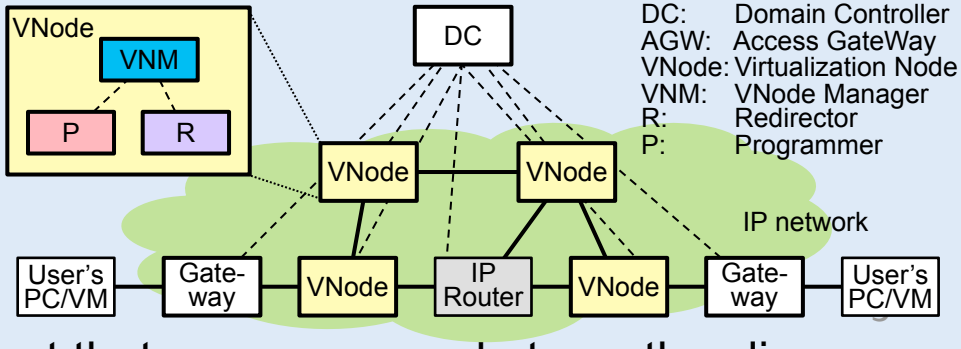
Why NRI and how?

- **Network-resource isolation (NRI) is necessary for network virtualization.**
  - It is important to avoid resource interference between slices (virtual networks) so that a single slice may not disrupt the whole infrastructure.
- **Two methods of NRI based on shaping and policing (QoS mechanisms) have been developed.**
  - **Per-slice shaping (PSS)**
  - **Per-link policing (PLP)**

2 Network Virtualization Platform and VNode

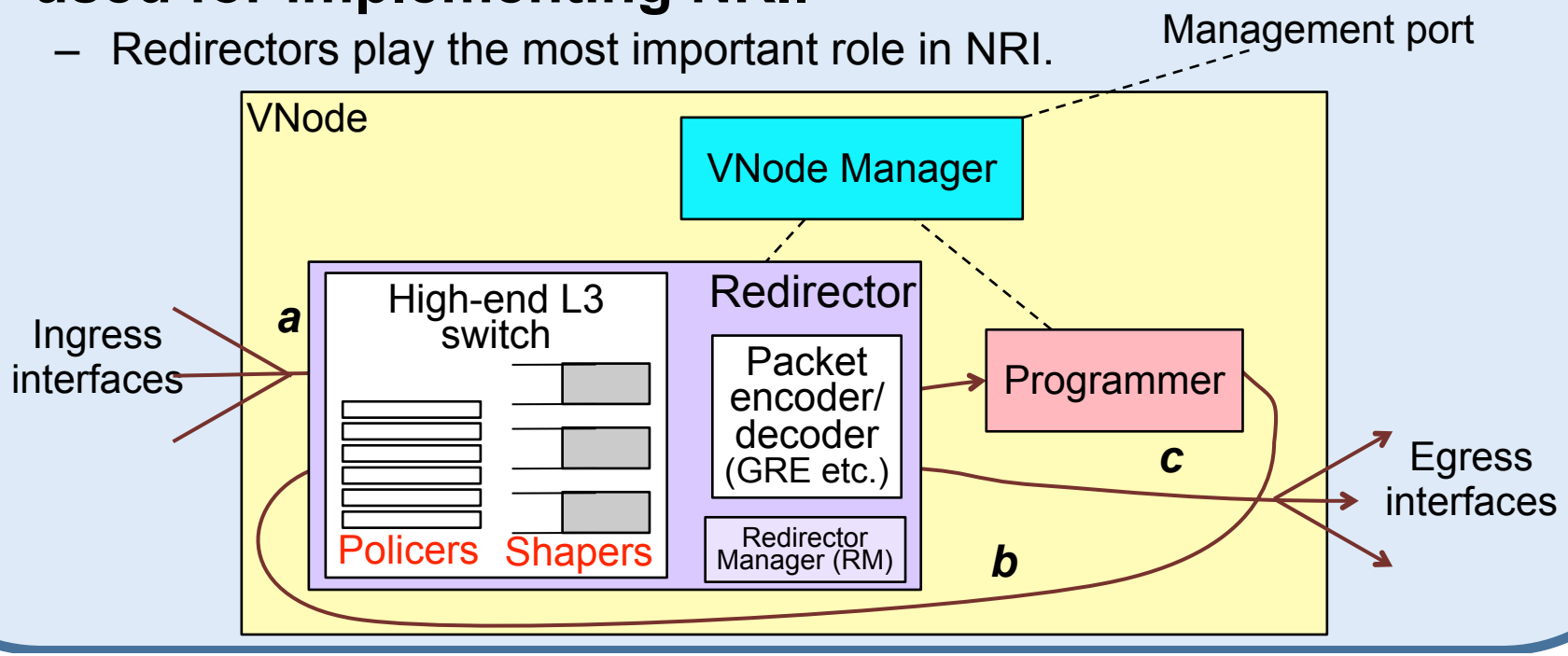
- **Virtualization node project (VNP)**
  - is a project in Japan aims to build virtualization-platform technology and a high-performance virtualization testbed.
- **Virtualization platform in VNP**
  - consists of a domain controller (DC), VNodes, and Gateways.
- **VNode (virtualization node): physical node**
  - forwards packets on the platform. Each packet on the platform contains a virtualized packet on a slice.
  - are connected by tunnels using a protocol such as GRE.



- **VNode consists of**
  - **Programmer**
    - is a programmable component that processes packets on the slices.
  - **Redirector**
    - is a component that can forward or route packets on the platform.
    - forward (redirect) packets from another VNode to a programmer and forward packets from a programmer to another VNode.
  - **VNode Manager**
    - a software component that manages the VNode.

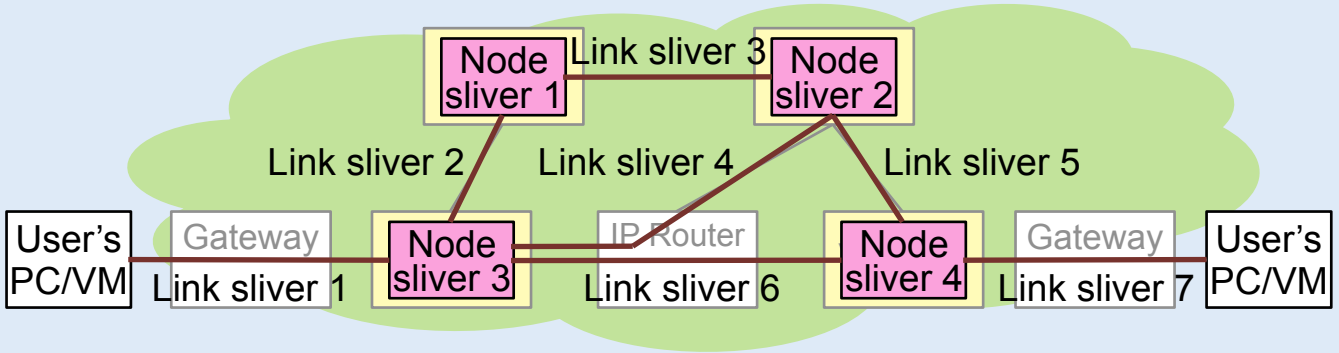
Internal Structure of Redirector in VNode

- **Redirector contains a high-end switch (or router) and a packet encoder/decoder** (such as a GRE encoder/decoder).
- **Packet encoder/decoder exists before/after the programmer.**
  - Decoder converts the VNode-external data format to the internal format.
  - Encoder converts vice versa.
- **High-end switch has policers and shapers that can be used for implementing NRI.**
  - Redirectors play the most important role in NRI.

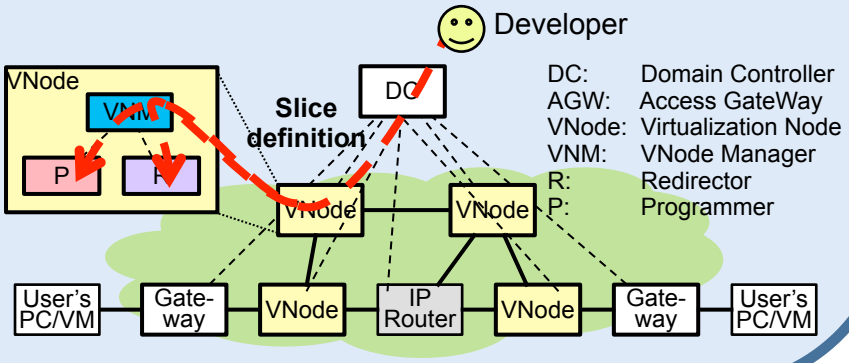


Slices (Virtual Networks) in VNP

- **Two types of slice components**
  - **Node Sliver** (or virtual node)
    - represents computational resources that exist in a VNode.
    - is used for control or protocol processing with an arbitrary packet format.
    - is generated by slicing physical computational resources.
  - **Link Sliver** (or virtual link)
    - represents resources of a virtual link that connects two node slivers.
    - is generated by slicing physical network resources such as bandwidth.

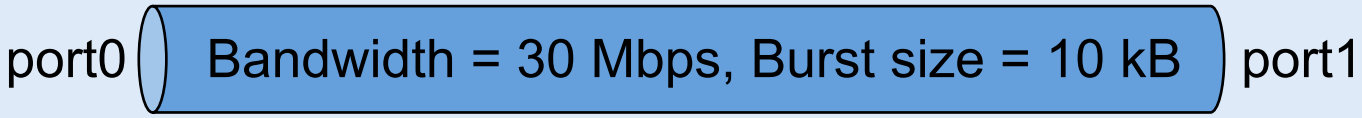


- **Slice definition**
  - is written by a (human) slice developer writes in XML.
  - is sent to DC, distributed to each VNode Manager, and sent to the programmer and the redirector.



Specifications for NRI

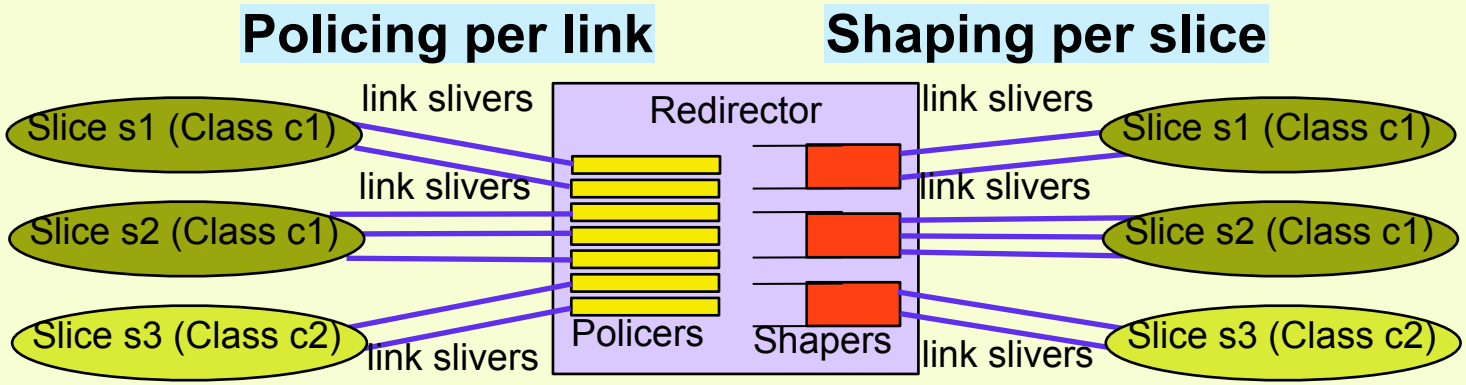
- **Bandwidth (and the burst size) is specified in link slivers.**
- **Example of link sliver specification:**




```
<linkSliver type="link" subtype="GRE" name="LinkSliver1">
    <vports><vport name="port0" /><vport name="port1" />
    </vports>
    <resources>
        <resource key="bandwidth" value="30M" />
        <resource key="burstSize" value="10k" />
    </resources>
</linkSliver>
```

Traffic control functions used for NRI

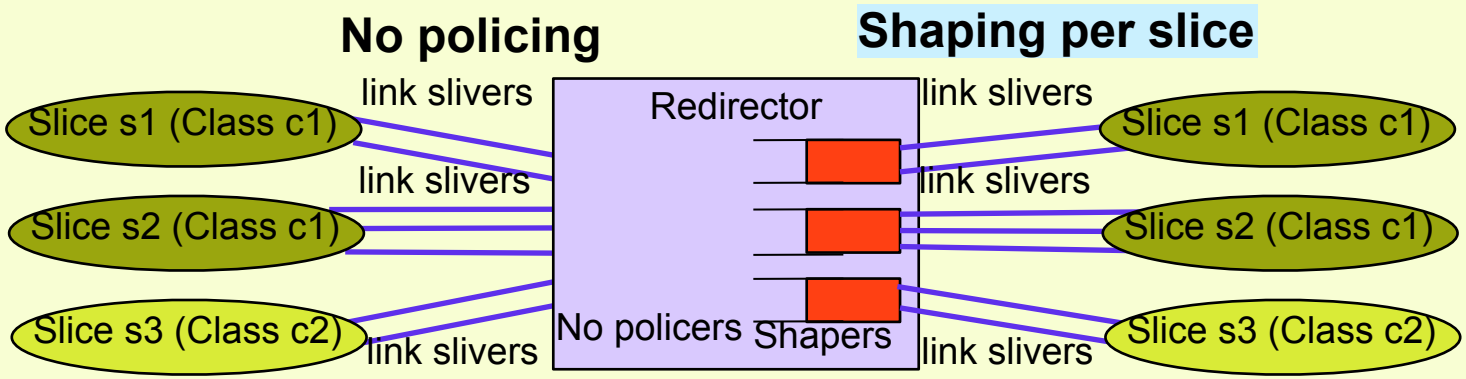
- **Shaping**
  - queues packets, and limits and schedules the egress traffic.
  - delays the packet, and drops it when the queue is filled.
  - is **more expensive and less scalable** than policing (i.e., requires more memory and scheduling overhead).
- **Policing**
  - measures network traffic without accumulating packets and drops packets when the bandwidth (or the burst size) exceeds a limit.
  - can be used for guaranteeing bandwidth of link slivers that shares a queue (i.e., divides bandwidth reserved for a queue to slices).
  - is **less expensive and more scalable** than shaping.



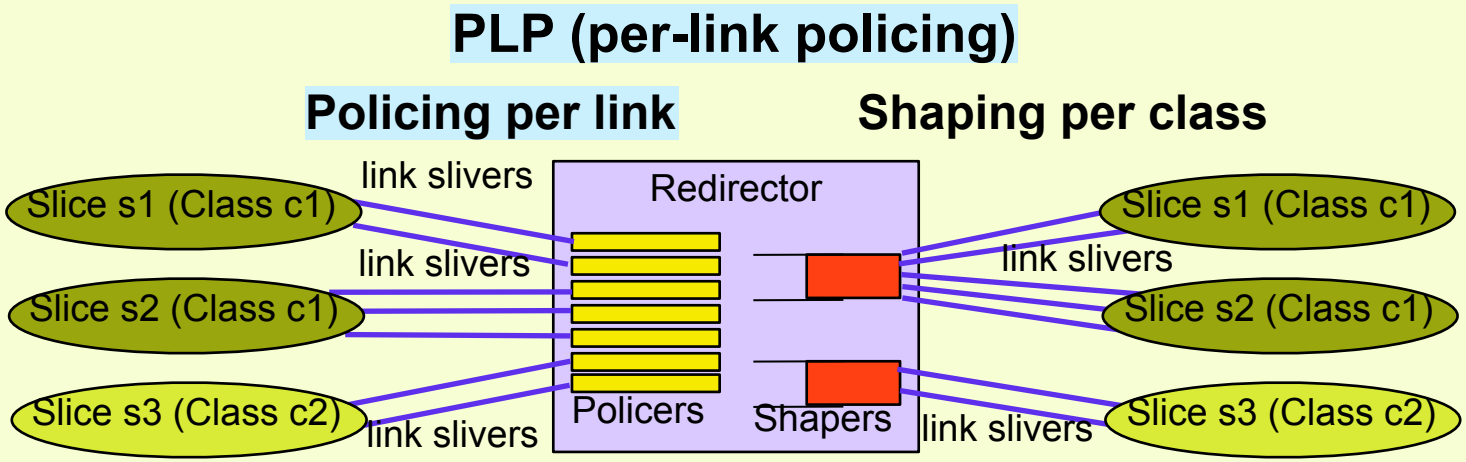
Methods of NRI

- **PSS (Per-slice shaping)**
  - isolates slices by shaping traffic per-slice instead of per-link-sliver (i.e., per-link shaping).
  - does not drop packets (does not use policing).
  - is **sufficient for NRI** between slices but does not guarantee per-link bandwidth.
  - is **more scalable than per-link shaping** (because using 80–90% less queues).

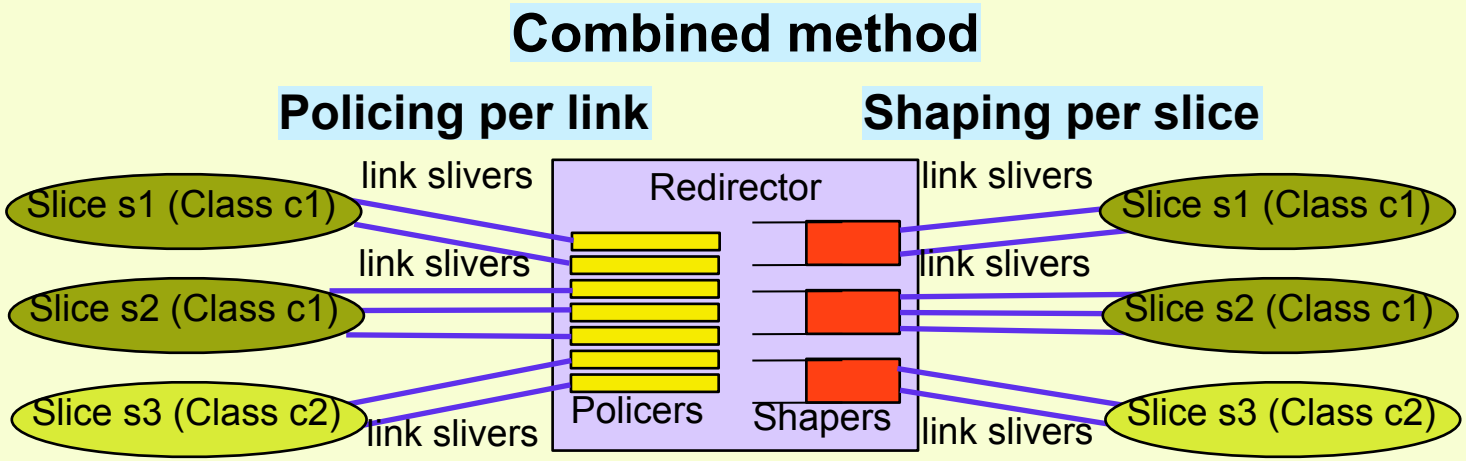
PSS (per-slice shaping)



- **PLP (Per-link policing)**
  - isolates slices by policing traffic per link-sliver.
  - guarantees per-link bandwidth by measuring and dropping packets per link-sliver.
  - uses shaping per slice-class (by per-class shaping).
  - is **more scalable than per-link shaping** (is applicable to tens or hundreds of slices)**.**
  - may be influenced more by other slices than PSS (may be worse in delay and jitter).



- **Combined method (PSS with PLP)**
  - isolates slices by policing traffic per sliver and shaping traffic per slice.
  - is as strict as PSS in isolation from other slices (is good in delay and jitter).
  - guarantees per-link bandwidth.



Implementation and Evaluation

- **Implementation using high-end L3 switches**
  - Three methods for NRI, i.e., PLP, PSS, and the combined method (PSS with PLP) have been implemented.
- **Evaluation of slow-path and fast-path node slivers**
  - Method: Three slices are used: one for foreground traffic to be measured and two for background cross traffic.
  - Result: Slow-path (Linux VM) node slivers

Isolation type	Delay (mS)		Jitter (mS)		Drop ratio	
	Average	Std dev	Average	Std dev	Average	Std dev
PLP	1.60	0.12	0.10	0.01	0	0
PSS	1.30	0.08	0.11	0.02	0	0
Combined	1.33	0.10	0.10	0.01	0	0
No isolation	12.08	4.28	0.12	0.01	0.41	0.05
(Congestion-less)	1.31	0.15	0.12	0.02	0	0

Conditions: Link sliver bandwidth = 100 Mbps, traffic = 90 Mbps. Cross traffic fills the link.

  - Result: Fast-path node sliver (using a network processor)
    - Slices can be isolated when the foreground traffic is 4.0 Gbps or less. (The link bandwidth is 10 Gbps.)

Conclusion

- **Two methods of NRI for virtualization networks are proposed.**
  - PSS enables NRI with 80–90% less queues compared to the per-link shaping.
  - PLP enables less strict isolation between tens or hundreds of slices using only one queue.
- **Evaluations: PSS performs slightly better in terms of delay and packet-drop ratio.**
- **Applications of PSS and PLP:**
  - PSS and the combined method are effective for delay-sensitive services.
  - PLP may be sufficiently used for the other types of services.

Network-resource Isolation for Virtualization Nodes

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Introduction

What are VNP, VNodes, and Slices?

Methods of NRI