Network Working Group
Internet-Draft
Intended status: Informational
Expires: May 23, 2020

D. Shytyi
L. Beylier
SFR
L. Iannone
Telecom ParisTech

November 20, 2019

A YANG Module for uCPE management. draft-shytyi-opsawg-vysm-07

Abstract

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

Status of This Memo

This Internet-Draft is submitted in full conformance with the provisions of BCP 78 and BCP 79.

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at https://datatracker.ietf.org/drafts/current/.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any time. It is inappropriate to use Internet-Drafts as reference material or to cite them other than as "work in progress."

This Internet-Draft will expire on May 23, 2020.

Table of Contents

1. Introduction

Network Function Virtualization is a technology that allows to virtualize the network services running on dedicaded hardware. This technology became a base for universal Customer-Premises Equipment (uCPE). This document defines the uCPE as harware 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 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.

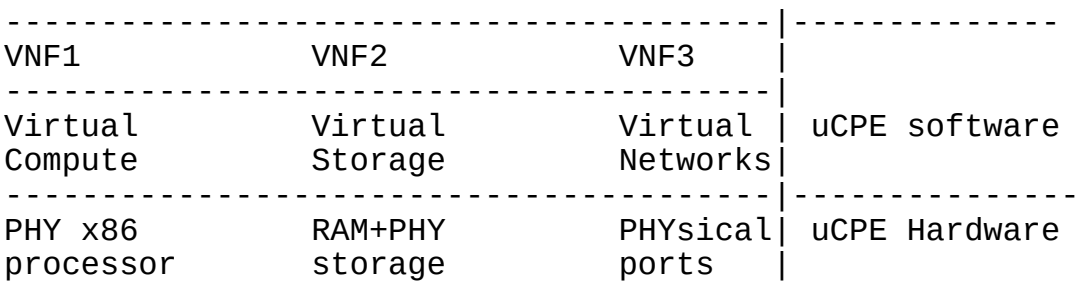
NE - Network Element.

NSYM - Network Yang Module.

VYSM - VNF YANG Model.

3. Universal CPE

Firstly, this document defines the platform that is controlled with VYSM - universal CPE (uCPE). The uCPE as harware with x86 capabilities that is generally running Linux distibution with additinal virtualisation layer. Virtualization layer provides virtual compute, virtual storage and virtual network resources. Each VNF runnning in the uCPE requires the amount of virtual resources (for example: 4 vCPUs, 4GB RAM, 40GB storege, 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.



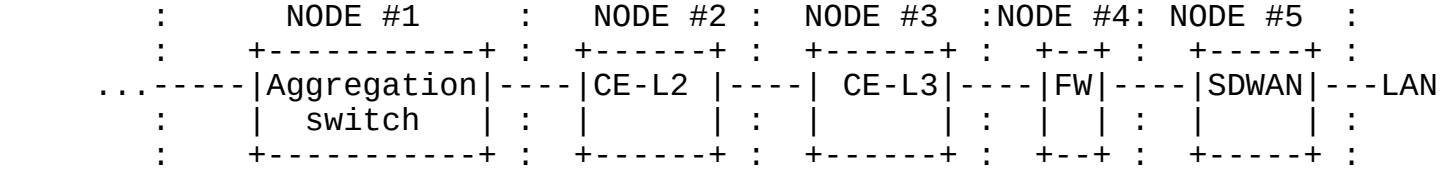
The next elements can be managed in the uCPE:

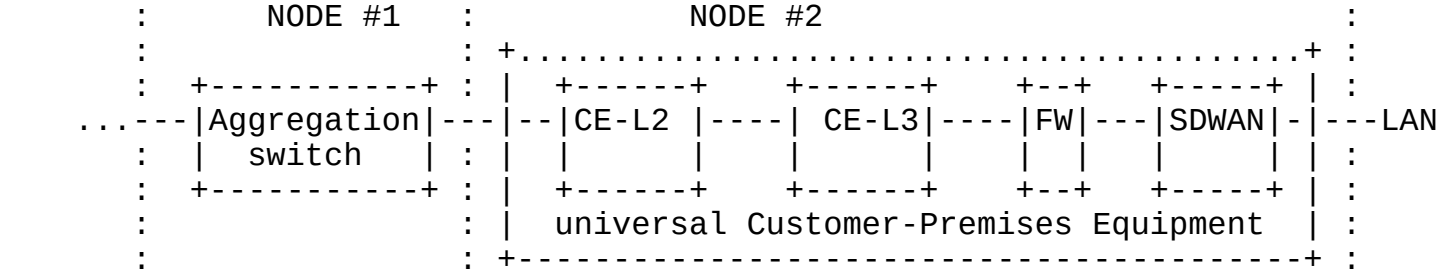
- Virtual Network Funcitons:
  - Number of assigned vCPUs.
  - Size of allocated RAM.
  - VNF day0 config (bootstrap).
  - vLinks that are attached to the VNF.
- Virtual Switches:
  - vLinks that are attached to the vSW.
- Virtual Links(vLinks).

- Physical Ports of the uCPE.

3.1. uCPE purpose

- uCPE replaces multiple types of equipment (Node#1 - Node#5) with 1 unit by virtualizing them as Virtual Network Functions on the top of NFVIs:





- uCPE falicitates the interconnection between the Network Funtions (NF) as interconnection between NF is performed via virtual links(that is part of the uCPE management). That meens that no need to hire technichian to cable the equipment, it could be done via orchestrator.

- uCPE falicitates the 0day configuration of the VNFs as its 0day configuration can be putted remotely.

3.2. uCPE VNF ecosystem example

uCPE supports a Virtual Network Funcitons of different type:

- SD-WAN

- vRouter

- vFirewall

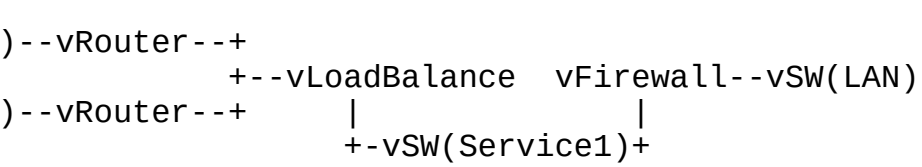
- vLB(vLoad Balancer)

- vCGNAT(vCarrier Grade NAT)
- virtual WAN Optimistaion
- vWireless LAN controller
- Other...

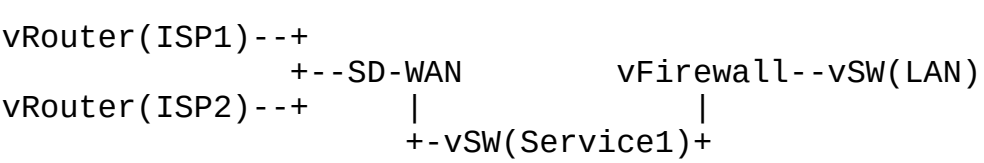
3.3. Internal uCPE service example

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):

- vSW(WAN)-l1-vRouter-l2-vSW(LAN).
- vSW(WAN)-l1-vRouter-l2-vSW(Service)-l3-vFirewall-l4-vSW(LAN).
- vSW(WAN)-l1-vRouter-l2-vSW(Service1)-l3-vFirewall-l4-vSW(Service2)-l5-SD-WAN-l6-vSW(LAN).
- vSW(WAN)-l1-SDWAN-l2-vSW(Service)-l3-vFirewall-l4-vSW(LAN).
-



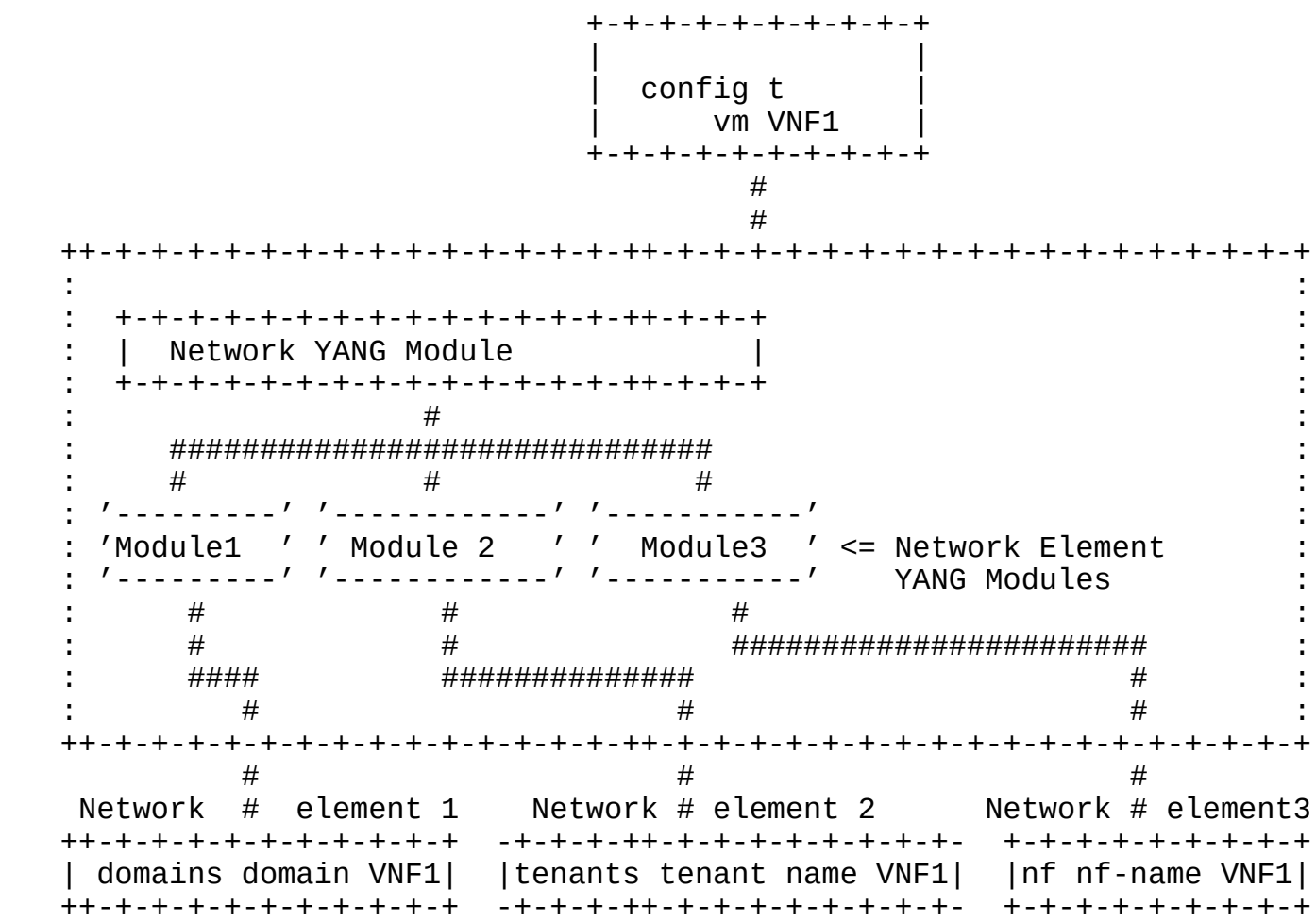
-



4. YANG Model for uCPE management

Secondly, this document defines and classifies the YANG Model for uCPE Management. This Module is modeled representation of the specific network requirements. It provides abstraction of network configuration and operations. The YANG Model for uCPE Management does not describe all configuration to be performed on the devices, but provides the configuration that is required for the "Network to Network Element(s)" decomposition process RFC 8199 [RFC8199]. Example of the decomposition is presented in the figure below.

The Network 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 Notrhbound 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 transormed 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. Components for uCPE Management

This section provides a components overview to manage the uCPE.

There are multiple RFCs and drafts produced by the IETF community, that are referenced in the YANG tree to manage the uCPE. Each document produced by the IETF covers a part of uCPE Management. The list of the documents is provided below:

- [RFC8530] - logical network elements (VNFs) properties.
- [RFC8345] - definition of networks, nodes, node-termination-points: network includes the uCPE with uCPE's physical termination points.
- [I-D.ietf-teas-sf-aware-topo-model]physical ports and service functions (VNFs) interconnection matrixes (PhyPort-VNF, VNF-VNF).

- This document itself provides yang modules that completes the existing documents produced by IETF.

This document introduces yang modules for ’logical network elements properties(VNFs)" part:

- day0-info: mapping between variables inside of the bootstap config and required values in the list "day0-info". In the bootstap config the variable could be putted instead value. The value could be set in the day0-info part (check the YANG model) and after the value in the list will be mapped to the variable in the bootstrap config.

- vCPU/vRAM/vDisk/VNF-ports leafs and lists.

The minimal list of yang models required for compilation of the YANG tree to manage the uCPE is presented below:

- ietf-interfaces

- ietf-logical-network-element

- ietf-ietf-network

- ietf-ietf-network-topology

- ietf-routing-types

- ietf-te-topology

- ietf-te-topology-sf

- ietf-te-types

- ietf-yang-schema-mount

- The YANG module introduced in this document

6. Diagram overview of YANG Data Model tree for uCPE management

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

```
module: ietf-network
  +--rw networks
     +--rw network* [network-id]
```

```
        +--rw network-id            network-id
        +--rw network-types
        |  +--rw tet:te-topology!
        |     +--rw tet-sf:sf!
        +--rw supporting-network* [network-ref]
        |  +--rw network-ref    -> /networks/network/network-id
        +--rw node* [node-id]
           +--rw node-id                 node-id
           +--rw supporting-node* [network-ref node-ref]
           |  +--rw network-ref    ->
           |  |         ../../../supporting-network/network-ref
           |  +--rw node-ref       -> /networks/network/node/node-id
           +--rw nt:termination-point* [tp-id]
           |  +--rw nt:tp-id                            tp-id
           |  +--rw nt:supporting-termination-point*
           |     |      [network-ref node-ref tp-ref]
           |     +--rw nt:network-ref
           |     |      -> ../../../nw:supporting-node/network-ref
           |     +--rw nt:node-ref
           |     |      -> ../../../nw:supporting-node/node-ref
           |     +--rw nt:tp-ref
           |            -> /nw:networks/network[nw:network-id=
           |            current()/../network-ref]/node
           |            [nw:node-id=current()/../node-ref]/
           |            termination-point/tp-id
           +--rw tet:te-node-id?         te-types:te-node-id
           +--rw tet:te!
           +--rw tet:te-node-template*
              |         -> ../../../../te/templates/
              |         node-template/name {template}?
              +--rw tet:te-node-attributes
                 |              ...
                 +--rw tet-sf:service-function
                    +--rw tet-sf:connectivity-matrices
                    |  +--rw tet-sf:connectivity-matrix* [id]
                    |     +--rw tet-sf:id                uint32
                    |     +--rw tet-sf:from
                    |     |  +--rw tet-sf:service-function-id?    string
                    |     |  +--rw tet-sf:sf-connection-point-id? string
                    |     +--rw tet-sf:to
                    |     |  +--rw tet-sf:service-function-id?    string
                    |     |  +--rw tet-sf:sf-connection-point-id? string
                    |     +--rw tet-sf:enabled?           boolean
                    |     +--rw tet-sf:direction? connectivity-direction
                    |     +--rw tet-sf:virtual-link-id?   string
                    +--rw tet-sf:link-terminations
                       +--rw tet-sf:link-termination* [id]
                          +--rw tet-sf:id           uint32
```

```
                          +--rw tet-sf:from
                          |  +--rw tet-sf:tp-ref?   -> ../../../../
                          |     ../../../nt:termination-point/tp-id
                          +--rw tet-sf:to
                          |  +--rw tet-sf:service-function-id?    string
                          |  +--rw tet-sf:sf-connection-point-id? string
                          +--rw tet-sf:enabled?   boolean
                          +--rw tet-sf:direction? connectivity-direction


logical-network-elements
     +--rw logical-network-element* [name]
        +--rw name           string
        +--rw managed?       boolean
        +--rw description?   string
        +--rw root
        +--rw logical-network-elements-properties
           +--rw sf-connection-points* [sf-connection-point-id]
           |  +--rw sf-connection-point-id   string
           +--rw ram?           uint64
           +--rw cpu?           uint64
           +--rw storages* [id]
           |  +--rw id          string
           |  +--rw location?   string
           +--rw day0-config
              +--rw location?        string
              +--rw day0-var-path?   string
              +--rw variable* [name]
                 +--rw name     string
                 +--rw value?   string
```

7. Logical Network Elements extension YANG Model

This section provides a YANG model that addresses the configuration of the uCPE VNF resources.

```
 <CODE BEGINS> file "ietf-ucpe-lne-properties@2019-11-21.yang"
 module ietf-ucpe-lne-properties {
   yang-version 1.1;
   namespace "urn:ietf:params:xml:ns:yang:ietf-ucpe-lne-properties";
   prefix ietf-ucpe;

   import ietf-logical-network-element {
     prefix lne;
     reference
       "RFC 8530: YANG Model for Logical Network Elements";
```

```
   }

   organization
     "SFR";
   contact
     "Dmytro Shytyi
      EMail:ietf.dmytro@shytyi.net";
   description
     "This is a Network Function Virtualization (NFV) YANG
      service model.

      Copyright (c) 2019 IETF Trust and the persons identified as
      authors of the code.  All rights reserved.

      Redistribution and use in source and binary forms, with or
      without modification, is permitted pursuant to, and subject to
      the license terms contained in, the Simplified BSD License set
      forth in Section 4.c of the IETF Trust's Legal Provisions
      Relating to IETF Documents
      (https://trustee.ietf.org/license-info).

      This version of this YANG module is part of RFC XXXX
      (https://www.rfc-editor.org/info/rfcXXXX); see the RFC itself
      for full legal notices.";

   revision 2019-11-21 {
     description
       "Augmentation of RFC 8530";
     reference
       "draft-shytyi-opsawg-vysm-07";
   }
   revision 2019-10-28 {
     description
       "Yang model with vPorts assigned to the interfaces";
     reference
       "draft-shytyi-opsawg-vysm-05";
   }
   revision 2019-10-19 {
     description
       "Yang model was cleaned. Interfaces added";
     reference
       "draft-shytyi-opsawg-vysm-04";
   }
   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";
  }

  augment "/lne:logical-network-elements/lne:logical-network-element" {
    container logical-network-element-properties {
      list sf-connection-points {
        key "sf-connection-point-id";
        leaf sf-connection-point-id {
          type string;
          description
            "Name of the connector";
        }
        description
          "Connection points of logical-network-element";
      }
      description
        "Set of Virtual Network Function 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
            "Number of
             vDisk attached to the VM";
        }
        leaf location {
          type string;
          description
            "External location where
```

```
              the image (ex.qcow2) is saved.";
          }
          description
            "Virtual storge/vDisk
             attached to 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
              "list of variables";
          }
          description
            "0day configuration:init config";
        }
      }
      description
        "Properties of logic-network-element";
    }
  }

 <CODE ENDS>
```

8. Security Considerations

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

9. IANA Considerations

No request to IANA at this time.

10. Acknowledgements

the authors would like to thank:

- Mahesh Jethanandani.
- Robert Varga.
- Bill Wu.
- Joe Clarke.
- Tom Petch.
- Martin Bjorklund.
- Schonwalder Jurgen.
- Dean Bogdanovic.
- Bo Wu.

for their valuable comments.

11. Normative References

[I-D.ietf-teas-sf-aware-topo-model] Bryskin, I., Liu, X., Lee, Y., Guichard, J., Contreras, L., Ceccarelli, D., and J. Tantsura, "SF Aware TE Topology YANG Model", draft-ietf-teas-sf-aware-topo-model-03 (work in progress), March 2019.

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC8199] Bogdanovic, D., Claise, B., and C. Moberg, "YANG Module Classification", RFC 8199, DOI 10.17487/RFC8199, July 2017, <https://www.rfc-editor.org/info/rfc8199>.

[RFC8345] Clemm, A., Medved, J., Varga, R., Bahadur, N., Ananthakrishnan, H., and X. Liu, "A YANG Data Model for Network Topologies", RFC 8345, DOI 10.17487/RFC8345, March 2018, <https://www.rfc-editor.org/info/rfc8345>.

[RFC8530] Berger, L., Hopps, C., Lindem, A., Bogdanovic, D., and X. Liu, "YANG Model for Logical Network Elements", RFC 8530, DOI 10.17487/RFC8530, March 2019, <https://www.rfc-editor.org/info/rfc8530>.

Appendix A. Example of the uCPE resources management

This section provides an overview of the deprecated YANG Model that MAY give an alternative view on the uCPE management.

```
module: ietf-example-ucpe
    +--rw ucpe* [name]
       +--rw name              string
       +--rw links* [link]
       |  +--rw link    string
       +--rw phyInterfaces* [interface]
       |  +--rw interface    string
       |  +--rw ports* [port]
       |     +--rw port    string
       |     +--rw link?   -> ../../../links/link
       +--rw switches* [switch]
       |  +--rw switch    string
       |  +--rw ports* [port]
       |     +--rw port    string
       |     +--rw name?   string
       |     +--rw link?   -> ../../../links/link
       +--rw vms* [vm]
          +--rw vm             string
          +--rw ports* [port]
          |  +--rw port    string
          |  +--rw name?   string
          |  +--rw link?   -> ../../../links/link
          +--rw ram?           uint64
          +--rw cpu?           uint64
          +--rw storages* [id]
          |  +--rw id          string
          |  +--rw location?   string
          +--rw day0-config
             +--rw location?        string
             +--rw day0-var-path?   string
             +--rw variable* [name]
                +--rw name     string
                +--rw value?   string
```

Appendix B. Deprecated VNF YANG Model

This section provides a deprecated yang model that addresses the configuration of the uCPE resources presented above.

```
<CODE BEGINS> file "ietf-example-ucpe@2019-10-28.yang"
module ietf-example-ucpe {
  namespace "urn:ietf:params:xml:ns:yang:ietf-example-ucpe";
  prefix ietf-example-ucpe;

  organization
    "SFR";
```

```
      contact
        "Dmytro Shytyi
         EMail:ietf.dmytro@shytyi.net";
      description
        "This is a Network Function Virtualization (NFV) YANG
         service model.

         Copyright (c) 2019 IETF Trust and the persons identified as
         authors of the code.  All rights reserved.

         Redistribution and use in source and binary forms, with or
         without modification, is permitted pursuant to, and subject to
         the license terms contained in, the Simplified BSD License set
         forth in Section 4.c of the IETF Trust's Legal Provisions
         Relating to IETF Documents
         (https://trustee.ietf.org/license-info).

         This version of this YANG module is part of RFC XXXX
         (https://www.rfc-editor.org/info/rfcXXXX); see the RFC itself
         for full legal notices.";

      revision 2019-10-28 {
        description
          "Yang model with vPorts assigned to the interfaces";
        reference
          "draft-shytyi-opsawg-vysm-05";
      }
      revision 2019-10-19 {
        description
          "Yang model was cleaned. Interfaces added";
        reference
          "draft-shytyi-opsawg-vysm-04";
      }
      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 string;
          description
            "ID of uCPE where
             a service is instantiated";
        }
        list links {
          key "link";
          leaf link {
            type string;
            description
              "Name of the virtual link from the pool
               of the links";
          }
          description
            "Pool of the virtual links that connect VMs and
             Interfaces";
        }
        list phyInterfaces {
          key "interface";
          leaf interface {
            type string;
            description
              "Name of physical interface";
          }
          list ports {
            key "port";
            leaf port {
              type string;
              description
                "Name of the connector";
            }
            leaf link {
              type leafref {
                path "../../../links/link";
              }
              description
                "Link that is connected to
                 the port via connector";
            }
            description
              "Set of the connectors the
               physical interface has";
          }
          description
            "Set of physical interfaces";
```

```
        }
        list switches {
          key "switch";
          leaf switch {
            type string;
            description
              "Name of the forwarding domain";
          }
          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 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;
            description
              "ID of the Virtual Machine";
          }
          list ports {
            key "port";
            leaf port {
              type string;
              description
```

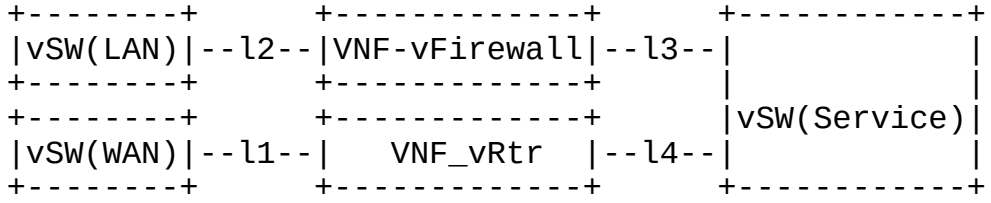
```
            "Name of the connector";
          }
          leaf name {
            type string;
            description
              "Name of
               the subconnector";
          }
          leaf link {
            type leafref {
              path "../../../links/link";
            }
            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
              "Number of
               vDisk attached to the VM";
          }
          leaf location {
            type string;
            description
              "External location where
               the image (ex.qcow2) is saved.";
          }
          description
            "Virtual storge/vDisk
```

```
             attached to 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
                "list of variables";
            }
            description
              "0day configuration:init config";
          }
          description
            "Set of the Virtual Machines configured
             on the universal Customer-Premises Equipment";
        }
        description
          "This is an uCPE management service";
      }
    }

    <CODE ENDS>
```

Appendix C. XML example of deprecated YANG model

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 Fuctions) 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>
    <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-vRtr</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/vRtr-x86.qcow2</location>
          </storages>
          <day0-config>
            <location>https://192.168.2.1/vRtr-day0.iso</location>
            <day0-var-path>/config.rom</day0-var-path>
            <variable>
              <name>hostname</name>
              <value>IETF-vRtr</value>
            </variable>
            <variable>
              <name>ipaddress</name>
              <value>192.168.1.2 255.255.255.0</value>
            </variable>
          </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>
```

Authors' Addresses

Dmytro Shytyi
SFR
Paris , Ile-de-France
France

Email: ietf.dmytro@shytyi.net
URI: https://dmytro.shytyi.net

Laurent Beylier
SFR
Paris , Ile-de-France
France

Email: laurent.beylier@sfr.com

Luigi Iannone
Telecom ParisTech
Paris , Ile-de-France
France

Email: luigi.iannone@telecom-paristech.fr