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A YANG Module for uCPE management.
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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.

VNF1	VNF2	VNF3	
Virtual Compute	Virtual Storage	Virtual Networks	uCPE software
PHY x86 processor	RAM+PHY storage	PHYSical ports	uCPE Hardware

The next elements can be managed in the uCPE:

- o Virtual Network Functions:
 - * Number of assigned vCPUs.
 - * Size of allocated RAM.
 - * VNF day0 config (bootstrap).
 - * vLinks that are attached to the VNF.
- o Virtual Switches:
 - * vLinks that are attached to the vSW.
- o Virtual Links(vLinks).
- o Physical Ports of the uCPE.

3.1. uCPE VNF ecosystem example

uCPE supports a Virtual Network Functions of different type:

- o SD-WAN
- o vRouter(vCPE)
- o vFirewall
- o vLB(vLoad Balancer)
- o vCGNAT(vCarrier Grade NAT)
- o virtual WAN Optimistaion
- o vWireless LAN controller
- o 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 swithes, 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):

- o vSW(WAN)-l1-vRouter(vCPE)-l2-vSW(LAN).
- o vSW(WAN)-l1-vRouter(vCPE)-l2-vSW(Service)-l3-vFirewall-14-vSW(LAN).
- o vSW(WAN)-l1-vRouter(vCPE)-l2-vSW(Service1)-l3-vFirewall-14-vSW(Service2)-15-SD-WAN-16-vSW(LAN).
- o vSW(WAN)-l1-SDWAN-l2-vSW(Service)-l3-vFirewall-14-vSW(LAN).
- o

```

vSW(WAN1)--vRouter--+
                    +--vLoadBalance  vFirewall--vSW(LAN)
vSW(WAN2)--vRouter--+   |
                        +-vSW(Service1)+

```

o

```

vSW(WAN1)--vRouter(ISP1)--+
                                +--SD-WAN                vFirewall--vSW(LAN)
vSW(WAN2)--vRouter(ISP2)--+   |                            |
                                +-vSW(Service1)+

```

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 inputted 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"

```

                                +---+---+---+---+---+---+
                                |               |
                                |   config t   |
                                |   vm VNF1    |
                                |               |
                                +---+---+---+---+
                                    #
                                    #
++-+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
:
: | Network Service YANG Module |
: +---+---+---+---+---+---+---+---+---+---+---+---+
:                                     #
: ##### orchestrator
: # # #
: '-----' '-----' '-----'
: 'Module1' ' Module 2' ' Module3' '<= Network Element
: '-----' '-----' '-----' YANG Modules
: # # #
: # # #####
: #### ##### #
: # # #
++-+---+---+---+---+---+---+---+---+---+---+---+---+
# # #
Network # element 1   Network # element 2   Network # element3
++-+---+---+---+---+---+---+---+---+---+---+---+---+
| domains domain VNF1| |tenants tenant name VNF1| |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 VYSM.

```

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   tring
  +--rw ietf-ucpe:switches* [switch]
    | +--rw ietf-ucpe:switch string
    | +--rw ietf-ucpe:ports* [port]
    |   +--rw ietf-ucpe:port uint64

```

```

|     +--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:day0-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: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

```

```

|         |  +--ro ucpe-if:out-errors?          yang:counter32
|         |  +--rw ucpe-interface:ports* [port]
|         |    +--rw ucpe-interface:port      string
|         |    +--rw ucpe-interface:link?->  ../../../../ietf-nfv:links/link
x--ro ucpe-if:interfaces-state
  x--ro ucpe-if:interface* [name]
    x--ro ucpe-if:name                string
    x--ro ucpe-if:type                 identityref
    x--ro ucpe-if:admin-status         enumeration {if-mib}?
    x--ro ucpe-if:oper-status          enumeration
    x--ro ucpe-if:last-change?         yang:date-and-time
    x--ro ucpe-if:if-index             int32 {if-mib}?
    x--ro ucpe-if:phys-address?       yang:phys-address
    x--ro ucpe-if:speed?               yang:gauge64
    x--ro ucpe-if:statistics
      x--ro ucpe-if:discontinuity-time yang:date-and-time
      x--ro ucpe-if:in-octets?         yang:counter64
      x--ro ucpe-if:in-unicast-pkts?   yang:counter64
      x--ro ucpe-if:in-broadcast-pkts? yang:counter64
      x--ro ucpe-if:in-multicast-pkts? yang:counter64
      x--ro ucpe-if:in-discards?       yang:counter32
      x--ro ucpe-if:in-errors?         yang:counter32
      x--ro ucpe-if:in-unknown-protos? yang:counter32
      x--ro ucpe-if:out-octets?        yang:counter64
      x--ro ucpe-if:out-unicast-pkts?  yang:counter64
      x--ro ucpe-if:out-broadcast-pkts? yang:counter64
      x--ro ucpe-if:out-multicast-pkts? yang:counter64
      x--ro ucpe-if:out-discards?      yang:counter32
      x--ro ucpe-if:out-errors?        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 Oday 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
                "Name of the switch";
        }
        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";
        }
        description
            "Set of the forwarding domains";
    }
    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 storge of the image for the
```

```
        Virtual Machine";
    }
    container day0-config {
        leaf location {
            type string;
            description
                "0day configuration location";
        }
        leaf day0-var-path {
            type string;
            description
                "path of the file that contains the
                0day variables";
        }
        list variable {
            key "name";
            leaf name {
                type string;
                description
                    "variable name";
            }
            leaf value {
                type string;
                description
                    "variable value";
            }
        }
        description
            "0day configuration:init config";
    }
    description
        "Set of the Virtual Machines configured on
        the universal Customer-Premises Equipment";
}
description
    "This is an CFS virtualization service";
}
}
```

<CODE ENDS>

```
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.

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    authors of the code. All rights reserved.

    Redistribution and use in source and binary forms, with or
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    Relating to IETF Documents
    (https://trustee.ietf.org/license-info).

    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";
  }

  /*
```

```
* Typedefs
*/

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.";
}

/*
* 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";
}
```

```
/*  
 * Data nodes  
 */
```

```
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.";
reference "RFC 2863: The Interfaces Group MIB - ifName";
}
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
configuration.";
  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 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";
```

```
    }
    config false;
    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;
    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;
```

```
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.

            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";
    }
}
}
}
}
}
/*
 * Legacy typedefs
 */
// typedef interface-state-ref {
//     type leafref {
//         path "/ietf-vysm:ucpe"+
//         "ucpe-if:interfaces-state/ucpe-if:interface/ucpe-if:name";
//     }
//     status deprecated;
//     description
```

```
//      "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 -
ifHCOutMulticastPkts";

}

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";

}

}

```

}
}
}
}
}

```

<CODE ENDS>

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.

```

+-----+           +-----+           +-----+
|vSW(LAN)|--l2--|VNF-vFirewall|--l3--|           |
+-----+           +-----+           |vSW(Service)|
+-----+           +-----+           +-----+
|vSW(WAN)|--l1--|   VNF_vCPE   |--l4--|           |
+-----+           +-----+           +-----+

```

```

<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>l0</port>
      <name>l2p10</name>
      <link>l2</link>
    </ports>
  </switches>
</switches>

```

```
<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>
```

```
    </day0-config>
  </vms>
<vms>
  <vm>VNF-vFirewall</vm>
  <ports>
    <port>1</port>
    <name>l3p1</name>
    <link>l3</link>
  </ports>
  <ports>
    <port>2</port>
    <name>l2p2</name>
    <link>l2</link>
  </ports>
  <ram>2048</ram>
  <cpu>2</cpu>
  <storages>
    <id>1</id>
    <location>http://192.168.2.1/vFirewall-x86.qcow2</location>
  </storages>
  <day0-config>
    <location>https://192.168.2.1/vFirewall-day0.iso</location>
    <day0-var-path>/config.rom</day0-var-path>
    <variable>
      <name>hostname</name>
      <value>vFirewall</value>
    </variable>
    <variable>
      <name>ipaddress</name>
      <value>192.168.1.3 255.255.255.0</value>
    </variable>
  </day0-config>
</vms>
</ucpe>
```

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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