I2NSF Working Group
Internet-Draft
Intended status: Standards Track
Expires: January 14, 2021

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July 13, 2020

I2NSF Consumer-Facing Interface YANG Data Model
draft-ietf-i2nsf-consumer-facing-interface-dm-09

Abstract

This document describes an information model and a YANG data model for the Consumer-Facing Interface between an Interface to Network Security Functions (I2NSF) User and Security Controller in an I2NSF system in a Network Functions Virtualization (NFV) environment. The information model defines various types of managed objects and the relationship among them needed to build the interface. The information model is organized based on the "Event-Condition-Action" (ECA) policy model defined by a capability information model for I2NSF [i2nsf-capability-im], and the data model is defined for enabling different users of a given I2NSF system to define, manage, and monitor security policies for specific flows within an administrative domain.

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1. Introduction

In a framework of Interface to Network Security Functions (I2NSF), each vendor can register their NSFs using a Developer's Management System (DMS). Assuming that vendors also provide the front-end web applications registered with an I2NSF User, the Consumer-Facing Interface is required because the web applications developed by each vendor need to have a standard interface specifying the data types used when the I2NSF User and Security Controller communicate using this interface. Therefore, this document specifies the required information, their data types, and encoding schemes so that high-level security policies (or configuration information for security policies) can be transferred to the Security Controller through the Consumer-Facing Interface. These policies can easily be translated by the Security Controller into low-level security policies. The Security Controller delivers the translated policies to Network Security Functions (NSFs) according to their respective security capabilities for the required securiy enforcement.

The Consumer-Facing Interface would be built using a set of objects, with each object capturing a unique set of information from Security Administrator (i.e., I2NSF User [RFC8329]) needed to express a Security Policy. An object may have relationship with various other objects to express a complete set of requirements. An information model captures the managed objects and relationship among these objects. The information model proposed in this document is structured in accordance with the "Event-Condition-Action" (ECA) policy model.

An NSF Capability model is proposed in [i2nsf-capability-im] as the basic model for both the NSF-Facing interface and Consumer-Facing Interface security policy model of this document.

[RFC3444] explains differences between an information and data model. This document uses the guidelines in [RFC3444] to define both the information and data model for Consumer-Facing Interface. Figure 1 shows a high-level abstraction of Consumer-Facing Interface. A data model, which represents an implementation of the information model in a specific data representation language, is also defined in this document.

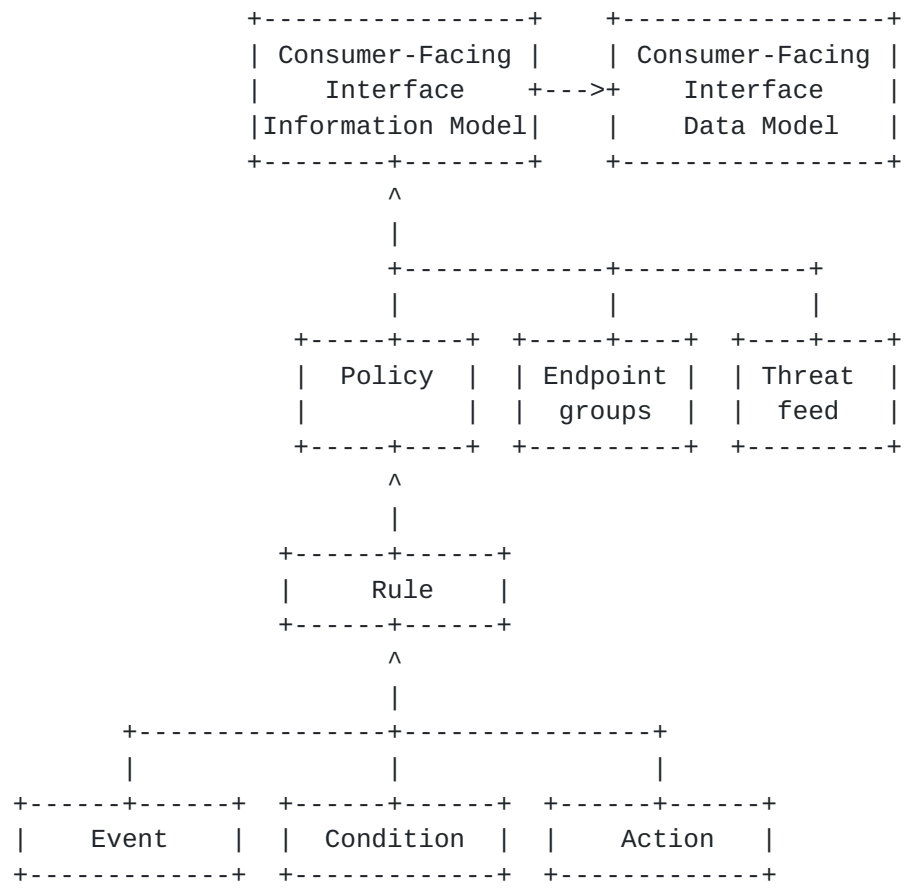

Figure 1: Diagram for High-level Abstraction of Consumer-Facing Interface

Data models are defined at a lower level of abstraction and provide many details. They provide details about the implementation of a protocol's specification, e.g., rules that explain how to map managed objects onto lower-level protocol constructs. Since conceptual models can be implemented in different ways, multiple data models can be derived from a single information model.

The efficient and flexible provisioning of network functions by a Network Functions Virtualization (NFV) system leads to a rapid advance in the network industry. As practical applications, Network Security Functions (NSFs), such as firewall, Intrusion Detection System (IDS)/Intrusion Prevention System (IPS), and attack mitigation, can also be provided as Virtual Network Functions (VNF) in the NFV system. By the efficient virtualization technology, these VNFs might be automatically provisioned and dynamically migrated based on real-time security requirements. This document presents a YANG data model to implement security functions based on NFV.

2. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC3444] RFC8174 [RFC8174].

3. Terminology

This document uses the terminology described in [i2nsf-terminology] [client-facing-inf-req].

This document follows the guidelines of [RFC8407], uses the common YANG types defined in [RFC6991], and adopts the Network Management Datastore Architecture (NMDA). The meaning of the symbols in tree diagrams is defined in [RFC8340].

4. Information Model for Policy

A Policy object represents a mechanism to express a Security Policy by Security Administrator (i.e., I2NSF User) using Consumer-Facing Interface toward Security Controller; the policy would be enforced on an NSF. Figure 2 shows the YANG tree of the Policy object. The Policy object SHALL have the following information:

Name: This field identifies the name of this object.

Rule: This field contains a list of rules. These rules are defined for 1) communication between two Endpoint Groups, 2) for preventing communication with externally or internally identified threats, and 3) for implementing business requirement such as controlling access to internal or external resources for meeting regulatory compliance or business objectives. An organization may restrict certain communication between a set of user and applications for example. The threats may be from threat feeds obtained from external sources or dynamically identified by using specialty devices in the network. Rule conflict analysis should be triggered by the monitoring service to perform an exhaustive detection of anomalies among the configuration rules installed into the security functions.

```
      +--rw i2nsf-cfi-policy* [policy-name]
         +--rw policy-name          string
         +--rw rules
         +--rw endpoint-groups
         +--rw threat-prevention
```

Figure 2: Policy YANG Data Tree

A policy is a container of Rule(s). In order to express a Rule, a Rule must have complete information such as where and when a policy needs to be applied. This is done by defining a set of managed objects and relationship among them. A Policy Rule may be related segmentation, threat mitigation or telemetry data collection from an NSF in the network, which will be specified as the sub-model of the policy model in the subsequent sections. Figure 3 shows the YANG data tree of the Rule object. The rule object SHALL have the following information:

Name: This field identifies the name of this object.

Event: This field includes the information to determine whether the Rule Condition can be evaluated or not. See details in Section 4.1.

Condition: This field contains all the checking conditions to apply to the objective traffic. See details in Section 4.2.

Action: This field identifies the action taken when a rule is matched. There is always an implicit action to drop traffic if no rule is matched for a traffic type. See details in Section 4.3.

IPsec-Method: This field contains the information about IPsec method type. There are two types such as IPsec-IKE and IPsec-IKEless [i2nsf-ipsec].

```
      +--rw rules* [rule-name]
         +--rw rule-name  string
         +--rw event
         +--rw (condition)?
         +--rw action
         +--rw ipsec-method
```

Figure 3: Rule YANG Data Tree

Note that in the case of policy conflicts, the resolution of the conflicted policies conforms to the guidelines of "Information Model of NSFs Capabilities" [i2nsf-capability-im].

4.1. Event Sub-model

The Event Object contains information related to scheduling a Rule. The Rule could be activated based on a set time or security event. Figure 4 shows the YANG tree of the Event object. Event object SHALL have following information:

Security-event: This field identifies for which security event the policy is enforced. The examples of security events are: "DDOS", "spyware", "trojan", and "ransomware".

Time-information: This represents the security rule is enforced based on the period information with the end time for the event.

Period: This represents the period of time the rule event is active.

End-time: This represents the end time of the event. If the rule time has pass the end-time, the rule will stop repeating"

Frequency: This represents how frequent the rule should be enforced. There are four options: "only-once", "daily", "weekly" and "monthly".

```
+--rw event
   +--rw security-event        identityref
   +--rw time-information
   |  +--rw start-date-time?   yang:date-and-time
   |  +--rw end-date-time?     yang:date-and-time
   |  +--rw period
   |  |  +--rw start-time?     time
   |  |  +--rw stop-time?      time
   |  |  +--rw day*            identityref
   |  |  +--rw date*           int32
   |  |  +--rw month*          string
   |  +--rw frequency?         enumeration
```

Figure 4: Event Sub-model YANG Data Tree

4.2. Condition Sub-model

This object represents Conditions that Security Administrator wants to apply the checking on the traffic in order to determine whether the set of actions in the Rule can be executed or not. The Condition Sub-model consists of three different types of containers each representing different cases, such as general firewall and DDoS-mitigation cases, and a case when the condition is based on the payload strings of packets. Each containers have source and destination-target to represent the source and destination for each case. Figure 5 shows the YANG tree of the Condition object. The Condition Sub-model SHALL have following information:

Case (Firewall-condition): This field represents the general firewall case, where a security admin can set up firewall conditions using the information present in this field. The source and destination is represented as firewall-source and firewall-destination, each referring to the IP-address-based groups defined in the endpoint-groups.

Case (DDoS-condition): This field represents the condition for DDoS mitigation, where a security admin can set up DDoS mitigation conditions using the information present in this field. The source and destination is represented as ddos-source and ddos-destination, each referring to the device-groups defined and registered in the endpoint-groups.

Case (Custom-condition): This field contains the payload string information. This information is useful when security rule condition is based on the string contents of incoming or outgoing packets. The source and destination is represented as custom-source and custom-destination, each referring to the payload-groups defined and registered in the endpoint-groups.

Case (Threat-feed-condition): This field contains the information obtained from threat-feeds (e.g., Palo-Alto, or RSA-netwitness). This information is useful when security rule condition is based on the existing threat reports gathered by other sources. The source and destination is represented as threat-feed-source and threat-feed-destination. For clarity, threat-feed-source/destination represent the source/destination of a target security threat, not the information source/destination of a threat-feed.

```
        +--rw condition
           +--:firewall-condition
           |  +--rw source  -> /../../user-group/name
           |  +--rw destination* -> /../../user-group/name
           +--:ddos-condition
           |  +--rw source* -> /../../device-group/name
           |  +--rw destination* -> /../../device-group/name
           |  +--rw rate-limit
           |     +--rw packet-threshold-per-second? uint32
           +--:location-condition
           |  +--rw source* -> /../../location-group/name
           |  +--rw destination  -> /../../location-group/name
           +--:custom-condition
           |  +--rw source* -> /../../payload-content/name
           |  +--rw destination  -> /../../payload-content/name
           +--:threat-feed-condition
           +--rw source* -> /../../threat-feed-list/name
           +--rw destination  -> /../../threat-feed-list/name
```

Figure 5: Condition Sub-model YANG Data Tree

4.3. Action Sub-model

This object represents actions that Security Admin wants to perform based on certain traffic class. Figure 6 shows the YANG tree of the Action object. The Action object SHALL have following information:

Primary-action: This field identifies the action when a rule is matched by an NSF. The action could be one of "PASS", "DROP", "ALERT", "RATE-LIMIT", and "MIRROR".

Secondary-action: This field identifies the action when a rule is matched by an NSF. The action could be one of "log", "syslog", "session-log".

```
        +--rw action
        +--rw primary-action      identityref
        +--rw secondary-action?   identityref
```

Figure 6: Action Sub-model YANG Data Tree

5. Information Model for Policy Endpoint Groups

The Policy Endpoint Group is a very important part of building User-Construct based policies. A Security Administrator would create and use these objects to represent a logical entity in their business

environment, where a Security Policy is to be applied. There are multiple managed objects that constitute a Policy's Endpoint Group as shown in Figure 7. Figure 8 shows the YANG tree of the Endpoint-Groups object. This section lists these objects and relationship among them.

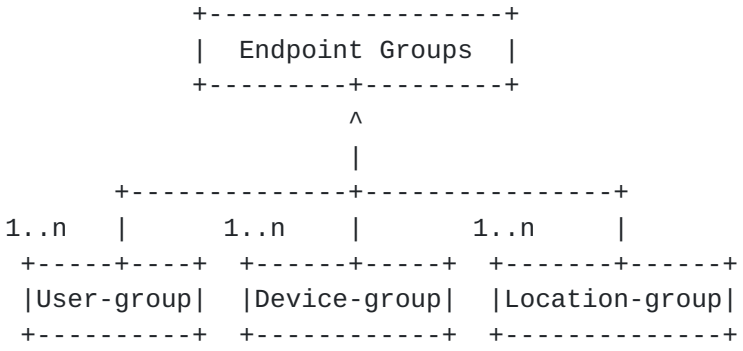

Figure 7: Endpoint Group Diagram

```
+--rw endpoint-groups
|  +--rw user-group* [name]
|  ...
|  +--rw device-group* [name]
|  ...
|  +--rw location-group* [name]
|  ...
```

Figure 8: Endpoint Group YANG Data Tree

5.1. User Group

This object represents a User-Group. Figure 9 shows the YANG tree of the User-Group object. The User-Group object SHALL have the following information:

Name: This field identifies the name of this object.

IP-address: This represents the IPv4 address of a user in the user group.

range-ipv4-address: This represents the IPv4 address of a user in the user gorup.

range-ipv6-address: This represents the IPv6 address of a user in the user gorup.

```
            +--rw user-group* [name]
            +--rw name              string
            +--rw (match-type)
               +--:(exact-match-ipv4)
               |  +--rw ipv4?            inet:ipv4-address
               +--:(exact-match-ipv6)
               |  +--rw ipv6?            inet:ipv6-address
               +--:(range-match-ipv4)
               |  +--rw range-ipv4-address
               |  +--rw start-ipv4-address    inet:ipv4-address
               |  +--rw end-ipv4-address      inet:ipv4-address
               +--:(range-match-ipv6)
                  +--rw range-ipv6-address*
                     +--rw start-ipv6-address      inet:ipv6-address
                     +--rw end-ipv6-address        inet:ipv6-address
```

Figure 9: User Group YANG Data Tree

5.2. Device Group

This object represents a Device-Group. Figure 10 shows the YANG tree of the Device-group object. The Device-Group object SHALL have the following information:

Name: This field identifies the name of this object.

IP-address: This represents the IPv4 address of a device in the device group.

range-ipv4-address: This represents the IPv4 address of a device in the device gorup.

range-ipv6-address: This represents the IPv6 address of a device in the device gorup.

Protocol: This represents the communication protocols used by the devices. The protocols are "SSH", "FTP", "SMTP", "HTTP", "HTTPS", and etc.

```
          +--rw device-group* [name]
             +--rw name                          string
             +--rw (match-type)
             |  +--:(exact-match-ipv4)
             |  |  +--rw ipv4?            inet:ipv4-address
             |  +--:(exact-match-ipv6)
             |  |  +--rw ipv6?            inet:ipv6-address
             |  +--:(range-match-ipv4)
             |  |  +--rw range-ipv4-address*
             |  |  |  +--rw start-ipv4-address    inet:ipv4-address
             |  |  |  +--rw end-ipv4-address      inet:ipv4-address
             |  +--:(range-match-ipv6)
             |  |  +--rw range-ipv6-address*
             |  |  |  +--rw start-ipv6-address    inet:ipv6-address
             |  |  |  +--rw end-ipv6-address      inet:ipv6-address
             +--rw protocol                       identityref
```

Figure 10: Device Group YANG Data Tree

5.3. Location Group

This object represents a location group based on either tag or other information. Figure 11 shows the YANG tree of the Location-Group object. The Location-Group object SHALL have the following information:

Name: This field identifies the name of this object.

geo-ip-ipv4: This field represents the IPv4 Geo-ip of a location.

geo-ip-ipv6: This field represents the IPv6 Geo-ip of a location.

continent: This field represents the continent where the location group member is at.

```
          +--rw location-group* [name]
             +--rw name                  string
             +--rw geo-ip-ipv4    inet:ipv4-address
             +--rw geo-ip-ipv6    inet:ipv6-address
             +--rw continent?            identityref
```

Figure 11: Location Group YANG Data Tree

6. Information Model for Threat Prevention

The threat prevention plays an important part in the overall security posture by reducing the attack surfaces. This information could come from various threat feeds (i.e., sources for obtaining the threat information). There are multiple managed objects that constitute this category. This section lists these objects and relationship among them. Figure 13 shows the YANG tree of a Threat-Prevention object.

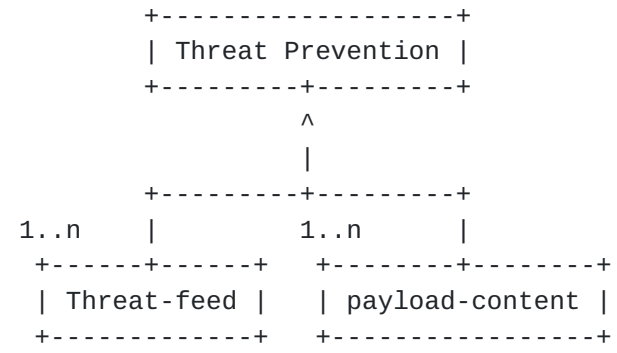

Figure 12: Threat Prevention Diagram

```
+--rw threat-prevention
   +--rw threat-feed-list* [name]
      ...
   +--rw payload-content* [name]
      ...
```

Figure 13: Threat Prevention YANG Data Tree

6.1. Threat Feed

This object represents a threat feed which provides signatures of malicious activities. Figure 14 shows the YANG tree of a Threat-feed-list. The Threat-Feed object SHALL have the following information:

name: This field identifies the name of this object.

Server-ipv4: This represents the IPv4 server address of the feed provider, it may be external or local servers.

Server-ipv6: This represents the IPv6 server address of the feed provider, it may be external or local servers.

description: This is the description of the threat feed. The descriptions should have clear indication of the security attack such as attack type (e.g., APT) and file types used (e.g., executable malware).

Threat-file-types: This field identifies the information about the file types identified and reported by the threat-feed.

signatures: This field contains the signatures of malicious programs or activities provided by the threat-feed. The examples of signature types are "YARA", "SURICATA", and "SNORT".

```
+--rw threat-prevention
   +--rw threat-feed-list* [name]
      +--rw name              identityref
      +--rw server-ipv4?      inet:ipv4-address
      +--rw server-ipv6?      inet:ipv6-address
      +--rw description?      string
      +--rw threat-file-types*     identityref
      +--rw signatures*            identityref
```

Figure 14: Threat Feed YANG Data Tree

6.2. Payload Content

This object represents a custom list created for the purpose of defining exception to threat feeds. Figure 15 shows the YANG tree of a Payload-content list. The Payload-Content object SHALL have the following information:

Name: This field identifies the name of this object. For example, the name "backdoor" indicates the payload content is related to backdoor attack.

description: This represents the description of how the payload content is related to a security attack.

Content: This contains the payload contents, which are involed in a security attack, as strings.

```
            +--rw payload-content* [name]
               +--rw name         string
               +--rw description  string
               +--rw content*     string
```

Figure 15: Payload Content in YANG Data Tree

7. Network Configuration Access Control Model (NACM) for I2NSF Consumer-Facing Interface

Network Configuration Access Control Model (NACM) provides a user group with an access control with the following features [RFC8341]:

- Independent control of action, data, and notification access is provided.
- A simple and familiar set of datastore permissions is used.
- Support for YANG security tagging allows default security modes to automatically exclude sensitive data.
- Separate default access modes for read, write, and execute permissions are provided.
- Access control rules are applied to configurable groups of users.

The data model of the I2NSF Consumer-Facing Interface utilizes the NACM's mechanisms to manage the access control on the I2NSF Consumer-Facing Interface. The NACM with the above features can be used to set up the access control rules of a user group in the I2NSF Consumer-Facing Interface. Figure 16 shows part of the NACM module to enable the access control of a user group for the I2NSF Consumer-Facing Interface. To use the NACM, a user needs to configure a NETCONF or RESTCONF server to enable the NACM module. Then, the user can simply use an account of root or admin user for the access control for the module of the I2NSF Consumer-Facing Interface (i.e., ietf-i2nsf-cfi-policy). An XML example to configure the access control a user group for the I2NSF Consumer-Facing Interface can be seen in Section 10.

```
   list rule {
     key "name";
     ordered-by user;
     leaf name {
       type string {
         length "1..max";
       }
       description
         "Arbitrary name assigned to the rule.";
     }

     leaf module-name {
       type union {
         type matchall-string-type;
         type string;
       }
       default "*";
       description
         "Name of the module associated with this rule."
     }

     leaf access-operations {
       type union {
         type matchall-string-type;
         type access-operations-type;
       }
       default "*";
       description
         "Access operations associated with this rule."
     }

     leaf action {
       type action-type;
       mandatory true;
       description
         "The access control action associated with the
          rule.  If a rule is determined to match a
          particular request, then this object is used
          to determine whether to permit or deny the
          request.";
     }
```

Figure 16: A Part of the NACM YANG Data Model

8. YANG Data Model of Consumer-Facing Interface

The main objective of this data model is to provide both an information model and the corresponding YANG data model of I2NSF Consumer-Facing Interface. This interface can be used to deliver control and management messages between an I2NSF User and Security Controller for the I2NSF User's high-level security policies.

The semantics of the data model must be aligned with the information model of the Consumer-Facing Interface. The transformation of the information model was performed so that this YANG data model can facilitate the efficient delivery of the control or management messages.

This data model is designed to support the I2NSF framework that can be extended according to the security needs. In other words, the model design is independent of the content and meaning of specific policies as well as the implementation approach. This document suggests a VoIP/VoLTE security service as a use case for policy rule generation.

This section describes a YANG data model for Consumer-Facing Interface, based on the information model of Consumer-Facing Interface to Security Controller.

```
<CODE BEGINS> file "ietf-i2nsf-cfi-policy@2020-07-13.yang"
module ietf-i2nsf-cfi-policy {
  yang-version 1.1;
  namespace
    "urn:ietf:params:xml:ns:yang:ietf-i2nsf-cfi-policy";
  prefix
    i2nsf-cfi;

  import ietf-inet-types{
    prefix inet;
  }

  import ietf-yang-types{
    prefix yang;
  }

  import ietf-netconf-acm {
    prefix nacm;
  }

  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>

     WG Chair: Linda Dunbar
     <mailto:linda.dunbar@futurewei.com>

     WG Chair: Yoav Nir
     <mailto:ynir.ietf@gmail.com>

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

     Editor: Chaehong Chung
     <mailto:darkhong@skku.edu>";

  description
    "This module is a YANG module for Consumer-Facing Interface.
     Copyright (c) 2020 IETF Trust and the persons
     identified as authors of the code. All rights reserved.
     Redistribution and use in source and binary forms, with or
     without modification, is permitted pursuant to, and subject
     to the license terms contained in, the Simplified BSD License
     set forth in Section 4.c of the IETF Trust's Legal Provisions
     Relating to IETF Documents
     http://trustee.ietf.org/license-info).
     This version of this YANG module is part of RFC XXXX; see
     the RFC itself for full legal notices.";

  revision "2020-07-13"{
    description "The latest revision";
    reference
      "draft-ietf-consumer-facing-interface-dm-08";
  }

  identity malware-file-type {
    description
      "Base identity for malware file types.";
  }

  identity executable-file {
    base malware-file-type;
    description
      "Identity for executable file types.";
  }

  identity doc-file {
    base malware-file-type;
```

```
    description
      "Identity for Microsoft document file types.";
  }

  identity html-app-file {
    base malware-file-type;
    description
      "Identity for html application file types.";
  }

  identity javascript-file {
    base malware-file-type;
    description
      "Identity for Javascript file types.";
  }

  identity pdf-file {
    base malware-file-type;
    description
      "Identity for pdf file types.";
  }

  identity dll-file {
    base malware-file-type;
    description
      "Identity for dll file types.";
  }

  identity msi-file {
    base malware-file-type;
    description
      "Identity for Microsoft installer file types.";
  }

  identity security-event-type {
    description
      "Base identity for security event types.";
  }

  identity ddos {
    base security-event-type;
    description
      "Identity for DDoS event types.";
  }

  identity spyware {
    base security-event-type;
    description
```

```
      "Identity for spyware event types.";
  }

  identity trojan {
    base security-event-type;
    description
      "Identity for Trojan infection event types.";
  }

  identity ransomware {
    base security-event-type;
    description
      "Identity for ransomware infection event types.";
  }

  identity i2nsf-ipsec {
    description
      "Base identity for IPsec method types.";
    reference
      "draft-ietf-i2nsf-sdn-ipsec-flow-protection-07";
  }

  identity ipsec-ike {
    base i2nsf-ipsec;
    description
      "Identity for ipsec-ike.";
    reference
      "draft-ietf-i2nsf-sdn-ipsec-flow-protection-07";
  }

  identity ipsec-ikeless {
    base i2nsf-ipsec;
    description
      "Identity for ipsec-ikeless.";
    reference
      "draft-ietf-i2nsf-sdn-ipsec-flow-protection-07";
  }

  identity continent {
    description
      "Base Identity for continent types.";
  }

  identity africa {
    base continent;
    description
      "Identity for africa.";
  }
```

```
  identity asia {
    base continent;
    description
      "Identity for asia.";
  }

  identity europe {
    base continent;
    description
      "Identity for europe.";
  }

  identity north-america {
    base continent;
    description
      "Identity for north-america.";
  }

  identity south-america {
    base continent;
    description
      "Identity for south-america.";
  }

  identity oceania {
    base continent;
    description
      "Identity for Oceania";
  }

  identity protocol-type {
    description
      "This identity represents the protocol types.";
  }

  identity ftp {
    base protocol-type;
    description
      "The identity for ftp protocol.";
    reference
      "RFC 959: File Transfer Protocol (FTP)";
  }

  identity ssh {
    base protocol-type;
    description
      "The identity for ssh protocol.";
    reference
```

```
      "RFC 4250: The Secure Shell (SSH) Protocol";
  }

  identity telnet {
    base protocol-type;
    description
      "The identity for telnet.";
    reference
      "RFC 854: Telnet Protocol";
  }

  identity smtp {
    base protocol-type;
    description
      "The identity for smtp.";
    reference
      "RFC 5321: Simple Mail Transfer Protocol (SMTP)";
  }

  identity sftp {
    base protocol-type;
    description
      "The identity for sftp.";
    reference
      "RFC 913: Simple File Transfer Protocol (SFTP)";
  }

  identity http {
    base protocol-type;
    description
      "The identity for http.";
    reference
      "RFC 2616: Hypertext Transfer Protocol (HTTP)";
  }

  identity https {
    base protocol-type;
    description
      "The identity for https.";
    reference
      "RFC 2818: HTTP over TLS (HTTPS)";
  }

  identity pop3 {
    base protocol-type;
    description
      "The identity for pop3.";
    reference
```

```
      "RFC 1081: Post Office Protocol -Version 3 (POP3)";
  }

  identity nat {
    base protocol-type;
    description
      "The identity for nat.";
    reference
      "RFC 1631: The IP Network Address Translator (NAT)";
  }

  identity primary-action {
    description
      "This identity represents the primary actions, such as
       PASS, DROP, ALERT, RATE-LIMIT, and MIRROR.";
  }

  identity pass {
    base primary-action;
    description
      "The identity for pass.";
  }

  identity drop {
    base primary-action;
    description
      "The identity for drop.";
  }

  identity alert {
    base primary-action;
    description
      "The identity for alert.";
  }

  identity rate-limit {
    base primary-action;
    description
      "The identity for rate-limit.";
  }

  identity mirror {
    base primary-action;
    description
      "The identity for mirroring.";
  }

  identity secondary-action {
```

```
    description
      "This field identifies additional actions if a rule is
       matched. This could be one of 'LOG', 'SYSLOG',
       'SESSION-LOG', etc.";
  }

  identity log {
    base secondary-action;
    description
      "The identity for logging.";
  }

  identity syslog {
    base secondary-action;
    description
      "The identity for system logging.";
  }

  identity session-log {
    base secondary-action;
    description
      "The identity for session logging.";
  }

  identity signature-type {
    description
      "This represents the base identity for signature types.";
  }

  identity signature-yara {
    base signature-type;
    description
      "This represents the YARA signatures.";
  }

  identity signature-snort {
    base signature-type;
    description
      "This represents the SNORT signatures.";
  }

  identity signature-suricata {
    base signature-type;
    description
      "This represents the SURICATA signatures.";
  }

  identity threat-feed-type {
```

```
    description
      "This represents the base identity for threat-feed.";
  }

  identity day {
    description
      "This represents the base for days.";
  }

  identity monday {
    base day;
    description
      "This represents monday.";
  }

  identity tuesday {
    base day;
    description
      "This represents tuesday.";
  }

  identity wednesday {
    base day;
    description
      "This represents wednesday.";
  }

  identity thursday {
    base day;
    description
      "This represents thursday.";
  }

  identity friday {
    base day;
    description
      "This represents friday.";
  }

  identity saturday {
    base day;
    description
      "This represents saturday.";
  }

  identity sunday {
    base day;
    description
```

```
      "This represents sunday.";
  }


  /*
  * Typedefs
  */
  typedef time{
    type string {
      pattern '\d{2}:\d{2}:\d{2}(\.\d+)?'
        + '(Z|[\+\-]\d{2}:\d{2})';
    }
    description
      "This is the format of time.";
  }

  /*
  * Groupings
  */

  grouping ipv4-list {
    description
      "Grouping for ipv4 based ip-addresses.";
    leaf-list ipv4 {
      type inet:ipv4-address;
      description
        "This is the entry for the ipv4 ip-addresses.";
    }
  }

  grouping ipv6-list {
    description
      "Grouping for ipv6 based ip-addresses.";
    leaf-list ipv6 {
      type inet:ipv6-address;
      description
        "This is the entry for the ipv6 ip-addresses.";
    }
  }

  grouping ipv4 {
    description
      "Grouping for ipv4 based ip-address.";
    leaf ipv4 {
      type inet:ipv4-address;
      description
        "This is the entry for the ipv4 ip-address.";
    }
```

```
  }

  grouping ipv6 {
    description
      "Grouping for ipv6 based ip-address.";
    leaf ipv6 {
      type inet:ipv6-address;
      description
        "This is the entry for the ipv6 ip-address.";
    }
  }

  grouping ip-address-info {
    description
      "There are two types to configure a security policy
      for IPv4 address, such as exact match and range match.";
    choice match-type {
      description
        "User can choose between 'exact match' and 'range match'.";
      case exact-match-ipv4 {
        uses ipv4;
        description
          "Exact ip-address match for ipv4 type addresses";
      }
      case exact-match-ipv6 {
        uses ipv6;
        description
          "Exact ip-address match for ipv6 type addresses";
      }
      case range-match-ipv4 {
        container range-ipv4-address {
          leaf start-ipv4-address {
            type inet:ipv4-address;
            description
              "Start IPv4 address for a range match.";
          }
          leaf end-ipv4-address {
            type inet:ipv4-address;
            description
              "End IPv4 address for a range match.";
          }
          description
            "Range match for an IP-address.";
        }
      }
      case range-match-ipv6 {
        container range-ipv6-address {
          leaf start-ipv6-address {
```

```
            type inet:ipv6-address;
            description
              "Start IPv6 address for a range match.";
          }
          leaf end-ipv6-address {
            type inet:ipv6-address;
            description
              "End IPv6 address for a range match.";
          }
          description
            "Range match for an IP-address.";
        }
      }
    }
  }

  grouping ipsec-based-method {
    description
      "This represents the ipsec-based method.";
    list ipsec-method {
      key "method";
      description
        "This represents the list of IPsec method types.";
      leaf method {
        type identityref {
          base i2nsf-ipsec;
        }
        description
          "This represents IPsec IKE and IPsec IKEless cases.
          If this is not set, it cannot support IPsec IKE or
          IPsec IKEless.";
        reference
          "draft-ietf-i2nsf-sdn-ipsec-flow-protection-07";
      }
    }
  }

  grouping user-group {
    description
      "The grouping for user-group entities, and contains
      information such as name & ip-address.";
    leaf name {
      type string;
      description
        "This represents the name of a user-group.
        A user-group name is used to map a user-group's
        name (e.g., employees) to an ip address.
        It is implementation dependent";
```

```
    }
    uses ip-address-info{
      refine match-type{
        mandatory true;
      }
      description
        "This represent the IP address of a user-group.";
    }
  }

  grouping device-group {
    description
      "This group represents device group information
      such as ip-address protocol.";
    leaf name {
      type string;
      description
      "This represents the name of a device-group.";
    }
    uses ip-address-info{
      refine match-type{
        mandatory true;
      }
    }
    leaf-list protocol {
      type identityref {
        base protocol-type;
      }
      description
        "This represents the communication protocols of
        devices.
        If this is not set, it cannot support the
        appropriate protocol";
    }
  }

  grouping location-group {
    description
      "This group represents location-group information
      such as geo-ip and continent.";
    leaf name {
      type string;
      description
        "This represents the name of a location.";
    }
    list geo-ip-ipv4 {
      key "ipv4-address";
      description
```

```
        "This represents the list of IPv4 address based on
        a location.";
      leaf ipv4-address{
        type inet:ipv4-address;
        description
          "This represents an IPv4 geo-ip of a location.";
      }
      leaf ipv4-prefix{
        type inet:ipv4-prefix;
        description
          "This represents the prefix for the IPv4-address.";
      }
    }
    list geo-ip-ipv6 {
      key "ipv6-address";
      description
        "This represents the list of IPv6 address based on
        a location.";
      leaf ipv6-address{
        type inet:ipv6-address;
        description
          "This represents an IPv6 geo-ip of a location.";
      }
      leaf ipv6-prefix{
        type inet:ipv6-prefix;
        description
          "This represents the prefix for the IPv6-address.";
      }
    }
    leaf continent {
      type identityref {
        base continent;
      }
      default asia;
      description
        "location-group-based on geo-ip of
        respective continent.";
    }
  }

  grouping threat-feed-info {
    description
      "This is the grouping for the threat-feed-list";
    leaf threat-type {
      type identityref {
        base threat-feed-type;
      }
      description
```

```
        "This represents the type of the threat-feed.";
    }
    leaf server-ipv4 {
      type inet:ipv4-address;
      description
        "The IPv4 ip-address for the threat-feed server.";
    }
    leaf server-ipv6 {
      type inet:ipv6-address;
      description
        "The IPv6 ip-address for the threat-feed server.";
    }
    leaf description {
      type string;
      description
        "This represents the descriptions of a threat-feed.
        The description should include information, such as
        the type, related threat, method, and file type.
        Structured Threat Information Expression (STIX) can
        be used for description of a threat [STIX].";
    }
  }

  grouping payload-string {
    description
      "The grouping for payload-string content.
      It contains information such as name and string
      content.";
    leaf description {
      type string;
      description
        "This represents the description of a payload.
        If this is not set, it cannot support the
        description of how the payload content is
        related to a security attack.";
    }
    leaf-list content {
      type string;
      description
        "This represents the string of the payload
        contents. This content leaf-list contains the
        payload of a packet to analyze a threat.
        Due to the types of threats, the type of the
        content is defined as string to accommodate
        any kind of a payload type such as HTTP, HTTPS,
        and SIP.
        If this is not set, it cannot support the
        payload contents involved in a security attack
```

```
        as strings";
    }
  }

  list i2nsf-cfi-policy {
    key "policy-name";
    description
      "This is the security policy list. Each policy in
      the list contains a list of security rules, and is
      a policy instance to have complete information
      such as where and when a policy needs to be
      applied.";
    leaf policy-name {
      type string;
      description
        "The name which identifies the policy.";    }
    container rules{
      description
        "This container is for rules.";
      nacm:default-deny-write;
      list rule {
        key "rule-name";
        ordered-by user;
        leaf rule-name {
          type string;
          description
            "This represents the name for the rule.";
        }
        description
          "There can be a single or multiple number of
          rules.";

        container event {
          description
            "This represents the event (e.g., a security
            event, for which a security rule is made.)";
          leaf security-event {
            type identityref {
              base security-event-type;
            }
            description
              "This contains the description of security
              events. If this is not set, it cannot
              support which security event is enforced";
          }

          container time-information {
            description
```

```
            "The time information when the security
            rule should be applied.";
          leaf start-date-time {
            type yang:date-and-time;
            description
              "This is the start date and time
              for policy.";
          }
          leaf end-date-time {
            type yang:date-and-time;
            description
              "This is the end date and time
              for policy. The policy will stop
              working after the specified
              end-date-time";
          }
          container period{
            when
              "/i2nsf-cfi-policy/rules/rule/event/frequency!='only-once'";
            description
              "This represents the repetition time.
              In case of frequency is weekly, the days
              can be set.";
            leaf start-time {
              type time;
              description
                "This is period start time for event.";
            }
            leaf end-time {
              type time;
              description
                "This is period end time for event.";
            }
            leaf-list day {
              when
                "/i2nsf-cfi-policy/rules/rule/event/frequency='weekly'";
              type identityref{
                base day;
              }
              description
                "This represents the repeated day of
                every week (e.g., monday and tuesday).
                More than one day can be specified";
            }
            leaf-list date {
              when
                "/i2nsf-cfi-policy/rules/rule/event/frequency='monthly'";
              type int32{
```

```
                range "1..31";
              }
              description
                "This represents the repeated date of
                every month. More than one date can be
                specified.";
            }
            leaf-list month {
              when
                "/i2nsf-cfi-policy/rules/rule/event/frequency='yearly'";
              type string{
                pattern '\d{2}-\d{2}';
              }
              description
                "This represents the repeated date and month
                of every year. More than one can be specified.
                Pattern used is Month-Date (MM-DD).";
            }
          }
        }

        leaf frequency {
          type enumeration {
            enum only-once {
              description
                "This represents the rule is enforced
                only once immediately and not repeated.
                The policy will continuously active from
                start time and terminated at end-time.";
            }
            enum daily {
              description
                "This represents the rule is enforced
                on a daily basis. The policy will be
                repeated daily until the end-date.";
            }
            enum weekly {
              description
                "This represents the rule is enforced
                on a weekly basis. The policy will be
                repeated weekly until the end-date. The
                repeated days can be specified.";
            }
            enum monthly {
              description
                "This represents the rule is enforced
                on a monthly basis. The policy will be
                repeated monthly until the end-date.";
```

```
            }
            enum yearly {
              description
                "This represents the rule is enforced
                on a yearly basis. The policy will be
                repeated yearly until the end-date.";
            }
          }
          default only-once;
          description
            "This represents how frequent the rule
            should be enforced.";
        }
      }


      container condition {
        description
        "The conditions for general security policies.";
        container firewall-condition {
          description
            "The general firewall condition.";
          leaf source {
            type leafref {
              path
                "/i2nsf-cfi-policy/endpoint-groups/user-group/name";
            }
            description
            "This describes the paths to the source reference.";
          }

          leaf-list destination {
            type leafref {
              path
                "/i2nsf-cfi-policy/endpoint-groups/user-group/name";
            }
            description
              "This describes the paths to the destination
              target reference.";
          }
        }

        container ddos-condition {
          description
            "The condition for DDoS mitigation.";
          leaf-list source {
            type leafref {
              path
```

```
                "/i2nsf-cfi-policy/endpoint-groups/device-group/name";
            }
            description
              "This describes the path to the
              source target references.";
          }
          leaf-list destination {
            type leafref {
              path
                "/i2nsf-cfi-policy/endpoint-groups/device-group/name";
            }
            description
              "This describes the path to the destination target
              references.";
          }
          container rate-limit {
            description
              "This describes the rate-limit.";
            leaf packet-threshold-per-second {
              type uint32;
              description
                "This is a trigger value for the condition.";
            }
          }
        }

        container location-condition {
          description
            "The condition for location based connection";
          leaf-list source {
            type leafref {
              path
                "/i2nsf-cfi-policy/endpoint-groups/location-group/name";
            }
            description
              "This describes the path to the location
              source reference.";
          }
          leaf-list destination {
            type leafref {
              path
                "/i2nsf-cfi-policy/endpoint-groups/location-group/name";
            }
            description
              "This describes the path to the location
              destination reference.";
          }
        }
```

```
          container custom-condition {
            description
              "The condition based on packet contents.";
            leaf-list source {
              type leafref {
               path
                "/i2nsf-cfi-policy/threat-preventions/payload-content/name";
              }
              description
                "Describes the payload string content condition
                source.";
            }
            leaf destination {
              type leafref {
               path
                "/i2nsf-cfi-policy/threat-preventions/payload-content/name";
              }
              description
                "Describes the payload string content condition
                destination.";
            }
          }

          container threat-feed-condition {
            description
              "The condition based on the threat-feed information.";
            leaf-list source {
              type leafref {
               path
                "/i2nsf-cfi-policy/threat-preventions/threat-feed-list/name";
              }
              description
                "Describes the threat-feed condition source.";
            }
            leaf destination {
              type leafref {
               path
                "/i2nsf-cfi-policy/threat-preventions/threat-feed-list/name";
              }
              description
                "Describes the threat-feed condition destination.";
            }
          }
        }

        container actions {
          description
            "This is the action container.";
```

```
          leaf primary-action {
            type identityref {
              base primary-action;
            }
            description
              "This represent the primary actions (e.g.,
              PASS, DROP, ALERT, and MIRROR) to be
              applied a condition.
              If this is not set, it cannot support
              the primary actions.";
          }
          leaf secondary-action {
            type identityref {
              base secondary-action;
            }
            description
              "This represents the secondary actions
              (e.g., log and syslog) to be applied
              if needed.
              If this is not set, it cannot support
              the secondary actions.";
          }
        }

        container ipsec-method {
          description
            "This container represents the IPsec IKE
            and IKEless cases.";
          leaf method {
            type identityref {
              base i2nsf-ipsec;
            }
            description
              "This references the IPsec method types,
              which includes IPsec IKE and IPsec IKEless
              cases.
              If this is not set, it cannot support
              IPsec IKE or IPsec IKEless.";
            reference
              "draft-ietf-i2nsf-sdn-ipsec-flow-protection-07";
          }
        }
      }
    }
    container endpoint-groups {
      description
        "A logical entity in their business
        environment, where a security policy
```

```
        is to be applied.";
      list user-group{
        uses user-group;
        key "name";
        description
          "This represents the user group.";
      }
      list device-group {
        key "name";
        uses device-group;
        description
          "This represents the device group.";
      }
      list location-group{
        key "name";
        uses location-group;
        description
          "This represents the location group.";
      }
    }

    container threat-preventions {
      description
        "this describes the list of threat-prevention.";
      list threat-feed-list {
        key "name";
        description
          "There can be a single or multiple number of
          threat-feeds.";
        leaf name {
          type string;
          description
            "This represents the name of the threat-feed.";
        }
        uses threat-feed-info;
        leaf-list threat-file-types {
          type identityref {
            base malware-file-type;
          }
          default executable-file;
          description
            "This contains a list of file types needed to
            be scanned for the virus.";
        }
        leaf-list signatures {
          type identityref {
            base signature-type;
          }
```

```
          default signature-suricata;
          description
            "This contains a list of signatures or hashes
            of the threats.";
        }
      }
      list payload-content {
        key "name";
        leaf name {
          type string;
          description
            "This represents the name of payload-content.
            It should give an idea of why specific payload
            content is marked as threat. For example, the
            name 'backdoor' indicates the payload content
            is related to backdoor attack.";
        }
        description
          "This represents the payload-string group.";
        uses payload-string;
      }
    }
  }
}
<CODE ENDS>
```

Figure 17: YANG for Consumer-Facing Interface

9. XML Configuration Examples of High-Level Security Policy Rules

Note: This section is informative with XML configuration examples.

This section is informative with XML configuration examples. This section shows XML configuration examples of high-level security policy rules that are delivered from the I2NSF User to the Security Controller over the Consumer-Facing Interface. The considered use cases are: Database registration, time-based firewall for web filtering, VoIP/VoLTE security service, and DDoS-attack mitigation.

9.1. Database Registration: Information of Positions and Devices (Endpoint Group)

If new endpoints are introduced to the network, it is necessary to first register their data to the database. For example, if new members are newly introduced in either of three different groups (i.e., user-group, device-group, and payload-group), each of them should be registered with information such as ip-addresses or protocols used by devices. Figure 18 shows an example XML

representation of the registered information for the user-group and device-group.

```
<?xml version="1.0" encoding="UTF-8" ?>
<i2nsf-cfi-policy xmlns="urn:ietf:params:xml:ns:yang:ietf-i2nsf-cfi-policy">
  <endpoint-groups>
    <user-group>
      <name>employees</name>
      <range-ipv4-address>
        <start-ipv4-address>221.159.112.1</start-ipv4-address>
        <end-ipv4-address>221.159.112.90</end-ipv4-address>
      </range-ipv4-address>
    </user-group>
    <device-group>
      <name>webservers</name>
      <range-ipv4-address>
        <start-ipv4-address>221.159.112.91</start-ipv4-address>
        <end-ipv4-address>221.159.112.97</end-ipv4-address>
      </range-ipv4-address>
      <protocol>http</protocol>
      <protocol>https</protocol>
    </device-group>
  </endpoint-groups>
</i2nsf-cfi-policy>
```

Figure 18: Registering User-group and Device-group Information

9.2. Scenario 1: Block SNS Access during Business Hours

The first example scenario is to "block SNS access during office hours" using a time-based firewall policy. In this scenario, all users registered as "employees" in the user-group list are unable to access Social Networking Services (SNS) during the office hours (weekdays). The XML instance is described below:

```
<?xml version="1.0" encoding="UTF-8" ?>
<i2nsf-cfi-policy xmlns="urn:ietf:params:xml:ns:yang:ietf-i2nsf-cfi-policy">
  <policy-name>security_policy_for_blocking_sns123</policy-name>
  <rules>
    <rule>
      <rule-name>block_access_to_sns_during_office_hours</rule-name>
      <event>
        <time-information>
          <start-date-time>2020-03-11T09:00:00.00Z</start-date-time>
          <end-date-time>2020-12-31T18:00:00.00Z</end-date-time>
          <period>
            <start-time>09:00:00Z</start-time>
            <end-time>18:00:00Z</end-time>
            <day>monday</day>
            <day>tuesday</day>
            <day>wednesday</day>
            <day>thursday</day>
            <day>friday</day>
          </period>
        </time-information>
        <frequency>weekly</frequency>
      </event>
      <condition>
        <firewall-condition>
          <source>employees</source>
        </firewall-condition>
      </condition>
      <actions>
        <primary-action>drop</primary-action>
      </actions>
    </rule>
  </rules>
</i2nsf-cfi-policy>
```

Figure 19: An XML Example for Time-based Firewall

Time-based-condition Firewall

1. The policy name is "security_policy_for_blocking_sns".

2. The rule name is "block_access_to_sns_during_office_hours".

3. The Source is "employees".

4. The destination target is "sns-websites". "sns-websites" is the key which represents the list containing the information, such as URL, about sns-websites.

5. The action required is to "drop" any attempt to connect to websites related to Social networking.

6. The IPsec method type used for nsf traffic steering is set to "ipsec-ike".

9.3. Scenario 2: Block Malicious VoIP/VoLTE Packets Coming to a Company

The second example scenario is to "block malicious VoIP/VoLTE packets coming to a company" using a VoIP policy. In this scenario, the calls comming from from VOIP and/or VOLTE sources with VOLTE IDs that are classified as malicious are dropped. The IP addresses of the employees and malicious VOIP IDs should be blocked are stored in the database or datastore of the enterprise. Here and the rest of the cases assume that the security administrators or someone responsible for the existing and newly generated policies, are not aware of which and/or how many NSFs are needed to meet the security requirements. Figure 20 represents the XML document generated from YANG discussed in previous sections. Once a high-level seucurity policy is created by a security admin, it is delivered by the Consumer-Facing Interface, through RESTCONF server, to the security controller. The XML instance is described below:

```
<?xml version="1.0" encoding="UTF-8" ?>
<i2nsf-cfi-policy xmlns="urn:ietf:params:xml:ns:yang:ietf-i2nsf-cfi-policy">
  <policy-name>
          security_policy_for_blocking_malicious_voip_packets
        </policy-name>
  <rules>
    <rule>
      <rule-name>Block_malicious_voip_and_volte_packets</rule-name>
      <conditions>
        <custom-condition>
          <source>malicious-id</source>
        </custom-condition>
        <firewall-condition>
          <destination>employees</destination>
        </firewall-condition>
      </conditions>
      <actions>
        <primary-action>drop</primary-action>
      </actions>
      <ipsec-method>
        <method>ipsec-ikeless</method>
      </ipsec-method>
    </rule>
  </rules>
</i2nsf-cfi-policy>
```

Figure 20: An XML Example for VoIP Security Service

Custom-condition Firewall

1. The policy name is "security_policy_for_blocking_malicious_voip_packets".

2. The rule name is "Block_malicious_voip_and_volte_packets".

3. The Source is "malicious-id". This can be a single ID or a list of IDs, depending on how the ID are stored in the database. The "malicious-id" is the key so that the security admin can read every stored malicious VOIP IDs that are named as "malicious-id".

4. The destination target is "employees". "employees" is the key which represents the list containing information about employees, such as IP addresses.

5. The action required is "drop" when any incoming packets are from "malicious-id".

6. The IPsec method used for nsf traffic steering is set to "ipsec-ikeless".

9.4. Scenario 3: Mitigate HTTP and HTTPS Flood Attacks on a Company Web Server

The third example scenario is to "Mitigate HTTP and HTTPS flood attacks on a company web server" using a DDoS-attack mitigation policy. Here, the time information is not set because the service provided by the network should be maintained at all times. If the packets sent by any sources are more than the set threshold, then the admin can set the percentage of the packets to be dropped to safely maintain the service. In this scenario, the source is set as "any" to block any sources which send abnormal amount of packets. The destination is set as "web_server01". Once the rule is set and delivered and enforced to the nsfs by the securiy controller, the NSFs will monitor the incoming packet amounts and the destination to act according to the rule set. The XML instance is described below:

```
<?xml version="1.0" encoding="UTF-8" ?>
<i2nsf-cfi-policy xmlns="urn:ietf:params:xml:ns:yang:ietf-i2nsf-cfi-policy">
  <policy-name>security_policy_for_ddos_attacks</policy-name>
  <rules>
    <rule>
      <rule-name>100_packets_per_second</rule-name>
      <conditions>
        <ddos-condition>
          <destination>webservers</destination>
          <rate-limit>
            <packet-threshold-per-second>100</packet-threshold-per-second>
          </rate-limit>
        </ddos-condition>
      </conditions>
      <actions>
        <primary-action>drop</primary-action>
      </actions>
      <ipsec-method>
        <method>ipsec-ikeless</method>
      </ipsec-method>
    </rule>
  </rules>
</i2nsf-cfi-policy>
```

Figure 21: An XML Example for DDoS-attack Mitigation

DDoS-condition Firewall

1. The policy name is "security_policy_for_ddos_attacks".

2. The rule name is "100_packets_per_second".

3. The destination target is "webservers". "webservers" is the key which represents the list containing information, such as IP addresses and ports, about web-servers.

4. The rate limit exists to limit the incoming amount of packets per second. In this case the rate limit is "100" packets per second. This amount depends on the packet receiving capacity of the server devices.

5. The Source is all sources which send abnormal amount of packets.

6. The action required is to "drop" packet reception is more than 100 packets per second.

7. The IPsec method used for nsf traffic steering is set to "ipsec-ike".

10. XML Configuration Example of a User Group's Access Control for I2NSF Consumer-Facing Interface

Note: This section is informative with an XML configuration example.

This is an example for creating privileges for a group of users (i.e., a user group) to access and use the I2NSF Consumer-Facing Interface to create security policies via the interface. For the access control of the Consumer-Facing Interface, the NACM module can be used. Figure 22 shows an XML example the access control of a user group (named Example-Group) for I2NSF Consumer-Facing Interface A group called Example-Group can be created and configured with NACM for the Consumer-Facing Interface. For Example-Group, a rule list can created with the name of Example-Group-Rules. Example-Group-Rules has two rules of Example-Group-Rule1 and Example-Group-Rule2 as follows. For Example-Group-Rule1, the privilege of "Read" is allowed to Example-Group for the Consumer-Facing Interface. On the other hand, for Example-Group-Rule2, the privileges of "Create", "Update", and "Delete" are denied against Example-Group for the Consumer-Facing Interface.

```
<?xml version="1.0" encoding="UTF-8" ?>
<nacm xmlns="urn:ietf:params:xml:ns:yang:ietf-netconf-acm">
  <enable-nacm>true</enable-nacm>
  <groups>
    <group>
      <name>Example-Group</name>
      <user-name>Alice</user-name>
      <user-name>Bob</user-name>
      <user-name>Eve</user-name>
    </group>
  </groups>
  <rule-list>
    <name>Example-Group-Rules</name>
    <group>Example-Group</group>
    <rule>
      <name>Example-Group-Rule1</name>
      <access-operations>read</access-operations>
      <module-name>ietf-i2nsf-cfi-policy</module-name>
      <action>permit</action>
    </rule>
    <rule>
      <name>Example-Group-Rule2</name>
      <access-operations>create update delete</access-operations>
      <module-name>ietf-i2nsf-cfi-policy</module-name>
      <action>deny</action>
    </rule>
  </rule-list>
</nacm>
```

Figure 22: An XML Example of a User Group's Access Control for I2NSF Consumer-Facing Interface

The access control for the I2NSF Consumer-Facing Interface is as follows.

1. The NACM is enabled.

2. As a group name, Example-Group is specified.

3. As members of the group, Alice, Bob, and Eve are specified.

4. As a rule list name, Example-Group-Rules is specified for managing privileges of Example-Group's members.

5. As the first rule name, Example-Group-Rule1 is specified. This rule is used to give read privilege to Example-Group's members for the module of the I2NSF Consumer-Facing Interface.

6. As the second rule name, Example-Group-Rule2 is specified. This rule is used to deny create, update, and delete privileges against Example-Group's members for the module of the I2NSF Consumer-Facing Interface.

11. Security Considerations

The data model for the I2NSF Consumer-Facing Interface is based on the I2NSF framework [RFC8329], so the same security considerations with the I2NSF framework should be included in this document. The data model needs a secure communication channel to protect the Consumer-Facing Interface between the I2NSF User and Security Controller. Also, the data model's management access control is based on Network Configuration Access Control Model(NACM) mechanisms [RFC8341].

12. 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-cfi-policy
Registrant Contact: The I2NSF.
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].

name: ietf-i2nsf-cfi-policy
namespace: urn:ietf:params:xml:ns:yang:ietf-i2nsf-cfi-policy
prefix: cfi-policy
reference: RFC 7950

13. Acknowledgments

This work was supported by Institute of Information & Communications Technology Planning & Evaluation (IITP) grant funded by the Korea MSIT (Ministry of Science and ICT) (R-20160222-002755, Cloud based Security Intelligence Technology Development for the Customized Security Service Provisioning).

14. Contributors

This document is made by the group effort of I2NSF working group. Many people actively contributed to this document, such as Mahdi F.

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Appendix A. Changes from draft-ietf-i2nsf-consumer-facing-interface-dm-08

The following changes are made from draft-ietf-i2nsf-consumer-facing-interface-dm-08:

- This version is revised according to the comments from Jan Lindblad who reviewed this document as a YANG doctor.

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