



Segment Routing SR/LDP interworking

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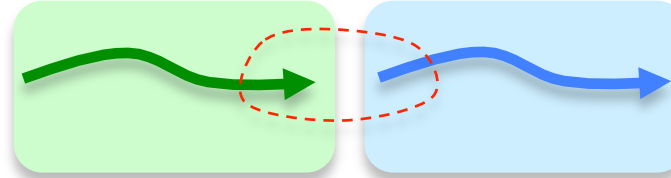
Segment Routing – SR/LDP interworking

- Simple, automatic and seamless interworking with LDP
- Role of Mapping Server
- Data plane interworking functionality
- Verify interworking forwarding entries

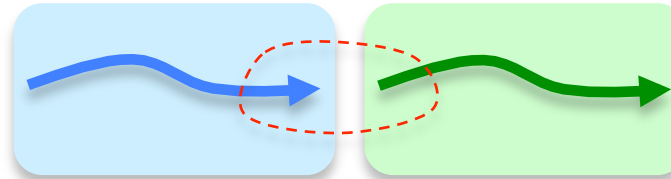
Interworking Deployment Model

Interworking Deployment Model

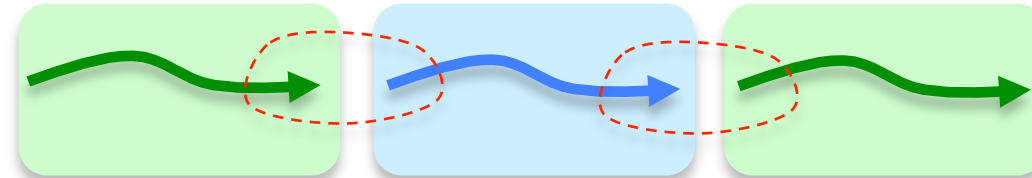
SR to LDP



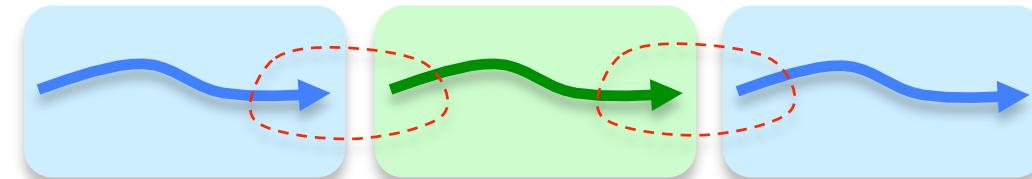
LDP to SR



SR over LDP



LDP over SR

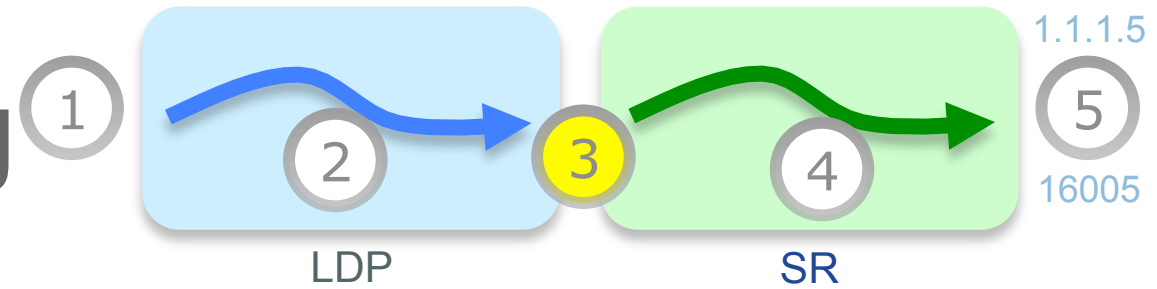


LDP

SR

LDP to SR

LDP to SR interworking

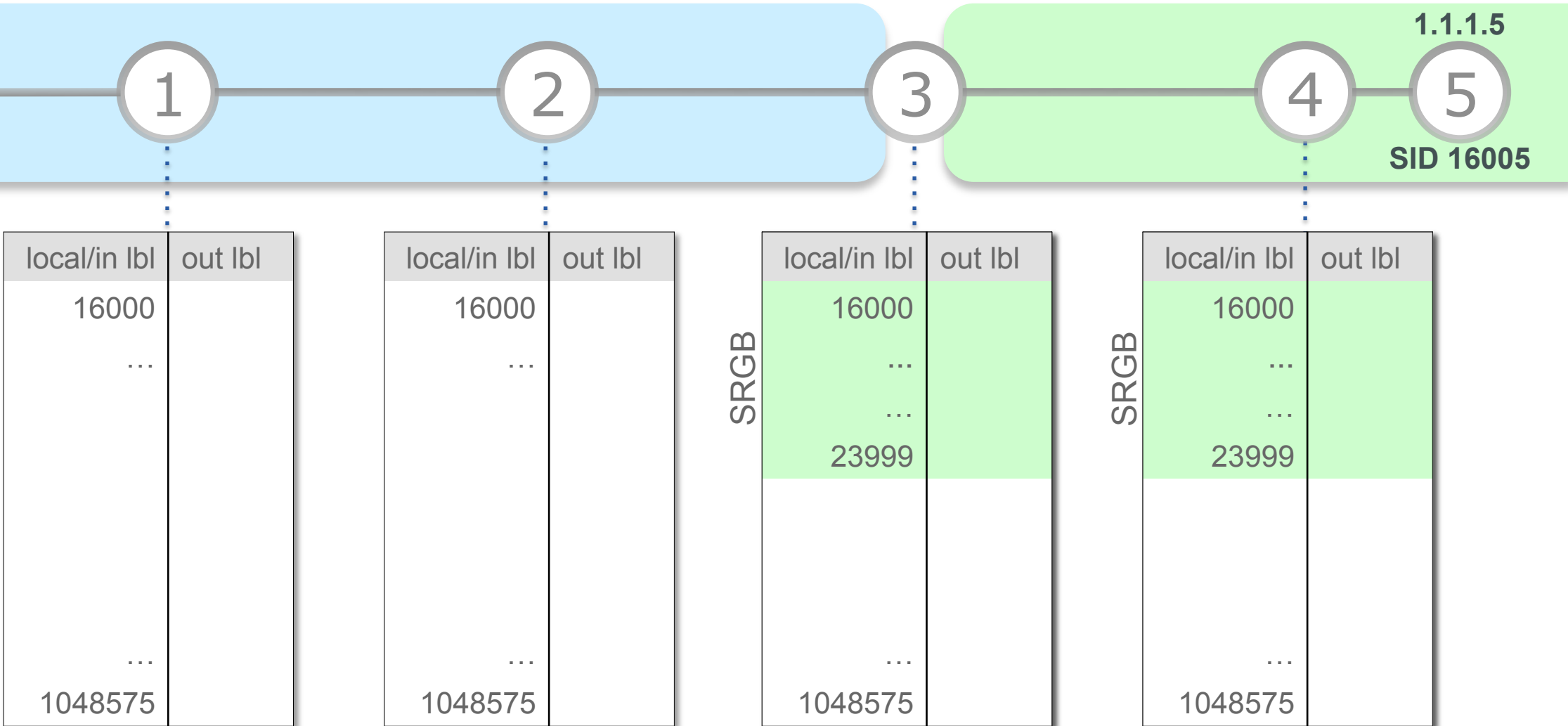


- When a node is LDP enabled but its next-hop along the SPT to the destination is not LDP enabled
 - no LDP outgoing label
- In this case, the LDP LSP is connected to the Prefix Segment
 - Any node on the LDP/SR border installs LDP-to-SR forwarding entry(ies)
- Node3 installs the following LDP-to-SR forwarding entry:
 - incoming label: local label allocated by LDP for 1.1.1.5/32
 - outgoing label: Prefix Segment bound to 1.1.1.5/32
 - outgoing interface: to Node4
- This entry is derived and installed automatically, no config required

LDP to SR interworking

SR

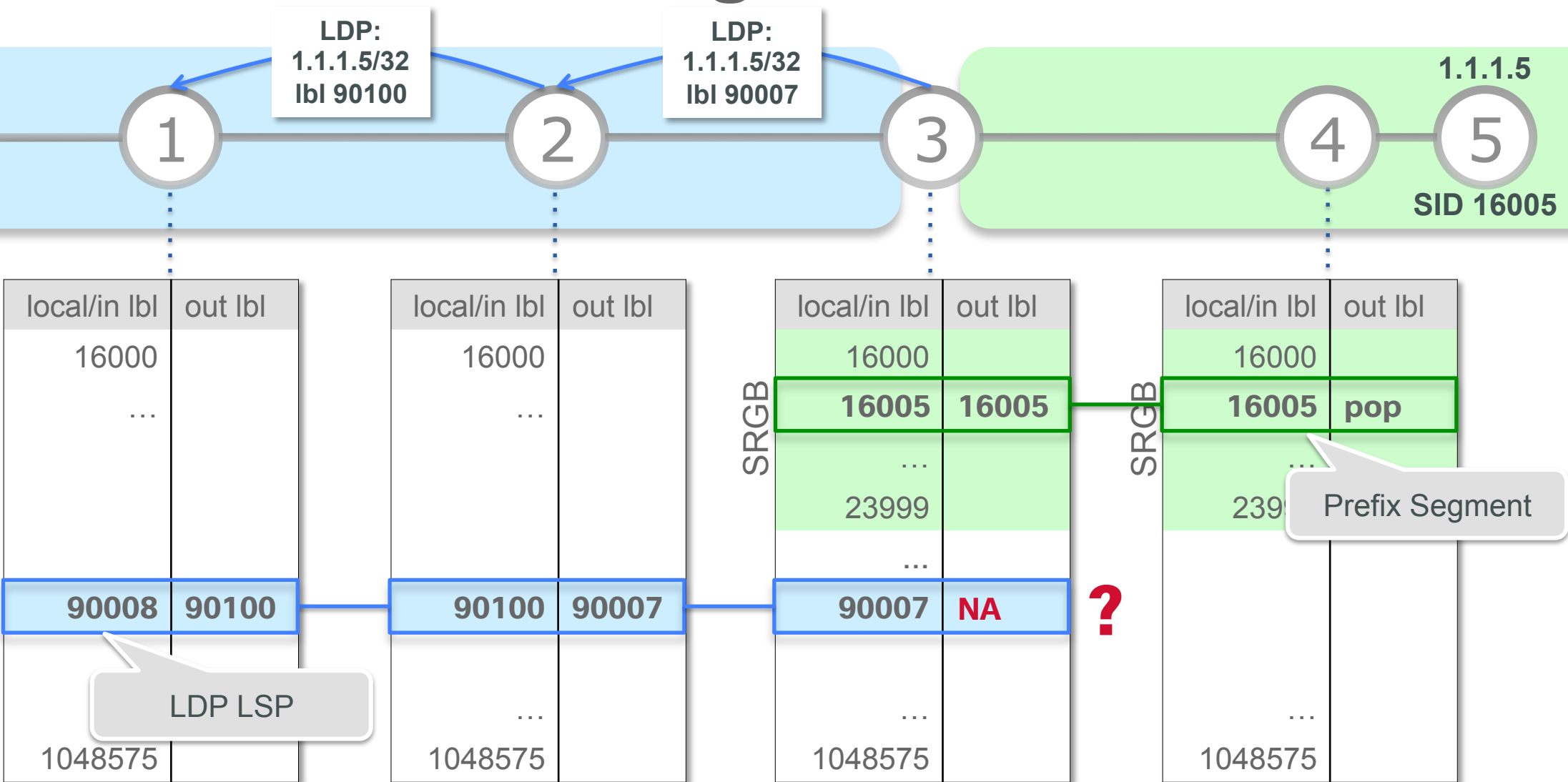
LDP



LDP to SR interworking

SR

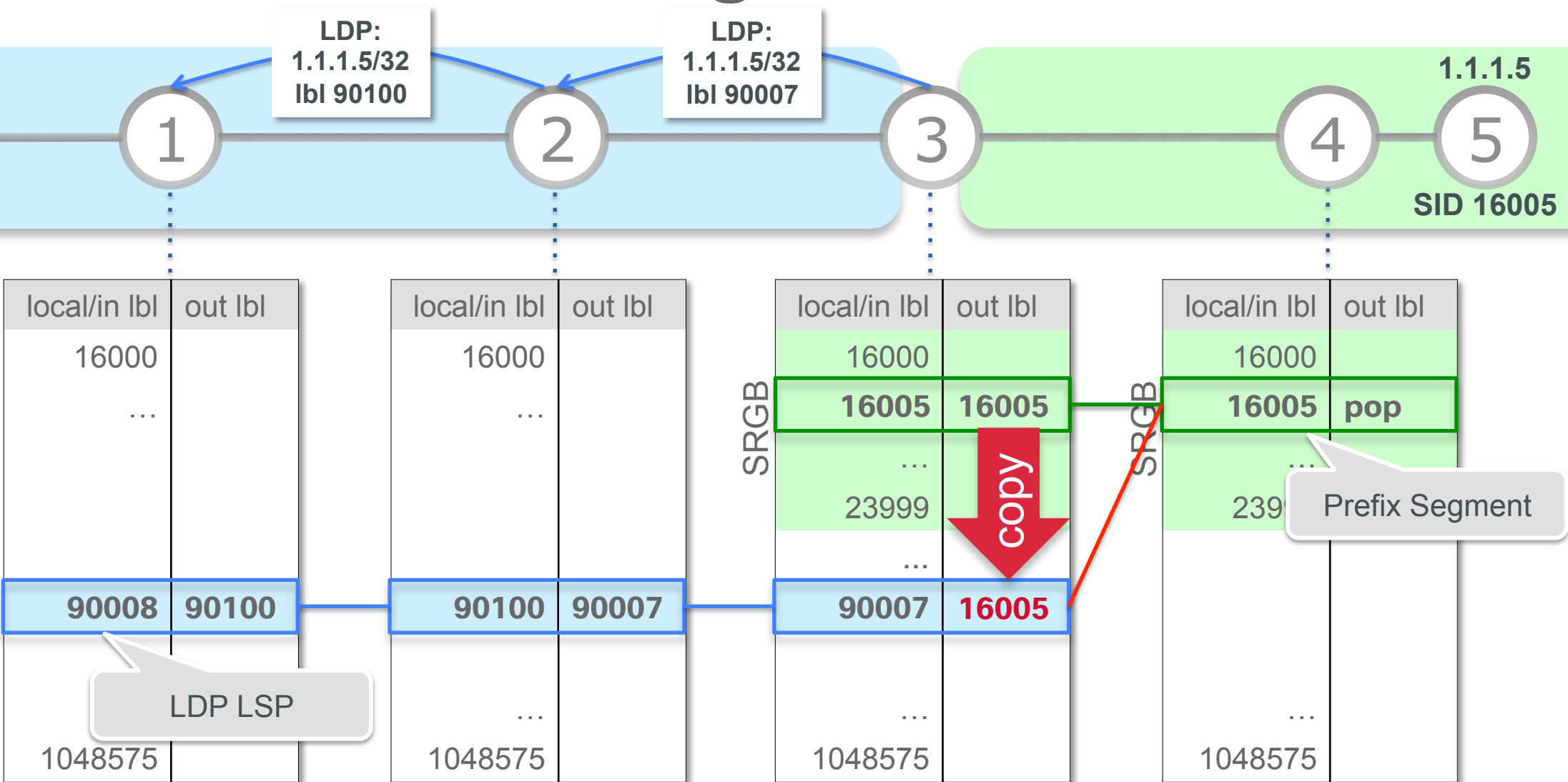
LDP



LDP to SR interworking

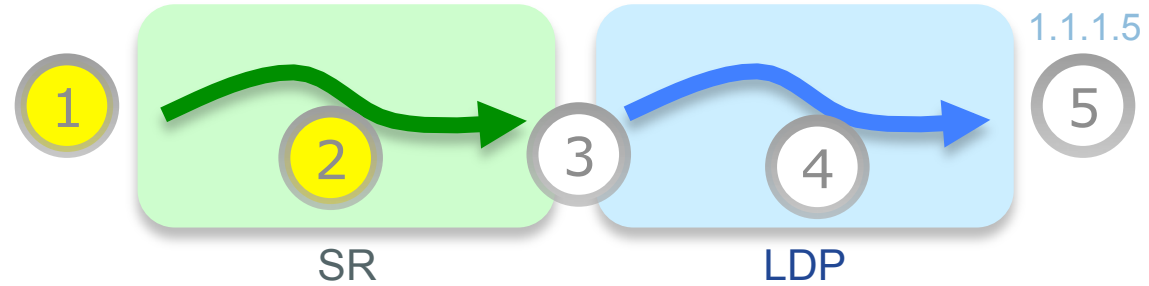
SR

LDP



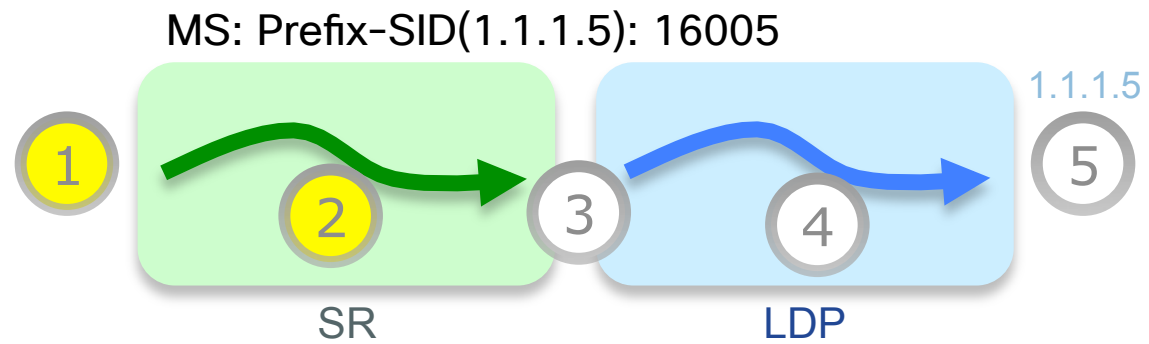
SR to LDP

SR to LDP interworking



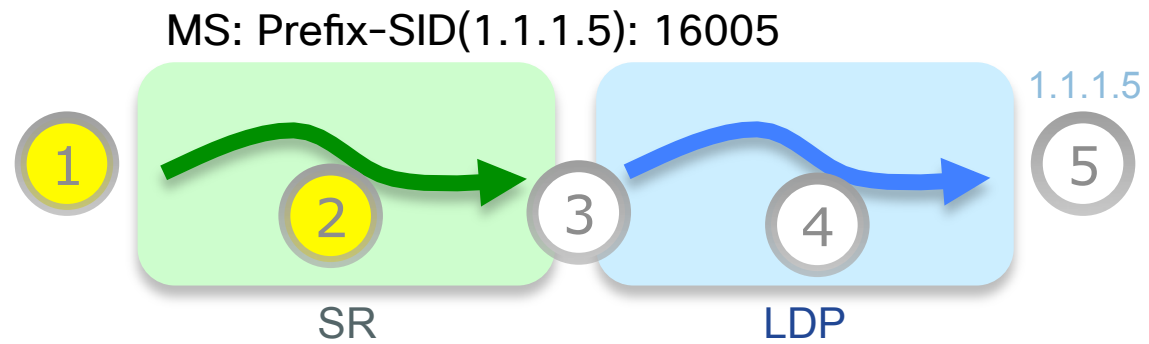
- When a destination is not SR enabled, the SR nodes don't have a prefix-SID for that destination, no SR transport possible
→ **Mapping Server (MS)** advertises prefix-SIDs on behalf of non-SR nodes
- SR nodes install Mapping Server advertised prefix-SIDs in their forwarding table
 - Establish SR connectivity to non-SR destinations within SR domain
- See Mapping Server section for more details

SR to LDP interworking



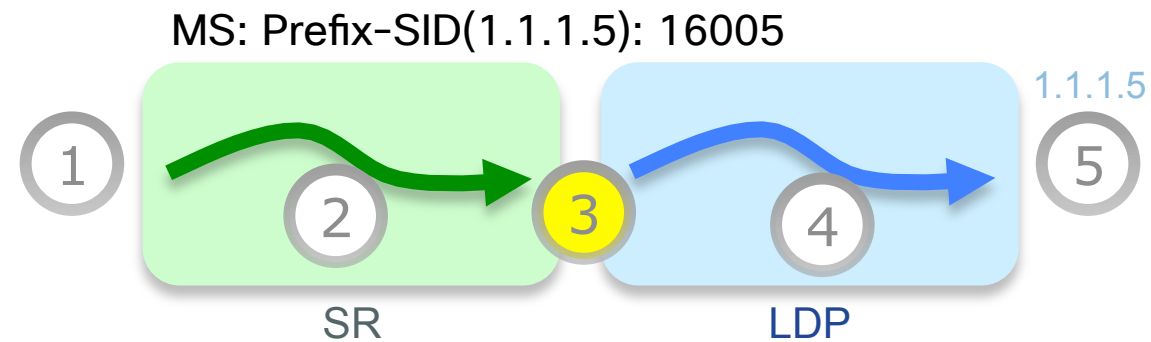
- Mapping Server advertises Prefix-SID 16005 for Node5's loopback, on behalf of Node5
 - It maps the prefix-SID 16005 to prefix 1.1.1.5/32
 - All nodes in the network receive this Mapping Server advertisement
 - The SR-enabled nodes use the prefix-to-SID mapping to install Segment Routing forwarding entries to destination Node5
 - The SR nodes use the prefix-to-SID mapping if no “native” prefix-SID is available
- Node1 and 2 have SR connectivity to destination Node5

SR to LDP interworking



- Node1 and 2 install the following SR imposition entry:
 - incoming prefix: 1.1.1.5/32
 - outgoing label: Prefix Segment 16005 bound to 1.1.1.5/32 (from Mapping Server)
 - outgoing interface: on shortest path to 1.1.1.5/32
- Node1 and 2 install the following SR forwarding entry:
 - incoming label: Prefix Segment 16005 bound to 1.1.1.5/32 (from Mapping Server)
 - outgoing label: Prefix Segment 16005 bound to 1.1.1.5/32 (from Mapping Server)
 - outgoing interface: on shortest path to 1.1.1.5/32

SR to LDP interworking

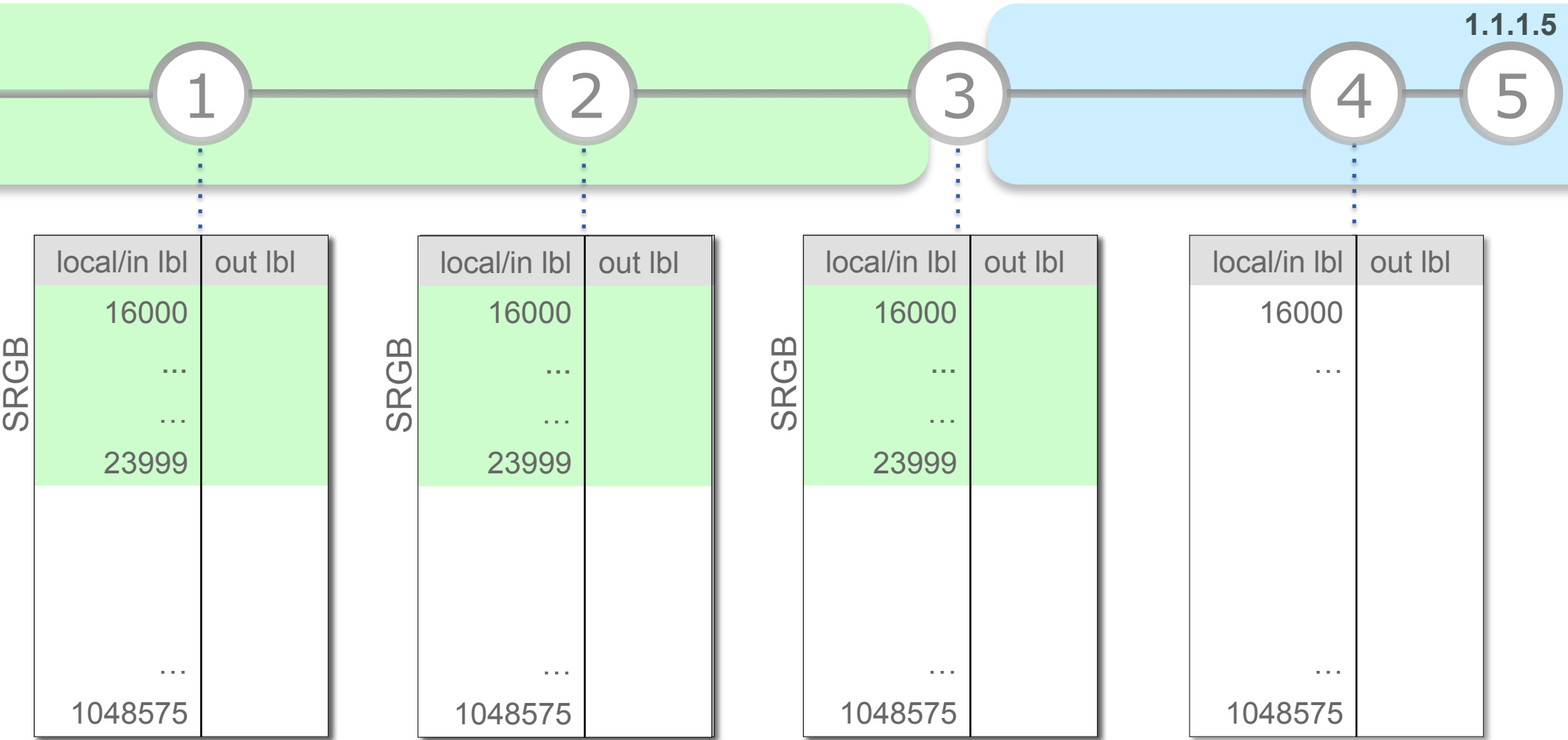


- When a node is SR capable but its next-hop along the SPT to the destination is not SR capable
 - no SR outgoing label available
- In this case, the Prefix Segment is connected to the LDP LSP
 - Any node on the SR/LDP border installs SR-to-LDP forwarding entry(ies)
- Node3 installs the following SR-to-LDP forwarding entry:
 - incoming label: Prefix Segment bound to 1.1.1.5/32 (from Mapping Server)
 - outgoing label: label advertised by LDP neighbor 4 for 1.1.1.5/32
 - outgoing interface: to Node4
- This entry is derived and installed automatically, no config required

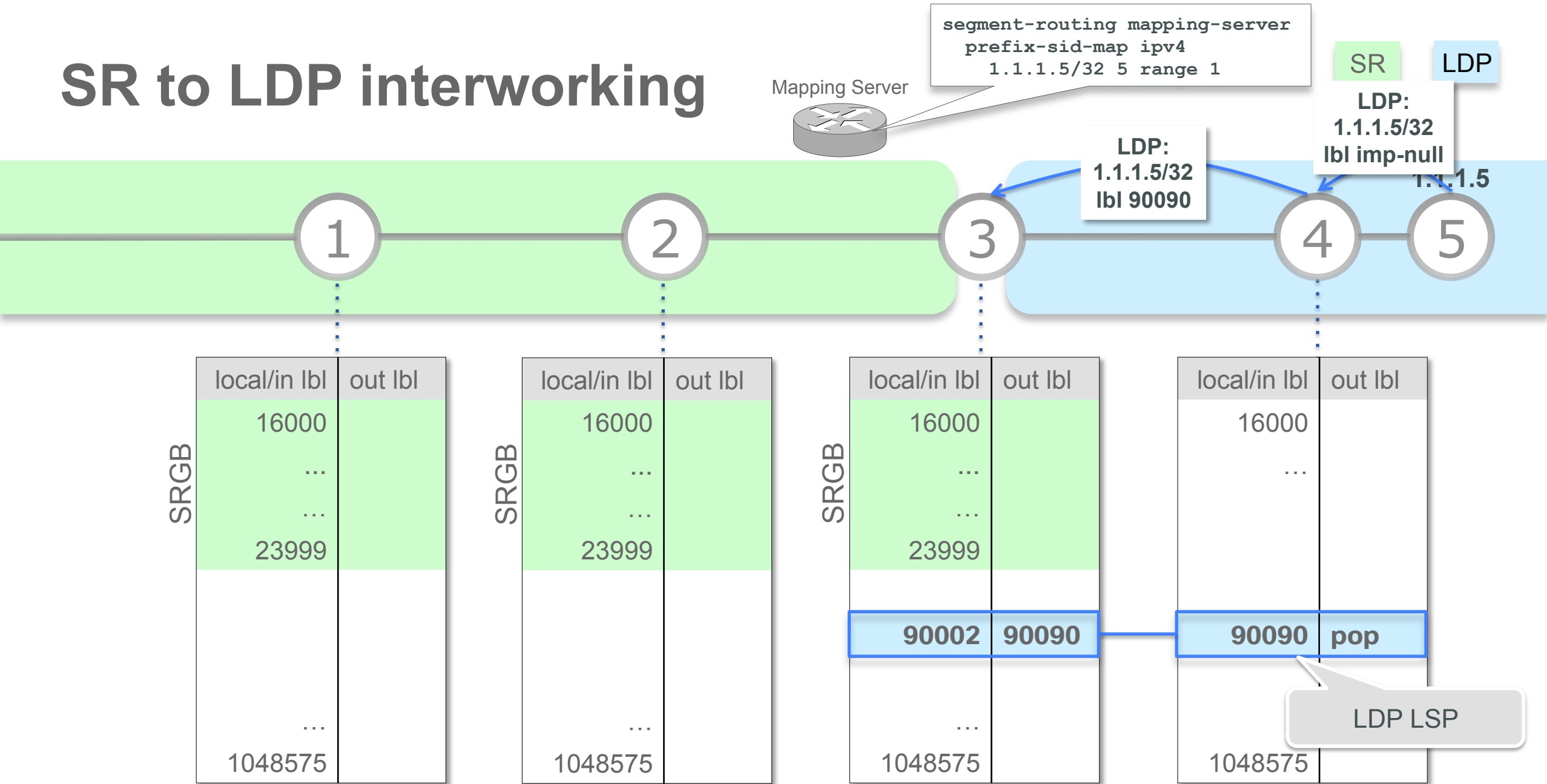
SR to LDP interworking

SR

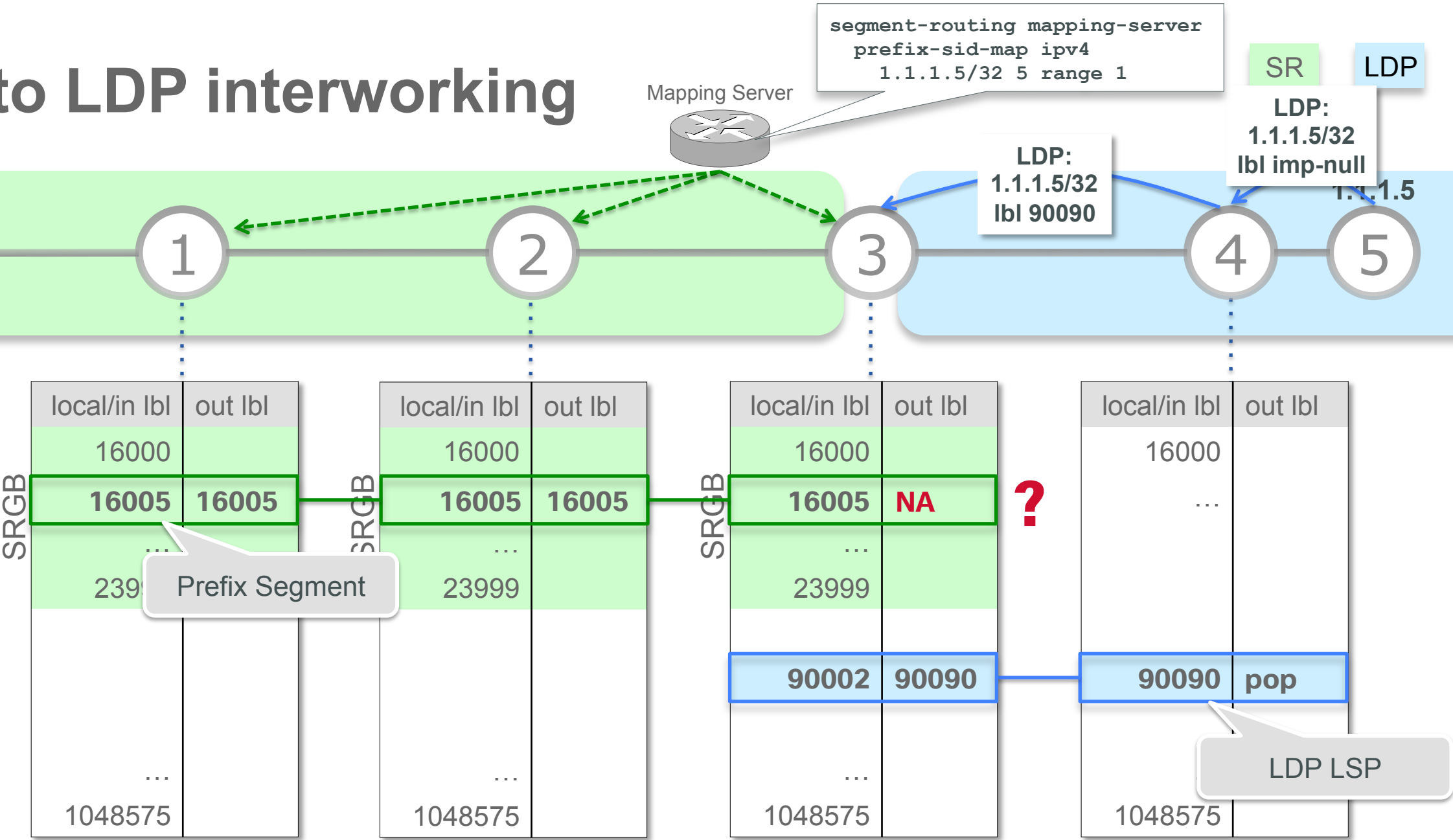
LDP



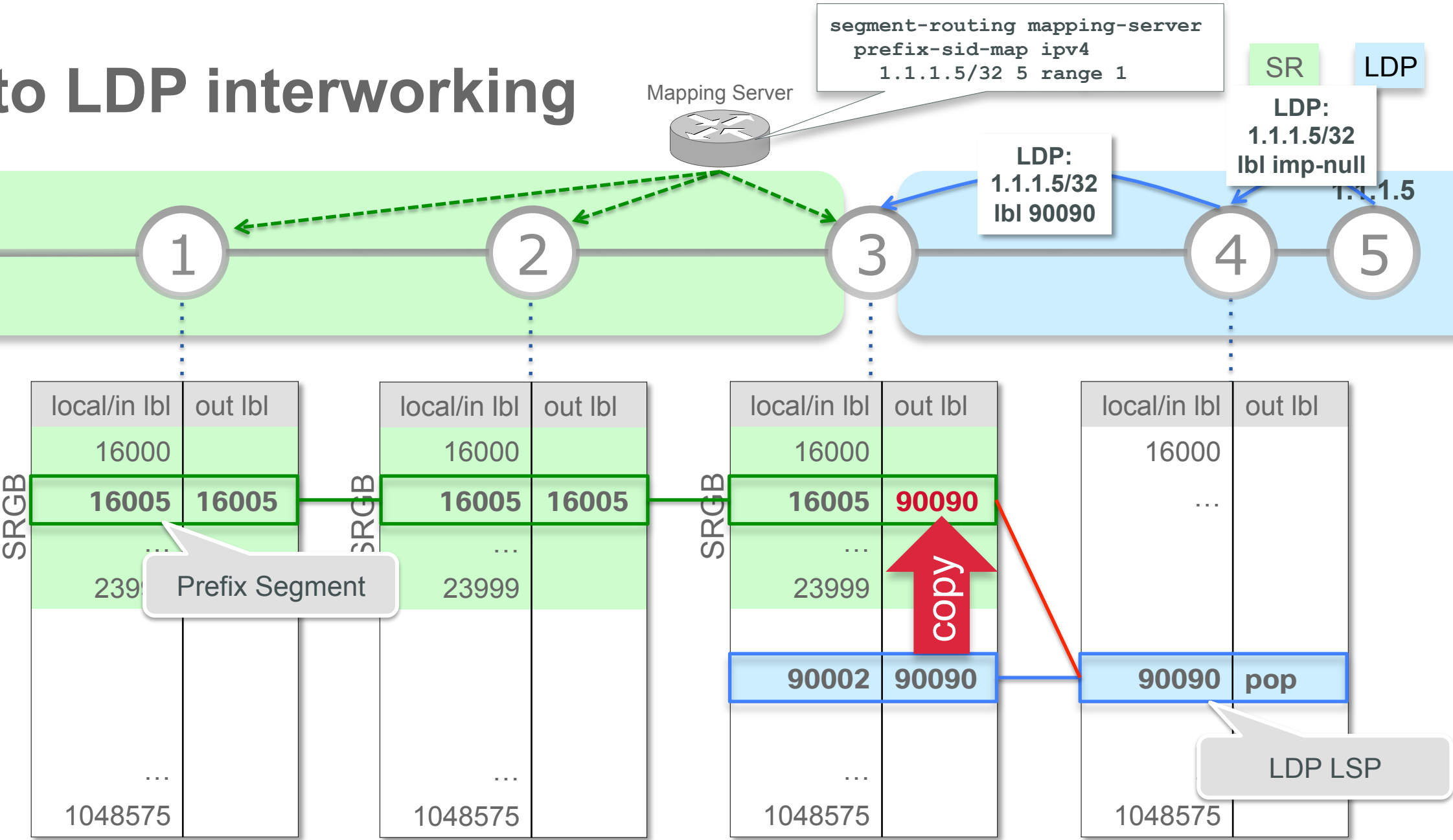
SR to LDP interworking

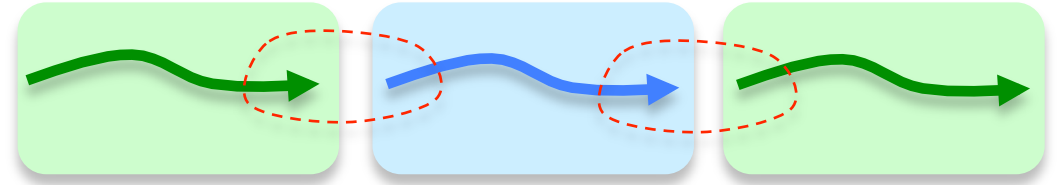


SR to LDP interworking



SR to LDP interworking

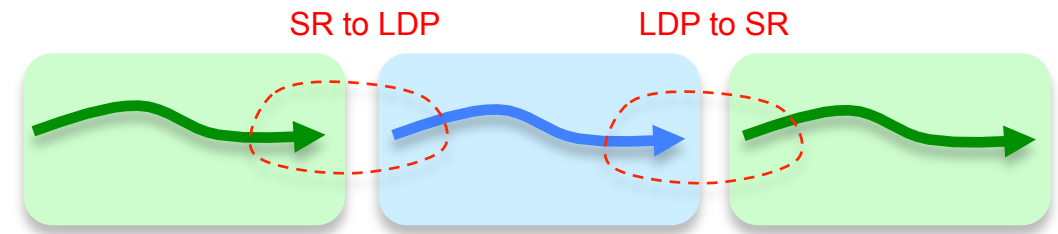




SR over LDP

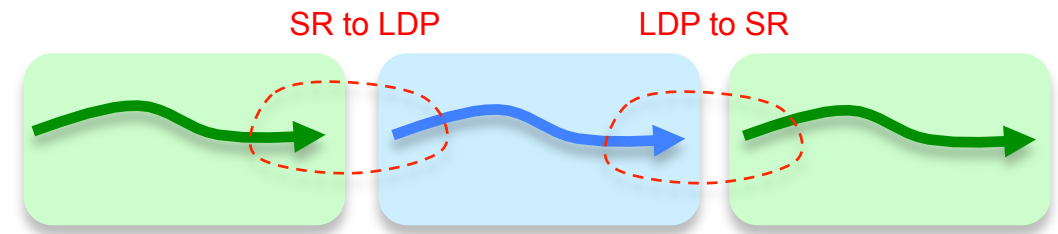
SR to LDP followed by LDP to SR

SR over LDP

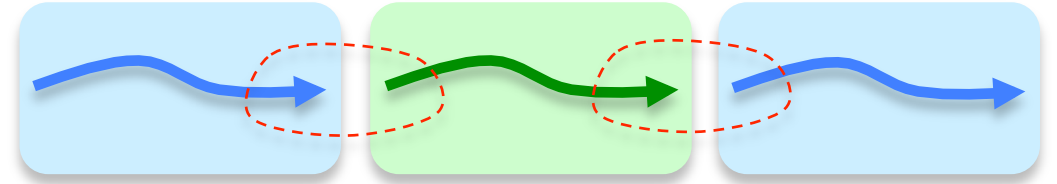


- At SR/LDP boundary, the SR prefix segment is mapped to an LDP LSP
 - SR to LDP
- At LDP/SR boundary, the LDP LSP is mapped to an SR prefix segment
 - LDP to SR

SR over LDP



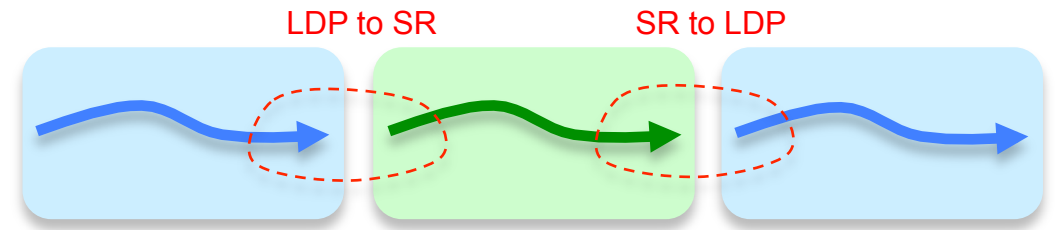
- Is a mapping server needed?
 - Yes, if SR Label Switched Path(s) go from SR island and terminate in LDP island
 - > In the SR island, a prefix-SID is needed to install the Prefix Segment
 - > the terminating node is LDP-only
 - > a mapping server advertises a prefix-SID on behalf of the LDP-only node
 - No, if no SR Label Switched Path(s) go from SR island and terminate in LDP island
 - > The SR nodes know the prefix-SID of the destination, since that node is SR as well



LDP over SR

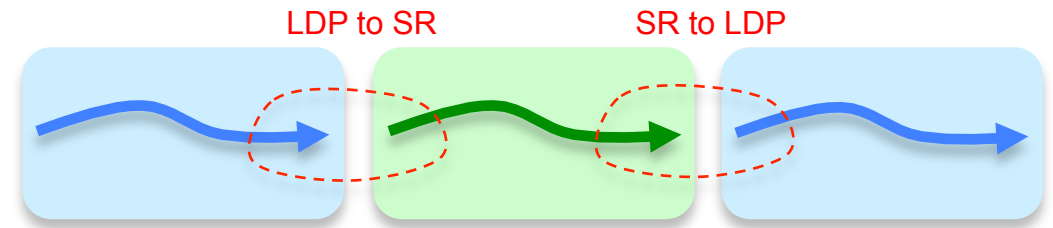
LDP to SR followed by SR to LDP

LDP over SR



- At LDP/SR boundary, the LDP LSP is mapped to an SR prefix segment
 - LDP to SR
- At SR/LDP boundary, the SR prefix segment is mapped to an LDP LSP
 - SR to LDP

LDP over SR



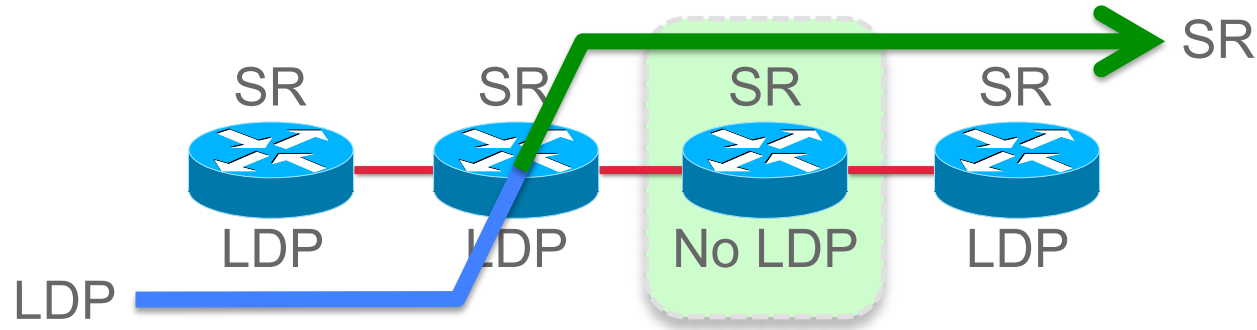
- Is a mapping server needed?
 - Yes!
 - > A prefix-SID is needed in the SR island to install the Prefix Segment
 - > The LDP-only nodes can't advertise a prefix-SID
 - > A mapping server advertises a prefix-SID on behalf of the LDP-only node

SR/LDP Interworking Notes

- SR/LDP interworking functionality is also applied on the Topology Independent LFA (TI-LFA) backup path
 - See TI-LFA section

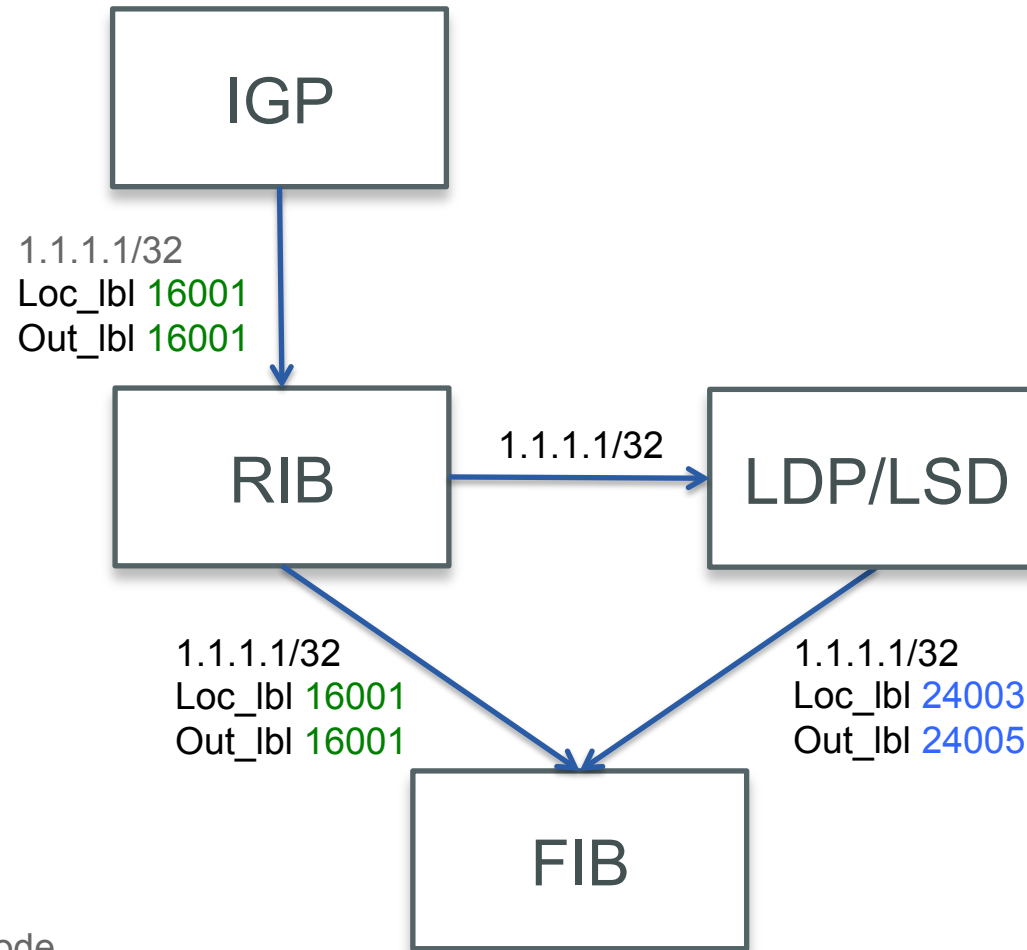
SR/LDP Interworking Notes

- The implementation keeps packets on the same transport type, SR or LDP, where possible
 - E.g. if sending LDP traffic and all nodes on a path are LDP capable, only LDP labels are used
 - If traversing an SR-only island between two SR+LDP areas, LDP carried packets will become SR carried and stay SR until the destination



SR/LDP interworking data plane

IGP/SR and LDP programming FIB

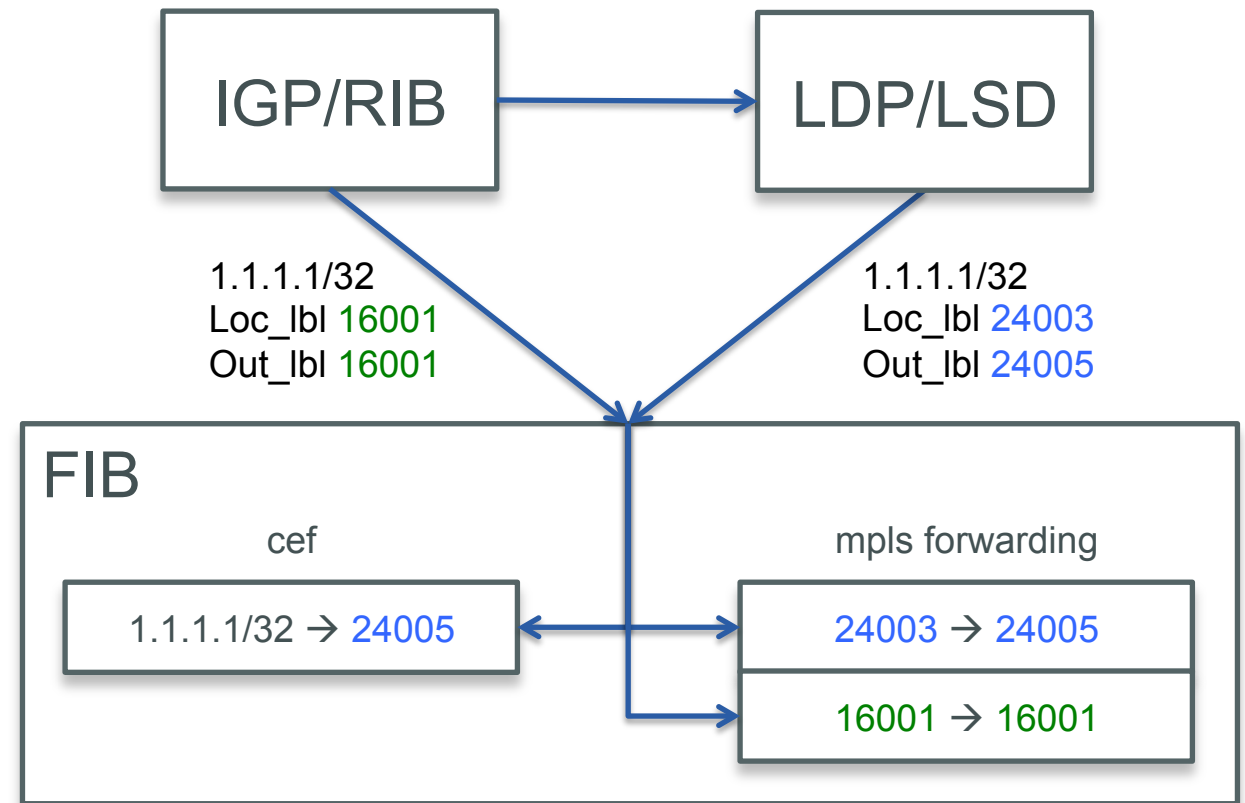


Loc_lbl: local label, allocated by local node
Out_lbl: outgoing label

16001: SR label
24003: LDP label

IGP/SR and LDP programming FIB

- This diagram illustrates the default behavior: prefer LDP label imposition
- The label imposition preference is configurable
 - See SR/LDP co-existence section

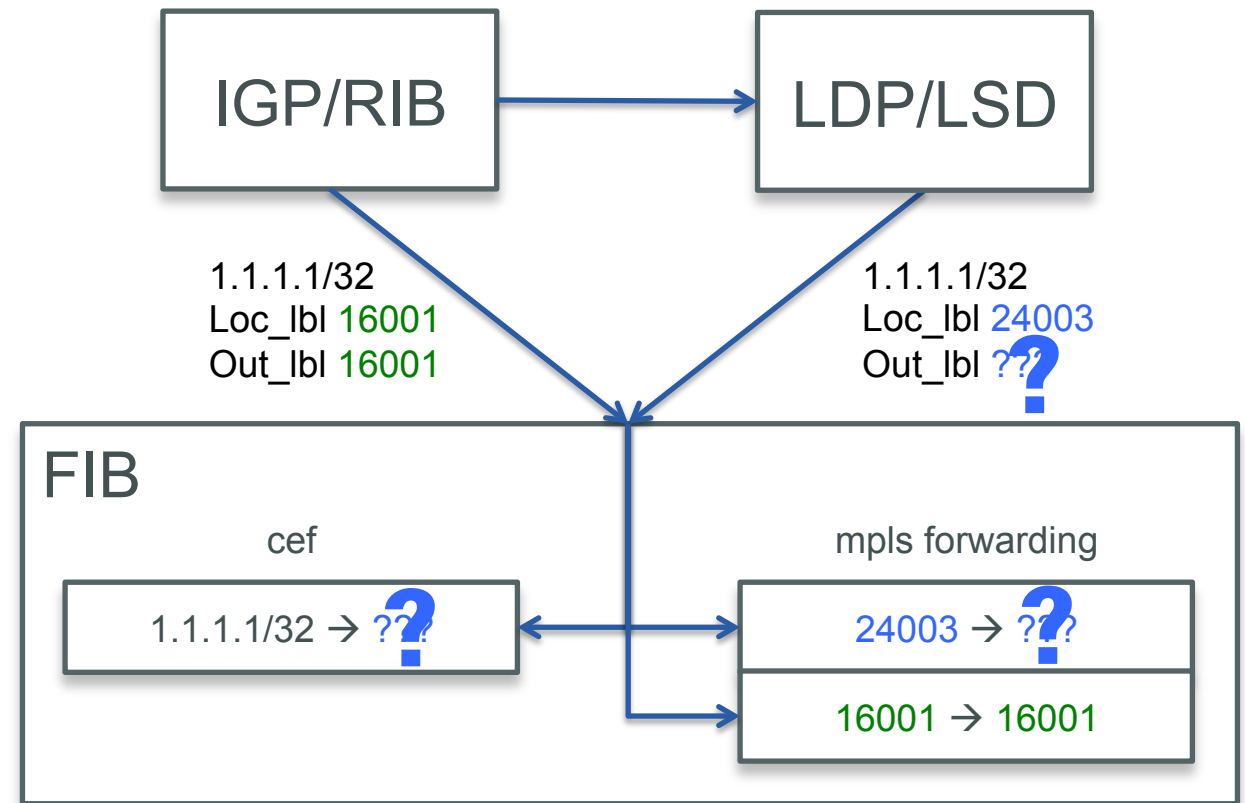


Loc_lbl: local label, allocated by local node
Out_lbl: outgoing label

16001: SR label
24003: LDP label

IGP/SR and LDP programming FIB

- Downstream neighbor not LDP-capable or did not advertise an LDP label binding
→ no outgoing LDP label

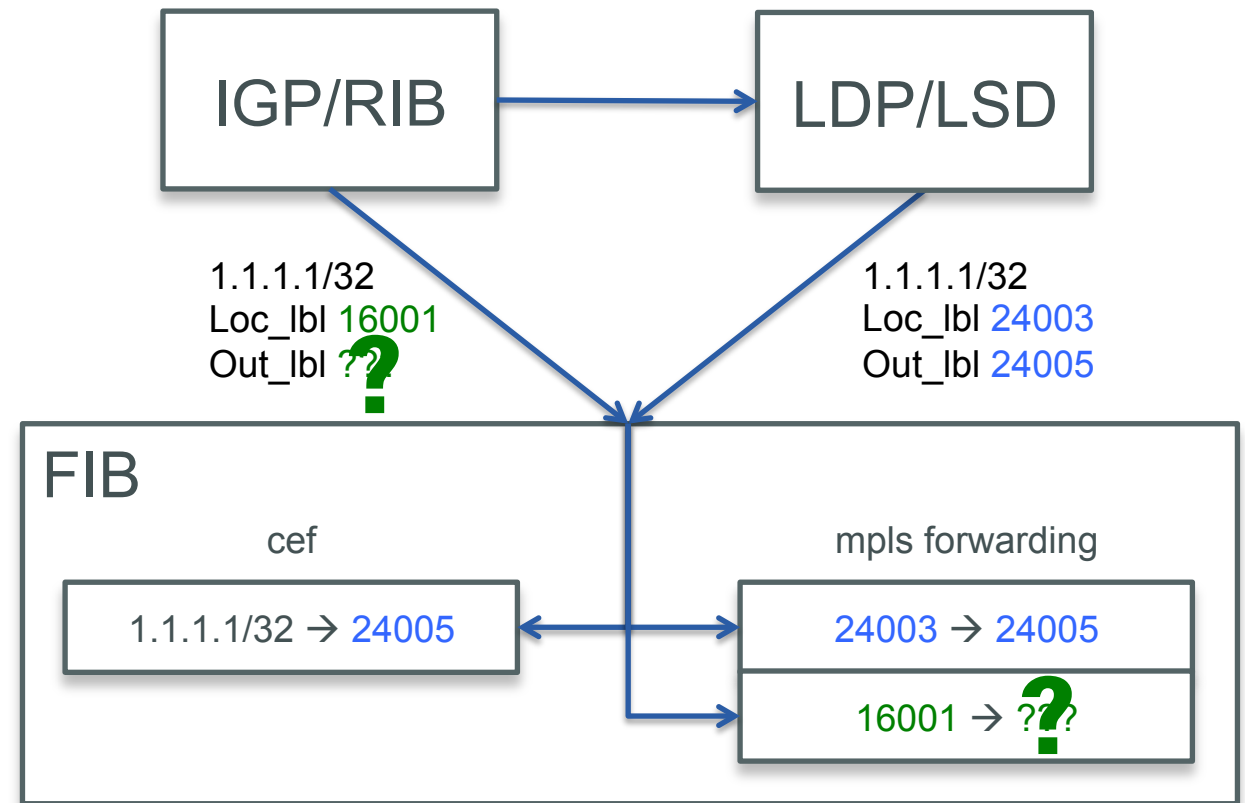


Loc_lbl: local label, allocated by local node
Out_lbl: outgoing label

16001: SR label
24003: LDP label

IGP/SR and LDP programming FIB

- Downstream neighbor not SR-capable
→ no outgoing SR label



Loc_lbl: local label, allocated by local node
Out_lbl: outgoing label

16001: SR label
24003: LDP label

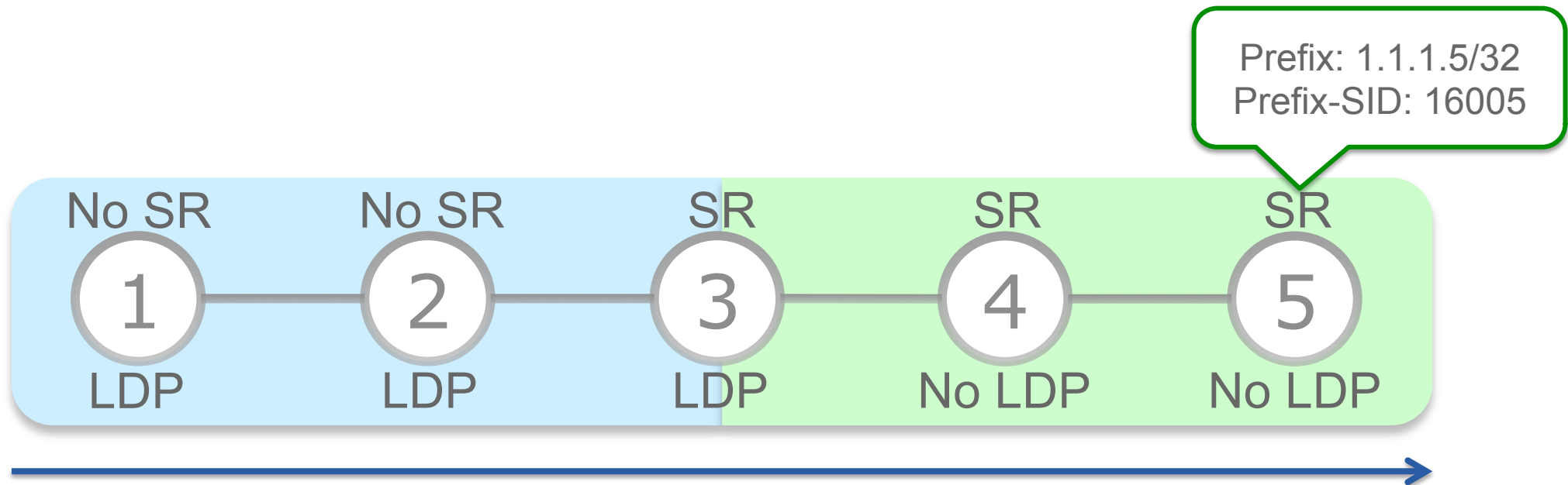
IGP/SR and LDP programming FIB

- The RIB and LSD label entries are “replaced”
 - The operation is sometimes called “merge”
- “Replacing” is done by replacing a RIB/LSD “unlabeled” entry by the valid out label of LSD/RIB for the same path
 - LSD (LDP) out label is “unlabeled” → use RIB out label
 - RIB (SR) out label is “unlabeled” → use LSD out label
- When is the out label “unlabeled”?
 - RIB (SR) out label is “unlabeled” if the downstream router is not SR-capable
 - LSD (LDP) out label is “unlabeled” if the downstream router is not LDP-capable or did not advertise an LDP label binding

SR/LDP interworking – SR/LDP to SR

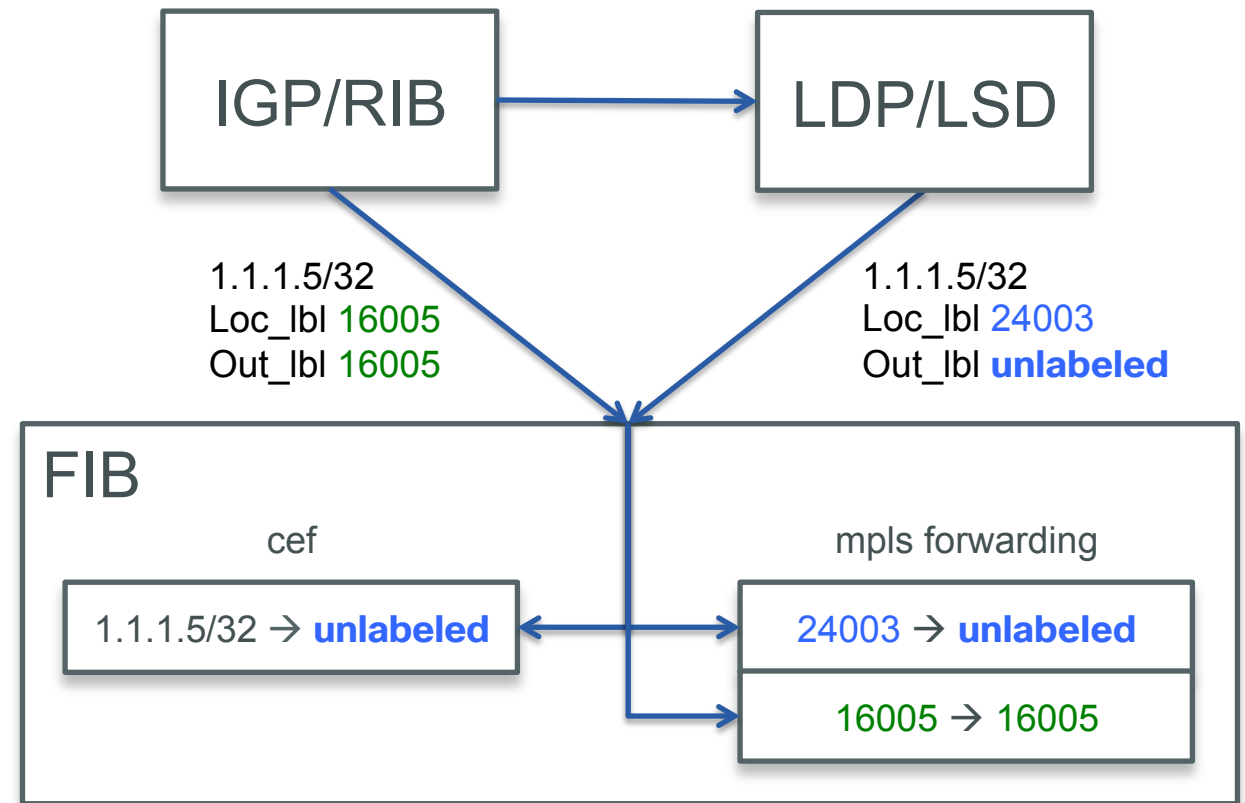
SR

LDP



SR/LDP interworking – SR/LDP to SR

- This diagram illustrates the behavior of Node3 in the topology
- Downstream neighbor 4 not LDP-capable
→ no outgoing LDP label

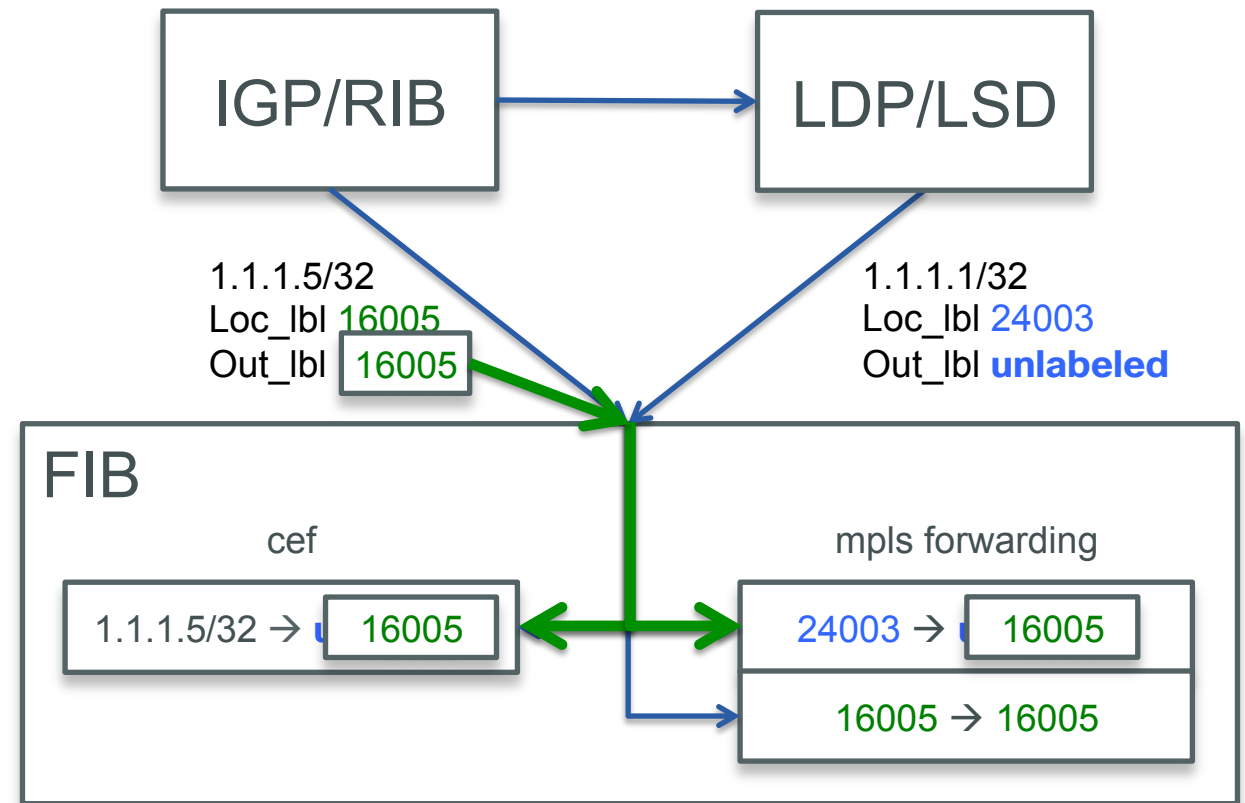


Loc_lbl: local label, allocated by local node
Out_lbl: outgoing label

16001: SR label
24003: LDP label

SR/LDP interworking – SR/LDP to SR

- FIB automatically replaces the unlabeled entries by replacing “unlabeled” by the valid outgoing label from the other source
 - Replace “unlabeled” by 16005



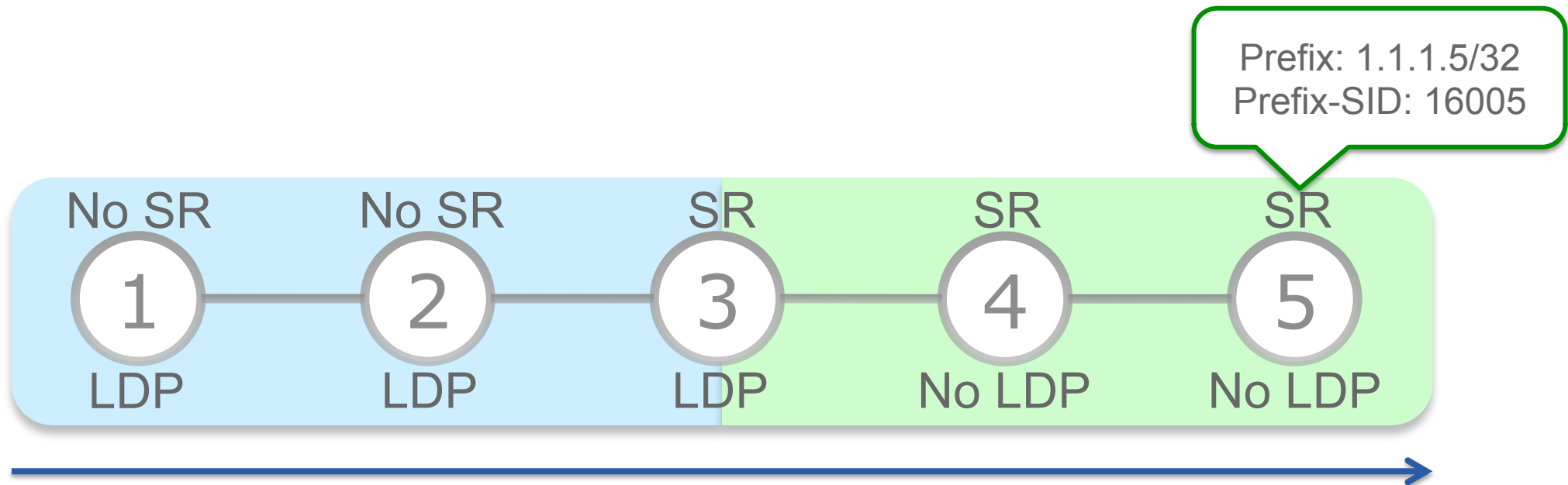
Loc_lbl: local label, allocated by local node
Out_lbl: outgoing label

16001: SR label
24003: LDP label

SR/LDP interworking – SR/LDP to SR

SR

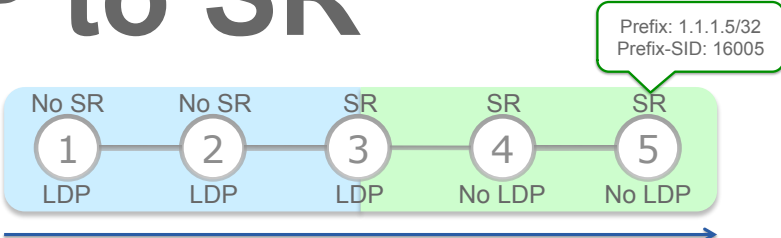
LDP



SR/LDP interworking – SR/LDP to SR

```
RP/0/0/CPU0:xrvr-3#show route 1.1.1.5/32 detail
Routing entry for 1.1.1.5/32
  Known via "isis 1", distance 115, metric 20, type level-2
  Installed May  2 15:47:42.950 for 00:29:30
  Routing Descriptor Blocks
    99.3.4.4, from 1.1.1.5, via GigabitEthernet0/0/0/1
      Route metric is 20
      Label: 0x3e81 (16005)
      Tunnel ID: None
      Extended communities count: 0
      Path id:1          Path ref count:0
      NHID:0x2(Ref:7)
  Route version is 0x2b (43)
  Local Label: 0x3e81 (16005)
  IP Precedence: Not Set
  QoS Group ID: Not Set
  Flow-tag: Not Set
  Route Priority: RIB_PRIORITY_NON_RECURSIVE_MEDIUM (7) SVD Type RIB_SVD_TYPE_LOCAL
  Download Priority 1, Download Version 157
  No advertising protos.
```

```
RP/0/0/CPU0:xrvr-3#show mpls ldp bindings 1.1.1.5/32
1.1.1.5/32, rev 20
  Local binding: label: 24003
  Remote bindings: (1 peers)
    Peer          Label
    -----
    1.1.1.2:0     24004
```



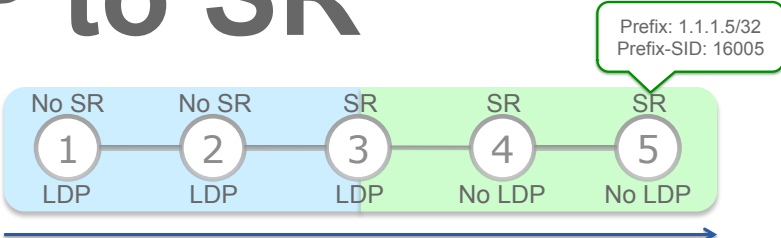
- RIB outgoing label
- RIB entry for 1.1.1.5/32
- RIB local label
- LDP entry for 1.1.1.5/32
- LDP local label
- No LDP outgoing label for the downstream neighbor

SR/LDP interworking – SR/LDP to SR

```
RP/0/0/CPU0:xrivr-3#show cef 1.1.1.5/32 flags
1.1.1.5/32, version 111, internal 0x4000001 0x5 (ptr 0xace3dd20) [1], 0x0
(0xace2655c), 0x228 (0xacbde048)
leaf flags: owner locked, inserted
leaf flags2: LDP/SR merge req, LDP/SR merge act
leaf ext flags: Priority change
Updated Mar  3 10:10:53.374
local adjacency 99.3.4.4
Prefix Len 32, traffic index 0, precedence n/a, priority 15
via 99.3.4.4, GigabitEthernet0/0/0/1, 11 dependencies, weight 0, class 0
[flags 0x0]
path-idx 0 NHID 0x0 [0xacadacb8 0x0]
next hop 99.3.4.4
tx adjacency
local label 24003      labels imposed {16005}

RP/0/0/CPU0:xrivr-3#show mpls forwarding labels 16005
Local   Outgoing   Prefix           Outgoing   Next Hop   Bytes
Label   Label       or ID            Interface  Next Hop   Switched
-----
16005   16005       SR Pfx (idx 1)   Gi0/0/0/1  99.3.4.4   0

RP/0/0/CPU0:xrivr-3#show mpls forwarding labels 24003
Local   Outgoing   Prefix           Outgoing   Next Hop   Bytes
Label   Label       or ID            Interface  Next Hop   Switched
-----
24003   16005       1.1.1.5/32       Gi0/0/0/1  99.3.4.4   6864
```



“LDP/SR merge req” flag is set,
no SR preference flag set
→ prefer LDP for ip2mpls
“LDP/SR merge act” flag shows
labels have been merged

cef (ip2mpls) label

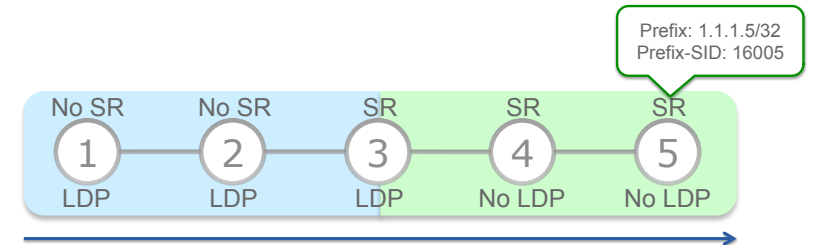
mpls2mpls labels SR

mpls2mpls labels LDP

SR/LDP interworking – SR/LDP to SR

- With “sr-prefer” configuration (Prefer SR over LDP)

```
RP/0/0/CPU0:xrvr-3#show cef 1.1.1.5/32 flags
1.1.1.5/32, version 157, internal 0x4000001 0x3 (ptr 0xace3e1a0) [1], 0x0
(0xace261b4), 0x228 (0xacbcde18)
leaf flags: owner locked, inserted
leaf flags2: LDP/SR merge req, RIB prec LSD
leaf ext flags: Priority change
Updated Mar  3 10:10:53.375
local adjacency 99.3.4.4
Prefix Len 32, traffic index 0, precedence n/a, priority 1
via 99.3.4.4, GigabitEthernet0/0/0/1, 11 dependencies, weight 0, class 0
[flags 0x0]
  path-idx 0 NHID 0x0 [0xacadacb8 0x0]
  next hop 99.3.4.4
  tx adjacency
  local label 16005      labels imposed {16005}
```



“LDP/SR merge req” flag is set
SR preference flag is set
→ prefer SR for ip2mpls

cef (ip2mpls) label

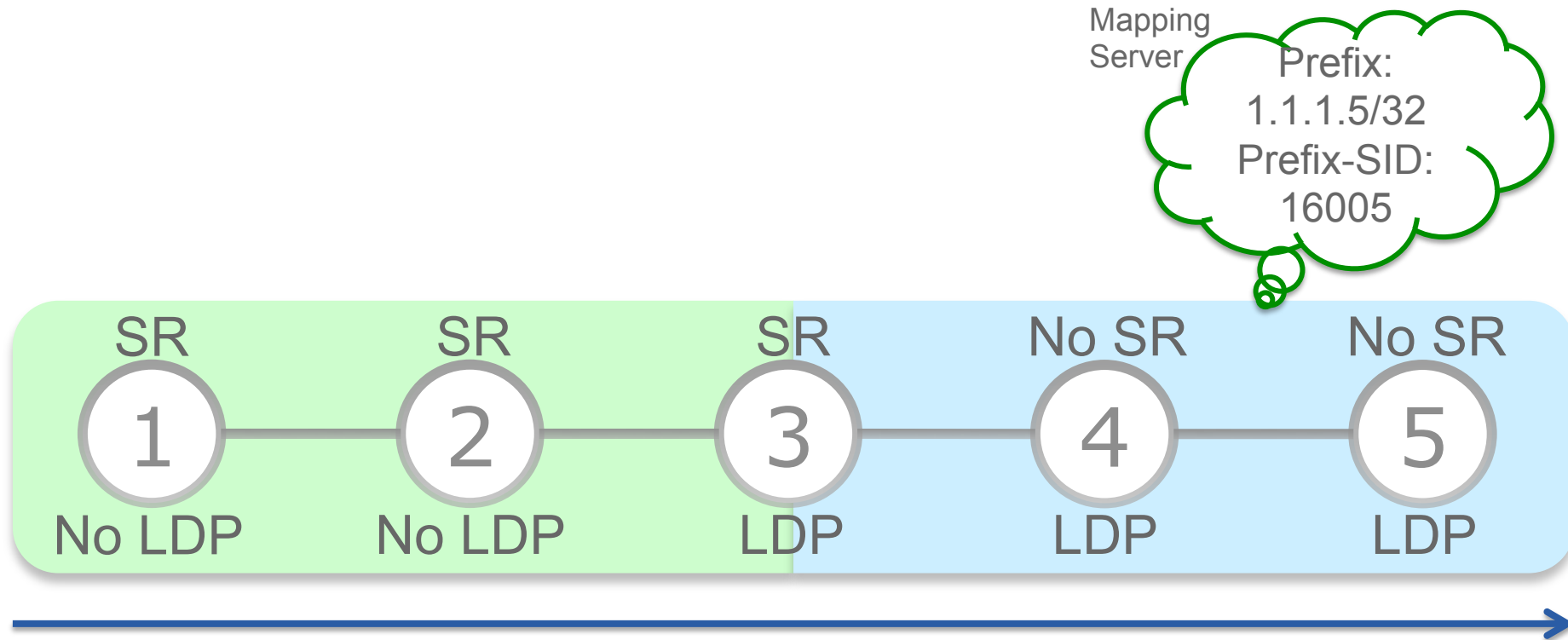
SR/LDP interworking – SR/LDP to LDP

- To have interworking from SR to LDP, a prefix-SID for the destination prefix must be advertised
 - by the destination itself, if it is SR-capable
 - by the **Mapping Server**, if the destination is **not SR-capable**

SR/LDP interworking – SR/LDP to LDP

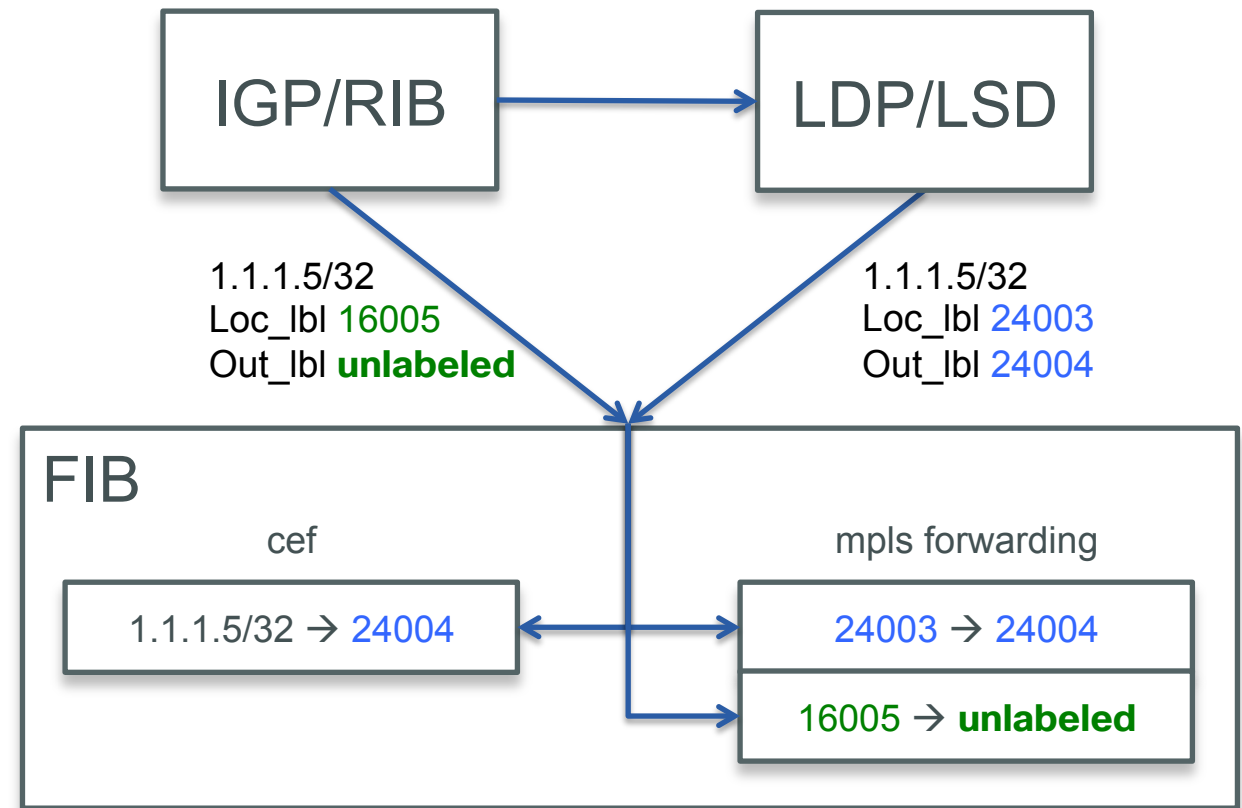
SR

LDP



IGP/SR and LDP programming FIB

- This diagram illustrates the behavior of Node3 in the topology
- Downstream neighbor 4 not SR-capable
→ no outgoing SR label

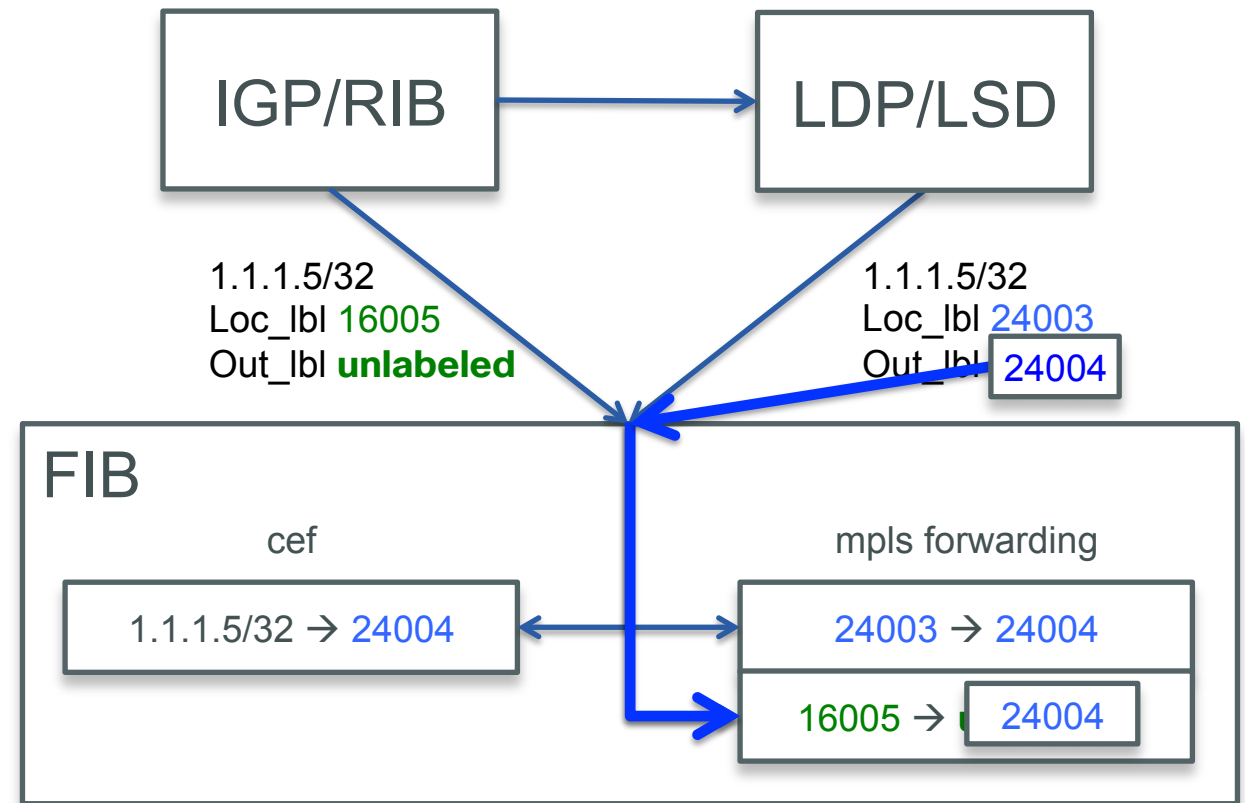


Loc_lbl: local label, allocated by local node
Out_lbl: outgoing label

16001: SR label
24003: LDP label

IGP/SR and LDP programming FIB

- FIB automatically fixes up the unlabeled entries by replacing “unlabeled” by the valid outgoing label from the other source
 - Replace “unlabeled” by 24004



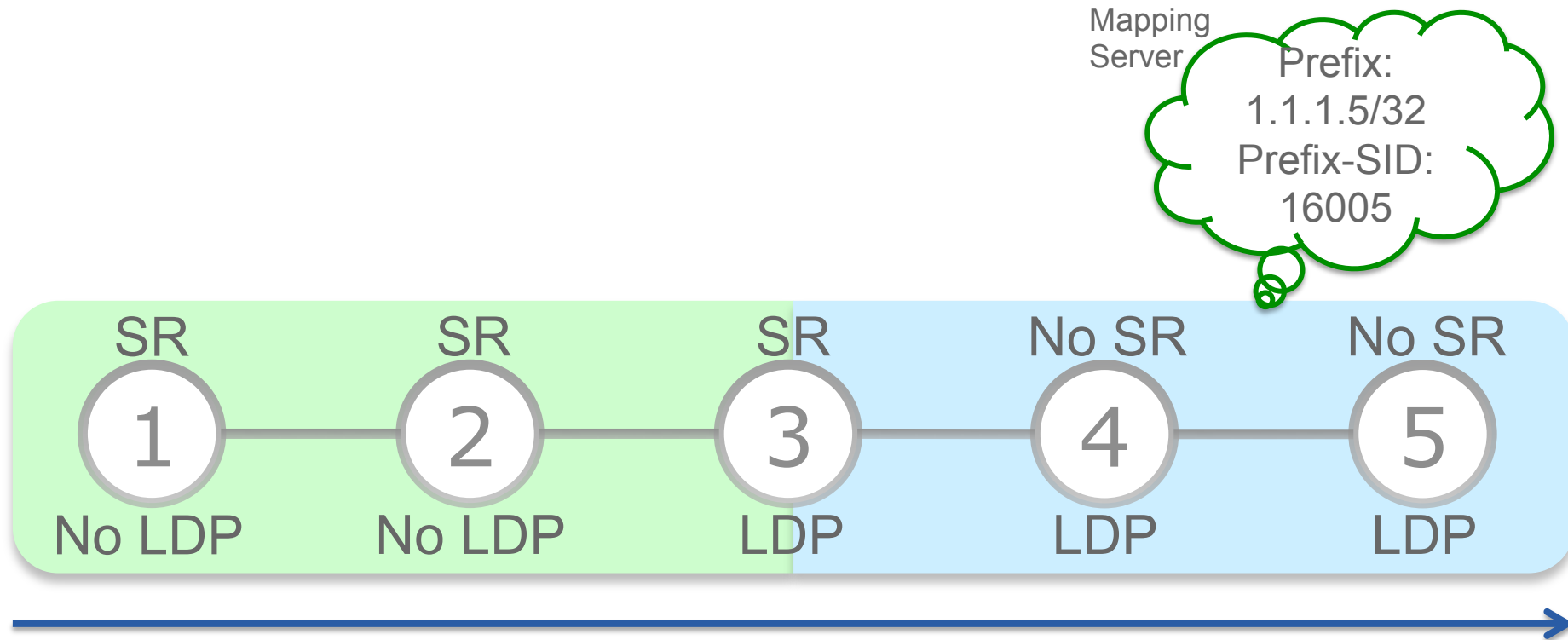
Loc_lbl: local label, allocated by local node
Out_lbl: outgoing label

16001: SR label
24003: LDP label

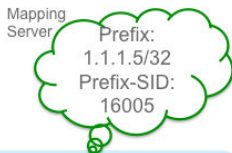
SR/LDP interworking – SR/LDP to LDP

SR

LDP

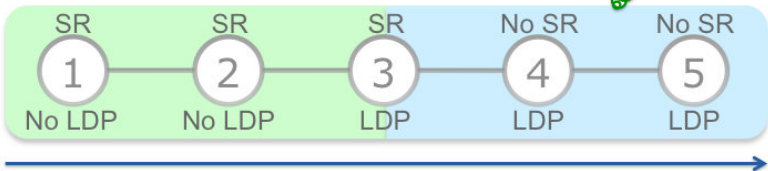


SR/LDP interworking – SR/LDP to LDP



```
RP/0/0/CPU0:xrivr-3#show route 1.1.1.5/32 detail
Routing entry for 1.1.1.5/32
  Known via "isis 1", distance 115, metric 20, type level-2
  Installed Apr 30 17:28:10.375 for 1d22h
  Routing Descriptor Blocks
    99.3.4.4, from 1.1.1.5, via GigabitEthernet0/0/0/0
    Route metric is 20
    Label: None
    Tunnel ID: None
    Extended communities count: 0
    Path id:1          Path ref count:0
    NHID:0x1(Ref:4)
  Route version is 0x16 (22)
  Local Label: 0x3e85 (16005)
  IP Precedence: Not Set
  QoS Group ID: Not Set
  Flow-tag: Not Set
  Route Priority: RIB_PRIORITY_NON_RECURSIVE_MEDIUM (7) SVD Type RIB_SVD_TYPE_LOCAL
  Download Priority 1, Download Version 139
  No advertising protos.
```

```
RP/0/0/CPU0:xrivr-3#show mpls ldp bindings 1.1.1.5/32
1.1.1.5/32, rev 24
  Local binding: label: 24003
  Remote bindings: (1 peers)
    Peer          Label
    -----
    1.1.1.4:0     24004
```



no RIB outgoing label

RIB entry for 1.1.1.5/32

RIB local label

LDP entry for 1.1.1.5/32

LDP local label

LDP outgoing label

SR/LDP interworking – SR/LDP to LDP



```
RP/0/0/CPU0:xrivr-3#show cef 1.1.1.5/32 flags
1.1.1.5/32, version 88, internal 0x4000001 0x1 (ptr 0xace3e0a0) [1], 0x0
(0xace362f8), 0x228 (0xacbd5338)
leaf flags: owner locked, inserted
leaf flags2: LDP/SR merge req
leaf ext flags: Priority change
Updated Apr 30 17:28:10.414
local adjacency 99.3.4.4
Prefix Len 32, traffic index 0, precedence n/a, priority 3
via 99.3.4.4, GigabitEthernet0/0/0/0, 11 dependencies, weight 0, class 0
[flags 0x0]
path-idx 0 NHID 0x0 [0xacaa3bf0 0x0]
next hop 99.3.4.4
tx adjacency
```

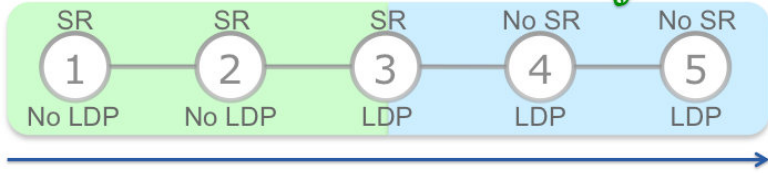
local_label 24003 labels imposed {24004}

```
RP/0/0/CPU0:xrivr-3#show mpls forwarding labels 24003
```

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
24003	24004	1.1.1.5/32	Gi0/0/0/0	99.3.4.4	7088

```
RP/0/0/CPU0:xrivr-3#show mpls forwarding labels 16005
```

Local Label	Outgoing Label	Prefix or ID	Outgoing Interface	Next Hop	Bytes Switched
16005	24004	SR Pfx (idx 1)	Gi0/0/0/0	99.3.4.4	14664



“LDP/SR merge req” flag is set, no SR preference flag set → prefer LDP for ip2mpls

cef (ip2mpls) label

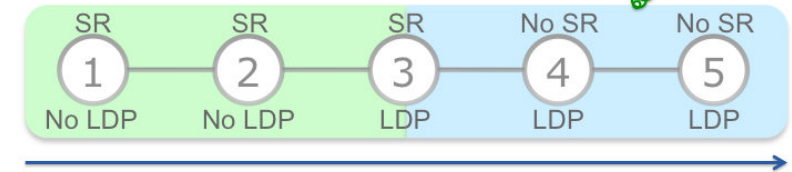
mpls2mpls labels LDP

mpls2mpls labels SR

SR/LDP interworking – SR/LDP to LDP

- With “sr-prefer” configuration (Prefer SR over LDP)

Mapping Server
Prefix:
1.1.1.5/32
Prefix-SID:
16005



```
RP/0/0/CPU0:xrvr-3#show cef 1.1.1.5/32 flags
1.1.1.5/32, version 148, internal 0x4000001 0x7 (ptr 0xace3e020) [1], 0x0
(0xace26340), 0x228 (0xacbcd08)
leaf flags: owner locked, inserted
leaf flags2: LDP/SR merge req, RIB prec LSD, LDP/SR merge act
leaf ext flags: Priority change
Updated Mar  3 10:10:53.375
local adjacency 99.3.4.4
Prefix Len 32, traffic index 0, precedence n/a, priority 15
via 99.3.4.4, GigabitEthernet0/0/0/0, 13 dependencies, weight 0, class 0
[flags 0x0]
  path-idx 0 NHID 0x0 [0xacadabf0 0x0]
  next hop 99.3.4.4
  tx adjacency
    local label 16005    labels imposed {24004}
```

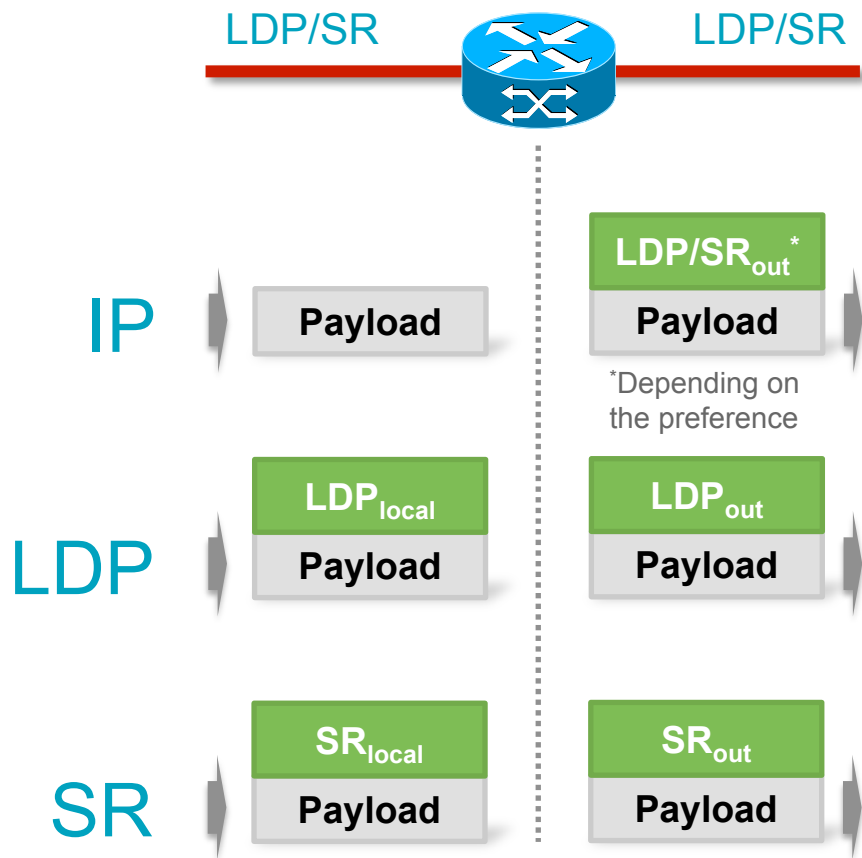
“LDP/SR merge req” flag is set,
SR preference flag is set
→ prefer SR for ip2mpls
“LDP/SR merge act” flag shows
labels have been merged

cef (ip2mpls) label

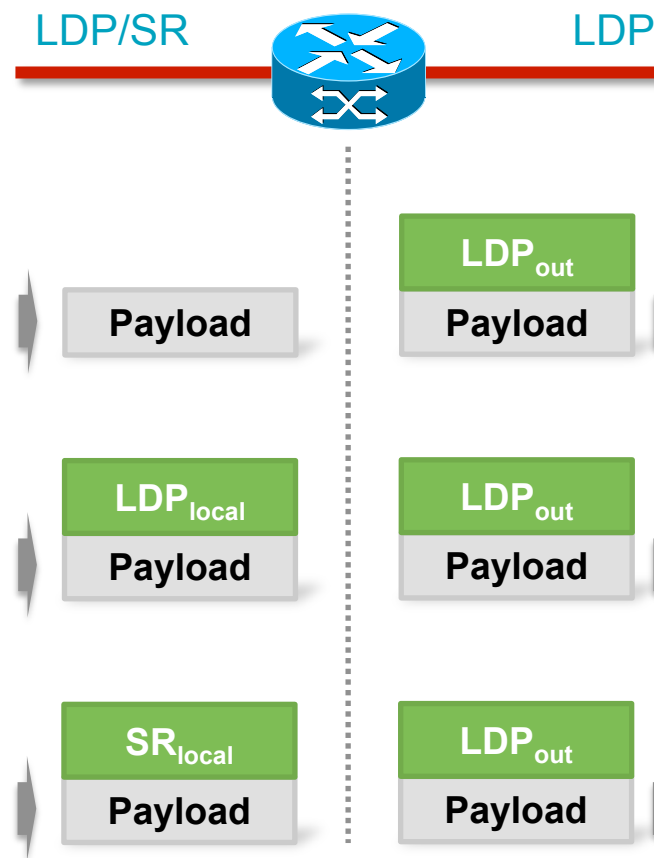
SR/LDP interworking – Overview

$LDP|SR_{local}$: local LDP|SR label
 $LDP|SR_{out}$: outgoing LDP|SR label

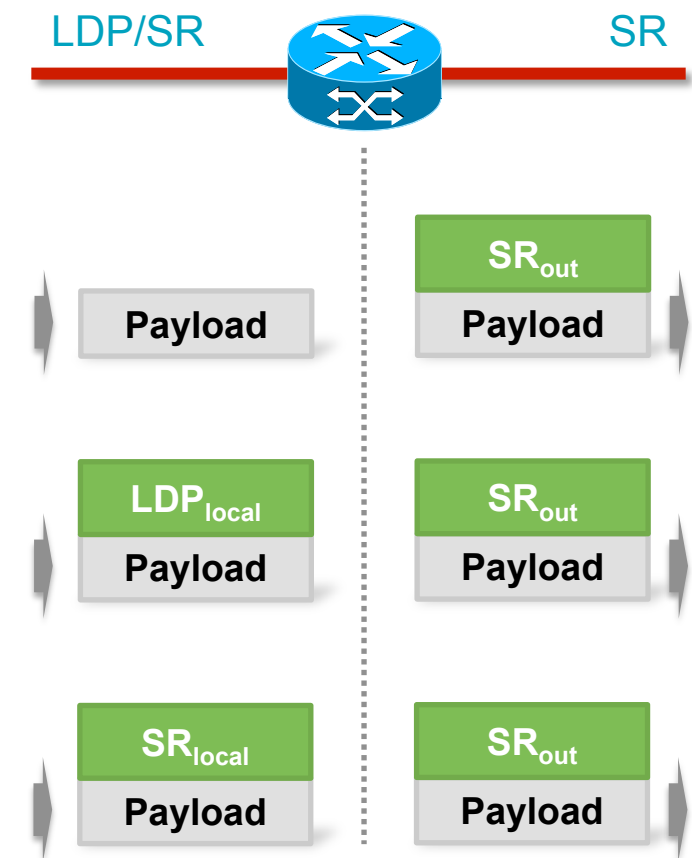
Ships in the night



to LDP



to SR



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