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A YANG Data Model for IP Traffic Flow Security

Abstract

This document describes a yang module for the management of IP Traffic Flow Security additions to IKEv2 and IPsec.

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1. Introduction

This document defines a YANG module [[RFC7950](#)] for the management of the IP Traffic Flow Security (IP-TFS) extensions as defined in [[I-D.ietf-ipsecme-iptfs](#)]. IP-TFS provides enhancements to an IPsec tunnel Security Association to provide improved traffic confidentiality. Traffic confidentiality reduces the ability of traffic analysis to determine identity and correlate observable traffic patterns. IP-TFS offers efficiency when aggregating traffic in fixed size IPsec tunnel packets.

The YANG data model in this document conforms to the Network Management Datastore Architecture (NMDA) defined in [[RFC8342](#)].

The published YANG modules for IPsec are defined in [[RFC9061](#)]. This document uses these models as a general IPsec model that is augmented for IP-TFS. The models in [[RFC9061](#)] provide for both an IKE and an IKELESS model.

1.1. Terminology & Concepts

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

[[RFC2119](#)] [[RFC8174](#)] when, and only when, they appear in all capitals, as shown here.

2. Overview

This document defines configuration and operational parameters of IP traffic flow security (IP-TFS). IP-TFS, defined in [[I-D.ietf-ipsecme-iptfs](#)], defines a security association for tunnel mode IPsec with characteristics that improve traffic confidentiality and reduce bandwidth efficiency loss. These documents assume familiarity with IP security concepts described in [[RFC4301](#)].

IP-TFS uses tunnel mode to improve confidentiality by hiding inner packet identifiable information, packet size and packet timing. IP-TFS provides a general capability allowing aggregation of multiple packets in uniform size outer tunnel IPsec packets. It maintains the outer packet size by utilizing combinations of aggregating, padding and fragmenting inner packets to fill out the IPsec outer tunnel packet. Zero byte padding is used to fill the packet when no data is available to send.

This document specifies an extensible configuration model for IP-TFS. This version utilizes the capabilities of IP-TFS to configure fixed size IP-TFS Packets that are transmitted at a constant rate. This model is structured to allow for different types of operation through future augmentation.

The IP-TFS YANG module augments IPsec YANG model from [[RFC9061](#)]. IP-TFS makes use of IPsec tunnel mode and adds a small number configuration items to tunnel mode IPsec. As defined in [[I-D.ietf-ipsecme-iptfs](#)], any SA configured to use IP-TFS supports only IP-TFS packets i.e. no mixed IPsec modes.

The behavior for IP-TFS is controlled by the source. The self-describing format of an IP-TFS packets allows a sending side to adjust the packet-size and timing independently from any receiver. Both directions are also independent, e.g. IP-TFS may be run only in one direction. This means that counters, which are created here for both directions may be 0 or not updated in the case of an SA that uses IP-TFS only in one direction.

Cases where IP-TFS statistics are active for one direction:

- *SA one direction - IP-TFS enabled

- *SA both directions - IP-TFS only enabled in one direction

Case where IP-TFS statistics are for both directions:

- *SA both directions - IP-TFS enable for both directions

The IP-TFS model support IP-TFS configuration and operational data.

This YANG module supports configuration of fixed size and fixed rate packets, and elements that may be augmented to support future configuration. The protocol specification [[I-D.ietf-ipsecme-iptfs](#)], goes beyond this simple fixed mode of operation by defining a general format for any type of scheme. In this document the outer IPsec packets can be sent with fixed or variable size (without padding). The configuration allows the fixed packet size to be determined by the path MTU. The fixed packet size can also be configured if a value lower than the path MTU is desired.

Other configuration items include:

- *Congestion Control. A congestion control setting to allow IP-TFS to reduce the packet rate when congestion is detected.
- *Fixed Rate configuration. The IP-TFS tunnel rate can be configured taking into account either layer 2 overhead or layer 3 overhead. Layer 3 overhead is the IP data rate and layer 2 overhead is the rate of bits on the link. The combination of packet size and rate determines the nominal maximum bandwidth and the transmission interval when fixed size packets are used.
- *User packet Fragmentation Control. While fragmentation is recommended for improved efficiency, a configuration is provided if users wish to observe the effect no-fragmentation on their data flows.

The YANG operational data allows the readout of the configured parameters as well as the per SA statistics and error counters for IP-TFS. Per SA IPsec packet statistics are provided as a feature and per SA IP-TFS specific statistics as another feature. Both sets of statistics augment the IPsec YANG models with counters that allow observation of IP-TFS packet efficiency.

[[RFC9061](#)] has a set of IPsec YANG management objects. IP-TFS YANG augments the IKE and the IKELESS models. In these models the Security Policy database entry and Security Association entry for an IPsec Tunnel can be augmented with IP-TFS.

3. YANG Management

3.1. YANG Tree

The following is the YANG tree diagram ([[RFC8340](#)]) for the IP-TFS extensions.

```

module: ietf-ipsec-iptfs
augment /nsfike:ipsec-ike/nsfike:conn-entry/nsfike:spd
    /nsfike:spd-entry/nsfike:ipsec-policy-config
    /nsfike:processing-info/nsfike:ipsec-sa-cfg:
  +--rw traffic-flow-security
    +--rw congestion-control?          boolean
    +--rw packet-size
      | +--rw use-path-mtu-discovery?  boolean
      | +--rw outer-packet-size?      uint16
    +--rw (tunnel-rate)?
      | +--:(l2-fixed-rate)
      | | +--rw l2-fixed-rate?        yang:counter64
      | +--:(l3-fixed-rate)
      | | +--rw l3-fixed-rate?        yang:counter64
    +--rw dont-fragment?              boolean
    +--rw max-aggregation-time?       decimal64
    +--rw window-size?               uint16
    +--rw send-immediately?          boolean
    +--rw lost-packet-timer-interval? decimal64
augment /nsfike:ipsec-ike/nsfike:conn-entry/nsfike:child-sa-info:
  +--ro traffic-flow-security
    +--ro congestion-control?          boolean
    +--ro packet-size
      | +--ro use-path-mtu-discovery?  boolean
      | +--ro outer-packet-size?      uint16
    +--ro (tunnel-rate)?
      | +--:(l2-fixed-rate)
      | | +--ro l2-fixed-rate?        yang:counter64
      | +--:(l3-fixed-rate)
      | | +--ro l3-fixed-rate?        yang:counter64
    +--ro dont-fragment?              boolean
    +--ro max-aggregation-time?       decimal64
    +--ro window-size?               uint16
    +--ro send-immediately?          boolean
    +--ro lost-packet-timer-interval? decimal64
augment /nsfikels:ipsec-ikeless/nsfikels:spd/nsfikels:spd-entry
    /nsfikels:ipsec-policy-config/nsfikels:processing-info
    /nsfikels:ipsec-sa-cfg:
  +--rw traffic-flow-security
    +--rw congestion-control?          boolean
    +--rw packet-size
      | +--rw use-path-mtu-discovery?  boolean
      | +--rw outer-packet-size?      uint16
    +--rw (tunnel-rate)?
      | +--:(l2-fixed-rate)
      | | +--rw l2-fixed-rate?        yang:counter64
      | +--:(l3-fixed-rate)
      | | +--rw l3-fixed-rate?        yang:counter64

```

```

    +--rw dont-fragment?                boolean
    +--rw max-aggregation-time?          decimal64
    +--rw window-size?                  uint16
    +--rw send-immediately?              boolean
    +--rw lost-packet-timer-interval?    decimal64
augment /nsfikels:ipsec-ikeless/nsfikels:sad/nsfikels:sad-entry:
  +--ro traffic-flow-security
    +--ro congestion-control?            boolean
    +--ro packet-size
      | +--ro use-path-mtu-discovery?    boolean
      | +--ro outer-packet-size?         uint16
    +--ro (tunnel-rate)?
      | +--:(l2-fixed-rate)
      | | +--ro l2-fixed-rate?           yang:counter64
      | +--:(l3-fixed-rate)
      | | +--ro l3-fixed-rate?           yang:counter64
    +--ro dont-fragment?                boolean
    +--ro max-aggregation-time?          decimal64
    +--ro window-size?                  uint16
    +--ro send-immediately?              boolean
    +--ro lost-packet-timer-interval?    decimal64
augment /nsfike:ipsec-ike/nsfike:conn-entry/nsfike:child-sa-info:
  +--ro ipsec-stats {ipsec-stats}?
    | +--ro tx-pkts?                    yang:counter64
    | +--ro tx-octets?                  yang:counter64
    | +--ro tx-drop-pkts?               yang:counter64
    | +--ro rx-pkts?                    yang:counter64
    | +--ro rx-octets?                  yang:counter64
    | +--ro rx-drop-pkts?               yang:counter64
  +--ro iptfs-inner-pkt-stats {iptfs-stats}?
    | +--ro tx-pkts?                    yang:counter64
    | +--ro tx-octets?                  yang:counter64
    | +--ro rx-pkts?                    yang:counter64
    | +--ro rx-octets?                  yang:counter64
    | +--ro rx-incomplete-pkts?         yang:counter64
  +--ro iptfs-outer-pkt-stats {iptfs-stats}?
    +--ro tx-all-pad-pkts?             yang:counter64
    +--ro tx-all-pad-octets?            yang:counter64
    +--ro tx-extra-pad-pkts?             yang:counter64
    +--ro tx-extra-pad-octets?           yang:counter64
    +--ro rx-all-pad-pkts?              yang:counter64
    +--ro rx-all-pad-octets?            yang:counter64
    +--ro rx-extra-pad-pkts?             yang:counter64
    +--ro rx-extra-pad-octets?           yang:counter64
    +--ro rx-errored-pkts?               yang:counter64
    +--ro rx-missed-pkts?                yang:counter64
augment /nsfikels:ipsec-ikeless/nsfikels:sad/nsfikels:sad-entry:
  +--rw ipsec-stats {ipsec-stats}?
    | +--ro tx-pkts?                    yang:counter64

```

```
| +--ro tx-octets?      yang:counter64
| +--ro tx-drop-pkts?   yang:counter64
| +--ro rx-pkts?        yang:counter64
| +--ro rx-octets?      yang:counter64
| +--ro rx-drop-pkts?   yang:counter64
+--ro iptfs-inner-pkt-stats {iptfs-stats}?
| +--ro tx-pkts?        yang:counter64
| +--ro tx-octets?      yang:counter64
| +--ro rx-pkts?        yang:counter64
| +--ro rx-octets?      yang:counter64
| +--ro rx-incomplete-pkts? yang:counter64
+--ro iptfs-outer-pkt-stats {iptfs-stats}?
  +--ro tx-all-pad-pkts? yang:counter64
  +--ro tx-all-pad-octets? yang:counter64
  +--ro tx-extra-pad-pkts? yang:counter64
  +--ro tx-extra-pad-octets? yang:counter64
  +--ro rx-all-pad-pkts? yang:counter64
  +--ro rx-all-pad-octets? yang:counter64
  +--ro rx-extra-pad-pkts? yang:counter64
  +--ro rx-extra-pad-octets? yang:counter64
  +--ro rx-errored-pkts? yang:counter64
  +--ro rx-missed-pkts? yang:counter64
```

3.2. YANG Module

The following is the YANG module for managing the IP-TFS extensions. The model contains references to [[I-D.ietf-ipsecme-iptfs](#)] and [[RFC5348](#)].

<CODE BEGINS> file "ietf-ipsec-iptfs@2022-05-17.yang"

```
module ietf-ipsec-iptfs {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-ipsec-iptfs";
  prefix iptfs;

  import ietf-i2nsf-ike {
    prefix nsfike;
  }
  import ietf-i2nsf-ikeless {
    prefix nsfikels;
  }
  import ietf-yang-types {
    prefix yang;
  }

  organization
    "IETF IPSECME Working Group (IPSECME)";
  contact
    "WG Web: <https://tools.ietf.org/wg/ipsecme/>
    WG List: <mailto:ipsecme@ietf.org>

    Author: Don Fedyk
            <mailto:dfedyk@labn.net>

    Author: Christian Hopps
            <mailto:chopps@chopps.org>";

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

  description
    "This module defines the configuration and operational state for
    managing the IP Traffic Flow Security functionality [RFC XXXX].

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    authors of the code. All rights reserved.

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    Relating to IETF Documents
    (https://trustee.ietf.org/license-info).

    This version of this YANG module is part of RFC XXXX
    (https://tools.ietf.org/html/rfcXXXX); see the RFC itself for
    full legal notices.";
```

```
revision 2022-05-17 {
    description
        "Initial Revision";
    reference
        "RFC XXXX: IP Traffic Flow Security YANG Module";
}
```

```
feature ipsec-stats {
    description
        "This feature indicates the device supports
        per SA IPsec statistics";
}
```

```
feature iptfs-stats {
    description
        "This feature indicates the device supports
        per SA IP Traffic Flow Security statistics";
}
```

```
/*-----*/
/* groupings */
/*-----*/
```

```
grouping ipsec-tx-stat-grouping {
    description
        "IPsec outbound statistics";
    leaf tx-pkts {
        type yang:counter64;
        config false;
        description
            "Outbound Packet count";
    }
    leaf tx-octets {
        type yang:counter64;
        config false;
        description
            "Outbound Packet bytes";
    }
    leaf tx-drop-pkts {
        type yang:counter64;
        config false;
        description
            "Outbound dropped packets count";
    }
}
```

```
grouping ipsec-rx-stat-grouping {
    description
        "IPsec inbound statistics";
}
```

```

leaf rx-pkts {
    type yang:counter64;
    config false;
    description
        "Inbound Packet count";
}
leaf rx-octets {
    type yang:counter64;
    config false;
    description
        "Inbound Packet bytes";
}
leaf rx-drop-pkts {
    type yang:counter64;
    config false;
    description
        "Inbound dropped packets count";
}
}

grouping iptfs-inner-tx-stat-grouping {
    description
        "IP-TFS outbound inner packet statistics";
    leaf tx-pkts {
        type yang:counter64;
        config false;
        description
            "Total number of IP-TFS inner packets sent. This
            count is whole packets only. A fragmented packet
            counts as one packet";
        reference
            "draft-ietf-ipsecme-iptfs";
    }
    leaf tx-octets {
        type yang:counter64;
        config false;
        description
            "Total number of IP-TFS inner octets sent. This is
            inner packet octets only. Does not count padding.";
        reference
            "draft-ietf-ipsecme-iptfs";
    }
}

grouping iptfs-outer-tx-stat-grouping {
    description
        "IP-TFS outbound inner packet statistics";
    leaf tx-all-pad-pkts {
        type yang:counter64;
    }
}

```

```

    config false;
    description
        "Total number of transmitted IP-TFS packets that
        were all padding with no inner packet data.";
    reference
        "draft-ietf-ipsecme-iptfs section 2.2.3";
}
leaf tx-all-pad-octets {
    type yang:counter64;
    config false;
    description
        "Total number transmitted octets of padding added to
        IP-TFS packets with no inner packet data.";
    reference
        "draft-ietf-ipsecme-iptfs section 2.2.3";
}
leaf tx-extra-pad-pkts {
    type yang:counter64;
    config false;
    description
        "Total number of transmitted outer IP-TFS packets
        that included some padding.";
    reference
        "draft-ietf-ipsecme-iptfs section 2.2.3.1";
}
leaf tx-extra-pad-octets {
    type yang:counter64;
    config false;
    description
        "Total number of transmitted octets of padding added
        to outer IP-TFS packets with data.";
    reference
        "draft-ietf-ipsecme-iptfs section 2.2.3.1";
}
}

grouping iptfs-inner-rx-stat-grouping {
    description
        "IP-TFS inner packet inbound statistics";
    leaf rx-pkts {
        type yang:counter64;
        config false;
        description
            "Total number of IP-TFS inner packets received.";
        reference
            "draft-ietf-ipsecme-iptfs section 2.2";
    }
    leaf rx-octets {
        type yang:counter64;

```

```

    config false;
    description
        "Total number of IP-TFS inner octets received. Does
        not include padding or overhead";
    reference
        "draft-ietf-ipsecme-iptfs section 2.2";
}
leaf rx-incomplete-pkts {
    type yang:counter64;
    config false;
    description
        "Total number of IP-TFS inner packets that were
        incomplete. Usually this is due to fragments not
        received. Also, this may be due to misordering or
        errors in received outer packets.";
    reference
        "draft-ietf-ipsecme-iptfs";
}
}

grouping iptfs-outer-rx-stat-grouping {
    description
        "IP-TFS outer packet inbound statistics";
    leaf rx-all-pad-pkts {
        type yang:counter64;
        config false;
        description
            "Total number of received IP-TFS packets that were
            all padding with no inner packet data.";
        reference
            "draft-ietf-ipsecme-iptfs section 2.2.3";
    }
    leaf rx-all-pad-octets {
        type yang:counter64;
        config false;
        description
            "Total number received octets of padding added to
            IP-TFS packets with no inner packet data.";
        reference
            "draft-ietf-ipsecme-iptfs section 2.2.3";
    }
    leaf rx-extra-pad-pkts {
        type yang:counter64;
        config false;
        description
            "Total number of received outer IP-TFS packets that
            included some padding.";
        reference
            "draft-ietf-ipsecme-iptfs section 2.2.3.1";
    }
}

```

```

}
leaf rx-extra-pad-octets {
    type yang:counter64;
    config false;
    description
        "Total number of received octets of padding added to
        outer IP-TFS packets with data.";
    reference
        "draft-ietf-ipsecme-iptfs section 2.2.3.1";
}
leaf rx-errored-pkts {
    type yang:counter64;
    config false;
    description
        "Total number of IP-TFS outer packets dropped due to
        errors.";
    reference
        "draft-ietf-ipsecme-iptfs";
}
leaf rx-missed-pkts {
    type yang:counter64;
    config false;
    description
        "Total number of IP-TFS outer packets missing
        indicated by missing sequence number.";
    reference
        "draft-ietf-ipsecme-iptfs";
}
}

grouping iptfs-config {
    description
        "This is the grouping for iptfs configuration";
    container traffic-flow-security {
        description
            "Configure the IPSec TFS in Security
            Association Database (SAD)";
        leaf congestion-control {
            type boolean;
            default "true";
            description
                "When set to true, the default, this enables the
                congestion control on-the-wire exchange of data that is
                required by congestion control algorithms as defined by
                RFC 5348. When set to false, IP-TFS sends fixed-sized
                packets over an IP-TFS tunnel at a constant rate.";
            reference
                "draft-ietf-ipsecme-iptfs section 2.5.2, RFC 5348";
        }
    }
}

```

```

container packet-size {
  description
    "Packet size is either auto-discovered or manually
    configured.";
  leaf use-path-mtu-discovery {
    type boolean;
    default "true";
    description
      "Utilize path mtu discovery to determine maximum
      IP-TFS packet size. If the packet size is explicitly
      configured, then it will only be adjusted downward if
      use-path-mtu-discovery is set.";
    reference
      "draft-ietf-ipsecme-iptfs section 4.2";
  }
  leaf outer-packet-size {
    type uint16;
    units bytes;
    description
      "On transmission, the size of the outer encapsulating
      tunnel packet (i.e., the IP packet containing the ESP
      payload).";
    reference
      "draft-ietf-ipsecme-iptfs section 4.2";
  }
}
choice tunnel-rate {
  description
    "TFS bit rate may be specified at layer 2 wire
    rate or layer 3 packet rate";
  leaf l2-fixed-rate {
    type yang:counter64;
    description
      "On transmission, target bandwidth/bit rate in bps
      for iptfs tunnel. This fixed rate is the nominal
      timing for the fixed size packet. If congestion
      control is enabled the rate may be adjusted down (or
      up if unset).";
    reference
      "draft-ietf-ipsecme-iptfs section 4.1";
  }
  leaf l3-fixed-rate {
    type yang:counter64;
    description
      "On transmission, target bandwidth/bit rate in bps
      for iptfs tunnel. This fixed rate is the nominal
      timing for the fixed size packet. If congestion
      control is enabled the rate may be adjusted down (or
      up if unset).";
  }
}

```

```

        reference
            "draft-ietf-ipsecme-iptfs section 4.1";
    }
}
leaf dont-fragment {
    type boolean;
    default "false";
    description
        "On transmission, disable packet fragmentation across
        consecutive iptfs tunnel packets; inner packets larger
        than what can be transmitted in outer packets will be
        dropped.";
    reference
        "draft-ietf-ipsecme-iptfs section 2.2.4 and 6.4.1";
}
leaf max-aggregation-time {
    type decimal64 {
        fraction-digits 6;
    }
    units "milliseconds";
    description
        "On transmission, maximum aggregation time is the
        maximum length of time a received inner packet can be
        held prior to transmission in the iptfs tunnel. Inner
        packets that would be held longer than this time, based
        on the current tunnel configuration will be dropped
        rather than be queued for transmission. Maximum
        aggregation time is configurable in milliseconds or
        fractional milliseconds down to 1 nanosecond.";
}
leaf window-size {
    type uint16 {
        range "0..65535";
    }
    description
        "On reception, the maximum number of out-of-order
        packets that will be reordered by an iptfs receiver
        while performing the reordering operation. The value 0
        disables any reordering.";
    reference
        "draft-ietf-ipsecme-iptfs section 2.2.3";
}
leaf send-immediately {
    type boolean;
    default false;
    description
        "On reception, send inner packets as soon as possible, do
        not wait for lost or misordered outer packets.
        Selecting this option reduces the inner (user) packet

```



```

        delay but can amplify out-of-order delivery of the
        inner packet stream in the presence of packet
        aggregation and any reordering.";
    reference
        "draft-ietf-ipsecme-iptfs section 2.5";
}
leaf lost-packet-timer-interval {
    type decimal64 {
        fraction-digits 6;
    }
    units "milliseconds";
    description
        "On reception, this interval defines the length of time
        an iptfs receiver will wait for a missing packet before
        considering it lost. If not using send-immediately,
        then each lost packet will delay inner (user) packets
        until this timer expires. Setting this value too low
        can impact reordering and reassembly. The value is
        configurable in milliseconds or fractional milliseconds
        down to 1 nanosecond.";
    reference
        "draft-ietf-ipsecme-iptfs section 2.2.3";
}
}
}

/*
 * IP-TFS ike configuration
 */

augment "/nsfike:ipsec-ike/nsfike:conn-entry/nsfike:spd/"
    + "nsfike:spd-entry/"
    + "nsfike:ipsec-policy-config/"
    + "nsfike:processing-info/"
    + "nsfike:ipsec-sa-cfg" {
    description
        "IP-TFS configuration for this policy.";
    uses iptfs-config;
}

augment "/nsfike:ipsec-ike/nsfike:conn-entry/"
    + "nsfike:child-sa-info" {
    description
        "IP-TFS configured on this SA.";
    uses iptfs-config {
        refine "traffic-flow-security" {
            config false;
        }
    }
}
}

```

```

}

/*
 * IP-TFS ikeless configuration
 */

augment "/nsfike:ipsec-ikeless/nsfike:spd/"
  + "nsfike:spd-entry/"
  + "nsfike:ipsec-policy-config/"
  + "nsfike:processing-info/"
  + "nsfike:ipsec-sa-cfg" {
  description
    "IP-TFS configuration for this policy.";
  uses iptfs-config;
}

augment "/nsfike:ipsec-ikeless/nsfike:sad/"
  + "nsfike:sad-entry" {
  description
    "IP-TFS configured on this SA.";
  uses iptfs-config {
    refine "traffic-flow-security" {
      config false;
    }
  }
}

/*
 * packet counters
 */

augment "/nsfike:ipsec-ike/nsfike:conn-entry/"
  + "nsfike:child-sa-info" {
  description
    "Per SA Counters";
  container ipsec-stats {
    if-feature "ipsec-stats";
    config false;
    description
      "IPsec per SA packet counters.";
    uses ipsec-tx-stat-grouping {
      //when "direction = 'outbound'";
    }
    uses ipsec-rx-stat-grouping {
      //when "direction = 'inbound'";
    }
  }
  container iptfs-inner-pkt-stats {
    if-feature "iptfs-stats";
  }
}

```

```

    config false;
    description
        "IPTFS per SA inner packet counters.";
    uses iptfs-inner-tx-stat-grouping {
        //when "direction = 'outbound'";
    }
    uses iptfs-inner-rx-stat-grouping {
        //when "direction = 'inbound'";
    }
}
container iptfs-outer-pkt-stats {
    if-feature "iptfs-stats";
    config false;
    description
        "IPTFS per SA outer packets counters.";
    uses iptfs-outer-tx-stat-grouping {
        //when "direction = 'outbound'";
    }
    uses iptfs-outer-rx-stat-grouping {
        //when "direction = 'inbound'";
    }
}
}

/*
 * packet counters
 */

augment "/nsfikels:ipsec-ikeless/nsfikels:sad/"
    + "nsfikels:sad-entry" {
    description
        "Per SA Counters";
    container ipsec-stats {
        if-feature "ipsec-stats";
        description
            "IPsec per SA packet counters.";
        uses ipsec-tx-stat-grouping {
            //when "direction = 'outbound'";
        }
        uses ipsec-rx-stat-grouping {
            //when "direction = 'inbound'";
        }
    }
    container iptfs-inner-pkt-stats {
        if-feature "iptfs-stats";
        config false;
        description
            "IPTFS per SA inner packet counters.";
        uses iptfs-inner-tx-stat-grouping {

```

```

        //when "direction = 'outbound'";
    }
    uses iptfs-inner-rx-stat-grouping {
        //when "direction = 'inbound'";
    }
}
container iptfs-outer-pkt-stats {
    if-feature "iptfs-stats";
    config false;
    description
        "IPTFS per SA outer packets counters.";
    uses iptfs-outer-tx-stat-grouping {
        //when "direction = 'outbound'";
    }
    uses iptfs-outer-rx-stat-grouping {
        //when "direction = 'inbound'";
    }
}
}
}

```

<CODE ENDS>

4. IANA Considerations

4.1. Updates to the IETF XML Registry

This document registers a URI in the "IETF XML Registry" [[RFC3688](#)]. Following the format in [[RFC3688](#)], the following registration has been made:

URI:

urn:ietf:params:xml:ns:yang:ietf-ipsec-iptfs

Registrant Contact:

The IESG.

XML:

N/A; the requested URI is an XML namespace.

4.2. Updates to the YANG Module Names Registry

This document registers one YANG module in the "YANG Module Names" registry [[RFC6020](#)]. Following the format in [[RFC6020](#)], the following registration has been made:

name:

ietf-ipsec-iptfs

namespace:

urn:ietf:params:xml:ns:yang:ietf-ipsec-iptfs

prefix:

iptfs

reference:

RFC XXXX (RFC Ed.: replace XXXX with actual RFC number and remove this note.)

5. Security Considerations

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

The Network Configuration Access Control Model (NACM) [[RFC8341](#)] provides the means to restrict access for particular NETCONF or RESTCONF users to a preconfigured subset of all available NETCONF or RESTCONF protocol operations and content.

The YANG module defined in this document can enable, disable and modify the behavior of IP traffic flow security, for the implications regarding these types of changes consult the [[I-D.ietf-ipsecme-iptfs](#)] which defines the functionality.

IP-TFS hides the traffic flows through the network, however anywhere that IP-TFS YANG statistics access is enabled, can reveal some information about traffic flows as well. Therefore, access to IP-TFS YANG statistics also needs to be protected from third party observation.

6. Acknowledgements

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7. References

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Appendix A. Examples

The following examples show configuration and operational data for the IKE-less and IKE cases using XML and JSON. Also, the operational statistics for the IKE-less case is illustrated.

A.1. Example XML Configuration

This example illustrates configuration for IP-TFS in the IKE-less case. Note that since this augments the IPsec IKE-less schema only minimal a IKE-less configuration to satisfy the schema has been populated.

```

<i:ipsec-ikeless
  xmlns:i="urn:ietf:params:xml:ns:yang:ietf-i2nsf-ikeless"
  xmlns:tfs="urn:ietf:params:xml:ns:yang:ietf-ipsec-iptfs">
  <i:spd>
    <i:spd-entry>
      <i:name>protect-policy-1</i:name>
      <i:direction>outbound</i:direction>
      <i:ipsec-policy-config>
        <i:traffic-selector>
          <i:local-prefix>192.0.2.0/16</i:local-prefix>
          <i:remote-prefix>198.51.100.0/16</i:remote-prefix>
        </i:traffic-selector>
        <i:processing-info>
          <i:action>protect</i:action>
          <i:ipsec-sa-cfg>
            <tfs:traffic-flow-security>
              <tfs:congestion-control>true</tfs:congestion-control>
              <tfs:packet-size>
                <tfs:use-path-mtu-discovery>
                  >true</tfs:use-path-mtu-discovery>
                </tfs:packet-size>
              <tfs:l2-fixed-rate>1000000000</tfs:l2-fixed-rate>
              <tfs:max-aggregation-time>
                >0.1</tfs:max-aggregation-time>
              <tfs>window-size>5</tfs>window-size>
              <tfs:send-immediately>false</tfs:send-immediately>
              <tfs:lost-packet-timer-interval>
                >0.2</tfs:lost-packet-timer-interval>
            </tfs:traffic-flow-security>
          </i:ipsec-sa-cfg>
        </i:processing-info>
      </i:ipsec-policy-config>
    </i:spd-entry>
  </i:spd>
</i:ipsec-ikeless>

```

Figure 1: Example IP-TFS XML configuration

A.2. Example XML Operational Data

This example illustrates operational data for IP-TFS in the IKE-less case. Note that since this augments the IPsec IKE-less schema only minimal IKE-less configuration to satisfy the schema has been populated.


```

<i:ipsec-ikeless
  xmlns:i="urn:ietf:params:xml:ns:yang:ietf-i2nsf-ikeless"
  xmlns:tfs="urn:ietf:params:xml:ns:yang:ietf-ipsec-iptfs">
  <i:sad>
    <i:sad-entry>
      <i:name>sad-1</i:name>
      <i:ipsec-sa-config>
        <i:spi>1</i:spi>
        <i:traffic-selector>
          <i:local-prefix>2001:DB8::0/16</i:local-prefix>
          <i:remote-prefix>2001:DB8::1:0/16</i:remote-prefix>
        </i:traffic-selector>
      </i:ipsec-sa-config>
      <tfs:traffic-flow-security>
        <tfs:congestion-control>true</tfs:congestion-control>
        <tfs:packet-size>
          <tfs:use-path-mtu-discovery
            >true</tfs:use-path-mtu-discovery>
          </tfs:packet-size>
        <tfs:l2-fixed-rate>1000000000</tfs:l2-fixed-rate>
        <tfs:max-aggregation-time>0.100</tfs:max-aggregation-time>
        <tfs>window-size>0</tfs>window-size>
        <tfs:send-immediately>true</tfs:send-immediately>
        <tfs:lost-packet-timer-interval
          >0.200</tfs:lost-packet-timer-interval>
        </tfs:traffic-flow-security>
      </i:sad-entry>
    </i:sad>
  </i:ipsec-ikeless>

```

Figure 2: Example IP-TFS XML Operational data

A.3. Example JSON Configuration

This example illustrates config data for IP-TFS in the IKE case. Note that since this augments the IPsec IKE schema only minimal ike configuration to satisfy the schema has been populated.

```

{
  "ietf-i2nsf-ike:ipsec-ike": {
    "ietf-i2nsf-ike:conn-entry": [
      {
        "name": "my-peer-connection",
        "ike-sa-encr-alg": [
          {
            "id": 1,
            "algorithm-type": 12,
            "key-length": 128
          }
        ],
        "local": {
          "local-pad-entry-name": "local-1"
        },
        "remote": {
          "remote-pad-entry-name": "remote-1"
        },
        "ietf-i2nsf-ike:spd": {
          "spd-entry": [
            {
              "name": "protect-policy-1",
              "ipsec-policy-config": {
                "traffic-selector": {
                  "local-prefix": "192.0.2.0/16",
                  "remote-prefix": "198.51.100.0/16"
                },
                "processing-info": {
                  "action": "protect",
                  "ipsec-sa-cfg": {
                    "ietf-ipsec-iptfs:traffic-flow-security": {
                      "congestion-control": "true",
                      "l2-fixed-rate": 10000000000,
                      "packet-size": {
                        "use-path-mtu-discovery": "true"
                      },
                      "max-aggregation-time": "0.1",
                      "window-size": "1",
                      "send-immediately": "false",
                      "lost-packet-timer-interval": "0.2"
                    }
                  }
                }
              }
            }
          ]
        }
      }
    ]
  }
}

```

}
}

Figure 3: Example IP-TFS JSON configuration

A.4. Example JSON Operational Data

This example illustrates operational data for IP-TFS in the IKE case. Note that since this augments the IPsec IKE tree only minimal IKE configuration to satisfy the schema has been populated.

```
{
  "ietf-i2nsf-ike:ipsec-ike": {
    "ietf-i2nsf-ike:conn-entry": [
      {
        "name": "my-peer-connection",
        "ike-sa-encr-alg": [
          {
            "id": 1,
            "algorithm-type": 12,
            "key-length": 128
          }
        ],
        "local": {
          "local-pad-entry-name": "local-1"
        },
        "remote": {
          "remote-pad-entry-name": "remote-1"
        },
        "ietf-i2nsf-ike:child-sa-info": {
          "ietf-ipsec-iptfs:traffic-flow-security": {
            "congestion-control": "true",
            "l2-fixed-rate": 1000000000,
            "packet-size": {
              "use-path-mtu-discovery": "true"
            },
            "max-aggregation-time": "0.1",
            "window-size": "5",
            "send-immediately": "false",
            "lost-packet-timer-interval": "0.2"
          },
          "max-aggregation-time": "0.1",
          "window-size": "5",
          "send-immediately": "false",
          "lost-packet-timer-interval": "0.2"
        }
      }
    ]
  }
}
```

Figure 4: Example IP-TFS JSON Operational data

A.5. Example JSON Operational Statistics

This example shows the JSON formatted statistics for IP-TFS. Note a unidirectional IP-TFS transmit side is illustrated, with arbitrary numbers for transmit.

```

{
  "ietf-i2nsf-ikeless:ipsec-ikeless": {
    "sad": {
      "sad-entry": [
        {
          "name": "sad-1",
          "ipsec-sa-config": {
            "spi": 1,
            "traffic-selector": {
              "local-prefix": "192.0.2.1/16",
              "remote-prefix": "198.51.100.0/16"
            }
          }
        },
        {
          "ietf-ipsec-iptfs:traffic-flow-security": {
            "window-size": "5",
            "send-immediately": "false",
            "lost-packet-timer-interval": "0.2"
          },
          {
            "ietf-ipsec-iptfs:ipsec-stats": {
              "tx-pkts": "300",
              "tx-octets": "80000",
              "tx-drop-pkts": "2",
              "rx-pkts": "0",
              "rx-octets": "0",
              "rx-drop-pkts": "0"
            },
            {
              "ietf-ipsec-iptfs:iptfs-inner-pkt-stats": {
                "tx-pkts": "250",
                "tx-octets": "75000",
                "rx-pkts": "0",
                "rx-octets": "0",
                "rx-incomplete-pkts": "0"
              },
              {
                "ietf-ipsec-iptfs:iptfs-outer-pkt-stats": {
                  "tx-all-pad-pkts": "40",
                  "tx-all-pad-octets": "40000",
                  "tx-extra-pad-pkts": "200",
                  "tx-extra-pad-octets": "30000",
                  "rx-all-pad-pkts": "0",
                  "rx-all-pad-octets": "0",
                  "rx-extra-pad-pkts": "0",
                  "rx-extra-pad-octets": "0",
                  "rx-errored-pkts": "0",
                  "rx-missed-pkts": "0"
                },
                {
                  "ipsec-sa-state": {
                    "sa-lifetime-current": {
                      "time": 80000,
                      "bytes": 4000606,

```

```
        "packets": 1000,  
        "idle": 5  
    }  
    }  
    }  
    ]  
    }  
    }  
}
```

Figure 5: Example IP-TFS JSON Statistics

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