Extending Network-virtualization Platforms by using a Specialized Packet Header and Node Plug-ins

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Outline

► VNode infrastructure is an architecture and testbed for network virtualization.
  ■ A VNode means a physical network node (not virtual node).
  ■ Developers can create slices (i.e., virtual networks) using predefined virtual-resource types.

► A plug-in architecture for VNode, which was proposed in previous papers, enables introducing new types.
  ■ Slice developers may require new virtual-resource types.
  ■ New virtual-resource types can be defined and implemented by using the plug-in architecture.

  ■ This method enables introducing new network-wide functions by new resource-type and plug-ins without modifying slices.
Developers can create slices using *predefined virtual-resource types* (i.e., virtual-node and -link types).
Plug-in Architecture
(Previously proposed)

▶ New virtual-resource types can be defined and implemented by using the plug-in architecture.

New types

New resource types (new function)
The proposed method enables introducing new network-wide functions by new link-type and plug-ins without modifying slices.
Platform-extension w/o Slice Modification: Method

➤ New functions and co-operation of plug-ins are introduced by resource-type-specific packet headers.

➤ Data plane is extended:

![Diagram showing VNode, Plug-ins, Extended VNode, Base data-plane component, Data plug-in 1, Data plug-in 2, Data plug-in 3, Data plug-in 4, Base platform header, Plug-in header 1, Plug-in header 2, Plug-in header 3, Plug-in header 4, Platform header, Packet on slice, Hidden from slices]
Example of Using Platform-extension:
Network-wide Delay Measurement

► Network-wide delay can be measured without affecting slice design/implementation by using a new link type.

► The plug-in header contains a timestamp.
Problem: Packet Identification in Programmable Slices

► Packets must be identified to track them (i.e., to measure the delay).

► Packet identity depends on the node function.
  ■ Packets may be absorbed, generated, or duplicated by the node program.
Solution: Slice Supplies Packet Id to Plug-ins

► The slice (developer) must define the identity of packets.
  ■ Simple identity: to specify identifier field.
  ■ Generic identity: to specify identity function.

► The plug-in identifies packets.
  ■ It removes and stores a platform header from a packet and restores it to the packet.

\[
id = f(p)
\]
**Evaluation: Conditions**

► A VLAN-based link type with delay measurement function (called MVL type) was introduced.

► The plug-in for MVL type was implemented by using network processors (NPs).
  ■ Cavium Octeon NP with twelve 750-MHz cores was used.

► The delay between two simulated terminals with two VNodes were measured.
  ■ Two terminals were simulated by one PC to avoid synchronization problem.
## Evaluation: Results

### Evaluation results
- Delay: 89 µS (σ = 12 µS) / node.
- Timestamp (TS) handling and header conversion (required for virtual-link processing):

<table>
<thead>
<tr>
<th>Implementation</th>
<th>Throughput (Gbps)*</th>
<th>Program lines</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TS insertion</td>
<td>TS deletion</td>
</tr>
<tr>
<td>NP program (in Phonepl)</td>
<td>10.0†</td>
<td>9.5†</td>
</tr>
<tr>
<td>Xeon program (in C)**</td>
<td>2.3† (4.0††)</td>
<td>2.2† (4.0††)</td>
</tr>
</tbody>
</table>

*Packet size: 1024 B. **Promiscuous mode is used. †No packet loss (< 10^{-6})
††Packet loss ratio = 10^{-3} ‡Comment-only lines are not counted.
Conclusion

► A method for introducing new functions without updating slice implementation is proposed.
  ■ Resource-type-specific (plug-in-specific) packet headers are used.
  ■ The packet headers are processed by the plug-in in each VNode.

► This method was applied to measurements of network edge-to-edge delay.
  ■ A hidden timestamp in each packet is used.
  ■ Timestamps do not affect slices; i.e., slices do not see timestamps.

► A virtual link with delay-measurement function was evaluated.
  ■ The throughput was 10-Gbps (i.e., wire rate).
  ■ The latency was less than 100 µS.

► Future work
  ■ Implementation of other node/link functions.
  ■ Handling multiple plug-in-specific headers.