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I2NSF Consumer-Facing Interface YANG Data Model

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 based on the "Event-Condition-Action" (ECA) policy model defined by a capability information model for I2NSF, 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) [[RFC8329](#)], each vendor can register their NSFs using a Developer's Management System (DMS). Assuming that vendors also provide the front-end web applications to 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 with each other 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 security 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 [[I-D.ietf-i2nsf-capability](#)] 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.

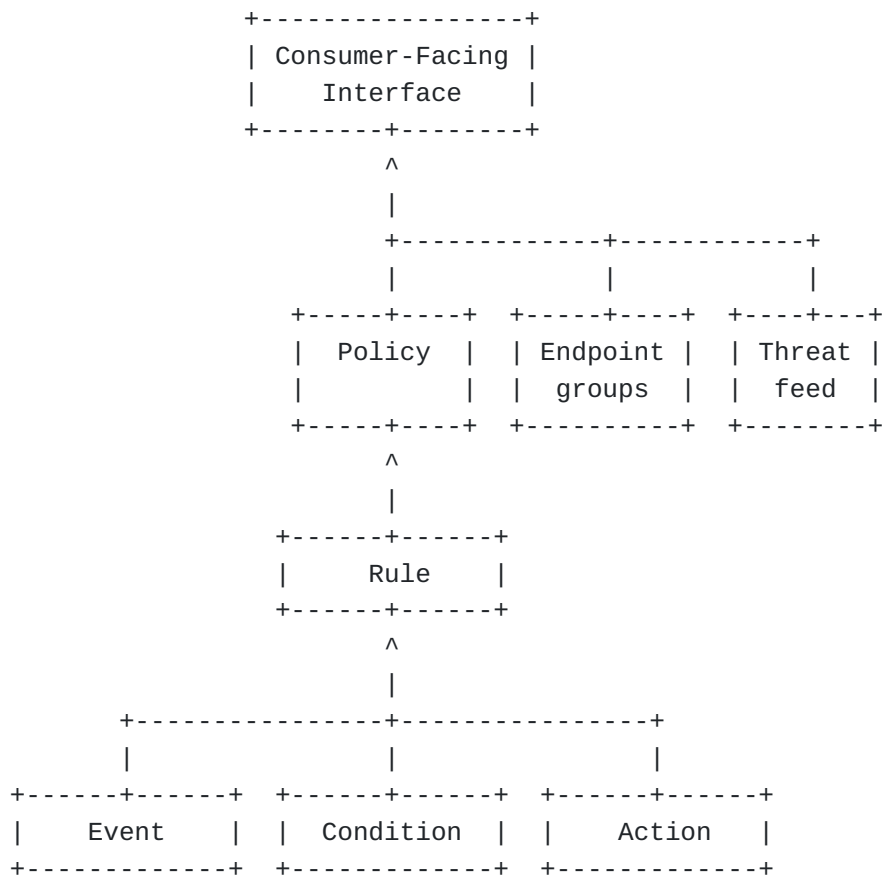


Figure 1: Diagram for High-level Abstraction of Consumer-Facing Interface

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. 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](#)], uses the common YANG types defined in [[RFC6991](#)], and adopts the Network Management Datastore Architecture (NMDA) [[RFC8342](#)]. The meaning of the symbols in tree diagrams is defined in [[RFC8340](#)].

3. 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.

Language: The language field indicates the language tag that is used for the natural language text that is included in all of the 'description' attributes. The language field is encoded following the rules in Section 2.1 of [[RFC5646](#)]. The default language tag is "en-US".

Resolution-strategy: This field represent how to resolve conflicts that occur between actions of the same or different policy rules that are matched and contained in this particular NSF.

Rules: 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.

```

module: ietf-i2nsf-cfi-policy
+--rw i2nsf-cfi-policy* [name]
  +--rw name                string
  +--rw language?           string
  +--rw resolution-strategy? identityref
  +--rw rules* [name]
    | ...
  +--rw endpoint-groups
    | ...
  +--rw threat-prevention
    ...

```

Figure 2: Policy YANG Data Tree

A policy is a list of rules. 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.

Priority: This field identifies the priority of the rule.

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.

```

+--rw rules* [name]
|   +--rw name          string
|   +--rw priority?     uint8
|   +--rw event
|   |   ...
|   +--rw condition
|   |   ...
|   +--rw action
|       ...

```

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" [[I-D.ietf-i2nsf-capability](#)].

3.1. Event Sub-model

The Event Object contains information related to scheduling a Rule. The Rule could be activated based on a security event (i.e., system event and system alarm). [Figure 4](#) shows the YANG tree of the Event object. Event object SHALL have following information:

System-event (also called alert): is defined as a warning about any changes of configuration, any access violation, the information of sessions and traffic flows.

System-alarm: is defined as a warning related to service degradation in system hardware.

```

|   +--rw event
|   |   +--rw system-event*  identityref
|   |   +--rw system-alarm*  identityref

```

Figure 4: Event Sub-model YANG Data Tree

3.2. 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): This field represents the general firewall case, where a security admin can set up firewall conditions using the information present in this field. The firewall attributes are represented by source, destination, transport layer protocol, port numbers, and ICMP parameters. Note that the YANG module only provide high-level ICMP messages that is shared between ICMPv4 and ICMPv6 (e.g., Destination Unreachable: Port Unreachable which is ICMPv4 type 3 code 3 or ICMPv6 type 1 code 4). Also note that QUIC protocol [[RFC9000](#)] is excluded in the data model as it is not considered in the initial I2NSF documents [[RFC8329](#)]. The QUIC traffic should not be treated as UDP traffic and will be considered in the future I2NSF documents.

Case (ddos): 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 rate of packet, byte, or flow threshold can be configured to mitigate the DDoS.

Case (anti-virus): This field represents the condition for Antivirus, where a security admin can set up Antivirus conditions using the information present in this field. The file names or types can be configured to be allowed without the Antivirus interruption.

Case (payload): 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 name referring to the payload-groups defined and registered in the endpoint-groups.

Case (url-category): This field represents the URL to be filtered. This information can be used to block or allow a certain URL or website. The url-name is a group of URL or websites to be matched.

Case (voice): This field contains the call source-id, call destination-id, and user-agent. This information can be used to filter a caller id or receiver id to prevent any VoIP or VoCN exploits or attack.

Case (context): This field provide extra information for the condition for filtering the network traffic. The given context

conditions are application filter, target, user condition, and geographic location.

Case (Threat-feed): 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.

```

|   +--rw condition
|   |   +--rw firewall
|   |   |   +--rw source*                union
|   |   |   +--rw destination*           union
|   |   |   +--rw transport-layer-protocol? identityref
|   |   |   +--rw range-port-number
|   |   |   |   +--rw start-port-number?  inet:port-number
|   |   |   |   +--rw end-port-number?    inet:port-number
|   |   |   +--rw icmp
|   |   |       +--rw message*    identityref
|   |   +--rw ddos
|   |   |   +--rw rate-limit
|   |   |       +--rw packet-rate-threshold?  uint64
|   |   |       +--rw byte-rate-threshold?    uint64
|   |   |       +--rw flow-rate-threshold?    uint64
|   |   +--rw anti-virus
|   |   |   +--rw exception-files*    string
|   |   +--rw payload
|   |   |   +--rw content*
|   |   |       -> /i2nsf-cfi-policy/threat-prevention/payload-content/name
|   |   +--rw url-category
|   |   |   +--rw url-name?
|   |   |       -> /i2nsf-cfi-policy/endpoint-groups/url-group/name
|   |   +--rw voice
|   |   |   +--rw source-id*          string
|   |   |   +--rw destination-id*    string
|   |   |   +--rw user-agent*        string
|   |   +--rw context
|   |   |   +--rw time
|   |   |   |   +--rw start-date-time?  yang:date-and-time
|   |   |   |   +--rw end-date-time?    yang:date-and-time
|   |   |   |   +--rw period
|   |   |   |   |   +--rw start-time?    time
|   |   |   |   |   +--rw end-time?      time
|   |   |   |   |   +--rw day*           day
|   |   |   |   |   +--rw date*         int32
|   |   |   |   |   +--rw month*        string
|   |   |   |   |   +--rw frequency?     enumeration
|   |   |   +--rw application
|   |   |   |   +--rw protocol*          identityref
|   |   |   +--rw device-type
|   |   |   |   +--rw device*            identityref
|   |   |   +--rw users
|   |   |   |   +--rw user* [id]
|   |   |   |   |   +--rw id            uint32
|   |   |   |   |   +--rw name?        string
|   |   |   |   +--rw group* [id]
|   |   |   |   |   +--rw id            uint32
|   |   |   |   |   +--rw name?        string

```

```
| | | +--rw geographic-location
| | |   +--rw source*
| | |       -> /i2nsf-cfi-policy/endpoint-groups/location-group/name
| | |   +--rw destination*
| | |       -> /i2nsf-cfi-policy/endpoint-groups/location-group/name
| | +--rw threat-feed
| |   +--rw name*
| |       -> /i2nsf-cfi-policy/threat-prevention/threat-feed-list/name
```

Figure 5: Condition Sub-model YANG Data Tree

3.3. 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", "reject", "rate-limit", "mirror", "invoke-signaling", "tunnel-encapsulation", "forwarding", and "transformation".

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

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

Figure 6: Action Sub-model YANG Data Tree

4. 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.

It is assumed that the information of Endpoint Groups (e.g., User-group, Device-group, and Location-group) such as the IP address(es) of each member in a group are stored in the I2NSF database available to the Security Controller, and that the IP address information of each group in the I2NSF database is synchronized with other systems in the networks under the same administration.

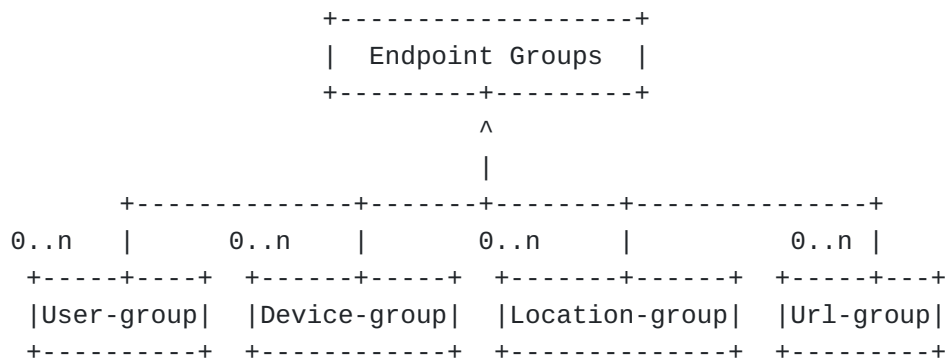


Figure 7: Endpoint Group Diagram

```

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

```

Figure 8: Endpoint Group YANG Data Tree

4.1. 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.

mac-address: This represents the MAC address of a user in the user group.

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

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

```

+--rw user-group* [name]
|   +--rw name                               string
|   +--rw mac-address*                       yang:mac-address
|   +--rw (match-type)
|       +--:(range-match-ipv4)
|           |   +--rw range-ipv4-address
|           |       +--rw start-ipv4-address    inet:ipv4-address-no-zone
|           |       +--rw end-ipv4-address      inet:ipv4-address-no-zone
|       +--:(range-match-ipv6)
|           +--rw range-ipv6-address
|               +--rw start-ipv6-address    inet:ipv6-address-no-zone
|               +--rw end-ipv6-address      inet:ipv6-address-no-zone

```

Figure 9: User Group YANG Data Tree

4.2. 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.

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

IPv6: This represents the IPv6 address of a device in the device group.

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

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

Application-protocol: This represents the application layer protocols of devices. If this is not set, it cannot support the appropriate protocol

```

+--rw device-group* [name]
|  +--rw name                string
|  +--rw (match-type)
|  |  +--:(range-match-ipv4)
|  |  |  +--rw range-ipv4-address
|  |  |  |  +--rw start-ipv4-address    inet:ipv4-address-no-zone
|  |  |  |  +--rw end-ipv4-address      inet:ipv4-address-no-zone
|  |  +--:(range-match-ipv6)
|  |  |  +--rw range-ipv6-address
|  |  |  |  +--rw start-ipv6-address    inet:ipv6-address-no-zone
|  |  |  |  +--rw end-ipv6-address      inet:ipv6-address-no-zone
|  +--rw application-protocol*  identityref

```

Figure 10: Device Group YANG Data Tree

4.3. 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 address of a location [[RFC8805](#)].

Geo-ip-ipv6: This field represents the IPv6 Geo-ip address of a location [[RFC8805](#)].

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

```

+--rw location-group* [name]
|  +--rw name                string
|  +--rw geo-ip-ipv4* [ipv4-address]
|  |  +--rw ipv4-address      inet:ipv4-address-no-zone
|  |  +--rw ipv4-prefix?     inet:ipv4-prefix
|  +--rw geo-ip-ipv6* [ipv6-address]
|  |  +--rw ipv6-address      inet:ipv6-address-no-zone
|  |  +--rw ipv6-prefix?     inet:ipv6-prefix
|  +--rw continent?         identityref

```

Figure 11: Location Group YANG Data Tree

4.4. URL Group

This object represents a URL group based on a Uniform Resource Locator (URL) or web address. [Figure 12](#) shows the YANG tree of the URL-Group object. The URLn-Group object SHALL have the following information:

Name: This field identifies the name of this object.

url: This field represents the new URL added by a user to the URL database.

```
+--rw url-group* [name]
  +--rw name      string
  +--rw url*      string
```

Figure 12: URL Group YANG Data Tree

5. 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 14](#) shows the YANG tree of a Threat-Prevention object.

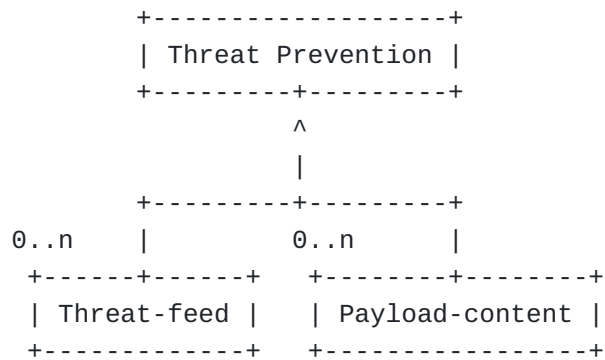


Figure 13: Threat Prevention Diagram


```

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

```

Figure 14: Threat Prevention YANG Data Tree

5.1. Threat Feed

This object represents a threat feed which provides the signatures of malicious activities. [Figure 15](#) 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.

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

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

It is assumed that the I2NSF User obtains the threat signatures (i.e., threat content patterns) from a threat-feed server (i.e., feed provider), which is a server providing threat signatures. With the obtained threat signatures, the I2NSF User can deliver them to the Security Controller. The retrieval of the threat signatures by the I2NSF User is out of scope in this document.

```

+--rw threat-prevention
  +--rw threat-feed-list* [name]
    +--rw name                string
    +--rw description?        string
    +--rw signatures*         identityref

```

Figure 15: Threat Feed YANG Data Tree

5.2. Payload Content

This object represents a custom list created for the purpose of defining an exception to threat feeds. [Figure 16](#) 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 a 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 involved in a security attack, such as strings.

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

Figure 16: Payload Content in YANG Data Tree

6. 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 17](#) 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 either a NETCONF server [[RFC6241](#)] or

a RESTCONF server [[RFC8040](#)] 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 9](#).

```

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 17: A Part of the NACM YANG Data Model

7. YANG Data Model of Consumer-Facing Interface

The main objective of this document 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 is 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.

With the YANG data model of I2NSF Consumer-Facing Interface, this document suggests use cases for security policy rules such as time-based firewall, VoIP/VoCN security service, and DDoS-attack mitigation in [Section 8](#).

7.1. YANG Module of Consumer-Facing Interface

This section describes a YANG module of Consumer-Facing Interface. This document provides identities in the data model to be used for configuration of an NSF. Each identity is used for a different type of configuration. The details are explained in the description of each identity. This YANG module imports from [[RFC6991](#)]. It makes references to [[RFC0768](#)] [[RFC0792](#)] [[RFC0793](#)] [[RFC0854](#)] [[RFC0959](#)] [[RFC1939](#)] [[RFC2595](#)] [[RFC3022](#)] [[RFC3261](#)] [[RFC3986](#)] [[RFC4250](#)] [[RFC4340](#)] [[RFC4443](#)] [[RFC5321](#)] [[RFC5646](#)] [[RFC8335](#)] [[RFC8805](#)] [[RFC9051](#)] [[Encyclopedia-Britannica](#)] [[IANA-ICMP-Parameters](#)] [[IANA-ICMPv6-Parameters](#)] [[I-D.ietf-httpbis-http2bis](#)] [[I-D.ietf-httpbis-messaging](#)] [[I-D.ietf-httpbis-semantics](#)] [[I-D.ietf-i2nsf-capability](#)] [[I-D.ietf-tcpm-rfc793bis](#)] [[I-D.ietf-tsvwg-rfc4960-bis](#)] [[SNORT](#)] [[STIX](#)] [[SURICATA](#)] [[YARA](#)].

<CODE BEGINS> file "ietf-i2nsf-cfi-policy@2022-03-23.yang"

```
module ietf-i2nsf-cfi-policy {
  yang-version 1.1;
  namespace
    "urn:ietf:params:xml:ns:yang:ietf-i2nsf-cfi-policy";
  prefix nsfcfi;

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

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

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

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

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

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

  description
    "This module is a YANG module for Consumer-Facing 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
    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
    (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 "2022-02-23" {
  description "Initial revision.";
  reference
    "RFC XXXX: I2NSF Consumer-Facing Interface YANG Data Model";

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

identity resolution-strategy {
  description
    "Base identity for resolution strategy";
  reference
    "draft-ietf-i2nsf-capability-data-model-26:
    I2NSF Capability YANG Data Model - Resolution Strategy";
}

identity fmr {
  base resolution-strategy;
  description
    "Conflict resolution with First Matching Rule (FMR).";
  reference
    "draft-ietf-i2nsf-capability-data-model-26:
    I2NSF Capability YANG Data Model - Resolution Strategy";
}

identity lmr {
  base resolution-strategy;
  description
    "Conflict resolution with Last Matching Rule (LMR)";
  reference
    "draft-ietf-i2nsf-capability-data-model-26:
    I2NSF Capability YANG Data Model - Resolution Strategy";
}

identity pmre {
  base resolution-strategy;
  description
    "Conflict resolution with Prioritized Matching Rule with
    Errors (PMRE)";
  reference
    "draft-ietf-i2nsf-capability-data-model-26:
    I2NSF Capability YANG Data Model - Resolution Strategy";
}

identity pmrn {
  base resolution-strategy;

```

```

description
  "Conflict resolution with Prioritized Matching Rule with
    No Errors (PMRN)";
reference
  "draft-ietf-i2nsf-capability-data-model-26:
    I2NSF Capability YANG Data Model - Resolution Strategy";
}

identity event {
  description
    "Base identity for policy events.";
  reference
    "draft-ietf-i2nsf-nsf-monitoring-data-model-15: I2NSF NSF
      Monitoring Interface YANG Data Model - Event";
}

identity system-event {
  base event;
  description
    "Base Identity for system events. System event (also called
      alert) is defined as a warning about any changes of
      configuration, any access violation, the information of
      sessions and traffic flows.";
  reference
    "draft-ietf-i2nsf-nsf-monitoring-data-model-15: I2NSF NSF
      Monitoring Interface YANG Data Model - System event";
}

identity system-alarm {
  base event;
  description
    "Base identity for system alarms. System alarm is defined as a
      warning related to service degradation in system hardware.";
  reference
    "draft-ietf-i2nsf-nsf-monitoring-data-model-15: I2NSF NSF
      Monitoring Interface YANG Data Model - System alarm";
}

identity access-violation {
  base system-event;
  description
    "Access-violation system event is an event when a user tries
      to access (read, write, create, or delete) any information or
      execute commands above their privilege (i.e., not-conformant
      with the access profile).";
  reference
    "draft-ietf-i2nsf-nsf-monitoring-data-model-15: I2NSF NSF
      Monitoring Interface YANG Data Model - System event for access
      violation";
}

```



```
}
```

```
identity configuration-change {  
    base system-event;  
    description  
        "The configuration-change system event is an event when a user  
        adds a new configuration or modify an existing configuration  
        (write configuration).";  
    reference  
        "draft-ietf-i2nsf-nsf-monitoring-data-model-15: I2NSF NSF  
        Monitoring Interface YANG Data Model - System event for  
        configuration change";  
}
```

```
identity memory-alarm {  
    base system-alarm;  
    description  
        "Memory is the hardware to store information temporarily or for  
        a short period, i.e., Random Access Memory (RAM). A  
        memory-alarm is emitted when the memory usage is exceeding  
        the threshold.";  
    reference  
        "draft-ietf-i2nsf-nsf-monitoring-data-model-15: I2NSF NSF  
        Monitoring Interface YANG Data Model - System alarm for  
        memory";  
}
```

```
identity cpu-alarm {  
    base system-alarm;  
    description  
        "CPU is the Central Processing Unit that executes basic  
        operations of the system. A cpu-alarm is emitted when the CPU  
        usage is exceeding a threshold.";  
    reference  
        "draft-ietf-i2nsf-nsf-monitoring-data-model-15: I2NSF NSF  
        Monitoring Interface YANG Data Model - System alarm for CPU";  
}
```

```
identity disk-alarm {  
    base system-alarm;  
    description  
        "Disk or storage is the hardware to store information for a  
        long period, i.e., Hard Disk and Solid-State Drive. A  
        disk-alarm is emitted when the disk usage is exceeding a  
        threshold.";  
    reference  
        "draft-ietf-i2nsf-nsf-monitoring-data-model-15: I2NSF NSF  
        Monitoring Interface YANG Data Model - System alarm for disk";  
}
```

```

identity hardware-alarm {
    base system-alarm;
    description
        "A hardware alarm is emitted when a hardware failure (e.g.,
        CPU, memory, disk, or interface) is detected. A hardware
        failure is a malfunction within the electronic circuits or
        electromechanical components of the hardware that makes it
        unusable.";
    reference
        "draft-ietf-i2nsf-nsf-monitoring-data-model-15: I2NSF NSF
        Monitoring Interface YANG Data Model - System alarm for
        hardware";
}

identity interface-alarm {
    base system-alarm;
    description
        "Interface is the network interface for connecting a device
        with the network. The interface-alarm is emitted when the
        state of the interface is changed.";
    reference
        "draft-ietf-i2nsf-nsf-monitoring-data-model-15: I2NSF NSF
        Monitoring Interface YANG Data Model - System alarm for
        interface";
}

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

identity transport-protocol {
    base protocol;
    description
        "Base identity for the Layer 4 (i.e., Transport Layer)
        Protocols";
}

identity tcp {
    base transport-protocol;
    description
        "Base identity for TCP condition capabilities";
    reference
        "RFC 793: Transmission Control Protocol
        draft-ietf-tcpm-rfc793bis: Transmission Control Protocol
        (TCP) Specification";
}

```

```

identity udp {
    base transport-protocol;
    description
        "Base identity for UDP condition capabilities";
    reference
        "RFC 768: User Datagram Protocol";
}

identity sctp {
    base transport-protocol;
    description
        "Identity for SCTP condition capabilities";
    reference
        "draft-ietf-tsvwg-rfc4960-bis-18: Stream Control Transmission
        Protocol";
}

identity dccp {
    base transport-protocol;
    description
        "Identity for DCCP condition capabilities";
    reference
        "RFC 4340: Datagram Congestion Control Protocol";
}

identity application-protocol {
    description
        "Base identity for Application protocol. Note that a subset of
        application protocols (e.g., HTTP, HTTPS, FTP, POP3, and
        IMAP) are handled in this YANG module, rather than all
        the existing application protocols.";
}

identity http {
    base application-protocol;
    description
        "The identity for Hypertext Transfer Protocol version 1.1
        (HTTP/1.1).";
    reference
        "draft-ietf-httpbis- semantics-19: HTTP Semantics
        draft-ietf-httpbis-messaging-19: HTTP/1.1";
}

identity https {
    base application-protocol;
    description
        "The identity for Hypertext Transfer Protocol version 1.1
        (HTTP/1.1) over TLS.";
    reference

```

```

    "draft-ietf-httpbis-semantics-19: HTTP Semantics
    draft-ietf-httpbis-messaging-19: HTTP/1.1";
}

identity http2 {
    base application-protocol;
    description
        "The identity for Hypertext Transfer Protocol version 2
        (HTTP/2).";
    reference
        "draft-ietf-httpbis-http2bis-07: HTTP/2";
}

identity https2 {
    base application-protocol;
    description
        "The identity for Hypertext Transfer Protocol version 2
        (HTTP/2) over TLS.";
    reference
        "draft-ietf-httpbis-http2bis-07: HTTP/2";
}

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

identity ssh {
    base application-protocol;
    description
        "The identity for Secure Shell (SSH) protocol.";
    reference
        "RFC 4250: The Secure Shell (SSH) Protocol";
}

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

identity smtp {
    base application-protocol;
    description

```

```

    "The identity for Simple Mail Transfer Protocol.";
reference
    "RFC 5321: Simple Mail Transfer Protocol (SMTP)";
}

identity pop3 {
    base application-protocol;
description
    "The identity for Post Office Protocol 3 (POP3).";
reference
    "RFC 1939: Post Office Protocol - Version 3 (POP3)";
}

identity pop3s {
    base application-protocol;
description
    "The identity for Post Office Protocol 3 (POP3) over TLS";
reference
    "RFC 1939: Post Office Protocol - Version 3 (POP3)
    RFC 2595: Using TLS with IMAP, POP3 and ACAP";
}

identity imap {
    base application-protocol;
description
    "The identity for Internet Message Access Protocol (IMAP).";
reference
    "RFC 9051: Internet Message Access Protocol (IMAP) - Version
    4rev2";
}

identity imaps {
    base application-protocol;
description
    "The identity for Internet Message Access Protocol (IMAP) over
    TLS";
reference
    "RFC 9051: Internet Message Access Protocol (IMAP) - Version
    4rev2";
}

identity action {
description
    "Base identity for action";
}

identity primary-action {
    base action;
description

```

```

    "Base identity for primary action. Primary action is an action
    that handle the forwarding of the packets or flows in an
    NSF.";
}

identity secondary-action {
    base action;
    description
        "Base identity for secondary action. Secondary action is an
        action in the background that does not affect the network,
        such as logging.";
}

identity ingress-action {
    base action;
    description
        "Base identity for ingress action. The action to handle the
        network traffic that is entering the secured network.";
    reference
        "draft-ietf-i2nsf-capability-data-model-26:
        I2NSF Capability YANG Data Model - Ingress Action";
}

identity egress-action {
    base action;
    description
        "Base identity for egress action. The action to handle the
        network traffic that is exiting the secured network.";
    reference
        "draft-ietf-i2nsf-capability-data-model-26:
        I2NSF Capability YANG Data Model - Egress Action";
}

identity pass {
    base ingress-action;
    base egress-action;
    description
        "The pass action allows traffic that matches
        the rule to proceed through the NSF to reach the
        destination.";
    reference
        "draft-ietf-i2nsf-capability-data-model-26:
        I2NSF Capability YANG Data Model - Actions and
        Default Action";
}

identity drop {
    base ingress-action;
    base egress-action;

```

```

description
    "The drop action denies the traffic that
    matches the rule. The drop action should do a silent drop,
    which does not give any response to the source.";
reference
    "draft-ietf-i2nsf-capability-data-model-26:
    I2NSF Capability YANG Data Model - Actions and
    Default Action";
}

identity reject {
    base ingress-action;
    base egress-action;
    description
        "The reject action denies a packet to go through the NSF
        entering or exiting the internal network and sends a response
        back to the source. The response depends on the packet and
        implementation. For example, a TCP packet is rejected with
        TCP RST response or a UDP packet may be rejected with an
        ICMPv4 response message with Type 3 Code 3 or ICMPv6 response
        message Type 1 Code 4 (i.e., Destination Unreachable:
        Destination port unreachable).";
}

identity mirror {
    base ingress-action;
    base egress-action;
    description
        "The mirror action copies a packet and sends the packet's copy
        to the monitoring entity while still allowing the packet or
        flow to go through the NSF.";
    reference
        "draft-ietf-i2nsf-capability-data-model-26:
        I2NSF Capability YANG Data Model - Actions and
        Default Action";
}

identity rate-limit {
    base ingress-action;
    base egress-action;
    description
        "The rate limit action limits the number of packets or flows
        that can go through the NSF by dropping packets or flows
        (randomly or systematically). The drop mechanism, e.g., silent
        drop and unreachable drop (i.e., reject), is up to the
        implementation";
    reference
        "draft-ietf-i2nsf-capability-data-model-26:
        I2NSF Capability YANG Data Model - Actions and

```

```

        Default Action";
    }

identity invoke-signaling {
    base egress-action;
    description
        "The invoke-signaling action is used to convey information of
        the event triggering this action to a monitoring entity.";
}

identity tunnel-encapsulation {
    base egress-action;
    description
        "The tunnel encapsulation action is used to encapsulate the
        packet to be tunneled across the network to enable a secure
        connection.";
}

identity forwarding {
    base egress-action;
    description
        "The forwarding action is used to relay the packet from one
        network segment to another node in the network.";
}

identity transformation {
    base egress-action;
    description
        "The transformation action is used to transform a packet by
        modifying it (e.g., HTTP-to-CoAP packet translation).
        Note that a subset of transformation (e.g., HTTP-to-CoAP) is
        handled in this YANG module, rather than all the existing
        transformations. Specific algorithmic transformations can be
        executed by a middlebox (e.g., NSF) for a given transformation
        name.";
    reference
        "RFC 8075: Guidelines for Mapping Implementations: HTTP to the
        Constrained Application Protocol (CoAP) - Translation between
        HTTP and CoAP.";
}

identity log-action {
    base action;
    description
        "Base identity for log action";
}

identity rule-log {
    base log-action;

```



```

    description
        "Log the policy rule that has been triggered by a packet or
        flow.";
}

identity session-log {
    base log-action;
    description
        "A session is a connection (i.e., traffic flow) of a data plane
        that includes source and destination information of IP
        addresses and transport port numbers with the protocol used.
        Log the session that triggered a policy rule.";
}

identity icmp-message {
    description
        "Base identity for ICMP Message types. Note that this YANG
        module only provide ICMP messages that is shared between
        ICMPv4 and ICMPv6 (e.g., Destination Unreachable: Port
        Unreachable which is ICMPv4 type 3 code 3 or ICMPv6 type 1
        code 4).";
    reference
        "RFC 792: Internet Control Message Protocol
        RFC 8335: PROBE: A Utility for Probing Interfaces
        IANA: Internet Control Message Protocol (ICMP)
        Parameters
        IANA: Internet Control Message Protocol version 6
        (ICMPv6) Parameters";
}

identity echo-reply {
    base icmp-message;
    description
        "Identity for 'Echo Reply' ICMP message type 0 in ICMPv4 or
        type 129 in ICMPv6";
}

identity destination-unreachable {
    base icmp-message;
    description
        "Identity for 'Destination Unreachable' ICMP message type 3 in
        ICMPv4 or type 1 in ICMPv6";
}

identity redirect {
    base icmp-message;
    description
        "Identity for 'Redirect' ICMP message type 5 in ICMPv4
        or type 137 in ICMPv6";
}

```

```

}

identity echo {
    base icmp-message;
    description
        "Identity for 'Echo' ICMP message type 8 in ICMPv4 or type 128
        in ICMPv6";
}

identity router-advertisement {
    base icmp-message;
    description
        "Identity for 'Router Advertisement' ICMP message type 9 in
        ICMPv4 or type 134 in ICMPv6";
}

identity router-solicitation {
    base icmp-message;
    description
        "Identity for 'Router Solicitation' ICMP message type 10 in
        ICMPv4 or type 135 in ICMPv6";
}

identity time-exceeded {
    base icmp-message;
    description
        "Identity for 'Time exceeded' ICMP message type 11 in ICMPv4
        or type 3 in ICMPv6";
}

identity parameter-problem {
    base icmp-message;
    description
        "Identity for 'Parameter Problem' ICMP message type 12 in
        ICMPv4 or type 4 in ICMPv6";
}

identity experimental-mobility-protocols {
    base icmp-message;
    description
        "Identity for 'Experimental Mobility Protocols' ICMP message
        type 41 in ICMPv4 or type 150 in ICMPv6";
}

identity extended-echo-request {
    base icmp-message;
    description
        "Identity for 'Extended Echo Request' ICMP message type 42
        in ICMPv4 or type 160 in ICMPv6";
}

```

```
}
```

```
identity extended-echo-reply {  
    base icmp-message;  
    description  
        "Identity for 'Extended Echo Reply' ICMP message type 43 in  
        ICMPv4 or type 161 in ICMPv6";  
}
```

```
identity port-unreachable {  
    base destination-unreachable;  
    description  
        "Identity for port unreachable in destination unreachable  
        message (i.e., ICMPv4 type 3 code 3 or ICMPv6 type 1 code 4)";  
}
```

```
identity request-no-error {  
    base extended-echo-request;  
    description  
        "Identity for request with no error in extended echo request  
        message (i.e., ICMPv4 type 42 code 0 or ICMPv6 type 160  
        code 0)";  
}
```

```
identity reply-no-error {  
    base extended-echo-reply;  
    description  
        "Identity for reply with no error in extended echo reply  
        message (i.e., ICMPv4 type 43 code 0 or ICMPv6 type 161  
        code 0)";  
}
```

```
identity malformed-query {  
    base extended-echo-reply;  
    description  
        "Identity for malformed query in extended echo reply message  
        (i.e., ICMPv4 type 43 code 1 or ICMPv6 type 161 code 1)";  
}
```

```
identity no-such-interface {  
    base extended-echo-reply;  
    description  
        "Identity for no such interface in extended echo reply message  
        (i.e., ICMPv4 type 43 code 2 or ICMPv6 type 161 code 2)";  
}
```

```
identity no-such-table-entry {  
    base extended-echo-reply;  
    description
```

```

    "Identity for no such table entry in extended echo reply
    message (i.e., ICMPv4 type 43 code 3 or ICMPv6 type 161
    code 3)";
}

identity multiple-interfaces-satisfy-query {
    base extended-echo-reply;
    description
        "Identity for multiple interfaces satisfy query in extended
        echo reply message (i.e., ICMPv4 type 43 code 4 or ICMPv6
        type 161 code 4) ";
    reference
        "RFC 792: Internet Control Message Protocol
        RFC 8335: PROBE: A Utility for Probing Interfaces";
}

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

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

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

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

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

```

```
identity continent {  
  description  
    "Base identity for continent types. The continents are based  
    on Encyclopedia Britannica";  
  reference  
    "Encyclopedia Britannica: Continent";  
}
```

```
identity africa {  
  base continent;  
  description  
    "Identity for Africa.";   
  reference  
    "Encyclopedia Britannica: Continent";  
}
```

```
identity asia {  
  base continent;  
  description  
    "Identity for Asia.";   
  reference  
    "Encyclopedia Britannica: Continent";  
}
```

```
identity antarctica {  
  base continent;  
  description  
    "Identity for Antarctica.";   
  reference  
    "Encyclopedia Britannica: Continent";  
}
```

```
identity europe {  
  base continent;  
  description  
    "Identity for Europe.";   
  reference  
    "Encyclopedia Britannica: Continent";  
}
```

```
identity north-america {  
  base continent;  
  description  
    "Identity for North America.";   
  reference  
    "Encyclopedia Britannica: Continent";  
}
```

```
identity south-america {
    base continent;
    description
        "Identity for South America.";
    reference
        "Encyclopedia Britannica: Continent";
}

identity australia {
    base continent;
    description
        "Identity for Australia";
    reference
        "Encyclopedia Britannica: Continent";
}

identity device-type {
    description
        "Base identity for types of device. This identity is used for
        type of the device for the source or destination of a packet
        or traffic flow. Note that the device type of either a source
        or destination can be known with the help of DHCP
        Fingerprinting and the interaction between an NSF and a DHCP
        server.";
}

identity computer {
    base device-type;
    description
        "Identity for computer such as personal computer (PC)
        and server.";
}

identity mobile-phone {
    base device-type;
    description
        "Identity for mobile-phone such as smartphone and
        cellphone";
}

identity voip-vocn-phone {
    base device-type;
    description
        "Identity for VoIP (Voice over Internet Protocol) or VoCN
        (Voice over Cellular Network, such as Voice over LTE or 5G)
        phone";
}

identity tablet {
```

```

    base device-type;
    description
        "Identity for tablet devices";
}

identity network-infrastructure-device {
    base device-type;
    description
        "Identity for network infrastructure devices
        such as switch, router, and access point";
}

identity iot-device {
    base device-type;
    description
        "Identity for Internet of Things (IoT) devices
        such as sensors, actuators, and low-power
        low-capacity computing devices";
}

identity ot {
    base device-type;
    description
        "Identity for Operational Technology (OT) devices (also
        known as industrial control systems) that interact
        with the physical environment and detect or cause direct
        change through the monitoring and control of devices,
        processes, and events such as programmable logic
        controllers (PLCs), digital oscilloscopes, building
        management systems (BMS), and fire control systems";
}

identity vehicle {
    base device-type;
    description
        "Identity for transportation vehicles that connect to and
        share data through the Internet over Vehicle-to-Everything
        (V2X) communications.";
}

/*
 * Typedefs
 */

typedef time {
    type string {
        pattern '(0[0-9]|1[0-9]|2[0-3]):[0-5][0-9]:[0-5][0-9](\\.\\d+)?'
        + '(Z|\\+\\-)((1[0-3]|0[0-9]):([0-5][0-9])|14:00)?';
    }
}

```

```

    description
        "The time type represents an instance of time of zero-duration
        in the specified timezone that recurs every day.";
}

typedef day {
    type enumeration {
        enum monday {
            description
                "This represents Monday.";
        }
        enum tuesday {
            description
                "This represents Tuesday.";
        }
        enum wednesday {
            description
                "This represents Wednesday";
        }
        enum thursday {
            description
                "This represents Thursday.";
        }
        enum friday {
            description
                "This represents Friday.";
        }
        enum saturday {
            description
                "This represents Saturday.";
        }
        enum sunday {
            description
                "This represents Sunday.";
        }
    }
    description
        "The type for representing the day of the week.";
}

/*
 * Groupings
 */

grouping ip-address-info {
    description
        "There are two types to configure a security policy
        for an IP address, such as IPv4 adress and IPv6 address.";
    choice match-type {

```



```

description
    "User can choose between IPv4 and IPv6.";
case range-match-ipv4 {
    container range-ipv4-address {
        leaf start-ipv4-address {
            type inet:ipv4-address-no-zone;
            mandatory true;
            description
                "A start IPv4 address for a range match.";
        }
        leaf end-ipv4-address {
            type inet:ipv4-address-no-zone;
            mandatory true;
            description
                "An end IPv4 address for a range match.";
        }
        description
            "A range match for IPv4 addresses is provided.
            Note that the start IPv4 address must be lower than
            the end IPv4 address.";
    }
}
case range-match-ipv6 {
    container range-ipv6-address {
        leaf start-ipv6-address {
            type inet:ipv6-address-no-zone;
            mandatory true;
            description
                "A start IPv6 address for a range match.";
        }
        leaf end-ipv6-address {
            type inet:ipv6-address-no-zone;
            mandatory true;
            description
                "An end IPv6 address for a range match.";
        }
        description
            "A range match for IPv6 addresses is provided.
            Note that the start IPv6 address must be lower than
            the end IPv6 address.";
    }
}
}
}

grouping user-group {
    description
        "This group represents user group information such as name and
        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 IP
        address(es), MAC address(es).
        It is dependent on implementation.";
}
leaf-list mac-address {
    type yang:mac-address;
    description
        "Represent the MAC Address of a user-group. A user-group
        can have multiple MAC Addresses.";
}
uses ip-address-info{
    description
        "This represents the IP addresses of a user-group.";
    refine match-type{
        mandatory true;
    }
}
}

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 application-protocol {
        type identityref {
            base application-protocol;
        }
        description
            "This represents the application layer 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 addresses based on a
      location.";
  leaf ipv4-address{
    type inet:ipv4-address-no-zone;
    description
      "This represents an IPv4 geo-ip address of a location.";
  }
  leaf ipv4-prefix{
    type inet:ipv4-prefix;
    description
      "This represents the prefix for the IPv4 addresses.";
  }
}
list geo-ip-ipv6 {
  key "ipv6-address";
  description
    "This represents the list of IPv6 addresses based on a
      location.";
  leaf ipv6-address{
    type inet:ipv6-address-no-zone;
    description
      "This represents an IPv6 geo-ip address of a location.";
  }
  leaf ipv6-prefix{
    type inet:ipv6-prefix;
    description
      "This represents the prefix for the IPv6 addresses.";
  }
}
leaf continent {
  type identityref {
    base continent;
  }
  default asia;
  description
    "location-group has geo-ip addresses of the corresponding
      continent.";
}

```

```

reference
  "RFC 8805: A Format for Self-Published IP Geolocation Feeds -
  An access control for a geographical location (i.e.,
  geolocation) that has the corresponding IP prefix.";
}

grouping payload-string {
  description
    "The grouping for payload-string content. It contains
    information such as name and string content.";
}

list i2nsf-cfi-policy {
  key "name";
  description
    "This is a security policy list. Each policy in the list
    contains a list of security policy rules, and is a policy
    instance to have the information of where and when a policy
    needs to be applied.";
  leaf name {
    type string;
    description
      "The name which identifies the policy.";
  }
  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 'leaf description' described in the
        'i2nsf-cfi-policy'."

        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";
}
leaf resolution-strategy {
    type identityref {
        base resolution-strategy;
    }
    default fmr;
    description
        "The resolution strategies that can be used to
        specify how to resolve conflicts that occur between
        actions of the same or different policy rules that
        are matched and contained in this particular NSF";

    reference
        "draft-ietf-i2nsf-capability-data-model-26:
        I2NSF Capability YANG Data Model - Resolution strategy";
}
list rules {
    key "name";

    description
        "There can be a single or multiple number of rules.";
    leaf name {
        type string;
        description
            "This represents the name for a rule.";
    }
}

leaf priority {
    type uint8 {
        range "1..255";
    }
    description
        "The priority keyword comes with a mandatory
        numeric value which can range from 1 through 255.
        Note that a higher number means a higher priority";
}
}

```

```

container event {
  description
    "This represents an event (i.e., a security event), for
    which a security rule is made.";
  leaf-list system-event {
    type identityref {
      base system-event;
    }
    description
      "The security policy rule according to
      system events.";
  }

  leaf-list system-alarm {
    type identityref {
      base system-alarm;
    }
    description
      "The security policy rule according to
      system alarms.";
  }
}

```

```

container condition {
  description
    "Conditions for general security policies.";
  container firewall {
    description
      "A general firewall condition based on the packet
      header.";
    leaf-list source {
      type union {
        type leafref {
          path "/i2nsf-cfi-policy/endpoint-groups/"
            + "user-group/name";
        }
        type leafref {
          path "/i2nsf-cfi-policy/endpoint-groups/"
            + "device-group/name";
        }
      }
    }
    description
      "This describes the path of the source.";
  }

  leaf-list destination {
    type union {
      type leafref {

```

```

        path "/i2nsf-cfi-policy/endpoint-groups/"
            + "user-group/name";
    }
    type leafref {
        path "/i2nsf-cfi-policy/endpoint-groups/"
            + "device-group/name";
    }
}
description
    "This describes the path to the destinations.";
}

leaf transport-layer-protocol {
    type identityref {
        base transport-protocol;
    }
    description
        "The transport-layer protocol to be matched.";
}

container range-port-number {
    leaf start-port-number {
        type inet:port-number;
        description
            "A start port number for range match.";
    }
    leaf end-port-number {
        type inet:port-number;
        description
            "An end port number for range match.";
    }
    description
        "A range match for transport-layer port number. Note
        that the start port number value must be lower than
        the end port number value";
}

container icmp {
    description
        "Represents the ICMPv4 and ICMPv6 packet header
        information to determine if the set of policy
        actions in this ECA policy rule should be executed
        or not.";
    reference
        "RFC 792: Internet Control Message Protocol
        RFC 8335: PROBE: A Utility for Probing Interfaces";

    leaf-list message {
        type identityref {

```

```

        base icmp-message;
    }
    description
        "The security policy rule according to
        ICMP message. The type is representing the
        ICMP message corresponds to the ICMP type and
        code.";
    reference
        "RFC 792: Internet Control Message Protocol
        RFC 8335: PROBE: A Utility for Probing Interfaces
        IANA: Internet Control Message Protocol (ICMP)
        Parameters
        IANA: Internet Control Message Protocol version 6
        (ICMPv6) Parameters";
    }
}
}

```

```

container ddos {
    description
        "A condition for a DDoS attack.";
    container rate-limit {
        description
            "This describes the rate-limit.";
        leaf packet-rate-threshold {
            type uint64;
            description
                "This is a trigger value for a rate limit of packet
                rate for a DDoS-attack mitigation.";
        }
        leaf byte-rate-threshold {
            type uint64;
            description
                "This is a trigger value for a rate limit of byte
                rate for a DDoS-attack mitigation.";
        }
        leaf flow-rate-threshold {
            type uint64;
            description
                "This is a trigger value for a rate limit of flow
                rate for a DDoS-attack mitigation.";
        }
    }
}
}

```

```

container anti-virus {
    description
        "A condition for anti-virus";
}

```



```

leaf-list exception-files {
    type string;
    description
        "The type or name of the files to be excluded by the
        antivirus. This can be used to keep the known
        harmless files.
        If the value starts with a regular expression (e.g.,
        '*.exe'), the antivirus should interpret it as a
        file pattern/type to be excluded.
        If the value does not start with a dot (e.g.,
        'example.exe'), the antivirus should interpret it as
        a file name/path to be excluded.";
}
}

container payload {
    description
        "A condition based on a packet's content.";
    leaf-list content {
        type leafref {
            path "/i2nsf-cfi-policy/threat-prevention/"
                + "payload-content/name";
        }
        description
            "This describes the paths to a packet content's";
    }
}

container url-category {
    description
        "Condition for url category";
    leaf url-name {
        type leafref {
            path "/i2nsf-cfi-policy/endpoint-groups/"
                + "url-group/name";
        }
        description
            "This is description for the condition of a URL's
            category such as SNS sites, game sites, ecommerce
            sites, company sites, and university sites.";
    }
}

container voice {
    description
        "For the VoIP/VoCN security system, a VoIP/
        VoCN security system can monitor each
        VoIP/VoCN flow and manage VoIP/VoCN
        security rules controlled by a centralized

```

server for VoIP/VoCN security service (called VoIP IPS). The VoIP/VoCN security system controls each switch for the VoIP/VoCN call flow management by manipulating the rules that can be added, deleted, or modified dynamically. Note that VoIP is Voice over Internet Protocol and VoCN is Voice over Cellular Network such as Voice over LTE or 5G";

reference

"RFC 3261: SIP: Session Initiation Protocol";

```
leaf-list source-id {  
    type string;  
    description  
        "The security policy rule according to  
        a source voice ID for VoIP and VoCN.";  
}
```

```
leaf-list destination-id {  
    type string;  
    description  
        "The security policy rule according to  
        a destination voice ID for VoIP and VoCN.";  
}
```

```
leaf-list user-agent {  
    type string;  
    description  
        "The security policy rule according to  
        an user agent for VoIP and VoCN.";  
}  
}
```

```
container context {  
    description  
        "Condition for matching the context of the packet, such  
        as geographic location, time, packet direction";  
    container time {  
        description  
            "The time when a security policy rule should be  
            applied.";  
        leaf start-date-time {  
            type yang:date-and-time;  
            description  
                "This is the start date and time for a security  
                policy rule.";  
        }  
        leaf end-date-time {
```

```

type yang:date-and-time;
description
    "This is the end date and time for a security policy
    rule. The policy rule will stop working after the
    specified end date and time.";
}
container period {
    when
        "../frequency!='only-once'";
    description
        "This represents the repetition time. In the case
        where the frequency is weekly, the days can be
        set.";
    leaf start-time {
        type time;
        description
            "This is a period's start time for an event.";
    }
    leaf end-time {
        type time;
        description
            "This is a period's end time for an event.";
    }
    leaf-list day {
        when
            "../frequency='weekly'";
        type day;
        min-elements 1;
        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
            "../frequency='monthly'";
        type int8 {
            range "1..31";
        }
        min-elements 1;
        description
            "This represents the repeated date of every month.
            More than one date can be specified.";
    }
    leaf-list month {
        when
            "../frequency='yearly'";
        type string{
            pattern '\d{2}-\d{2}';
        }
    }
}

```

```

    }
    min-elements 1;
    description
        "This represents the repeated date and month of
        every year. More than one can be specified.
        A pattern used here is Month and Date (MM-DD).";
    }
}

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

```

```

}

container application {
    description
        "Condition for application";
    leaf-list protocol {
        type identityref {
            base application-protocol;
        }
        description
            "The condition based on the application layer
            protocol";
    }
}

container device-type {
    description
        "Condition for type of the destination device";
    leaf-list device {
        type identityref {
            base device-type;
        }
        description
            "The device attribute that can identify a device,
            including the device type (i.e., router, switch,
            pc, ios, or android) and the device's owner as
            well.";
    }
}

container users {
    description
        "Condition for users";
    list user {
        key "id";
        description
            "The user with which the traffic flow is associated
            can be identified by either a user ID or username.
            The user-to-IP address mapping is assumed to be
            provided by the unified user management system via
            network.";
        leaf id {
            type uint32;
            description
                "The ID of the user.";
        }
        leaf name {
            type string;
            description

```

```

        "The name of the user.";
    }
}
list group {
    key "id";
    description
        "The user group with which the traffic flow is
        associated can be identified by either a group ID
        or group name. The group-to-IP address and
        user-to-group mappings are assumed to be provided by
        the unified user management system via network.";
    leaf id {
        type uint32;
        description
            "The ID of the group.";
    }
    leaf name {
        type string;
        description
            "The name of the group.";
    }
}
}

container geographic-location {
    description
        "A condition for a location-based connection";
    leaf-list source {
        type leafref {
            path "/i2nsf-cfi-policy/endpoint-groups/"
                + "location-group/name";
        }
        description
            "This describes the paths to a location's sources.";
    }
    leaf-list destination {
        type leafref {
            path "/i2nsf-cfi-policy/endpoint-groups/"
                + "location-group/name";
        }
        description
            "This describes the paths to a location's
            destinations.";
    }
}
}

container threat-feed {
    description

```

```

        "A condition based on the threat-feed information.";
    leaf-list name {
        type leafref {
            path "/i2nsf-cfi-policy/threat-prevention/"
                + "threat-feed-list/name";
        }
        description
            "This describes the paths to a threat-feed's sources.";
    }
}

container action {
    description
        "This is the action container.";
    container primary-action {
        description
            "This represents primary actions (e.g., ingress and
            egress actions) to be applied to a condition.
            If this is not set, it cannot support the primary
            actions.";
        leaf action {
            type identityref {
                base primary-action;
            }
            description
                "Ingress actions: pass, drop, reject, rate-limit,
                and mirror.
                Egress actions: pass, drop, reject, rate-limit,
                mirror, invoke-signaling, tunnel-encapsulation,
                forwarding, and transformation..";
        }
    }
}

container secondary-action {
    description
        "This represents secondary actions (e.g., log and syslog)
        to be applied if they are needed. If this is not set,
        it cannot support the secondary actions.";
    leaf log-action {
        type identityref {
            base secondary-action;
        }
        description
            "Log action: rule log and session log";
    }
}
}
}
}

```

```

container endpoint-groups {
  description
    "A logical entity in a business environment, where a security
    policy is to be applied.";
  list user-group{
    uses user-group;
    key "name";
    description
      "This represents a user group.";
  }
  list device-group {
    key "name";
    uses device-group;
    description
      "This represents a device group.";
  }
  list location-group{
    key "name";
    uses location-group;
    description
      "This represents a location group.";
  }
  list url-group {
    key "name";
    description
      "This describes the list of URL.";
    leaf name {
      type string;
      description
        "This is the name of URL group, e.g., SNS sites,
        gaming sites, ecommerce sites";
    }
    leaf-list url {
      type string;
      description
        "Specifies the URL to be added into the group.";
      reference
        "RFC 3986: Uniform Resource Identifier (URI): Generic
        Syntax";
    }
  }
}

container threat-prevention {
  description
    "The container for 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.";
}
leaf description {
    type string;
    description
        "This represents the descriptions of a threat-feed. The
        description should include information, such as type,
        threat, method, and file type. Structured Threat
        Information Expression (STIX) can be used for
        description of a threat [STIX].";
}
leaf-list signatures {
    type identityref {
        base signature-type;
    }
    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 a packet's payload-content.
            It should give an idea of why a specific payload content
            is marked as a threat. For example, the name 'backdoor'
            indicates the payload content is related to a backdoor
            attack.";
    }
    leaf description {
        type string;
        description
            "This represents the description of a payload. Describe
            how the payload content is related to a security
            attack.";
    }
    leaf-list content {
        type binary;
        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

```



```

<?xml version="1.0" encoding="UTF-8" ?>
<i2nsf-cfi-policy
  xmlns="urn:ietf:params:xml:ns:yang:ietf-i2nsf-cfi-policy">
  <name>security_policy_for_blocking_sns</name>
  <endpoint-groups>
    <user-group>
      <name>employees</name>
      <range-ipv4-address>
        <start-ipv4-address>192.0.2.11</start-ipv4-address>
        <end-ipv4-address>192.0.2.90</end-ipv4-address>
      </range-ipv4-address>
    </user-group>
    <device-group>
      <name>webservers</name>
      <range-ipv4-address>
        <start-ipv4-address>198.51.100.11</start-ipv4-address>
        <end-ipv4-address>198.51.100.20</end-ipv4-address>
      </range-ipv4-address>
      <application-protocol>http</application-protocol>
      <application-protocol>https</application-protocol>
    </device-group>
    <url-group>
      <name>sns-websites</name>
      <url>example1.com</url>
      <url>example2.com</url>
    </url-group>
  </endpoint-groups>
</i2nsf-cfi-policy>

```

Figure 19: Registering User-group and Device-group Information with IPv4 Addresses

Also, [Figure 20](#) shows an example XML representation of the registered information for the user-group and device-group with IPv6 addresses [[RFC3849](#)].

```

<?xml version="1.0" encoding="UTF-8" ?>
<i2nsf-cfi-policy
  xmlns="urn:ietf:params:xml:ns:yang:ietf-i2nsf-cfi-policy">
  <name>security_policy_for_blocking_sns</name>
  <endpoint-groups>
    <user-group>
      <name>employees</name>
      <range-ipv6-address>
        <start-ipv6-address>2001:db8:0:1::11</start-ipv6-address>
        <end-ipv6-address>2001:db8:0:1::90</end-ipv6-address>
      </range-ipv6-address>
    </user-group>
    <device-group>
      <name>webservers</name>
      <range-ipv6-address>
        <start-ipv6-address>2001:db8:0:2::11</start-ipv6-address>
        <end-ipv6-address>2001:db8:0:2::20</end-ipv6-address>
      </range-ipv6-address>
      <application-protocol>http</application-protocol>
      <application-protocol>https</application-protocol>
    </device-group>
    <url-group>
      <name>sns-websites</name>
      <url>SNS_1</url>
      <url>SNS_2</url>
    </url-group>
  </endpoint-groups>
</i2nsf-cfi-policy>

```

Figure 20: Registering User-group and Device-group Information with IPv6 Addresses

8.2. 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">
  <name>security_policy_for_blocking_sns</name>
  <rules>
    <name>block_access_to_sns_during_office_hours</name>
    <condition>
      <firewall>
        <source>employees</source>
      </firewall>
      <url-category>
        <url-name>sns-websites</url-name>
      </url-category>
      <context>
        <time>
          <start-date-time>2021-03-11T09:00:00.00Z</start-date-time>
          <end-date-time>2021-12-31T18:00:00.00Z</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>
          <frequency>weekly</frequency>
        </time>
      </context>
    </condition>
    <actions>
      <primary-action>
        <action>drop</action>
      </primary-action>
    </actions>
  </rules>
</i2nsf-cfi-policy>

```

Figure 21: 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.

8.3. Scenario 2: Block Malicious VoIP/VoCN Packets Coming to a Company

The second example scenario is to "block malicious VoIP/VoCN packets coming to a company" using a VoIP policy. In this scenario, the calls coming from from VOIP and/or VoCN sources with VoCN 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 NSF's are needed to meet the security requirements. [Figure 22](#) represents the XML document generated from YANG discussed in previous sections. Once a high-level security 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">
  <name>
    security_policy_for_blocking_malicious_voip_packets
  </name>
  <rules>
    <name>Block_malicious_voip_and_vocn_packets</name>
    <condition>
      <voice>
        <source-id>malicious-id</source-id>
      </voice>
      <firewall>
        <destination>employees</destination>
      </firewall>
    </condition>
    <actions>
      <primary-action>
        <action>drop</action>
      </primary-action>
    </actions>
  </rules>
</i2nsf-cfi-policy>
```

Figure 22: 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_vocn_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".

8.4. Scenario 3: Mitigate Flood Attacks on a Company Web Server

The third example scenario is to "Mitigate 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 NSF's 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">
  <name>security_policy_for_ddos_attacks</name>
  <rules>
    <name>1000_packets_per_second</name>
    <condition>
      <ddos>
        <rate-limit>
          <packet-rate-threshold>1000</packet-rate-threshold>
        </rate-limit>
      </ddos>
    </condition>
    <actions>
      <primary-action>
        <action>drop</action>
      </primary-action>
    </actions>
  </rules>
</i2nsf-cfi-policy>

```

Figure 23: 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 "1000_packets_per_second".
3. The rate limit exists to limit the incoming amount of packets per second. In this case the rate limit is "1000" packets per second. This amount depends on the packet receiving capacity of the server devices.
4. The Source is all sources which send abnormal amount of packets.
5. The action required is to "drop" packet reception is more than 1000 packets per second.

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

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 24](#) 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 be 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 24: 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.

10. 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 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-cfi-policy

namespace: urn:ietf:params:xml:ns:yang:ietf-i2nsf-cfi-policy

prefix: nsfcfi

reference: RFC XXXX

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

11. 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 Network Configuration Access Control Model (NACM) [[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 contents. Thus, NACM SHOULD be used to restrict the NSF registration from unauthorized users.

There are a number of data nodes defined in this YANG module that are writable, creatable, and deletable (i.e., config true, which is the default). These data nodes may be considered sensitive or vulnerable in some network environments. Write operations to these data nodes could have a negative effect on network and security operations. These data nodes are collected into a single list node with the following sensitivity/vulnerability:

- *list i2nsf-cfi-policy: Writing to almost any element of this YANG module would directly impact on the configuration of NSFs, e.g., completely turning off security monitoring and mitigation capabilities; altering the scope of this monitoring and mitigation; creating an overwhelming logging volume to overwhelm downstream analytics or storage capacity; creating logging patterns which are confusing; or rendering useless trained statistics or artificial intelligence models.

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. These are the subtrees and data nodes with their sensitivity/vulnerability:

- *list i2nsf-cfi-policy: The leak of this node to an attacker could reveal the specific configuration of security controls to an attacker. An attacker can craft an attack path that avoids observation or mitigations; one may reveal topology information to inform additional targets or enable lateral movement; one enables the construction of an attack path that avoids observation or mitigations; one provides an indication that the operator has discovered the attack. This node also holds a list of endpoint data that is considered private to the users.

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14. References

14.1. Normative References

[RFC0768]

- Postel, J., "User Datagram Protocol", STD 6, RFC 768, DOI 10.17487/RFC0768, August 1980, <<https://www.rfc-editor.org/info/rfc768>>.
- [RFC0792] Postel, J., "Internet Control Message Protocol", STD 5, RFC 792, DOI 10.17487/RFC0792, September 1981, <<https://www.rfc-editor.org/info/rfc792>>.
- [RFC0793] Postel, J., "Transmission Control Protocol", STD 7, RFC 793, DOI 10.17487/RFC0793, September 1981, <<https://www.rfc-editor.org/info/rfc793>>.
- [RFC0854] Postel, J. and J. Reynolds, "Telnet Protocol Specification", STD 8, RFC 854, DOI 10.17487/RFC0854, May 1983, <<https://www.rfc-editor.org/info/rfc854>>.
- [RFC0959] Postel, J. and J. Reynolds, "File Transfer Protocol", STD 9, RFC 959, DOI 10.17487/RFC0959, October 1985, <<https://www.rfc-editor.org/info/rfc959>>.
- [RFC1939] Myers, J. and M. Rose, "Post Office Protocol - Version 3", STD 53, RFC 1939, DOI 10.17487/RFC1939, May 1996, <<https://www.rfc-editor.org/info/rfc1939>>.
- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <<https://www.rfc-editor.org/info/rfc2119>>.
- [RFC2595] Newman, C., "Using TLS with IMAP, POP3 and ACAP", RFC 2595, DOI 10.17487/RFC2595, June 1999, <<https://www.rfc-editor.org/info/rfc2595>>.
- [RFC3261] Rosenberg, J., Schulzrinne, H., Camarillo, G., Johnston, A., Peterson, J., Sparks, R., Handley, M., and E. Schooler, "SIP: Session Initiation Protocol", RFC 3261, DOI 10.17487/RFC3261, June 2002, <<https://www.rfc-editor.org/info/rfc3261>>.
- [RFC3688] Mealling, M., "The IETF XML Registry", BCP 81, RFC 3688, DOI 10.17487/RFC3688, January 2004, <<https://www.rfc-editor.org/info/rfc3688>>.
- [RFC3986] Berners-Lee, T., Fielding, R., and L. Masinter, "Uniform Resource Identifier (URI): Generic Syntax", STD 66, RFC

3986, DOI 10.17487/RFC3986, January 2005, <<https://www.rfc-editor.org/info/rfc3986>>.

[RFC4250] Lehtinen, S. and C. Lonvick, Ed., "The Secure Shell (SSH) Protocol Assigned Numbers", RFC 4250, DOI 10.17487/RFC4250, January 2006, <<https://www.rfc-editor.org/info/rfc4250>>.

[RFC4340] Kohler, E., Handley, M., and S. Floyd, "Datagram Congestion Control Protocol (DCCP)", RFC 4340, DOI 10.17487/RFC4340, March 2006, <<https://www.rfc-editor.org/info/rfc4340>>.

[RFC4443] Conta, A., Deering, S., and M. Gupta, Ed., "Internet Control Message Protocol (ICMPv6) for the Internet Protocol Version 6 (IPv6) Specification", STD 89, RFC 4443, DOI 10.17487/RFC4443, March 2006, <<https://www.rfc-editor.org/info/rfc4443>>.

[RFC5321] Klensin, J., "Simple Mail Transfer Protocol", RFC 5321, DOI 10.17487/RFC5321, October 2008, <<https://www.rfc-editor.org/info/rfc5321>>.

[RFC5646] Phillips, A., Ed. and M. Davis, Ed., "Tags for Identifying Languages", BCP 47, RFC 5646, DOI 10.17487/RFC5646, September 2009, <<https://www.rfc-editor.org/info/rfc5646>>.

[RFC6241] Enns, R., Ed., Bjorklund, M., Ed., Schoenwaelder, J., Ed., and A. Bierman, Ed., "Network Configuration Protocol

(NETCONF)", RFC 6241, DOI 10.17487/RFC6241, June 2011, <<https://www.rfc-editor.org/info/rfc6241>>.

[RFC6242] Wasserman, M., "Using the NETCONF Protocol over Secure Shell (SSH)", RFC 6242, DOI 10.17487/RFC6242, June 2011, <<https://www.rfc-editor.org/info/rfc6242>>.

[RFC6991] Schoenwaelder, J., Ed., "Common YANG Data Types", RFC 6991, DOI 10.17487/RFC6991, July 2013, <<https://www.rfc-editor.org/info/rfc6991>>.

[RFC7950] Bjorklund, M., Ed., "The YANG 1.1 Data Modeling Language", RFC 7950, DOI 10.17487/RFC7950, August 2016, <<https://www.rfc-editor.org/info/rfc7950>>.

[RFC8040] Bierman, A., Bjorklund, M., and K. Watsen, "RESTCONF Protocol", RFC 8040, DOI 10.17487/RFC8040, January 2017, <<https://www.rfc-editor.org/info/rfc8040>>.

[RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <<https://www.rfc-editor.org/info/rfc8174>>.

[RFC8329] Lopez, D., Lopez, E., Dunbar, L., Strassner, J., and R. Kumar, "Framework for Interface to Network Security Functions", RFC 8329, DOI 10.17487/RFC8329, February 2018, <<https://www.rfc-editor.org/info/rfc8329>>.

[RFC8335] Bonica, R., Thomas, R., Linkova, J., Lenart, C., and M. Boucadair, "PROBE: A Utility for Probing Interfaces", RFC 8335, DOI 10.17487/RFC8335, February 2018, <<https://www.rfc-editor.org/info/rfc8335>>.

[RFC8340] Bjorklund, M. and L. Berger, Ed., "YANG Tree Diagrams", BCP 215, RFC 8340, DOI 10.17487/RFC8340, March 2018, <<https://www.rfc-editor.org/info/rfc8340>>.

[RFC8341] Bierman, A. and M. Bjorklund, "Network Configuration Access Control Model", STD 91, RFC 8341, DOI 10.17487/RFC8341, March 2018, <<https://www.rfc-editor.org/info/rfc8341>>.

[RFC8342] Bjorklund, M., Schoenwaelder, J., Shafer, P., Watsen, K., and R. Wilton, "Network Management Datastore Architecture (NMDA)", RFC 8342, DOI 10.17487/RFC8342, March 2018, <<https://www.rfc-editor.org/info/rfc8342>>.

[RFC8407] Bierman, A., "Guidelines for Authors and Reviewers of Documents Containing YANG Data Models", BCP 216, RFC

8407, DOI 10.17487/RFC8407, October 2018, <<https://www.rfc-editor.org/info/rfc8407>>.

[RFC8446] Rescorla, E., "The Transport Layer Security (TLS) Protocol Version 1.3", RFC 8446, DOI 10.17487/RFC8446, August 2018, <<https://www.rfc-editor.org/info/rfc8446>>.

[RFC8525] Bierman, A., Bjorklund, M., Schoenwaelder, J., Watsen, K., and R. Wilton, "YANG Library", RFC 8525, DOI 10.17487/RFC8525, March 2019, <<https://www.rfc-editor.org/info/rfc8525>>.

[RFC9051] Melnikov, A., Ed. and B. Leiba, Ed., "Internet Message Access Protocol (IMAP) - Version 4rev2", RFC 9051, DOI 10.17487/RFC9051, August 2021, <<https://www.rfc-editor.org/info/rfc9051>>.

[I-D.ietf-httpbis-http2bis] Thomson, M. and C. Benfield, "HTTP/2", Work in Progress, Internet-Draft, draft-ietf-httpbis-http2bis-07, 24 January 2022, <<https://www.ietf.org/archive/id/draft-ietf-httpbis-http2bis-07.txt>>.

[I-D.ietf-httpbis-messaging] Fielding, R. T., Nottingham, M., and J. Reschke, "HTTP/1.1", Work in Progress, Internet-Draft, draft-ietf-httpbis-messaging-19, 12 September 2021, <<https://www.ietf.org/archive/id/draft-ietf-httpbis-messaging-19.txt>>.

[I-D.ietf-httpbis-semantics] Fielding, R. T., Nottingham, M., and J. Reschke, "HTTP Semantics", Work in Progress, Internet-Draft, draft-ietf-httpbis-semantics-19, 12 September 2021, <<https://www.ietf.org/archive/id/draft-ietf-httpbis-semantics-19.txt>>.

[I-D.ietf-i2nsf-capability] Xia, L., Strassner, J., Basile, C., and D. R. Lopez, "Information Model of NSFs Capabilities", Work in Progress, Internet-Draft, draft-ietf-i2nsf-capability-05, 24 April 2019, <<https://www.ietf.org/archive/id/draft-ietf-i2nsf-capability-05.txt>>.

[I-D.ietf-tcpm-rfc793bis]
Eddy, W. M., "Transmission Control Protocol (TCP) Specification", Work in Progress, Internet-Draft, draft-ietf-tcpm-rfc793bis-28, 7 March 2022, <<https://www.ietf.org/archive/id/draft-ietf-tcpm-rfc793bis-28.txt>>.

[I-D.ietf-tsvwg-rfc4960-bis] Stewart, R. R., Tüxen, M., and K. E. E. Nielsen, "Stream Control Transmission Protocol", Work in Progress, Internet-Draft, draft-ietf-tsvwg-rfc4960-

bis-19, 5 February 2022, <<https://www.ietf.org/archive/id/draft-ietf-tsvwg-rfc4960-bis-19.txt>>.

14.2. Informative References

- [RFC3022] Srisuresh, P. and K. Egevang, "Traditional IP Network Address Translator (Traditional NAT)", RFC 3022, DOI 10.17487/RFC3022, January 2001, <<https://www.rfc-editor.org/info/rfc3022>>.
- [RFC3444] Pras, A. and J. Schoenwaelder, "On the Difference between Information Models and Data Models", RFC 3444, DOI 10.17487/RFC3444, January 2003, <<https://www.rfc-editor.org/info/rfc3444>>.
- [RFC3849] Huston, G., Lord, A., and P. Smith, "IPv6 Address Prefix Reserved for Documentation", RFC 3849, DOI 10.17487/RFC3849, July 2004, <<https://www.rfc-editor.org/info/rfc3849>>.
- [RFC5737] Arkko, J., Cotton, M., and L. Vegoda, "IPv4 Address Blocks Reserved for Documentation", RFC 5737, DOI 10.17487/RFC5737, January 2010, <<https://www.rfc-editor.org/info/rfc5737>>.
- [RFC8805] Kline, E., Duleba, K., Szamonek, Z., Moser, S., and W. Kumari, "A Format for Self-Published IP Geolocation Feeds", RFC 8805, DOI 10.17487/RFC8805, August 2020, <<https://www.rfc-editor.org/info/rfc8805>>.
- [RFC9000] Iyengar, J., Ed. and M. Thomson, Ed., "QUIC: A UDP-Based Multiplexed and Secure Transport", RFC 9000, DOI 10.17487/RFC9000, May 2021, <<https://www.rfc-editor.org/info/rfc9000>>.
- [IANA-ICMP-Parameters] Internet Assigned Numbers Authority (IANA), "Assigned Internet Protocol Numbers", February 2021, <<https://www.iana.org/assignments/protocol-numbers/protocol-numbers.xhtml>>.
- [IANA-ICMPv6-Parameters] Internet Assigned Numbers Authority (IANA), "Internet Control Message Protocol version 6 (ICMPv6)

Parameters", February 2021, <<https://www.iana.org/assignments/icmpv6-parameters/icmpv6-parameters.xhtml>>.

[Encyclopedia-Britannica]

Britannica, "Continent", September 2020, <<https://www.britannica.com/science/continent>>.

[YARA] Alvarez, V., Bengen, H., Metz, J., Buehlmann, S., and W. Shields, "YARA", YARA Documents <https://yara.readthedocs.io/en/v3.5.0/>, August 2020.

[SURICATA] Julien, V. and ., "SURICATA", SURICATA Documents <https://suricata-ids.org/docs/>, August 2020.

[SNORT] Roesch, M., Green, C., and B. Caswell, "SNORT", SNORT Documents <https://www.snort.org/#documents>, August 2020.

[STIX] Jordan, B., Piazza, R., and T. Darley, "Structured Threat Information Expression (STIX)", STIX Version 2.1: Committee Specification 01 <https://docs.oasis-open.org/cti/stix/v2.1/stix-v2.1.pdf>, March 2020.

Appendix A. Changes from draft-ietf-i2nsf-consumer-facing-interface-dm-16

The following changes are made from draft-ietf-i2nsf-consumer-facing-interface-dm-16:

*This version has been updated to synchronize its contents with the contents in other I2NSF YANG data model documents.

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