Virtualizer Explained

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1 Introduction

The motivation is to explain the new NF-FG YANG model. The model includes infrastructure virtualization combined with the mapped resource request.

We will gradually introduce the different concepts with figures and examples.

2 Infrastructure View: Basics

2.1 1-Node

Figure 1: 1-node infrastructure: topology

Listing 1: 1-node infrastructure: YANG tree

```
module: unify−virtualizer
  +−−rw virtualizer
     +−−rw id?      string
     +−−rw name?    string
     +−−rw nodes
     |  +−−rw node* [id]
     |     +−−rw id              string
     |     +−−rw name?           string
     |     +−−rw type            string
     |     +−−rw ports
     |     |  +−−rw port* [id]
     |     |     +−−rw id             string
     |     |     +−−rw name?          string
     |     |     +−−rw port_type?     string
     |     |     +−−rw (port−type)?
     |     |        +−−:(port−abstract)
     |     |        |  +−−rw capability?   string
     |     |        +−−:(port−sap)
     |     |           +−−rw (sap−type)?
     |     |              +−−:(vx−lan)
     |     |                 +−−rw vxlan?        string
     |     +−−rw resources
     |     |  +−−rw cpu       string
     |     |  +−−rw mem       string
     |     |  +−−rw storage   string
```

Listing 2: 1-node infrastructure: xml example

```
<virtualizer xmlns="urn:unify:virtualizer">
    <id>UUID001</id>
    <name>Single node simple infrastructure report</name>
    <nodes>
        <node>
            <id>UUID11</id>
            <name>single Bis-Bis node</name>
            <type>BisBis</type>
            <ports>
                <port>
                    <id>0</id>
                    <name>SAP0 port</name>
                    <port_type>port-sap</port_type>
                    <vxlan>...</vxlan>
                </port>
                <port>
                    <id>1</id>
                    <name>North port</name>
                    <port_type>port-abstract</port_type>
                    <capability>...</capability>
                </port>
                <port>
                    <id>2</id>
                    <name>East port</name>
                    <port_type>port-abstract</port_type>
                    <capability>...</capability>
                </port>
            </ports>
            <resources>
                <cpu>20</cpu>
                <mem>64 GB</mem>
                <storage>100 TB</storage>
            </resources>
        </node>
    </nodes>
</virtualizer>
```

2.2 3-Node

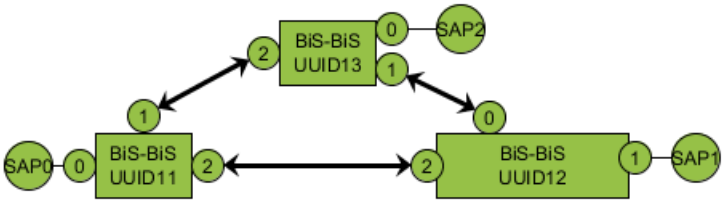

Figure 2: 3-node infrastructure: topology

Listing 3: 3-node infrastructure: YANG tree

```
module: unify−virtualizer
  +−−rw virtualizer
     +−−rw id?      string
     +−−rw name?    string
     +−−rw nodes
     |  +−−rw node* [id]
     |     +−−rw id              string
     |     +−−rw name?           string
     |     +−−rw type            string
     |     +−−rw ports
     |     |  +−−rw port* [id]
     |     |     +−−rw id             string
     |     |     +−−rw name?          string
     |     |     +−−rw port_type?     string
     |     |     +−−...
     |     +−−rw resources
     |     |  +−−rw cpu        string
     |     |  +−−rw mem        string
     |     |  +−−rw storage    string
     +−−rw links
        +−−rw link* [src dst]
           +−−rw id?          string
           +−−rw name?        string
           +−−rw src          port−ref
           +−−rw dst          port−ref
           +−−rw resources
              +−−rw delay?       string
              +−−rw bandwidth?   string
```

Listing 4: 3-node infrastructure: xml example

```
<virtualizer xmlns="urn:unify:virtualizer">
    <id>UUID002</id>
    <name>3-node simple infrastructure report</name>
    <nodes>
        <node>
            <id>UUID11</id>
            <name>West Bis-Bis node</name>
            <type>BisBis</type>
            <ports>
                <port>
                    <id>0</id>
                    <name>SAP0 port</name>
                    <port_type>port-sap</port_type>
                    <vxlan>...</vxlan>
                </port>
                <port>
                    <id>1</id>
                    <name>North port</name>
                    <port_type>port-abstract</port_type>
                    <capability>...</capability>
                </port>
                <port>
                    <id>2</id>
                    <name>East port</name>
                    <port_type>port-abstract</port_type>
                    <capability>...</capability>
                </port>
            </ports>
            <resources>
                <cpu>20</cpu>
                <mem>64 GB</mem>
                <storage>100 TB</storage>
            </resources>
        </node>
        <node>
            <id>UUID12</id>
            <name>East Bis-Bis node</name>
            <type>BisBis</type>
            <ports>
                <port>
                    <id>1</id>
                    <name>SAP1 port</name>
                    <port_type>port-sap</port_type>
                    <vxlan>...</vxlan>
                </port>
                <port>
                    <id>0</id>
                    <name>North port</name>
                    <port_type>port-abstract</port_type>
                    <capability>...</capability>
                </port>
                <port>
                    <id>2</id>
                    <name>West port</name>
                    <port_type>port-abstract</port_type>
                    <capability>...</capability>
```

```
            </port>
        </ports>
        <resources>
            <cpu>10</cpu>
            <mem>32 GB</mem>
            <storage>100 TB</storage>
        </resources>
    </node>
    <node>
        <id>UUID13</id>
        <name>North Bis-Bis node</name>
        <type>BisBis</type>
        <ports>
            <port>
                <id>0</id>
                <name>SAP2 port</name>
                <port_type>port-sap</port_type>
                <vxlan>...</vxlan>
            </port>
            <port>
                <id>1</id>
                <name>East port</name>
                <port_type>port-abstract</port_type>
                <capability>...</capability>
            </port>
            <port>
                <id>2</id>
                <name>West port</name>
                <port_type>port-abstract</port_type>
                <capability>...</capability>
            </port>
        </ports>
        <resources>
            <cpu>20</cpu>
            <mem>64 GB</mem>
            <storage>1 TB</storage>
        </resources>
    </node>
</nodes>
<links>
    <link>
        <id>0</id>
        <name>Horizontal link</name>
        <src>../../nodes/node[id=UUID11]/ports/port[id=2]</src>
        <dst>../../nodes/node[id=UUID12]/ports/port[id=2]</dst>
        <resources>
            <delay>2 ms</delay>
            <bandwidth>10 Gb</bandwidth>
        </resources>
    </link>
    <link>
        <id>1</id>
        <name>West link</name>
        <src>../../nodes/node[id=UUID11]/ports/port[id=1]</src>
        <dst>../../nodes/node[id=UUID13]/ports/port[id=2]</dst>
        <resources>
            <delay>5 ms</delay>
```

```
114                 <bandwidth>10 Gb</bandwidth>
115             </resources>
116         </link>
117         <link>
118             <id>2</id>
119             <name>East link</name>
120             <src>../../nodes/node[id=UUID12]/ports/port[id=0]</src>
121             <dst>../../nodes/node[id=UUID13]/ports/port[id=1]</dst>
122             <resources>
123                 <delay>2 ms</delay>
124                 <bandwidth>5 Gb</bandwidth>
125             </resources>
126         </link>
127     </links>
128 </virtualizer>
```

2.3 1-Node with Delay Matrix

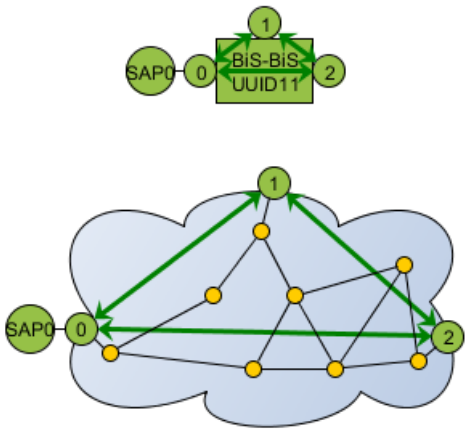

Figure 3: 1-node with Delay Matrix: topology

Listing 5: 1-node with Delay Matrix: YANG tree

```
module: unify−virtualizer
  +−−rw virtualizer
     +−−rw id?      string
     +−−rw name?    string
     +−−rw nodes
     |  +−−rw node* [id]
     |     +−−rw id              string
     |     +−−rw name?           string
     |     +−−rw type            string
     |     +−−rw ports
     |     |  +−−rw port* [id]
     |     |     +−−rw id             string
     |     |     +−−rw name?          string
     |     |     +−−rw port_type?     string
     |     |     +−−...
     |     +−−rw links
     |     |  +−−rw link* [src dst]
     |     |     +−−rw id?          string
     |     |     +−−rw name?        string
     |     |     +−−rw src          port−ref
     |     |     +−−rw dst          port−ref
     |     |     +−−rw resources
     |     |        +−−rw delay?       string
     |     |        +−−rw bandwidth?   string
     |     +−−rw resources
     |     |  +−−rw cpu        string
     |     |  +−−rw mem        string
     |     |  +−−rw storage    string
     +−−rw links
        +−−rw link* [src dst]
           +−−rw id?          string
           +−−rw name?        string
           +−−rw src          port−ref
           +−−rw dst          port−ref
           +−−rw resources
              +−−rw delay?       string
              +−−rw bandwidth?   string
```

Listing 6: 1-node with Delay Matrix: xml example

```
<virtualizer xmlns="urn:unify:virtualizer">
    <id>UUID001</id>
    <name>Single node with link internal delays infrastructure report</name>
    <nodes>
        <node>
            <id>UUID11</id>
            <name>single Bis−Bis node</name>
            <type>BisBis</type>
            <ports>
                <port>
                    <id>0</id>
                    <name>SAP0 port</name>
                    <port_type>port−sap</port_type>
                    <vxlan>...</vxlan>
                </port>
                <port>
                    <id>1</id>
                    <name>North port</name>
                    <port_type>port−abstract</port_type>
                    <capability>...</capability>
                </port>
                <port>
                    <id>2</id>
                    <name>East port</name>
                    <port_type>port−abstract</port_type>
                    <capability>...</capability>
                </port>
            </ports>
            <links>
                <link>
                    <id>int0</id>
                    <name>internal horizontal</name>
                    <src>../../ports/port[id=0]</src>
                    <dst>../../ports/port[id=2]</dst>
                    <resources>
                        <delay>1 ms</delay>
                        <bandwidth>40 Gb</bandwidth>
                    </resources>
                </link>
                <link>
                    <id>int1</id>
                    <name>internal left</name>
                    <src>../../ports/port[id=0]</src>
                    <dst>../../ports/port[id=1]</dst>
                    <resources>
                        <delay>5 ms</delay>
                        <bandwidth>10 Gb</bandwidth>
                    </resources>
                </link>
                <link>
                    <id>int2</id>
                    <name>internal right</name>
                    <src>../../ports/port[id=1]</src>
                    <dst>../../ports/port[id=2]</dst>
                    <resources>
                        <delay>2 ms</delay>
```

```
57                      <bandwidth>81 Gb</bandwidth>
58                  </resources>
59              </link>
60          </links>
61          <resources>
62              <cpu>20</cpu>
63              <mem>64 GB</mem>
64              <storage>100 TB</storage>
65          </resources>
66      </node>
67  </nodes>
68 </virtualizer>
```

3 Resource Requests

3.1 Simple Request

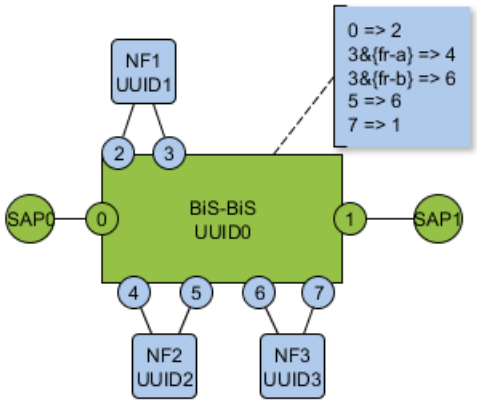

Figure 4: 1-node with a simple request: topology

Listing 7: 1-node with a simple request: YANG tree

```
module: unify−virtualizer
  +−−rw virtualizer
     +−−rw id?      string
     +−−rw name?    string
     +−−rw nodes
     |  +−−rw node* [id]
     |     +−−rw id              string
     |     +−−rw name?           string
     |     +−−rw type            string
     |     +−−rw ports
     |     |  +−−rw port* [id]
     |     |     +−−rw id             string
     |     |     +−−rw name?          string
     |     |     +−−rw port_type?     string
     |     |     +−−rw (port−type)?
     |     |        +−−:(port−abstract)
     |     |        |  +−−rw capability?   string
     |     |        +−−:(port−sap)
     |     |           +−−rw (sap−type)?
     |     |              +−−:(vx−lan)
     |     |                 +−−rw vxlan?        string
     |     +−−rw resources
     |     |  +−−rw cpu        string
     |     |  +−−rw mem        string
     |     |  +−−rw storage    string
     |     +−−rw NF_instances
     |     |  +−−rw node* [id]
     |     |     +−−rw id           string
     |     |     +−−rw name?        string
     |     |     +−−rw type         string
     |     |     +−−rw ports
     |     |     |  +−−rw port* [id]
     |     |     |     +−−rw id             string
     |     |     |     +−−rw name?          string
     |     |     |     +−−rw port_type?     string
     |     |     |     +−−rw (port−type)?
     |     |     |        +−−:(port−abstract)
     |     |     |        |  +−−rw capability?   string
     |     |     |        +−−:(port−sap)
     |     |     |           +−−rw (sap−type)?
     |     |     |              +−−:(vx−lan)
     |     |     |                 +−−rw vxlan?        string
     |     |     +−−rw resources
     |     |        +−−rw cpu        string
     |     |        +−−rw mem        string
     |     |        +−−rw storage    string
     |     +−−rw flowtable
     |        +−−rw flowentry* [port match action]
     |           +−−rw port      port−ref
     |           +−−rw match     string
     |           +−−rw action    string
```

Listing 8: 1-node with a simple request: xml example

```
<virtualizer xmlns="urn:unify:virtualizer">
    <id>UUID001</id>
    <name>Single node simple request</name>
    <nodes>
        <node>
            <id>UUID11</id>
            <NF_instances>
                <node>
                    <id>NF1</id>
                    <name>first NF</name>
                    <type>Parental control B.4</type>
                    <ports>
                        <port>
                            <id>2</id>
                            <name>in</name>
                            <port_type>port-abstract</port_type>
                            <capability>...</capability>
                        </port>
                        <port>
                            <id>3</id>
                            <name>out</name>
                            <port_type>port-abstract</port_type>
                            <capability>...</capability>
                        </port>
                    </ports>
                    <!-- example may contain <resources> here -->
                </node>
                <node>
                    <id>NF2</id>
                    <name>cache</name>
                    <type>Http Cache 1.2</type>
                    <ports>
                        <port>
                            <id>4</id>
                            <name>in</name>
                            <port_type>port-abstract</port_type>
                            <capability>...</capability>
                        </port>
                        <port>
                            <id>5</id>
                            <name>out</name>
                            <port_type>port-abstract</port_type>
                            <capability>...</capability>
                        </port>
                    </ports>
                    <!-- example may contain <resources> here -->
                </node>
                <node>
                    <id>NF3</id>
                    <name>firewall</name>
                    <type>Stateful firewall C</type>
                    <ports>
                        <port>
                            <id>6</id>
                            <name>in</name>
                            <port_type>port-abstract</port_type>
```

```
57                          <capability>...</capability>
58                      </port>
59                      <port>
60                          <id>7</id>
61                          <name>out</name>
62                          <port_type>port-abstract</port_type>
63                          <capability>...</capability>
64                      </port>
65                  </ports>
66                  <!-- example may contain <resources> here -->
67              </node>
68          </NF_instances>
69          <flowtable>
70              <flowentry>
71                  <port>../../ports/port[id=0]</port>
72                  <match>*</match>
73                  <action>output:../../NF_instances/node[id=NF1]/ports/port[id=2]</action
    >
74              </flowentry>
75              <flowentry>
76                  <port>../../NF_instances/node[id=NF1]/ports/port[id=3]</port>
77                  <match>fr-a</match>
78                  <action>output:../../NF_instances/node[id=NF2]/ports/port[id=4]</action
    >
79              </flowentry>
80              <flowentry>
81                  <port>../../NF_instances/node[id=NF1]/ports/port[id=3]</port>
82                  <match>fr-b</match>
83                  <action>output:../../NF_instances/node[id=NF3]/ports/port[id=6]</action
    >
84              </flowentry>
85              <flowentry>
86                  <port>../../NF_instances/node[id=NF2]/ports/port[id=5]</port>
87                  <match>*</match>
88                  <action>output:../../ports/port[id=1]</action>
89              </flowentry>
90              <flowentry>
91                  <port>../../NF_instances/node[id=NF3]/ports/port[id=7]</port>
92                  <match>*</match>
93                  <action>output:../../ports/port[id=1]</action>
94              </flowentry>
95          </flowtable>
96      </node>
97  </nodes>
98 </virtualizer>
```

3.2 Request with Virtual Link Requirements

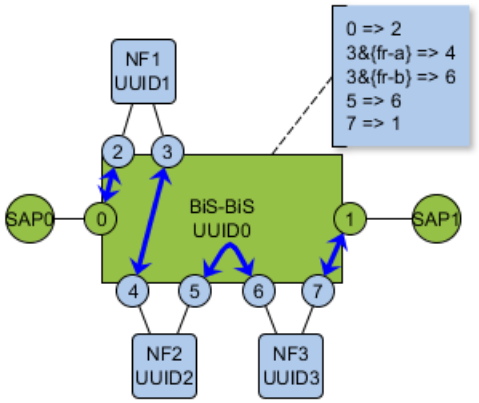

Figure 5: Request with Virtual Link Requirements: topology

Listing 9: Request with Virtual Link Requirements: YANG tree

```
module: unify−virtualizer
  +−−rw virtualizer
     +−−rw id?      string
     +−−rw name?    string
     +−−rw nodes
     |  +−−rw node* [id]
     |     +−−rw id              string
     |     +−−rw name?           string
     |     +−−rw type            string
     |     +−−rw ports
     |     |  +−−rw port* [id]
     |     |     +−−rw id             string
     |     |     +−−rw name?          string
     |     |     +−−rw port_type?     string
     |     |     +−−rw (port−type)?
     |     |        +−−:(port−abstract)
     |     |        |  +−−rw capability?   string
     |     |        +−−:(port−sap)
     |     |           +−−rw (sap−type)?
     |     |              +−−:(vx−lan)
     |     |                 +−−rw vxlan?        string
     |     +−−rw links
     |     |  +−−rw link* [src dst]
     |     |     +−−rw id?          string
     |     |     +−−rw name?        string
     |     |     +−−rw src          port−ref
     |     |     +−−rw dst          port−ref
     |     |     +−−rw resources
     |     |        +−−rw delay?       string
     |     |        +−−rw bandwidth?   string
     |     +−−rw resources
     |     |  +−−rw cpu        string
     |     |  +−−rw mem        string
     |     |  +−−rw storage    string
     |     +−−rw NF_instances
     |     |  +−−rw node* [id]
     |     |     +−−rw id           string
     |     |     +−−rw name?        string
     |     |     +−−rw type         string
     |     |     +−−rw ports
     |     |     |  +−−rw port* [id]
     |     |     |     +−−rw id             string
     |     |     |     +−−rw name?          string
     |     |     |     +−−rw port_type?     string
     |     |     |     +−−rw (port−type)?
     |     |     |        +−−:(port−abstract)
     |     |     |        |  +−−rw capability?   string
     |     |     |        +−−:(port−sap)
     |     |     |           +−−rw (sap−type)?
     |     |     |              +−−:(vx−lan)
     |     |     |                 +−−rw vxlan?        string
     |     |     +−−rw resources
     |     |        +−−rw cpu        string
     |     |        +−−rw mem        string
     |     |        +−−rw storage    string
     |     +−−rw flowtable
```

```
57      |          +--rw flowentry* [port match action]
58      |             +--rw port       port-ref
59      |             +--rw match      string
60      |             +--rw action     string
61      |             +--rw resources
62      |                +--rw delay?       string
63      |                +--rw bandwidth?   string
```

Listing 10: Request with Virtual Link Requirements: xml example

```
<virtualizer xmlns="urn:unify:virtualizer">
    <id>UUID001</id>
    <name>Single node simple request with inter-virtual port delays</name>
    <nodes>
        <node>
            <id>UUID11</id>
            <NF_instances>
                <node>
                    <id>NF1</id>
                    <name>first NF</name>
                    <type>Parental control B.4</type>
                    <ports>
                        <port>
                            <id>2</id>
                            <name>in</name>
                            <port_type>port-abstract</port_type>
                            <capability>...</capability>
                        </port>
                        <port>
                            <id>3</id>
                            <name>out</name>
                            <port_type>port-abstract</port_type>
                            <capability>...</capability>
                        </port>
                    </ports>
                    <!-- example may contain <resources> here -->
                </node>
                <node>
                    <id>NF2</id>
                    <name>cache</name>
                    <type>Http Cache 1.2</type>
                    <ports>
                        <port>
                            <id>4</id>
                            <name>in</name>
                            <port_type>port-abstract</port_type>
                            <capability>...</capability>
                        </port>
                        <port>
                            <id>5</id>
                            <name>out</name>
                            <port_type>port-abstract</port_type>
                            <capability>...</capability>
                        </port>
                    </ports>
                    <!-- example may contain <resources> here -->
                </node>
            </NF_instances>
            <flowtable>
                <flowentry>
                    <port>../../ports/port[id=0]</port>
                    <match>*</match>
                    <action>output:../../NF_instances/node[id=NF1]/ports/port[id=2]</action
    >
                    <resources>
                        <delay>50 ms</delay>
```

```
56                      <bandwidth>1 Mb</bandwidth>
57                  </resources>
58              </flowentry>
59              <flowentry>
60                  <port>../../NF_instances/node[id=NF1]/ports/port[id=3]</port>
61                  <match>fr-a</match>
62                  <action>output:../../NF_instances/node[id=NF2]/ports/port[id=4]</action
        >
63                  <resources>
64                      <delay>25 ms</delay>
65                      <bandwidth>2 Mb</bandwidth>
66                  </resources>
67              </flowentry>
68              <flowentry>
69                  <port>../../NF_instances/node[id=NF1]/ports/port[id=3]</port>
70                  <match>fr-b</match>
71                  <action>output:../../NF_instances/node[id=NF3]/ports/port[id=6]</action
        >
72              </flowentry>
73              <flowentry>
74                  <port>../../NF_instances/node[id=NF2]/ports/port[id=5]</port>
75                  <match>*</match>
76                  <action>output:../../ports/port[id=1]</action>
77              </flowentry>
78              <flowentry>
79                  <port>../../NF_instances/node[id=NF3]/ports/port[id=7]</port>
80                  <match>*</match>
81                  <action>output:../../ports/port[id=1]</action>
82              </flowentry>
83          </flowtable>
84      </node>
85  </nodes>
86 </virtualizer>
```

3.3 Request with NF Requirements

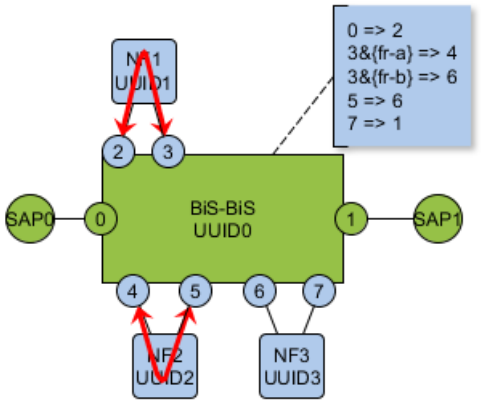

Figure 6: Request with NF Requirements: topology

Listing 11: Request with NF Requirements: YANG tree

```
module: unify−virtualizer
  +−−rw virtualizer
     +−−rw id?      string
     +−−rw name?    string
     +−−rw nodes
     |  +−−rw node* [id]
     |     +−−rw id              string
     |     +−−rw name?           string
     |     +−−rw type            string
     |     +−−rw ports
     |     |  +−−rw port* [id]
     |     |     +−−rw id             string
     |     |     +−−rw name?          string
     |     |     +−−rw port_type?     string
     |     |     +−−rw (port−type)?
     |     |        +−−:(port−abstract)
     |     |        |  +−−rw capability?   string
     |     |        +−−:(port−sap)
     |     |           +−−rw (sap−type)?
     |     |              +−−:(vx−lan)
     |     |                 +−−rw vxlan?        string
     |     +−−rw links
     |     |  +−−rw link* [src dst]
     |     |     +−−rw id?          string
     |     |     +−−rw name?        string
     |     |     +−−rw src          port−ref
     |     |     +−−rw dst          port−ref
     |     |     +−−rw resources
     |     |        +−−rw delay?       string
     |     |        +−−rw bandwidth?   string
     |     +−−rw resources
     |     |  +−−rw cpu       string
     |     |  +−−rw mem       string
     |     |  +−−rw storage   string
     |     +−−rw NF_instances
     |     |  +−−rw node* [id]
     |     |     +−−rw id           string
     |     |     +−−rw name?        string
     |     |     +−−rw type         string
     |     |     +−−rw ports
     |     |     |  +−−rw port* [id]
     |     |     |     +−−rw id             string
     |     |     |     +−−rw name?          string
     |     |     |     +−−rw port_type?     string
     |     |     |     +−−rw (port−type)?
     |     |     |        +−−:(port−abstract)
     |     |     |        |  +−−rw capability?   string
     |     |     |        +−−:(port−sap)
     |     |     |           +−−rw (sap−type)?
     |     |     |              +−−:(vx−lan)
     |     |     |                 +−−rw vxlan?        string
     |     |     +−−rw links
     |     |     |  +−−rw link* [src dst]
     |     |     |     +−−rw id?          string
     |     |     |     +−−rw name?        string
     |     |     |     +−−rw src          port−ref
```

```
57      |       |       |       +--rw dst           port-ref
58      |       |       |       +--rw resources
59      |       |       |          +--rw delay?       string
60      |       |       |          +--rw bandwidth?   string
61      |       |       +--rw resources
62      |       |          +--rw cpu        string
63      |       |          +--rw mem        string
64      |       |          +--rw storage    string
65      |       +--rw flowtable
66      |          +--rw flowentry* [port match action]
67      |             +--rw port       port-ref
68      |             +--rw match      string
69      |             +--rw action     string
```

Listing 12: Request with NF Requirements: xml example

```
<virtualizer xmlns="urn:unify:virtualizer">
    <id>UUID001</id>
    <name>Single node simple request with intra-NF virtual link requirements</name>
    <nodes>
        <node>
            <id>UUID11</id>
            <NF_instances>
                <node>
                    <id>NF1</id>
                    <name>first NF</name>
                    <type>Parental control B.4</type>
                    <ports>
                        <port>
                            <id>2</id>
                            <name>in</name>
                            <port_type>port-abstract</port_type>
                            <capability>...</capability>
                        </port>
                        <port>
                            <id>3</id>
                            <name>out</name>
                            <port_type>port-abstract</port_type>
                            <capability>...</capability>
                        </port>
                    </ports>
                    <links>
                        <link>
                            <id>012345</id>
                            <name>requirement on NF delay</name>
                            <src>../../ports/port[id=2]</src>
                            <dst>../../ports/port[id=3]</dst>
                            <resources>
                                <delay>20 ms</delay>
                                <bandwidth>1 Mb</bandwidth>
                            </resources>
                        </link>
                    </links>
                    <!-- example may contain <resources> here -->
                </node>
            </NF_instances>
            <!-- <flowtable> omitted here -->
        </node>
    </nodes>
</virtualizer>
```

Appendix A YANG definition

A.1 YANG UML

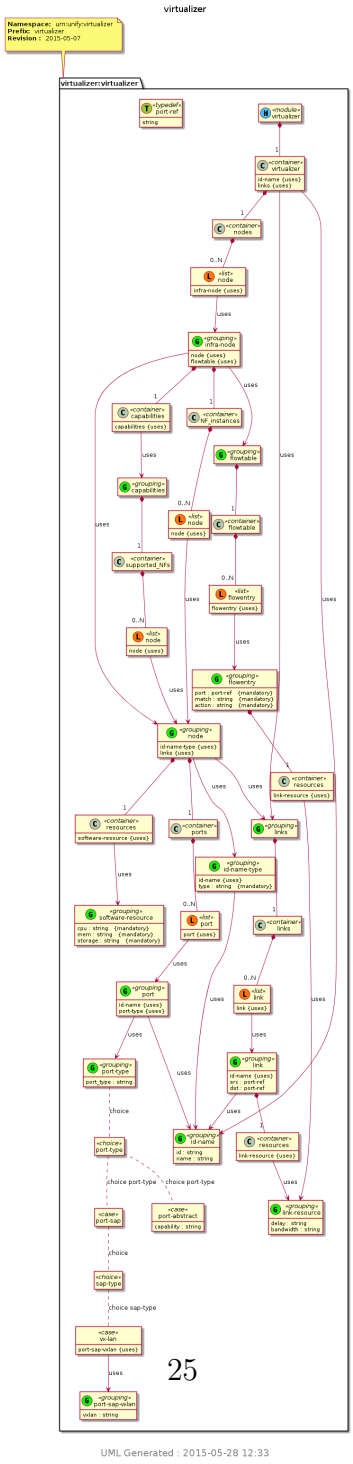

Figure 7: Virtualizer UML diagram

A.2 YANG module

Listing 13: virtualizer.yang

```
module virtualizer {
  namespace "urn:unify:virtualizer";
  prefix "virtualizer";
  organization "ETH";
  contact "Robert Szabo <robert.szabo@ericsson.com>";

  revision 2015-05-07
  {
    description "Virtualizer's data model";
  }

  //========================== REUSABLE GROUPS
     ==================================

  grouping id-name {
    leaf id { type string; }
    leaf name { type string;}
  }

  grouping id-name-type {
    uses id-name;
    leaf type {
      type string;
      mandatory true;
    }
  }

  // ------------ PORTS -------

  typedef port-ref {
    type string;
  }

  grouping port-sap-vxlan {
    leaf vxlan {type string;} // for example
    // container vx_lan {
    //    leaf remote_ip { type string; }
    //    leaf local_ip { type string; }
    //    leaf tunnel_key { type uint32; }
    // }
  }

  grouping port-type {
    leaf port_type {type string;} // TODO: enumerated
    choice port-type {
      description "Different port types: abstract and SAPs";
      case port-abstract {
        leaf capability { type string; }
      }
      case port-sap {
        choice sap-type {
          case vx-lan { // for example
            uses port-sap-vxlan;
```

```
53            }
54          }
55        }
56      }
57    }
58
59    grouping port {
60      uses id-name;
61      uses port-type;
62    }
63
64    // ------------ FLOW CONTROLS -------
65
66    grouping flowentry {
67      leaf port {
68        type port-ref;
69        mandatory true;
70      }
71      leaf match {
72        type string;
73        mandatory true;
74      }
75      leaf action {
76        type string;
77        mandatory true;
78      }
79      container resources{
80        uses link-resource;
81      }
82
83    }
84
85    grouping flowtable {
86      container flowtable {
87        list flowentry {
88          key "port match action";
89          uses flowentry;
90        }
91      }
92    }
93
94    // ------------ LINKS -------
95
96    grouping link-resource {
97      leaf delay {
98        type string;
99        mandatory false;
100     }
101     leaf bandwidth {
102       type string;
103       mandatory false;
104     }
105   }
106
107   grouping link {
108     uses id-name;
109     leaf src {
```

```
110       type port-ref;
111     }
112     leaf dst {
113       type port-ref;
114     }
115     container resources{
116       uses link-resource;
117     }
118   }
119
120   grouping links {
121     container links {
122       list link {
123         key "src dst";
124         uses link;
125       }
126     }
127   }
128
129   // ---------- CAPABILITIES --------------------
130
131   grouping capabilities {
132     container supported_NFs { // if supported NFs are enumerated
133       list node{
134         key "id";
135         uses node;
136       }
137     }
138     // TODO: add other capabilities
139   }
140
141   // ---------- NODE --------------------
142
143   grouping software-resource {
144     leaf cpu {
145       type string;
146       mandatory true;
147     }
148     leaf mem {
149       type string;
150       mandatory true;
151     }
152     leaf storage {
153       type string;
154       mandatory true;
155     }
156   }
157
158   grouping node {
159     description "Any node: infrastructure or NFs";
160     uses id-name-type;
161     container ports {
162       list port{
163         key "id";
164         uses port;
165       }
166     }
```

```
167     uses links;
168     container resources{
169       uses software-resource;
170     }
171   }
172
173   grouping infra-node { // they can contain other nodes (as NFs)
174     uses node;
175     container NF_instances {
176       list  node{
177         key "id";
178         uses node;
179       }
180     }
181     container capabilities {
182       uses  capabilities ;
183     }
184     uses flowtable;
185   }
186
187
188
189   //========================== NF-FG: Virtualizer and the Mapped request
        ==================================
190
191   container virtualizer {
192     description "Container for a single  virtualizer ";
193     uses id-name;
194
195     container nodes{
196       list  node{ // infra  nodes
197         key "id";
198         uses infra-node;
199       }
200     }
201     uses links; // infra  links
202   }
203 }
```