:sequence>
  </xs:complexType>
</xs:element>

</xs:schema>

```

3.5. Filter Dependencies

Note that when multiple filters are specified (in-line Filter, Named Profiles), they are applied collectively, so event notifications need to pass all specified filters in order to be sent to the subscriber. If a filter is specified to look for data of a particular value, and the data item is not present within a particular event notification for its value to be checked against, it will be filtered out. For example, if one were to check for 'severity=critical' in a

configuration event notification where this field was not supported, then the notification would be filtered out.

Note that the order that filters are applied does not matter since the resulting set of notifications is the intersection of the set of notifications that pass each filtering criteria.

3.5.1. Named Profiles

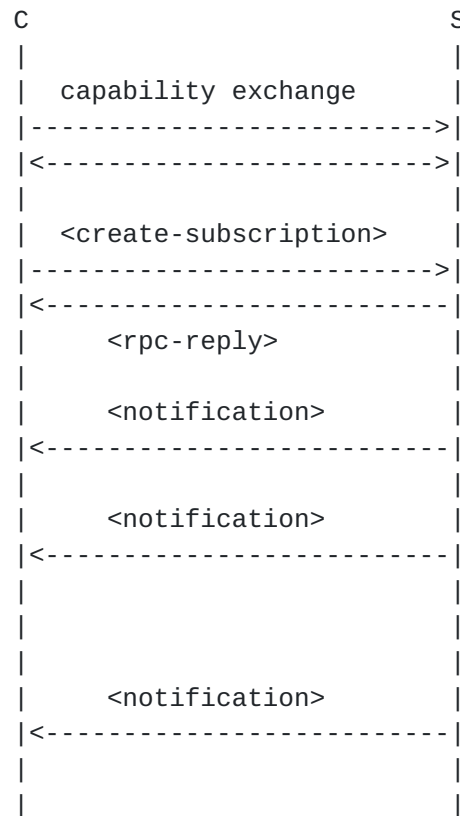
A named profile is a filter that is created ahead of time and applied at the time an event notification subscription is created . Note that changes to the profile after the subscription has been created will have no effect on the subscription. Since named profiles exist outside of the subscription, they persist after the subscription has been torn down.

3.5.2. Filtering

Just-in-time filtering is explicitly stated when the event notification subscription is created. This is specified via the Filter parameter. Filters only exist as parameters to the subscription.

3.6. Message Flow

The following figure depicts message flow between a Netconf client (C) and Netconf server (S) in order create a subscription and begin the flow of notifications.



4. XML Schema for Event Notifications

```
<?xml version="1.0" encoding="UTF-8"?>
  <xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
    xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0"
    xmlns:netconf="urn:ietf:params:xml:ns:netconf:base:1.0"
    targetNamespace="urn:ietf:params:xml:ns:netconf:notification:1.0"
    elementFormDefault="qualified"
    attributeFormDefault="unqualified"
    xml:lang="en">

    <!-- import standard XML definitions -->

    <xs:import namespace="http://www.w3.org/XML/1998/namespace"
      schemaLocation="http://www.w3.org/2001/xml.xsd">
      <xs:annotation>
        <xs:documentation>
          This import accesses the xml: attribute groups for the
          xml:lang as declared on the error-message element.
        </xs:documentation>
      </xs:annotation>
    </xs:import>

    <!-- import base netconf definitions -->
    <xs:import namespace="urn:ietf:params:xml:ns:netconf:base:1.0"
      schemaLocation="urn:ietf:params:xml:ns:netconf:base:1.0" />

    <!-- ***** Type definitions *****-->

    <xs:complexType name="StreamsList">
      <xs:annotation>
        <xs:documentation>
          A list of event streams.
        </xs:documentation>
      </xs:annotation>
      <xs:sequence>
        <xs:element name="stream" maxOccurs="unbounded"/>
      </xs:sequence>
    </xs:complexType>

    <!-- ***** Symmetrical Operations *****-->

    <!-- <create-subscription> operation -->

    <xs:complexType name="createSubscriptionType">
```



```
<xs:complexContent>
  <xs:extension base="netconf:rpcOperationType">
    <xs:sequence>
      <xs:element name="streams"
        type="StreamsList" minOccurs="0"/>
      <xs:element name="filter"
        type="netconf:filterInlineType" minOccurs="0"/>
      <xs:element name="named-profile"
        type="xs:string" minOccurs="0"/>
      <xs:element name="startTime" type="xs:dateTime"
        minOccurs="0" />
    </xs:sequence>
  </xs:extension>
</xs:complexContent>
</xs:complexType>

<xs:element name="create-subscription"
  type="createSubscriptionType"
  substitutionGroup="netconf:rpcOperation"/>

<!-- ***** One-way Operations *****-->

<!-- <Event> operation -->
<xs:complexType name="NotificationType">
  <xs:sequence>
    <xs:element name="data" type="netconf:dataInlineType" />
  </xs:sequence>
</xs:complexType>

<xs:element name="notification" type="NotificationType"/>

</xs:schema>
```


5. Mapping to Transport Protocols

Currently, the NETCONF family of specification allows for running NETCONF over a number of transport protocols, some of which support multiple configurations. Some of these options will be better suited for supporting event notifications than others.

5.1. SSH

Session establishment and two-way messages are based on the NETCONF over SSH transport mapping [NETCONF SSH]

One-way event messages are supported as follows: Once the session has been established and capabilities have been exchanged, the server may send complete XML documents to the NETCONF client containing notification elements. No response is expected from the NETCONF client.

As the examples in [NETCONF SSH] illustrate, a special character sequence, MUST be sent by both the client and the server after each XML document in the NETCONF exchange. This character sequence cannot legally appear in an XML document, so it can be unambiguously used to identify the end of the current document in the event notification of an XML syntax or parsing error, allowing resynchronization of the NETCONF exchange.

The NETCONF over SSH session to receive an event notification might look like the following. In the example below the event notification contents (delimited by <data> </data> tags) are not defined in this document and are provided herein simply for illustration purposes. The sample notification shows a configuration change on the running configuration as a result of an <edit-config> operation. It has one containment node (<interfaces>), with one element <interface> and two changed attributes (<name> and <mtu>) (Note that this does not refer to XML attributes). The same example is used in the BEEP and SOAP transport mapping sections.


```
<?xml version="1.0" encoding="UTF-8"?>
  <notification
    xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
    <data xmlns="http://example.com/event/1.0">
      <severity>notice</severity>
      <eventClasses><configuration/><audit/></eventClasses>
      <sequenceNumber>2</sequenceNumber>
      <dateAndTime>2000-01-12T12:13:14Z</dateAndTime>
      <user>Fred Flinstone</user>
      <operation>
        <edit-config>
          <target>
            <running/>
          </target>
          <edit-config>
            <top xmlns="http://example.com/schema/1.2/config">
              <interfaces>
                <interface>
                  <name>Ethernet0/0</name>
                  <mtu>1500</mtu>
                </interface>
              </interfaces>
            </top>
          </config>
        </edit-config>
      </operation>
    </data>
  </event>
</data>
</notification>
]]>]]>
```

5.2. BEEP

Session establishment and two-way messages are based on the NETCONF over BEEP transport mapping [NETCONF BEEP]

5.2.1. One-way Notification Messages in Beep

One-way notification messages can be supported either by mapping to the existing one-to-many BEEP construct or by creating a new one-to-none construct.

This area is for future study.

5.2.1.1. One-way messages via the One-to-many Construct

Messages in one-to-many exchanges: "rpc", "notification", "rpc-reply"

Messages in positive replies: "rpc-reply"

5.2.1.2. One-way notification messages via the One-to-none Construct

Note that this construct would need to be added to an extension or update to 'The Blocks Extensible Exchange Protocol Core' [[RFC3080](#)].

MSG/NoANS: the client sends a "MSG" message, the server, sends no reply.

In one-to-none exchanges, no reply to the "MSG" message is expected.

5.3. SOAP

Session management and message exchange are based on the NETCONF over SOAP transport mapping [NETCONF SOAP]

Note that the use of "persistent connections" "chunked transfer-coding" when using HTTP becomes even more important in the supporting of event notifications

5.3.1. A NETCONF over Soap over HTTP Example

```
C: POST /netconf HTTP/1.1
C: Host: netconfdevice
C: Content-Type: text/xml; charset=utf-8
C: Accept: application/soap+xml, text/*
C: Cache-Control: no-cache
C: Pragma: no-cache
C: Content-Length: 465
C:
C: <?xml version="1.0" encoding="UTF-8"?>
C: <soapenv:Envelope
C:   xmlns:soapenv="http://www.w3.org/2003/05/soap-envelope">
C:   <soapenv:Body>
C:     <rpc message-id="101"
C:       xmlns=
C:         "xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
C:       <create-subscription>
C:     </create-subscription>
C:   </rpc>
C: </soapenv:Body>
C: </soapenv:Envelope>
```


The response:

```
S: HTTP/1.1 200 OK
S: Content-Type: application/soap+xml; charset=utf-8
S: Content-Length: 917
S:
S: <?xml version="1.0" encoding="UTF-8"?>
S: <soapenv:Envelope
S:   xmlns:soapenv="http://www.w3.org/2003/05/soap-envelope">
S:   <soapenv:Body>
S:     <rpc-reply message-id="101"
S:       xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
S:       <data>
S:         <top xmlns=
S:           "http://example.com/schema/1.2/notification">
S:         </top>
S:       </data>
S:     </rpc-reply>
S:   </soapenv:Body>
S: </soapenv:Envelope>
```

And then some time later

```
S: HTTP/1.1 200 OK
S: Content-Type: application/soap+xml; charset=utf-8
S: Content-Length: 917
S:
S: <?xml version="1.0" encoding="UTF-8"?>
S: <soapenv:Envelope
S:   xmlns:soapenv="http://www.w3.org/2003/05/soap-envelope">
S:   <soapenv:Body>
S:     <notification
S:       xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
S:     <data>
S:       <eventClasses><configuration/><audit/></eventClasses>
S:       <sequenceNumber>2</sequenceNumber>
S:       <dateAndTime>2000-01-12T12:13:14Z</dateAndTime>
S:       <user>Fred Flinstone</user>
S:       <operation>
S:         <edit-config>
S:         <target>
S:           <running/>
S:         </target>
S:       <config>
S:         <top xmlns="http://example.com/schema/1.2/config">
S:         <interfaces>
S:           <interface>
S:             <name>Ethernet0/0</name>
```



```
S:          <mtu>1500</mtu>
          </interface>
S:          </interfaces>
S:          </top>
S:          </config>
S:          </edit-config>
S:          </operation>
S:          </data>
S:    </notification>
S:  </soapenv:Body>
S: </soapenv:Envelope>
```


6. Filtering examples

The following section provides examples to illustrate the various methods of filtering content on an event notification subscription.

6.1. Subtree Filtering

XML subtree filtering is not well suited for creating elaborate filter definitions given that it only supports equality comparisons and logical OR operations (e.g. in an event subtree give me all event notifications which have severity=critical or severity=major or severity=minor). Nevertheless, it may be used for defining simple event notification forwarding filters as shown below.

In order to illustrate the use of filter expressions it is necessary to assume some of the event notification content (only for example purposes). The examples herein assume that the event notification schema definition has an <eventClasses> element identifying the event category (e.g. fault, state, config, etc.) and events have a <severity> element

The following example illustrates selecting events which have severities of critical, major, or minor (presumably fault events). The filtering criteria evaluation is as follows:

```
((severity=critical) | (severity=major) | (severity=minor))
```

```
<rpc message-id="101"
  xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
  <create-subscription
    xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
    <filter type="subtree">
      <event xmlns="http://example.com/event/1.0">
        <severity>critical</severity>
      </event>
      <event xmlns="http://example.com/event/1.0">
        <severity>major</severity>
      </event>
      <event xmlns="http://example.com/event/1.0">
        <severity>minor</severity>
      </event>
    </netconf:filter>
  </create-subscription>
</rpc>
```


The following example illustrates selecting fault, state, config EventClasses or events which are related to card Ethernet0. The filtering criteria evaluation is as follows:

```
(fault | state | config | card=Ethernet0)
```

```
<rpc message-id="101"
  xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
  <create-subscription>
    <netconf:filter type="subtree">
      <top
        xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
        <event>
          <eventClasses>fault</eventClasses>
        </event>
        <event>
          <eventClasses>state</eventClasses>
        </event>
        <event>
          <eventClasses>config</eventClasses>
        </event>
        <event>
          <card>Ethernet0</card>
        </event>
      </top>
    </netconf:filter>
  </create-subscription>
</rpc>
```

6.2. XPATH filters

The following example illustrates selecting fault EventClass notifications that have severities of critical, major, or minor. The filtering criteria evaluation is as follows:

```
((fault) & ((severity=critical) | (severity=major) | (severity =
minor)))
```



```
<rpc message-id="101"
  xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
  <create-subscription>
    <netconf:filter type="xpath">
      (/event[eventClasses/fault] and
      (/event[severity="critical"] or
      /event[severity="major"] or /event[severity="minor"]))
    </netconf:filter>
  </create-subscription>
</rpc>
```

The following example illustrates selecting fault, state and config EventClasses which have severities of critical, major, or minor and come from card Ethernet0. The filtering criteria evaluation is as follows:

((fault | state | config) & ((fault & severity=critical) | (fault & severity=major) | (fault & severity = minor) | (card=Ethernet0)))

```
<rpc message-id="101"
  xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
  <create-subscription>
    <netconf:filter type="xpath">
      ((/event[eventClasses/fault] or
      /event[eventClasses/state] or
      /event[eventClasses/config]) and
      ( (/event[eventClasses/fault] and
      /event[severity="critical"]) or
      (/event[eventClasses/fault] and
      /event[severity="major"]) or
      (/event[eventClasses/fault] and
      /event[severity="minor"]) or
      /event[card="Ethernet0"])))
    </netconf:filter>
  </create-subscription>
</rpc>
```


7. Notification Replay Capability

7.1. Overview

Replay is the ability to create an event subscription that will resend recently sent notifications. These notifications are sent the same way as normal notifications.

A replay of notifications is specified by including an optional parameter to the subscription command that indicates the start time of the replay. The end time of the replay is implicitly defined to be the time the replay request was initiated.

An implementation that supports replay is not expected to have an unlimited supply of saved notifications available to accommodate any replay request. If a client requests a replay of notifications that predate the oldest notification available, then the NETCONF server must return a warning message in the RPC reply and start replaying the notifications it does have available, within the other constraints, such as filtering, that the client has provided. The warning message enables the NETCONF client to differentiate between the case that there were no notifications generated within a given time period from the case that no notifications are currently in the log from that period.

The actual number of stored notifications available for retrieval at any given time is an NETCONF server implementation specific matter. Control parameters for this aspect of the feature are outside the scope of the current work.

A given subscription is either a replay subscription or a normal subscription, which sends event notifications as they happen. A replay subscription terminates once the it has completed replaying past events.

7.2. Dependencies

This capability is dependent on the notification capability being supported. It also requires that the device supporting the Netconf server also support some form of notification logging, although it puts no restrictions on the size or form of the log, nor where it resides within the device.

7.3. Capability Identifier

The Event Notification Replay capability is identified by following capability string:

<http://ietf.org/netconf/notificationReplay/1.0>

7.4. New Operations

None

7.5. Modifications to Existing Operations

7.5.1. create-subscription

This capability adds an optional parameter to the <create-subscription> command called 'startTime'. This identifies the earliest date and time of interest for event notifications being replayed. Events generated before this time are not matched.

Note that while a notification has three potential times associated it - the time it was generated, the time it was logged and the time it was sent out by the NETCONF server - the startTime parameter is related to generation time.

Negative Response:

An <rpc-error> element is included in the <rpc-reply> if the startTime in replay request predates the oldest notification available to be replayed.

Error-tag: start-time-value

Error-type: protocol

Error-severity: warning

Error-info: none

Error-message: Start time predates oldest available notification to be replayed

7.5.2. Interactions with Other Capabilities

[Editor's Note: If this capability does not interact with other capabilities, this section may be omitted.]

7.6. Replay Complete Notification

The following notification is the last notification sent over a replay subscription. It indicates that replay is complete.


```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema xmlns:xs="http://www.w3.org/2001/XMLSchema"
  xmlns="urn:ietf:params:xml:ns:netconf:replayNotification:1.0"
  targetNamespace=
    "urn:ietf:params:xml:ns:netconf:replayNotification:1.0">

  <xs:element name="replayCompleteNotification" >
    <xs:annotation>
      <xs:documentation>
        This notification is sent to signal the end of a replay
        subscription.
      </xs:documentation>
    </xs:annotation>
    <xs:complexType>
      <xs:sequence>
        <xs:element name="eventClass" default="informational">
          <xs:annotation>
            <xs:documentation>
              The event classification of this notification.
            </xs:documentation>
          </xs:annotation>
        </xs:element>
        <xs:element name="timeGenerated" type="xs:dateTime"/>
        <xs:element name="numberEventsReplayed" type="xs:integer"/>
      </xs:sequence>
    </xs:complexType>
  </xs:element>
</xs:schema>
```


8. Security Considerations

The access control framework and the choice of transport will have a major impact on the security of the solution.

Note that the <notification> elements are never sent before the transport layer and the netconf layer (capabilities exchange) have been established, and the manager has been identified and authenticated.

It is recommended that care be taken to ensure the secure operation of the following commands:

- o <create-subscription> invocation
- o use of <kill-session>
- o read-only data models
- o read-write data models
- o notification content

One issue related to the notifications draft is the transport of data from non-netconf streams, such as syslog and SNMP. Note that this data may be more vulnerable (or is not more vulnerable) when being transported over netconf than when being transported using the protocol normally used for transporting it, depending on the security credentials of the two subsystems.

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