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Authors: R.G. Wilton      S. Mansfield  
         Cisco Systems     Ericsson

## Common Interface Extension YANG Data Models

### Abstract

This document defines two YANG modules that augment the Interfaces data model defined in the "YANG Data Model for Interface Management" with additional configuration and operational data nodes to support common lower layer interface properties, such as interface MTU.

The YANG modules in this document conform to the Network Management Datastore Architecture (NMDA) defined in RFC 8342.

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## 1. Introduction

This document defines two [NMDA compatible \[RFC8342\] YANG 1.1 \[RFC7950\]](#) modules for the management of network interfaces. It defines various augmentations to the [generic interfaces data model \[RFC8343\]](#) to support configuration of lower layer interface properties that are common across many types of network interface.

One of the aims of this document is to provide a standard definition for these configuration items regardless of the underlying interface

type. For example, a definition for configuring or reading the MAC address associated with an interface is provided that can be used for any interface type that uses Ethernet framing.

Several of the augmentations defined here are not backed by any formal standard specification. Instead, they are for features that are commonly implemented in equivalent ways by multiple independent network equipment vendors. The aim of this document is to define common paths and leaves for the configuration of these equivalent features in a uniform way, making it easier for users of the YANG model to access these features in a vendor independent way. Where necessary, a description of the expected behavior is also provided with the aim of ensuring vendors implementations are consistent with the specified behavior.

Given that the modules contain a collection of discrete features with the common theme that they generically apply to interfaces, it is plausible that not all implementers of the YANG module will decide to support all features. Hence, separate feature keywords are defined for each logically discrete feature to allow implementers the flexibility to choose which specific parts of the model they support.

The augmentations are split into two separate YANG modules that each focus on a particular area of functionality. The two YANG modules defined in this document are:

`ietf-if-extensions.yang` - Defines extensions to the IETF interface data model to support common configuration data nodes.

`ietf-if-ethernet-like.yang` - Defines a module for any configuration and operational data nodes that are common across interfaces that use Ethernet framing.

### **1.1. 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.

### **1.2. Tree Diagrams**

Tree diagrams used in this document follow the notation defined in [[RFC8340](#)].

## 2. Interface Extensions Module

The Interfaces Extensions YANG module provides some basic extensions to the IETF interfaces YANG module.

The module provides:

- \*A link flap suppression feature used to provide control over short-lived link state flaps.
- \*An interface link state dampening feature that is used to provide control over longer lived link state flaps.
- \*An encapsulation container and extensible choice statement for use by any interface types that allow for configurable L2 encapsulations.
- \*A loopback configuration leaf that is primarily aimed at loopback at the physical layer.
- \*MTU configuration leaves applicable to all packet/frame based interfaces.
- \*A forwarding mode leaf to indicate the OSI layer at which the interface handles traffic.
- \*A generic "sub-interface" identity that an interface identity definition can derive from if it defines a sub-interface.
- \*A parent interface leaf useable for all types of sub-interface that are children of parent interfaces.

The "ietf-if-extensions" YANG module has the following structure:

```

module: ietf-if-extensions
augment /if:interfaces/if:interface:
  +--rw link-flap-suppression {link-flap-suppression}?
  | +--rw down?                uint32
  | +--rw up?                  uint32
  | +--ro carrier-transitions? yang:counter64
  | +--ro timer-running?       enumeration
  +--rw dampening! {dampening}?
  | +--rw half-life?           uint32
  | +--rw reuse?               uint32
  | +--rw suppress?            uint32
  | +--rw max-suppress-time?   uint32
  | +--ro penalty?             uint32
  | +--ro suppressed?          boolean
  | +--ro time-remaining?      uint32
  +--rw encapsulation
  | +--rw (encaps-type)?
  +--rw loopback?              identityref {loopback}?
  +--rw max-frame-size?        uint32 {max-frame-size}?
  +--ro forwarding-mode?       identityref
augment /if:interfaces/if:interface:
  +--rw parent-interface if:interface-ref {sub-interfaces}?
augment /if:interfaces/if:interface/if:statistics:
  +--ro in-discard-unknown-encaps? yang:counter64
      {sub-interfaces}?

```

## 2.1. Link Flap Suppression

The link flap suppression feature augments the IETF interfaces data model with configuration for a simple algorithm that is used, generally on physical interfaces, to suppress short transient changes in the interface link state. It can be used in conjunction with the dampening feature described in [Section 2.2](#) to provide effective control of unstable links and unwanted state transitions.

The principle of the link flap suppression feature is to use a short per interface timer to ensure that any interface link state transition that occurs and reverts back within the specified time interval is entirely suppressed without providing any signalling to any upper layer protocols that the state transition has occurred. E.g. in the case that the link state transition is suppressed then there is no change of the `/if:interfaces/if:interface/oper-status` or `/if:interfaces/if:interfaces/last-change` leaves for the interface that the feature is operating on. One obvious side effect of using this feature that is that any state transition will always be delayed by the specified time interval.

The configuration allows for separate timer values to be used in the suppression of down->up->down link transitions vs up->down->up link transitions.

The link flap suppression down timer leaf specifies the amount of time that an interface that is currently in link up state must be continuously down before the down state change is reported to higher level protocols. Use of this timer can cause traffic to be black holed for the configured value and delay reconvergence after link failures, therefore its use is normally restricted to cases where it is necessary to allow enough time for another protection mechanism (such as an optical layer automatic protection system) to take effect.

The link flap suppression up timer leaf specifies the amount of time that an interface that is currently in link down state must be continuously up before the down->up link state transition is reported to higher level protocols. This timer is generally useful as a debounce mechanism to ensure that a link is relatively stable before being brought into service. It can also be used effectively to limit the frequency at which link state transition events may occur. The default value for this leaf is determined by the underlying network device.

## **2.2. Dampening**

The dampening feature introduces a configurable exponential decay mechanism to suppress the effects of excessive interface link state flapping. This feature allows the network operator to configure a device to automatically identify and selectively dampen a local interface which is flapping. Dampening an interface keeps the interface operationally down until the interface stops flapping and becomes stable. Configuring the dampening feature can improve convergence times and stability throughout the network by isolating failures so that disturbances are not propagated, which reduces the utilization of system processing resources by other devices in the network and improves overall network stability.

The basic algorithm uses a counter that is increased by 1000 units every time the underlying interface link state changes from up to down. If the counter increases above the suppress threshold then the interface is kept down (and out of service) until either the maximum suppression time is reached, or the counter has reduced below the reuse threshold. The half-life period determines that rate at which the counter is periodically reduced by half.

### **2.2.1. Suppress Threshold**

The suppress threshold is the value of the accumulated penalty that triggers the device to dampen a flapping interface. The flapping interface is identified by the device and assigned a penalty for each up to down link state change, but the interface is not automatically dampened. The device tracks the penalties that a flapping interface accumulates. When the accumulated penalty reaches or exceeds the suppress threshold, the interface is placed in a suppressed state.

### **2.2.2. Half-Life Period**

The half-life period determines how fast the accumulated penalties can decay exponentially. The accumulated penalty decays at a rate that causes its value to be reduced by half after each half-life period.

### **2.2.3. Reuse Threshold**

If, after one or more half-life periods, the accumulated penalty decreases below the reuse threshold and the underlying interface link state is up then the interface is taken out of suppressed state and is allowed to go up.

### **2.2.4. Maximum Suppress Time**

The maximum suppress time represents the maximum amount of time an interface can remain dampened when a new penalty is assigned to an interface. The default of the maximum suppress timer is four times the half-life period. The maximum value of the accumulated penalty is calculated using the maximum suppress time, reuse threshold and half-life period.

## **2.3. Encapsulation**

The encapsulation container holds a choice node that is to be augmented with datalink layer specific encapsulations, such as HDLC, PPP, or sub-interface 802.1Q tag match encapsulations. The use of a choice statement ensures that an interface can only have a single datalink layer protocol configured.

The different encapsulations themselves are defined in separate YANG modules defined in other documents that augment the encapsulation choice statement. For example the Ethernet specific basic 'dot1q-vlan' encapsulation is defined in `ietf-if-l3-vlan.yang` and the 'flexible' encapsulation is defined in `ietf-flexible-encapsulation.yang`, both modules from [\[I-D.ietf-netmod-sub-intf-vlan-model\]](#).

## 2.4. Loopback

The loopback configuration leaf allows any physical interface to be configured to be in one of the possible following physical loopback modes, i.e. internal loopback, line loopback, or use of an external loopback connector. The use of YANG identities allows for the model to be extended with other modes of loopback if required.

The following loopback modes are defined:

- \*Internal loopback - All egress traffic on the interface is internally looped back within the interface to be received on the ingress path.
- \*Line loopback - All ingress traffic received on the interface is internally looped back within the interface to the egress path.
- \*Loopback Connector - The interface has a physical loopback connector attached that loops all egress traffic back into the interface's ingress path, with equivalent semantics to internal loopback.

## 2.5. Maximum frame size

A maximum frame size configuration leaf (max-frame-size) is provided to specify the maximum size of a layer 2 frame that may be transmitted or received on an interface. The value includes the overhead of any layer 2 header, the maximum length of the payload, and any frame check sequence (FCS) bytes. If configured, the max-frame-size leaf on an interface also restricts the max-frame-size of any child sub-interfaces, and the available MTU for protocols.

## 2.6. Sub-interface

The sub-interface feature specifies the minimal leaves required to define a child interface that is parented to another interface.

A sub-interface is a logical interface that handles a subset of the traffic on the parent interface. Separate configuration leaves are used to classify the subset of ingress traffic received on the parent interface to be processed in the context of a given sub-interface. All egress traffic processed on a sub-interface is given to the parent interface for transmission. Otherwise, a sub-interface is like any other interface in /if:interfaces and supports the standard interface features and configuration.

For some vendor specific interface naming conventions the name of the child interface is sufficient to determine the parent interface, which implies that the child interface can never be reparented to a different parent interface after it has been created without



deleting the existing sub-interface and recreating a new sub-interface. Even in this case it is useful to have a well-defined leaf to cleanly identify the parent interface.

The model also allows for arbitrarily named sub-interfaces by having an explicit parent-interface leaf define the child -> parent relationship. In this naming scenario it is also possible for implementations to allow for logical interfaces to be reparented to new parent interfaces without needing the sub-interface to be destroyed and recreated.

## **2.7. Forwarding Mode**

The forwarding mode leaf provides additional information as to what mode or layer an interface is logically operating and forwarding traffic at. The implication of this leaf is that for traffic forwarded at a given layer that any headers for lower layers are stripped off before the packet is forwarded at the given layer. Conversely, on egress any lower layer headers must be added to the packet before it is transmitted out of the interface.

The following forwarding modes are defined:

- \*Physical - Traffic is being forwarded at the physical layer. This includes DWDM or OTN based switching.
- \*Data-link - Layer 2 based forwarding, such as Ethernet/VLAN based switching, or L2VPN services.
- \*Network - Network layer based forwarding, such as IP, MPLS, or L3VPNs.

## **3. Interfaces Ethernet-Like Module**

The Interfaces Ethernet-Like Module is a small module that contains all configuration and operational data that is common across interface types that use Ethernet framing as their datalink layer encapsulation.

This module currently contains leaves for the configuration and reporting of the operational MAC address and the burnt-in MAC address (BIA) associated with any interface using Ethernet framing.

The "ietf-if-ethernet-like" YANG module has the following structure:

```
module: ietf-if-ethernet-like
augment /if:interfaces/if:interface:
  +-rw ethernet-like
    +-rw mac-address?      yang:mac-address
    |      {configurable-mac-address}?
    +-ro bia-mac-address? yang:mac-address
augment /if:interfaces/if:interface/if:statistics:
  +-ro in-drop-unknown-dest-mac-pkts? yang:counter64
  +-ro in-discard-overflows?          yang:counter64
```

#### 4. Interface Extensions YANG Module

This YANG module augments the interface container defined in [\[RFC8343\]](#). It also contains references to [\[RFC6991\]](#) and [\[RFC7224\]](#).

```
<CODE BEGINS> file "ietf-if-extensions@2023-01-26.yang"
```

```
module ietf-if-extensions {
  yang-version 1.1;

  namespace "urn:ietf:params:xml:ns:yang:ietf-if-extensions";

  prefix if-ext;

  import ietf-yang-types {
    prefix yang;
    reference "RFC 6991: Common YANG Data Types";
  }

  import ietf-interfaces {
    prefix if;
    reference
      "RFC 8343: A YANG Data Model For Interface Management";
  }

  import iana-if-type {
    prefix ianaift;
    reference "RFC 7224: IANA Interface Type YANG Module";
  }

  organization
    "IETF NETMOD (NETCONF Data Modeling Language) Working Group";

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

    Editor: Robert Wilton
           <mailto:rwilton@cisco.com>";

  description
    "This module contains common definitions for extending the IETF
    interface YANG model (RFC 8343) with common configurable layer 2
    properties.

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```

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.

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```
revision 2023-01-26 {
  description
    "Initial revision.";

  reference
    "RFC XXXX, Common Interface Extension YANG Data Models";
}

feature link-flap-suppression {
  description
    "This feature indicates that configurable interface link
    delay is supported, which is a feature is used to limit the
    propagation of very short interface link state flaps.";
  reference "RFC XXXX, Section 2.1 Link Flap Suppression";
}

feature dampening {
  description
    "This feature indicates that the device supports interface
    dampening, which is a feature that is used to limit the
    propagation of interface link state flaps over longer
    periods.";
  reference "RFC XXXX, Section 2.2 Dampening";
}

feature loopback {
  description
    "This feature indicates that configurable interface loopback is
    supported.";
  reference "RFC XXXX, Section 2.4 Loopback";
}

feature max-frame-size {
  description
    "This feature indicates that the device supports configuring or
    reporting the maximum frame size on interfaces.";
  reference "RFC XXXX, Section 2.5 Maximum Frame Size";
}

feature sub-interfaces {
```

```

description
    "This feature indicates that the device supports the
    instantiation of sub-interfaces. Sub-interfaces are defined
    as logical child interfaces that allow features and forwarding
    decisions to be applied to a subset of the traffic processed
    on the specified parent interface.";
reference "RFC XXXX, Section 2.6 Sub-interface";
}

/*
 * Define common identities to help allow interface types to be
 * assigned properties.
 */
identity sub-interface {
    description
        "Base type for generic sub-interfaces.

        New or custom interface types can derive from this type to
        inherit generic sub-interface configuration.";
reference "RFC XXXX, Section 2.6 Sub-interface";
}

identity ethSubInterface{
    base ianaift:l2vlan;
    base sub-interface;

    description
        "This identity represents the child sub-interface of any
        interface types that uses Ethernet framing (with or without
        802.1Q tagging).";
}

identity loopback {
    description "Base identity for interface loopback options";
reference "RFC XXXX, Section 2.4";
}

identity internal {
    base loopback;
    description
        "All egress traffic on the interface is internally looped back
        within the interface to be received on the ingress path.";
reference "RFC XXXX, Section 2.4";
}

identity line {
    base loopback;
    description
        "All ingress traffic received on the interface is internally
        looped back within the interface to the egress path.";
reference "RFC XXXX, Section 2.4";
}

```

```

}
identity connector {
  base loopback;
  description
    "The interface has a physical loopback connector attached that
    loops all egress traffic back into the interface's ingress
    path, with equivalent semantics to loopback internal.";
  reference "RFC XXXX, Section 2.4";
}

identity forwarding-mode {
  description "Base identity for forwarding-mode options.";
  reference "RFC XXXX, Section 2.7";
}
identity physical {
  base forwarding-mode;
  description
    "Physical layer forwarding. This includes DWDM or OTN based
    optical switching.";
  reference "RFC XXXX, Section 2.7";
}
identity data-link {
  base forwarding-mode;
  description
    "Layer 2 based forwarding, such as Ethernet/VLAN based
    switching, or L2VPN services.";
  reference "RFC XXXX, Section 2.7";
}
identity network {
  base forwarding-mode;
  description
    "Network layer based forwarding, such as IP, MPLS, or L3VPNs.";
  reference "RFC XXXX, Section 2.7";
}

/*
 * Augments the IETF interfaces model with leaves to configure
 * and monitor link-flap-suppression on an interface.
 */
augment "/if:interfaces/if:interface" {
  description
    "Augments the IETF interface model with optional common
    interface level commands that are not formally covered by any
    specific standard.";

  /*
   * Defines standard YANG for the Link Flap Suppression feature.

```

```

*/
container link-flap-suppression {
  if-feature "link-flap-suppression";
  description
    "Holds link flap related feature configuration.";
  leaf down {
    type uint32;
    units milliseconds;
    description
      "Delays the propagation of a 'loss of carrier signal' event
      that would cause the interface state to go down, i.e. the
      command allows short link flaps to be suppressed. The
      configured value indicates the minimum time interval (in
      milliseconds) that the link signal must be continuously
      down before the interface state is brought down. If not
      configured, the behavior on loss of link signal is
      vendor/interface specific, but with the general
      expectation that there should be little or no delay.";
  }
  leaf up {
    type uint32;
    units milliseconds;
    description
      "Defines the minimum time interval (in milliseconds) that
      the link signal must be continuously present and error
      free before the interface state is allowed to transition
      from down to up. If not configured, the behavior is
      vendor/interface specific, but with the general
      expectation that sufficient default delay should be used
      to ensure that the interface is stable when enabled before
      being reported as being up. Configured values that are
      too low for the hardware capabilities may be rejected.";
  }
  leaf carrier-transitions {
    type yang:counter64;
    units transitions;
    config false;
    description
      "Defines the number of times the underlying link state
      has changed to, or from, state up. This counter should be
      incremented even if the high layer interface state changes
      are being suppressed by a running link flap suppression
      timer.";
  }
  leaf timer-running {
    type enumeration {
      enum none {
        description
          "No link flap suppression timer is running.";
      }
    }
  }
}

```

```

    }
    enum up {
        description
            "link-flap-suppression up timer is running.  The
            underlying link state is up, but interface state is
            not reported as up.";
    }
    enum down {
        description
            "link-flap-suppression down timer is running.
            Interface state is reported as up, but the underlying
            link state is actually down.";
    }
}
config false;
description
    "Reports whether a link flap suppression timer is actively
    running, in which case the interface state does not match
    the underlying link state.";
}

reference "RFC XXXX, Section 2.1 Link Flap Suppression";
}

/*
 * Augments the IETF interfaces model with a container to hold
 * generic interface dampening
 */
container dampening {
    if-feature "dampening";
    presence
        "Enable interface link flap dampening with default settings
        (that are vendor/device specific).";
    description
        "Interface dampening limits the propagation of interface link
        state flaps over longer periods.";
    reference "RFC XXXX, Section 2.2 Dampening";

    leaf half-life {
        type uint32;
        units seconds;
        description
            "The time (in seconds) after which a penalty would be half
            its original value.  Once the interface has been assigned
            a penalty, the penalty is decreased at a decay rate
            equivalent to the half-life.  For some devices, the
            allowed values may be restricted to particular multiples
            of seconds.  The default value is vendor/device
            specific.";
    }
}

```



```

    reference "RFC XXXX, Section 2.3.2 Half-Life Period";
}

leaf reuse {
    type uint32;
    description
        "Penalty value below which a stable interface is
        unsuppressed (i.e. brought up) (no units). The default
        value is vendor/device specific. The penalty value for a
        link up->down state change is 1000 units.";
    reference "RFC XXXX, Section 2.2.3 Reuse Threshold";
}

leaf suppress {
    type uint32;
    description
        "Limit at which an interface is suppressed (i.e. held down)
        when its penalty exceeds that limit (no units). The value
        must be greater than the reuse threshold. The default
        value is vendor/device specific. The penalty value for a
        link up->down state change is 1000 units.";
    reference "RFC XXXX, Section 2.2.1 Suppress Threshold";
}

leaf max-suppress-time {
    type uint32;
    units seconds;
    description
        "Maximum time (in seconds) that an interface can be
        suppressed before being unsuppressed if no further link
        up->down state change penalties have been applied. This
        value effectively acts as a ceiling that the penalty value
        cannot exceed. The default value is vendor/device
        specific.";
    reference "RFC XXXX, Section 2.2.4 Maximum Suppress Time";
}

leaf penalty {
    type uint32;
    config false;
    description
        "The current penalty value for this interface. When the
        penalty value exceeds the 'suppress' leaf then the
        interface is suppressed (i.e. held down).";
    reference "RFC XXXX, Section 2.2 Dampening";
}

leaf suppressed {
    type boolean;

```

```

    config false;
    description
        "Represents whether the interface is suppressed (i.e. held
        down) because the 'penalty' leaf value exceeds the
        'suppress' leaf.";
    reference "RFC XXXX, Section 2.2 Dampening";
}

leaf time-remaining {
    when '../suppressed = "true"' {
        description
            "Only suppressed interfaces have a time remaining.";
    }
    type uint32;
    units seconds;
    config false;
    description
        "For a suppressed interface, this leaf represents how long
        (in seconds) that the interface will remain suppressed
        before it is allowed to go back up again.";
    reference "RFC XXXX, Section 2.2 Dampening";
}
}

/*
 * Various types of interfaces support a configurable layer 2
 * encapsulation, any that are supported by YANG should be
 * listed here.
 *
 * Different encapsulations can hook into the common encaps-type
 * choice statement.
 */
container encapsulation {
    when
        "derived-from-or-self(..if:type,
            'ianaift:ethernetCsmacd') or
        derived-from-or-self(..if:type,
            'ianaift:ieee8023adLag') or
        derived-from-or-self(..if:type, 'ianaift:pos') or
        derived-from-or-self(..if:type,
            'ianaift:atmSubInterface') or
        derived-from-or-self(..if:type, 'ianaift:l2vlan') or
        derived-from-or-self(..if:type, 'ethSubInterface')" {

    description
        "All interface types that can have a configurable L2
        encapsulation.";
}
}

```

```

description
  "Holds the OSI layer 2 encapsulation associated with an
  interface.";
choice encaps-type {
  description
    "Extensible choice of layer 2 encapsulations";
  reference "RFC XXXX, Section 2.3 Encapsulation";
}
}

/*
 * Various types of interfaces support loopback configuration,
 * any that are supported by YANG should be listed here.
 */
leaf loopback {
  when "derived-from-or-self(..if:type,
    'ianaift:ethernetCsmacd') or
    derived-from-or-self(..if:type, 'ianaift:sonet') or
    derived-from-or-self(..if:type, 'ianaift:atm') or
    derived-from-or-self(..if:type, 'ianaift:otnOtu')" {
  description
    "All interface types that support loopback configuration.";
  }
  if-feature "loopback";
  type identityref {
    base loopback;
  }
  description "Enables traffic loopback.";
  reference "RFC XXXX, Section 2.4 Loopback";
}

/*
 * Allows the maximum frame size to be configured or reported.
 */
leaf max-frame-size {
  if-feature "max-frame-size";
  type uint32 {
    range "64 .. max";
  }
  description
    "The maximum size of layer 2 frames that may be transmitted
    or received on the interface (including any frame header,
    maximum frame payload size, and frame checksum sequence).

    If configured, the max-frame-size also limits the maximum
    frame size of any child sub-interfaces. The MTU available
    to higher layer protocols is restricted to the maximum frame
    payload size, and MAY be further restricted by explicit
    layer 3 or protocol specific MTU configuration.";
}

```

```

    reference "RFC XXXX, Section 2.5 Maximum Frame Size";
}

/*
 * Augments the IETF interfaces model with a leaf that indicates
 * which mode, or layer, is being used to forward the traffic.
 */
leaf forwarding-mode {
    type identityref {
        base forwarding-mode;
    }
    config false;

    description
        "The forwarding mode that the interface is operating in.";
    reference "RFC XXXX, Section 2.7 Forwarding Mode";
}
}

/*
 * Add generic support for sub-interfaces.
 *
 * This should be extended to cover all interface types that are
 * child interfaces of other interfaces.
 */
augment "/if:interfaces/if:interface" {
    when "derived-from(if:type, 'sub-interface') or
        derived-from-or-self(if:type, 'ianaift:l2vlan') or
        derived-from-or-self(if:type, 'ianaift:atmSubInterface') or
        derived-from-or-self(if:type, 'ianaift:frameRelay')" {
        description
            "Any ianaift:types that explicitly represent sub-interfaces
            or any types that derive from the sub-interface identity.";
    }
    if-feature "sub-interfaces";

    description
        "Adds a parent interface field to interfaces that model
        sub-interfaces.";
    leaf parent-interface {

        type if:interface-ref;

        mandatory true;
        description
            "This is the reference to the parent interface of this
            sub-interface.";
        reference "RFC XXXX, Section 2.6 Sub-interface";
    }
}

```

```

    }
  }

/*
 * Add discard counter for unknown sub-interface encapsulation
 */
augment "/if:interfaces/if:interface/if:statistics" {
  when "derived-from-or-self(..if:type,
    'ianaift:ethernetCsmacd') or
    derived-from-or-self(..if:type,
    'ianaift:ieee8023adLag') or
    derived-from-or-self(..if:type, 'ianaift:ifPwType')" {
    description
      "Applies to interfaces that can demultiplex ingress frames to
      sub-interfaces.";
  }
  if-feature "sub-interfaces";

  description
    "Augment the interface model statistics with a sub-interface
    demux discard counter.";

  leaf in-discard-unknown-encaps {
    type yang:counter64;
    units frames;
    description
      "A count of the number of frames that were well formed, but
      otherwise discarded because their encapsulation does not
      classify the frame to the interface or any child
      sub-interface. E.g., a frame might be discarded because the
      it has an unknown VLAN Id, or does not have a VLAN Id when
      one is expected.

      For consistency, frames counted against this counter are
      also counted against the IETF interfaces statistics. In
      particular, they are included in in-octets and in-discards,
      but are not included in in-unicast-pkts, in-multicast-pkts
      or in-broadcast-pkts, because they are not delivered to a
      higher layer.

      Discontinuities in the values of this counter can occur at
      re-initialization of the management system, and at other
      times as indicated by the value of the 'discontinuity-time'
      leaf defined in the ietf-interfaces YANG module
      (RFC 8343).";
  }
}
}
}

```

<CODE ENDS>

## 5. Interfaces Ethernet-Like YANG Module

This YANG module augments the interface container defined in [RFC 8343](#) [[RFC8343](#)] for Ethernet-like interfaces. This includes Ethernet interfaces, 802.3 LAG (802.1AX) interfaces, Switch Virtual interfaces, and Pseudo-Wire Head-End interfaces. It also contains references to [[RFC6991](#)], [[RFC7224](#)], and [[IEEE 802.3.2 2019](#)].

```
<CODE BEGINS> file "ietf-if-ethernet-like@2023-01-26.yang"

module ietf-if-ethernet-like {
  yang-version 1.1;

  namespace
    "urn:ietf:params:xml:ns:yang:ietf-if-ethernet-like";

  prefix ethlike;

  import ietf-interfaces {
    prefix if;
    reference
      "RFC 8343: A YANG Data Model For Interface Management";
  }

  import ietf-yang-types {
    prefix yang;
    reference "RFC 6991: Common YANG Data Types";
  }

  import iana-if-type {
    prefix ianaift;
    reference "RFC 7224: IANA Interface Type YANG Module";
  }

  organization
    "IETF NETMOD (NETCONF Data Modeling Language) Working Group";

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

    Editor:   Robert Wilton
              <mailto:rwilton@cisco.com>";

  description
    "This module contains YANG definitions for configuration for
    'Ethernet-like' interfaces.  It is applicable to all interface
    types that use Ethernet framing and expose an Ethernet MAC
    layer, and includes such interfaces as physical Ethernet
    interfaces, Ethernet LAG interfaces and VLAN sub-interfaces.

    Additional interface configuration and counters for physical
    Ethernet interfaces are defined in
    ieee802-ethernet-interface.yang, as part of IEEE Std
    802.3.2-2019.

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



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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.";

```
revision 2023-01-26 {
  description "Initial revision.";

  reference
    "RFC XXXX, Common Interface Extension YANG Data Models";
}

feature configurable-mac-address {
  description
    "This feature indicates that MAC addresses on Ethernet-like
    interfaces can be configured.";
  reference
    "RFC XXXX, Section 3, Interfaces Ethernet-Like Module";
}

/*
 * Configuration parameters for Ethernet-like interfaces.
 */
augment "/if:interfaces/if:interface" {
  when "derived-from-or-self(if:type, 'ianaift:ethernetCsmacd') or
    derived-from-or-self(if:type, 'ianaift:ieee8023adLag') or
    derived-from-or-self(if:type, 'ianaift:ifPwType')" {
    description "Applies to all Ethernet-like interfaces";
  }
  description
    "Augment the interface model with parameters for all
    Ethernet-like interfaces.";

  container ethernet-like {
    description
      "Contains parameters for interfaces that use Ethernet framing
      and expose an Ethernet MAC layer.";

    leaf mac-address {
      if-feature "configurable-mac-address";
      type yang:mac-address;
      description
```

```

        "The MAC address of the interface. The operational value
        matches the /if:interfaces/if:interface/if:phys-address
        leaf defined in ietf-interface.yang.";
    }

    leaf bia-mac-address {
        type yang:mac-address;
        config false;
        description
            "The 'burnt-in' MAC address. I.e the default MAC address
            assigned to the interface if no MAC address has been
            explicitly configured on it.";
    }
}

/*
 * Configuration parameters for Ethernet-like interfaces.
 */
augment "/if:interfaces/if:interface/if:statistics" {
    when "derived-from-or-self(..if:type,
        'ianaift:ethernetCsmacd') or
        derived-from-or-self(..if:type,
        'ianaift:ieee8023adLag') or
        derived-from-or-self(..if:type, 'ianaift:ifPwType')" {
        description "Applies to all Ethernet-like interfaces";
    }
    description
        "Augment the interface model statistics with additional
        counters related to Ethernet-like interfaces.";

    leaf in-discard-unknown-dest-mac-pkts {
        type yang:counter64;
        units frames;
        description
            "A count of the number of frames that were well formed, but
            otherwise discarded because the destination MAC address did
            not pass any ingress destination MAC address filter.

            For consistency, frames counted against this counter are
            also counted against the IETF interfaces statistics. In
            particular, they are included in in-octets and in-discards,
            but are not included in in-unicast-pkts, in-multicast-pkts
            or in-broadcast-pkts, because they are not delivered to a
            higher layer.

            Discontinuities in the values of this counter can occur at
            re-initialization of the management system, and at other

```

```
    times as indicated by the value of the 'discontinuity-time'  
    leaf defined in the ietf-interfaces YANG module  
    (RFC 8343).";  
}  
  
leaf in-discard-overflows {  
    type yang:counter64;  
    units frames;  
    description  
        "A count of the number of frames discarded because of  
        overflows.";  
}  
}  
}
```

<CODE ENDS>

## 6. Examples

The following sections give some examples of how different parts of the YANG modules could be used. Examples are not given for the more trivial configuration, or for sub-interfaces, for which examples are contained in [[I-D.ietf-netmod-sub-intf-vlan-model](#)].

### 6.1. Carrier delay configuration

The following example shows how the operational state datastore could look like for an Ethernet interface without any link flap suppression configuration. The down leaf value of 0 indicates that link down events as always propagated to high layers immediately, but an up leaf value of 50 indicates that the interface must be up and stable for at least 50 msec before the interface is reported as being up to the high layers.

```
<?xml version="1.0" encoding="utf-8"?>
<interfaces
  xmlns="urn:ietf:params:xml:ns:yang:ietf-interfaces"
  xmlns:ianaift="urn:ietf:params:xml:ns:yang:iana-if-type"
  xmlns:if-ext="urn:ietf:params:xml:ns:yang:ietf-if-extensions">
  <interface>
    <name>eth0</name>
    <type>ianaift:ethernetCsmacd</type>
    <if-ext:link-flap-suppression>
      <if-ext:down>0</if-ext:down>
      <if-ext:up>50</if-ext:up>
    </if-ext:link-flap-suppression>
  </interface>
</interfaces>
```

The following example shows explicit link flap suppression delay up and down values have been configured. A 50 msec down leaf value has been used to potentially allow optical protection to recover the link before the higher layer protocol state is flapped. A 1 second (1000 milliseconds) up leaf value has been used to ensure that the link is always reasonably stable before allowing traffic to be carried over it. This also has the benefit of greatly reducing the rate at which higher layer protocol state flaps could occur.

```
<?xml version="1.0" encoding="utf-8"?>
<config xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <interfaces
    xmlns="urn:ietf:params:xml:ns:yang:ietf-interfaces"
    xmlns:ianaift="urn:ietf:params:xml:ns:yang:iana-if-type"
    xmlns:if-ext="urn:ietf:params:xml:ns:yang:ietf-if-extensions">
    <interface>
      <name>eth0</name>
      <type>ianaift:ethernetCsmacd</type>
      <if-ext:link-flap-suppression>
        <if-ext:down>50</if-ext:down>
        <if-ext:up>1000</if-ext:up>
      </if-ext:link-flap-suppression>
    </interface>
  </interfaces>
</config>
```

## 6.2. Dampening configuration

The following example shows what the operational state datastore may look like for an interface configured with interface dampening. The 'suppressed' leaf indicates that the interface is currently suppressed (i.e. down) because the 'penalty' is greater than the 'suppress' leaf threshold. The 'time-remaining' leaf indicates that the interface will remain suppressed for another 103 seconds before the 'penalty' is below the 'reuse' leaf value and the interface is allowed to go back up again.

```

<?xml version="1.0" encoding="utf-8"?>
<interfaces
  xmlns="urn:ietf:params:xml:ns:yang:ietf-interfaces"
  xmlns:ianaift="urn:ietf:params:xml:ns:yang:iana-if-type">
  <interface>
    <name>eth0</name>
    <type>ianaift:ethernetCsmacd</type>
    <oper-status>down</oper-status>
    <dampening
      xmlns="urn:ietf:params:xml:ns:yang:ietf-if-extensions">
      <half-life>60</half-life>
      <reuse>750</reuse>
      <suppress>2000</suppress>
      <max-suppress-time>240</max-suppress-time>
      <penalty>2480</penalty>
      <suppressed>true</suppressed>
      <time-remaining>103</time-remaining>
    </dampening>
  </interface>
</interfaces>

```

### 6.3. MAC address configuration

The following example shows how the operational state datastore could look like for an Ethernet interface without an explicit MAC address configured. The `mac-address` leaf always reports the actual operational MAC address that is in use. The `bia-mac-address` leaf always reports the default MAC address assigned to the hardware.

```

<?xml version="1.0" encoding="utf-8"?>
<interfaces
  xmlns="urn:ietf:params:xml:ns:yang:ietf-interfaces"
  xmlns:ianaift="urn:ietf:params:xml:ns:yang:iana-if-type">
  <interface>
    <name>eth0</name>
    <type>ianaift:ethernetCsmacd</type>
    <phys-address>00:00:5E:00:53:30</phys-address>
    <ethernet-like
      xmlns="urn:ietf:params:xml:ns:yang:ietf-if-ethernet-like">
      <mac-address>00:00:5E:00:53:30</mac-address>
      <bia-mac-address>00:00:5E:00:53:30</bia-mac-address>
    </ethernet-like>
  </interface>
</interfaces>

```

The following example shows the intended configuration for interface eth0 with an explicit MAC address configured.

```
<?xml version="1.0" encoding="utf-8"?>
<config xmlns="urn:ietf:params:xml:ns:netconf:base:1.0">
  <interfaces
    xmlns="urn:ietf:params:xml:ns:yang:ietf-interfaces"
    xmlns:ianaift="urn:ietf:params:xml:ns:yang:iana-if-type">
    <interface>
      <name>eth0</name>
      <type>ianaift:ethernetCsmacd</type>
      <ethernet-like
        xmlns="urn:ietf:params:xml:ns:yang:ietf-if-ethernet-like">
        <mac-address>00:00:5E:00:53:35</mac-address>
      </ethernet-like>
    </interface>
  </interfaces>
</config>
```

After the MAC address configuration has been successfully applied, the operational state datastore reporting the interface MAC address properties would contain the following, with the mac-address leaf updated to match the configured value, but the bia-mac-address leaf retaining the same value - which should never change.

```
<?xml version="1.0" encoding="utf-8"?>
<interfaces
  xmlns="urn:ietf:params:xml:ns:yang:ietf-interfaces"
  xmlns:ianaift="urn:ietf:params:xml:ns:yang:iana-if-type">
  <interface>
    <name>eth0</name>
    <type>ianaift:ethernetCsmacd</type>
    <phys-address>00:00:5E:00:53:35</phys-address>
    <ethernet-like
      xmlns="urn:ietf:params:xml:ns:yang:ietf-if-ethernet-like">
      <mac-address>00:00:5E:00:53:35</mac-address>
      <bia-mac-address>00:00:5E:00:53:30</bia-mac-address>
    </ethernet-like>
  </interface>
</interfaces>
```

## 7. Acknowledgements

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## 8. IANA Considerations

### 8.1. YANG Module Registrations

The following YANG modules are requested to be registered in the IANA "YANG Module Names" [[RFC6020](#)] registry:

The ietf-if-extensions module:

Name: ietf-if-extensions

XML Namespace: urn:ietf:params:xml:ns:yang:ietf-if-extensions

Prefix: if-ext

Reference: [RFCXXXX]

The ietf-if-ethernet-like module:

Name: ietf-if-ethernet-like

XML Namespace: urn:ietf:params:xml:ns:yang:ietf-if-ethernet-like

Prefix: ethlike

Reference: [RFCXXXX]

This document registers two URIs in the "IETF XML Registry" [[RFC3688](#)]. Following the format in RFC 3688, the following registrations have been made.

URI: urn:ietf:params:xml:ns:yang:ietf-if-extensions

Registrant Contact: The IESG.

XML: N/A, the requested URI is an XML namespace.

URI: urn:ietf:params:xml:ns:yang:ietf-if-ethernet-like

Registrant Contact: The IESG.

XML: N/A, the requested URI is an XML namespace.

## 9. Security Considerations

The YANG module defined in this memo is designed to be accessed via the NETCONF protocol [RFC 6241](#) [[RFC6241](#)]. The lowest NETCONF layer is the secure transport layer and the mandatory to implement secure



transport is SSH [RFC 6242](#) [[RFC6242](#)]. The NETCONF access control model [RFC 8341](#) [[RFC8341](#)] provides the means to restrict access for particular NETCONF users to a pre-configured subset of all available NETCONF protocol operations and content.

There are a number of data nodes defined in this YANG module which are writable/creatable/deletable (i.e. config true, which is the default). These data nodes may be considered sensitive or vulnerable in some network environments. Write operations (e.g. edit-config) to these data nodes without proper protection can have a negative effect on network operations. These are the subtrees and data nodes and their sensitivity/vulnerability:

### 9.1. ietf-if-extensions.yang

The ietf-if-extensions YANG module contains various configuration leaves that affect the behavior of interfaces. Modifying these leaves can cause an interface to go down, or become unreliable, or to drop traffic forwarded over it. More specific details of the possible failure modes are given below.

The following leaf could cause the interface to go down and stop processing any ingress or egress traffic on the interface. It could also cause broadcast traffic storms.

```
*/if:interfaces/if:interface/loopback
```

The following leaves could cause instabilities at the interface link layer, and cause unwanted higher layer routing path changes if the leaves are modified, although they would generally only affect a device that had some underlying link stability issues:

```
*/if:interfaces/if:interface/link-flap-suppression/down
```

```
*/if:interfaces/if:interface/link-flap-suppression/up
```

```
*/if:interfaces/if:interface/dampening/half-life
```

```
*/if:interfaces/if:interface/dampening/reuse
```

```
*/if:interfaces/if:interface/dampening/suppress
```

```
*/if:interfaces/if:interface/dampening/max-suppress-time
```

The following leaves could cause traffic loss on the interface because the received or transmitted frames do not comply with the frame matching criteria on the interface and hence would be dropped:

```
*/if:interfaces/if:interface/encapsulation
```

`*/if:interfaces/if:interface/max-frame-size`

`*/if:interfaces/if:interface/forwarding-mode`

Changing the parent-interface leaf could cause all traffic on the affected interface to be dropped. The affected leaf is:

`*/if:interfaces/if:interface/parent-interface`

## 9.2. `ietf-if-ethernet-like.yang`

Generally, the configuration nodes in the `ietf-if-ethernet-like` YANG module are concerned with configuration that is common across all types of Ethernet-like interfaces. The module currently only contains a node for configuring the operational MAC address to use on an interface. Adding/modifying/deleting this leaf has the potential risk of causing protocol instability, excessive protocol traffic, and general traffic loss, particularly if the configuration change caused a duplicate MAC address to be present on the local network. The following leaf is affected:

`*interfaces/interface/ethernet-like/mac-address`

## 10. References

### 10.1. Normative References

- [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>>.
- [RFC3688] Mealling, M., "The IETF XML Registry", BCP 81, RFC 3688, DOI 10.17487/RFC3688, January 2004, <<https://www.rfc-editor.org/info/rfc3688>>.
- [RFC6020] Bjorklund, M., Ed., "YANG - A Data Modeling Language for the Network Configuration Protocol (NETCONF)", RFC 6020,

DOI 10.17487/RFC6020, October 2010, <<https://www.rfc-editor.org/info/rfc6020>>.

[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>>.

[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>>.

[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>>.

[RFC8343] Bjorklund, M., "A YANG Data Model for Interface Management", RFC 8343, DOI 10.17487/RFC8343, March 2018, <<https://www.rfc-editor.org/info/rfc8343>>.

## 10.2. Informative References

[I-D.ietf-netmod-sub-intf-vlan-model] Wilton, R. and S. Mansfield, "Sub-interface VLAN YANG Data Models", Work in Progress, Internet-Draft, draft-ietf-netmod-sub-intf-vlan-model-08, 26 January 2023, <<https://www.ietf.org/archive/id/draft-ietf-netmod-sub-intf-vlan-model-08.txt>>.

[IEEE\_802.3.2\_2019] IEEE, "IEEE Standard for Ethernet - YANG Data Model Definitions", IEEE 802-3, DOI 10.1109/IEEESTD.2019.8737019, 14 June 2019, <<https://ieeexplore.ieee.org/document/8737019>>.

[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>>.

[RFC7224] Bjorklund, M., "IANA Interface Type YANG Module", RFC 7224, DOI 10.17487/RFC7224, May 2014, <<https://www.rfc-editor.org/info/rfc7224>>.

**[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](https://www.rfc-editor.org/info/rfc8341)>.

**Authors' Addresses**

Robert Wilton  
Cisco Systems

Email: [rwilton@cisco.com](mailto:rwilton@cisco.com)

Scott Mansfield  
Ericsson

Email: [scott.mansfield@ericsson.com](mailto:scott.mansfield@ericsson.com)