

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

```

1  module: unify-virtualizer
2    +--rw virtualizer
3      +--rw id?    string
4      +--rw name?  string
5      +--rw nodes
6        +--rw node* [id]
7          +--rw id      string
8          +--rw name?   string
9          +--rw type    string
10         +--rw ports
11           +--rw port* [id]
12             +--rw id      string
13             +--rw name?   string
14             +--rw port_type? string
15             +--rw (port-type)?
16               +--:(port-abstract)
17                 | +--rw capability? string
18               +--:(port-sap)
19                 +--rw (sap-type)?
20                   +--:(vx-lan)
21                     +--rw vxlan?    string
22       +--rw resources
23         +--rw cpu    string
24         +--rw mem    string
25         +--rw storage string

```

Listing 2: 1-node infrastructure: xml example

```

1 <virtualizer xmlns="urn:unify:virtualizer">
2   <id>UUID001</id>
3   <name>Single node simple infrastructure report</name>
4   <nodes>
5     <node>
6       <id>UUID11</id>
7       <name>single Bis-Bis node</name>
8       <type>BisBis</type>
9       <ports>
10        <port>
11          <id>0</id>
12          <name>SAP0 port</name>
13          <port_type>port-sap</port_type>
14          <vxlan>...</vxlan>
15        </port>
16        <port>
17          <id>1</id>
18          <name>North port</name>
19          <port_type>port-abstract</port_type>
20          <capability>...</capability>
21        </port>
22        <port>
23          <id>2</id>
24          <name>East port</name>
25          <port_type>port-abstract</port_type>
26          <capability>...</capability>
27        </port>
28      </ports>
29      <resources>
30        <cpu>20</cpu>
31        <mem>64 GB</mem>
32        <storage>100 TB</storage>
33      </resources>
34    </node>
35  </nodes>
36 </virtualizer>

```

2.2 3-Node

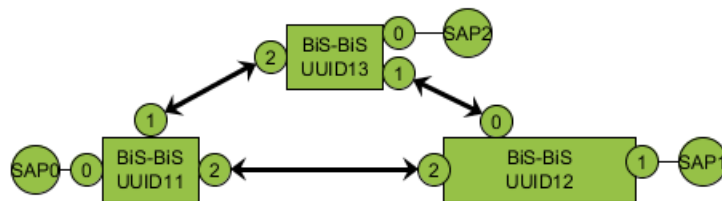


Figure 2: 3-node infrastructure: topology

Listing 3: 3-node infrastructure: YANG tree

```

1  module: unify-virtualizer
2    +--rw virtualizer
3      +--rw id?      string
4      +--rw name?    string
5      +--rw nodes
6        +--rw node* [id]
7          +--rw id      string
8          +--rw name?   string
9          +--rw type    string
10         +--rw ports
11           +--rw port* [id]
12             +--rw id      string
13             +--rw name?   string
14             +--rw port.type? string
15             +--...
16         +--rw resources
17           +--rw cpu      string
18           +--rw mem      string
19           +--rw storage  string
20     +--rw links
21       +--rw link* [src dst]
22         +--rw id?      string
23         +--rw name?    string
24         +--rw src      port-ref
25         +--rw dst      port-ref
26         +--rw resources
27           +--rw delay?  string
28           +--rw bandwidth? string

```

Listing 4: 3-node infrastructure: xml example

```

1 <virtualizer xmlns="urn:unify:virtualizer">
2   <id>UUID002</id>
3   <name>3-node simple infrastructure report</name>
4   <nodes>
5     <node>
6       <id>UUID11</id>
7       <name>West Bis-Bis node</name>
8       <type>BisBis</type>
9       <ports>
10        <port>
11          <id>0</id>
12          <name>SAP0 port</name>
13          <port_type>port-sap</port_type>
14          <vxlan>...</vxlan>
15        </port>
16        <port>
17          <id>1</id>
18          <name>North port</name>
19          <port_type>port-abstract</port_type>
20          <capability>...</capability>
21        </port>
22        <port>
23          <id>2</id>
24          <name>East port</name>
25          <port_type>port-abstract</port_type>
26          <capability>...</capability>
27        </port>
28      </ports>
29      <resources>
30        <cpu>20</cpu>
31        <mem>64 GB</mem>
32        <storage>100 TB</storage>
33      </resources>
34    </node>
35    <node>
36      <id>UUID12</id>
37      <name>East Bis-Bis node</name>
38      <type>BisBis</type>
39      <ports>
40        <port>
41          <id>1</id>
42          <name>SAP1 port</name>
43          <port_type>port-sap</port_type>
44          <vxlan>...</vxlan>
45        </port>
46        <port>
47          <id>0</id>
48          <name>North port</name>
49          <port_type>port-abstract</port_type>
50          <capability>...</capability>
51        </port>
52        <port>
53          <id>2</id>
54          <name>West port</name>
55          <port_type>port-abstract</port_type>
56          <capability>...</capability>

```

```

57     </port>
58 </ports>
59 <resources>
60   <cpu>10</cpu>
61   <mem>32 GB</mem>
62   <storage>100 TB</storage>
63 </resources>
64 </node>
65 <node>
66   <id>UUID13</id>
67   <name>North Bis-Bis node</name>
68   <type>BisBis</type>
69   <ports>
70     <port>
71       <id>0</id>
72       <name>SAP2 port</name>
73       <port_type>port-sap</port_type>
74       <vxlan>...</vxlan>
75     </port>
76     <port>
77       <id>1</id>
78       <name>East port</name>
79       <port_type>port-abstract</port_type>
80       <capability>...</capability>
81     </port>
82     <port>
83       <id>2</id>
84       <name>West port</name>
85       <port_type>port-abstract</port_type>
86       <capability>...</capability>
87     </port>
88   </ports>
89   <resources>
90     <cpu>20</cpu>
91     <mem>64 GB</mem>
92     <storage>1 TB</storage>
93   </resources>
94 </node>
95 </nodes>
96 <links>
97   <link>
98     <id>0</id>
99     <name>Horizontal link</name>
100    <src>../nodes/node[id=UUID11]/ports/port[id=2]</src>
101    <dst>../nodes/node[id=UUID12]/ports/port[id=2]</dst>
102    <resources>
103      <delay>2 ms</delay>
104      <bandwidth>10 Gb</bandwidth>
105    </resources>
106  </link>
107  <link>
108    <id>1</id>
109    <name>West link</name>
110    <src>../nodes/node[id=UUID11]/ports/port[id=1]</src>
111    <dst>../nodes/node[id=UUID13]/ports/port[id=2]</dst>
112    <resources>
113      <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

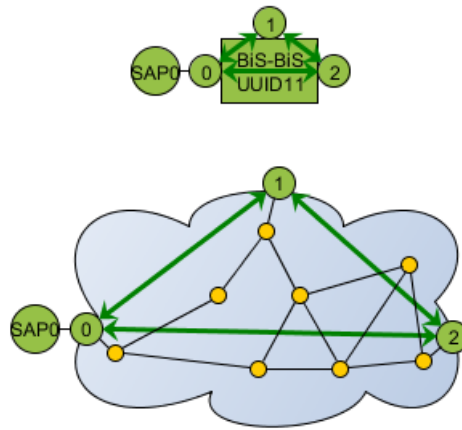


Figure 3: 1-node with Delay Matrix: topology

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

```

1  module: unify-virtualizer
2    +--rw virtualizer
3      +--rw id?    string
4      +--rw name?  string
5      +--rw nodes
6        +--rw node* [id]
7          +--rw id      string
8          +--rw name?   string
9          +--rw type    string
10         +--rw ports
11           +--rw port* [id]
12             +--rw id      string
13             +--rw name?   string
14             +--rw port.type? string
15             +--...
16         +--rw links
17           +--rw link* [src dst]
18             +--rw id?    string
19             +--rw name?  string
20             +--rw src    port-ref
21             +--rw dst    port-ref
22             +--rw resources
23               +--rw delay?  string
24               +--rw bandwidth? string
25         +--rw resources
26           +--rw cpu    string
27           +--rw mem    string
28           +--rw storage string
29   +--rw links
30     +--rw link* [src dst]
31       +--rw id?    string
32       +--rw name?  string
33       +--rw src    port-ref
34       +--rw dst    port-ref
35       +--rw resources
36         +--rw delay?  string
37         +--rw bandwidth? string

```

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

```

1 <virtualizer xmlns="urn:unify:virtualizer">
2   <id>UUID001</id>
3   <name>Single node with link internal delays infrastructure report</name>
4   <nodes>
5     <node>
6       <id>UUID11</id>
7       <name>single Bis-Bis node</name>
8       <type>BisBis</type>
9       <ports>
10        <port>
11          <id>0</id>
12          <name>SAP0 port</name>
13          <port_type>port-sap</port_type>
14          <vxlan>...</vxlan>
15        </port>
16        <port>
17          <id>1</id>
18          <name>North port</name>
19          <port_type>port-abstract</port_type>
20          <capability>...</capability>
21        </port>
22        <port>
23          <id>2</id>
24          <name>East port</name>
25          <port_type>port-abstract</port_type>
26          <capability>...</capability>
27        </port>
28      </ports>
29      <links>
30        <link>
31          <id>int0</id>
32          <name>internal horizontal</name>
33          <src>../ports/port[id=0]</src>
34          <dst>../ports/port[id=2]</dst>
35          <resources>
36            <delay>1 ms</delay>
37            <bandwidth>40 Gb</bandwidth>
38          </resources>
39        </link>
40        <link>
41          <id>int1</id>
42          <name>internal left</name>
43          <src>../ports/port[id=0]</src>
44          <dst>../ports/port[id=1]</dst>
45          <resources>
46            <delay>5 ms</delay>
47            <bandwidth>10 Gb</bandwidth>
48          </resources>
49        </link>
50        <link>
51          <id>int2</id>
52          <name>internal right</name>
53          <src>../ports/port[id=1]</src>
54          <dst>../ports/port[id=2]</dst>
55          <resources>
56            <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

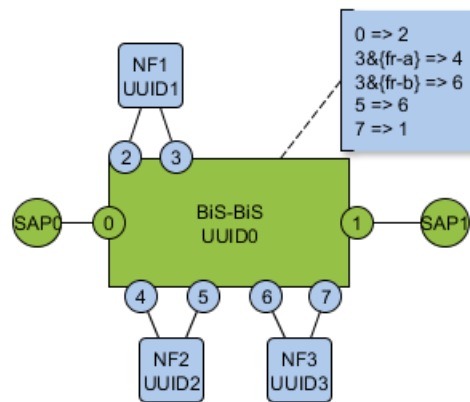


Figure 4: 1-node with a simple request: topology

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

```

1  module: unify-virtualizer
2    +--rw virtualizer
3      +--rw id?    string
4      +--rw name?  string
5      +--rw nodes
6        +--rw node* [id]
7          +--rw id      string
8          +--rw name?   string
9          +--rw type    string
10         +--rw ports
11           +--rw port* [id]
12             +--rw id      string
13             +--rw name?   string
14             +--rw port_type? string
15             +--rw (port-type)?
16               +--:(port-abstract)
17                 | +--rw capability? string
18               +--:(port-sap)
19                 +--rw (sap-type)?
20                   +--:(vx-lan)
21                     +--rw vxlan?    string
22         +--rw resources
23           +--rw cpu    string
24           +--rw mem    string
25           +--rw storage string
26         +--rw NF_instances
27           +--rw node* [id]
28             +--rw id      string
29             +--rw name?   string
30             +--rw type    string
31             +--rw ports
32               +--rw port* [id]
33                 +--rw id      string
34                 +--rw name?   string
35                 +--rw port_type? string
36                 +--rw (port-type)?
37                   +--:(port-abstract)
38                     | +--rw capability? string
39                   +--:(port-sap)
40                     +--rw (sap-type)?
41                       +--:(vx-lan)
42                         +--rw vxlan?    string
43             +--rw resources
44               +--rw cpu    string
45               +--rw mem    string
46               +--rw storage string
47         +--rw flowtable
48           +--rw flowentry* [port match action]
49             +--rw port    port-ref
50             +--rw match   string
51             +--rw action  string

```

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

```

1 <virtualizer xmlns="urn:unify:virtualizer">
2   <id>UUID001</id>
3   <name>Single node simple request</name>
4   <nodes>
5     <node>
6       <id>UUID11</id>
7       <NF_instances>
8         <node>
9           <id>NF1</id>
10          <name>first NF</name>
11          <type>Parental control B.4</type>
12          <ports>
13            <port>
14              <id>2</id>
15              <name>in</name>
16              <port_type>port-abstract</port_type>
17              <capability>...</capability>
18            </port>
19            <port>
20              <id>3</id>
21              <name>out</name>
22              <port_type>port-abstract</port_type>
23              <capability>...</capability>
24            </port>
25          </ports>
26          <!-- example may contain <resources> here -->
27        </node>
28        <node>
29          <id>NF2</id>
30          <name>cache</name>
31          <type>Http Cache 1.2</type>
32          <ports>
33            <port>
34              <id>4</id>
35              <name>in</name>
36              <port_type>port-abstract</port_type>
37              <capability>...</capability>
38            </port>
39            <port>
40              <id>5</id>
41              <name>out</name>
42              <port_type>port-abstract</port_type>
43              <capability>...</capability>
44            </port>
45          </ports>
46          <!-- example may contain <resources> here -->
47        </node>
48        <node>
49          <id>NF3</id>
50          <name>firewall</name>
51          <type>Stateful firewall C</type>
52          <ports>
53            <port>
54              <id>6</id>
55              <name>in</name>
56              <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

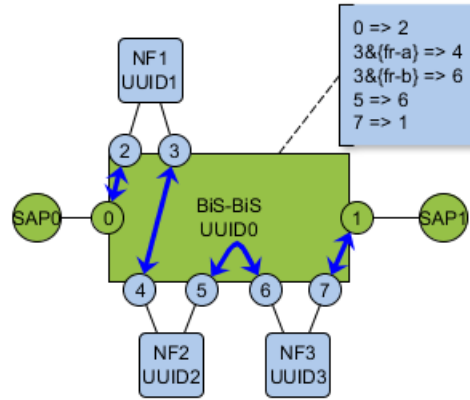


Figure 5: Request with Virtual Link Requirements: topology

Listing 9: Request with Virtual Link Requirements: YANG tree

```

1  module: unify-virtualizer
2    +--rw virtualizer
3      +--rw id?      string
4      +--rw name?    string
5      +--rw nodes
6        +--rw node* [id]
7          +--rw id      string
8          +--rw name?    string
9          +--rw type     string
10         +--rw ports
11           +--rw port* [id]
12             +--rw id      string
13             +--rw name?    string
14             +--rw port_type? string
15             +--rw (port-type)?
16               +--:(port-abstract)
17               | +--rw capability? string
18               +--:(port-sap)
19               +--rw (sap-type)?
20               +--:(vx-lan)
21               +--rw vxlan?      string
22         +--rw links
23           +--rw link* [src dst]
24             +--rw id?      string
25             +--rw name?    string
26             +--rw src      port-ref
27             +--rw dst      port-ref
28             +--rw resources
29               +--rw delay?    string
30               +--rw bandwidth? string
31         +--rw resources
32           +--rw cpu      string
33           +--rw mem      string
34           +--rw storage  string
35       +--rw NF_instances
36         +--rw node* [id]
37           +--rw id      string
38           +--rw name?    string
39           +--rw type     string
40           +--rw ports
41             +--rw port* [id]
42               +--rw id      string
43               +--rw name?    string
44               +--rw port_type? string
45               +--rw (port-type)?
46                 +--:(port-abstract)
47                 | +--rw capability? string
48                 +--:(port-sap)
49                 +--rw (sap-type)?
50                 +--:(vx-lan)
51                 +--rw vxlan?      string
52           +--rw resources
53             +--rw cpu      string
54             +--rw mem      string
55             +--rw storage  string
56       +--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

```

1 <virtualizer xmlns="urn:unify:virtualizer">
2   <id>UUID001</id>
3   <name>Single node simple request with inter-virtual port delays</name>
4   <nodes>
5     <node>
6       <id>UUID11</id>
7       <NF_instances>
8         <node>
9           <id>NF1</id>
10          <name>first NF</name>
11          <type>Parental control B.4</type>
12          <ports>
13            <port>
14              <id>2</id>
15              <name>in</name>
16              <port_type>port-abstract</port_type>
17              <capability>...</capability>
18            </port>
19            <port>
20              <id>3</id>
21              <name>out</name>
22              <port_type>port-abstract</port_type>
23              <capability>...</capability>
24            </port>
25          </ports>
26          <!-- example may contain <resources> here -->
27        </node>
28        <node>
29          <id>NF2</id>
30          <name>cache</name>
31          <type>Http Cache 1.2</type>
32          <ports>
33            <port>
34              <id>4</id>
35              <name>in</name>
36              <port_type>port-abstract</port_type>
37              <capability>...</capability>
38            </port>
39            <port>
40              <id>5</id>
41              <name>out</name>
42              <port_type>port-abstract</port_type>
43              <capability>...</capability>
44            </port>
45          </ports>
46          <!-- example may contain <resources> here -->
47        </node>
48      </NF_instances>
49      <flowtable>
50        <flowentry>
51          <port>../..ports/port[id=0]</port>
52          <match>*</match>
53          <action>output:../..NF_instances/node[id=NF1]/ports/port[id=2]</action>
54        </flowentry>
55      </flowtable>
56    </node>
57  </nodes>
58  <resources>
59    <delay>50 ms</delay>
60  </resources>
61 </virtualizer>

```

```

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

```

3.3 Request with NF Requirements

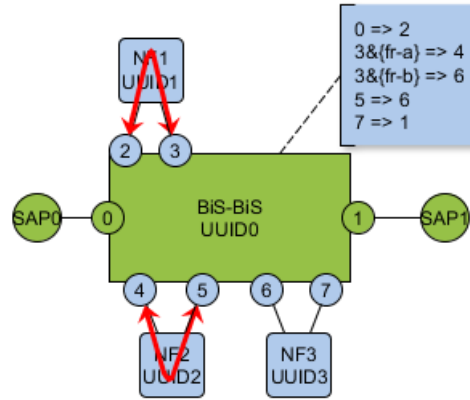


Figure 6: Request with NF Requirements: topology

Listing 11: Request with NF Requirements: YANG tree

```

1  module: unify-virtualizer
2    +--rw virtualizer
3      +--rw id?      string
4      +--rw name?    string
5      +--rw nodes
6        +--rw node* [id]
7          +--rw id      string
8          +--rw name?    string
9          +--rw type     string
10         +--rw ports
11           +--rw port* [id]
12             +--rw id      string
13             +--rw name?    string
14             +--rw port_type? string
15             +--rw (port-type)?
16               +--:(port-abstract)
17               | +--rw capability? string
18               +--:(port-sap)
19                 +--rw (sap-type)?
20                 +--:(vx-lan)
21                 +--rw vxlan?      string
22         +--rw links
23           +--rw link* [src dst]
24             +--rw id?      string
25             +--rw name?    string
26             +--rw src      port-ref
27             +--rw dst      port-ref
28             +--rw resources
29               +--rw delay?    string
30               +--rw bandwidth? string
31         +--rw resources
32           +--rw cpu      string
33           +--rw mem      string
34           +--rw storage  string
35         +--rw NF_instances
36           +--rw node* [id]
37             +--rw id      string
38             +--rw name?    string
39             +--rw type     string
40             +--rw ports
41               +--rw port* [id]
42                 +--rw id      string
43                 +--rw name?    string
44                 +--rw port_type? string
45                 +--rw (port-type)?
46                   +--:(port-abstract)
47                   | +--rw capability? string
48                   +--:(port-sap)
49                     +--rw (sap-type)?
50                     +--:(vx-lan)
51                     +--rw vxlan?      string
52           +--rw links
53             +--rw link* [src dst]
54               +--rw id?      string
55               +--rw name?    string
56               +--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

```

1 <virtualizer xmlns="urn:unify:virtualizer">
2   <id>UUID001</id>
3   <name>Single node simple request with intra-NF virtual link requirements</name>
4   <nodes>
5     <node>
6       <id>UUID11</id>
7       <NF_instances>
8         <node>
9           <id>NF1</id>
10          <name>first NF</name>
11          <type>Parental control B.4</type>
12          <ports>
13            <port>
14              <id>2</id>
15              <name>in</name>
16              <port_type>port-abstract</port_type>
17              <capability>...</capability>
18            </port>
19            <port>
20              <id>3</id>
21              <name>out</name>
22              <port_type>port-abstract</port_type>
23              <capability>...</capability>
24            </port>
25          </ports>
26          <links>
27            <link>
28              <id>012345</id>
29              <name>requirement on NF delay</name>
30              <src>../ports/port[id=2]</src>
31              <dst>../ports/port[id=3]</dst>
32              <resources>
33                <delay>20 ms</delay>
34                <bandwidth>1 Mb</bandwidth>
35              </resources>
36            </link>
37          </links>
38          <!-- example may contain <resources> here -->
39        </node>
40      </NF_instances>
41      <!-- <flowtable> omitted here -->
42    </node>
43  </nodes>
44 </virtualizer>

```


A.1 YANG UML

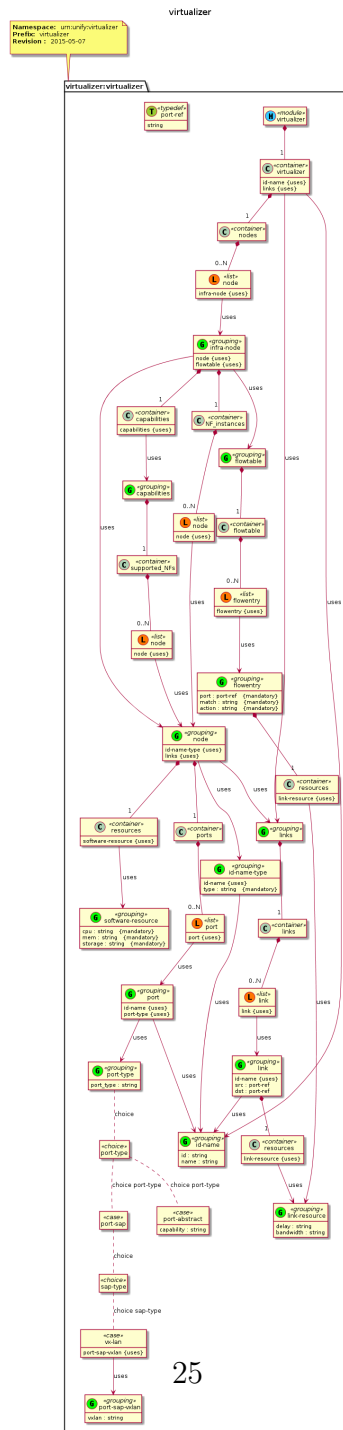


Figure 7: Virtualizer UML diagram

A.2 YANG module

Listing 13: virtualizer.yang

```
1 module virtualizer {
2   namespace "urn:unify:virtualizer";
3   prefix "virtualizer";
4   organization "ETH";
5   contact "Robert Szabo <robert.szabo@ericsson.com>";
6
7   revision 2015-05-07
8   {
9     description "Virtualizer's data model";
10  }
11
12  //===== REUSABLE GROUPS
13  //=====
14  grouping id-name {
15    leaf id { type string; }
16    leaf name { type string;}
17  }
18
19  grouping id-name-type {
20    uses id-name;
21    leaf type {
22      type string;
23      mandatory true;
24    }
25  }
26
27  // ----- PORTS -----
28
29  typedef port-ref {
30    type string;
31  }
32
33  grouping port-sap-vxlan {
34    leaf vxlan {type string;} // for example
35    // container vx_lan {
36    //   leaf remote_ip { type string; }
37    //   leaf local_ip { type string; }
38    //   leaf tunnel_key { type uint32; }
39    // }
40  }
41
42  grouping port-type {
43    leaf port_type {type string;} // TODO: enumerated
44    choice port-type {
45      description "Different port types: abstract and SAPs";
46      case port-abstract {
47        leaf capability { type string; }
48      }
49      case port-sap {
50        choice sap-type {
51          case vx-lan { // for example
52            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 grouping flowtable {
85   container flowtable {
86     list flowentry {
87       key "port match action";
88       uses flowentry;
89     }
90   }
91 }
92
93 // ----- LINKS -----
94
95 grouping link-resource {
96   leaf delay {
97     type string;
98     mandatory false;
99   }
100   leaf bandwidth {
101     type string;
102     mandatory false;
103   }
104 }
105
106 grouping link {
107   uses id-name;
108   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 }

```