SR IGP Flex Algo

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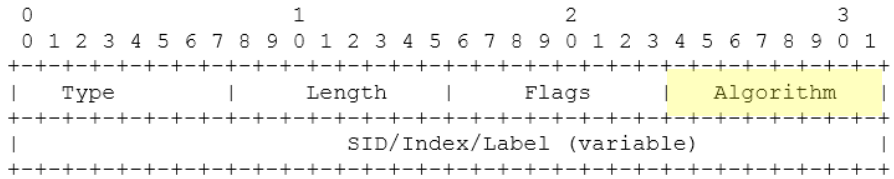
SR IGP Flex Algo

- Complements the SRTE solution by adding new Prefix-Segments with specific optimization objective and constraints
  - minimize igp-metric or delay or te-metric
  - avoid SRLG or affinity
- Leverages the SRTE benefits of simplicity and automation
  - Automated sub-50msec FRR (TILFA)
  - On-Demand Policy (ODN)
  - Automated Steering (AS)

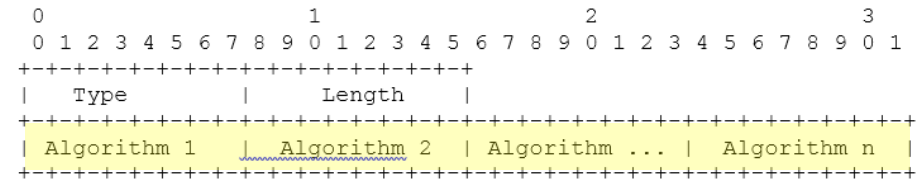
IGP SR Algorithm

- Each Prefix SID is related to an algorithm



- Each node advertises its ALGO capability

The SR-Algorithm sub-TLV has following format:



Currently defined algorithms

- 0: Shortest Path First (SPF) algorithm based on link metric.
  - This is the well-known shortest path algorithm as computed by the IS-IS Decision process. Consistent with the deployed practice for link-state protocols, algorithm 0 permits any node to overwrite the SPF path with a different path based on local policy
- 1: Strict Shortest Path First (SPF) algorithm based on link metric.
  - The algorithm is identical to algorithm 0 but algorithm 1 requires that all nodes along the path will honor the SPF routing decision. Local policy MUST NOT alter the forwarding decision computed by algorithm 1 at the node claiming to support algorithm

Flexible Algorithm

- 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, …
- Example
  - Operator1 defines Flex-Algo 128 as “minimize IGP metric and avoid link-affinity “green”
  - Operator2 defines Flex-Algo 128 as “minimize delay metric and avoid link-affinity “blue”

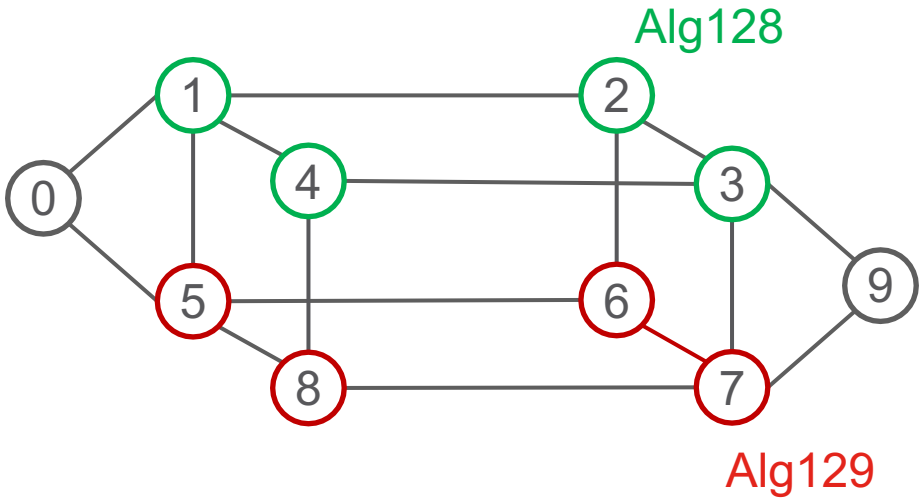
Flex-Algo Participation Advertisement

- Each node MUST advertise Flex-Algo(s) that it is participating in

Nodes 0 and 9 participate to Algo 0 and 128 and 129

Nodes 1/2/3/4 participate to Algo 0 and 128

Nodes 5/6/7/8 participate to Algo 0 and 129



Prefix-SID for each Flex-Algo

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

Node 9 advertises

Prefix SID 16009 for ALGO 0

Prefix SID 16809 for ALGO 128

Prefix SID 16909 for ALGO 129

Node 2 advertises

Prefix SID 16002 for ALGO 0

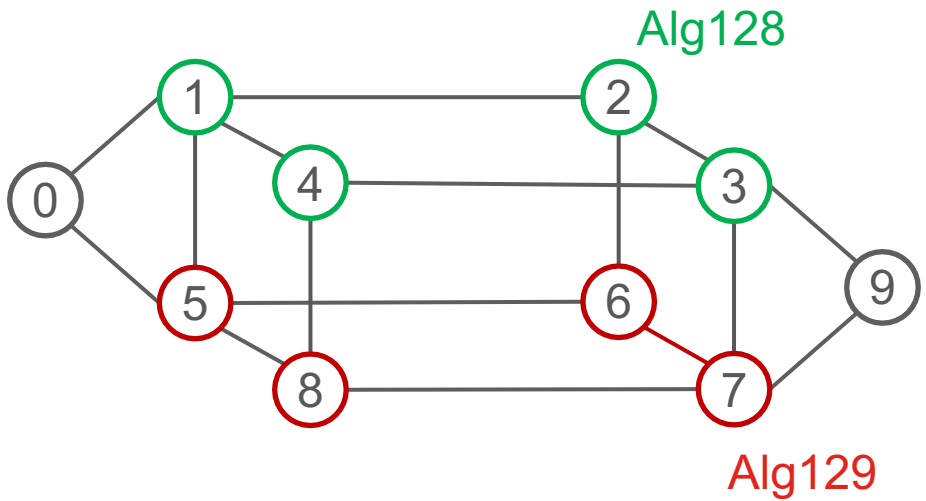
Prefix SID 16802 for ALGO 128

For example, for node N: 16000 + N

+ 0 for Algo 0

+ 800 for Algo 128

+ 900 for Algo 129



No additional loopback address

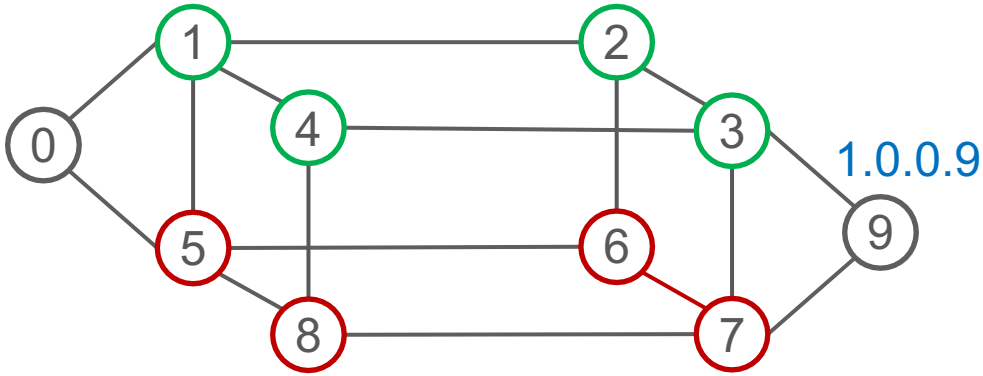
- Flex-Algo Prefix SID's can be advertised as additional prefix-SID's of the existing loopback address

Node 9 advertises loopback0 1.0.0.9/32 with

Prefix SID 16009 for ALGO 0

Prefix SID 16809 for ALGO 128

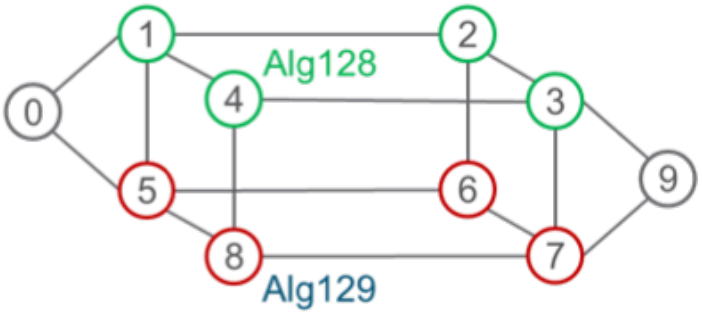
Prefix SID 16909 for ALGO 129



Flex-Algo Definition

- Each node MUST have the definition of the Flex-Algo(s) that it is participating in
  - e.g. ALGO 128: minimize on IGP metric and avoid TE affinity RED
- Local configuration
  - likely automated via a solution such as NSO
- Learned from a central entity via ISIS flooding
  - new top TLV defined for Flex-Algo definition advertisement

Algo 128: minimize IGP metric
Algo 129: minimize IGP metric



Flex-Algo Computation and Prefix-SID installation

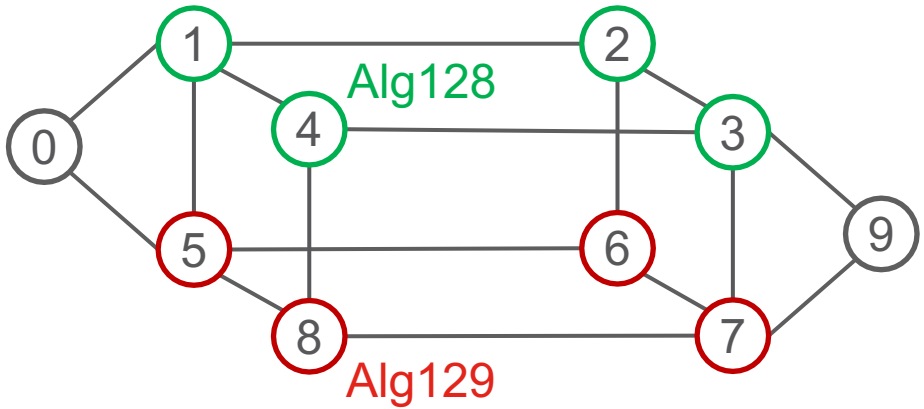
- A node N computes Flex-Algo K if
  - it is enabled for K, and
  - it has a consistent definition for K
- If so, the first step is to define the topology of K
  - N prunes any node that is not advertising participation to K
  - N prunes any link that is excluded by the algorithm of K
    - > e.g. if K excludes TE-affinity RED then any link with TE-affinity RED is pruned
  - The resulting topology is called Topo(K)

Flex-Algo Computation and Prefix-SID installation

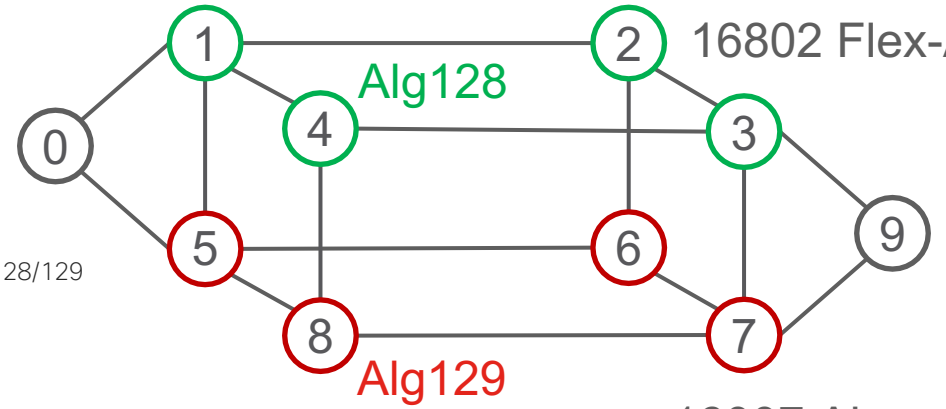
- The second step is to compute shortest-path tree on Topo(K) with the metric defined by K
  - it could be the IGP metric, the TE metric or the delay
- The third step is to install any reachable Prefix-SID of Flex-Algo K in the forwarding table

Example 1

- Grey nodes support Algo 0/128/129
- Green nodes support 0/128
- Red nodes support 0/129
- Algo 128: minimize IGP metric
- Algo 129: minimize IGP metric
- Nodes advertise a Prefix SID for each Algo they support
  - For example, for node N: 16000 + N
    - > + 0 for Algo 0
    - > + 800 for Algo 128
    - > + 900 for Algo 129



Example 1



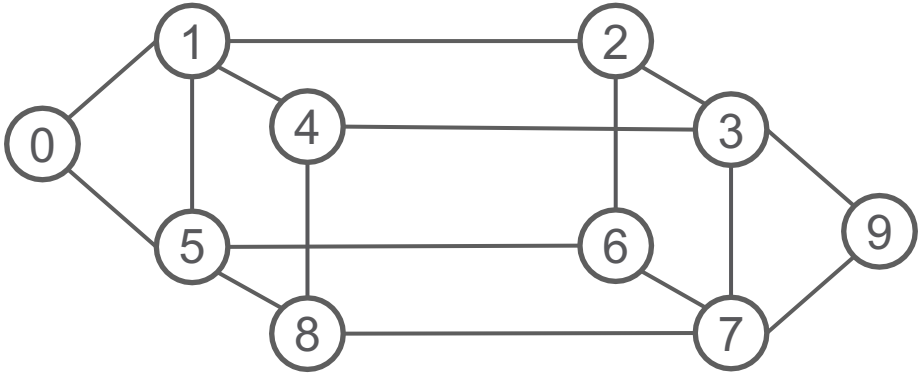
16002 Algo 0
16802 Flex-Algo 128

16009 Algo 0
16809 Flex-Algo 128
16909 Flex-Algo 129

16007 Algo 0
16907 Flex-Algo 129

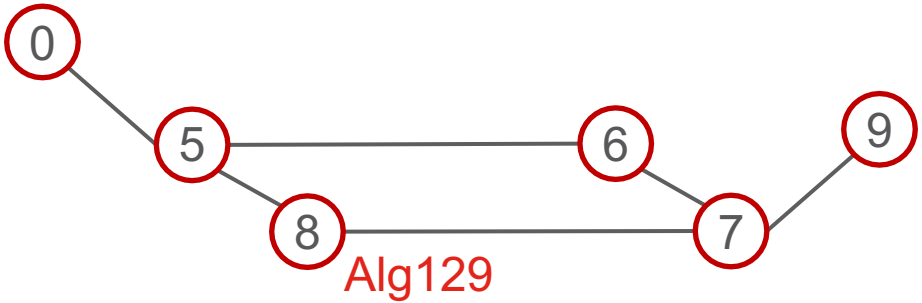
- Grey nodes support Algo 0/128/129
- Green nodes support 0/128
- Red nodes support 0/129
- Algo 128: minimize IGP metric
- Algo 129: minimize IGP metric
- Nodes advertise a Prefix SID for each Algo they support
  - For example, for node N: 16000 + N
    - + 0 for Algo 0
    - + 800 for Algo 128
    - + 900 for Algo 129

Example 1 – Topo(0)

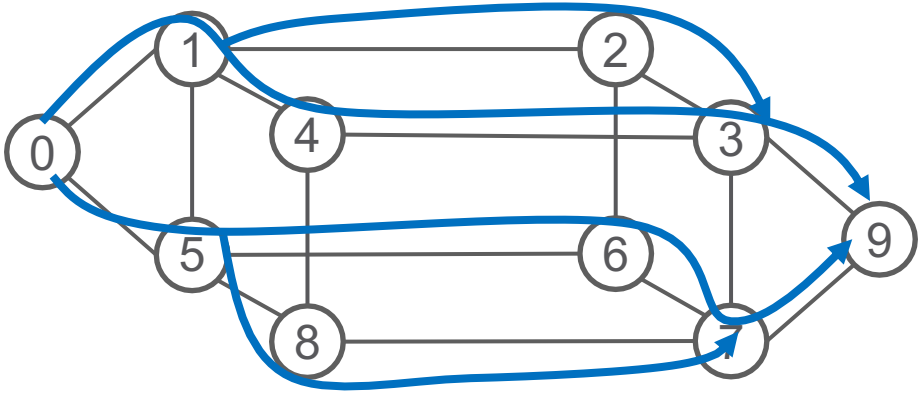


Example 1 – Topo(128)

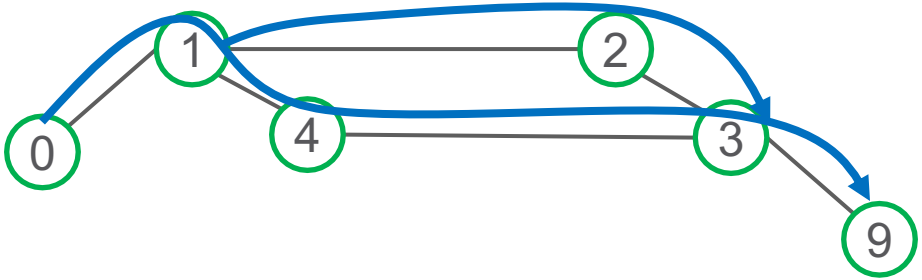
Example 1 – Topo(129)



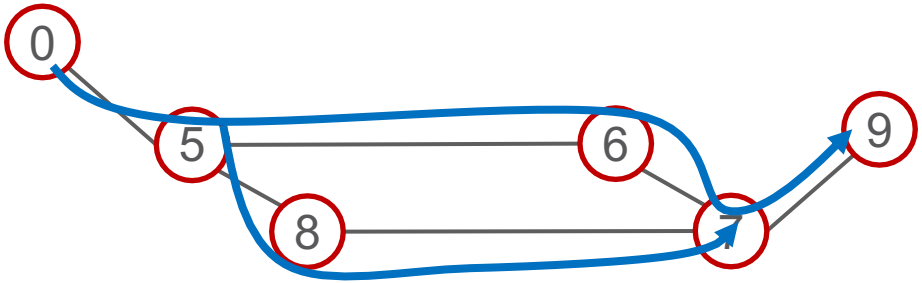
Example 1 – Prefix-SID 16009 of Algo 0



Example 1 – Prefix-SID 16809 of Flex-Algo 128



Example 1 – Prefix-SID 16909 of Flex-Algo 129

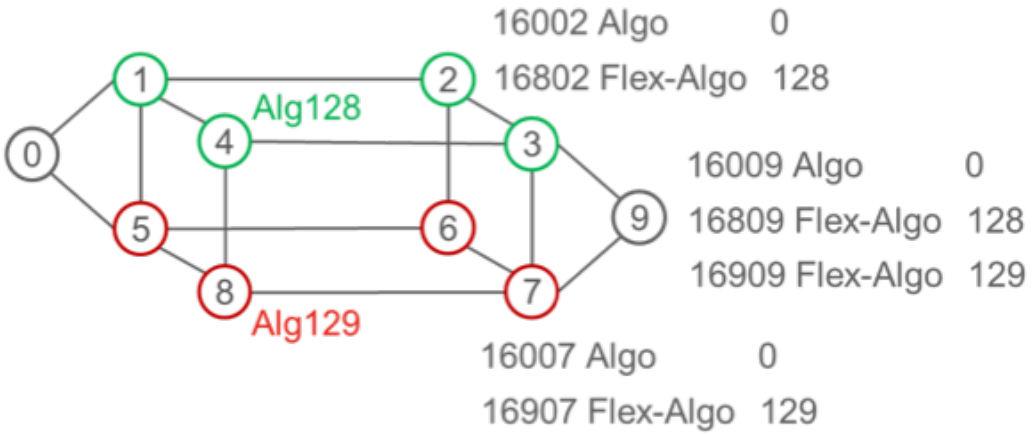


Example 1 – FIB of node 0

- 16009 via 1 or 5
- 16809 via 1
- 16909 via 5

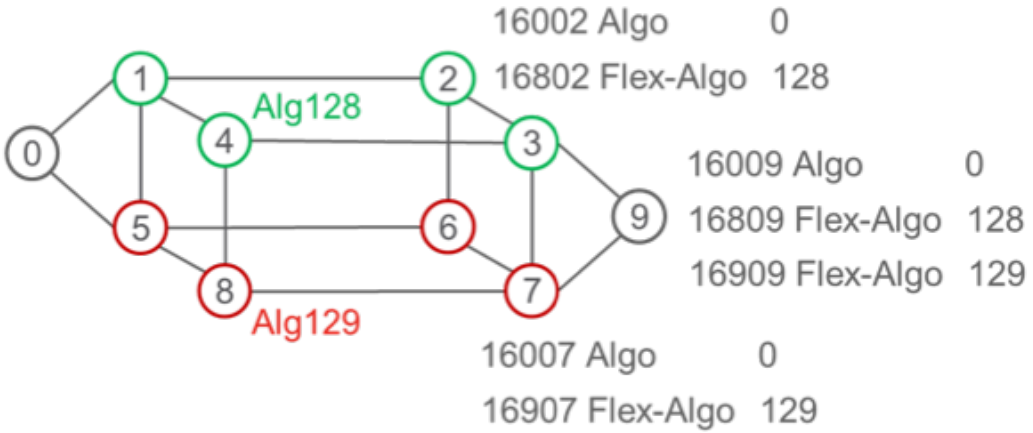
- 16002 via 1
- 16802 via 1

- 16007 via 5
- 16907 via 5



Example 1 – FIB of node 1

- 16009 via 2 or 4
- 16809 via 2 or 4
- 16002 via 2
- 16802 via 2



- Node 1 does not install Prefix-SID for Flex-Algo 129 as Node1 does not participate in 129

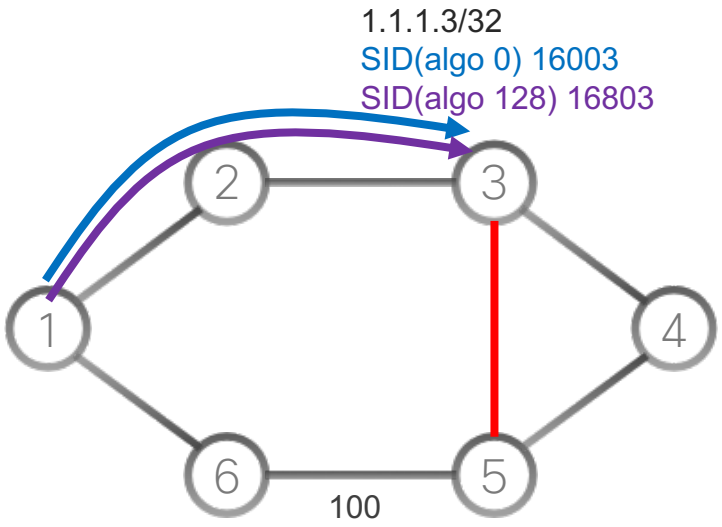
Notes

- This computation is performed by any node part of K
- If a node is part of 2 Flex-Algo's, it performs the described computation independently for each Flex-Algo
- ECMP is obviously supported in each Flex-Algo

TI-LFA

- The TI-LFA algorithm is performed within Topo(K)
- The backup path is expressed with Prefix-SID's of Algo K
- Benefits: the backup path is optimized per Flex-Algo!

Example – Primary paths per Algo



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

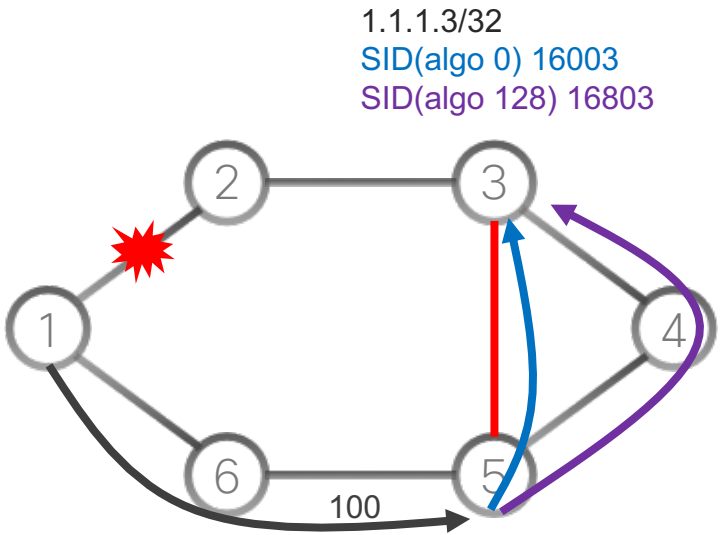
At node 1 for destination 3

16003 => 16003 via 2

16803 => 16803 via 2

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

Example – TILFA Backup path per Algo



At node 1 for destination 3

16003 => 16003 via 2
Backup: <24065, 16003> via 6

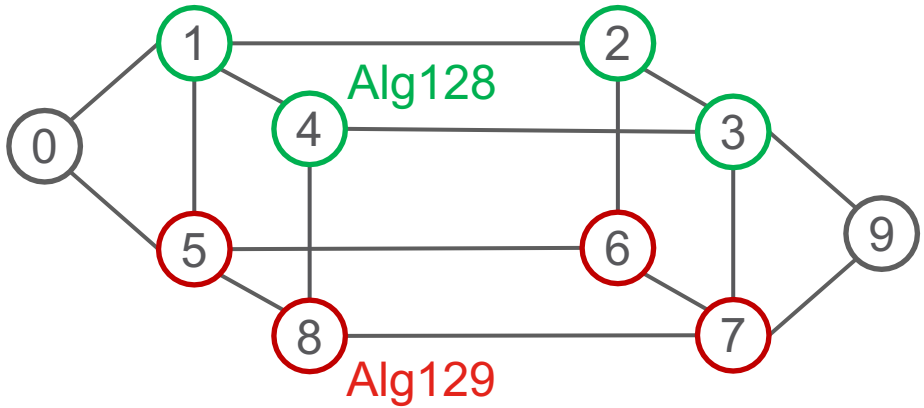
16803 => 16803 via 2
Backup: <24065, 16803> via 6

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

Use-Case – Dual Plane

- Grey nodes support Algo 0/128/129
- Green nodes support 0/128
- Red nodes support 0/129
- Algo 128: minimize IGP metric
- Algo 129: minimize IGP metric
- Nodes advertise a Prefix SID for each Algo they support
  - For example, for node N: 16000 + N
    - > + 0 for Algo 0
    - > + 800 for Algo 128
    - > + 900 for Algo 129

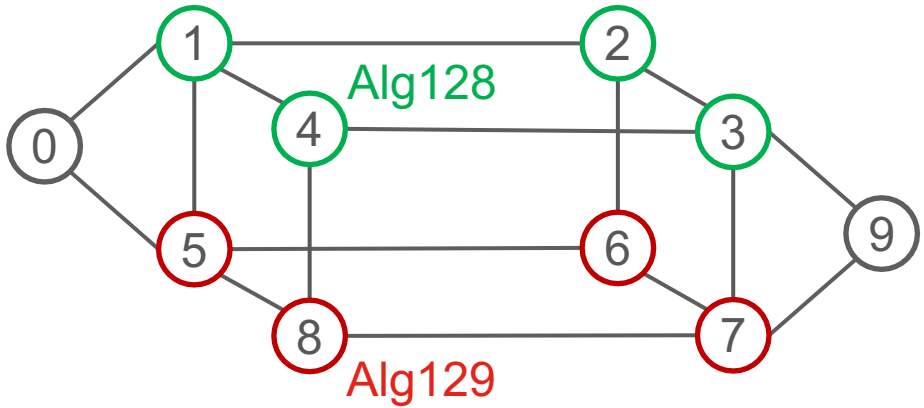


Note: use of TE-affinities is not necessary

CLI – Dual Plane

Config of Node 2

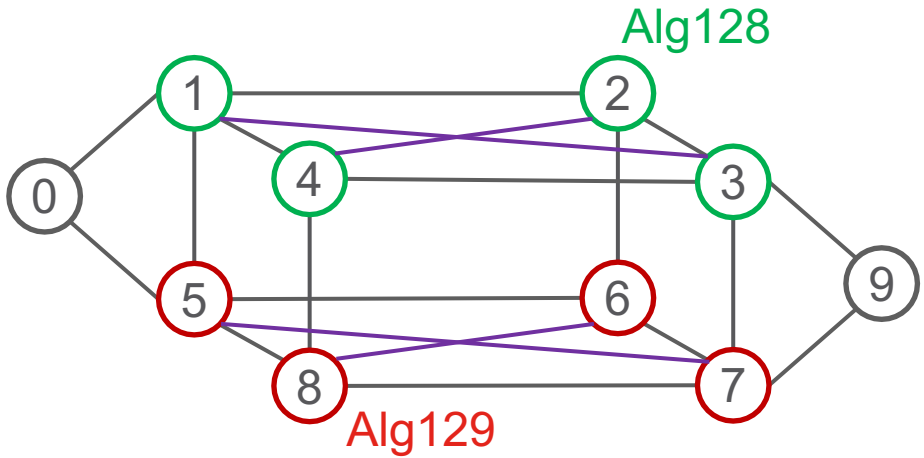
```
router isis 1
 is-type level-2-only
 net 49.0001.0000.0000.0002.00
 flex-algo 128
!
 address-family ipv4 unicast
   router-id 1.1.1.2
   segment-routing mpls
 !
 interface Loopback0
   address-family ipv4 unicast
    prefix-sid absolute 16002
    prefix-sid algorithm 128 absolute 16802
 !
```

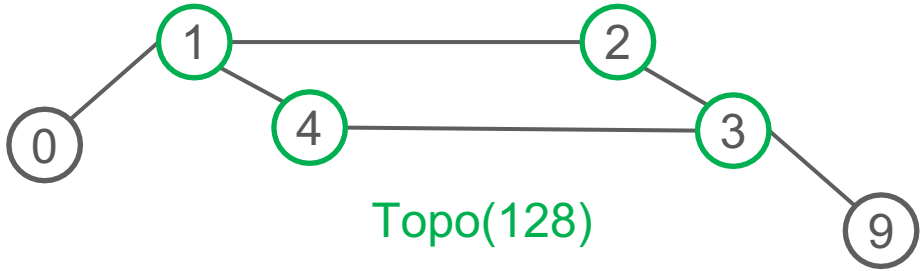


Note: use of TE-affinities is not necessary

Use-Case – Dual Plane with link affinity

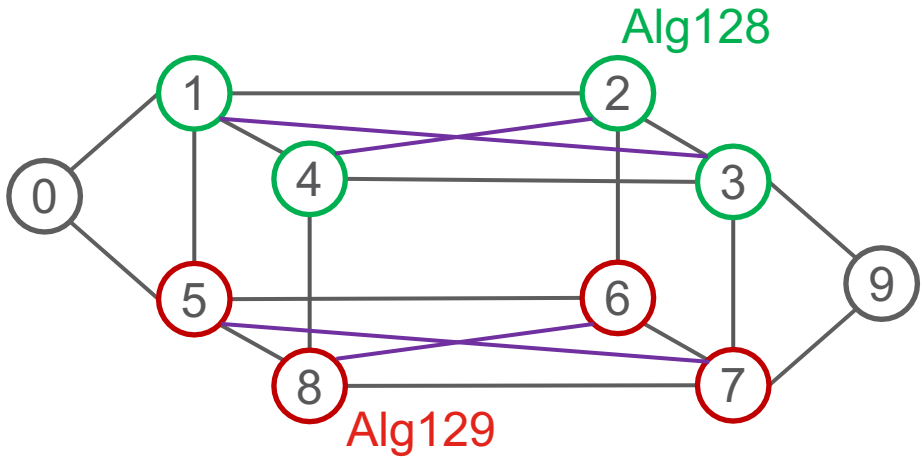
- Grey nodes support Algo 0/128/129
- Green nodes support 0/128
- Red nodes support 0/129
- Algo 128: minimize IGP metric and exclude purple links
- Algo 129: minimize IGP metric and exclude purple links





CLI – Dual Plane with link affinity

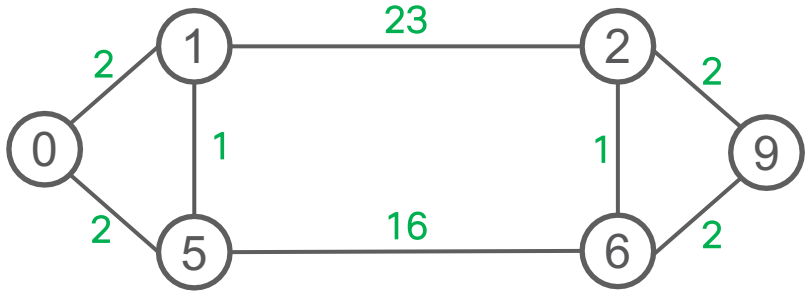
```
router isis 1
 is-type level-2-only
 net 49.0001.0000.0000.0002.00
 affinity-map PURPLE bit-position 1
 flex-algo 128
   exclude affinity PURPLE
 !
 address-family ipv4 unicast
   router-id 1.1.1.2
   segment-routing mpls
 !
 interface Loopback0
   address-family ipv4 unicast
    prefix-sid absolute 16002
    prefix-sid algorithm 128 absolute 16802
 !
 interface GigabitEthernet0/2/0/4
  affinity flex-algo PURPLE
```

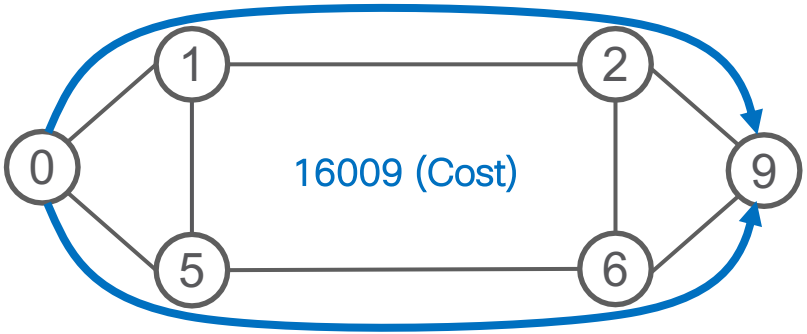


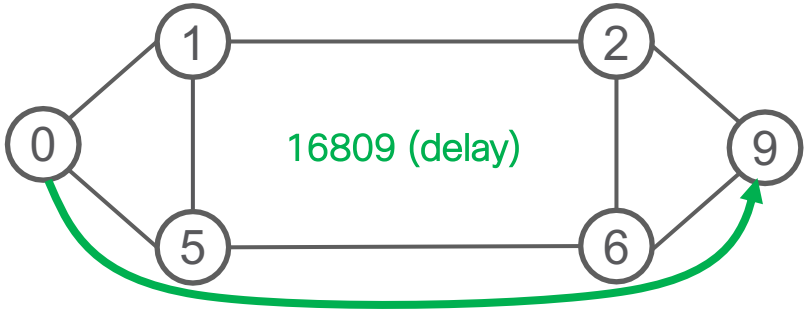
Config of Node 2

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

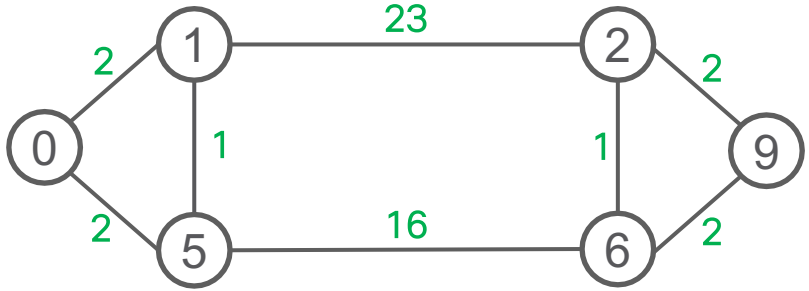






CLI – delay vs Cost of Transport

```
router isis 1
 is-type level-2-only
 net 49.0001.0000.0000.0002.00
 flex-algo 128
   metric-type delay
 !
 address-family ipv4 unicast
   router-id 1.1.1.2
   segment-routing mpls
 !
 interface Loopback0
   address-family ipv4 unicast
    prefix-sid absolute 16002
    prefix-sid algorithm 128 absolute 16802
 !
performance-measurement
   interface GigE0/0/2/6
     delay-measurement
```



Config of Node 2

Automated Steering

- SRTE Automated Steering is leveraged for IGP Flex-Algo

```
segment-routing
  traffic-eng
    on-demand color 100
       dynamic mpls
          flex-algo 128
```

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

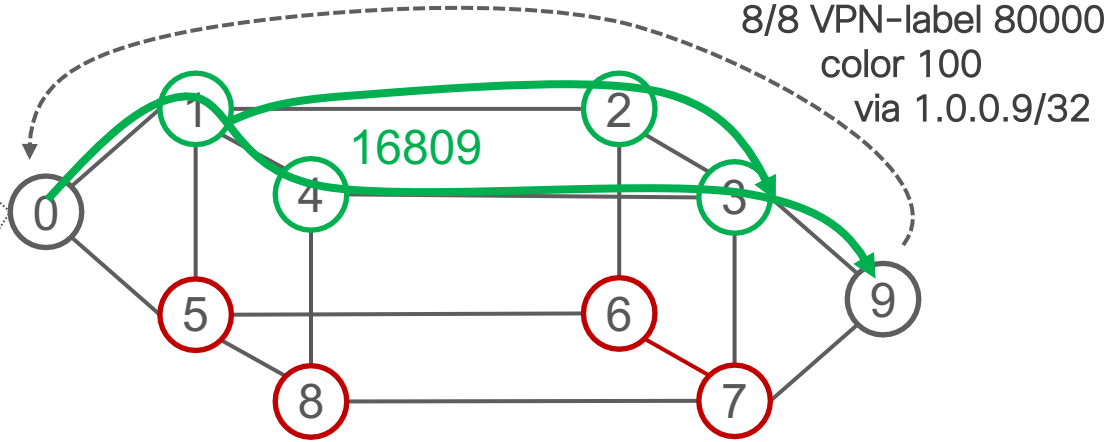
Automated Steering – Dual Plane

```
segment-routing
  traffic-eng
    on-demand color 100
      dynamic mpls
       flex-algo 128

router isis 1
  flex-algo 128
```

```
FIB

8/8: push 80000 16809
```



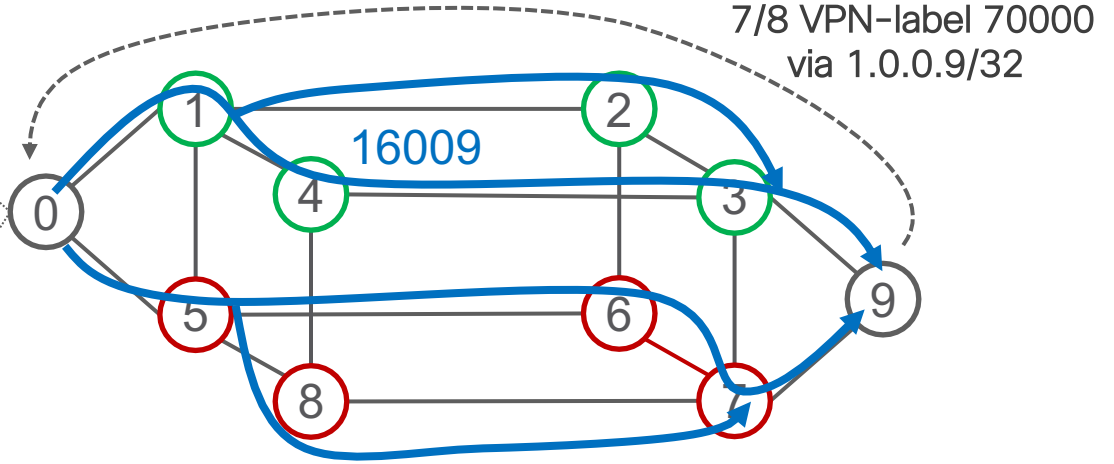
- Node 0 automatically steers any BGP route with color 100 from 9 via 16809 hence via the green plane only
- One single Flex-Algo Prefix-SID expresses the end-to-end SLA path

Automated Steering – Dual Plane

```
segment-routing
  traffic-eng
    on-demand color 100
      dynamic mpls
       flex-algo 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)

Consistency

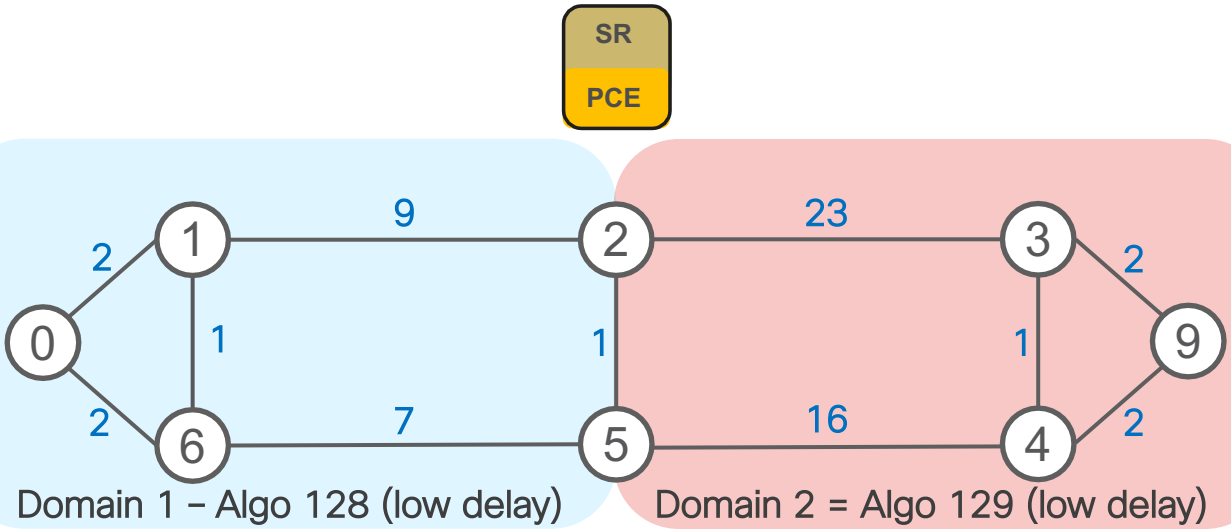
- Any node advertises his definition of Flex-Algo
- As soon as a difference between two definitions of the same Flex-Algo is detected, the Flex-Algo is disabled
  - any Prefix-SID of that Flex-Algo is removed from FIB
  - no path is computed
- Recommendation
  - configure two nodes to advertise the Flex-Algo definition for the domain
    - one with a higher priority
  - do not configure any per-node local definition
  - this way, all the nodes deterministically use the same definition
- Or leverage a solution such as NSO to ensure the domain-wide consistency of the config

OSPF and SRv6

- Same applies to OSPF
- Same applies to SRv6

ODN and AS Inter-Domain delay

```
segment-routing
 traffic-eng
  on-demand color 100
   dynamic mpls
    pce
    metric-type delay
```

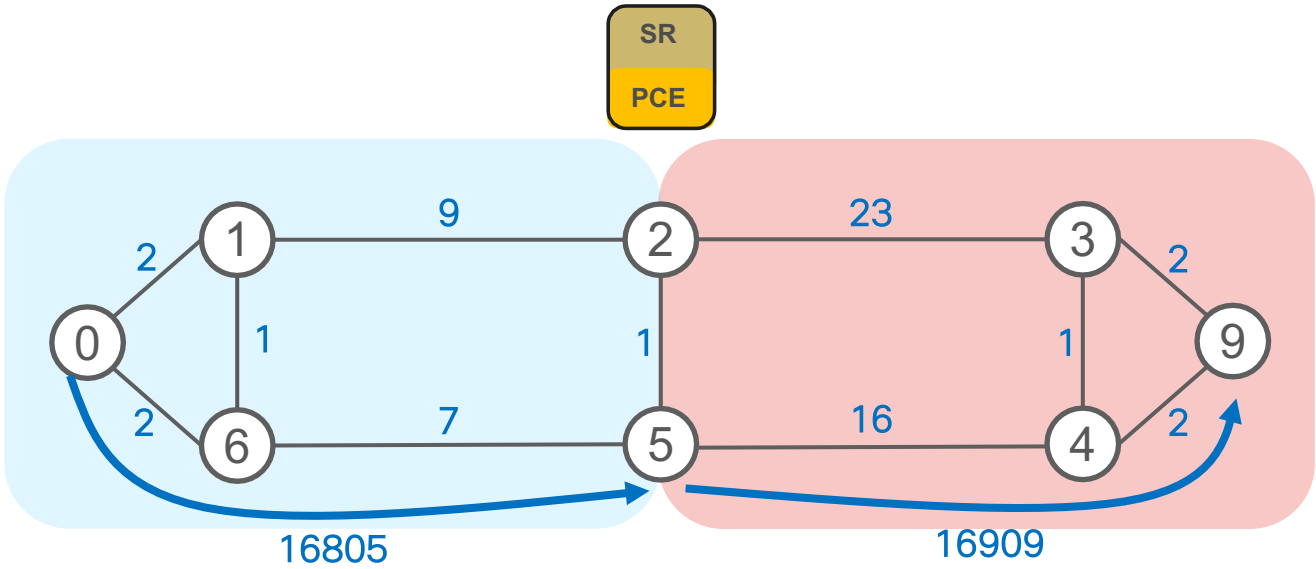


- The delay of each link is reported in drawing
- The ISIS metric per link is 10
- 9 advertises 2/8 with color 100

ODN and AS Inter-Domain delay – Cont.

```
FIB

2/8: push <16805, 16909>
```



- Upon receiving 2/8, node 0 dynamically creates an SRTE policy to 9
- As 9 is beyond its domain, node 0 requests the computation from its PCE and indicates that Flex-Algo128 is needed
- PCE replies with MPLS stack <16805, 16809>

IETF

- draft-ietf-spring-segment-routing
  - Prefix-SID per Algorithm
- draft-filsfils-spring-segment-routing-policy
  - SRTE architecture, ODN, AS
- draft-hegdeppsenak-isis-sr-flex-algo
  - Customization of Algo and consistency
- 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

" Flex Algo is very valuable addition to SRTE solution that allow to auto-steer unicast and multicast traffic via any topology/path based on operator defined logic.

Ease of configuration and operational management, ability to provision dynamic constrained paths based on a single SR label with local repair (TI-LFA) respecting the same constraints as the primary path are some of the benefits that we might realize with Flex Algo."

Arkadiy Gulko – Thomson Reuters

Real

- Visit the SR booth and enjoy the numerous demos!

Conclusion

SR IGP Flexible Algorithm

- Scalability
  - Single SID is used to enforce traffic on the Flex-algo specific path
- Flexible
  - Any operator can define its custom algorithm
- Functionality
  - Optimum TILFA backup paths respecting the same constraints as primary path
  - Inter-domain SR Policy based on SR IGP Flex Algo
  - Applicable to multicast
- Automation and Simplicity
  - TE-path from anywhere to anywhere automatically computed by IGP
  - ODN and Automated Steering
  - Network-wide consistency check

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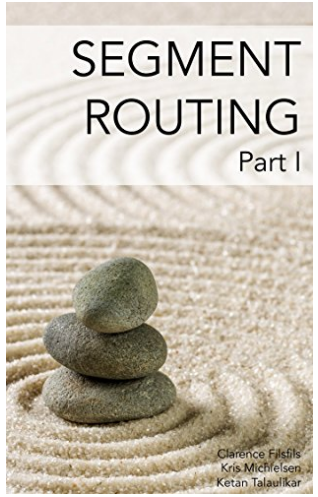

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