Providing Infrastructure Functions for Virtual Networks by Applying Node Plug-in Architecture

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Background

- ***VNode* and *VNode Infrastructure* was developed in a collaborative project.**

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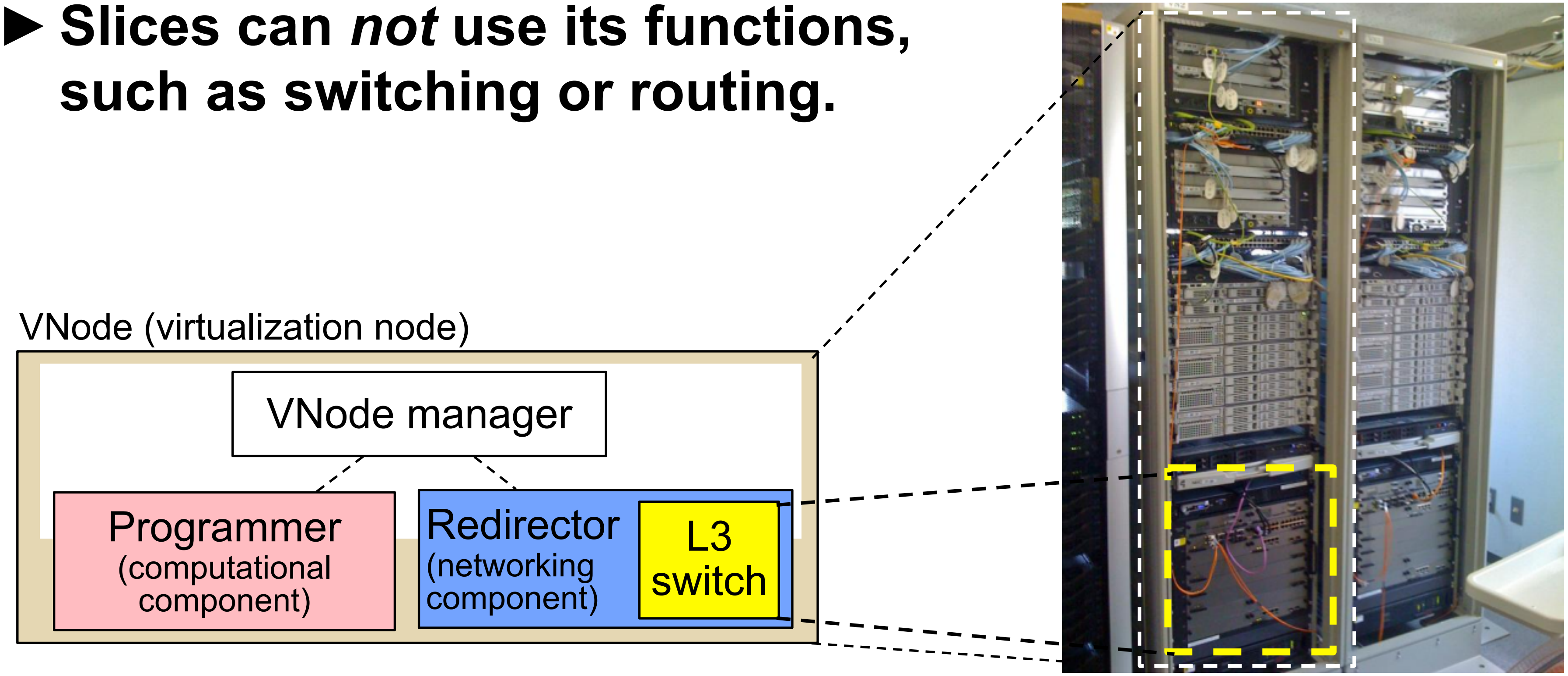
- **VNode is** a physical node with network-virtualization functions.
- **VNode Infrastructure is a network architecture and testbed with network-virtualization function.**
  - On this infrastructure, multiple developers can create and use slices (i.e., virtual networks) concurrently and independently.

Background (cont'd)

- ► VMs (virtual nodes) in VNodes can implement routing and switching, but the performance is limited.
- ► VNode contains a layer-3 (L3) switch, which has high-performance routing and switching functions.
- ► Slices can *not* use its functions, such as switching or routing.



Proposal

- A method for supporting L3 switch functions to slices is proposed.
- This method is based on the node plug-in architecture, which was proposed in previous papers.

VNode Infrastructure and Slice Definition (Previous Work)

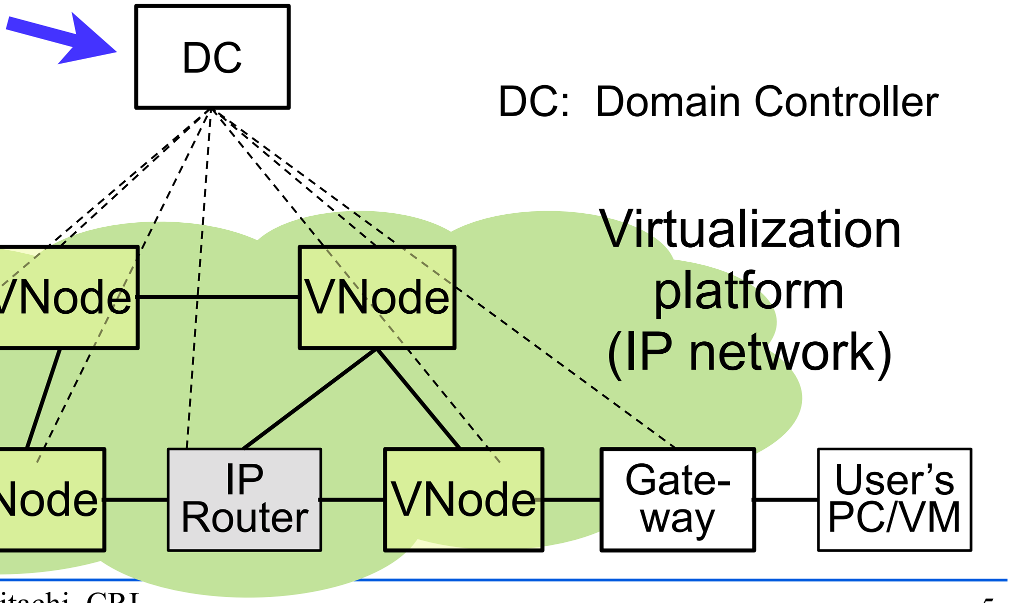
- **A developer can create a slice by sending a slice definition (RSpecs) to the management server (i.e., DC).**
- **A slice definition contains definitions of virtual nodes and links of *predefined types*.**

Slice definition

```
<nodeSliver name="..." ...>
  <instance type="SlowPath_VM">...
  </instance>
  ...
</nodeSliver>
...
<linkSliver name="..." type="link" ...>
  ...
</linkSliver>
...
```

Predefined virtual-node type

Predefined virtual-link type



Plug-in Architecture for VNode (Previous Work)

- ▶ **Plug-ins enable new types of virtual nodes/links to be added to VNode.**
- ▶ **New types can be specified in a slice definition.**
  - ■ All the implementation parameters can be specified by the developer, or

```
<nodeSliver name="vrf1" …>
 <instance type="extension">
  <params>
   <param key="PlugInName" value="intSw" />
   <param key="DataPort" value="vlan" />
   <param key="ControlPort" value="192.168.110.61" />
   <param key="Command-runNodeSliver" value="run_vrf" />
   <param key="Command-stopNodeSliver" value="stop_vrf" />
   ...
  </params>
 </instance>
 <vports><vport name="p1"/> … <vport name="pm"/
 </vports>
</nodeSliver>
```

Plug-in name, control and data I/F

Plug-in parameters

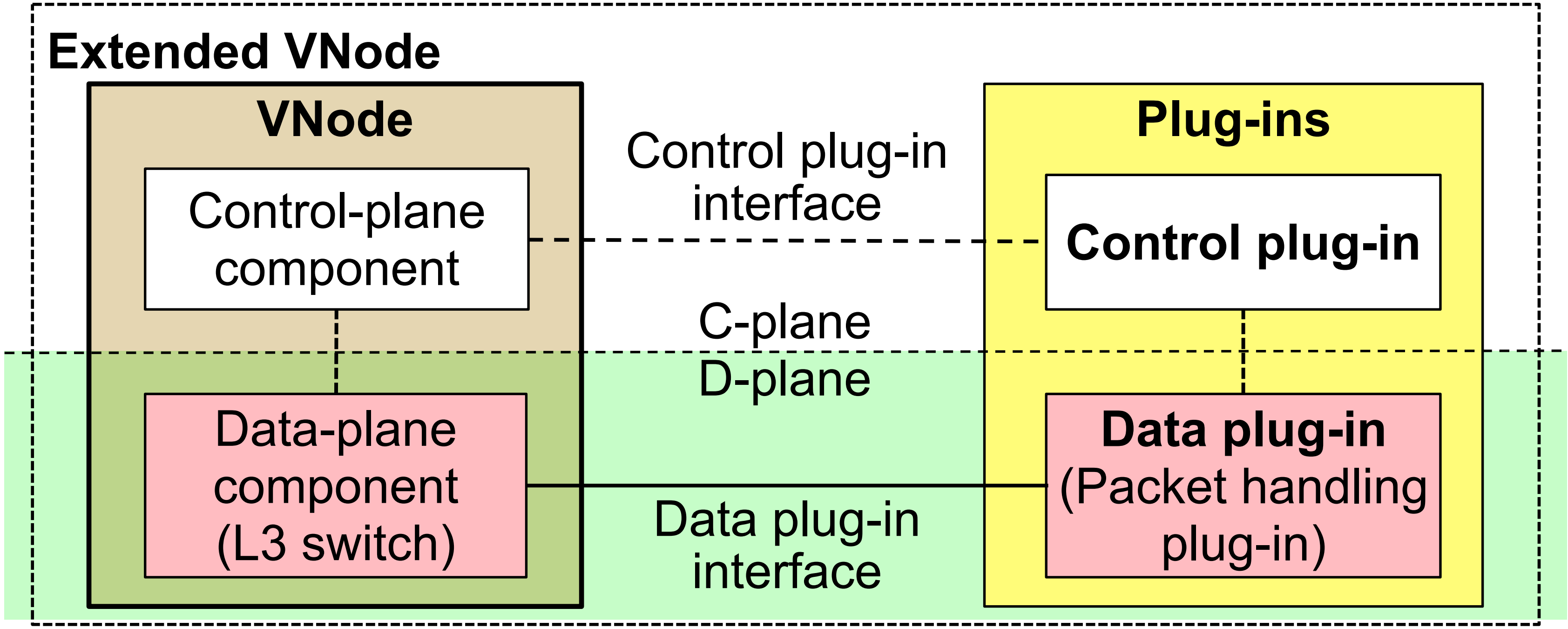
  - ■ The implementation parameters can be hidden from the developer (can be supplied by control/management components).

```
<nodeSliver name="vrf1" …>
  <instance type="virtual_router">
    <params>
      ...
     </params>
  </instance>
  <vports><vport name="p1"/> … <vport name="pm"/></vports>
</nodeSliver>
```

New virtual node-type name

Plug-in Architecture for VNode (Previous Work) (cont'd)

- **New types are implemented by a combination of two types of plug-ins:**
  - *Data plug-ins* extend data-plane functions such as packet forwarding.
  - *Control plug-ins* extend control-plane functions: manages data plug-ins.

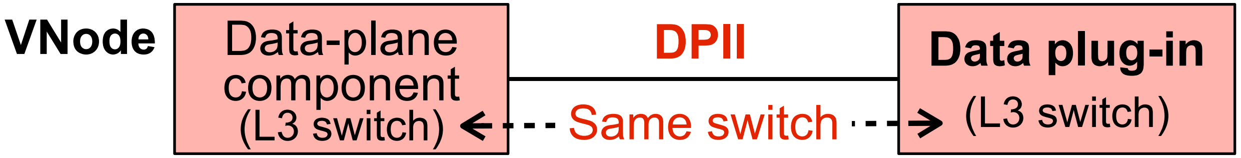


Proposal: Plug-ins and Interfaces for L3 Switch Functions

▶ Data plug-in: the L3 switch

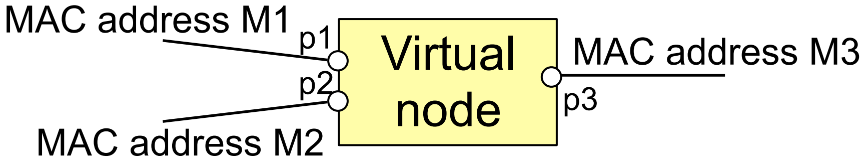
- The same switch as the data-plane component of the VNode,
- The data plug-in must be isolated from the VNode.

▶ Data plug-in interface (DPII) is extended:



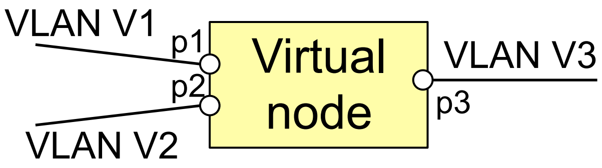
- **Original DPII is MAC-address-based**

PDMAC	PSMAC	PEType	SDMAC	SSMAC	SEType	Payload



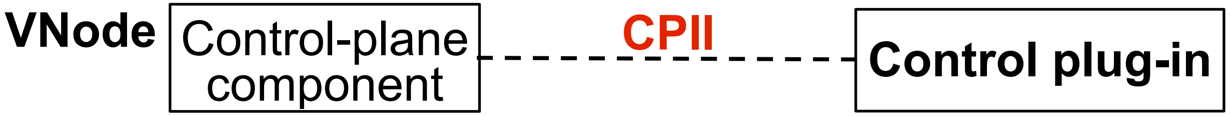
- **New DPII is VLAN-based — L3-switch requirements**

SDMAC	SSMAC	SEType	VLAN tag	Payload



Proposal: Plug-ins and Interfaces for L3 Switch Functions (cont'd)

- **Control plug-in must be developed.**
  - It assigns VLAN IDs for the DPII.
- **Control plug-in interface (CPII)**

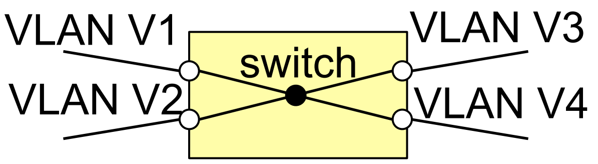


  - CLI is used for CPII.
  - Command names for this CLI must be specified.
    - E.g., when they are specified in slice definitions:

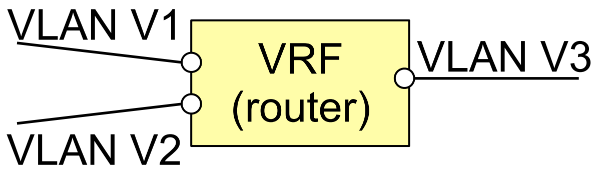
```
   <param key="Command-runNodeSliver" value="run_vrf" />
   <param key="Command-stopNodeSliver" value="stop_vrf" />
```

  - Parameters for the commands must be specified.

L3 Switch Functions to be Provided to Slices



- ▶ **Switching function (of Ethernet)**
  - Number of ports is arbitrary.
  - No plug-in parameters are required.

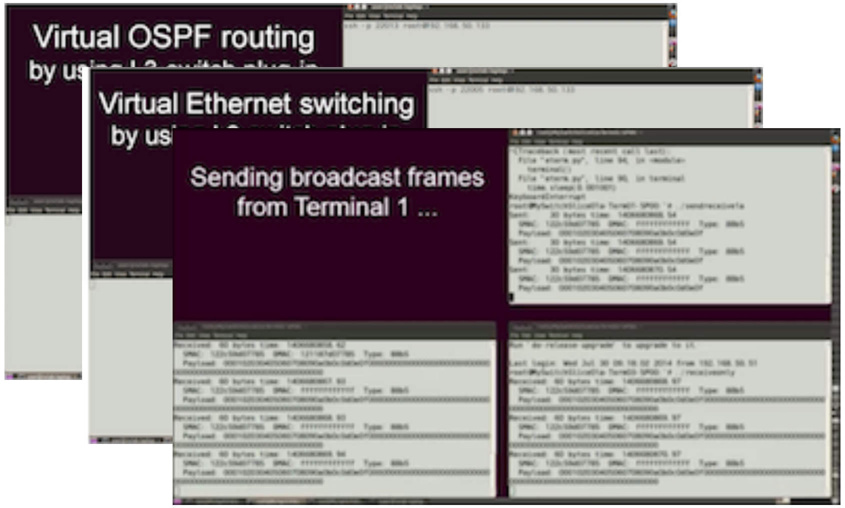


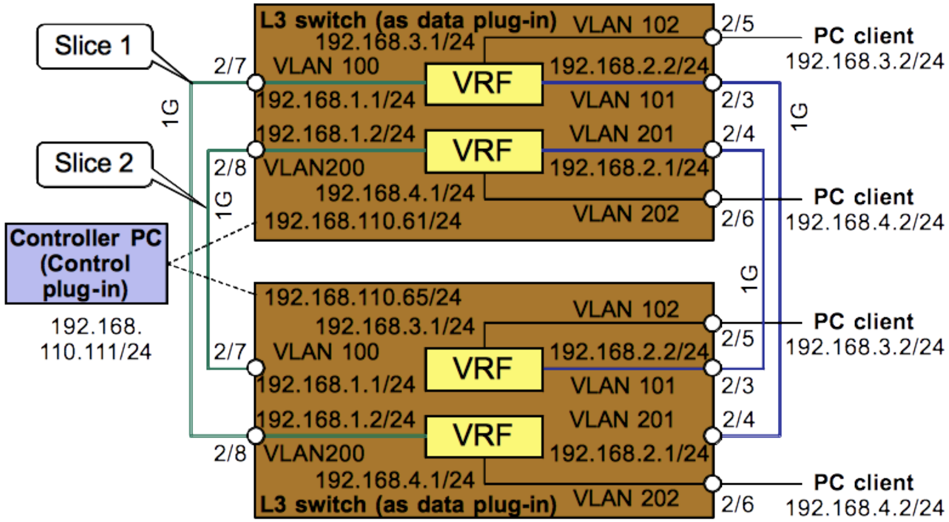
- ▶ **Routing function (VRF function)**
  - Number of ports is arbitrary.
  - Routing parameters are specified as parameters in the slice definition.

```
<param key="routing_protocol" value="ospf" />
<param key="ospf_subnet" value="192.168.0.0" />
<param key="ospf_mask" value="0.0.15.255" />
<param key="ospf_area" value="110" />
<param key="ospf_domain" value="1" />
<param key="router_ip" value="192.168.101.1" />
```

Prototyping and Evaluation

- ▶ **The plug-in interfaces were partially implemented to a type of VNode called NACE (NC).**
- ▶ **The control plug-in was implemented in Perl.**
  - ■ It communicates with the L3 switch through CLI,
- ▶ **OSPF-based IP routing and Ethernet switching plug-ins were implemented.**
  - ■ Routing and switching among three terminals were tested.
  - ■ Rerouting between two virtual routers were tested.





Prototyping and Evaluation (cont’d)

- **Virtual-node development cost** (when plug-in parameters are embedded to control components)
  - **Ethernet switching**: only 8 lines are required for specifying a virtual switch.
    - 16 lines with plug-in parameters.
  - **OSPF routing**: only 19 lines (including OSPF parameters) are required for specifying a virtual router
    - 25 lines with plug-in parameters.

```
<nodeSliver name="sw1" …>
  <instance type="virtual_switch" />
  <vports>
    <vport name="p1"/>
    …
    <vport name="pm"/>
  </vports>
</nodeSliver>
```

```
<nodeSliver name="vrf1" …>
  <instance type="virtual_router">
    <params>
      <param key="P1" value="V1" />
      …
      <param key="Pn" value="Vn" />
    </params>
  </instance>
  <vports>
    <vport name="p1"/>
    …
    <vport name="pm"/>
  </vports>
</nodeSliver>
```

Summary and Conclusion

► Summary

- A method for supporting L3 switch functions, which is based on the node plug-in architecture, is proposed.
- OSPF routing and Ethernet switching functions were prototyped for VNode by this method and evaluated.

► Conclusions

- Plug-ins for routing and switching can easily be developed.
- Slice developers can easily use the plug-in functions in slices.

► Future work

- Extending switch/router plug-ins and implementing new plug-ins (e.g., switching non-Ethernet addresses).