

Realizing Network Slices in IP/MPLS Networks

draft-bestbar-teas-ns-packet-00

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Agenda

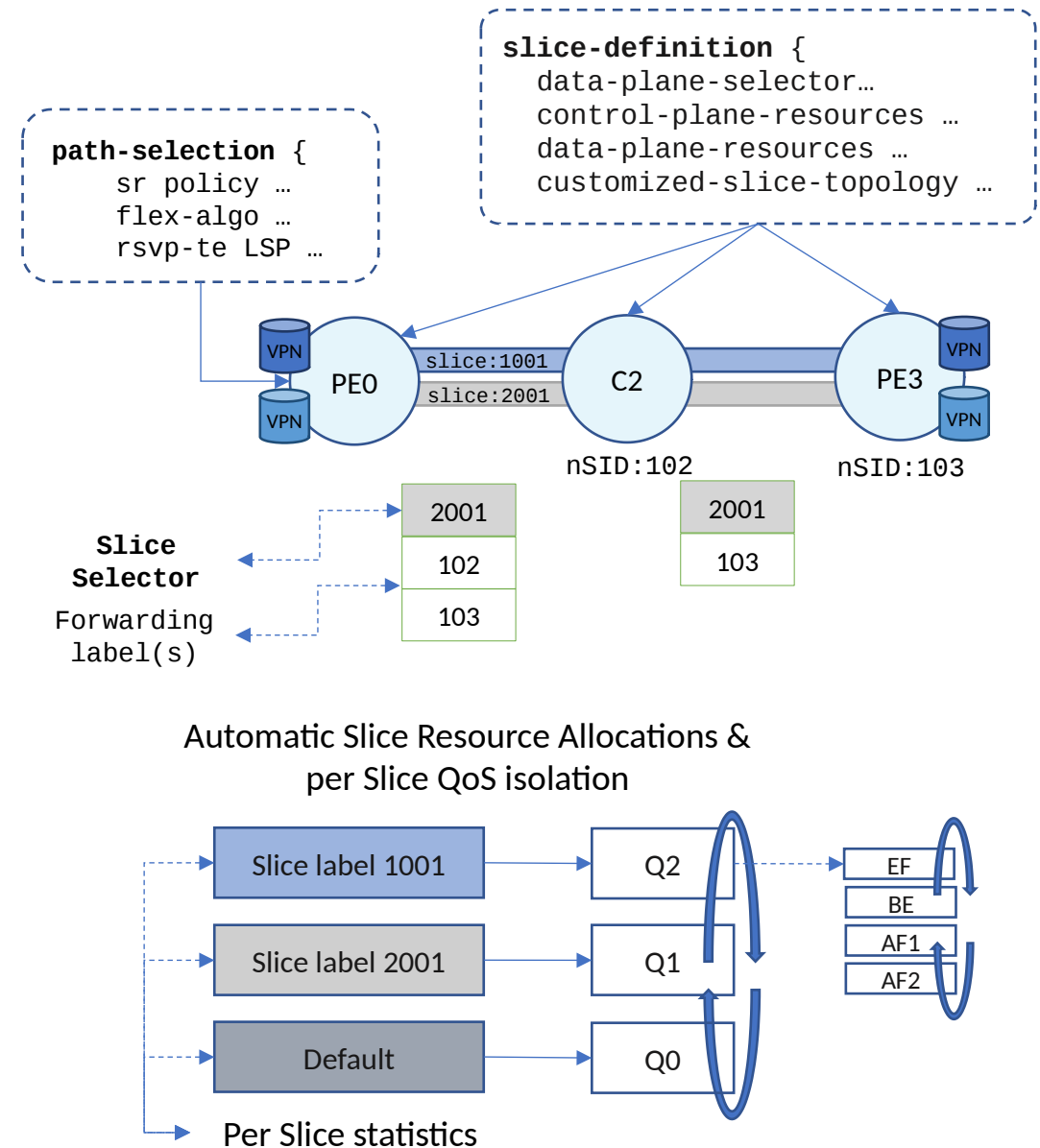
- Introduction
- Slice Per Hop Definition
- Solution approaches
- Next Steps

Introduction

- Solution to realize network slicing in IP/MPLS networks
 - Based on DiffServ principles
 - Slicing from a device and network resource level perspective
 - Ensure proper placement of paths and respective treatment of traffic traversing network slice resources
 - Agnostic to the path control technique used in the network slicing domain
- Multiple network slices can be realized on top of a shared physical IP/MPLS infrastructure network
 - Dynamically created and managed
- Traffic traversing shared network resources may require specific treatment to meet target SLOs
 - A Slice Selector within a packet identifies slice traffic
 - Device specific slice resources instantiated on-demand: Slice Queues and Slice PHB
- Placement of traffic on slice resources optimized based on network slice resource utilization
 - Slice-aware TE
- Differentiation of traffic within same network slice is also possible
 - Diffserv Class Selector (CS) in the packet distinguishes traffic within same slice

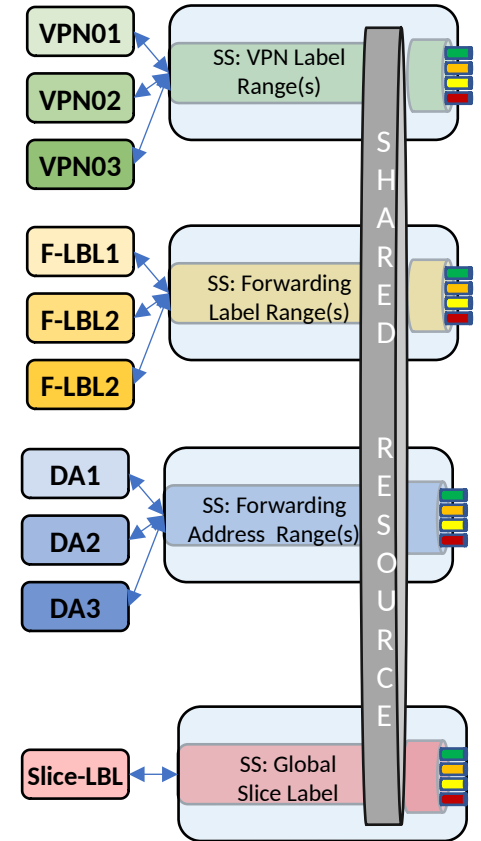
Solution Overview

- Approaches to network resource slicing:
 - Control plane slicing, Data plane slicing, mix of Control and Data plane slicing
 - Hybrid options possible
- An integral Slice Per Hop Definition, encompassing:
 - Data plane Slice Selector
 - Data plane resources (H-QoS PHBs)
 - Control plane resources (bandwidths, priorities, shared-resource groups)
 - Slice specific topology facilitating Slice aware TE
- Multiple options for Slice Per Hop Definition dissemination
 - Programmed via Netconf/gRPC interface(s)
 - Exchanged in IGP and/or BGP
 - Configured directly on device(s)
- Multiple options for path selection and control techniques within a Slice (SR Policy, Flex-algo, RSVP-TE LSP, ...)



Slice Per-Hop Definition (1/2)

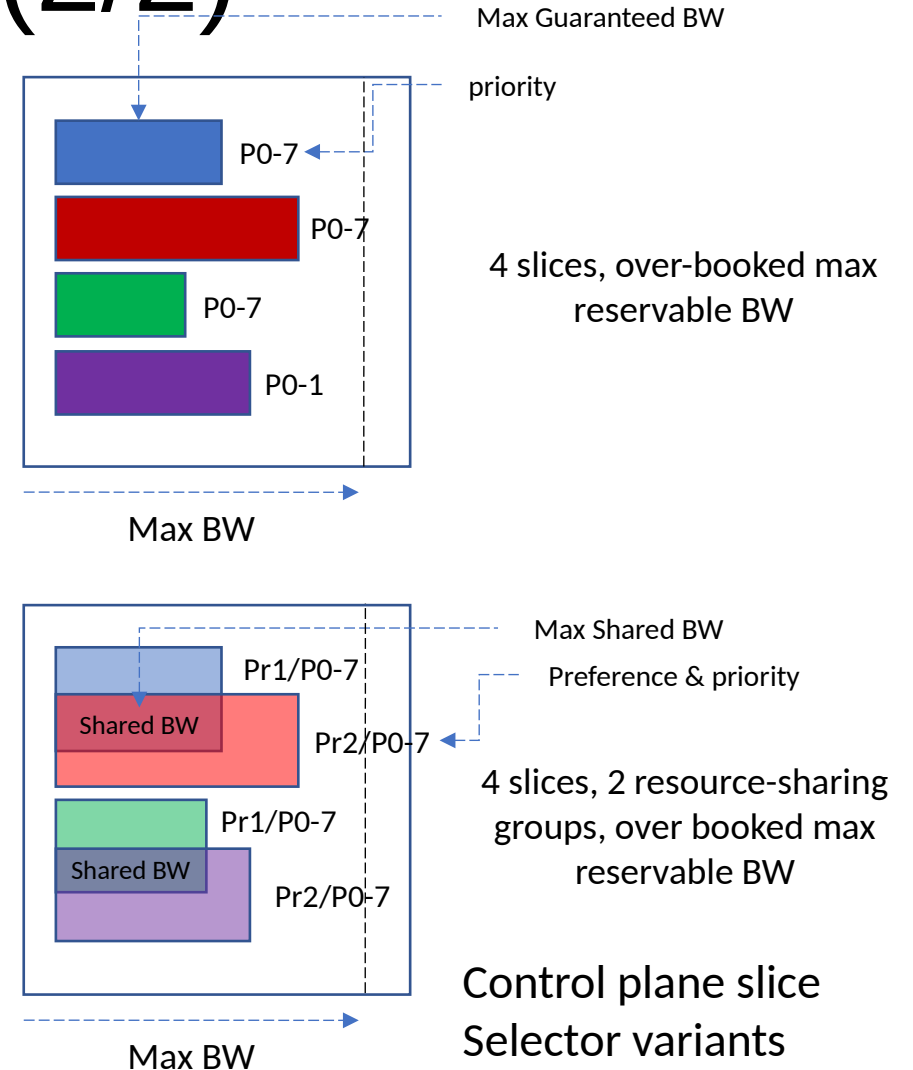
- Data plane Slice Selector
 - A range of MPLS forwarding labels (for each destination) mapping to a Slice
 - A range of MPLS VPN service labels mapping to a single Slice
 - A single Global label mapping to a Slice
 - A set of IP destinations mapped to a slice
 - A multi-field packet selector
- Data plane resources (H-QoS PHBs)
 - A Slice QoS profile or a reference to device local profile
 - Different profiles to multiple interfaces possible



Data plane Slice Selector variants

Slice Per-Hop Definition (2/2)

- Control-plane resources management
 - Slice-aware Bandwidth Engineering
 - Preference-based preemption of Slice-aware TE paths
 - Resource sharing
 - Protection
- Slice topology for Slice aware TE
 - Slice Membership: Topological elements (link/node) participating in a slice
 - Single Topology can cater to multiple slices

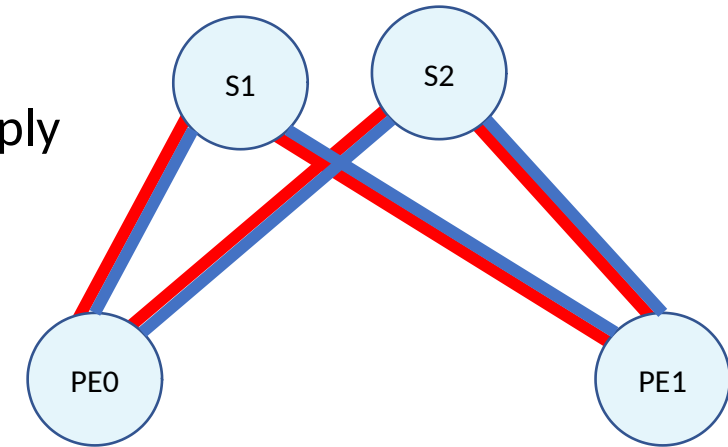




Slicing uses transport or Slice label
inferred PHB

Data plane only network slicing

- Data plane network resource slicing
 - Slice Selector – identifies packets belonging to a specific slice
 - Per slice CoS profile is applied on participating links and nodes
 - Transit nodes classify incoming traffic (e.g. using Slice label) and apply per slice scheduling
- Control plane
 - No control plane awareness of slice resources
 - No slice-aware path placement/TE
- Use-case
 - Suitable when no BW engineering is required and ECMP is leveraged between endpoints (e.g. Spine/Leaf deployment)
 - Does not address all network slice SLOs being standardized at IETF

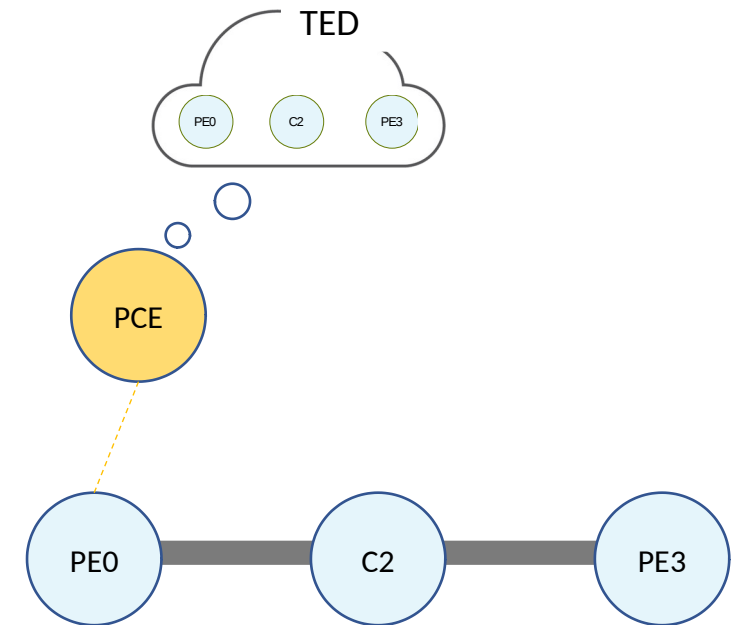


— RED slice is 50% of each link
— GREEN slice is 50% of each link



Control plane only network slicing

- Control plane network resource slicing
 - Link resources are sliced in control plane
 - Per slice link maximum and available BW
 - Ingress router/PCE forms per slice TED using the link-state
 - Slice-aware path computation and path placement
 - CSPF uses the slice aware TED to select optimal TE path
 - Control plane preemption in case of contention on a specific link resource
 - In case of degradation of LAG, control plane can preempt LSP(s) to avoid congestion
- Data plane
 - No per slice classification of traffic or per slice PHB on transit routers
 - Policing can happen on slice incoming traffic

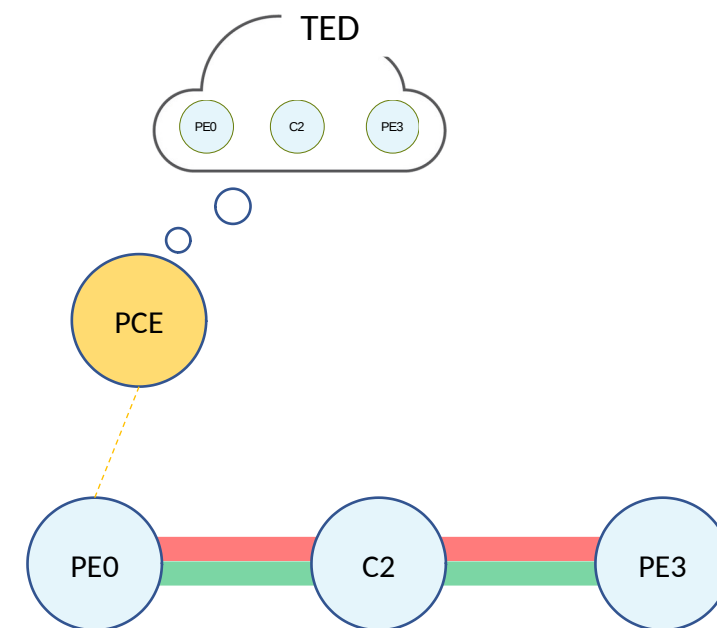


Simple, consistent, 4-8Q
PHBs may still be deployed



Control and data plane network slicing

- Control plane and data plane network slicing
 - Combination of the previous two
 - Slice-aware TE enables ingress/PCE to do proper placement of LSPs based on per slice link available BW
 - Data plane Per-Hop Behavior on transit nodes provides guarantees in case of congestion on a link
 - Covers strict and shared resource slice isolation requirements



Next Steps

- Slice-aware TE
 - Protocol Extensions -- Coordination with relevant drafts
- Request review and feedback

YANG Data Model for Network Slice Per-Hop Definition

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Overview

- YANG data model for programming Network Slice Per Hop Definition (Slice-PHD) on IP/MPLS devices
 - Multiple Slice Selector options
 - Flexible and hierarchical Slice PHB(s)
 - Covers resource management in control plane and data plane
 - Mapping of a slice to a logical topology

Network Slice Per Hop Definition Model

Model Structure

```
module: ietf-network-slice-phd
  +--rw network-slicing!
    +--rw network-slice-phbs
      | +--rw network-slice-phb* [id]
      | .....
    +--rw network-slices
      +--rw network-slice* [name]
        | .....
        +--rw slice-resource-reservation
          | .....
        +--rw slice-selectors
          | +--rw slice-selector* [id]
          | .....
        +--rw slice-phb? ns-phb-ref
          | .....
        +--rw slice-membership
          | .....
```

Slice-PHDs

network-slices container

▪ Key elements

- Slice Resource Reservation
- Slice Selectors
- Slice PHB
- Slice Membership

Slice-PHBs

network-slice-phbs container

- Referenced by Slice-PHDs

Network Slice Per Hop Definition Model

Slice Per-Hop-Behaviors

```
+--rw network-slice-phbs
|  +--rw network-slice-phb* [id]
|    +--rw id                               uint16
|    +--rw (profile-type)?
|      +--:(profile)
|        |  +--rw profile?                  string
|        +--:(custom-profile)
|        .....
|
```

Slice-PHBs container (network-slice-phbs)

- Carries a list of Slice-PHB entries
- Slice-PHB entry
 - Referenced by one or more Slice-PHD
 - Options:
 - Reference to a generic PHB profile
 - Custom PHB profile

Network Slice Per Hop Definition Model

Slice Resource Reservation

```
+--rw slice-resource-reservation
| +--rw preference?                               uint16
| +--rw (max-bw-type)?
| | +--:(bw-value)
| | | +--rw maximum-bandwidth?                   uint64
| | +--:(bw-percentage)
| |   +--rw maximum-bandwidth-percent?
| |     rt-types:percentage
| +--rw shared-resource-groups*                   uint32
| +--rw protection
|   +--rw backup-slice-id?                         uint32
|   +--rw (backup-bw-type)?
|     +--:(backup-bw-value)
|     | +--rw backup-bandwidth?                   uint64
|     +--:(backup-bw-percentage)
|       +--rw backup-bandwidth-percent?
|         rt-types:percentage
```

slice-resource-reservation Container

- Slice-aware Bandwidth Engineering
- Preference-based preemption of Slice-aware TE paths
- Sharing of resources amongst a group of slices
- Slice Protection

Network Slice Per Hop Definition Model

Slice Selectors

```
+--rw slice-selectors
| +--rw slice-selector* [id]
|   +--rw id          uint16
|   +--rw mpls
|     +--rw (ss-mpls-type)?
|       +--:(label-value)
|         +--rw label?
|           |
|           | rt-types:mpls-label
|           +--rw label-position?      identityref
|           +--rw label-position-offset? uint8
|       +--:(label-ranges)
|         +--rw label-range* [index]
|           +--rw index                string
|           +--rw start-label?
|             |
|             | rt-types:mpls-label
|             +--rw end-label?
|               |
|               | rt-types:mpls-label
|               +--rw label-position?
|                 |
|                 | identityref
|               +--rw label-position-offset? uint8
|   +--rw ipv4
|     +--rw destination-prefix* inet:ipv4-prefix
|   +--rw ipv6
|     +--rw (ss-ipv6-type)?
|       +--:(ipv6-destination)
|         +--rw destination-prefix*
|           |
|           | inet:ipv6-prefix
|         +--:(ipv6-flow-label)
|           +--rw slid-flow-labels
|             +--rw slid-flow-label* [slid]
|               +--rw slid          inet:ipv6-flow-label
|               +--rw bitmask?     uint32
|   +--rw acl-ref* ns-acl-ref
```

slice-selectors Container

- Set of data plane field selectors
- Slice Selector (SS)
 - Identify packets belonging to the given network slice
 - 16-bit ID
 - SS with the lowest ID is the default used by all the topological elements that are members of the given network slice
 - Other entries are used to override the default on select topological elements

Network Slice Per Hop Definition Model

Slice Membership

```
+--rw slice-membership
  +--rw filter-policies
    +--rw filter-policy* [id]
      +--rw id
        |      uint16
      +--rw (filter-type)?
        | +--:(topology-ref)
        | | +--rw (topo-ref-type)?
        | |   +--:(algo-id)
        | |   | +--rw algo-id?                uint8
        | |   +--:(te-topo-id)
        | |     +--rw te-topology-identifier
        | |       +--rw provider-id?   te-global-id
        | |       +--rw client-id?    te-global-id
        | |       +--rw topology-id?
        | |         te-topology-id
        | +--:(custom-topology)
        | +--rw include
        | | +--rw link-affinity*   string
        | | +--rw link-name*      string
        | | +--rw node-prefix*    inet:ip-prefix
        | | +--rw as*             inet:as-number
        | +--rw exclude
        | | +--rw link-affinity*   string
        | | +--rw link-name*      string
        | | +--rw node-prefix*    inet:ip-prefix
        | | +--rw as*             inet:as-number
      +--rw slice-selector?
        |      ns-ss-ref
      +--rw slice-phb?
        |      ns-phb-ref
```

slice-membership Container

- Set of filtering policies
 - Determine which topological elements belong the specific network slice
- Filtering Policy
 - Reference a predefined topology (or)
 - Specify rules to construct customized topology
- Slice members can optionally override the default Slice-PHB and/or the default slice selector.

Next Steps

- Request review and feedback