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I2NSF Application Interface YANG Data Model

Abstract

This document describes an information model and a YANG data model
for the Application Interface between an Interface to Network
Security Functions (I2NSF) Analyzer and Security Controller in an
I2NSF system in a Network Functions Virtualization (NFV)
environment. The YANG data model described in this document is based
on the I2NSF NSF-Facing Interface [I-D.ietf-i2nsf-nsf-facing-
interface-dm] and the I2NSF Monitoring Interface [I-D.ietf-i2nsf-
nsf-monitoring-data-model] for enabling feedback delivery based on
the information received from the Network Security Function (NSF).

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1. Introduction

In Interface to Network Security Functions (I2NSF) [RFC8329], the
Monitoring Interface [I-D.ietf-i2nsf-nsf-monitoring-data-model] is
defined as an interface to collect information (e.g., network
statistics, resources) from NSF(s). The information can be received
by a query or a report. In a query-based, the information is
obtained by a request from a client (I2NSF Analyzer). But in a
report-based, the information is provided by a server (NSFs) when
the notification or alarm is triggered by an event. In this model,
the report-based collection information is used for realizing the
Security Management Automation (SMA) in cloud-based security
services [I-D.jeong-i2nsf-security-management-automation]. as the
information is sent automatically by the NSFs. Figure 1 shows the
I2NSF Framework for Security Management Automation.

```
    +------------+
    | I2NSF User |
    +------------+
          ^
          | Consumer-Facing Interface
          v
+------------------+     Registration     +---------------------+
|Security Controller|<-------------------->|Developer's Mgmt System|
+------------------+       Interface      +---------------------+
       ^      ^
       |      |
       |      | Application Interface  +---------------------+
       |      +----------------------->|    I2NSF Analyzer    |
       |                               +----------------+-----+
       | NSF-Facing Interface                           ^
       |                                                |
       +--------------------------+                     |
       |                          |                     |
       v                          v                     |
  +------+---------+      +-------+--------+             |
  |     NSF-1      | ...  |     NSF-N      |  Monitoring |
  |   (Firewall)   |      |(DDoS Mitigator)+-------------+
  +------+---------+      +-------+--------+    Interface |
       |                          |                     |
       +--------------------------------------------------+
```
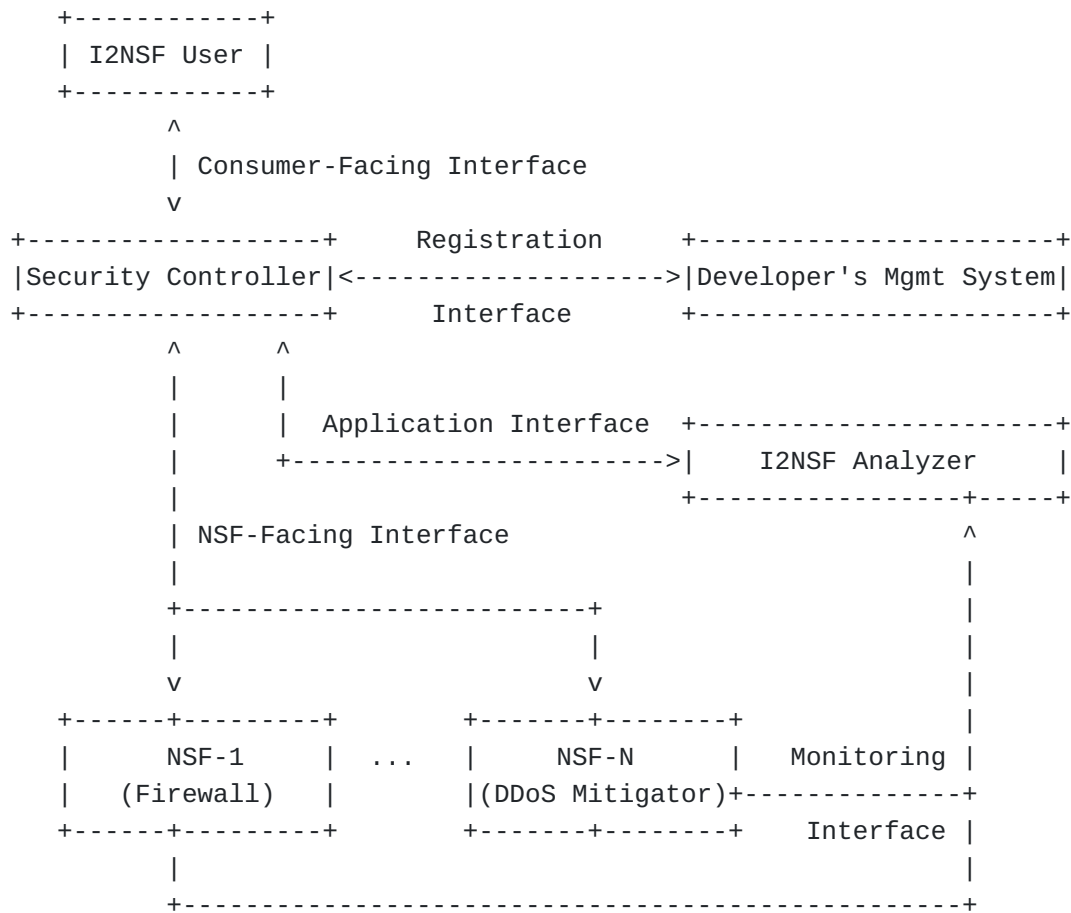
        Figure 1: I2NSF Framework for Security Management Automation

   The automatic reports by the NSFs are collected in a single instance
   (i.e., I2NSF Analyzer) to be analyzed. By analyzing the information,
   a new security policy can be produced to further enhance the
   security of the network. To create the automated system, the
   analyzer should be done automatically with the help of machine
   learning. The automated analyzer is not in the scope of this
   document.

   The new security policy needs to be delivered from the I2NSF
   Analyzer to the Security Controller so the new policy can be listed
   and monitored properly. For that purpose, this document introduces
   the Application Interface as the intermediary between the I2NSF
   Analyzer and the Security Controller. Then the policy should be
   delivered directly to the NSFs by the Security Controller via the
   NSF-Facing Interface [I-D.ietf-i2nsf-nsf-facing-interface-dm].

   The purpose of this document is to provide a standard for a feedback
   interface in an I2NSF Framework called Application Interface. With

the provided Application Interface, the realization of Security
Management Automation (SMA) should be possible.

2. Terminology

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

This document uses the terminology described in [RFC8329].

This document follows the guidelines of [RFC8407] and adopts the
Network Management Datastore Architecture (NMDA). The meaning of the
symbols in tree diagrams is defined in [RFC8340].

3. Information Model for Application Interface

This document introduces Application Interface as an interface to
deliver a report of the augmentation or generation of security
policy rules created by I2NSF Analyzer to Security Controller [I-
D.jeong-i2nsf-security-management-automation]. This allows Security
Controller to actively reinforce the network with its security
policy management. Figure 2 shows the high-level concept of
Application Interface such as Policy Reconfiguration and Feedback
Information.

```
                    +-----------------+
                    |  Application    |
                    |   Interface     |
                    +--------+--------+
                             ^
                             |
                 +-----------+-----------+
                 |                       |
          +--------+--------+      +-------+-----+
          |    Policy       |      |  Feedback   |
          | Reconfiguration |      | Information |
          +--------+--------+      +-------+-----+
                   ^                       ^
                   |                       |
                 +-----------+-----------+
                             |
                 +------------+------------+
                 |           |            |
            +-----+-----+ +-----+----+ +-----+-----+
            |  NSF Name | |  Problem | |  Solution |
            +-----------+ +----------+ +-----------+
```
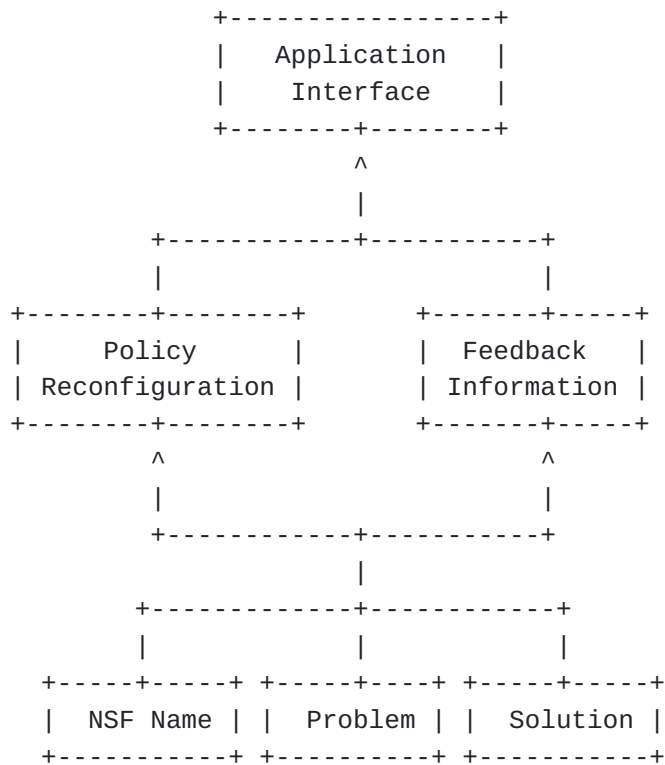
Figure 2: Diagram for Application Interface

Both policy reconfiguration and feedback information provide the
following high-level abstraction:

   *NSF Name: It is the name or IP address of the NSF for identifying
    the NSF with problem. The name is a unique string to identify an
    NSF, including a Fully Qualified Domain Name (FQDN).

   *Problem: It describes the issue(s) in the NSF that needs to be
    handled.

   *Solution: It specifies the possible solution(s) for the problem.

3.1. Information Model for Policy Reconfiguration

Policy reconfiguration is the rearrangement of a security policy in
a different form or combination of the existing security policy to
enhance the security service in the network. A policy
reconfiguration is generated by the I2NSF Analyzer after receiving
and analyzing monitoring information of NSF Events from an NSF [I-
D.ietf-i2nsf-nsf-monitoring-data-model].

Policy reconfiguration works together with the three I2NSF
interfaces defined for the I2NSF Framework, i.e., NSF-Facing

Interface [I-D.ietf-i2nsf-nsf-facing-interface-dm], NSF Monitoring
Interface [I-D.ietf-i2nsf-nsf-monitoring-data-model], and
Application Interface, to create a closed-loop system for
reinforcing the network security. Figure 3 shows an illustration of
the closed-loop system for the I2NSF Framework.

```
  +------------+                              +----------+
  |  Security  | <--------------------------|  I2NSF   |
  | Controller |    Application Interface    | Analyzer |
  +------------+   (Policy Reconfiguration) +----------+
         |                                         ^
         |                                         |
NSF-Facing |                +---------+            | Monitoring
  Interface |      +------->|  NSF-1  |-------+     | Interface
   (Policy  |      |        +---------+       |     |(Monitoring
Configuration)|    |                          |     | Data &
         |      |        +---------+          |     | Statistics)
  +-------+------->|  NSF-2  |-------+-----+
         |      |        +---------+       |
         |      |             .            |
         |      |             .            |
         |      |             .            |
         |      |        +---------+       |
  +------->|  NSF-n  |-------+
                  +---------+
```
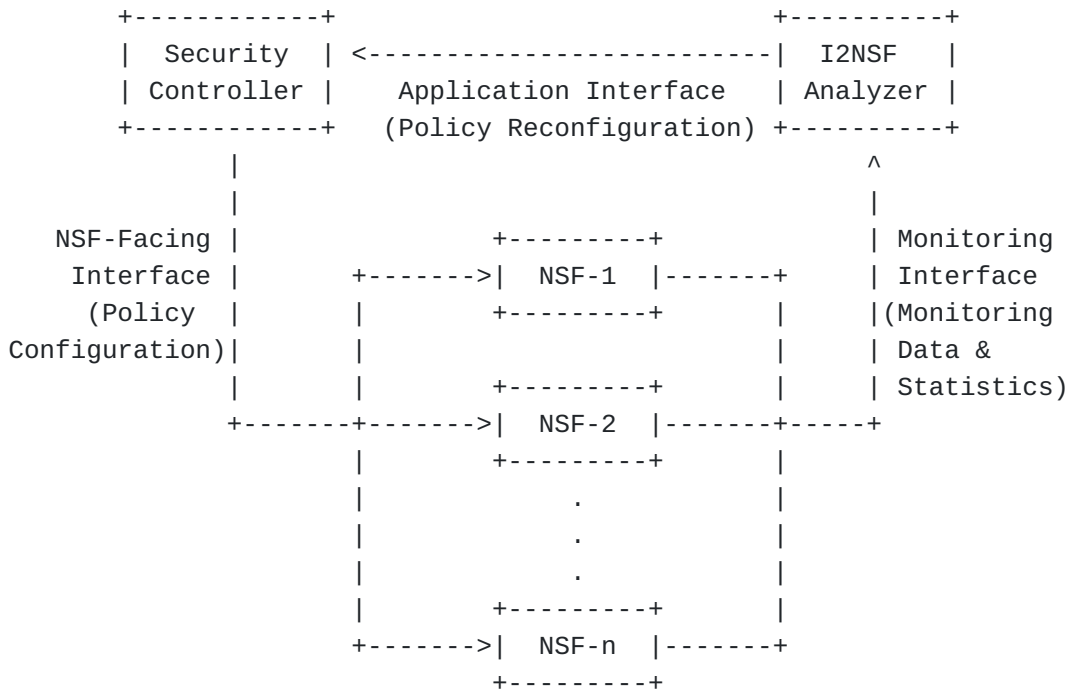
       Figure 3: A Close Loop Architecture for Security Management Automation
                                  (SMA)

   Figure 3 shows a close-loop system between Security Controller, NSF,
   and I2NSF Analyzer. The Security Controller delivers a security
   policy to an appropriate NSF via the NSF-Facing Interface [I-D.ietf-
   i2nsf-nsf-facing-interface-dm]. The NSF will prepare for a security
   service according to the given configuration and provide a security
   service for the network. The NSF SHOULD also provide monitoring
   information (e.g., NSF Events and System Alarms) to be analyzed.
   This monitoring information can be delivered from the NSF to an
   I2NSF Analyzer via the Monitoring Interface [I-D.ietf-i2nsf-nsf-
   monitoring-data-model]. Then the I2NSF Analyzer analyzes the
   monitoring information for the reconfiguration of an existing
   security policy, the generation of a new security policy, and the
   feedback for security system management (e.g., the scaling-up or
   scaling-down of resources related to NSFs). To fully automate the
   close-loop system, the I2NSF Analyzer should analyze the monitoring
   information automatically using machine learning techniques (e.g.,
   Deep Learning [Deep-Learning]). The results of the analysis may

trigger the reconfiguration of an existing security policy or the generation of a new security policy to strengthen the network security. The reconfiguration or configuration request will be delivered from the I2NSF Analyzer to the Security Controller via the Application Interface.

To realize the close loop system, the Application Interface needs to properly follow the similar guidelines for the I2NSF Framework [RFC8329]. The Application Interface follows [I-D.ietf-i2nsf-nsf-facing-interface-dm] to create a security policy to reconfigure an existing security policy of NSF(s) or to generate a new security policy.

Application Interface holds a list of security policies so that the (re)configuration of a security policy and the feedback information can be provided to the Security Controller. Each policy consists of a list of rule to be enhanced on the NSF. Note that the synchronization of the list of security policies should be done between the Security Controller and the I2NSF Analyzer and the specific mechanism is out of the scope of this document. A (re)configured security policy rule should be able to cope with attacks or failures that can happen to the network in near future. Such a rule is reconfigured or generated by the I2NSF Analyzer to tackle a detected problem in the network. It uses the Event-Condition-Action (ECA) model as the basis for the design of I2NSF Policy (Re)configuration as described in [RFC8329] and [I-D.ietf-i2nsf-capability-data-model].

An example of Policy (Re)configuration is a DDoS Attack that is detected by a DDoS Mitigator. The DDoS Mitigator creates monitoring information and delivers it to the I2NSF Analyzer. The I2NSF Analyzer analyzes the information and generates a new policy to handle the DDoS Attack, such as a firewall rule to drop all packets from the source of the DDoS Attack.

3.2. YANG Tree Structure for Policy Reconfiguration

The YANG tree structure for policy reconfiguration is provided through the augmentation of the NSF-Facing Interface YANG Module [I-D.ietf-i2nsf-nsf-facing-interface-dm] as follows:

```
augment /nsfintf:i2nsf-security-policy:
  +--rw nsf-name?   union
  +--rw problem
     +--rw (attack-detection)?
        +--:(ddos-detected)
        |  +--rw ddos-detected
        |     +--rw attack-src-ip*    inet:ip-address
        |     +--rw attack-dst-ip*    inet:ip-prefix
        |     +--rw attack-src-port*  inet:port-number
        |     +--rw attack-dst-port*  inet:port-number
        +--:(virus-detected)
        |  +--rw virus-detected
        |     +--rw virus-name?   string
        |     +--rw file-type?    string
        |     +--rw file-name?    string
        +--:(intrusion-detected)
        |  +--rw intrusion-detected
        |     +--rw protocol?     identityref
        |     +--rw app?          identityref
        |     +--rw attack-type?  identityref
        +--:(web-attack-detected)
        |  +--rw web-attack-detected
        |     +--rw attack-type?     identityref
        |     +--rw req-method?      identityref
        |     +--rw req-uri?         string
        |     +--rw req-user-agent?  string
        |     +--rw req-cookie?      string
        |     +--rw req-host?        string
        |     +--rw response-code?   string
        +--:(voip-vocn-detected)
           +--rw voip-vocn-detected
              +--rw source-voice-id*       string
              +--rw destination-voice-id*  string
              +--rw user-agent*            string
```

Figure 4: YANG Tree Structure of Policy Reconfiguration

The policy reconfiguration must include the following information:

NSF Name: The name or IP address (IPv4 or IPv6) of the NSF to be
configured. If the given nsf-name is not IP address, the name can
be an arbitrary string including FQDN (Fully Qualified Domain
Name).

Problem: The issue that is emitted by an NSF via the I2NSF
Monitoring Interface. The problem for policy configuration
includes the NSF Events described in NSF Monitoring Interface
YANG Data Model [I-D.ietf-i2nsf-nsf-monitoring-data-model], such

as DDoS detection, Virus detection, Intrusion detection, Web-attack detection, and Voice over Internet Protocol (VoIP) or Voice over Cellular Network (VoCN) violation detection.

Solution: The solution for policy (re)configuration is the security policy that is reconfigured or generated to solve a detected attack. The security policy can be configured using the NSF-Facing Interface YANG data model [I-D.ietf-i2nsf-nsf-facing-interface-dm].

3.3. Information Model for Feedback Information

Feedback information is information about problem(s) of an NSF for a security service such as system resource over-usage or malfunction. This problem cannot be handled by creating a new policy. In the similar way with policy reconfiguration, the feedback information should be delivered from the I2NSF Analyzer to the Security Controller that will be able to handle the reported problem(s).
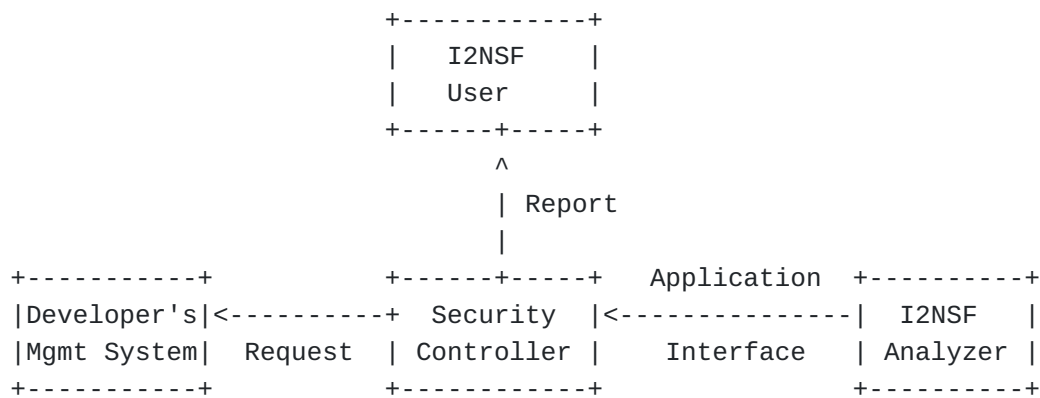
```
                       +------------+
                       |   I2NSF    |
                       |   User     |
                       +------+-----+
                              ^
                              | Report
                              |
 +-----------+         +------+-----+    Application  +----------+
 |Developer's|<---------+  Security  |<---------------|   I2NSF  |
 |Mgmt System|  Request | Controller |    Interface   | Analyzer |
 +-----------+         +------------+                 +----------+
```

Figure 5: Handling of Feedback Information

Figure 5 shows the handling of feedback information. For feedback information, the given feedback is not a security policy, hence the Security Controller needs to take an action to handle the reported problem(s). The action includes the reporting to the I2NSF User and the requesting of the system resource management of the relevant NSF(s) to the Developer's Management System (DMS). DMS will communicate with the Management and Orchestration (MANO) Unit in the Network Functions Virtualization (NFV) Framework to deal with the system management issue(s) of the relevant NSFs [I-D.ietf-i2nsf-applicability]. The details of the handling process are out of the scope of this document.

3.4. YANG Tree Structure for Feedback Information

The YANG tree structure for feedback information is provided with
the use of the NSF Monitoring Interface YANG Module [I-D.ietf-i2nsf-
nsf-monitoring-data-model] as follows:

```
module: ietf-i2nsf-feedback-policy
  +--rw i2nsf-feedback-information* [nsf-name time]
     +--rw nsf-name     union
     +--rw time         yang:date-and-time
     +--rw language?    string
     +--rw problem
     |  +--rw (alarm-type)?
     |     +--:(memory-alarm)
     |     |  +--rw memory-alarm
     |     |     +--rw usage?       uint8
     |     |     +--rw message?     string
     |     |     +--rw duration?    uint32
     |     +--:(cpu-alarm)
     |     |  +--rw cpu-alarm
     |     |     +--rw usage?       uint8
     |     |     +--rw message?     string
     |     |     +--rw duration?    uint32
     |     +--:(disk-alarm)
     |     |  +--rw disk-alarm
     |     |     +--rw disk-id?     string
     |     |     +--rw usage?       uint8
     |     |     +--rw message?     string
     |     |     +--rw duration?    uint32
     |     +--:(hardware-alarm)
     |     |  +--rw hardware-alarm
     |     |     +--rw component-name?   string
     |     |     +--rw message?          string
     |     |     +--rw duration?         uint32
     |     +--:(interface-alarm)
     |        +--rw interface-alarm
     |           +--rw interface-id?      string
     |           +--rw interface-state?   enumeration
     |           +--rw message?           string
     |           +--rw duration?          uint32
     +--rw solution*    string
```

Figure 6: YANG Tree Structure of Feedback Information

Figure 6 shows the high-level abstraction of Feedback Information.
The feedback information should include:

  *NSF Name: The name or IP address (IPv4 or IPv6) of the NSF that
   detected the problem. If the given nsf-name is not IP address,
   the name can be an arbitrary string including FQDN.

  *Time: The time of the delivery of the feedback information.

  *Language: The language tag that is used for the natural language
   text that is included in the "message" and "solution" attributes.
   The language field is encoded following the rules in Section 2.1
   of [RFC5646]. The default language tag is "en-US".

  *Problem: The issue that is emitted by an NSF via the I2NSF
   Monitoring Interface. The problem for feedback information
   includes the system alarms described in NSF Monitoring Interface
   YANG Data Model [I-D.ietf-i2nsf-nsf-monitoring-data-model], such
   as Memory alarm, CPU alarm, Disk alarm, Hardware alarm, and
   Interface alarm.

  *Solution: A possible solution given as feedback is in the form of
   a free-form string (as a high-level instruction).

4. YANG Data Model of Application Interface

This section shows the YANG module of Application Interface. The
YANG module in this document is referencing to [RFC6991] [I-D.ietf-
i2nsf-nsf-facing-interface-dm] [I-D.ietf-i2nsf-nsf-monitoring-data-
model].

The YANG module makes references to [RFC5646] [RFC8343] [I-D.ietf-
httpbis-semantics]

```
<CODE BEGINS> file "ietf-i2nsf-feedback-policy@2022-02-22.yang"

module ietf-i2nsf-feedback-policy {
  yang-version 1.1;
  namespace
    "urn:ietf:params:xml:ns:yang:ietf-i2nsf-feedback-policy";
  prefix nsffbck;

  import ietf-inet-types{
    prefix inet;
    reference "RFC 6991";
  }

  import ietf-yang-types{
    prefix yang;
    reference "RFC 6991";
  }

  import ietf-i2nsf-policy-rule-for-nsf {
    prefix nsfintf;
    reference
      "Section 4.1 of draft-ietf-i2nsf-nsf-facing-interface-dm-21";
  }

  import ietf-i2nsf-nsf-monitoring {
    prefix nsfmi;
    reference
      "Section 7 of draft-ietf-i2nsf-nsf-monitoring-data-model-15";
  }

  organization
    "IETF I2NSF (Interface to Network Security Functions)
     Working Group";

  contact
    "WG Web: <http://tools.ietf.org/wg/i2nsf>
     WG List: <mailto:i2nsf@ietf.org>

     Editor: Patrick Lingga
     <mailto:patricklink@skku.edu>

     Editor: Jaehoon Paul Jeong
     <mailto:pauljeong@skku.edu>";

  description
    "This module is a YANG module for Application Interface.

     Copyright (c) 2022 IETF Trust and the persons identified as
     authors of the code. All rights reserved.
```

```
      Redistribution and use in source and binary forms, with or
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      (https://trustee.ietf.org/license-info).

      This version of this YANG module is part of RFC XXXX
      (https://www.rfc-editor.org/info/rfcXXXX); see the RFC itself
      for full legal notices.";

// RFC Ed.: replace XXXX with an actual RFC number and remove
// this note.

revision "2022-02-22" {
  description "Initial revision.";
  reference
    "RFC XXXX: I2NSF Application Interface YANG Data Model";

  // RFC Ed.: replace XXXX with an actual RFC number and remove
  // this note.
}


augment "/nsfintf:i2nsf-security-policy" {
  description
  "Augment the NSF-Facing Interface Data Model for the policy
   reconfiguration";
  leaf nsf-name {
    type union {
      type string;
      type inet:ip-address;
    }
    description
      "The name or IP address (IPv4 or IPv6) of the NSF to be
       configured. If the given nsf-name is not IP address, the
       name can be an arbitrary string including FQDN (Fully
       Qualified Domain Name).";
  }

  container problem {
    description
     "Problem: The issue that is emitted by an NSF via the
      I2NSF Monitoring Interface such as DDoS detection, Virus
      detection, Intrusion detection, Web-attack detection, and
      VoIP/VoCN violation detection.";
    choice attack-detection {
      description
        "The detected attack type";
```

```
case ddos-detected {
  container ddos-detected {
    leaf-list attack-src-ip {
      type inet:ip-address;
      description
        "The source IPv4 (or IPv6) addresses of attack
         traffic. It can hold multiple IPv4 (or IPv6)
         addresses.";
    }
    leaf-list attack-dst-ip {
      type inet:ip-prefix;
      description
        "The destination IPv4 (or IPv6) addresses of attack
         traffic. It can hold multiple IPv4 (or IPv6)
         addresses.";
    }
    leaf-list attack-src-port {
      type inet:port-number;
      description
        "The source ports of the DDoS attack";
    }
    leaf-list attack-dst-port {
      type inet:port-number;
      description
        "The destination ports of the DDoS attack";
    }
    description
      "A container for DDoS Attack";
  }
  description
    "A DDoS Attack is detected";
}
case virus-detected {
  container virus-detected {
    leaf virus-name {
      type string;
      description
        "The name of the detected virus";
    }
    leaf file-type {
      type string;
      description
        "The type of file virus code is found in (if
         applicable).";
      reference
        "IANA Website: Media Types";
    }
    leaf file-name {
      type string;
```

```
          description
            "The name of file virus code is found in (if
             applicable).";
        }
        description
          "A Virus Attack is detected";
      }
    description
      "A virus is detected";
  }
  case intrusion-detected {
    container intrusion-detected {
      leaf protocol {
        type identityref {
          base nsfmi:transport-protocol;
        }
        description
          "The transport protocol type for
           nsf-detection-intrusion notification";
      }
      leaf app {
        type identityref {
          base nsfmi:application-protocol;
        }
        description
          "The employed application layer protocol";
      }
      leaf attack-type {
        type identityref {
          base nsfmi:intrusion-attack-type;
        }
        description
          "The sub attack type for intrusion attack";
      }
      description
        "An intrusion is detected";
    }
  }
  case web-attack-detected {
    container web-attack-detected {
      leaf attack-type {
        type identityref {
          base nsfmi:web-attack-type;
        }
        description
          "Concrete web attack type, e.g., SQL injection,
           command injection, XSS, and CSRF.";
      }
      leaf req-method {
```

```
        type identityref {
          base nsfmi:req-method;
        }
        description
          "The HTTP request method, e.g., PUT or GET.";
        reference
          "draft-ietf-httpbis-semantics-19: HTTP Semantics -
           Request Methods";
      }
      leaf req-uri {
        type string;
        description
          "The Requested URI";
      }
      leaf req-user-agent {
        type string;
        description
          "The request user agent";
      }
      leaf req-cookie {
        type string;
        description
          "The HTTP Cookie previously sent by the server with
           Set-Cookie";
      }
      leaf req-host {
        type string;
        description
          "The domain name of the requested host";
      }
      leaf response-code {
        type string;
        description
          "The HTTP Response code";
        reference
          "IANA Website: Hypertext Transfer Protocol (HTTP)
           Status Code Registry";
      }
      description
        "A web attack is detected";
    }
  description
    "A web attack is detected";
}
case voip-vocn-detected {
  container voip-vocn-detected {
    leaf-list source-voice-id {
      type string;
      description
```

```
                    "The detected source voice ID for Voice over Internet
                     Protocol (VoIP) and Voice over Cellular Network
                     (VoCN) that violates the security policy.";
                }
                leaf-list destination-voice-id {
                  type string;
                  description
                    "The detected destination voice ID for Voice over
                     Internet Protocol (VoIP) and Voice over Cellular
                     Network (VoCN) that violates the security policy.";
                }
                leaf-list user-agent {
                  type string;
                  description
                    "The detected user-agent for VoIP and VoCN that
                     violates the security policy.";
                }
                description
                  "A violation of VoIP/VoCN is detected";
              }
              description
                "A violation of VoIP/VoCN is detected";
          }
        }
      }
    }

    list i2nsf-feedback-information {
      key "nsf-name time";

      description
        "Feedback information is information about problem(s) of an
         NSF for a security service such as system resource over-usage
         or malfunction. ";

      leaf nsf-name {
        type union {
          type string;
          type inet:ip-address;
        }
        description
          "The name or IP address (IPv4 or IPv6) of the NSF to be
           configured. If the given nsf-name is not IP address, the
           name can be an arbitrary string including FQDN (Fully
           Qualified Domain Name).";
      }

      leaf time {
        type yang:date-and-time;
```

```
    description
      "The time of the feedback information delivered";
}

leaf language {
  type string {
    pattern '(([A-Za-z]{2,3}(-[A-Za-z]{3}(-[A-Za-z]{3})'
          + '{,2})?|[A-Za-z]{4}|[A-Za-z]{5,8})(-[A-Za-z]{4})?'
          + '(-([A-Za-z]{2}|[0-9]{3}))?(-([A-Za-z0-9]{5,8}'
          + '|([0-9][A-Za-z0-9]{3})))*(-[0-9A-WY-Za-wy-z]'
          + '(-([A-Za-z0-9]{2,8}))+)*(-[Xx](-([A-Za-z0-9]'
          + '{1,8}))+)?|[Xx](-([A-Za-z0-9]{1,8}))+|'
          + '(([Ee][Nn]-[Gg][Bb]-[Oo][Ee][Dd]|[Ii]-'
          + '[Aa][Mm][Ii]|[Ii]-[Bb][Nn][Nn]|[Ii]-'
          + '[Dd][Ee][Ff][Aa][Uu][Ll][Tt]|[Ii]-'
          + '[Ee][Nn][Oo][Cc][Hh][Ii][Aa][Nn]'
          + '|[Ii]-[Hh][Aa][Kk]|'
          + '[Ii]-[Kk][Ll][Ii][Nn][Gg][Oo][Nn]|'
          + '[Ii]-[Ll][Uu][Xx]|[Ii]-[Mm][Ii][Nn][Gg][Oo]|'
          + '[Ii]-[Nn][Aa][Vv][Aa][Jj][Oo]|[Ii]-[Pp][Ww][Nn]|'
          + '[Ii]-[Tt][Aa][Oo]|[Ii]-[Tt][Aa][Yy]|'
          + '[Ii]-[Tt][Ss][Uu]|[Ss][Gg][Nn]-[Bb][Ee]-[Ff][Rr]|'
          + '[Ss][Gg][Nn]-[Bb][Ee]-[Nn][Ll]|[Ss][Gg][Nn]-'
          + '[Cc][Hh]-[Dd][Ee])|([Aa][Rr][Tt]-'
          + '[Ll][Oo][Jj][Bb][Aa][Nn]|[Cc][Ee][Ll]-'
          + '[Gg][Aa][Uu][Ll][Ii][Ss][Hh]|'
          + '[Nn][Oo]-[Bb][Oo][Kk]|[Nn][Oo]-'
          + '[Nn][Yy][Nn]|[Zz][Hh]-[Gg][Uu][Oo][Yy][Uu]|'
          + '[Zz][Hh]-[Hh][Aa][Kk][Kk][Aa]|[Zz][Hh]-'
          + '[Mm][Ii][Nn]|[Zz][Hh]-[Mm][Ii][Nn]-'
          + '[Nn][Aa][Nn]|[Zz][Hh]-[Xx][Ii][Aa][Nn][Gg])))';
  }
  default "en-US";
  description
    "The value in this field indicates the language tag
     used for all of the text in the module
     (i.e., 'leaf message' and 'leaf-list solution').

     The attribute is encoded following the rules in Section 2.1
     in RFC 5646. The default language tag is 'en-US'";
  reference
    "RFC 5646: Tags for Identifying Languages";
}

container problem {
  description
    "The issue that is emitted by an NSF via the I2NSF Monitoring
     Interface. The problem for feedback information includes the
     system alarms, such as Memory alarm, CPU alarm, Disk alarm,
```

```
         Hardware alarm, and Interface alarm.";
     choice alarm-type {
       description
         "The detected alarm type";
       case memory-alarm {
         container memory-alarm {
           leaf usage {
             type uint8 {
               range "0..100";
             }
             units "percent";
             description
               "The average usage for the duration of the alarm.";
           }
           leaf message {
             type string;
             description
               "A message explaining the problem.";
           }
           leaf duration {
             type uint32;
             description
               "Specify the duration of the first alarm triggered
                until the feedback information is created.";
           }
           description
             "The container for memory-alarm";
         }
         description
           "The detected alarm type is memory-alarm";
       }
       case cpu-alarm {
         container cpu-alarm {
           leaf usage {
             type uint8 {
               range "0..100";
             }
             units "percent";
             description
               "The average usage for the duration of the alarm.";
           }
           leaf message {
             type string;
             description
               "A message explaining the problem.";
           }
           leaf duration {
             type uint32;
             description
```

```
            "Specify the duration of the first alarm triggered
             until the feedback information is created.";
        }
      description
        "The container for cpu-alarm";
    }
    description
      "The detected alarm type is cpu-alarm";
  }
  case disk-alarm {
    container disk-alarm {
      leaf disk-id {
        type string;
        description
          "The ID of the storage disk. It is a free form
           identifier to identify the storage disk.";
      }
      leaf usage {
        type uint8 {
          range "0..100";
        }
        units "percent";
        description
          "The average usage for the duration of the alarm.";
      }
      leaf message {
        type string;
        description
          "A message explaining the problem.";
      }
      leaf duration {
        type uint32;
        description
          "Specify the duration of the first alarm triggered
           until the feedback information is created.";
      }
      description
        "The container for disk-alarm";
    }
    description
      "The detected alarm type is disk-alarm";
  }
  case hardware-alarm {
    container hardware-alarm {
      leaf component-name {
        type string;
        description
          "The hardware component responsible for generating
           the message. Applicable for Hardware Failure
```

```
        Alarm.";
      }
      leaf message {
        type string;
        description
          "A message explaining the problem.";
      }
      leaf duration {
        type uint32;
        description
          "Specify the duration of the first alarm triggered
           until the feedback information is created.";
      }
      description
        "The container for hardware-alarm";
    }
    description
      "The detected alarm type is hardware-alarm";
  }
  case interface-alarm {
    container interface-alarm {
      leaf interface-id {
        type string;
        description
          "The interface ID responsible for generating
           the message.";
      }
      leaf interface-state {
        type enumeration {
          enum up {
            value 1;
            description
              "The interface state is up and not congested.
               The interface is ready to pass packets.";
          }
          enum down {
            value 2;
            description
              "The interface state is down, i.e., does not pass
               any packets.";
          }
          enum congested {
            value 3;
            description
              "The interface state is up but congested.";
          }
          enum testing {
            value 4;
            description
```

```
                  "In some test mode.  No operational packets can
                   be passed.";
              }
              enum unknown {
                value 5;
                description
                  "Status cannot be determined for some reason.";
              }
              enum dormant {
                value 6;
                description
                  "Waiting for some external event.";
              }
              enum not-present {
                value 7;
                description
                  "Some component (typically hardware) is
                   missing.";
              }
              enum lower-layer-down {
                value 8;
                description
                  "Down due to state of lower-layer interface(s).";
              }
            }
            description
              "The state of the interface. Applicable for Network
               Interface Failure Alarm.";
            reference
              "RFC 8343: A YANG Data Model for Interface Management
               - Operational States";
          }
          leaf message {
            type string;
            description
              "A message explaining the problem.";
          }
          leaf duration {
            type uint32;
            description
              "Specify the duration of the first alarm triggered
               until the feedback information is created.";
          }
          description
            "The container for interface-alarm";
        }
        description
          "The detected alarm type is interface-alarm";
      }
```

```
          }
        }

     leaf-list solution {
       type string;
       description
          "A possible solution given as feedback is in the form of
           a free-form string (as a high-level instruction).";
     }
   }
}

<CODE ENDS>
```

                  Figure 7: YANG for Application Interface

5. IANA Considerations

   This document requests IANA to register the following URI in the
   "IETF XML Registry" [RFC3688]:

```
URI: urn:ietf:params:xml:ns:yang:ietf-i2nsf-feedback-policy
Registrant Contact: The IESG.
XML: N/A; the requested URI is an XML namespace.
```

   This document requests IANA to register the following YANG module in
   the "YANG Module Names" registry [RFC7950][RFC8525]:

```
name: ietf-i2nsf-feedback-policy
namespace: urn:ietf:params:xml:ns:yang:ietf-i2nsf-feedback-policy
prefix: nsffb
reference: RFC XXXX

// RFC Ed.: replace XXXX with an actual RFC number and remove
// this note.
```

6. XML Configuration Examples of Feedback Policy

   This section shows XML configuration examples of feedback policy
   rules that are delivered from the I2NSF Analyzer to the Security
   Controller over the Application Interface after the I2NSF Analyzer
   analyzes the Monitoring Information.

6.1. Feedback Policy for DDoS Detection

   In this example, the scenario can be seen in Figure 8.

```
                           +---------------------------------+
+---------------+          | Secure Network (203.0.113.0/24) |
| DDoS Attacker |          |                                 |
| 192.0.2.8,    | DDoS     | +---------+        +---------+   |
| 192.0.2.9,    +-------->| |Firewall |        |Server 1 |   |
| 192.0.2.10    | Attack   | +---------+        +---------+   |
+---------------+          |      |                           |
                          |      v             +---------+   |
                          | +---------+        |Server 2 |   |
                          | |DDoS     | ----> +---------+    |
                          | |Mitigator|                      |
                          | +---------+        +---------+    |
                          |                    |Server 3 |   |
                          |                    +---------+    |
                          +---------------------------------+


                  Figure 8: A Scenario Example of DDoS Attack
```
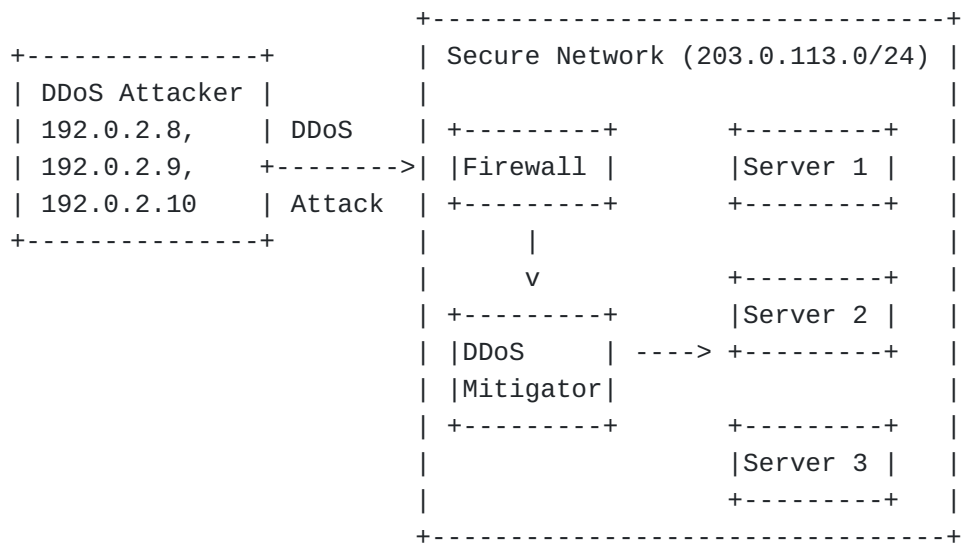
In this scenario, a DDoS Mitigator detects a DDoS Attack and sends a
notification to the I2NSF Analyzer as shown in Figure 9.

```
<?xml version="1.0" encoding="UTF-8"?>
<notification
 xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
  <eventTime>2021-08-27T09:00:01.00Z</eventTime>
  <i2nsf-nsf-event
    xmlns="urn:ietf:params:xml:ns:yang:ietf-i2nsf-nsf-monitoring">
    <i2nsf-nsf-detection-ddos>
      <attack-type
        xmlns:nsfmi="urn:ietf:params:xml:ns:yang:\
                   ietf-i2nsf-nsf-monitoring">
        nsfmi:syn-flood
      </attack-type>
      <acquisition-method
        xmlns:nsfmi="urn:ietf:params:xml:ns:yang:\
                   ietf-i2nsf-nsf-monitoring">
        nsfmi:subscription
      </acquisition-method>
      <emission-type
        xmlns:nsfmi="urn:ietf:params:xml:ns:yang:\
                   ietf-i2nsf-nsf-monitoring">
        nsfmi:on-change
      </emission-type>
      <dampening-type
        xmlns:nsfmi="urn:ietf:params:xml:ns:yang:\
                   ietf-i2nsf-nsf-monitoring">
        nsfmi:on-repetition
      </dampening-type>
      <start-time>2021-08-27T09:00:00.00Z</start-time>
      <attack-src-ip>192.0.2.8</attack-src-ip>
      <attack-src-ip>192.0.2.9</attack-src-ip>
      <attack-src-ip>192.0.2.10</attack-src-ip>
      <attack-dst-ip>203.0.113.0/24</attack-dst-ip>
      <attack-rate>100</attack-rate>
      <message>A DDoS Attack is detected</message>
      <nsf-name>DDoS_mitigator</nsf-name>
    </i2nsf-system-detection-alarm>
  </i2nsf-event>
</notification>
```

Figure 9: A Detected DDoS Attack by DDoS Mitigator

In the scenario shown in Figure 9, the description of the XML
example is as follows:

1. The DDoS attack is detected at 9 am on August 27 in 2021.

2. The sources of the attack are 192.0.2.8, 192.0.2.9, and
   192.0.2.10.

3. The destination of the attack is 203.0.113.0/24.

After receiving the information, the I2NSF Analyzer analyzes the data and creates a new feedback policy to enforce the security of the network. The I2NSF Analyzer delivers a feedback policy to the Security Controller as shown in Figure 10.

```xml
<?xml version="1.0" encoding="UTF-8" ?>
<i2nsf-security-policy
 xmlns="urn:ietf:params:xml:ns:yang:ietf-i2nsf-feedback-policy">
  <system-policy-name>
    feedback_policy_for_ddos_attack
  </system-policy-name>
  <rules>
    <rule-name>deny_ddos_attack</rule-name>
    <event>
      <start-date-time>2021-08-27T09:00:01.00Z</start-date-time>
    </event>
    <condition>
      <ipv4>
        <ipv4-range>
          <start>192.0.2.8</start>
          <end>192.0.2.10</end>
        <ipv4-range>
      </ipv4>
    </condition>
    <actions>
      <packet-action>
        <ingress-action>drop</ingress-action>
      </packet-action>
    </actions>
  </rules>
  <nsf-name>Firewall</nsf-name>
  <problem>
    <ddos-detected>
      <attack-src-ip>192.0.2.8</attack-src-ip>
      <attack-src-ip>192.0.2.9</attack-src-ip>
      <attack-src-ip>192.0.2.10</attack-src-ip>
      <attack-dst-ip>203.0.113.0/24</attack-dst-ip>
    </ddos-detected>
  </problem>
</i2nsf-security-policy>
```

Figure 10: Policy Reconfiguration for a Detected DDoS Attack

The policy reconfiguration in [Figure 10](#) means the following:

1. The feedback policy is named as
   "feedback_policy_for_ddos_attack".

2. The rule is named as "deny_ddos_attack".

3. The rule starts from 09:00 am on August 24 in 2021. The
   condition of the rule is from the sources of the IP addresses
   192.0.2.8, 192.0.2.9, and 192.0.2.10.

4. The action required is to "drop" any access from the the IP
   addresses have been identified as malicious.

5. The NSF to be configured is named "Firewall".

6. The problem that triggered the generation of the feedback is a
   DDoS attack from the sources of the IP addresses 192.0.2.8,
   192.0.2.9, and 192.0.2.10 to the protected network of
   203.0.113.0/24.

6.2. Feedback Information for Overloaded NSF

In this scenario, an NSF is overloaded and sends a notification to
the I2NSF Analyzer as shown in [Figure 11](#).

```xml
<?xml version="1.0" encoding="UTF-8"?>
<notification
 xmlns="urn:ietf:params:xml:ns:netconf:notification:1.0">
  <eventTime>2021-08-27T07:43:52.181088+00:00</eventTime>
  <i2nsf-event
    xmlns="urn:ietf:params:xml:ns:yang:ietf-i2nsf-nsf-monitoring">
    <i2nsf-system-detection-alarm>
      <alarm-category
        xmlns:nsfmi="urn:ietf:params:xml:ns:yang:\
                     ietf-i2nsf-nsf-monitoring">
        nsfmi:memory-alarm
      </alarm-category>
      <acquisition-method
        xmlns:nsfmi="urn:ietf:params:xml:ns:yang:\
                     ietf-i2nsf-nsf-monitoring">
        nsfmi:subscription
      </acquisition-method>
      <emission-type
        xmlns:nsfmi="urn:ietf:params:xml:ns:yang:\
                     ietf-i2nsf-nsf-monitoring">
        nsfmi:on-change
      </emission-type>
      <dampening-type
        xmlns:nsfmi="urn:ietf:params:xml:ns:yang:\
                     ietf-i2nsf-nsf-monitoring">
        nsfmi:on-repetition
      </dampening-type>
      <usage>98</usage>
      <threshold>80</threshold>
      <message>Memory Usage Exceeded the Threshold</message>
      <nsf-name>firewall</nsf-name>
      <severity>high</severity>
    </i2nsf-system-detection-alarm>
  </i2nsf-event>
</notification>
```

              Figure 11: The Monitoring of an Overloaded NSF

   In the scenario shown in Figure 11, the description of the XML
   example is as follows:

     1. The NSF that sends the information is named "firewall".

     2. The memory usage of the NSF triggered the alarm.

     3. The memory usage of the NSF is 98 percent.

     4. The memory threshold to trigger the alarm is 80 percent.

5. The event is delivered at 2021-08-27T07:43:52.181088+00:00.

   After receiving the information, the I2NSF Analyzer analyzes the
   data and creates a new feedback policy to solve the problem that is
   detected in the NSF. The I2NSF Analyzer delivers a feedback
   information to the Security Controller as shown in Figure 12.

```
<?xml version="1.0" encoding="UTF-8" ?>
<i2nsf-feedback-information
 xmlns="urn:ietf:params:xml:ns:yang:ietf-i2nsf-feedback-policy">
  <time>2021-08-27T08:43:52.000000+00:00</time>
  <nsf-name>Firewall</nsf-name>
  <problem>
    <memory-alarm>
      <usage>95</usage>
      <message>Memory Usage Exceeded the Threshold</message>
      <duration>3600</duration>
    </memory-alarm>
  </problem>
  <solution>
    Add more memory capacity to the NSF
  </solution>
  <solution>
    Create a new NSF with the same security service
  </solution>
</i2nsf-feedback-information>
```

             Figure 12: Feedback Information for the Overloaded NSF

   The feedback information in Figure 12 means the following:

      1. The name of the NSF that needs to be handled is called
         "Firewall".

      2. The feedback information is delivered at
         2021-08-27T08:43:52.000000+00:00.

      3. The problem is that the Memory Usage Exceeded the Threshold
         with the average usage of memory as 95.

      4. The problem persists for 3,600 seconds (1 hour) without any
         fix.

      5. The proposed solution to the problem is to add more memory
         capacity in hardware to the NSF or to create a new NSF with the
         same security service.

7. Security Considerations

The YANG module specified in this document defines a data schema designed to be accessed through network management protocols such as NETCONF [RFC6241] or RESTCONF [RFC8040]. The lowest NETCONF layer is the secure transport layer, and the required secure transport is Secure Shell (SSH) [RFC6242]. The lowest RESTCONF layer is HTTPS, and the required secure transport is TLS [RFC8446].

The NETCONF access control model [RFC8341] provides a means of restricting access to specific NETCONF or RESTCONF users to a preconfigured subset of all available NETCONF or RESTCONF protocol operations and content.

There are a number of data nodes defined in this YANG module that are writable/creatable/deletable (i.e., config true, which is the default). These data nodes may be considered sensitive or vulnerable in some network environments. Write operations (e.g., edit-config) to these data nodes without proper protection can have a negative effect on network operations. And the data model in this document uses the data model from NSF-Facing Interface data model, it MUST follow the Security Considerations mentioned in the [I-D.ietf-i2nsf-nsf-facing-interface-dm].

Some of the readable data nodes in this YANG module may be considered sensitive or vulnerable in some network environments. It is thus important to control read access (e.g., via get, get-config, or notification) to these data nodes. This document also MUST follow the Security Considerations about the readable data nodes mentioned in the [I-D.ietf-i2nsf-nsf-facing-interface-dm].

8. Acknowledgments

9. Contributors

This document is made by the group effort of I2NSF working group. Many people actively contributed to this document, such as Linda Dunbar, Yoav Nir, Susan Hares, and Diego Lopez. The authors sincerely appreciate their contributions.

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