



Segment Routing MPLS data plane

Clarence Filsfils
Kris Michielsen

Segment Routing – MPLS data plane

- Segment Routing leverages existing MPLS data plane
- How to verify Segment Routing MPLS forwarding

Segment Routing MPLS Data Plane

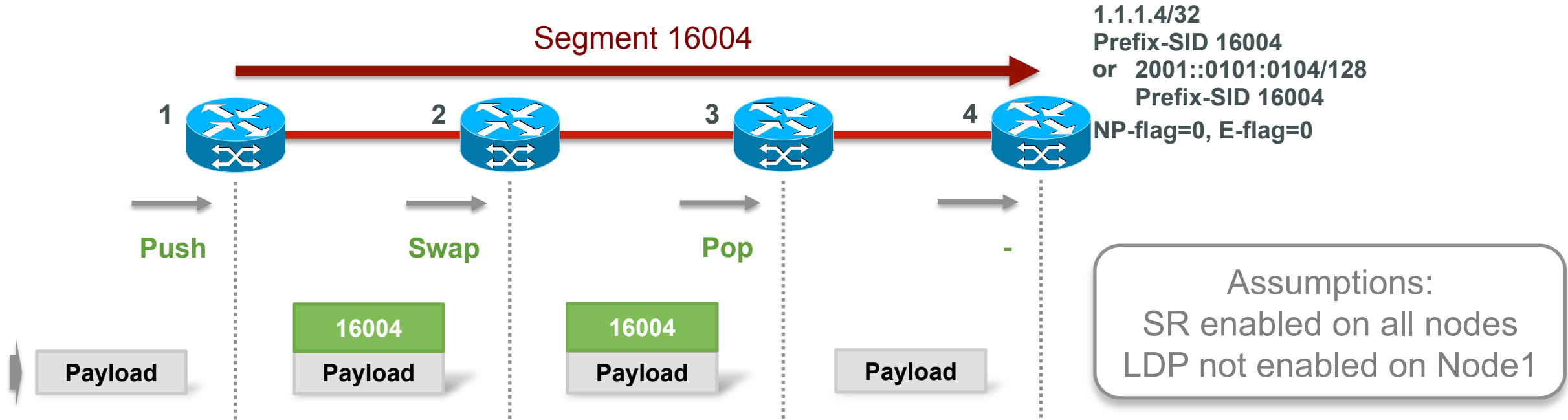
MPLS Data Plane Operations

- Segment Routing uses the **existing MPLS data plane**
 - Segment → label
 - Segment list → label stack
- Uses Penultimate Hop Popping (PHP) and Explicit-Null functionalities
 - Default: PHP is enabled
 - Explicit-Null label can be enabled if needed

MPLS Data Plane Operations

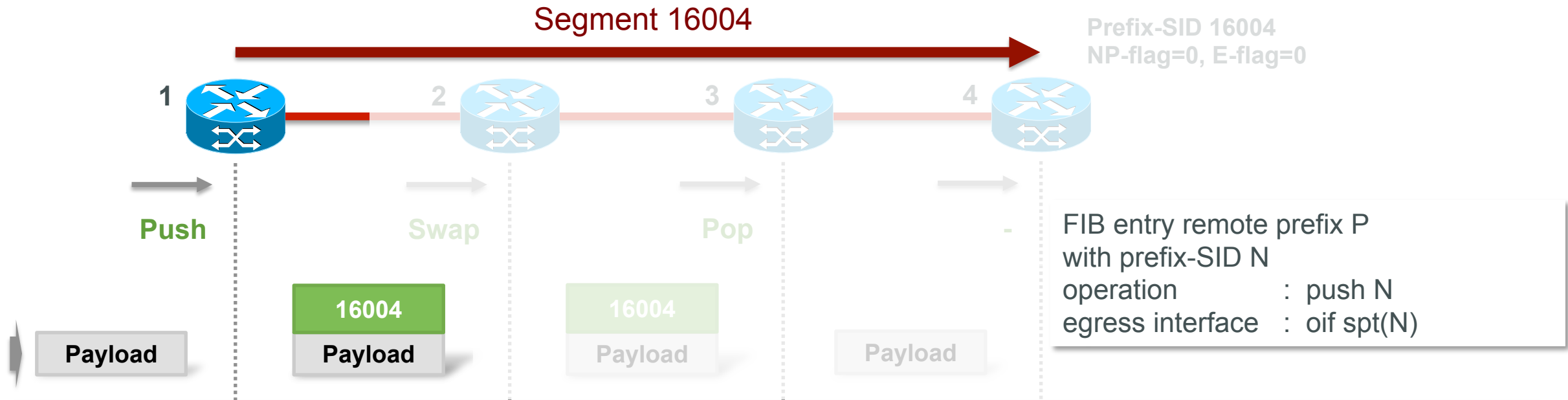
- A node imposes a prefix-SID label on a packet if:
 - The destination itself, or the next-hop that the destination resolves on, matches a FEC with a Prefix-SID
 - The downstream neighbor is SR enabled
 - The node is configured to prefer SR label imposition or the matching FEC (see above) does not have an associated LDP label

MPLS Data Plane Operations



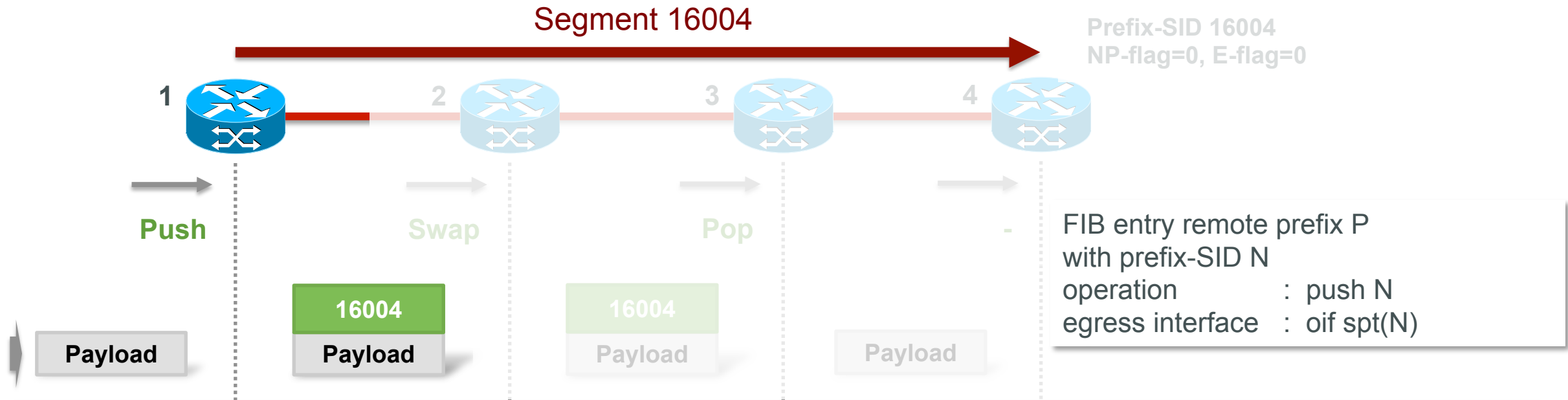
- Node4 advertises its loopback ipv4 prefix 1.1.1.4/32 with attached prefix-SID 16004
 - Or node4 advertises ipv6 prefix 2001::0101:0104/128 with attached prefix-SID 16004
- Node4 requests the default PHP functionality (noPHP-flag=0, ExpNull-flag=0)

MPLS Data Plane Operations – push label



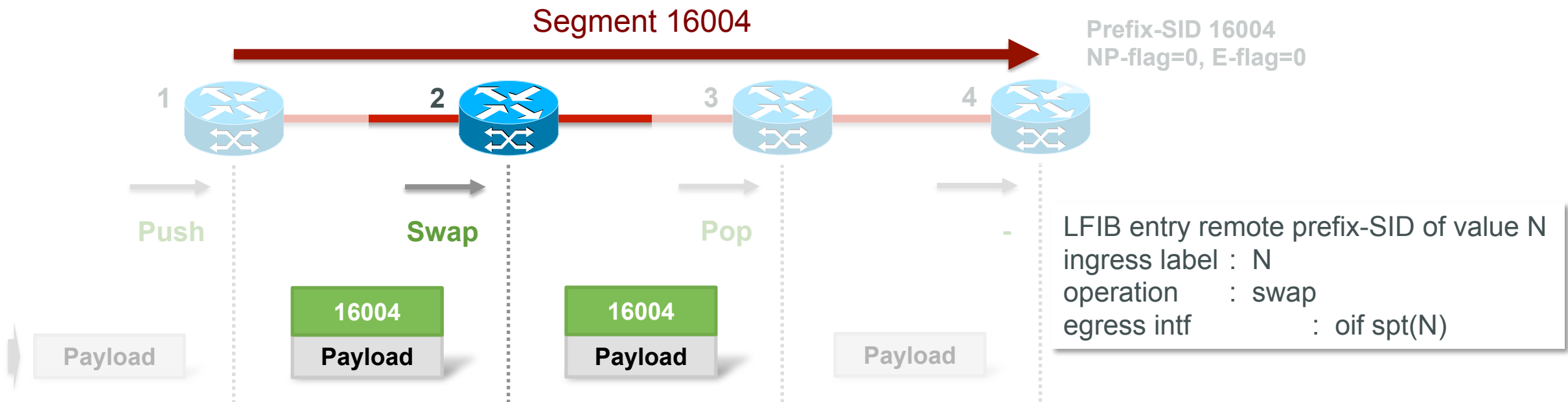
```
RP/0/0/CPU0:Node1#show cef 1.1.1.4/32
1.1.1.4/32, version 277, internal 0x4004001 0x0 (ptr 0xacce39a4) [1], 0x0 (0xaccde760), 0x450 (0xacd8b58)
local adjacency 10.0.0.2
Prefix Len 32, traffic index 0, precedence n/a, priority 1
via 99.1.2.2, GigabitEthernet0/0/0/0, 5 dependencies, weight 0, class 0 [flags 0x0]
path-idx 0 NHID 0x0 [0xacbb3bf0 0x0]
next hop 99.1.2.2
local adjacency
local label 16004          labels imposed {16004}
```

MPLS Data Plane Operations – push label



```
RP/0/0/CPU0:Node1#show cef ipv6 2001::0101:0104/128
2001::101:104/128, version 809, internal 0x1000001 0x1 (ptr 0xa138ad74) [1], 0x0 (0xa1355878), 0xa28 (0xa14db3e0)
local adjacency fe80::f816:3eff:fe01:7de8
Prefix Len 128, traffic index 0, precedence n/a, priority 15
via fe80::f816:3eff:fe01:7de8, GigabitEthernet0/0/0/0, 7 dependencies, weight 0, class 0 [flags 0x0]
path-idx 0 NHID 0x20009 [0xa0c8e7c4 0x0]
next hop fe80::f816:3eff:fe01:7de8
local adjacency
local label 16004 labels imposed {16004}
```

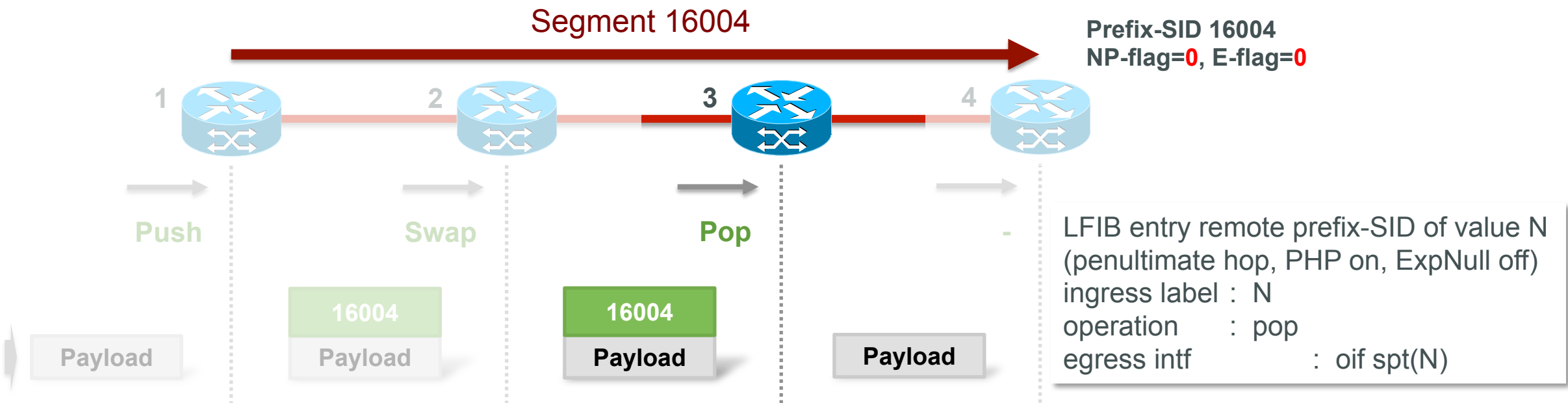

MPLS Data Plane Operations – swap label



```
RP/0/0/CPU0:Node2#show mpls forwarding labels 16004
```

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
16004	16004	SR Pfx (idx 4)	Gi0/0/0/1	99.2.3.3	0

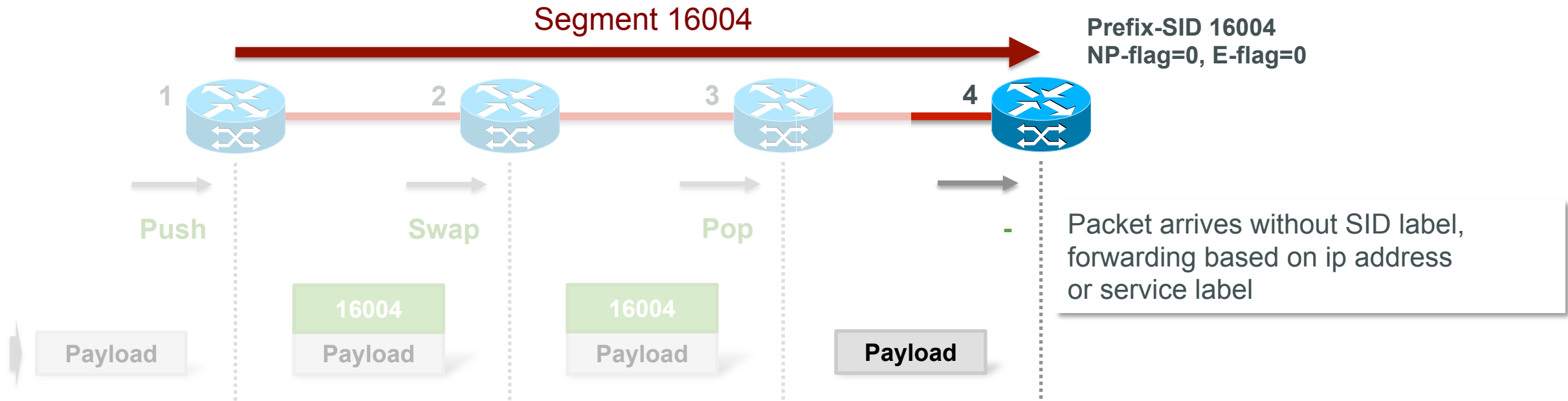
MPLS Data Plane Operations – pop label



```
RP/0/0/CPU0:Node3#show mpls forwarding labels 16004
```

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
16004	Pop	SR Pfx (idx 4)	Gi0/0/0/1	99.3.4.4	0

MPLS Data Plane Operations



MPLS Data Plane Operations – Explicit-Null

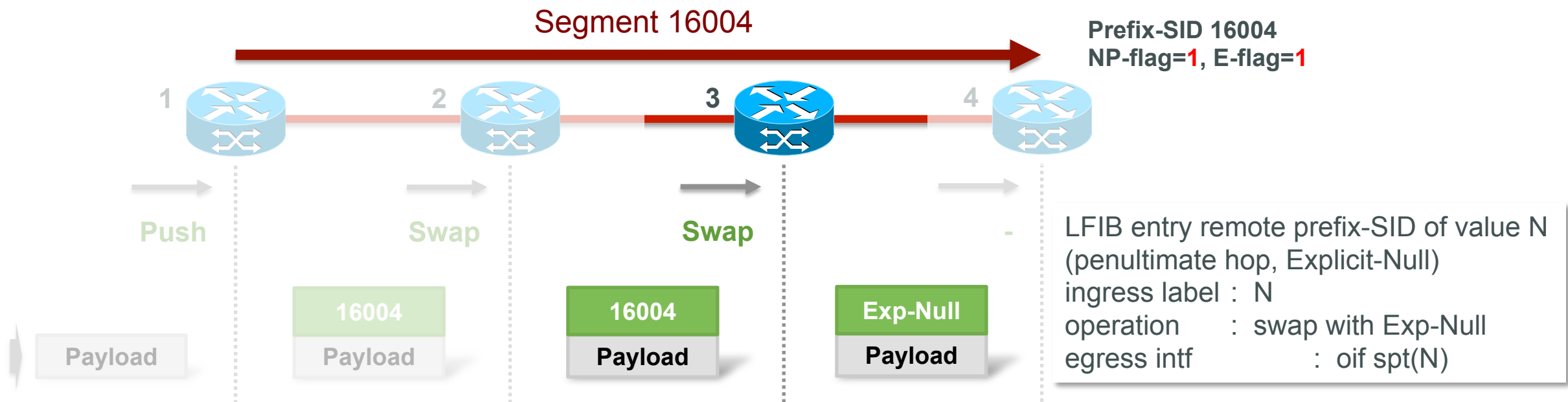
- Explicit-Null behavior is configurable for a prefix-SID
 - If the originator of a Prefix-SID wants to receive the packet with the original EXP/TC bits (e.g. QoS pipe model), he can set the E-flag in the Prefix-SID. This causes the penultimate-hop to swap the prefix-SID with explicit-null (hence preserving the EXP/TC) instead of popping the Prefix-SID
- To set the E-flag on a locally originated Prefix-SID:

```
router isis 1
 interface Loopback0
  address-family ipv4 unicast
   prefix-sid absolute 16001 explicit-null
```



- See “SR IGP Control Plane” slides for more info

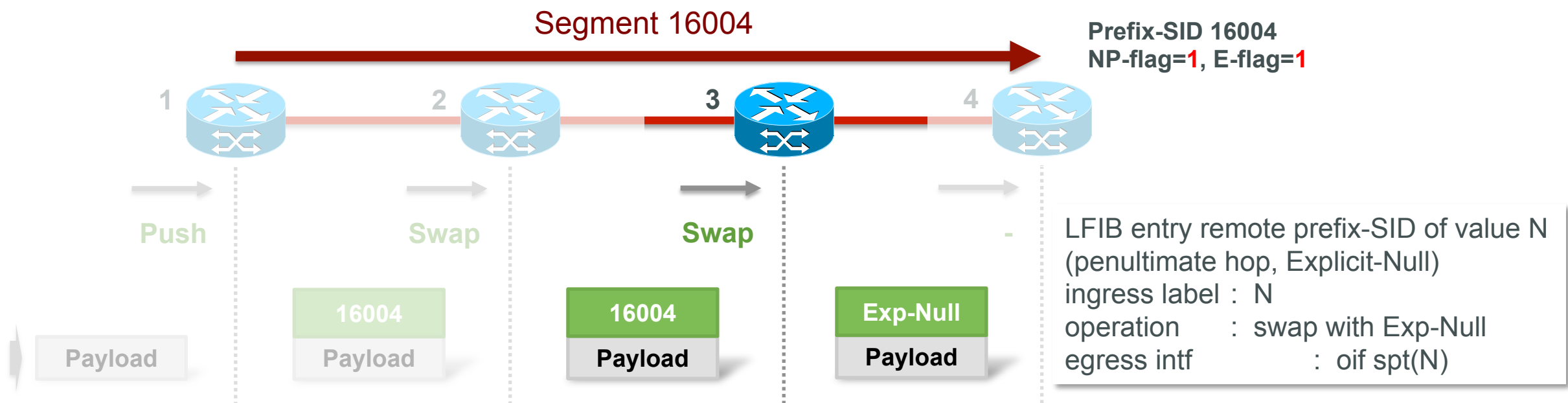
MPLS Data Plane Operations – Explicit-Null



```
RP/0/0/CPU0:Node3#show mpls forwarding labels 16004
```

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
16004	Exp-Null-v4	SR Pfx (idx 4)	Gi0/0/0/1	99.3.4.4	0

MPLS Data Plane Operations – Explicit-Null label

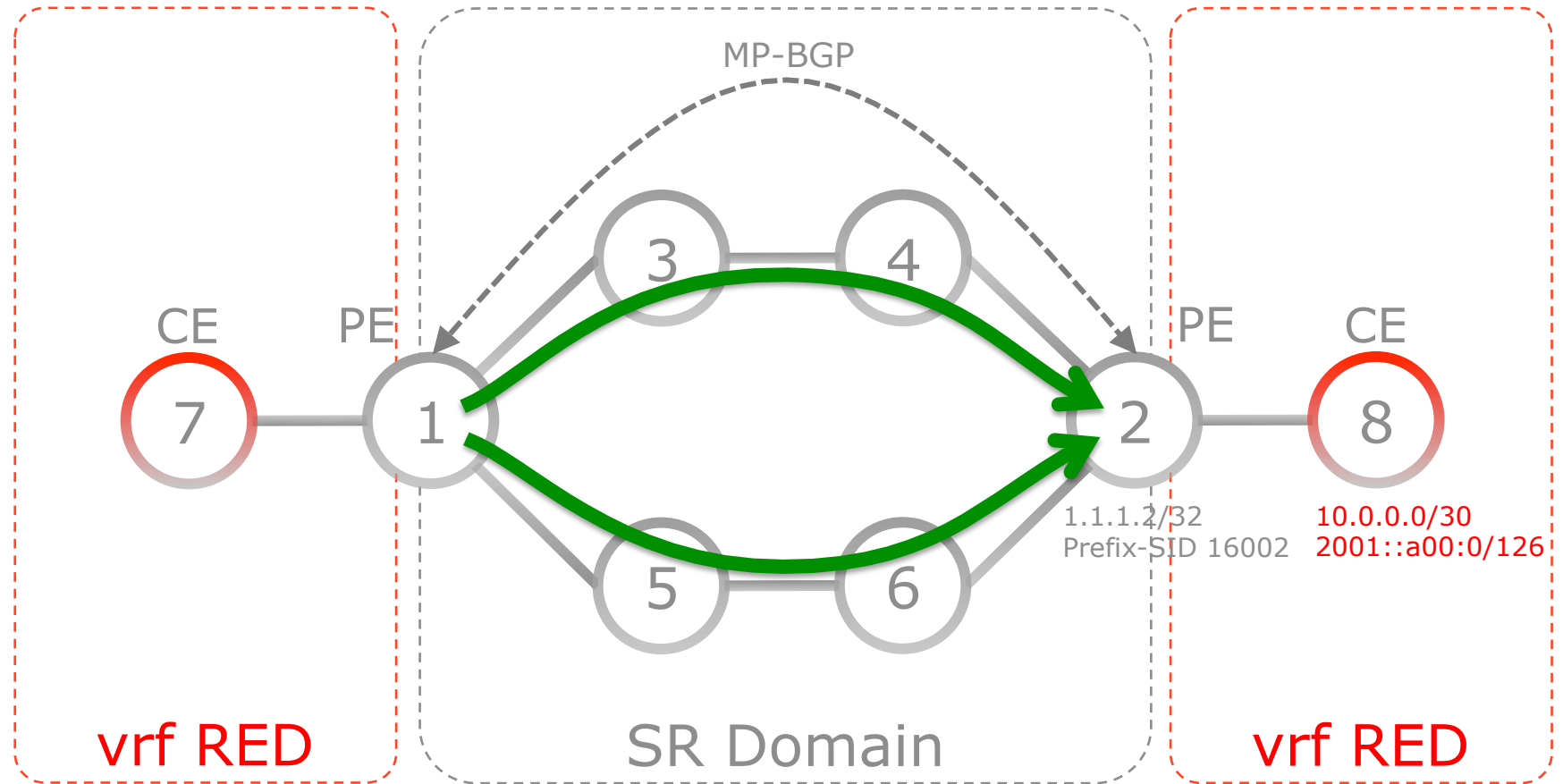


```
RP/0/0/CPU0:Node3#show mpls forwarding labels 16004
```

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
16004	Exp-Null-v6	SR Pfx (idx 4)	Gi0/0/0/0	fe80::f816:3eff:fe1d:384a	\
					0

Simple and Efficient Transport of MPLS services

- MPLS services ride on the prefix segments
- Simple, one less protocol to operate (LDP)



Verifying IP Forwarding (global table)

```
RP/0/0/CPU0:xrvr-1#show cef 1.1.1.2/32
```

```
1.1.1.2/32, version 652, internal 0x4004001 0x0 (ptr 0xacca7ba4) [2], 0x0  
(0xacca27a8), 0x450 (0xacfd1c10)
```

```
Updated Jan 28 09:00:55.333
```

```
local adjacency 99.1.3.3
```

```
Prefix Len 32, traffic index 0, precedence n/a, priority 1
```

```
via 99.1.3.3, GigabitEthernet0/0/0/0, 8 dependencies, weight 0, class 0
```

```
[flags 0x0]
```

```
path-idx 0 NHID 0x0 [0xacbbaeac 0x0]
```

```
next hop 99.1.3.3
```

```
local adjacency
```

```
local label 16002 labels imposed {16002}
```

```
via 99.1.5.5, GigabitEthernet0/0/0/1, 8 dependencies, weight 0, class 0
```

```
[flags 0x0]
```

```
path-idx 1 NHID 0x0 [0xacbbac54 0x0]
```

```
next hop 99.1.5.5
```

```
local adjacency
```

```
local label 16002 labels imposed {16002}
```

Global prefix

2 paths (ECMP)

Push label stack:
{Prefix-SID}

Verifying IP Forwarding (VRF RED)

```
RP/0/0/CPU0:xrvr-1#show cef vrf RED 10.0.0.0/30
10.0.0.0/30, version 27, internal 0x14004001 0x0 (ptr 0xacca79a4) [1], 0x0
(0x0), 0x410 (0xacd3372c)
Updated Jan 27 10:05:33.906
Prefix Len 30, traffic index 0, precedence n/a, priority 3
via 1.1.1.2, 5 dependencies, recursive [flags 0x6000]
path-idx 0 NHID 0x0 [0xacfc0e24 0x0]
next hop VRF - 'default', table - 0xe0000000
next hop 1.1.1.2 via 16002/0/21
  next hop 99.1.3.3/32 Gi0/0/0/0      labels imposed {16002 90001}
  next hop 99.1.6.6/32 Gi0/0/0/1      labels imposed {16002 90001}
```

VPN prefix (VRF RED)

BGP nexthop, egress PE

2 paths (ECMP)
Push label stack:
{Prefix-SID to egress PE, BGP VPN label}

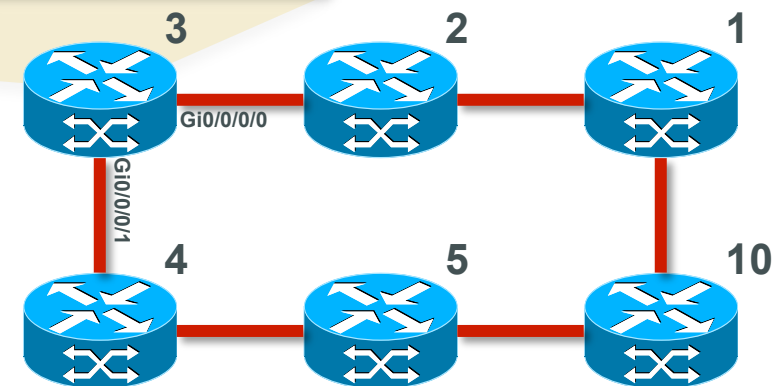
Verifying MPLS Forwarding

```
RP/0/0/CPU0:xrvr-3#show mpls forwarding
```

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
16001	16001	SR Pfx (idx 1)	Gi0/0/0/0	99.2.3.2	0
16002	Exp-Null-v4	SR Pfx (idx 2)	Gi0/0/0/0	99.2.3.2	0
16004	Pop	SR Pfx (idx 4)	Gi0/0/0/1	99.3.4.4	0
16005	16005	SR Pfx (idx 5)	Gi0/0/0/1	99.3.4.4	0
16010	16010	SR Pfx (idx 10)	Gi0/0/0/0	99.2.3.2	0
	16010	SR Pfx (idx 10)	Gi0/0/0/1	99.3.4.4	0
24032	Pop	SR Adj (idx 1)	Gi0/0/0/0	99.2.3.2	0
24034	Pop	SR Adj (idx 3)	Gi0/0/0/1	99.3.4.4	0

prefix-SIDs of remote nodes

adjacency-SIDs



Node n advertises prefix-SID $16000+n$

Verifying MPLS Forwarding

RP/0/0/CPU0:xrvr-3#show mpls forwarding

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
16001	16001	SR Pfx (idx 1)	Gi0/0/0/0	99.2.3.2	0
16002	Exp-Null-v4	SR Pfx (idx 2)	Gi0/0/0/0	99.2.3.2	0
16004	Pop	SR Pfx (idx 4)	Gi0/0/0/1	99.3.4.4	0
16005	16005	SR Pfx (idx 5)	Gi0/0/0/1	99.3.4.4	0
16010	16010	SR Pfx (idx 10)	Gi0/0/0/0	99.2.3.2	0
	16010	SR Pfx (idx 10)	Gi0/0/0/1	99.3.4.4	0
24032	Pop	SR Adj (idx 1)	Gi0/0/0/0	99.2.3.2	0
24034	Pop	SR Adj (idx 3)	Gi0/0/0/1	99.3.4.4	0

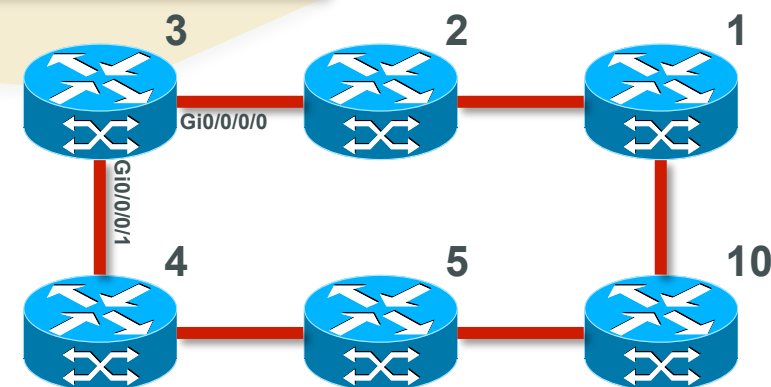
Remote prefix-SID

Neighbor prefix-SID
Explicit-Null

Neighbor prefix-SID
PHP on

Remote prefix-SIDs
ECMP

Node n advertises prefix-SID $16000+n$



Visit us:

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Thank you.

