Abstract

This document provides a YANG data model for uCPE management (VYSM) and definition of the uCPE equipment. The YANG Service Model serves as a base framework for managing an universal Customer-Premises Equipment (uCPE) subsystem. The model can be used by a Network Service Orchestrator.

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1. Introduction

Network Function Virtualization is a technology that allows to virtualize the network services running on dedicated hardware. This technology became a base for universal Customer-Premises Equipment (uCPE). This document defines the uCPE as hardware with x86 capabilities that has a hypervisor. In other words, uCPE is a host that may run multiple Virtual Machines with guest OSs, where each Guest OS may represent a Physical Network Function. This document presents the YANG Service Model (VYSM) to manage from an Orchestrator the infrastructure inside the uCPE.

2. Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

Link - is an entity that enables link layer communication of nodes.

Port - node connector to the link.

NE - Network Element.

NSYM - Network Service Yang Module.

VYSM - VNF YANG Service Model.
3. Universal CPE

Firstly, this document defines the platform that is controlled with VYSM - universal CPE (uCPE). The uCPE as hardware with x86 capabilities that is generally running Linux distribution with additional virtualisation layer. Virtualization layer provides virtual compute, virtual storage and virtual network resources. Each VNF running in the uCPE requires the amount of virtual resources (for example: 4 vCPUs, 4GB RAM, 40GB storage, 4 vPorts). VNFs MAY be interconnected between each other and physical ports via Virtual Networks. Topology construction and VM lifecycle management is allowed via high level interface (Configuration can be done in the same transaction). The figure below presents the uCPE architecture.

<table>
<thead>
<tr>
<th>VNF1</th>
<th>VNF2</th>
<th>VNF3</th>
<th>uCPE software</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual Compute</td>
<td>Virtual Storage</td>
<td>Virtual Networks</td>
<td></td>
</tr>
<tr>
<td>PHY x86 processor</td>
<td>RAM+PHY storage</td>
<td>PHYsical ports</td>
<td>uCPE Hardware</td>
</tr>
</tbody>
</table>

The next elements can be managed in the uCPE:

- Virtual Network Functions:
  * Number of assigned vCPUs.
  * Size of allocated RAM.
  * VNF day0 config (bootstrap).
  * vLinks that are attached to the VNF.

- Virtual Switches:
  * vLinks that are attached to the vSW.

- Virtual Links (vLinks).

- Physical Ports of the uCPE.
3.1. uCPE VNF ecosystem example

uCPE supports a Virtual Network Functions of different type:

- SD-WAN
- vRouter (vCPE)
- vFirewall
- vLB (vLoad Balancer)
- vCGNAT (vCarrier Grade NAT)
- virtual WAN Optimisation
- vWireless LAN controller
- Other...

3.2. Internal uCPE service example

The VNF in the uCPE could be a vRouter or vFirewall or an SD-WAN that is not a default part of virtual network resources of the uCPE. Multiple VNFs MAY be instantiated in the uCPE. With support of links and switches, VNFs MAY participate a service chains. Example of service chains (Note that virtual switch "vs(WAN)" connected to LAN ports and vSW(WAN) is connected to WAN ports):

- vSW(WAN) -11- vRouter(vCPE) -12- vSW(LAN).
- vSW(WAN) -11-vRouter(vCPE) -12-vSW(Service)-13-vFirewall-14-vSW(LAN).
- vSW(WAN) -11-vRouter(vCPE) -12-vSW(Service1) -13-vFirewall-14-vSW(Service2) -15-SD-WAN-16-vSW(LAN).
- vSW(WAN) -11-SDWAN-12-vSW(Service) -13-vFirewall-14-vSW(LAN).

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4. YANG Service Model for uCPE management

Secondly, this document defines and classifies the VYSM as Network Service YANG Module (NSYM) layer component RFC 8199 [RFC8199]. Thus it inherits the characteristics of the NSYM Layer. VYSM is a modeled representation of the specific service requirements. It provides abstraction of services configuration and operations that MAY be implemented in Network Elements (NEs). Thus VYSM does not describe all configuration to be performed on the devices, but provides the configuration that is required for the "Network Service to Network Element(s)" decomposition process RFC 8199 [RFC8199]. Example of the decomposition is presented in the figure below.

The Network Service YANG module exposes the configuration commands via the Northbound interfaces of the orchestrator. Therefore the set of the commands modeled in the VYSM can be inputed via Northbound interfaces (for example CLI). In the example the command "vm VNF1" is passed via Northbound interface to the orchestrator. It defines the virtual machine name. Further the same configuration MAY be transformed to the one or multiple Network Element payloads (for example xml for NETCONF) that carry an equivalent of commands such as "nf nf-name VNF1"
5. uCPE YANG Service Model tree diagram overview

This section provides an overview of the Service YANG Model (VSYM) that MAY be made with "pyang" utility. The figure below presents the tree diagram of VSYM.

```
module: ietf-ucpe
    +-rw ietf-ucpe:ucpe* [name]
    |  +-rw ietf-ucpe:name            -> /ncs:devices/device/name
    |  +-rw ietf-ucpe:device*         -> ../name
    |  +-rw ietf-ucpe:links* [link]
    |     |  +-rw ietf-ucpe:link      string
    |     |-rw ietf-ucpe:switches* [switch]
    |     |     +-rw ietf-ucpe:switch string
    |     |     +-rw ietf-ucpe:ports* [port]
    |     |         |  +-rw ietf-ucpe:port    uint64
```

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---rw ietf-ucpe:name?  string
---rw ietf-ucpe:link?  --> ../../links/link

---rw ietf-ucpe:vms* [vm]
  ---rw ietf-ucpe:vm  string

---rw ietf-ucpe:ports* [port]
  ---rw ietf-ucpe:port  string
  ---rw ietf-ucpe:name?  string
  ---rw ietf-ucpe:link?  --> ../../links/link

---rw ietf-ucpe:ram?  string
---rw ietf-ucpe:cpu?  string

---rw ietf-ucpe:storages* [id]
  ---rw ietf-ucpe:id  string
  ---rw ietf-ucpe:location?  string

---rw ietf-ucpe:day0-config
  ---rw ietf-ucpe:location?  string
  ---rw ietf-ucpe:var-path?  string

---rw ietf-ucpe:variable* [name]
  ---rw ietf-ucpe:name  string
  ---rw ietf-ucpe:value?  string

---rw ucpe-if:interfaces
  ---rw ucpe-if:interface* [name]
    ---rw ucpe-if:name  string
    ---rw ucpe-if:description?  string
    ---rw ucpe-if:type  identityref
    ---rw ucpe-if:enabled?  boolean
    ---rw ucpe-if:link-up-down-trap-enable?  enumeration {if-mib}?
    ---ro ucpe-if:admin-status  enumeration {if-mib}?
    ---ro ucpe-if:oper-status  enumeration
    ---ro ucpe-if:last-change?  yang:date-and-time
    ---ro ucpe-if:index  int32 {if-mib}?
    ---ro ucpe-if:phys-address?  yang:phys-address
    ---ro ucpe-if:higher-layer-if*  interface-ref
    ---ro ucpe-if:lower-layer-if*  interface-ref
    ---ro ucpe-if:speed?  yang:gauge64
    ---ro ucpe-if:statistics
      ---ro ucpe-if:discontinuity-time  yang:date-and-time
      ---ro ucpe-if:in-octets?  yang:counter64
      ---ro ucpe-if:in-unicast-pkts?  yang:counter64
      ---ro ucpe-if:in-broadcast-pkts?  yang:counter64
      ---ro ucpe-if:in-multicast-pkts?  yang:counter64
      ---ro ucpe-if:in-discards?  yang:counter32
      ---ro ucpe-if:in-errors?  yang:counter32
      ---ro ucpe-if:in-unknown-protos?  yang:counter32
      ---ro ucpe-if:out-octets?  yang:counter64
      ---ro ucpe-if:out-unicast-pkts?  yang:counter64
      ---ro ucpe-if:out-broadcast-pkts?  yang:counter64
      ---ro ucpe-if:out-multicast-pkts?  yang:counter64
      ---ro ucpe-if:out-discards?  yang:counter32
6. Specification of the VNF YANG Service Model

This section presents the specification of the VYSM.

<CODE BEGINS> file "ietf-ucpe@2019-09-16.yang"
module ietf-vysm-service {
    namespace "urn:ietf:params:xml:ns:yang:nfv-service";
    prefix ietf-ucpe;

    import tailf-ncs {
        prefix ncs;
    }

    organization "SFR";
    contact
        "Dmytro Shytyi";
EMail:ietf.dmytro@shytyi.net

description
"This is a Network Function Virtualization (NFV) YANG service model."

revision 2019-09-16 {
  description
  "Added 0day config for VNFs. Yang model modified according to the received comments.";
  reference "draft-shytyi-opsawg-vysm-00";
}
revision 2018-01-07 {
  description
  "Initial revision.";
  reference "draft-shytyi-netmod-vysm-01";
}

list ucpe {
  key "name";
  leaf name {
    type leafref {
      path "/ncs:devices/ncs:device/ncs:name";
    }
    description
    "Name of the instance of the service";
  }
  leaf-list device {
    type leafref {
      path "../name";
    }
    description
    "List of the devices in available in the orchestrator";
  }
  // replace with your own stuff here

list links {
  key "link";
  leaf link {
    type string {
      pattern "[a-zA-Z0-9]*";
    }
    description
    "Name of the virtual link from the pool of the links";
  }
  description
  "Pool of the virtual links that connect
VMs and Interfaces;
}
list switches {
    key "switch";
    leaf switch {
        type string;
        description
    }
}

list ports {
    key "port";
    leaf port {
        type uint64 {
            range "10..15";
        }
        description
            "Name of the connector";
    }
    leaf name {
        type string;
        description
            "Name of the subconnector";
    }
    leaf link {
        type leafref {
            path "././././links/link";
        }
        description
            "Link that is connected to the switch via port";
    }
    description
        "Set of the connectors the forwarding domain has";
}

list vms {
    key "vm";
    leaf vm {
        type string {
            pattern "[a-zA-Z]*";
        }
        description
            "Name of the Virtual Machine";
    }
}
list ports {
    key "port";
}
leaf port {
    type string;
    description
        "Name of the connector";
}
leaf name {
    type string;
    description
        "Name of the subconnector";
}
leaf link {
    type leafref {
        path ../../../links/link;
    }
    description
        "Link that connects the VM with a
         switch or Interface via connector";
}
description
    "Set of Virtual Machine connectors";
leaf ram {
    type uint64;
    description
        "Size of RAM to allocate for the
         Guest OS";
}
leaf cpu {
    type uint64;
    description
        "Number of vCPUs to allocate for the
         Guest OS";
}
list storages {
    key "id";
    leaf id {
        type string;
        description
            "Name of the Storage";
    }
    leaf location {
        type string;
        description
            "External location where the image is
             saved.";
    }
    description
        "Virtual storage of the image for the
module ietf-vysm-interfaces {
  namespace "urn:ietf:params:xml:ns:yang:ucpe-interface";
  prefix ucpe-interface;

  import tailf-ncs {

  }

prefix ncs;
}
}

import ietf-vysm-service {
  prefix ietf-nfv;
}

import ietf-interfaces {
  prefix ietf-if;
}

organization "SFR";
contact
  "Dmytro Shytyi
  EMail: ietf.dmytro@shytyi.net";

description
  "This is a Network Function Virtualization (NFV) YANG
  model for interfaces."

revision 2019-10-03 {
  description
    "Initial revision.";
  reference "draft-shytyi-opsawg-vysm-01";
}

augment "/ietf-nfv:ucpe/ietf-if:interfaces/ietf-if:interface" {
  list ports {
    key "port";
    leaf port {
      type string;
      description
        "Name of the connector";
    }
    leaf link {
      type leafref {
        path "../../..../ietf-nfv:links/ietf-nfv:link";
      }
      description
        "Link that is connected to the port
         via connector";
    }
    description
      "Set of the connectors the physical
       interface has";
  }
}

<CODE ENDS>
module ietf-interfaces {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-ucpe-interfaces";
  prefix ucpe-if;

  import ietf-yang-types {
    prefix yang;
  }
  import ietf-vysm-service {
    prefix ietf-vysm;
  }

  organization "IETF NETMOD (Network Modeling) Working Group";
  contact
    "WG Web: <https://datatracker.ietf.org/wg/netmod/>
    WG List: <mailto:netmod@ietf.org>
    Editor: Martin Bjorklund
    <mailto:mbj@tail-f.com>";
  description
    "This module contains a collection of YANG definitions for managing network interfaces.
    
    Copyright (c) 2018 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 8343; see the RFC itself for full legal notices.";

  revision 2018-02-20 {
    description
      "Updated to support NMDA.";
    reference "RFC 8343: A YANG Data Model for Interface Management";
  }
  revision 2014-05-08 {
    description
      "Initial revision.";
    reference "RFC 7223: A YANG Data Model for Interface Management";
  }
/*
typedef interface-ref {
  type leafref {
    path "/ietf-vysm:ucpe/"+
    "ucpe-if:interfaces/ucpe-if:interface/ucpe-if:name";
  }
  description
    "This type is used by data models that need to reference
    interfaces.";
}

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

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";
}
augment "/ietf-vysm:ucpe" {
  container interfaces {
    description "Interface parameters.";
    list interface {
      key "name";
      description "The list of interfaces on the device.

      The status of an interface is available in this list in the operational state. 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 operational state. If the configuration of a user-controlled interface cannot be used by the system, the configured interface is not instantiated in the operational state.

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

        If a client tries to create configuration for a system-controlled interface that is not present in the operational state, 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 Network Configuration Protocol (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 operational state.

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.

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 configuration.

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 intended configuration 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 intended configuration are reflected in ifAdminStatus."

  reference "RFC 2863: The Interfaces Group MIB – ifAdminStatus";
}

leaf link-up-down-trap-enable {
  if-feature if-mib;
  type enumeration {
    enum "enabled" {
      value 1;
      description
        "The device will generate linkUp/linkDown SNMP notifications for this interface."
    }
    enum "disabled" {
      value 2;
      description
        "The device will not generate linkUp/linkDown SNMP notifications for this interface."
    }
  }
  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";

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.";
    }
  }
  config false;
  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)."
}

} config false;
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;
   config false;
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";
leaf phys-address {
    type yang:phys-address;
    config false;
    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-ref;
    config false;
    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-ref;
    config false;
    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";
    config false;
    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 {
  config false;
  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;
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.

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 -
  ifOutErrors";
}
"This type is used by data models that need to reference
the operationally present interfaces."

/*
 * Legacy operational state data nodes
 */

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

  list interface {
    key "name";
    status deprecated;
    description
      "The list of interfaces on the device."

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

    leaf name {
      type string;
      status deprecated;
      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;
      status deprecated;
      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;
status deprecated;
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;
status deprecated;
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;
  status deprecated;
  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;
  status deprecated;
  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;
status deprecated;

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;
    status deprecated;
    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;
    status deprecated;
    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"
    status deprecated;
    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 {
  status deprecated;
  description
  "A collection of interface-related statistics objects."
  leaf discontinuity-time {
    type yang:date-and-time;
    mandatory true;
    status deprecated;
    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;
    status deprecated;
    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;
    status deprecated;
    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;
status deprecated;
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;
    status deprecated;
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;
    status deprecated;
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;
  status deprecated;
  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;
  status deprecated;
  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;
  status deprecated;
  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;
    status deprecated;
    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;
    status deprecated;
    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;
    status deprecated;
    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 - ifHCOOutMulticastPkts"

leaf out-discards {
  type yang:counter32;
  status deprecated;
  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;
  status deprecated;
  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.

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 - ifOutErrors"

}
7. XML example

The XML example below presents the configuration of the next service in the uCPE, where: vSW(LAN), vSW(WAN), vSW(Service) - virtual switches; l1, l2, l3, l4 - virtual links; VMs represent PNFs (Physical Network Functions) that could be bootstrapped with 0day config/license.

```
<ucpe xmlns="urn:ietf:params:xml:ns:yang:ietf-ucpe">
  <name>ucpe1</name>
  <links>
    <link>l1</link>
  </links>
  <links>
    <link>l2</link>
  </links>
  <links>
    <link>l3</link>
  </links>
  <links>
    <link>l4</link>
  </links>
  <switches>
    <switch>lan</switch>
    <ports>
      <port>10</port>
      <name>l2p10</name>
      <link>l2</link>
    </ports>
  </switches>
</ucpe>
```
<switch>service</switch>

<ports>
  <port>10</port>
  <name>l3p10</name>
  <link>l3</link>
</ports>

<ports>
  <port>11</port>
  <name>l4p10</name>
  <link>l4</link>
</ports>
</switches>

<switches>
  <switch>wan</switch>
  <ports>
    <port>10</port>
    <link>l1</link>
  </ports>
</switches>

<vms>
  <vm>VNF-vCPE</vm>
  <ports>
    <port>1</port>
    <name>l1p1</name>
    <link>l1</link>
  </ports>
  <ports>
    <port>2</port>
    <name>l4p2</name>
    <link>l4</link>
  </ports>
  <ram>2048</ram>
  <cpu>2</cpu>
  <storages>
    <id>1</id>
    <location>http://192.168.2.1/vCPE-x86.qcow2</location>
  </storages>
  <day0-config>
    <location>https://192.168.2.1/vCPE-day0.iso</location>
    <day0-var-path>/config.rom</day0-var-path>
    <variable>
      <name>hostname</name>
      <value>IETF-vCPE</value>
    </variable>
    <variable>
      <name>ipaddress</name>
      <value>192.168.1.2 255.255.255.0</value>
    </variable>
  </day0-config>
</vms>
8. Security Considerations

At this time, no security considerations are addressed by this memo.

9. IANA Considerations

No request to IANA at this time.
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11. Normative References


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