A Node Plug-in Architecture for Evolving Network Virtualization Nodes

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Outline

- **What is VNode?**
  - VNode is a physical node with network virtualization function.
- **Evolution of VNode**
  - VNode allows independent evolution of components of VNode.
- **Proposal**
  - An architecture and a method for evolving the components in two steps using plug-ins are proposed.
- **Prototyping and evaluation**

What is VNode?

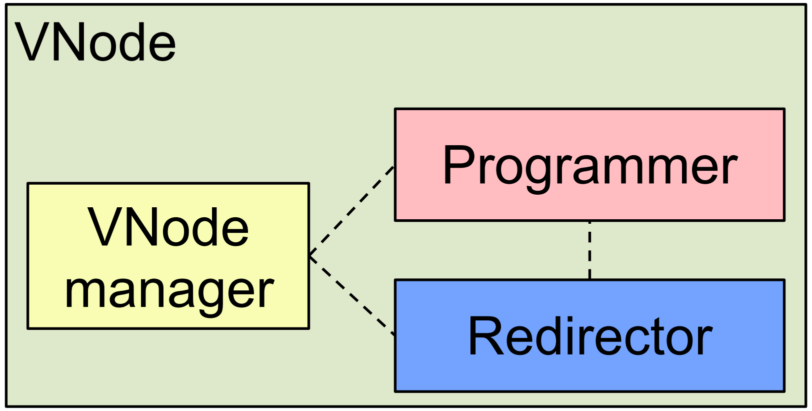
- **We are developing *VNode* and *VNode Platform* in a collaborative project directed by Prof. Aki Nakao.**

- **VNode Platform is a network-virtualization platform.**
  - On this platform, multiple developers can create and use slices (virtual networks) concurrently and independently.

- **VNode is** physical node with network-virtualization functions.

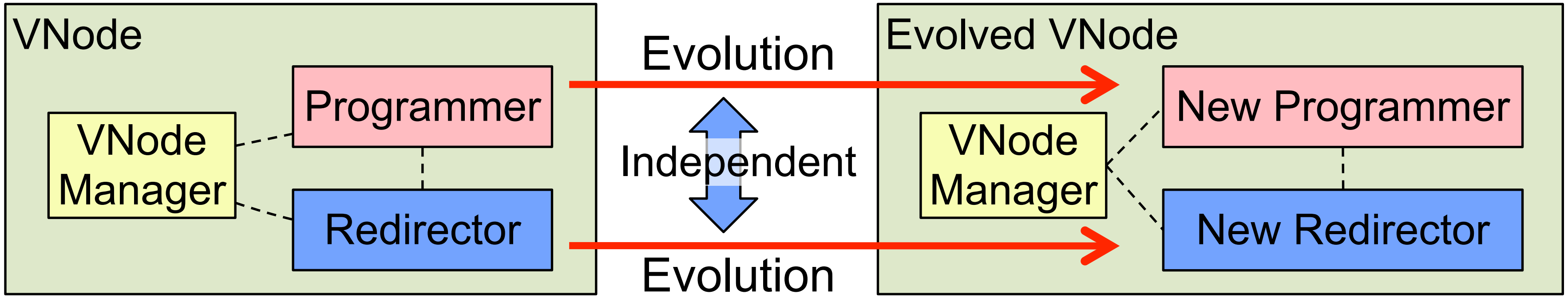
Components of VNode

- ▶ **VNode consists of three components:**
  - ■ **Programmer**: a *deeply-programmable* computational component (software & hardware).
    - ● Deeply-programmable: Data-plane is programmable.
  - ■ **Redirector**: a networking component (software & hardware).
  - ■ **VNode manager**: a control component.



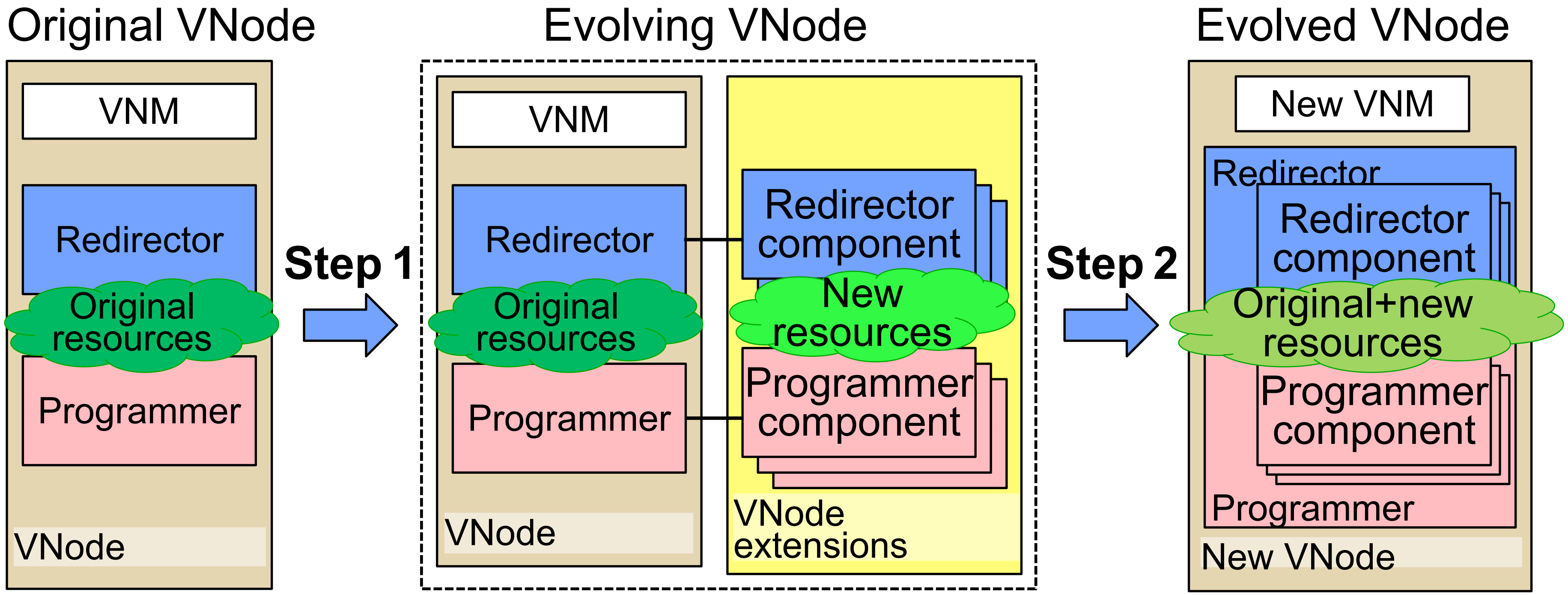
Evolution of VNode

- **Programmer and redirector may evolve by using *new node hardware* or *software*, or *new functions*.**
  - **New hardware/software**: New network processors, GPGPUs, New types of VMs, etc.
  - **New functions**: A new protocol stack, etc.
- **Programmer and redirector can evolve independently because they are *modular*.**
  - The interfaces can be clearly defined and work efficiently.
- **However, no method for this evolution has been available.**



Proposed Method: Two-step Evolution of VNode

- **Step 1: To develop new subcomponents as plug-ins and to connect them to the original components.**
  - The subcomponents (software & hardware) can be dynamically evolving without interference to existing slices.
- **Step 2: To merge the plug-ins into the components.**
  - The merged components are static and stable.



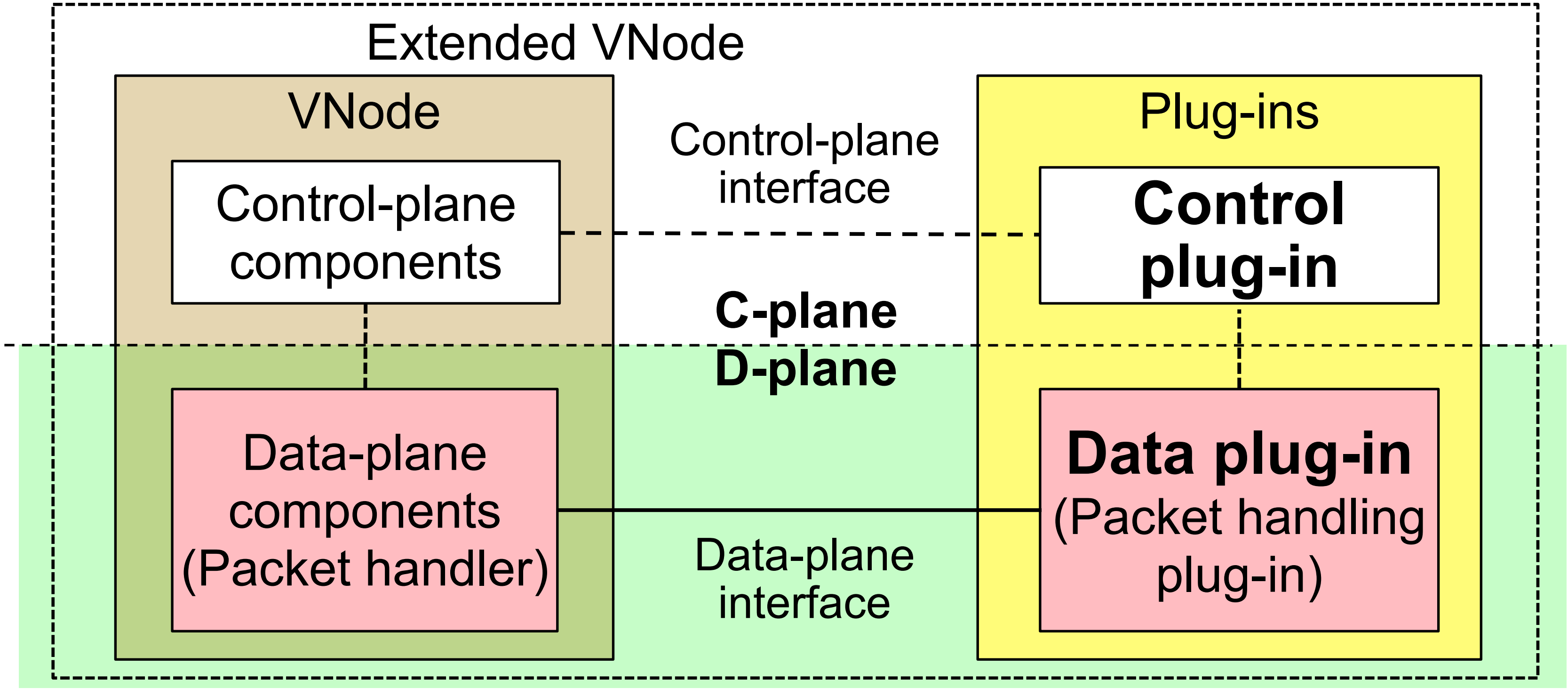
Plug-in Architecture for Step 1

▶ Data plug-in and Control plug-in

- A new data-plane function is implemented by a data plug-in.
- A data plug-in requires new control functions, which are implemented by a control plug-in.

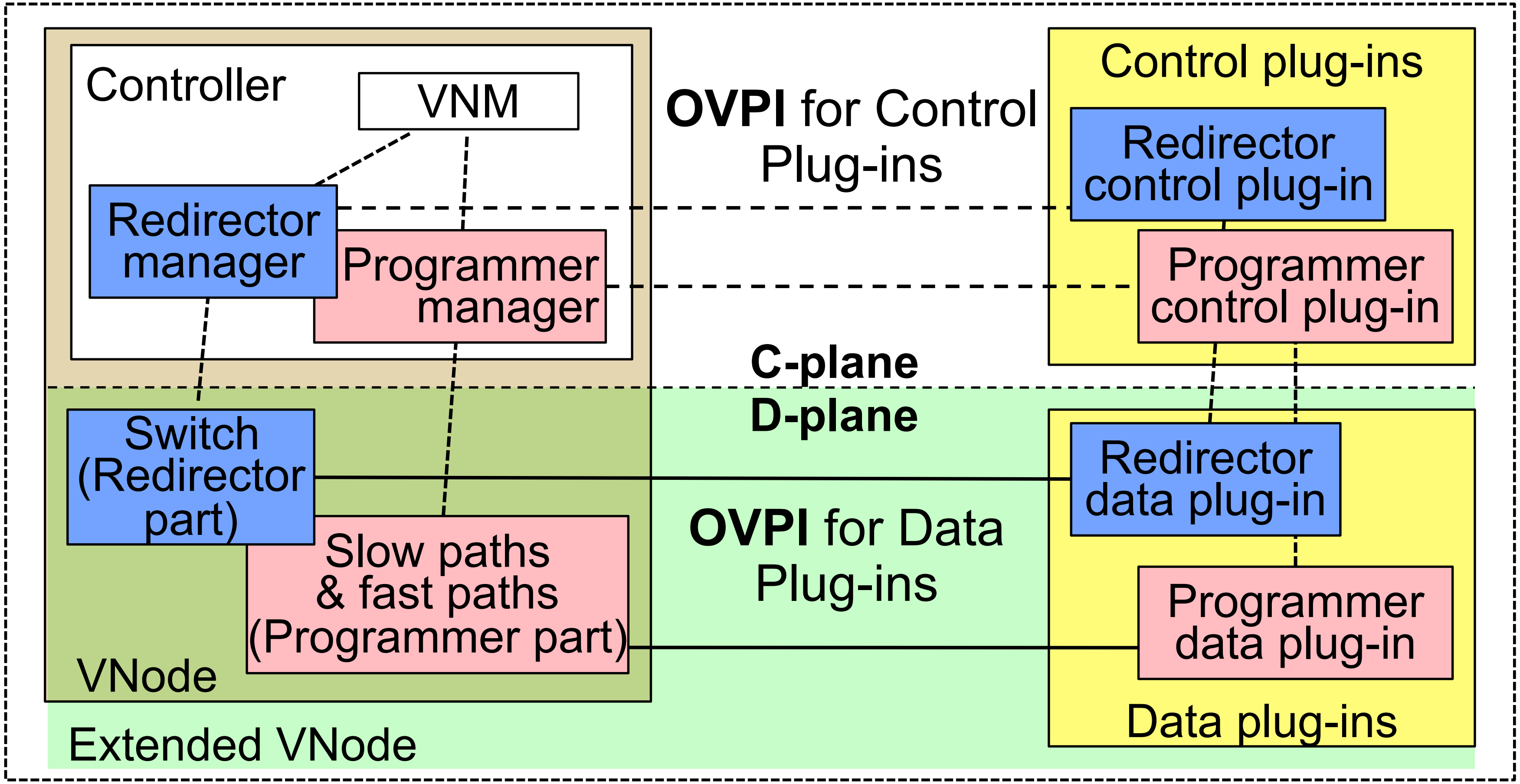
▶ Plug-ins may be placed at logically and physically distant location from VNode.

- **VNode**: in a public testbed, **Plug-ins**: in a private network.



Plug-in Interfaces for Step 1

- ► ***Open VNode plug-in interfaces*** **(*OVPIs*) are defined.**
- ► **Two types of OVPIs: C-plane and D-plane interfaces.**



Design of OVPI for Control Plug-ins

▶ Components of Control OVPI

- **Plug-in host name or address**
  - It specifies the host that contains the plug-in.
  - It is usually a domain name or an IP address.
- **Plug-in identifier**
  - It specifies a plug-in in the host.
- **Parameters**
  - They specify control information including a slice identifiers.

▶ Examples

- CLI of the plug-in host:
  add_link vlan=*id* esmac=*p1* edmac=*p2* ismac=*p3.*
- XML-RPC (connected to the host):

```
<methodCall><methodName>create-slivers</methodName>
 <params>
  <param>
    <linkSliver type=“link” name=“virtual-link-1”>
     <vports>
       <vport name=“vport0“>
         <params><param key="controller" value="plug-in-0-addr" />
                     <param key="port" value="data-plug-in-0-port"/></params></vport>
       <vport name="vport1“> … </vport></vports>
     <params><param key="ExtensionName" value="vlan_link" /></params></linkSliver>...
```

Design of OVPI for Data Plug-ins

- **Components of Data OVPI**
  - **Plug-in channel tag**
    - A host and a plug-in are not specified separately.
    - A tag (such as a VLAN identifier) can specify a collection of plug-ins.
  - **Parameters**
    - They are protocol parameters such as addresses.
    - Some of them can be used for identifying the slice.
- **Examples**
  - A VLAN can be used for the data-plane protocol.
    - Plug-in channel tag: A VLAN identifier.
    - Parameters: Source and destination MAC addresses.
  - GRE/IP can be used for the data-plane protocol.
    - Plug-in tag: A key in the GRE header
    - Parameters: Addresses in the IP header.

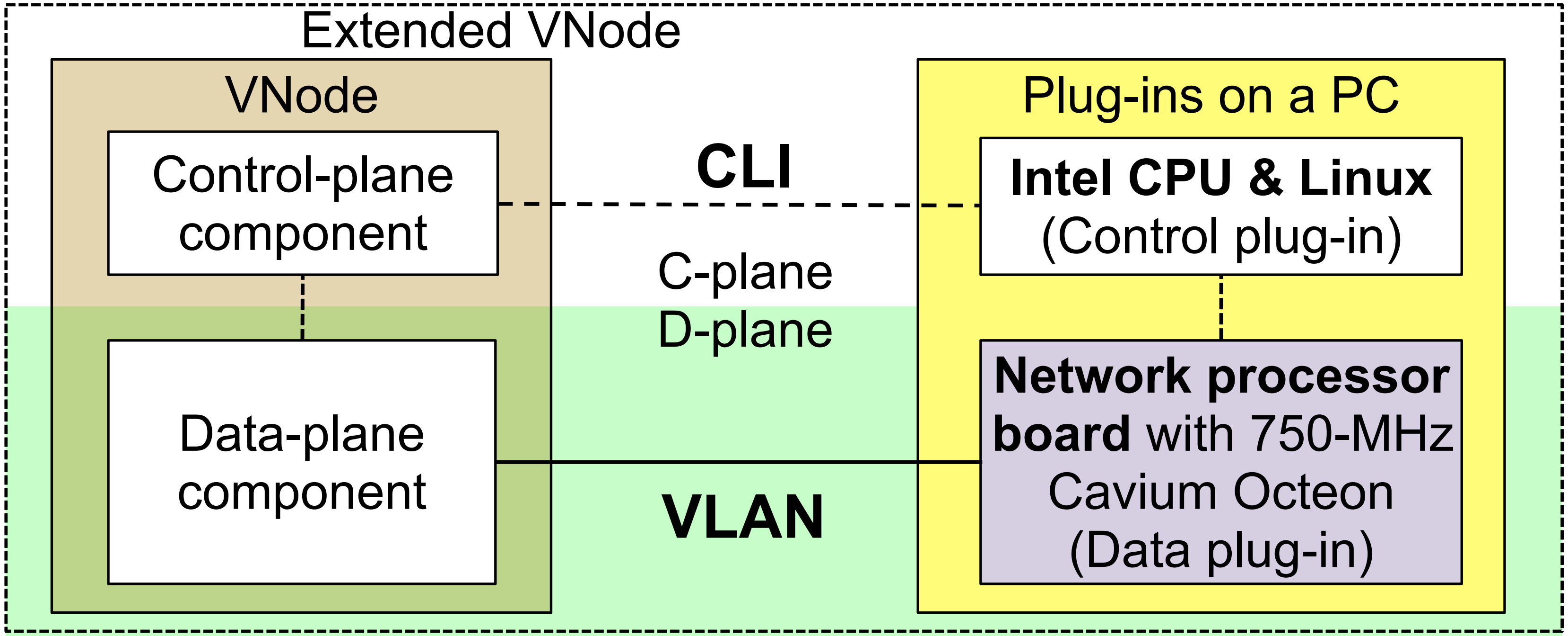
Prototyping & Evaluation: Architecture

▶ Data plug-in and OVPI

- VLAN is used for data OVPI.
- Data plug-in is a network processor (NP) board with Cavium Octeon with a program (software & hardware).

▶ Control plug-in and OVPI

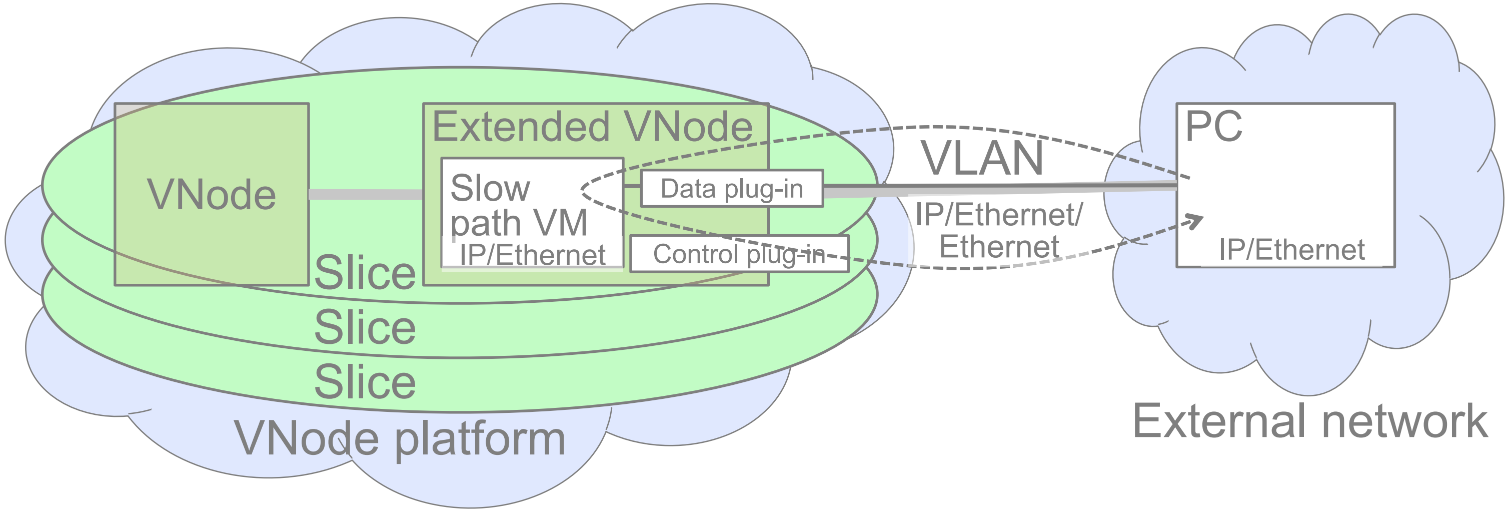
- CLI is used for control OVPI.
- Control plug-in is a Linux PC with a C program.


Extended VNode
VNode
Control-plane component
Data-plane component
CLI
C-plane
D-plane
VLAN
Plug-ins on a PC
Intel CPU & Linux (Control plug-in)
Network processor board with 750-MHz Cavium Octeon (Data plug-in)

Prototyping & Evaluation: Two Sets of Plug-ins

▶ 1: Network accommodation

- It connects a slice to an external network through a VLAN.



- This is a re-implementation of a function supported by the platform.

▶ 2: New type of virtual link

- VNode platform only have a type of GRE-based virtual links.
- A type of VLAN-based virtual links is implemented by using plug-ins.

(to be continued …)

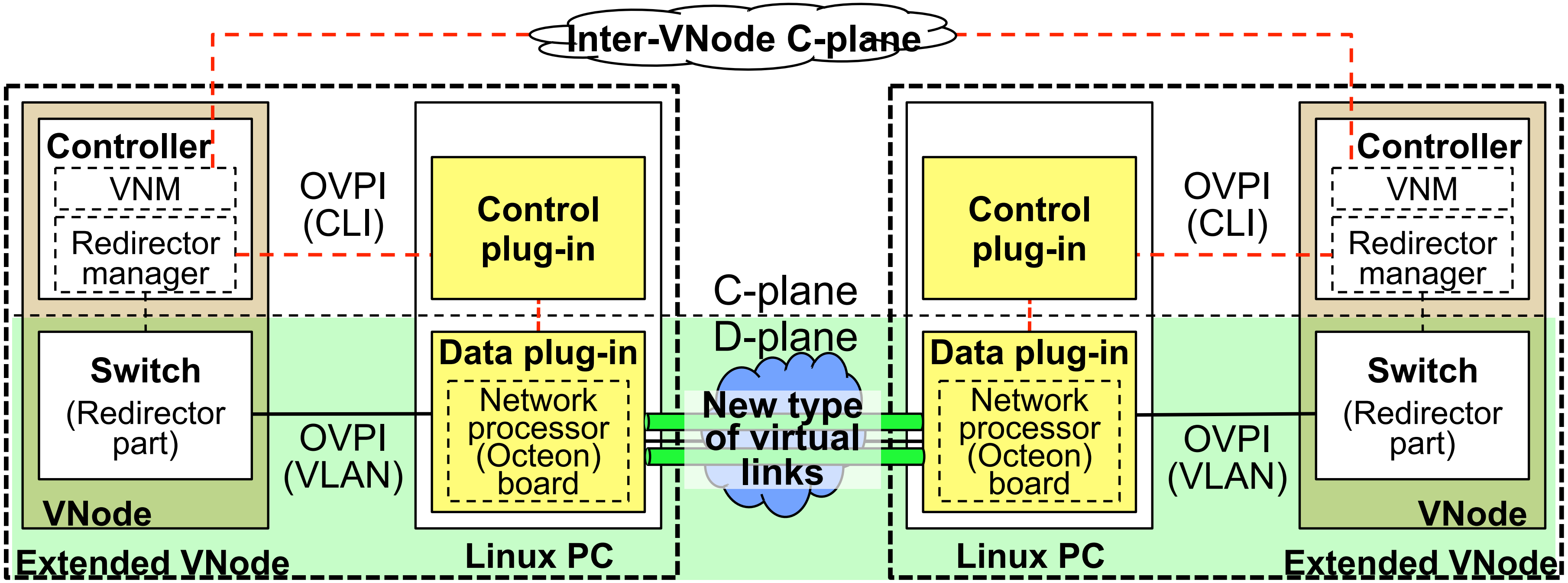
Prototype & Evaluation: VLAN-based Virtual Link

▶ Prototype development

- Two evolving VNodes with plug-ins were developed.
- A new type of virtual links was implemented on the VNodes.
  - Controllers in VNodes “tunnels” control information of data plug-ins.

▶ Evaluation

- A slice with two virtual nodes and a VLAN-based virtual link between the nodes is created.
- The virtual link worked correctly and the throughput was 9 Gbps.



Summary and Future Work

- **A method for evolving VNodes by two steps was proposed.**
  - **Step 1**: Data & control plug-ins, connected to a VNode by OVPIs, are used.
  - **Step 2**: Plug-ins are merged into VNode.
- **Programmer and redirector can be independently evolved using this method.**
  - Only redirector plug-ins has been tested.
- **Prototypes of OVPIs and plug-ins were developed and evaluated.**
  - The evolving redirector can support new types of network accommodation functions and new types of virtual links.
  - The throughput is close to a wire rate of 10 Gbps.
- **Future work**
  - To implement programmer plug-ins.
  - To implement more new types of virtual links (redirector plug-ins).
  - To apply this method to VNodes in Japan-wide testbed, JGN-X.