Understand and Troubleshoot Flexible Algorithm in ISIS

Contents

Introduction

This document describes the operation of Flexible Algorithm (Flex-Algo) in IS-IS and provides relevant commands for verification and troubleshooting.

Prerequisites

Requirements

- Cisco recommends that you have basic knowledge of ISIS Segment routing traffic engineering.

Components Used

- The information in this document is based on Device: Aggregation Services Router 9000 (ASR9K).
- The information in this document was created from the devices in a specific lab environment. All the devices used in this document started with a cleared (default) configuration. If your network is live, ensure that you understand the potential impact of any command.

Flex-Algo Overview

- Flex-Algo is identified by a numerical value in the range 0–255; values 0–127 are reserved, while 128–255 are user-defined.
- A Flex-Algo is defined by a metric type (Interior Gateway Protocol (IGP) metric, delay metric, or TE metric) and a set of constraints (example link affinity, Shared Risk Link Group (SRLG)).
- By leveraging Flex-Algo, networks can implement network slicing, that is logical segmentation of the network, where path computation is restricted to the topology that satisfies the defined constraints.

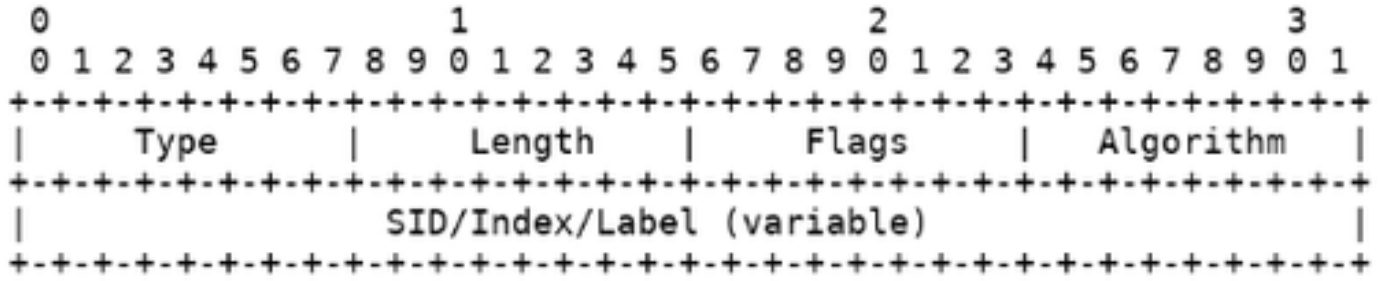


Figure 1 : Prefix-SID Sub-TLV Format (with Algorithm field)

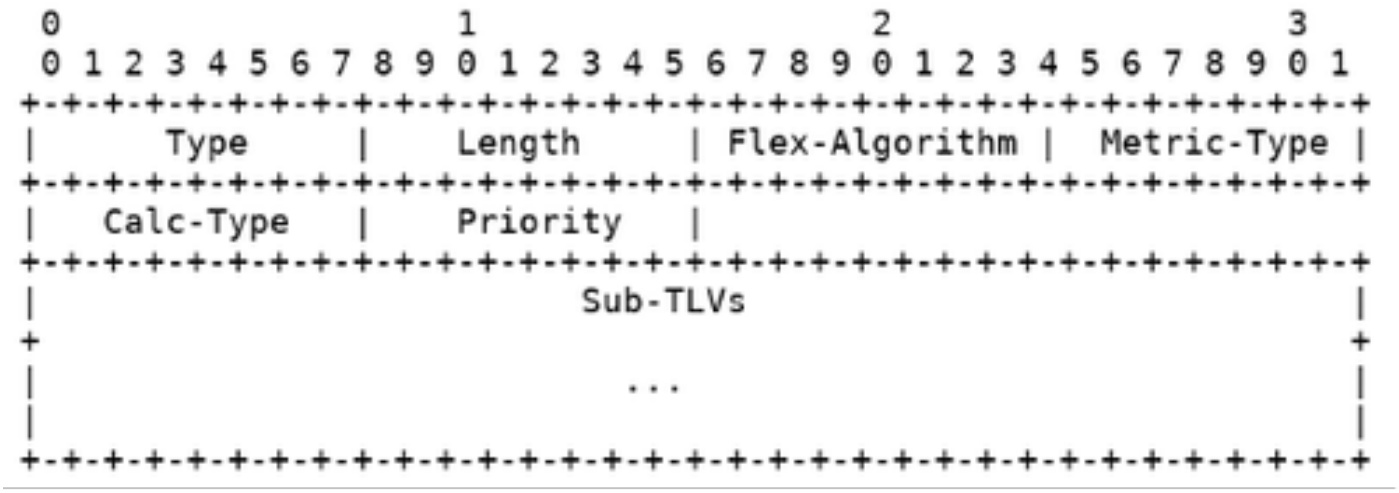


Figure 2 : Flex-Algo Definition（FAD） TLV Format

Network Topology

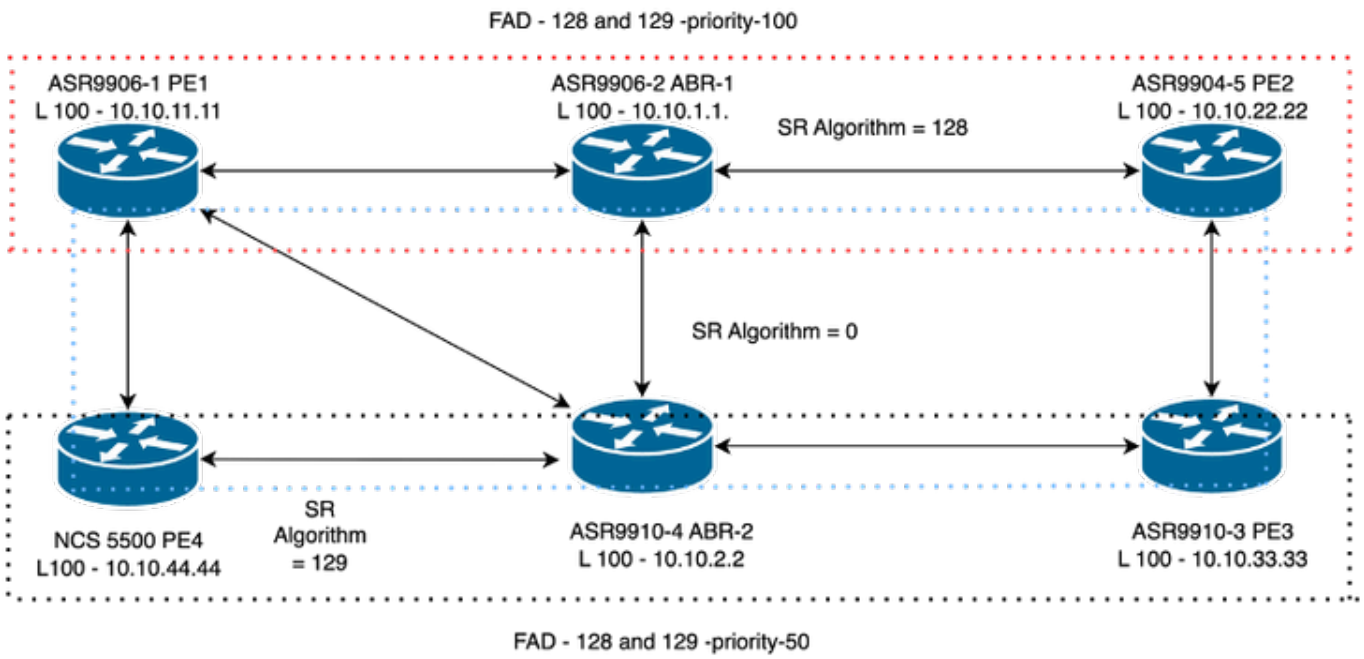


Figure 3 : Network topology Diagram

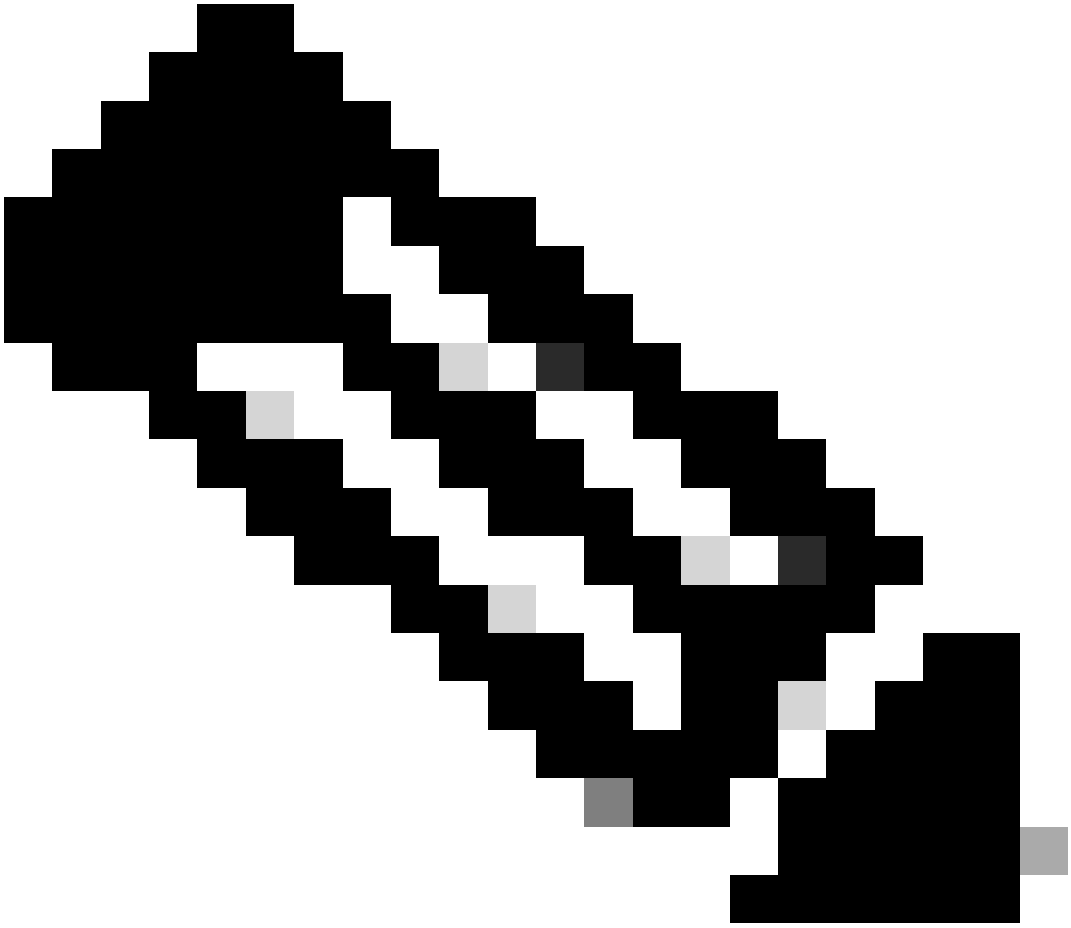
Network

- Algorithm 128 → Defines a latency-optimized slice.
- Algorithm 129 → Defines a TE-optimized slice.
- ABR1 and ABR2 advertise their Flex-Algo Definitions (FAD TLVs) in IS-IS Link-State Protocol Data Unit (LSPs).
- A FAD originator can be any router in the IS-IS domain; a router does not need to participate in each Flex-Algo to advertise its definition.

Flex Algo Configuration

<#root>

```
router isis core
flex-algo 128
   interface Loopback100
      passive
      address-family ipv4 unicast


prefix-sid index 11

 explicit-null


prefix-sid algorithm 128 index 811

 explicit-null
```



Note:

- index 11 - Prefix-SID bound to Flex-Algo 0 (default shortest path first (SPF)).
- index 811 - Prefix-SID bound to Flex-Algo 128.
- Flex-Algo Prefix-SIDs enable network slicing , For a given prefix (example Loopback100), multiple Prefix-SIDs can be advertised—each tied to a specific Flex-Algo.
- The first Prefix-SID (Index 11) is automatically associated with Flex-Algo 0 (default IGP shortest-path algorithm).
- The second Prefix-SID (Index 811) is explicitly associated with Flex-Algo 128, a user-defined algorithm.

Flex-Algo 129 defined by metric-type TE

Configuration

On ABR2 :

<#root>

```
router isis core
flex-algo 129
  priority 50
  metric-type te
  advertise-definition

interface Loopback100
  address-family ipv4 unicast
```

prefix-sid algorithm 129 index 92 explicit-null >>

```
Prefix-SID bound to Flex-Algo 129

interface HundredGigE0/1/0/2
  point-to-point
  address-family ipv4 unicast
   fast-reroute per-prefix
   fast-reroute per-prefix ti-lfa
```

te-metric flex-algo 20 level 2 >>

```
20 is the TE metric value for this link , need to be enabled on the links only between those routers pa
```

Verification

<#root>

```
PE3#show isis flex-algo 129
IS-IS core Flex-Algo Database
Flex-Algo 129:
  Level-2:
```

Definition Priority: 100

Definition Source: ASR9906-2-ABR-1.00

Definition Equal to Local: No

Definition Metric Type: TE

```
    Definition Flex-Algo Prefix Metric: No
    <snip>
```

FRR Disabled: No

Microloop Avoidance Disabled: No

```
  UCMP Disabled: No
```

Data Plane Segment Routing: Yes

```
  Data Plane IP: Yes
```

<#root>

```
PE3#show isis database 55A1-2-PE4.00-00  verbose internal
IS-IS core (Level-2) Link State Database
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime/Rcvd  ATT/P/OL  Len  Received  From
55A1-2-PE4.00-00      0x00000149   0xfe2f        995  /1200         0/0/0     282  09:21:39  ASR9910-4-A
<snip>
```

TLV code:242

```
 length:28
    Router Cap:     10.10.44.44 D:0 S:0
      SubTLV code:2 length:9
        Segment Routing: I:1 V:0, SRGB Base: 16000 Range: 8000
      SubTLV code:23 length:2
        Node Maximum SID Depth:
          Label Imposition: 12
      SubTLV code:19 length:3
        SR Algorithm:
          Algorithm: 0
          Algorithm: 1
```

Algorithm: 129

```
      SubTLV code:29 length:1
        IP Algorithm:
          Algorithm: 129
```

TLV code:22

```
 length:117
    Metric: 10         IS-Extended ASR9910-4-ABR-2.00
      SubTLV code:4 length:8
        Local Interface ID: 32, Remote Interface ID: 38
      SubTLV code:6 length:4
```

Interface IP Address: 10.10.244.44

```
      SubTLV code:8 length:4
```

Neighbor IP Address: 10.10.244.2

```
      SubTLV code:9 length:4
        Physical BW: 10000000 kbits/sec
      SubTLV code:16 length:9
```

Application Specific Link Attributes:

L flag: 0, SA-Length: 1, UDA-Length: 1

Standard Applications: 0x10 FLEX-ALGO

User Defined Applications: 0x10

SubTLV code:18 length:3

Admin. Weight: 20 >>>>>>>>>> configured TE metric

<#root>

```
PE3#show isis topology flex-algo 129
IS-IS core paths to IPv4 Unicast (Level-2) routers
System Id        Metric     Next-Hop        Interface        SNPA
ASR9910-4-ABR-2
```

20

```
       ASR9910-4-ABR-2  Hu0/1/0/0       *PtoP*        >> 1 hop away from PE3
55A1-2-PE4
```

40

```
        ASR9910-4-ABR-2  Hu0/1/0/0       *PtoP*        >> 2 hops away from PE3
```

Flex-Algo 128 defined by metric-type delay

Configuration

<#root>

```
router isis core
flex-algo 128
  priority 100
```

metric-type delay

```
  advertise-definition

performance-measurement
```

interface HundredGigE0/1/0/0

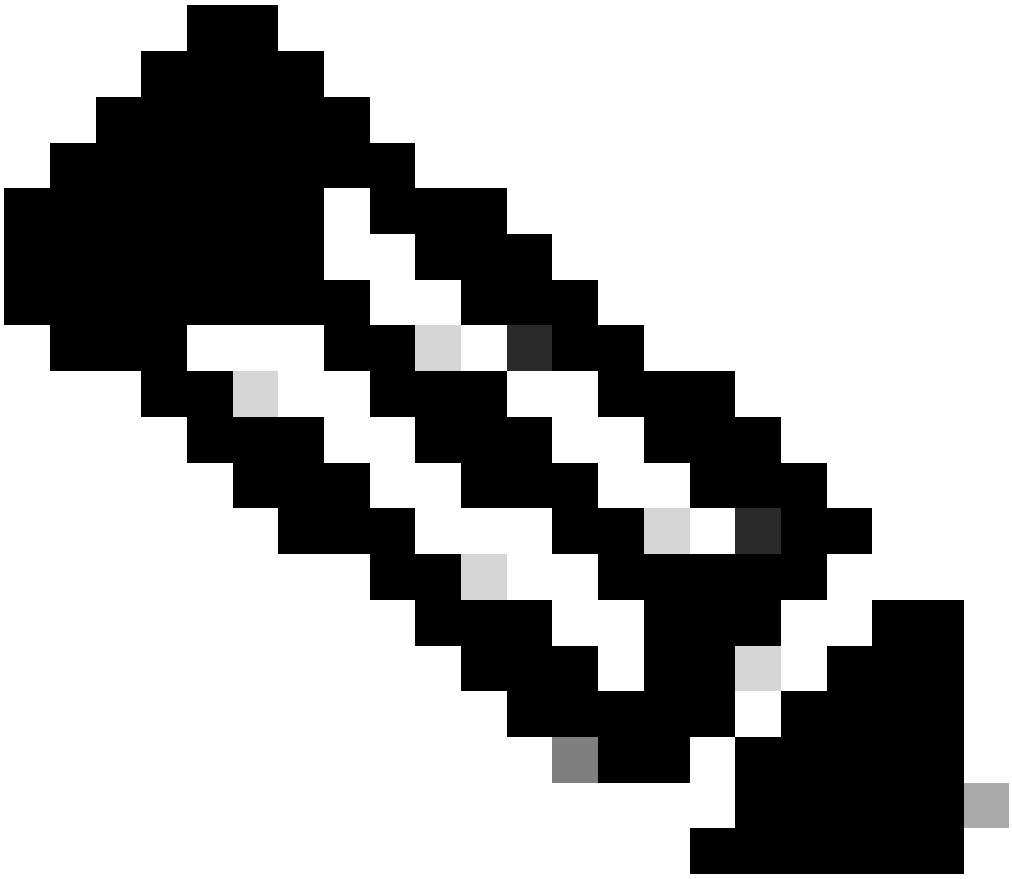
delay-measurement

```
 >>> this CLI needs to be enabled only on those interfaces between those routers participating in Flex-
  !
 !
 interface HundredGigE0/1/0/3
  delay-measurement
```

Verification

<#root>

```
PE1#show isis flex-algo 128
IS-IS core Flex-Algo Database
Flex-Algo 128:
  Level-2:
    Definition Priority: 100


    Definition Source: ASR9906-2-ABR-1.00


    Definition Equal to Local: No
    Definition Metric Type: Delay


    Definition Flex-Algo Prefix Metric: No
```



Note:

- On PE2 :

performance-measurement

interface HundredGigE0/1/0/1 >> link between PE2 and ABR 1

delay-measurement advertise-delay 100 >> delay is statically configured

- This increases the delay metric by +100 in the direction from PE2 towards PE1
- hence the delay to reach ABR 1 from PE2 is 100

<#root>

```
PE1#show isis database ASR-9904-5-PE2.00-00 verbose internal
IS-IS core (Level-2) Link State Database
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime/Rcvd ATT/P/OL LSP Length
ASR-9904-5-PE2.00-00  0x00000231   0x6084        1131 /1200         0/0/0   310
<snip>
```

TLV code:242

```
 length:25
<snip>
```

SubTLV code:19

```
 length:3
        SR Algorithm:
          Algorithm: 0
          Algorithm: 1
          Algorithm: 128
```

TLV code:22

```
 length:144
    Metric: 10         IS-Extended ASR9906-2-ABR-1.00
      SubTLV code:4 length:8
        Local Interface ID: 17, Remote Interface ID: 22
      SubTLV code:6 length:4
        Interface IP Address: 10.10.221.22
      SubTLV code:8 length:4
        Neighbor IP Address: 10.10.221.1
      SubTLV code:9 length:4
        Physical BW: 99999998 kbits/sec
      SubTLV code:33 length:4
   Link Average Delay: 100 us
      SubTLV code:34 length:8
Link Min/Max Delay: 100/100 us
      SubTLV code:35 length:4
Link Delay Variation: 0 us
      SubTLV code:16 length:14
        Application Specific Link Attributes:
          L flag: 0, SA-Length: 1, UDA-Length: 1
          Standard Applications: 0x10 FLEX-ALGO
          User Defined Applications: 0x10
          SubTLV code:34 length:8
            Link Min/Max Delay: 100/100 us >>> delay calculated on this link due to the confoguration
```

<#root>

```
PE2#show isis topology flex-algo 128
IS-IS core paths to IPv4 Unicast (Level-2) routers
System Id               Metric    Next-Hop                Interface       SNPA
```

```
ASR9906-2-ABR-1

100

       ASR9906-2-ABR-1          Hu0/1/0/1       *PtoP*
ASR9906-1-PE1

112

       ASR9906-2-ABR-1          Hu0/1/0/1       *PtoP*
```

When there is no manual advertise-delay configured on the interface, using the default delay measurement profile enabled on the interface probes are sent on the links to measure the delay on the interface.

<#root>

```
ABR-1#show performance-measurement sessions
----------------------------------------------------------------------------------------------------------------
0/1/CPU0
----------------------------------------------------------------------------------------------------------------
Transport type              : Interface
Measurement type            : Delay Measurement
Interface name              : HundredGigE0/1/0/0
Nexthop                     : Unknown

Delay Measurement session:
Session ID                   : 4097
Profile Keys:

Profile name                 : default


Profile type.                : Interface Delay Measurement



Last advertisement:
Advertised at: Sep 26 2025 14:00:36.179 (247623.282 seconds ago)
Advertised reason: Periodic timer, min delay threshold crossed
Advertised delays (uSec): avg: 12, min: 12, max: 13, variance: 0
A flag set: False

Next advertisement:
Threshold check scheduled in 2 more probes (roughly every 120 seconds)
Aggregated delays (uSec): avg: 12, min: 11, max: 12, variance: 1

Rolling average (uSec): 11



Current computation:
Started at: Sep 29 2025 10:47:17.373 (22.88 seconds ago)

Packets Sent: 8, received: 8



Measured delays (uSec): avg: 12, min: 11, max: 12, variance: 1 >>>>>>>>>>>> the delay measured using pro



Next probe scheduled at: Sep 29 2025 10:47:47.369 (in 7.908 seconds)
```

Next packet will be sent in 1.908 seconds

Packet sent every 3.0 seconds

Responder IP : 10.10.111.11

Number of Hops : 1

<#root>

ABR-1#show isis database ASR9906-1-PE1.00-00 verbose internal
IS-IS core (Level-2) Link State Database
LSPID LSP Seq Num LSP Checksum LSP Holdtime/Rcvd ATT/P/OL LSP Length
ASR9906-1-PE1.00-00 0x00000777 0x13ef 497 /1200 0/0/0 370
<snip>

TLV code:22

length:197
Metric: 10 IS-Extended ASR9906-2-ABR-1.00
SubTLV code:4 length:8
Local Interface ID: 40, Remote Interface ID: 21
SubTLV code:6 length:4

Interface IP Address: 10.10.111.11

SubTLV code:8 length:4

Neighbor IP Address: 10.10.111.1

SubTLV code:9 length:4
Physical BW: 99999998 kbits/sec
SubTLV code:33 length:4

Link Average Delay: 12 us >>>>>>>>>>>>>> the calculated delay is propagated via ISIS which is used by th

SubTLV code:34 length:8

Link Min/Max Delay: 12/13 us

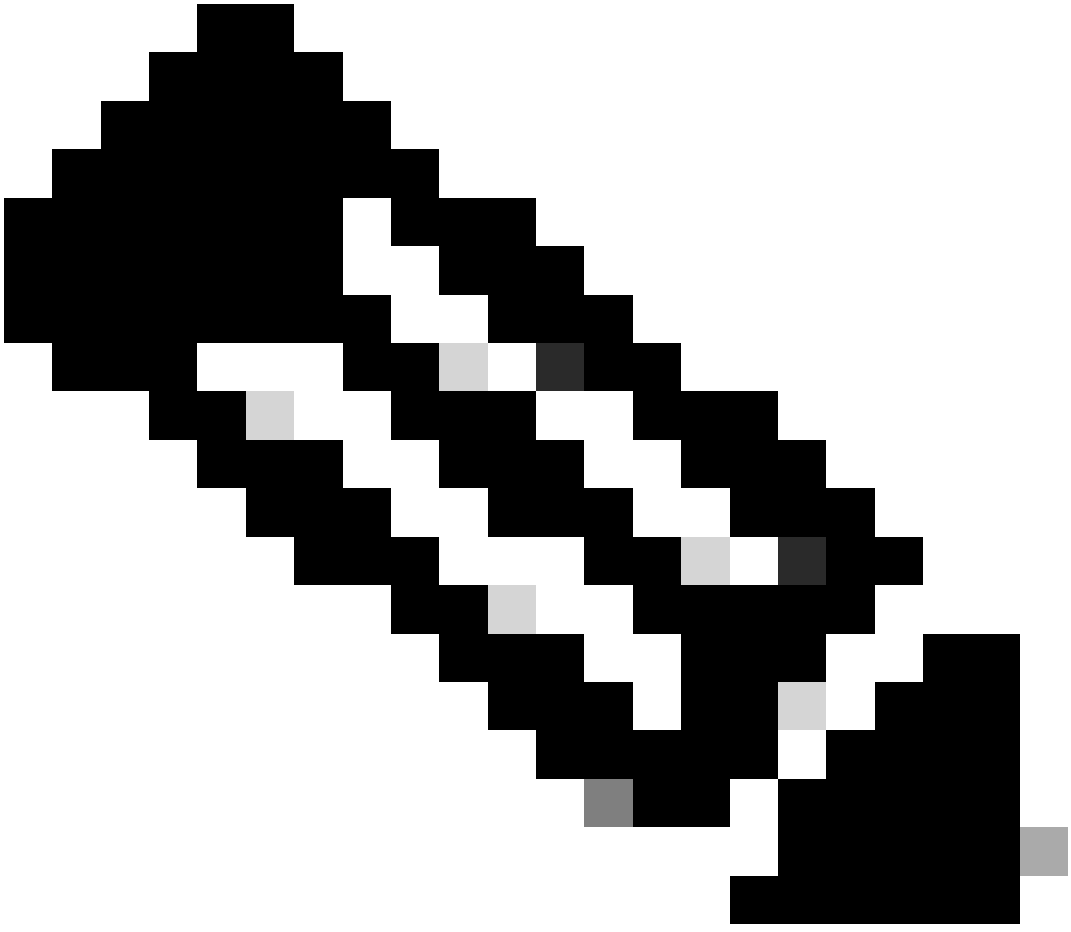
SubTLV code:35 length:4
Link Delay Variation: 0 us
SubTLV code:16 length:14
Application Specific Link Attributes:
L flag: 0, SA-Length: 1, UDA-Length: 1
Standard Applications: 0x10 FLEX-ALGO
User Defined Applications: 0x10
SubTLV code:34 length:8

Link Min/Max Delay: 12/13 us

<#root>

PE1#show isis topology flex-algo 128

```
IS-IS core paths to IPv4 Unicast (Level-2) routers
System Id                  Metric    Next-Hop                Interface       SNPA
ASR9906-2-ABR-1

12

       ASR9906-2-ABR-1          Hu0/1/0/0       *PtoP*
ASR-9904-5-PE2

24

       ASR9906-2-ABR-1          Hu0/1/0/0       *PtoP*
```



Note:

- From PE1 to reach ABR 1 there is only 12 us delay
- From PE1 to reach PE2 there is 24 us delay

Topology-Independent Loop-Free Alternate (TI-LFA) and

Microloop Avoidance (MLA) on FLEX-ALGO 129

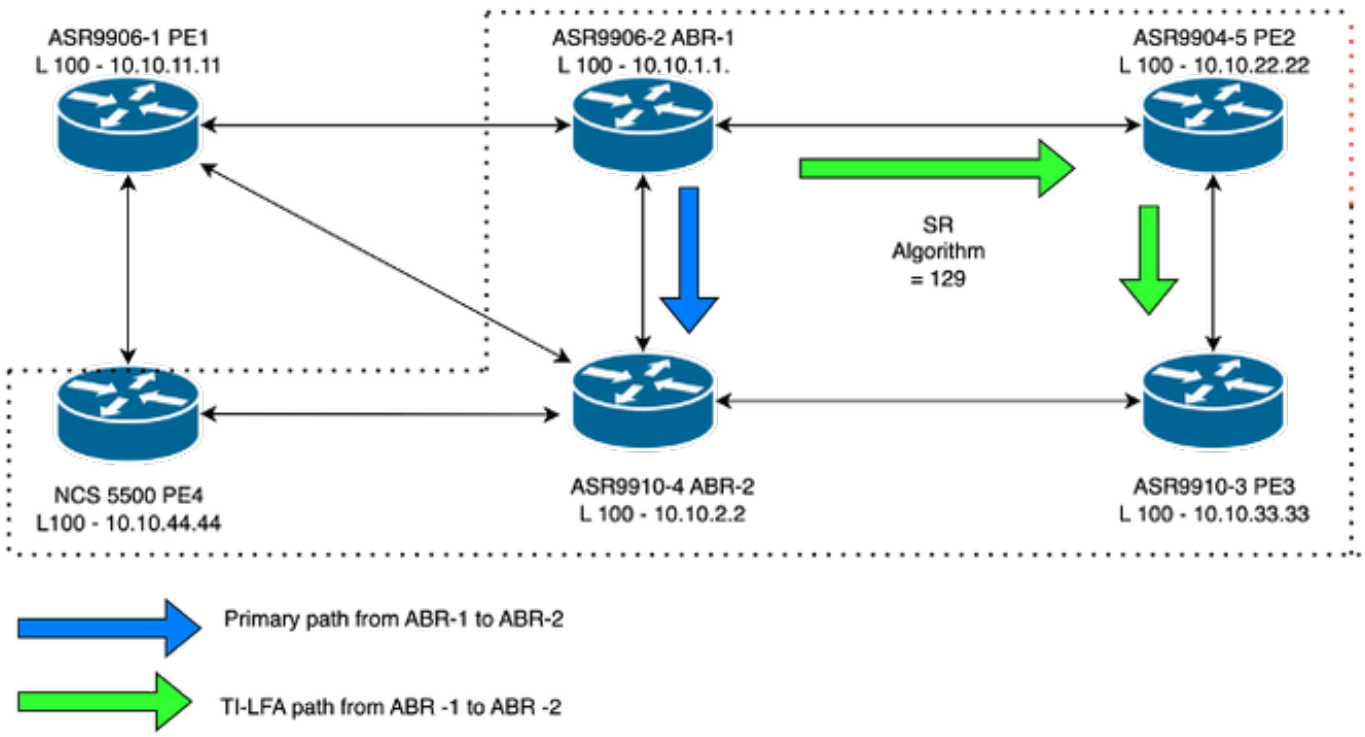
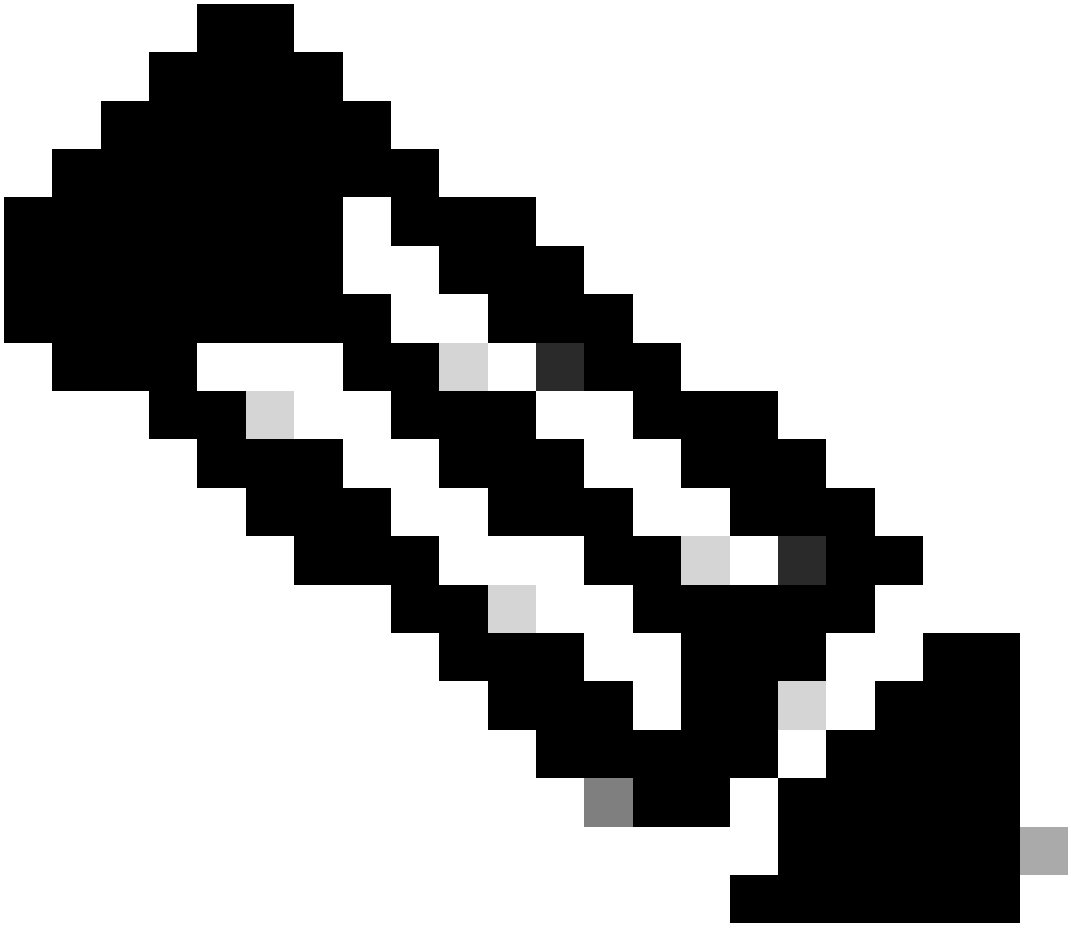


Figure 4 : Network topology Diagram used to demonstrate TI-LFA and MLA for Flex-Algo 129

<#root>

```
ABR-1#show isis fast-reroute flex-algo 129 10.10.2.2/32  detail
L2 10.10.2.2/32 [20/115] Label: 16092, medium priority
   Installed Sep 17 10:40:08.503 for 00:16:25
     via 10.10.12.2, HundredGigE0/1/0/1, Label: Exp-Null-v4, ASR9910-4-ABR-2, SRGB Base: 16000, Weight:


Backup path: TI-LFA (link),

 via 10.10.221.22, HundredGigE0/1/0/3 ASR-9904-5-PE2, SRGB Base: 16000, Weight: 0, Metric: 60


P node: ASR9910-3-PE3.00 [10.10.33.33], Label: 16933 >>>>>>>>>> TI-LFA precomputed path for FRR


         Prefix label: 16092


         Backup-src: ASR9910-4-ABR-2.00
       P: No, TM: 60, LC: No, NP: No, D: No, SRLG: Yes
     src ASR9910-4-ABR-2.00-00, 10.10.2.2, prefix-SID index 92, R:0 N:1 P:1 E:1 V:0 L:0, Alg:129
```



Note:

- 16933 PE3 Flex-Algo 129 label
- 16092 ABR -2 Flex-Algo 129 label
- The TI-LFA path is also restricted with the logical network slice of flex algo 129

On ABR-1 when the link between ABR 1 and 2 is shut down MLA-tunnel is triggered

<#root>

```
ABR-1 #show isis microloop avoidance 10.10.2.2/32 flex-algo 129 detail

10.10.2.2/32 participated in 1 of 6 microloop avoidance events
number start     spf             duration  cleanup        duration  pins: ipv4   ipv6
---    ---       ---               ---     ---               ---        ---     ---
5      restart   10:59:16.440     0 ms    10:59:16.643                   3      0
       trigger: Link down, near node: ASR9906-2-ABR-1.00, far node: ASR9910-4-ABR-2.00
         via 10.10.221.22, Hu0/1/0/3,
```

Labels: 16933

In both the TI-LFA and MLA , flex-algo 129 runs its own constrained SPF, precomputes a fast reroute tunnel that respects Algo 129 constraints , using only FLEX-ALGO 129 labels.

Link Affinity-Map Constraints

- Affinity is a 32-bit attribute associated with an IGP link, administratively assigned by the operator.
- Each bit position corresponds to a semantic meaning defined by the operator.
- These affinity bits are advertised in the IGP (OSPF/IS-IS) as part of the link's TE attributes.

When a Flex-Algo computes its shortest path tree (SPF), it applies affinity constraints during path selection:

- Include-Any (IA): The computed path must traverse at least one link that has any of the specified affinity bits set.
- Include-All (IAll): The computed path must traverse only links that collectively contain all of the specified affinity bits.
- Exclude-Any (EA): The computed path must avoid all links that carry any of the specified affinity bits.

Configuration

On ABR 1and 2

<#root>

```
On ABR 1and 2
router isis core
affinity-map ALGO-129 bit-position 6


flex-algo 129
  priority 100
  metric-type te
  advertise-definition
  affinity exclude-any ALGO-129
```

Post this configuration on the FAD advertised

Verification

<#root>

```
PE4#show isis database ASR9906-2-ABR-1.00-00  verbose internal
IS-IS core (Level-2) Link State Database
LSPID                 LSP Seq Num  LSP Checksum  LSP Holdtime/Rcvd  ATT/P/OL  Len  Received  From
ASR9906-2-ABR-1.00-00  0x0000023f   0xa89f        871  /1200         0/0/0     453  11:12:43  ASR9906-1
  TLV code:242 length:44
    Router Cap:     10.10.1.1 D:0 S:0
      <snip>
      SubTLV code:19 length:4
        SR Algorithm:
          Algorithm: 0
```

```
          Algorithm: 1
          Algorithm: 128

          Algorithm: 129


      SubTLV code:26

 length:4
        Flex-Algo Definition:


Algorithm: 129 Metric-Type: 2

 Alg-type: 0 Priority: 100
          SubTLV code:1 length:4


Flex-Algo Exclude-Any Ext Admin Group: >>> FAD to exclude any link with this bit position set



              0x00000040
```

<#root>

```
PE4#show isis flex-algo 129
IS-IS core Flex-Algo Database
Flex-Algo 129:
  Level-2:
    Definition Priority: 100
    Definition Source: ASR9906-2-ABR-1.00
    Definition Equal to Local: No
    Definition Metric Type: TE
    Definition Flex-Algo Prefix Metric: No

    Exclude Any Affinity Bit Positions: 6
```

Path taken from PE4 to PE3 when the link affinity-map is not configured on any of the links

```
PE4#traceroute sr-mpls labels 16933 lsp-end-point 10.10.33.33
Type escape sequence to abort.
  0 10.10.244.44 MRU 1500 [Labels: 16933/explicit-null Exp: 0/0] >>>>>>>>>>>>>>>>>>>> PE4
L 1 10.10.244.2 MRU 1500 [Labels: explicit-null/explicit-null Exp: 0/0] 5 ms >>>>>>>>ABR2
! 2 10.10.32.33 4 ms >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>PE3
```

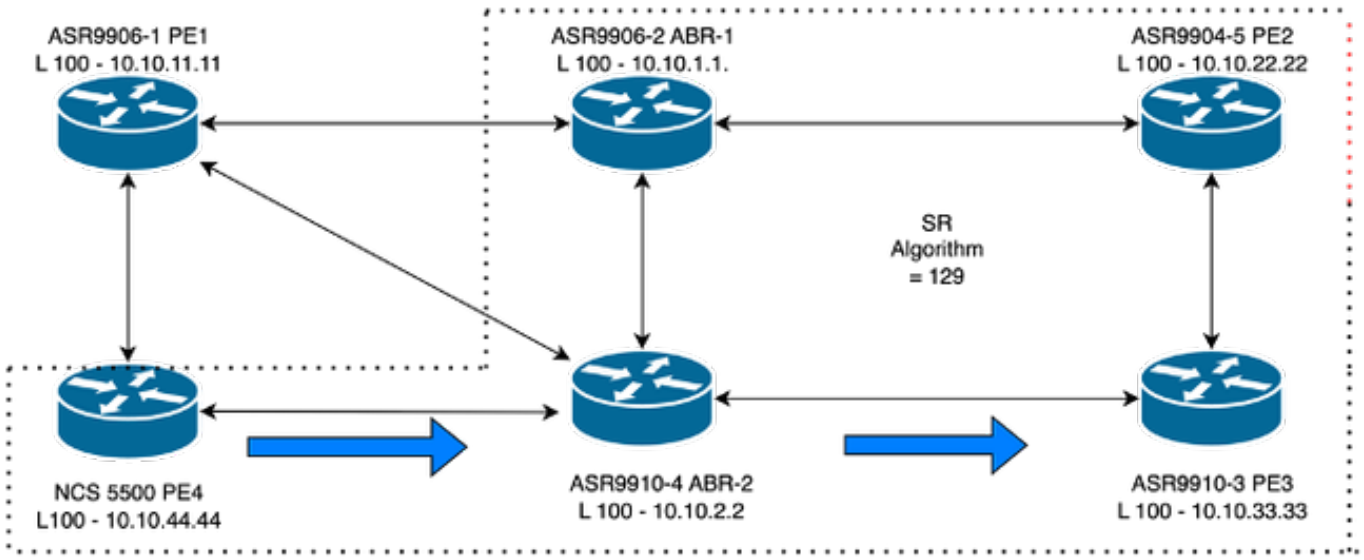


Figure 5 : traceroute between PE4 to PE3 with no affinity map defined

Configuration on ABR-2 of the affinity map

<#root>

```
router isis core
affinity-map ALGO-129 bit-position 6 >
> define the bit position and associate it with a name
router isis core
interface HundredGigE0/1/0/2
 >>> link between ABR-2 to PE3
affinity flex-algo ALGO-129
 >>>>> link affinity map
  point-to-point
  address-family ipv4 unicast
   fast-reroute per-prefix
   fast-reroute per-prefix ti-lfa
   te-metric flex-algo 20 level 2
```

Verification

<#root>

```
PE4#show isis database ASR9910-4-ABR-2.00-00  verbose internal
<snip>
TLV code:22 length:193
<snip>
      SubTLV code:6 length:4
        Interface IP Address: 10.10.32.2
```

```
      SubTLV code:8 length:4

        Neighbor IP Address: 10.10.32.33


      SubTLV code:9 length:4
        Physical BW: 99999998 kbits/sec, 12499999744 bytes/sec
      SubTLV code:16 length:21
        Application Specific Link Attributes:
          L flag: 0, SA-Length: 1, UDA-Length: 1
          Standard Applications: 0x10 FLEX-ALGO
          User Defined Applications: 0x10
          SubTLV code:14 length:4

            Ext Admin Group:


              0x00000040 >>>>>> link affinity flooded via IGP


          SubTLV code:3 length:4
            Affinity: 0x00000040
          SubTLV code:18 length:3
            Admin. Weight: 20
```

As per the FAD for Flex Algo 129 from PE4 towards PE3, it needs to exclude any link with affinity map bit position 6.

```
PE4#traceroute sr-mpls labels 16933 lsp-end-point 10.10.33.33

  0 10.10.244.44 MRU 1500 [Labels: 16933/explicit-null Exp: 0/0]
L 1 10.10.244.2 MRU 1500 [Labels: 16933/explicit-null Exp: 0/0] 5 ms >>>>>>>>>>>>>> ABR2
L 2 10.10.12.1 MRU 1500 [Labels: 16933/explicit-null Exp: 0/0] 4 ms >>>>>>>>>>>>>> ABR1
L 3 10.10.221.22 MRU 1500 [Labels: explicit-null/explicit-null Exp: 0/0] 15 ms >>> PE2
! 4 10.10.233.33 4 ms >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>> PE3
```

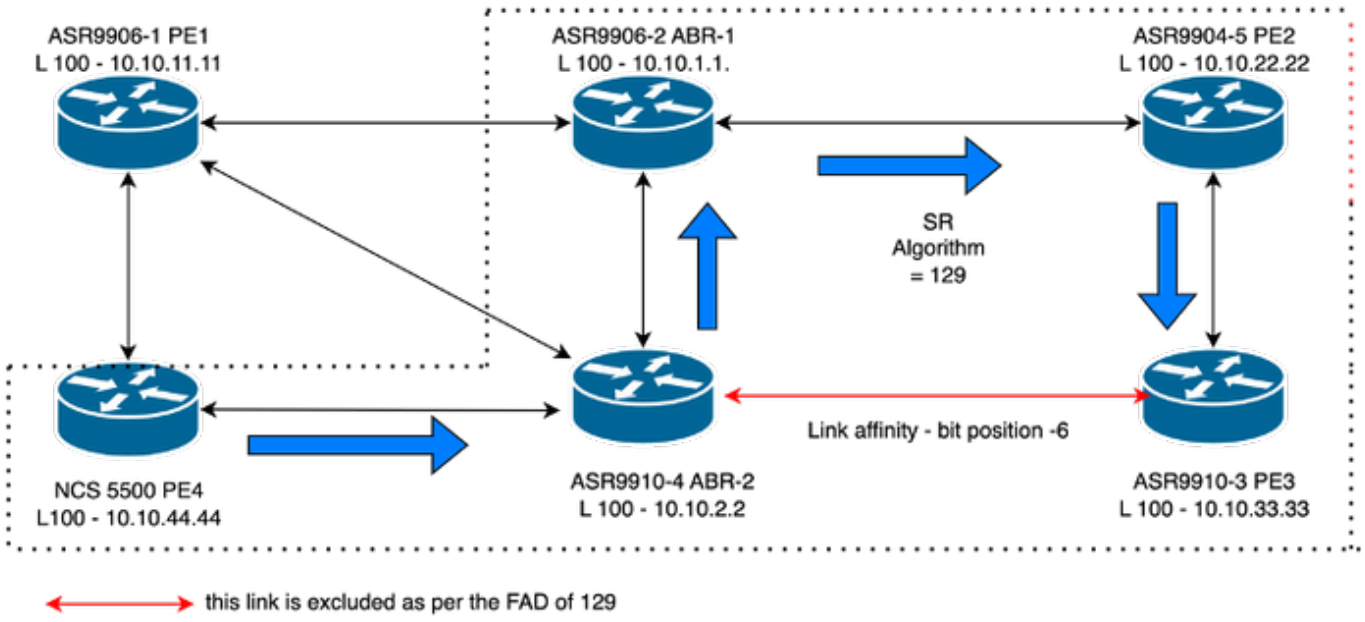
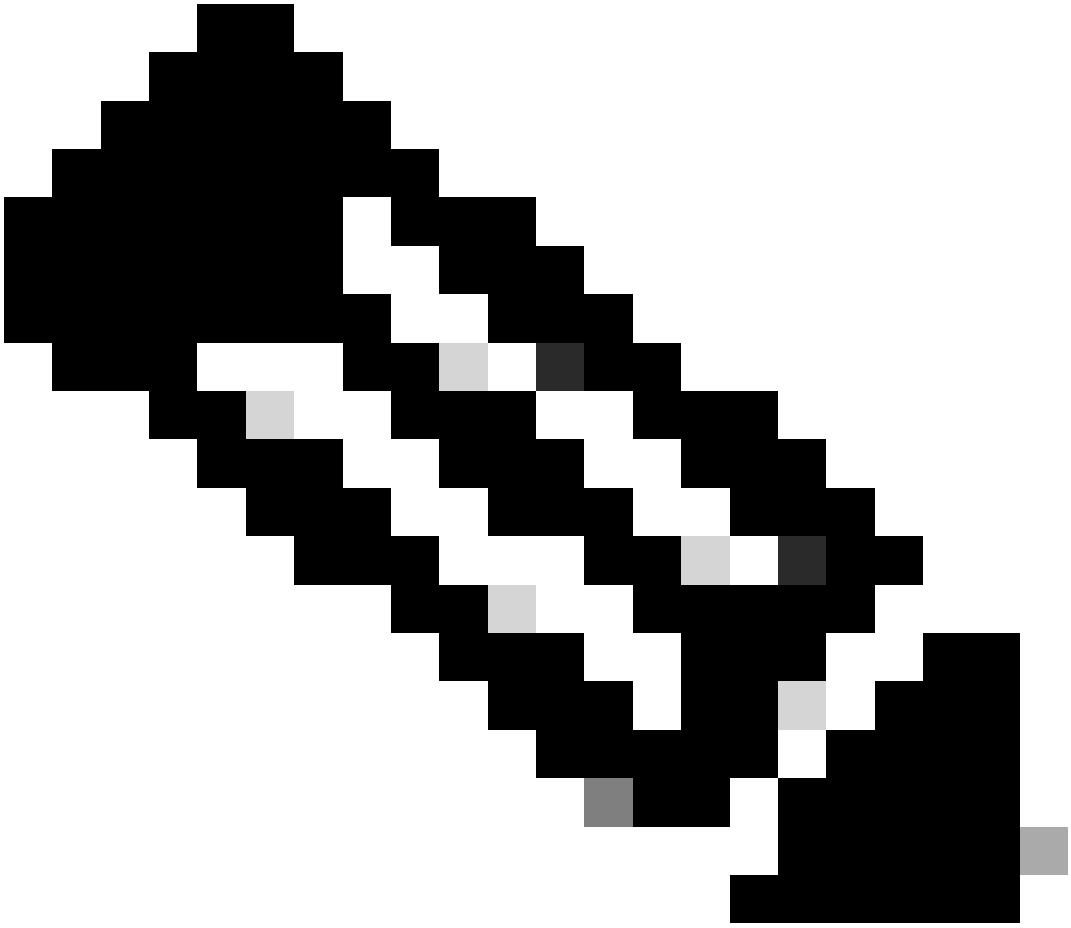


Figure 6 : the path taken from PE4 to PE3 after configuring the affinity map



Note: Similarly, using “include any” and “include all” in the FAD of a flex algo, we can influence the path calculation from the head end towards the tail end.

Conclusion

This document describes the use of Flexible Algorithm (Flex-Algo) to logically slice an IS-IS domain into multiple network slices. Each slice can define its own path computation rules and constraints, enabling differentiated treatment of traffic streams based on SLA requirements or traffic sensitivity.

Commands

```
show isis flex-algo <>
show isis flex-algo 129 neighbors
show isis topology flex-algo
show isis database <> verbose detail
show isis route <>  flex-algo <> detail
show mpls forwarding labels <> detail
```

```
show isis microloop avoidance <> flex-algo <>  detail
show isis fast-reroute flex-algo <>  <prefix> detail
```