Unleashing Segment Routing TE with SR Flexible Algorithms

Jose Liste, Technical Marketing Engineer (jliste@cisco.com)

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Why are we here?

- Have you ever wished you could tailor IGP computation to fit your own traffic engineering needs? Such as by computing:
  - Paths considering a subset of the routers in your network
  - Paths that minimize cumulative delay to a destination based on measured per-link delay
  - Paths traversing only encrypted MACsec links
  - Paths traversing only high speed interfaces

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Why are we here?

- All these use cases are now possible !!!
- And furthermore, they are possible at scale and without adding any extra state into the network
- Meet SR IGP Flexible Algorithms !!!
  - A new member of SRTE family

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Agenda

- Overview
- Operation
- Use Cases

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SR Flexible Algorithm Overview

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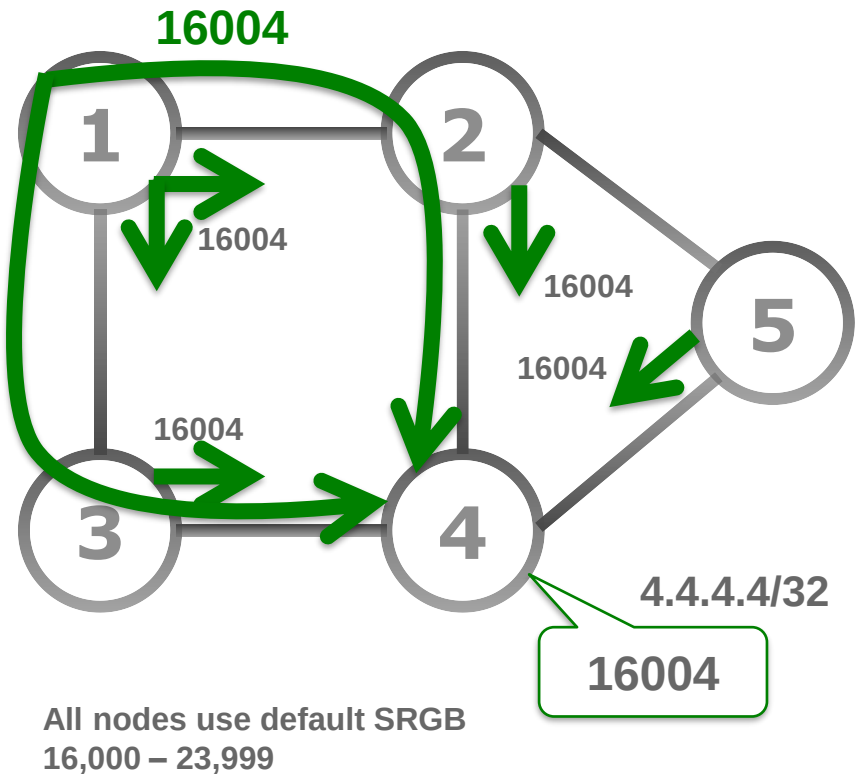
Recap – IGP Prefix Segment

- IGP Prefix-SID
  - Advertised as label value
  - Operator-allocated value from SRGB
  - Advertised as index
- Distributed by ISIS/OSPF
- Shortest-path to the IGP prefix
  - Equal-Cost Multi-Path (ECMP)-aware
- Global Segment
  - Programmed in every node



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SR IGP Flexible Algorithm

- Complements the SRTE solution with customizable Prefix-SIDs

- Leverages the SRTE benefits of simplicity and automation
  - Automated sub-50msec FRR (TILFA)
  - On-Demand Policy (ODN)
  - Automated Steering (AS)

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SR IGP Flexible Algorithm

- Complements the SRTE solution with customizable Prefix-SIDs

- We call “Flex-Algo”
  - The algorithm is defined by the operator, on a per-deployment basis
- Flex-Algo K is defined as
  - The minimization of a specified metric: IGP, delay, …
  - The exclusion of certain link properties: link-affinity, SRLG, …

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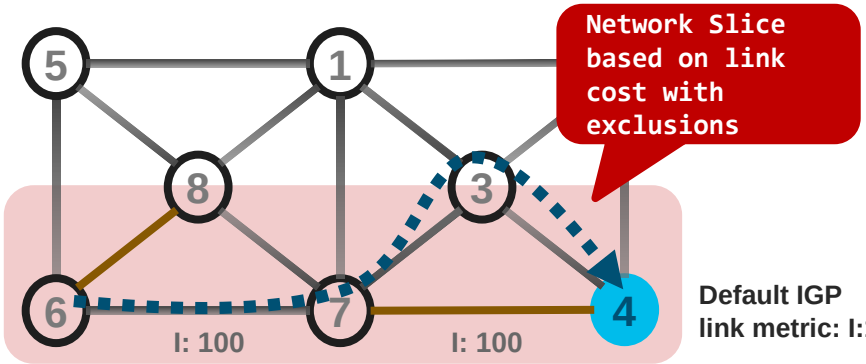
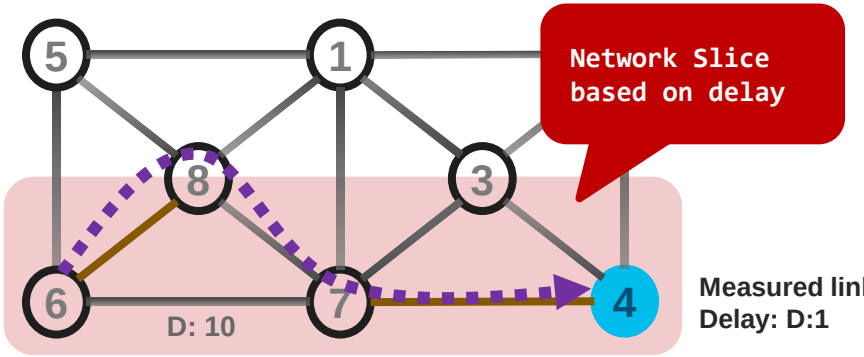
SR IGP Flexible Algorithms

- Examples
  - Operator defines Flex-Algo 128 as “minimize IGP metric while avoiding links with link-affinity “brown”
  - Operator defines Flex-Algo 129 as “minimize delay metric”





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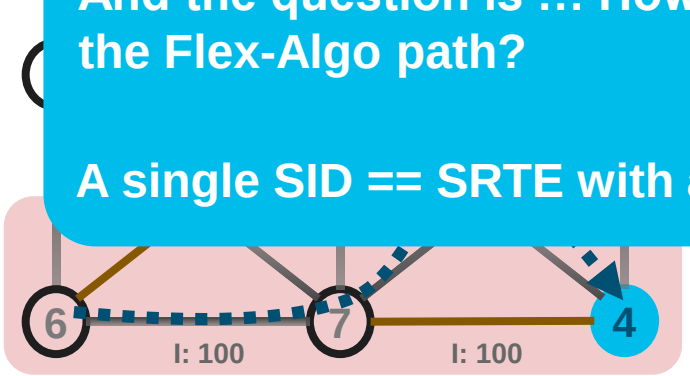
SR IGP Flexible Algorithms

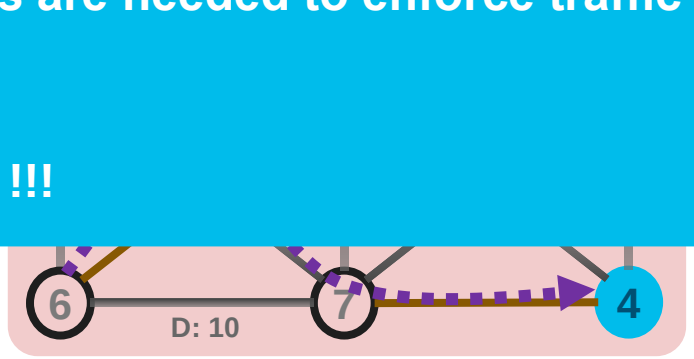
- Examples
  - Operator defines Flex-Algo 128 as “minimize IGP metric while avoiding links with link-affinity “brown”
  - Operator defines Flex-Algo 129 as “minimize delay metric”

And the question is … How many labels are needed to enforce traffic on the Flex-Algo path?

A single SID == SRTE with a single SID !!!



Default IGP link metric: I:10



Measured link Delay: D:1

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SR Flexible Algorithm Operation

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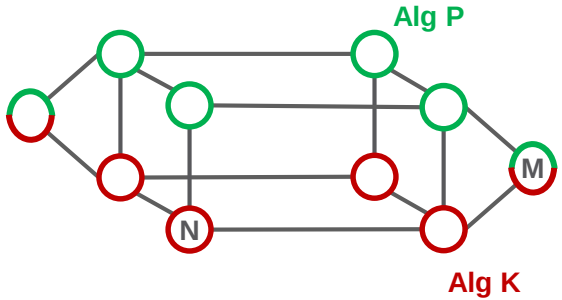
Flex-Algo Operation



1

- Flex-Algo Membership
  - Each node MUST advertise Flex-Algo(s) that it is participating in
  - A Flex-Algo instance can be enabled on all or a subset of nodes
  - Each node can participate in multiple Flex-Algo(s)

  - Example:
    - Node N is enabled to participate in Flex-Algo instance K
    - Node M is enabled to participate in Flex-Algo instances K and P

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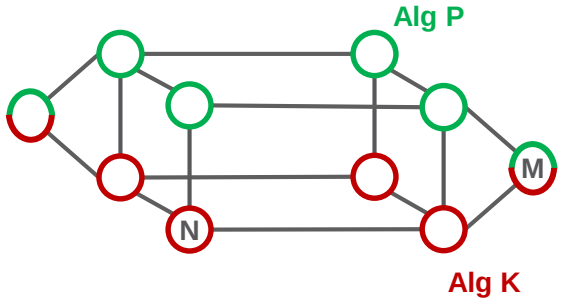
Flex-Algo Operation



2

- Flex-Algo Prefix SIDs
  - If a node advertises participation in a Flex-Algo likely it also advertises a prefix SID for that Flex-Algo

  - Example:
  - Node N advertises
    - Prefix SID 1600N for ALGO 0
    - Prefix SID 1700N for ALGO K
  - Node M advertises
    - Prefix SID 1600M for ALGO 0
    - Prefix SID 1700M for ALGO K
    - Prefix SID 1800M for ALGO P

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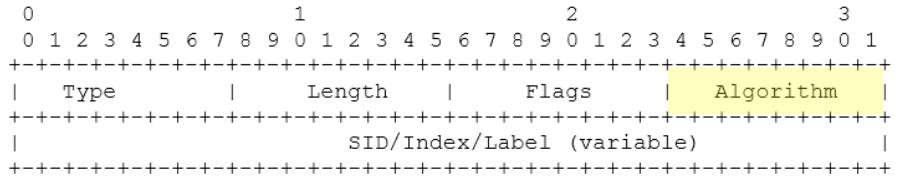
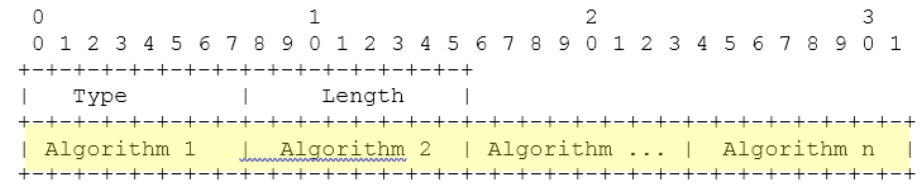
Flex-Algo Participation and Prefix-SID

- Each Prefix SID is related to an algorithm



- Each node advertises its ALGO capability

The SR-Algorithm sub-TLV has following format:



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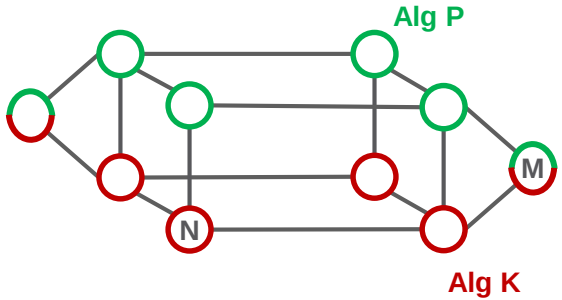
Flex-Algo Operation



2

- Flex-Algo Prefix SIDs (cont.)
  - No additional loopback address
  - Flex-Algo Prefix SID's can be advertised as additional prefix-SID's of the existing loopback address
  - Example:
  - Node M advertises loopback0 1.1.1.M/32 with
    - Prefix SID 1600M for ALGO 0
    - Prefix SID 1700M for ALGO K
    - Prefix SID 1800M for ALGO P

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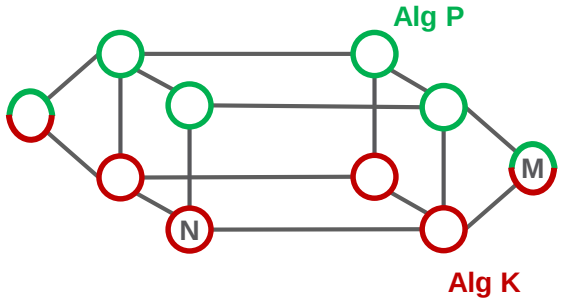
Flex-Algo Operation



3

- Flex-Algo Definition
  - Each node MUST have a consistent definition of the Flex-Algo(s) that it is participating in
  - Local configuration
    - likely automated during day-0 provisioning
  - Learned from a central entity via IGP flooding
    - new top TLV defined for Flex-Algo definition advertisement
  - Example:
    - Flex-Algo instance K == minimize delay metric

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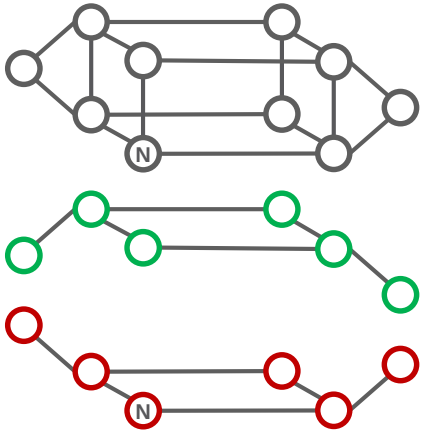
Flex-Algo Operation (cont.)



4 • Flex-Algo Computation
  - N prunes any node not a member of K
  - N prunes any link that is exclude by K
  - Resulting topology is called Topo(K)
  - N compute shortest-path tree on Topo(K) with metric defined by K

5 • Flex-Algo Prefix SID FIB installation
  - N installs any reachable Prefix-SID of K in the forwarding table along the computed shortest-path on Topo(K)

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Topology Independent LFA (TI-LFA)

- TI-LFA algorithm is performed within Topo(K)
- Backup path is expressed with Prefix-SIDs of Algo K

- Benefits: the backup path is optimized per Flex-Algo !!!

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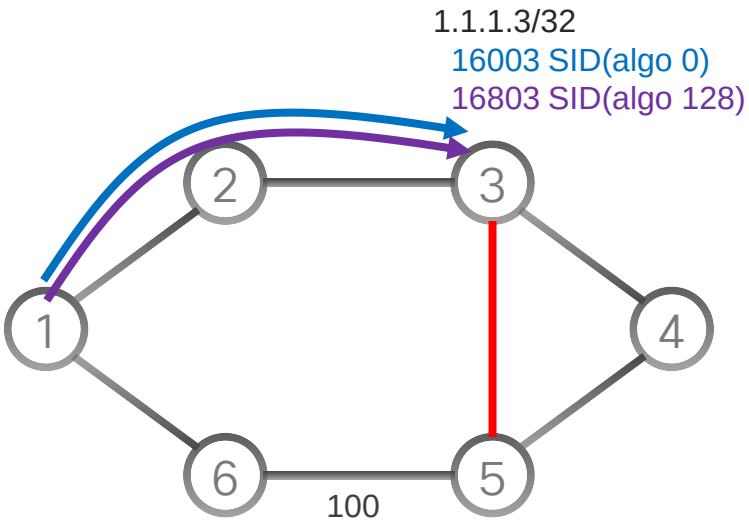
Example – Primary paths per Algo



Each node in this topology supports SR alg0, alg128
Default IGP link metric: I:10

At node 1 for destination 3

16003 => 16003 via 2

16803 => 16803 via 2

All nodes participate in Flex-Algo 128 which is defined as min IGP metric and avoid red affinity

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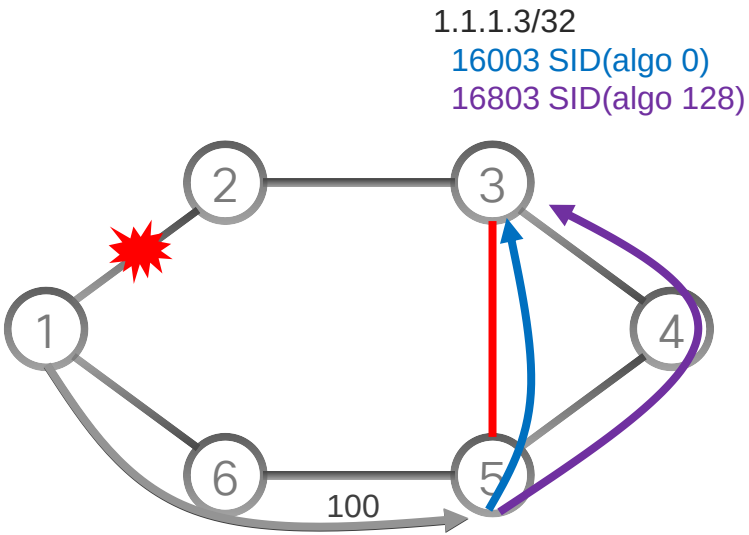
Example – TI-LFA Backup path per Algo



At node 1 for destination 3

16003 => 16003 via 2

→ backup: <24065, 16003> via 6

16803 => 16803 via 2

→ backup: <24065, 16803> via 6

The usage of Algo-128 Prefix-SID 16803 ensures that the Algo 128 backup path also avoids the red link

Reminder: 240XY is the Adj SID from node X to node Y

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OSPF and SRv6

- Same applies to OSPF
- Same applies to SRv6

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IETF

- draft-ietf-spring-segment-routing
  - Prefix-SID per Algorithm
- draft-ietf-spring-segment-routing-policy
  - SR Policy architecture, ODN, AS
- draft-ietf-lsr-flex-algo
  - Customization of Algo and consistency
- draft-ketant-idr-bgp-ls-flex-algo
  - Flex-Algo definition advertisement with BGP Link-State
- draft-ietf-isis-te-app
  - Used to flood Flex-Algo specific link affinities
- RFC7810 (IS-IS Traffic Engineering (TE) Metric Extensions)
  - Used to advertise extended TE metrics – e.g. link delay

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SR Flexible Algorithm Use-Cases

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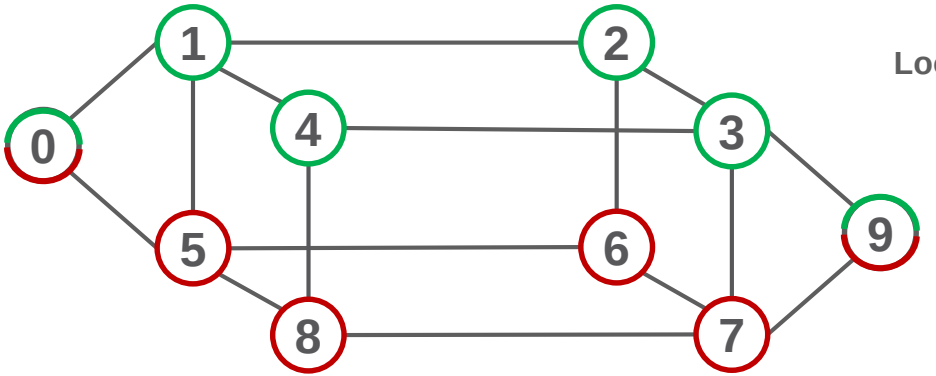
Use-Case – Multi-Plane Networks



Loopback 1.1.1.9/32

16009 Algo 0

16809 Flex-Algo 128

16909 Flex-Algo 129

- All the nodes support Algo 0: minimize IGP metric
- Green nodes also support 128: minimize IGP metric
- Red nodes also support 129: minimize Delay

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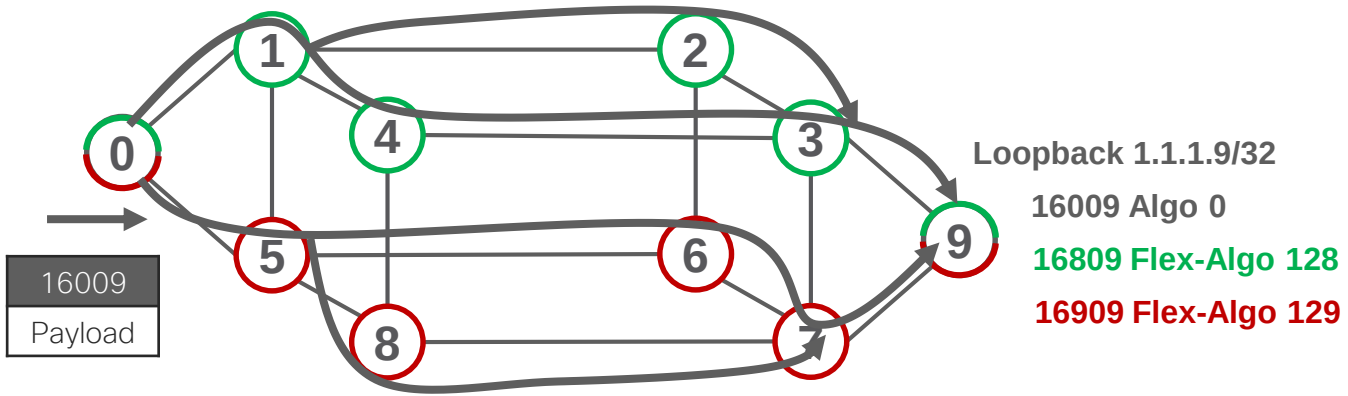
Use-Case – Multi-Plane Networks (cont.)



- Path to Node 9 across Algo 0

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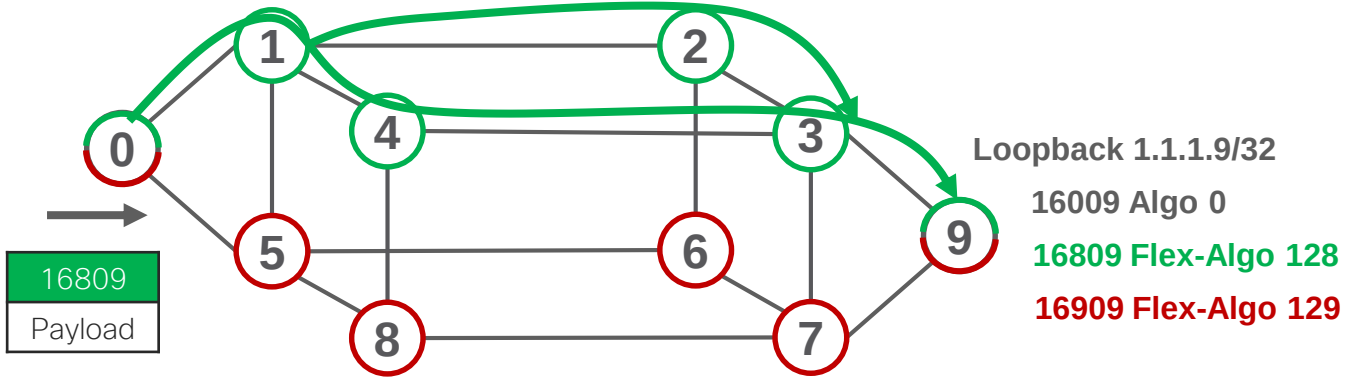
Use-Case – Multi-Plane Networks (cont.)



- Path to Node 9 across Flex-Algo 128

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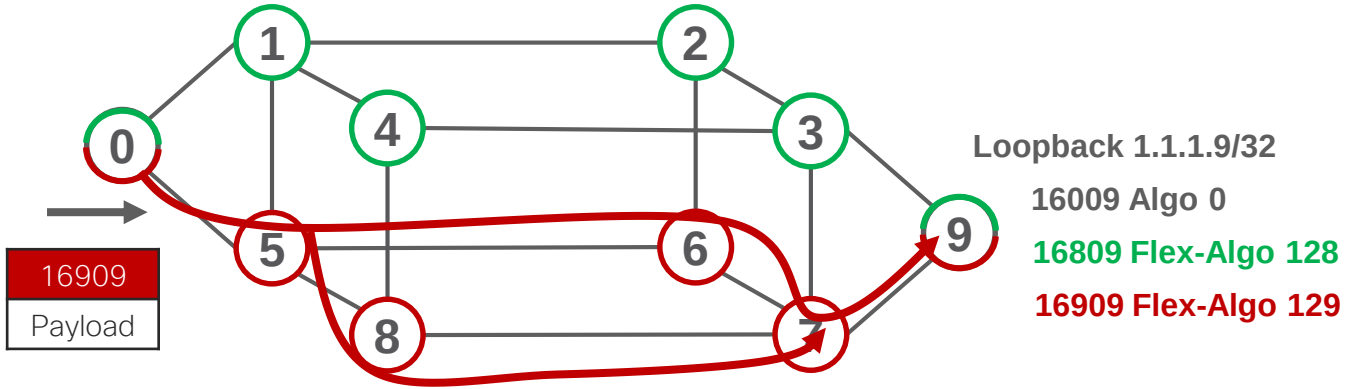
Use-Case – Multi-Plane Networks (cont.)



- Path to Node 9 across Flex-Algo 129

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Automated Steering

- SRTE Automated Steering (AS) is leveraged for IGP Flex-Algo

```
segment-routing
  traffic-eng
    on-demand color 100
       dynamic mpls
          sid-algorithm 128
```

"Any 100-colored BGP route should be steered via the prefix-SID(ALGO 128) of the BGP nhop"

Cisco IOS-XR configurations shown

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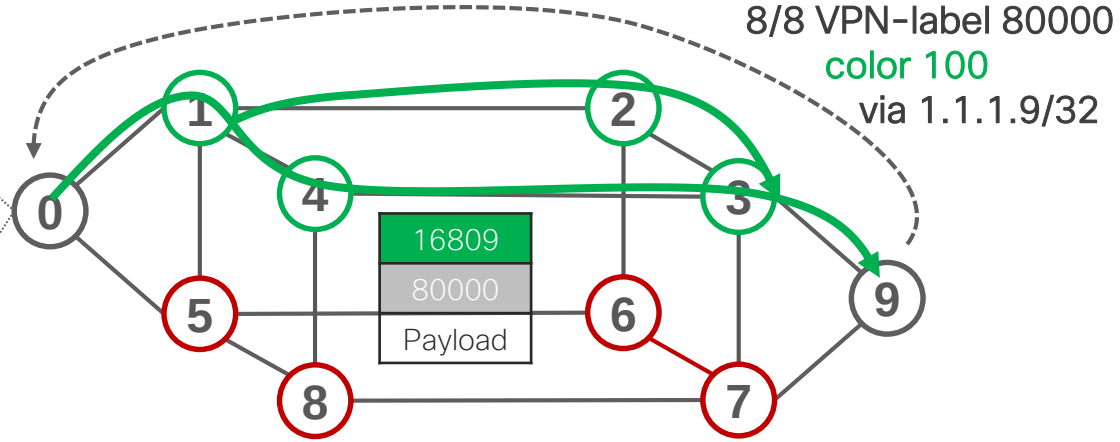
Automated Steering – Multi-Plane

```
segment-routing
  traffic-eng
    on-demand color 100
      dynamic mpls
       sid-algorithm 128

router isis 1
  flex-algo 128
```

```
FIB

8/8: push 80000 16809
```



- Node 0 automatically steers any BGP route with color 100 from 9 via 16809 hence via the green plane only
- One single Flex-Algo Prefix-SID expresses the end-to-end SLA path

Cisco IOS-XR configurations shown

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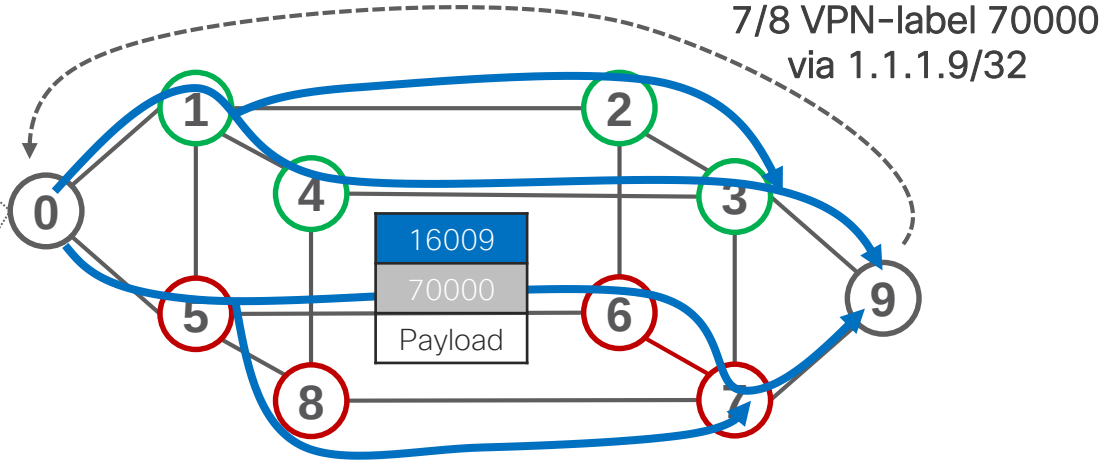
Automated Steering – Multi-Plane

```
segment-routing
  traffic-eng
    on-demand color 100
      dynamic mpls
       sid-algorithm 128

router isis 1
  flex-algo 128
```

```
FIB

7/8: push 70000 16009
```



- Node 0 automatically steers any BGP route without color from 9 via 16009 (any plane)

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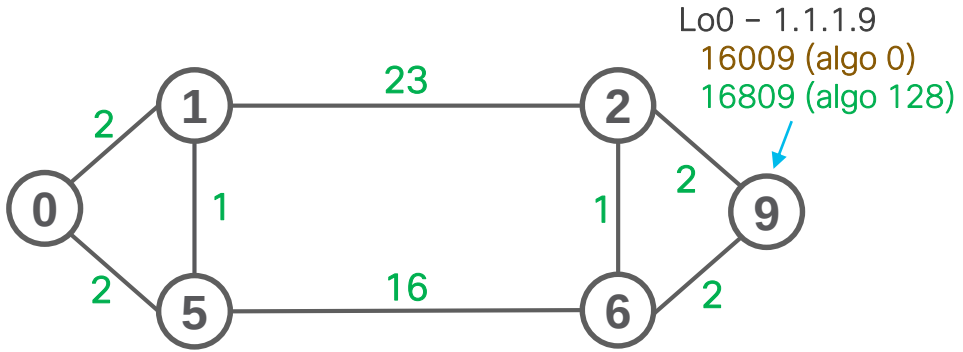
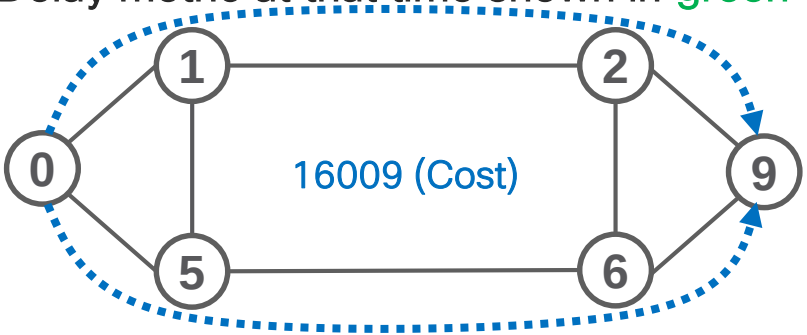
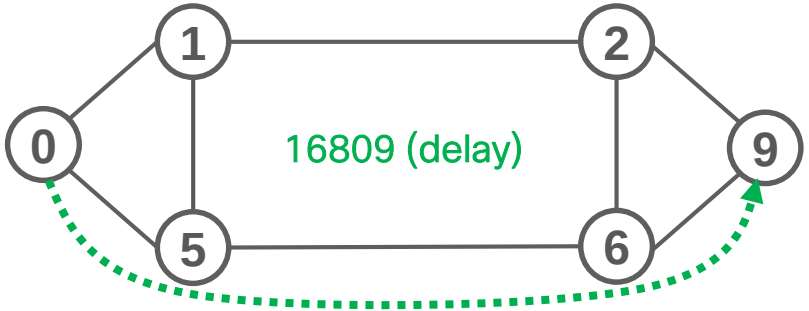
Use-Case – Delay vs Cost of Transport

- All nodes support Algo 0 & 128
- ISIS link metric 10
- Algo 128: minimize delay metric
- Per-link measurement of delay and advertisement as delay metric via ISIS
- Delay metric at that time shown in green







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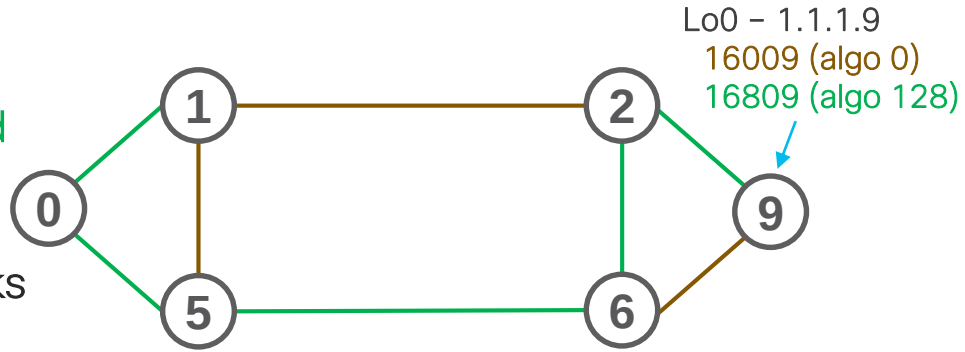
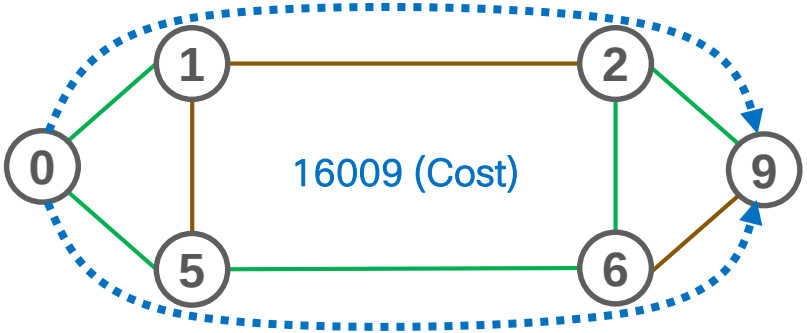
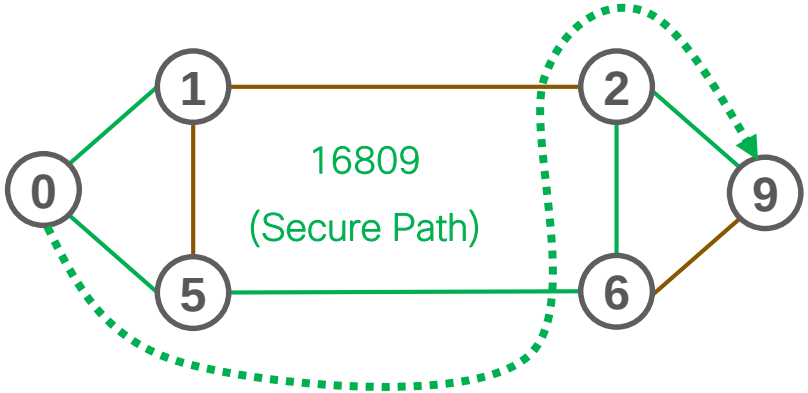
Use-Case – SRTE for Intelligent Secure Paths

- ISIS link metric 10
- Link colors shown Unencrypted / Encrypted
- All nodes support Algo 0 & 128
- Algo 128: minimize IGP while traversing links with encryption enabled (exclude brown)
- Per-link colors flooded in IGP







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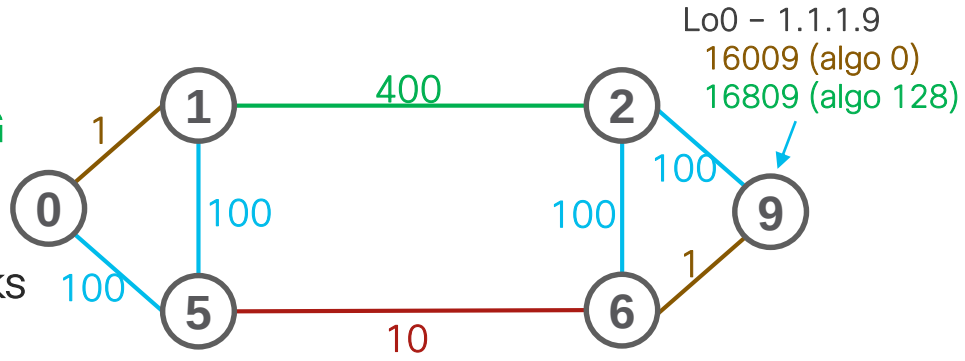
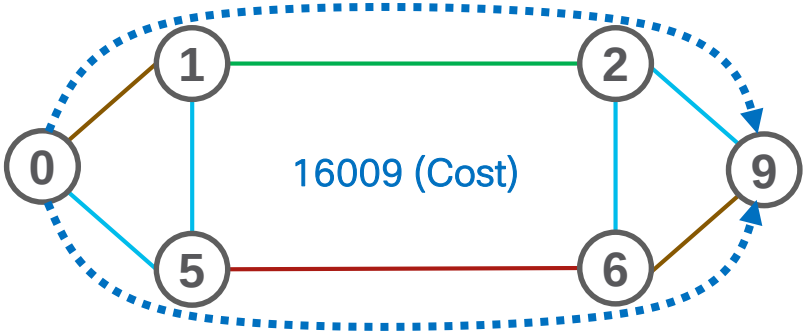
Use-Case - SRTE for High-BW Links Preference

- ISIS link metric 10
- Link colors shown 1G / 10G / 100G / 400G
- All nodes support Algo 0 & 128
- Algo 128: minimize IGP while traversing links of 100G or more (exclude brown and red)
- Per-link colors flooded in IGP





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Demonstration

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If we had more time ...

- Inter-Domain path computation with Flex-Algo

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Conclusions

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SR IGP Flexible Algorithm

- Complements the SRTE solution by adding new Prefix-Segments with specific optimization objective and constraints
  - minimize igp-metric or delay or te-metric
  - avoid link-affinity or SRLG
- TE path from anywhere to anywhere automatically computed by IGP
- Single SID is used to enforce traffic on the Flex-Algo specific path
- Leverages the SRTE benefits of simplicity and automation
  - Automated sub-50msec FRR (LFA / TI-LFA)
  - On-Demand Policy (ODN)
  - Automated Steering (AS)

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Resources / Stay Up-To-Date

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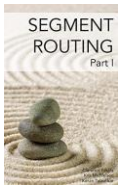
https://www.linkedin.com/groups/8266623

https://twitter.com/SegmentRouting

https://www.facebook.com/SegmentRouting/



Segment Routing, Part I / II - Textbooks

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Thank You

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