

A YANG Data Model for Interface Management

Abstract

This document defines a YANG data model for the management of network interfaces. It is expected that interface-type-specific data models augment the generic interfaces data model defined in this document. The data model includes configuration data and state data (status information and counters for the collection of statistics).

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1. Introduction

This document defines a YANG [RFC6020] data model for the management of network interfaces. It is expected that interface-type-specific data models augment the generic interfaces data model defined in this document.

Network interfaces are central to the management of many Internet protocols. Thus, it is important to establish a common data model for how interfaces are identified, configured, and monitored.

The data model includes configuration data and state data (status information and counters for the collection of statistics).

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].

The following terms are used within this document:

- o system-controlled interface: An interface is said to be system-controlled if the system creates and deletes the interface independently of what has been explicitly configured. Examples are interfaces representing physical hardware that appear and disappear when hardware (e.g., a line card or hot-pluggable wireless interface) is added or removed. System-controlled interfaces may also appear if a certain functionality is enabled (e.g., a loopback interface might appear if the IP protocol stack is enabled).
- o user-controlled interface: An interface is said to be user-controlled if the creation of the interface is controlled by adding explicit interface configuration to the running configuration datastore and the removal of the interface is controlled by removing explicit interface configuration from the running configuration datastore. Examples are VLAN interfaces configured on a system-controlled Ethernet interface.

The following terms are defined in [RFC6241] and are not redefined here:

- o client
- o configuration data
- o server
- o state data

The following terms are defined in [RFC6020] and are not redefined here:

- o augment
- o data model
- o data node
- o presence container

1.2. Tree Diagrams

A simplified graphical representation of the data model is used in this document. The meaning of the symbols in these diagrams is as follows:

- o Brackets "[" and "]" enclose list keys.
- o Abbreviations before data node names: "rw" means configuration (read-write), and "ro" means state data (read-only).
- o Symbols after data node names: "?" means an optional node, "!" means a presence container, and "*" denotes a list and leaf-list.
- o Parentheses enclose choice and case nodes, and case nodes are also marked with a colon (":").
- o Ellipsis ("...") stands for contents of subtrees that are not shown.

2. Objectives

This section describes some of the design objectives for the model presented in Section 5.

- o It is recognized that existing implementations will have to map the interface data model defined in this memo to their proprietary native data model. To facilitate such mappings, the data model should be simple.
- o The data model should be suitable for new implementations to use as is, without requiring a mapping to a different native model.
- o References to interfaces should be as simple as possible, preferably by using a single leafref.
- o The mapping to ifIndex [RFC2863] used by the Simple Network Management Protocol (SNMP) to identify interfaces must be clear.
- o The model must support interface layering: both (1) simple layering, where one interface is layered on top of exactly one other interface, and (2) more complex scenarios, where one interface results from the aggregation of N other interfaces or when N interfaces are multiplexed over one other interface.

- o The data model should support the pre-provisioning of interface configuration, i.e., it should be possible to configure an interface whose physical interface hardware is not present on the device. It is recommended that devices that support dynamic addition and removal of physical interfaces also support pre-provisioning.
- o The data model should support physical interfaces as well as logical interfaces.
- o The data model should include read-only counters in order to gather statistics for sent and received octets and packets, received packets with errors, and packets that could not be sent due to errors.

3. Interfaces Data Model

This document defines the YANG module "ietf-interfaces", which has the following structure:

```

+--rw interfaces
|   +--rw interface* [name]
|       +--rw name                string
|       +--rw description?        string
|       +--rw type                 identityref
|       +--rw enabled?            boolean
|       +--rw link-up-down-trap-enable? enumeration
+--ro interfaces-state
    +--ro interface* [name]
        +--ro name                string
        +--ro type                 identityref
        +--ro admin-status         enumeration
        +--ro oper-status          enumeration
        +--ro last-change?         yang:date-and-time
        +--ro if-index             int32
        +--ro phys-address?        yang:phys-address
        +--ro higher-layer-if*     interface-state-ref
        +--ro lower-layer-if*     interface-state-ref
        +--ro speed?              yang:gauge64
        +--ro statistics
            +--ro discontinuity-time yang:date-and-time
            +--ro in-octets?         yang:counter64
            +--ro in-unicast-pkts?   yang:counter64
            +--ro in-broadcast-pkts? yang:counter64
            +--ro in-multicast-pkts? yang:counter64
            +--ro in-discards?       yang:counter32
            +--ro in-errors?         yang:counter32
            +--ro in-unknown-protos? yang:counter32

```

```

+--ro out-octets?          yang:counter64
+--ro out-unicast-pkts?   yang:counter64
+--ro out-broadcast-pkts? yang:counter64
+--ro out-multicast-pkts? yang:counter64
+--ro out-discards?       yang:counter32
+--ro out-errors?         yang:counter32

```

3.1. The Interface Lists

The data model for interfaces presented in this document uses a flat list of interfaces. Each interface in the list is identified by its name. Furthermore, each interface has a mandatory "type" leaf.

The "iana-if-type" module [RFC7224] defines YANG identities for the interface types in the IANA-maintained "ifType definitions" registry.

There is one list of configured interfaces ("/interfaces/interface"), and a separate list for the operational state of all interfaces ("/interfaces-state/interface").

It is expected that interface-type-specific data models augment the interface lists and possibly use the "type" leaf to make the augmentation conditional.

As an example of such an interface-type-specific augmentation, consider this YANG snippet. For a more complete example, see Appendix A.

```

import interfaces {
  prefix "if";
}
import iana-if-type {
  prefix ianaift;
}

augment "/if:interfaces/if:interface" {
  when "if:type = 'ianaift:ethernetCsmacd'";

  container ethernet {
    leaf duplex {
      ...
    }
  }
}

```

For system-controlled interfaces, the "name" is the device-specific name of the interface. The 'config false' list `"/interfaces-state/interface"` contains all existing interfaces on the device.

If the device supports arbitrarily named user-controlled interfaces, the Network Configuration Protocol (NETCONF) server advertises the "arbitrary-names" feature. If the device does not advertise this feature, the names of user-controlled interfaces MUST match the device's naming scheme. How a client can learn the naming scheme of such devices is outside the scope of this document. See Appendices E.1 and E.2 for examples.

When a system-controlled interface is created by the system, the system tries to apply the interface configuration in `"/interfaces/interface"` with the same name as the new interface. If no such interface configuration is found, or if the configured type does not match the real interface type, the system creates the interface without applying explicit configuration.

When a user-controlled interface is created, the configuration determines the name of the interface.

Depending on the operating system and the physical attachment point to which a network interface may be attached or removed, it may be impossible for an implementation to provide predictable and consistent names for system-controlled interfaces across insertion/removal cycles as well as in anticipation of initial insertion. The ability to provide configurations for such interfaces is therefore dependent on the implementation and cannot be assumed in all cases.

3.2. Interface References

An interface is identified by its name, which is unique within the server. This property is captured in the "interface-ref" and "interface-state-ref" typedefs, which other YANG modules SHOULD use when they need to reference a configured interface or operationally used interface, respectively.

3.3. Interface Layering

There is no generic mechanism for how an interface is configured to be layered on top of some other interface. It is expected that interface-type-specific models define their own data nodes for interface layering by using "interface-ref" types to reference lower layers.

Below is an example of a model with such nodes. For a more complete example, see Appendix B.

```

import interfaces {
    prefix "if";
}
import iana-if-type {
    prefix ianaift;
}

augment "/if:interfaces/if:interface" {
    when "if:type = 'ianaift:ieee8023adLag'";

    leaf-list slave-if {
        type if:interface-ref;
        must "/if:interfaces/if:interface[if:name = current()]"
            + "/if:type = 'ianaift:ethernetCsmacd'" {
            description
                "The type of a slave interface must be
                'ethernetCsmacd'.";
        }
    }
    // other bonding config params, failover times, etc.
}

```

While the interface layering is configured in interface-type-specific models, two generic state data leaf-lists, "higher-layer-if" and "lower-layer-if", represent a read-only view of the interface layering hierarchy.

4. Relationship to the IF-MIB

If the device implements the IF-MIB [RFC2863], each entry in the "/interfaces-state/interface" list is typically mapped to one ifEntry. The "if-index" leaf MUST contain the value of the corresponding ifEntry's ifIndex.

In most cases, the "name" of an "/interfaces-state/interface" entry is mapped to ifName. The IF-MIB allows two different ifEntries to have the same ifName. Devices that support this feature and also support the data model defined in this document cannot have a 1-1 mapping between the "name" leaf and ifName.

The configured "description" of an "interface" has traditionally been mapped to ifAlias in some implementations. This document allows this mapping, but implementers should be aware of the differences in the value space and persistence for these objects. See the YANG module definition of the leaf "description" in Section 5 for details.

The IF-MIB also defines the writable object `ifPromiscuousMode`. Since this object typically is not implemented as a configuration object by SNMP agents, it is not mapped to the "ietf-interfaces" module.

The `ifMtu` object from the IF-MIB is not mapped to the "ietf-interfaces" module. It is expected that interface-type-specific YANG modules provide interface-type-specific MTU leaves by augmenting the "ietf-interfaces" model.

There are a number of counters in the IF-MIB that exist in two versions: one with 32 bits and one with 64 bits. The 64-bit versions were added to support high-speed interfaces with a data rate greater than 20,000,000 bits/second. Today's implementations generally support such high-speed interfaces, and hence only 64-bit counters are provided in this data model. Note that NETCONF and SNMP may differ in the time granularity in which they provide access to the counters. For example, it is common that SNMP implementations cache counter values for some time.

The objects `ifDescr` and `ifConnectorPresent` from the IF-MIB are not mapped to the "ietf-interfaces" module.

The following tables list the YANG data nodes with corresponding objects in the IF-MIB.

YANG data node in /interfaces-state/interface	IF-MIB object
name	ifName
type	ifType
admin-status	ifAdminStatus
oper-status	ifOperStatus
last-change	ifLastChange
if-index	ifIndex
link-up-down-trap-enable	ifLinkUpDownTrapEnable
phys-address	ifPhysAddress
higher-layer-if and lower-layer-if	ifStackTable
speed	ifSpeed and ifHighSpeed
discontinuity-time	ifCounterDiscontinuityTime
in-octets	ifHCInOctets
in-unicast-pkts	ifHCInUcastPkts
in-broadcast-pkts	ifHCInBroadcastPkts
in-multicast-pkts	ifHCInMulticastPkts
in-discards	ifInDiscards
in-errors	ifInErrors
in-unknown-protos	ifInUnknownProtos
out-octets	ifHCOctets
out-unicast-pkts	ifHCOUcastPkts
out-broadcast-pkts	ifHCOBroadcastPkts
out-multicast-pkts	ifHCOMulticastPkts
out-discards	ifOutDiscards
out-errors	ifOutErrors

YANG State Data Nodes and Related IF-MIB Objects

YANG data node in /interfaces/interface	IF-MIB object
description	ifAlias

YANG Config Data Nodes and Related IF-MIB Objects

5. Interfaces YANG Module

This YANG module imports typedefs from [RFC6991].

```
<CODE BEGINS> file "ietf-interfaces@2014-05-08.yang"

module ietf-interfaces {

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

  import ietf-yang-types {
    prefix yang;
  }

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

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

    WG Chair: Thomas Nadeau
              <mailto:tnadeau@lucidvision.com>

    WG Chair: Juergen Schoenwaelder
              <mailto:j.schoenwaelder@jacobs-university.de>

    Editor:   Martin Bjorklund
              <mailto:mbj@tail-f.com>";

  description
    "This module contains a collection of YANG definitions for
    managing network interfaces.

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```

```
revision 2014-05-08 {
  description
    "Initial revision.";
  reference
    "RFC 7223: A YANG Data Model for Interface Management";
}

/*
 * Typedefs
 */

typedef interface-ref {
  type leafref {
    path "/if:interfaces/if:interface/if:name";
  }
  description
    "This type is used by data models that need to reference
    configured interfaces.";
}

typedef interface-state-ref {
  type leafref {
    path "/if:interfaces-state/if:interface/if:name";
  }
  description
    "This type is used by data models that need to reference
    the operationally present interfaces.";
}

/*
 * Identities
 */

identity interface-type {
  description
    "Base identity from which specific interface types are
    derived.";
}

/*
 * Features
 */

feature arbitrary-names {
  description
    "This feature indicates that the device allows user-controlled
    interfaces to be named arbitrarily.";
}
```

```
feature pre-provisioning {
  description
    "This feature indicates that the device supports
    pre-provisioning of interface configuration, i.e., it is
    possible to configure an interface whose physical interface
    hardware is not present on the device."
}

feature if-mib {
  description
    "This feature indicates that the device implements
    the IF-MIB."
  reference
    "RFC 2863: The Interfaces Group MIB"
}

/*
 * Configuration data nodes
 */

container interfaces {
  description
    "Interface configuration parameters."

  list interface {
    key "name";

    description
      "The list of configured interfaces on the device.

      The operational state of an interface is available in the
      /interfaces-state/interface list. If the configuration of a
      system-controlled interface cannot be used by the system
      (e.g., the interface hardware present does not match the
      interface type), then the configuration is not applied to
      the system-controlled interface shown in the
      /interfaces-state/interface list. If the configuration
      of a user-controlled interface cannot be used by the system,
      the configured interface is not instantiated in the
      /interfaces-state/interface list."

    leaf name {
      type string;
      description
        "The name of the interface.

        A device MAY restrict the allowed values for this leaf,
        possibly depending on the type of the interface."
    }
  }
}
```

For system-controlled interfaces, this leaf is the device-specific name of the interface. The 'config false' list /interfaces-state/interface contains the currently existing interfaces on the device.

If a client tries to create configuration for a system-controlled interface that is not present in the /interfaces-state/interface list, the server MAY reject the request if the implementation does not support pre-provisioning of interfaces or if the name refers to an interface that can never exist in the system. A NETCONF server MUST reply with an rpc-error with the error-tag 'invalid-value' in this case.

If the device supports pre-provisioning of interface configuration, the 'pre-provisioning' feature is advertised.

If the device allows arbitrarily named user-controlled interfaces, the 'arbitrary-names' feature is advertised.

When a configured user-controlled interface is created by the system, it is instantiated with the same name in the /interface-state/interface list.";

}

```
leaf description {
  type string;
  description
    "A textual description of the interface.
```

A server implementation MAY map this leaf to the ifAlias MIB object. Such an implementation needs to use some mechanism to handle the differences in size and characters allowed between this leaf and ifAlias. The definition of such a mechanism is outside the scope of this document.

Since ifAlias is defined to be stored in non-volatile storage, the MIB implementation MUST map ifAlias to the value of 'description' in the persistently stored datastore.

Specifically, if the device supports ':startup', when ifAlias is read the device MUST return the value of 'description' in the 'startup' datastore, and when it is written, it MUST be written to the 'running' and 'startup' datastores. Note that it is up to the implementation to

decide whether to modify this single leaf in 'startup' or perform an implicit copy-config from 'running' to 'startup'.

If the device does not support ':startup', ifAlias MUST be mapped to the 'description' leaf in the 'running' datastore.";

```
reference
  "RFC 2863: The Interfaces Group MIB - ifAlias";
}

leaf type {
  type identityref {
    base interface-type;
  }
  mandatory true;
  description
    "The type of the interface.

    When an interface entry is created, a server MAY
    initialize the type leaf with a valid value, e.g., if it
    is possible to derive the type from the name of the
    interface.

    If a client tries to set the type of an interface to a
    value that can never be used by the system, e.g., if the
    type is not supported or if the type does not match the
    name of the interface, the server MUST reject the request.
    A NETCONF server MUST reply with an rpc-error with the
    error-tag 'invalid-value' in this case.";
  reference
    "RFC 2863: The Interfaces Group MIB - ifType";
}

leaf enabled {
  type boolean;
  default "true";
  description
    "This leaf contains the configured, desired state of the
    interface.

    Systems that implement the IF-MIB use the value of this
    leaf in the 'running' datastore to set
    IF-MIB.ifAdminStatus to 'up' or 'down' after an ifEntry
    has been initialized, as described in RFC 2863.
```

```

    Changes in this leaf in the 'running' datastore are
    reflected in ifAdminStatus, but if ifAdminStatus is
    changed over SNMP, this leaf is not affected.";
reference
    "RFC 2863: The Interfaces Group MIB - ifAdminStatus";
}

leaf link-up-down-trap-enable {
    if-feature if-mib;
    type enumeration {
        enum enabled {
            value 1;
        }
        enum disabled {
            value 2;
        }
    }
    description
        "Controls whether linkUp/linkDown SNMP notifications
        should be generated for this interface.

        If this node is not configured, the value 'enabled' is
        operationally used by the server for interfaces that do
        not operate on top of any other interface (i.e., there are
        no 'lower-layer-if' entries), and 'disabled' otherwise.";
reference
    "RFC 2863: The Interfaces Group MIB -
    ifLinkUpDownTrapEnable";
}
}

/*
 * Operational state data nodes
 */

container interfaces-state {
    config false;
    description
        "Data nodes for the operational state of interfaces.";

    list interface {
        key "name";
    }
}

```



```
description
  "The list of interfaces on the device.

  System-controlled interfaces created by the system are
  always present in this list, whether they are configured or
  not.";

leaf name {
  type string;
  description
    "The name of the interface.

    A server implementation MAY map this leaf to the ifName
    MIB object. Such an implementation needs to use some
    mechanism to handle the differences in size and characters
    allowed between this leaf and ifName. The definition of
    such a mechanism is outside the scope of this document.";
  reference
    "RFC 2863: The Interfaces Group MIB - ifName";
}

leaf type {
  type identityref {
    base interface-type;
  }
  mandatory true;
  description
    "The type of the interface.";
  reference
    "RFC 2863: The Interfaces Group MIB - ifType";
}

leaf admin-status {
  if-feature if-mib;
  type enumeration {
    enum up {
      value 1;
      description
        "Ready to pass packets.";
    }
    enum down {
      value 2;
      description
        "Not ready to pass packets and not in some test mode.";
    }
  }
}
```

```
    enum testing {
      value 3;
      description
        "In some test mode.";
    }
  }
  mandatory true;
  description
    "The desired state of the interface.

    This leaf has the same read semantics as ifAdminStatus.";
  reference
    "RFC 2863: The Interfaces Group MIB - ifAdminStatus";
}

leaf oper-status {
  type enumeration {
    enum up {
      value 1;
      description
        "Ready to pass packets.";
    }
    enum down {
      value 2;
      description
        "The interface does not pass any packets.";
    }
    enum testing {
      value 3;
      description
        "In some test mode. No operational packets can
        be passed.";
    }
    enum unknown {
      value 4;
      description
        "Status cannot be determined for some reason.";
    }
    enum dormant {
      value 5;
      description
        "Waiting for some external event.";
    }
    enum not-present {
      value 6;
      description
        "Some component (typically hardware) is missing.";
    }
  }
}
```

```
    enum lower-layer-down {
      value 7;
      description
        "Down due to state of lower-layer interface(s).";
    }
  }
  mandatory true;
  description
    "The current operational state of the interface.

    This leaf has the same semantics as ifOperStatus.";
  reference
    "RFC 2863: The Interfaces Group MIB - ifOperStatus";
}

leaf last-change {
  type yang:date-and-time;
  description
    "The time the interface entered its current operational
    state.  If the current state was entered prior to the
    last re-initialization of the local network management
    subsystem, then this node is not present.";
  reference
    "RFC 2863: The Interfaces Group MIB - ifLastChange";
}

leaf if-index {
  if-feature if-mib;
  type int32 {
    range "1..2147483647";
  }
  mandatory true;
  description
    "The ifIndex value for the ifEntry represented by this
    interface.";
  reference
    "RFC 2863: The Interfaces Group MIB - ifIndex";
}

leaf phys-address {
  type yang:phys-address;
  description
    "The interface's address at its protocol sub-layer.  For
    example, for an 802.x interface, this object normally
    contains a Media Access Control (MAC) address.  The
    interface's media-specific modules must define the bit
```

```
    and byte ordering and the format of the value of this
    object. For interfaces that do not have such an address
    (e.g., a serial line), this node is not present.";
  reference
    "RFC 2863: The Interfaces Group MIB - ifPhysAddress";
}

leaf-list higher-layer-if {
  type interface-state-ref;
  description
    "A list of references to interfaces layered on top of this
    interface.";
  reference
    "RFC 2863: The Interfaces Group MIB - ifStackTable";
}

leaf-list lower-layer-if {
  type interface-state-ref;
  description
    "A list of references to interfaces layered underneath this
    interface.";
  reference
    "RFC 2863: The Interfaces Group MIB - ifStackTable";
}

leaf speed {
  type yang:gauge64;
  units "bits/second";
  description
    "An estimate of the interface's current bandwidth in bits
    per second. For interfaces that do not vary in
    bandwidth or for those where no accurate estimation can
    be made, this node should contain the nominal bandwidth.
    For interfaces that have no concept of bandwidth, this
    node is not present.";
  reference
    "RFC 2863: The Interfaces Group MIB -
    ifSpeed, ifHighSpeed";
}
```

```
container statistics {
  description
    "A collection of interface-related statistics objects.";

  leaf discontinuity-time {
    type yang:date-and-time;
    mandatory true;
    description
      "The time on the most recent occasion at which any one or
      more of this interface's counters suffered a
      discontinuity.  If no such discontinuities have occurred
      since the last re-initialization of the local management
      subsystem, then this node contains the time the local
      management subsystem re-initialized itself.";
  }

  leaf in-octets {
    type yang:counter64;
    description
      "The total number of octets received on the interface,
      including framing characters.

      Discontinuities in the value of this counter can occur
      at re-initialization of the management system, and at
      other times as indicated by the value of
      'discontinuity-time'.";
    reference
      "RFC 2863: The Interfaces Group MIB - ifHCInOctets";
  }

  leaf in-unicast-pkts {
    type yang:counter64;
    description
      "The number of packets, delivered by this sub-layer to a
      higher (sub-)layer, that were not addressed to a
      multicast or broadcast address at this sub-layer.

      Discontinuities in the value of this counter can occur
      at re-initialization of the management system, and at
      other times as indicated by the value of
      'discontinuity-time'.";
    reference
      "RFC 2863: The Interfaces Group MIB - ifHCInUcastPkts";
  }
}
```

```
leaf in-broadcast-pkts {
  type yang:counter64;
  description
    "The number of packets, delivered by this sub-layer to a
    higher (sub-)layer, that were addressed to a broadcast
    address at this sub-layer.

    Discontinuities in the value of this counter can occur
    at re-initialization of the management system, and at
    other times as indicated by the value of
    'discontinuity-time'.";
  reference
    "RFC 2863: The Interfaces Group MIB -
    ifHCInBroadcastPkts";
}

leaf in-multicast-pkts {
  type yang:counter64;
  description
    "The number of packets, delivered by this sub-layer to a
    higher (sub-)layer, that were addressed to a multicast
    address at this sub-layer. For a MAC-layer protocol,
    this includes both Group and Functional addresses.

    Discontinuities in the value of this counter can occur
    at re-initialization of the management system, and at
    other times as indicated by the value of
    'discontinuity-time'.";
  reference
    "RFC 2863: The Interfaces Group MIB -
    ifHCInMulticastPkts";
}

leaf in-discards {
  type yang:counter32;
  description
    "The number of inbound packets that were chosen to be
    discarded even though no errors had been detected to
    prevent their being deliverable to a higher-layer
    protocol. One possible reason for discarding such a
    packet could be to free up buffer space.

    Discontinuities in the value of this counter can occur
    at re-initialization of the management system, and at
    other times as indicated by the value of
    'discontinuity-time'.";
```

```
reference
  "RFC 2863: The Interfaces Group MIB - ifInDiscards";
}

leaf in-errors {
  type yang:counter32;
  description
    "For packet-oriented interfaces, the number of inbound
    packets that contained errors preventing them from being
    deliverable to a higher-layer protocol. For character-
    oriented or fixed-length interfaces, the number of
    inbound transmission units that contained errors
    preventing them from being deliverable to a higher-layer
    protocol.

    Discontinuities in the value of this counter can occur
    at re-initialization of the management system, and at
    other times as indicated by the value of
    'discontinuity-time'.";
  reference
    "RFC 2863: The Interfaces Group MIB - ifInErrors";
}

leaf in-unknown-protos {
  type yang:counter32;
  description
    "For packet-oriented interfaces, the number of packets
    received via the interface that were discarded because
    of an unknown or unsupported protocol. For
    character-oriented or fixed-length interfaces that
    support protocol multiplexing, the number of
    transmission units received via the interface that were
    discarded because of an unknown or unsupported protocol.
    For any interface that does not support protocol
    multiplexing, this counter is not present.

    Discontinuities in the value of this counter can occur
    at re-initialization of the management system, and at
    other times as indicated by the value of
    'discontinuity-time'.";
  reference
    "RFC 2863: The Interfaces Group MIB - ifInUnknownProtos";
}
```

```
leaf out-octets {
  type yang:counter64;
  description
    "The total number of octets transmitted out of the
    interface, including framing characters.

    Discontinuities in the value of this counter can occur
    at re-initialization of the management system, and at
    other times as indicated by the value of
    'discontinuity-time'.";
  reference
    "RFC 2863: The Interfaces Group MIB - ifHCOutOctets";
}

leaf out-unicast-pkts {
  type yang:counter64;
  description
    "The total number of packets that higher-level protocols
    requested be transmitted, and that were not addressed
    to a multicast or broadcast address at this sub-layer,
    including those that were discarded or not sent.

    Discontinuities in the value of this counter can occur
    at re-initialization of the management system, and at
    other times as indicated by the value of
    'discontinuity-time'.";
  reference
    "RFC 2863: The Interfaces Group MIB - ifHCOutUcastPkts";
}

leaf out-broadcast-pkts {
  type yang:counter64;
  description
    "The total number of packets that higher-level protocols
    requested be transmitted, and that were addressed to a
    broadcast address at this sub-layer, including those
    that were discarded or not sent.

    Discontinuities in the value of this counter can occur
    at re-initialization of the management system, and at
    other times as indicated by the value of
    'discontinuity-time'.";
  reference
    "RFC 2863: The Interfaces Group MIB -
    ifHCOutBroadcastPkts";
}
```



```
leaf out-multicast-pkts {
  type yang:counter64;
  description
    "The total number of packets that higher-level protocols
    requested be transmitted, and that were addressed to a
    multicast address at this sub-layer, including those
    that were discarded or not sent. For a MAC-layer
    protocol, this includes both Group and Functional
    addresses.

    Discontinuities in the value of this counter can occur
    at re-initialization of the management system, and at
    other times as indicated by the value of
    'discontinuity-time'.";
  reference
    "RFC 2863: The Interfaces Group MIB -
    ifHCOutMulticastPkts";
}

leaf out-discards {
  type yang:counter32;
  description
    "The number of outbound packets that were chosen to be
    discarded even though no errors had been detected to
    prevent their being transmitted. One possible reason
    for discarding such a packet could be to free up buffer
    space.

    Discontinuities in the value of this counter can occur
    at re-initialization of the management system, and at
    other times as indicated by the value of
    'discontinuity-time'.";
  reference
    "RFC 2863: The Interfaces Group MIB - ifOutDiscards";
}

leaf out-errors {
  type yang:counter32;
  description
    "For packet-oriented interfaces, the number of outbound
    packets that could not be transmitted because of errors.
    For character-oriented or fixed-length interfaces, the
    number of outbound transmission units that could not be
    transmitted because of errors.
```


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:

/interfaces/interface: This list specifies the configured interfaces on a device. Unauthorized access to this list could cause the device to ignore packets it should receive and process.

/interfaces/interface/enabled: This leaf controls whether an interface is enabled or not. Unauthorized access to this leaf could cause the device to ignore packets it should receive and process.

8. Acknowledgments

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9. References

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Appendix A. Example: Ethernet Interface Module

This section gives a simple example of how an Ethernet interface module could be defined. It demonstrates how media-specific configuration parameters can be conditionally augmented to the generic interface list. It also shows how operational state parameters can be conditionally augmented to the operational interface list. The example is not intended as a complete module for Ethernet configuration.

```
module ex-ethernet {
  namespace "http://example.com/ethernet";
  prefix "eth";

  import ietf-interfaces {
    prefix if;
  }
  import iana-if-type {
    prefix ianaift;
  }

  // configuration parameters for Ethernet interfaces
  augment "/if:interfaces/if:interface" {
    when "if:type = 'ianaift:ethernetCsmacd'";

    container ethernet {
      choice transmission-params {
        case auto {
          leaf auto-negotiate {
            type empty;
          }
        }
        case manual {
          leaf duplex {
            type enumeration {
              enum "half";
              enum "full";
            }
          }
        }
      }
    }
  }
}
```

```

        leaf speed {
            type enumeration {
                enum "10Mb";
                enum "100Mb";
                enum "1Gb";
                enum "10Gb";
            }
        }
    }
}
// other Ethernet-specific params...
}

// operational state parameters for Ethernet interfaces
augment "/if:interfaces-state/if:interface" {
    when "if:type = 'ianaift:ethernetCsmacd'";

    container ethernet {
        leaf duplex {
            type enumeration {
                enum "half";
                enum "full";
            }
        }
        // other Ethernet-specific params...
    }
}
}

```

Appendix B. Example: Ethernet Bonding Interface Module

This section gives an example of how interface layering can be defined. An Ethernet bonding interface that bonds several Ethernet interfaces into one logical interface is defined.

```

module ex-ethernet-bonding {
    namespace "http://example.com/ethernet-bonding";
    prefix "bond";

    import ietf-interfaces {
        prefix if;
    }
    import iana-if-type {
        prefix ianaift;
    }
}

```

```

augment "/if:interfaces/if:interface" {
  when "if:type = 'ianaift:ieee8023adLag'";

  leaf-list slave-if {
    type if:interface-ref;
    must "/if:interfaces/if:interface[if:name = current()]"
      + "/if:type = 'ianaift:ethernetCsmacd'" {
      description
        "The type of a slave interface must be 'ethernetCsmacd'.";
    }
  }
  leaf bonding-mode {
    type enumeration {
      enum round-robin;
      enum active-backup;
      enum broadcast;
    }
  }
  // other bonding config params, failover times, etc.
}
}

```

Appendix C. Example: VLAN Interface Module

This section gives an example of how a VLAN interface module can be defined.

```

module ex-vlan {
  namespace "http://example.com/vlan";
  prefix "vlan";

  import ietf-interfaces {
    prefix if;
  }
  import iana-if-type {
    prefix ianaift;
  }

  augment "/if:interfaces/if:interface" {
    when "if:type = 'ianaift:ethernetCsmacd' or
      if:type = 'ianaift:ieee8023adLag'";
    leaf vlan-tagging {
      type boolean;
      default false;
    }
  }
}

```

```

augment "/if:interfaces/if:interface" {
  when "if:type = 'ianaift:l2vlan'";

  leaf base-interface {
    type if:interface-ref;
    must "/if:interfaces/if:interface[if:name = current()]"
      + "/vlan:vlan-tagging = 'true'" {
      description
        "The base interface must have VLAN tagging enabled.";
    }
  }
  leaf vlan-id {
    type uint16 {
      range "1..4094";
    }
    must "../base-interface" {
      description
        "If a vlan-id is defined, a base-interface must
        be specified.";
    }
  }
}
}
}

```

Appendix D. Example: NETCONF <get> Reply

This section gives an example of a reply to the NETCONF <get> request for a device that implements the example data models above.

```

<rpc-reply
  xmlns="urn:ietf:params:xml:ns:netconf:base:1.0"
  message-id="101">
  <data>

    <interfaces
      xmlns="urn:ietf:params:xml:ns:yang:ietf-interfaces"
      xmlns:ianaift="urn:ietf:params:xml:ns:yang:iana-if-type"
      xmlns:vlan="http://example.com/vlan">

      <interface>
        <name>eth0</name>
        <type>ianaift:ethernetCsmacd</type>
        <enabled>>false</enabled>
      </interface>
    
```



```
<interface>
  <name>eth1</name>
  <type>ianaift:ethernetCsmacd</type>
  <enabled>true</enabled>
  <vlan:vlan-tagging>true</vlan:vlan-tagging>
</interface>

<interface>
  <name>eth1.10</name>
  <type>ianaift:l2vlan</type>
  <enabled>true</enabled>
  <vlan:base-interface>eth1</vlan:base-interface>
  <vlan:vlan-id>10</vlan:vlan-id>
</interface>

<interface>
  <name>lol</name>
  <type>ianaift:softwareLoopback</type>
  <enabled>true</enabled>
</interface>

</interfaces>

<interfaces-state
  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>
    <admin-status>down</admin-status>
    <oper-status>down</oper-status>
    <if-index>2</if-index>
    <phys-address>00:01:02:03:04:05</phys-address>
    <statistics>
      <discontinuity-time>
        2013-04-01T03:00:00+00:00
      </discontinuity-time>
      <!-- counters now shown here -->
    </statistics>
  </interface>

  <interface>
    <name>eth1</name>
    <type>ianaift:ethernetCsmacd</type>
    <admin-status>up</admin-status>
    <oper-status>up</oper-status>
    <if-index>7</if-index>
```

```
<phys-address>00:01:02:03:04:06</phys-address>
<higher-layer-if>eth1.10</higher-layer-if>
<statistics>
  <discontinuity-time>
    2013-04-01T03:00:00+00:00
  </discontinuity-time>
  <!-- counters now shown here -->
</statistics>
</interface>

<interface>
  <name>eth1.10</name>
  <type>ianaift:l2vlan</type>
  <admin-status>up</admin-status>
  <oper-status>up</oper-status>
  <if-index>9</if-index>
  <lower-layer-if>eth1</lower-layer-if>
  <statistics>
    <discontinuity-time>
      2013-04-01T03:00:00+00:00
    </discontinuity-time>
    <!-- counters now shown here -->
  </statistics>
</interface>

<!-- This interface is not configured -->
<interface>
  <name>eth2</name>
  <type>ianaift:ethernetCsmacd</type>
  <admin-status>down</admin-status>
  <oper-status>down</oper-status>
  <if-index>8</if-index>
  <phys-address>00:01:02:03:04:07</phys-address>
  <statistics>
    <discontinuity-time>
      2013-04-01T03:00:00+00:00
    </discontinuity-time>
    <!-- counters now shown here -->
  </statistics>
</interface>

<interface>
  <name>lol1</name>
  <type>ianaift:softwareLoopback</type>
  <admin-status>up</admin-status>
  <oper-status>up</oper-status>
  <if-index>1</if-index>
  <statistics>
```

```
    <discontinuity-time>
      2013-04-01T03:00:00+00:00
    </discontinuity-time>
    <!-- counters now shown here -->
  </statistics>
</interface>

</interfaces-state>
</data>
</rpc-reply>
```

Appendix E. Examples: Interface Naming Schemes

This section gives examples of some implementation strategies.

The examples make use of the example data model "ex-vlan" (see Appendix C) to show how user-controlled interfaces can be configured.

E.1. Router with Restricted Interface Names

In this example, a router has support for 4 line cards, each with 8 ports. The slots for the cards are physically numbered from 0 to 3, and the ports on each card from 0 to 7. Each card has Fast Ethernet or Gigabit Ethernet ports.

The device-specific names for these physical interfaces are "fastethernet-N/M" or "gigabitethernet-N/M".

The name of a VLAN interface is restricted to the form "<physical-interface-name>.<subinterface-number>".

It is assumed that the operator is aware of this naming scheme. The implementation auto-initializes the value for "type" based on the interface name.

The NETCONF server does not advertise the "arbitrary-names" feature in the <hello> message.

An operator can configure a physical interface by sending an <edit-config> containing:

```
<interface nc:operation="create">
  <name>fastethernet-1/0</name>
</interface>
```

When the server processes this request, it will set the leaf "type" to "ianaift:ethernetCsmacd". Thus, if the client performs a <get-config> right after the <edit-config> above, it will get:

```
<interface>
  <name>fastethernet-1/0</name>
  <type>ianaift:ethernetCsmacd</type>
</interface>
```

The client can configure a VLAN interface by sending an <edit-config> containing:

```
<interface nc:operation="create">
  <name>fastethernet-1/0.10005</name>
  <type>ianaift:l2vlan</type>
  <vlan:base-interface>fastethernet-1/0</vlan:base-interface>
  <vlan:vlan-id>5</vlan:vlan-id>
</interface>
```

If the client tries to change the type of the physical interface with an <edit-config> containing:

```
<interface nc:operation="merge">
  <name>fastethernet-1/0</name>
  <type>ianaift:tunnel</type>
</interface>
```

then the server will reply with an "invalid-value" error, since the new type does not match the name.

E.2. Router with Arbitrary Interface Names

In this example, a router has support for 4 line cards, each with 8 ports. The slots for the cards are physically numbered from 0 to 3, and the ports on each card from 0 to 7. Each card has Fast Ethernet or Gigabit Ethernet ports.

The device-specific names for these physical interfaces are "fastethernet-N/M" or "gigabitethernet-N/M".

The implementation does not restrict the user-controlled interface names. This allows an operator to more easily apply the interface configuration to a different interface. However, the additional level of indirection also makes it a bit more complex to map interface names found in other protocols to configuration entries.

The NETCONF server advertises the "arbitrary-names" feature in the <hello> message.

Physical interfaces are configured as in Appendix E.1.

An operator can configure a VLAN interface by sending an `<edit-config>` containing:

```
<interface nc:operation="create">
  <name>acme-interface</name>
  <type>ianaift:l2vlan</type>
  <vlan:base-interface>fastethernet-1/0</vlan:base-interface>
  <vlan:vlan-id>5</vlan:vlan-id>
</interface>
```

If necessary, the operator can move the configuration named "acme-interface" over to a different physical interface with an `<edit-config>` containing:

```
<interface nc:operation="merge">
  <name>acme-interface</name>
  <vlan:base-interface>fastethernet-1/1</vlan:base-interface>
</interface>
```

E.3. Ethernet Switch with Restricted Interface Names

In this example, an Ethernet switch has a number of ports, each identified by a simple port number.

The device-specific names for the physical interfaces are numbers that match the physical port number.

An operator can configure a physical interface by sending an `<edit-config>` containing:

```
<interface nc:operation="create">
  <name>6</name>
</interface>
```

When the server processes this request, it will set the leaf "type" to "ianaift:ethernetCsmacd". Thus, if the client performs a `<get-config>` right after the `<edit-config>` above, it will get:

```
<interface>
  <name>6</name>
  <type>ianaift:ethernetCsmacd</type>
</interface>
```

E.4. Generic Host with Restricted Interface Names

In this example, a generic host has interfaces named by the kernel. The system identifies the physical interface by the name assigned by the operating system to the interface.

The name of a VLAN interface is restricted to the form "`<physical-interface-name>:<vlan-number>`".

The NETCONF server does not advertise the "arbitrary-names" feature in the `<hello>` message.

An operator can configure an interface by sending an `<edit-config>` containing:

```
<interface nc:operation="create">
  <name>eth8</name>
</interface>
```

When the server processes this request, it will set the leaf "type" to "ianaift:ethernetCsmacd". Thus, if the client performs a `<get-config>` right after the `<edit-config>` above, it will get:

```
<interface>
  <name>eth8</name>
  <type>ianaift:ethernetCsmacd</type>
</interface>
```

The client can configure a VLAN interface by sending an `<edit-config>` containing:

```
<interface nc:operation="create">
  <name>eth8:5</name>
  <type>ianaift:l2vlan</type>
  <vlan:base-interface>eth8</vlan:base-interface>
  <vlan:vlan-id>5</vlan:vlan-id>
</interface>
```

E.5. Generic Host with Arbitrary Interface Names

In this example, a generic host has interfaces named by the kernel. The system identifies the physical interface by the name assigned by the operating system to the interface.

The implementation does not restrict the user-controlled interface names. This allows an operator to more easily apply the interface configuration to a different interface. However, the additional level of indirection also makes it a bit more complex to map interface names found in other protocols to configuration entries.

The NETCONF server advertises the "arbitrary-names" feature in the <hello> message.

Physical interfaces are configured as in Appendix E.4.

An operator can configure a VLAN interface by sending an <edit-config> containing:

```
<interface nc:operation="create">
  <name>acme-interface</name>
  <type>ianaift:l2vlan</type>
  <vlan:base-interface>eth8</vlan:base-interface>
  <vlan:vlan-id>5</vlan:vlan-id>
</interface>
```

If necessary, the operator can move the configuration named "acme-interface" over to a different physical interface with an <edit-config> containing:

```
<interface nc:operation="merge">
  <name>acme-interface</name>
  <vlan:base-interface>eth3</vlan:base-interface>
</interface>
```

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