



Enabling Segment Routing Flexible Algorithm

Segment Routing Flexible Algorithm allows operators to customize IGP shortest path computation according to their own needs. An operator can assign custom SR prefix-SIDs to realize forwarding beyond link-cost-based SPF. As a result, Flexible Algorithm provides a traffic engineered path automatically computed by the IGP to any destination reachable by the IGP.

The SR architecture associates prefix-SIDs to an algorithm which defines how the path is computed. Flexible Algorithm allows for user-defined algorithms where the IGP computes paths based on a user-defined combination of metric type and constraint.

This document describes the IS-IS extension to support Segment Routing Flexible Algorithm on an MPLS data-plane.

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Prerequisites for Flexible Algorithm

Segment routing must be enabled on the router before the Flexible Algorithm functionality is activated.

Building Blocks of Segment Routing Flexible Algorithm

This section describes the building blocks that are required to support the SR Flexible Algorithm functionality in IS-IS .

Flexible Algorithm Definition

Many possible constraints may be used to compute a path over a network. Some networks are deployed with multiple planes. A simple form of constraint may be to use a particular plane. A more sophisticated form of constraint can include some extended metric, like delay, as described in [RFC7810]. Even more advanced case could be to restrict the path and avoid links with certain affinities. Combinations of these are also possible. To provide a maximum flexibility, the mapping between the algorithm value and its meaning can be defined by the user. When all the routers in the domain have the common understanding what the particular algorithm

value represents, the computation for such algorithm is consistent and the traffic is not subject to looping. Here, since the meaning of the algorithm is not defined by any standard, but is defined by the user, it is called a Flexible Algorithm.

Flexible Algorithm Membership

An algorithm defines how the best path is computed by IGP. Routers advertise the support for the algorithm as a node capability. Prefix-SIDs are also advertised with an algorithm value and are tightly coupled with the algorithm itself.

An algorithm is a one octet value. Values from 128 to 255 are reserved for user defined values and are used for Flexible Algorithm representation.

Flexible Algorithm Definition Advertisement

To guarantee the loop free forwarding for paths computed for a particular Flexible Algorithm, all routers in the network must share the same definition of the Flexible Algorithm. This is achieved by dedicated router(s) advertising the definition of each Flexible Algorithm. Such advertisement is associated with the priority to make sure that all routers will agree on a single and consistent definition for each Flexible Algorithm.

Definition of Flexible Algorithm includes:

- Metric type
- Affinity constraints

To enable the router to advertise the definition for the particular Flexible Algorithm, **advertise-definition** command is used. At least one router in the area, preferably two for redundancy, must advertise the Flexible Algorithm definition. Without the valid definition being advertised, the Flexible Algorithm will not be functional.

Flexible Algorithm Prefix-SID Advertisement

To be able to forward traffic on a Flexible Algorithm specific path, all routers participating in the Flexible Algorithm will install a MPLS labeled path for the Flexible Algorithm specific SID that is advertised for the prefix. Only prefixes for which the Flexible Algorithm specific Prefix-SID is advertised is subject to Flexible Algorithm specific forwarding.

Calculation of Flexible Algorithm Path

A router may compute path for multiple Flexible Algorithms. A router must be configured to support particular Flexible Algorithm before it can compute any path for such Flexible Algorithm. A router must have a valid definition of the Flexible Algorithm before Flexible Algorithm is used.

When computing the shortest path tree for particular Flexible Algorithm:

- All nodes that don't advertise support for Flexible Algorithm are pruned from the topology.
- If the Flexible Algorithm definition includes affinities that are excluded, then all links for which any of such affinities are advertised will be pruned from the topology.

- Router uses the metric that is part of the Flexible Algorithm definition. If the metric isn't advertised for the particular link, the link is pruned from the topology.

Configuring Microloop Avoidance for Flexible Algorithm

By default, Microloop Avoidance per Flexible Algorithm instance follows Microloop Avoidance configuration for algo-0. For information about configuring Microloop Avoidance, see [Configure Segment Routing Microloop Avoidance](#).

You can disable Microloop Avoidance for Flexible Algorithm using the following commands:

```
router isis instance flex-algo algo microloop avoidance disable
```

```
router ospf process flex-algo algo microloop avoidance disable
```

Configuring LFA / TI-LFA for Flexible Algorithm

By default, LFA/TI-LFA per Flexible Algorithm instance follows LFA/TI-LFA configuration for algo-0. For information about configuring TI-LFA, see [Configure Topology-Independent Loop-Free Alternate \(TI-LFA\)](#).

You can disable TI-LFA for Flexible Algorithm using the following commands:

```
router isis instance flex-algo algo fast-reroute disable
```

```
router ospf process flex-algo algo fast-reroute disable
```

Installation of Forwarding Entries for Flexible Algorithm Paths

Flexible Algorithm path to any prefix must be installed in the forwarding using the Prefix-SID that was advertised for such Flexible Algorithm. If the Prefix-SID for Flexible Algorithm is not known, such Flexible Algorithm path is not installed in forwarding for such prefix..

Only MPLS to MPLS entries are installed for a Flexible Algorithm path. No IP to IP or IP to MPLS entries are installed. These follow the native IPG paths computed based on the default algorithm and regular IGP metrics.

Configuring Flexible Algorithm

The following ISIS configuration sub-mode is used to configure Flexible Algorithm:

```
router isis instance flex-algo algo
```

```
router ospf process flex-algo algo
```

algo—value from 128 to 255

Configuring Flexible Algorithm Definitions

The following commands are used to configure Flexible Algorithm definition under the flex-algo sub-mode:

- `metric-type delay`



Note By default the regular IGP metric is used. If delay metric is enabled, the advertised delay on the link is used as a metric for Flexible Algorithm computation.

- **affinity exclude-any** *name1, name2, ...*
name—name of the affinity map
- **priority** *priority value*
priority value—priority used during the Flexible Algorithm definition election.

The following command is used to enable advertisement of the Flexible Algorithm definition in IS-IS:

```
router isis instance flex-algo algo advertise-definition
```

Configuring Affinity

The following command is used for defining the affinity-map. Affinity-map associates the name with the particular bit positions in the Extended Admin Group bitmask.

```
router isis instance flex-algo algo affinity-map name bit-position bit number
```

```
router ospf process flex-algo algo affinity-map name bit-position bit number
```

The following command is used to associate the affinity with an interface:

```
router isis instance interface type interface-path-id affinity flex-algo anomaly name 1, name 2, ...
```

```
router ospf process area area interface type interface-path-id affinity flex-algo anomaly name 1, name 2, ...
```

name—name of the affinity-map

You can configure both normal and anomaly values. For the following example, the **blue** affinity is advertised; however, if a metric is received with the anomaly flag set, it will change to **red**:

```
router isis 1
interface GigabitEthernet0/0/0/2
affinity flex-algo blue
affinity flex-algo anomaly red
```

Configuring Prefix-SID Advertisement

The following command is used to advertise prefix-SID for default and strict-SPF algorithm:

```
router isis instance interface type interface-path-id address-family {ipv4 | ipv6} [unicast]
prefix-sid [strict-spf | algorithm algorithm-number] [index | absolute] sid value
```

```
router ospf process area area interface Loopback interface-instance prefix-sid [strict-spf
| algorithm algorithm-number] [index | absolute] sid value
```

- *algorithm-number*—Flexible Algorithm number

- *sid value*—SID value

Example: Configuring IS-IS Flexible Algorithm

```

router isis 1
  affinity-map red bit-position 65
  affinity-map blue bit-position 8
  affinity-map green bit-position 201

  flex-algo 128
    advertise-definition
    affinity exclude-any red
    affinity include-any blue
  !
  flex-algo 129
    affinity exclude-any green
  !
!
address-family ipv4 unicast
  segment-routing mpls
!
interface Loopback0
  address-family ipv4 unicast
    prefix-sid algorithm 128 index 100
    prefix-sid algorithm 129 index 101
!
!
interface GigabitEthernet0/0/0/0
  affinity flex-algo red
!
interface GigabitEthernet0/0/0/1
  affinity flex-algo blue red
!
interface GigabitEthernet0/0/0/2
  affinity flex-algo blue
!

```

Example: Traffic Steering to Flexible Algorithm Paths

BGP Routes on PE – Color Based Steering

SR-TE On Demand Next-Hop (ODN) feature can be used to steer the BGP traffic towards the Flexible Algorithm paths.

The following example configuration shows how to setup BGP steering local policy, assuming two router: R1 (2.2.2.2) and R2 (4.4.4.4), in the topology.

Configuration on router R1:

```

vrf Test
  address-family ipv4 unicast
    import route-target
    1:150
  !
  export route-policy SET_COLOR_RED_HI_BW
  export route-target

```

```

        1:150
    !
    !
    !
    interface Loopback0
    ipv4 address 2.2.2.2 255.255.255.255
    !
    interface Loopback150
    vrf Test
    ipv4 address 2.2.2.222 255.255.255.255
    !
    interface TenGigE0/1/0/3/0
    description exr1 to cxr1
    ipv4 address 10.0.20.2 255.255.255.0
    !
    extcommunity-set opaque color129-red-igp
    129
    end-set
    !
    route-policy PASS
    pass
    end-policy
    !
    route-policy SET_COLOR_RED_HI_BW
    set extcommunity color color129-red-igp
    pass
    end-policy
    !
    router isis 1
    is-type level-2-only
    net 49.0001.0000.0000.0002.00
    log adjacency changes
    affinity-map RED bit-position 28
    flex-algo 128
    priority 228
    !
    address-family ipv4 unicast
    metric-style wide
    advertise link attributes
    router-id 2.2.2.2
    segment-routing mpls
    !
    interface Loopback0
    address-family ipv4 unicast
    prefix-sid index 2
    prefix-sid algorithm 128 index 282
    !
    !
    interface TenGigE0/1/0/3/0
    point-to-point
    address-family ipv4 unicast
    !
    !
    !
    router bgp 65000
    bgp router-id 2.2.2.2
    address-family ipv4 unicast
    !
    address-family vpnv4 unicast
    retain route-target all
    !
    neighbor-group RR-services-group
    remote-as 65000
    update-source Loopback0

```

```

        address-family ipv4 unicast
        !
        address-family vpnv4 unicast
        !
    !
neighbor 4.4.4.4
    use neighbor-group RR-services-group
!
vrf Test
    rd auto
    address-family ipv4 unicast
    redistribute connected
    !
segment-routing
traffic-eng
    logging
    policy status
    !
segment-list sl-cxr1
    index 10 mpls label 16294
    !
policy pol-foo
    color 129 end-point ipv4 4.4.4.4
    candidate-paths
    preference 100
    explicit segment-list sl-cxr1
    !
    !
    !
!
!
!

```

Configuration on router R2:

```

vrf Test
address-family ipv4 unicast
    import route-target
    1:150
    !
    export route-policy SET_COLOR_RED_HI_BW
    export route-target
    1:150
    !
!
!
interface TenGigE0/1/0/1
description cxr1 to exr1
ipv4 address 10.0.20.1 255.255.255.0
!
extcommunity-set opaque color129-red-igp
    129
end-set
!
route-policy PASS
    pass
end-policy
!
route-policy SET_COLOR_RED_HI_BW
    set extcommunity color color129-red-igp
    pass
end-policy
!
router isis 1

```

```

is-type level-2-only
net 49.0001.0000.0000.0004.00
log adjacency changes
affinity-map RED bit-position 28
affinity-map BLUE bit-position 29
affinity-map GREEN bit-position 30
flex-algo 128
    priority 228
!
flex-algo 129
    priority 229
!
flex-algo 130
    priority 230
!
address-family ipv4 unicast
    metric-style wide
    advertise link attributes
    router-id 4.4.4.4
    segment-routing mpls
!
interface Loopback0
    address-family ipv4 unicast
        prefix-sid index 4
        prefix-sid algorithm 128 index 284
        prefix-sid algorithm 129 index 294
        prefix-sid algorithm 130 index 304
    !
!
interface GigabitEthernet0/0/0/0
    point-to-point
    address-family ipv4 unicast
    !
!
interface TenGigE0/1/0/1
    point-to-point
    address-family ipv4 unicast
    !
!
router bgp 65000
    bgp router-id 4.4.4.4
    address-family ipv4 unicast
    !
    address-family vpnv4 unicast
    !
    neighbor-group RR-services-group
        remote-as 65000
        update-source Loopback0
        address-family ipv4 unicast
        !
        address-family vpnv4 unicast
        !
    !
    neighbor 10.1.1.1
        use neighbor-group RR-services-group
    !
    neighbor 2.2.2.2
        use neighbor-group RR-services-group
    !
vrf Test
    rd auto
    address-family ipv4 unicast
        redistribute connected
    !

```



```
neighbor 25.1.1.2
  remote-as 4
  address-family ipv4 unicast
    route-policy PASS in
    route-policy PASS out
  !
!
!
segment-routing
!
end
```

