Configure SR-TE Policies

This module provides information about segment routing for traffic engineering (SR-TE) policies, how to configure SR-TE policies, and how to steer traffic into an SR-TE policy.

- SR-TE Policy Overview, on page 1
- Instantiation of an SR Policy, on page 1
- SR-TE Policy Path Types, on page 2
- Protocols, on page 14
- Traffic Steering, on page 16

SR-TE Policy Overview

Segment routing for traffic engineering (SR-TE) uses a “policy” to steer traffic through the network. An SR-TE policy path is expressed as a list of segments that specifies the path, called a segment ID (SID) list. Each segment is an end-to-end path from the source to the destination, and instructs the routers in the network to follow the specified path instead of following the shortest path calculated by the IGP. If a packet is steered into an SR-TE policy, the SID list is pushed on the packet by the head-end. The rest of the network executes the instructions embedded in the SID list.

An SR-TE policy is identified as an ordered list (head-end, color, end-point):

- Head-end – Where the SR-TE policy is instantiated
- Color – A numerical value that distinguishes between two or more policies to the same node pairs (Head-end – End point)
- End-point – The destination of the SR-TE policy

Every SR-TE policy has a color value. Every policy between the same node pairs requires a unique color value.

An SR-TE policy uses one or more candidate paths. A candidate path is a single segment list (SID-list) or a set of weighted SID-lists (for weighted equal cost multi-path [WECMP]). A candidate path is either dynamic or explicit. See *SR-TE Policy Path Types* section for more information.

Instantiation of an SR Policy

An SR policy is instantiated, or implemented, at the head-end router.

The following sections provide details on the SR policy instantiation methods:

• Manually Provisioned SR Policy, on page 2

Manually Provisioned SR Policy

Manually provisioned SR policies are configured on the head-end router. These policies can use dynamic paths or explicit paths. See the SR-TE Policy Path Types, on page 2 section for information on manually provisioning an SR policy using dynamic or explicit paths.

SR-TE Policy Path Types

A **dynamic** path is based on an optimization objective and a set of constraints. The head-end computes a solution, resulting in a SID-list or a set of SID-lists. When the topology changes, a new path is computed. If the head-end does not have enough information about the topology, the head-end might delegate the computation to a Segment Routing Path Computation Element (SR-PCE). For information on configuring SR-PCE, see *Configure Segment Routing Path Computation Element* chapter.

An **explicit** path is a specified SID-list or set of SID-lists.

An SR-TE policy initiates a single (selected) path in RIB/FIB. This is the preferred valid candidate path.

A candidate path has the following characteristics:

- It has a preference – If two policies have same {color, endpoint} but different preferences, the policy with the highest preference is selected.
- It is associated with a single binding SID (BSID) – A BSID conflict occurs when there are different SR policies with the same BSID. In this case, the policy that is installed first gets the BSID and is selected.
- It is valid if it is usable.

A path is selected when the path is valid and its preference is the best among all candidate paths for that policy.

Note The protocol of the source is not relevant in the path selection logic.

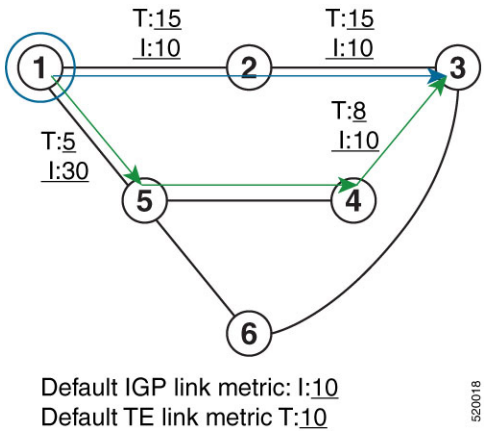
Dynamic Paths

Optimization Objectives

Optimization objectives allow the head-end router to compute a SID-list that expresses the shortest dynamic path according to the selected metric type:

- IGP metric — Refer to the "Implementing IS-IS" and "Implementing OSPF" chapters in the *Routing Configuration Guide for Cisco ASR 9000 Series Routers*.
- TE metric — See the Configure Interface TE Metrics, on page 3 section for information about configuring TE metrics.

This example shows a dynamic path from head-end router 1 to end-point router 3 that minimizes IGP or TE metric:



- The blue path uses the minimum IGP metric: Min-Metric (1 → 3, IGP) = SID-list <16003>; cumulative IGP metric: 20
- The green path uses the minimum TE metric: Min-Metric (1 → 3, TE) = SID-list <16005, 16004, 16003>; cumulative TE metric: 23

Configure Interface TE Metrics

Use the **metric** *value* command in SR-TE interface submode to configure the TE metric for interfaces. The *value* range is from 0 to 2147483647.

```
Router# configure
Router(config)# segment-routing
Router(config-sr)# traffic-eng
Router(config-sr-te)# interface type interface-path-id
Router(config-sr-te-if)# metric value
```

Configuring TE Metric: Example

The following configuration example shows how to set the TE metric for various interfaces:

```
segment-routing
 traffic-eng
  interface TenGigE0/0/0/0
   metric 100
  !
  interface TenGigE0/0/0/1
   metric 1000
  !
  interface TenGigE0/0/2/0
   metric 50
  !
 !
end
```

Constraints

Constraints allow the head-end router to compute a dynamic path according to the selected metric type:

- TE affinity — You can apply a color or name to links or interfaces by assigning affinity bit-maps to them. You can then specify an affinity (or relationship) between an SR policy path and link colors. SR-TE computes a path that includes or excludes links that have specific colors,or combinations of colors. See the Named Interface Link Admin Groups and SR-TE Affinity Maps, on page 4 section for information on named interface link admin groups and SR-TE Affinity Maps.
- Disjoint — SR-TE computes a path that is disjoint from another path in the same disjoint-group. Disjoint paths do not share network resources. Path disjointness may be required for paths between the same pair of nodes, between different pairs of nodes, or a combination (only same head-end or only same end-point).
- Flexible Algorithm — Flexible Algorithm allows for user-defined algorithms where the IGP computes paths based on a user-defined combination of metric type and constraint.

Named Interface Link Admin Groups and SR-TE Affinity Maps

Named Interface Link Admin Groups and SR-TE Affinity Maps provide a simplified and more flexible means of configuring link attributes and path affinities to compute paths for SR-TE policies.

In the traditional TE scheme, links are configured with attribute-flags that are flooded with TE link-state parameters using Interior Gateway Protocols (IGPs), such as Open Shortest Path First (OSPF).

Named Interface Link Admin Groups and SR-TE Affinity Maps let you assign, or map, up to 32 color names for affinity and attribute-flag attributes instead of 32-bit hexadecimal numbers. After mappings are defined, the attributes can be referred to by the corresponding color name in the CLI. Furthermore, you can define constraints using *include-any*, *include-all*, and *exclude-any* arguments, where each statement can contain up to 10 colors.

Note You can configure affinity constraints using attribute flags or the Flexible Name Based Policy Constraints scheme; however, when configurations for both schemes exist, only the configuration pertaining to the new scheme is applied.

Configure Named Interface Link Admin Groups and SR-TE Affinity Maps

Use the **affinity name** *NAME* command in SR-TE interface submode to assign affinity to interfaces. Configure this on routers with interfaces that have an associated admin group attribute.

```
Router# configure
Router(config)# segment-routing
Router(config-sr)# traffic-eng
Router(config-sr-te)# interface TenGigE0/0/1/2
Router(config-sr-if)# affinity
Router(config-sr-if-affinity)# name RED
```

Use the **affinity-map name** *NAME* **bit-position** *bit-position* command in SR-TE sub-mode to define affinity maps. The *bit-position* range is from 0 to 255.

Configure affinity maps on the following routers:

- Routers with interfaces that have an associated admin group attribute.
- Routers that act as SR-TE head-ends for SR policies that include affinity constraints.

```
Router# configure
Router(config)# segment-routing
Router(config-sr)# traffic-eng
```

```
Router(config-sr-te)# affinity-map
Router(config-sr-te-affinity-map)# name RED bit-position 23
```

Configuring Link Admin Group: Example

The following example shows how to assign affinity to interfaces and to define affinity maps. This configuration is applicable to any router (SR-TE head-end or transit node) with colored interfaces.

```
segment-routing
 traffic-eng
  interface TenGigE0/0/1/1
   affinity
    name CROSS
    name RED
   !
  !
  interface TenGigE0/0/1/2
   affinity
    name RED
   !
  !
  interface TenGigE0/0/2/0
   affinity
    name BLUE
   !
  !
  affinity-map
   name RED bit-position 23
   name BLUE bit-position 24
   name CROSS bit-position 25
  !
end
```

Configure SR Policy with Dynamic Path

To configure a SR-TE policy with a dynamic path, optimization objectives, and affinity constraints, complete the following configurations:

1. Define the optimization objectives. See the Optimization Objectives, on page 2 section.
2. Define the constraints. See the Constraints, on page 3 section.
3. Create the policy.

The following example shows a configuration of an SR policy at an SR-TE head-end router. The policy has a dynamic path with optimization objectives and affinity constraints computed by the head-end router.

```
segment-routing
 traffic-eng
  policy foo
   color 100 end-point ipv4 1.1.1.2
   candidate-paths
    preference 100
     dynamic
      metric
       type te
      !
     !
     constraints
      affinity
```

```
      exclude-any
       name RED
      !
     !
    !
   !
  !
 !
```

The following example shows a configuration of an SR policy at an SR-TE head-end router. The policy has a dynamic path with optimization objectives and affinity constraints computed by the SR-PCE.

```
segment-routing
 traffic-eng
  policy baa
   color 101 end-point ipv4 1.1.1.2
   candidate-paths
    preference 100
     dynamic
      pcep
      !
      metric
       type te
      !
     !
     constraints
      affinity
       exclude-any
        name BLUE
       !
      !
     !
    !
   !
  !
```

Explicit Paths

Configure SR-TE Policy with Explicit Path

To configure a SR-TE policy with an explicit path, complete the following configurations:

1. Create the segment lists. A segment list can use IP addresses or MPLS labels, or a combination of both.

Note The IP address can be link or a Loopback address.

Note A segment list can use both IP addresses and MPLS labels, but once you enter an MPLS label, you cannot enter an IP address.

2. Create the SR-TE policy.

Configure Local SR-TE Policy Using Explicit Paths

Note When configuring an explicit path using IP addresses of intermediate links, the SR-TE process selects either the protected or the unprotected Adj-SID of the link, depending on the order in which the Adj-SIDs were received.

Create a segment list with IP addresses:

```
Router# configure
Router(config)# segment-routing
Router(config-sr)# traffic-eng
Router(config-sr-te)# segment-list name SIDLIST1
Router(config-sr-te-sl)# index 10 address ipv4 1.1.1.2
Router(config-sr-te-sl)# index 20 address ipv4 1.1.1.3
Router(config-sr-te-sl)# index 30 address ipv4 1.1.1.4
Router(config-sr-te-sl)# exit
```

Create a segment list with MPLS labels:

```
Router(config-sr-te)# segment-list name SIDLIST2
Router(config-sr-te-sl)# index 10 mpls label 16002
Router(config-sr-te-sl)# index 20 mpls label 16003
Router(config-sr-te-sl)# index 30 mpls label 16004
Router(config-sr-te-sl)# exit
```

Create a segment list with IP addresses and MPLS labels:

```
Router(config-sr-te)# segment-list name SIDLIST3
Router(config-sr-te-sl)# index 10 address ipv4 1.1.1.2
Router(config-sr-te-sl)# index 20 mpls label 16003
Router(config-sr-te-sl)# index 30 mpls label 16004
Router(config-sr-te-sl)# exit
```

Create the SR-TE policy:

```
Router(config-sr-te)# policy POLICY1
Router(config-sr-te-policy)# color 10 end-point ipv4 1.1.1.4
Router(config-sr-te-policy)# candidate-paths
Router(config-sr-te-policy-path)# preference 100
Router(config-sr-te-policy-path-pref)# explicit segment-list SIDLIST1
Router(config-sr-te-policy-path-pref)# exit
Router(config-sr-te-pp-info)# exit

Router(config-sr-te)# policy POLICY2
Router(config-sr-te-policy)# color 20 end-point ipv4 1.1.1.4
Router(config-sr-te-policy)# candidate-paths
Router(config-sr-te-policy-path)# preference 100
Router(config-sr-te-policy-path-pref)# explicit segment-list SIDLIST2
Router(config-sr-te-policy-path-pref)# exit
Router(config-sr-te-pp-info)# exit

Router(config-sr-te)# policy POLICY3
Router(config-sr-te-policy)# color 30 end-point ipv4 1.1.1.4
Router(config-sr-te-policy)# candidate-paths
Router(config-sr-te-policy-path)# preference 100
Router(config-sr-te-policy-path-pref)# explicit segment-list SIDLIST3
Router(config-sr-te-policy-path-pref)# commit
```

Running Configuration

```
Router# show running-configuration
segment-routing
 traffic-eng
  segment-list SIDLIST1
   index 10 address ipv4 1.1.1.2
   index 20 address ipv4 1.1.1.3
   index 30 address ipv4 1.1.1.4
  !
  segment-list SIDLIST2
   index 10 mpls label 16002
   index 20 mpls label 16003
   index 30 mpls label 16004
  !
  segment-list SIDLIST3
   index 10 address ipv4 1.1.1.2
   index 20 mpls label 16003
   index 30 mpls label 16004
  !
  policy POLICY1
   color 10 end-point ipv4 1.1.1.4
   candidate-paths
    preference 100
     explicit segment-list SIDLIST1
    !
   !
  !
  policy POLICY2
   color 20 end-point ipv4 1.1.1.4
   candidate-paths
    preference 100
     explicit segment-list SIDLIST2
    !
   !
  !
  policy POLICY3
   color 30 end-point ipv4 1.1.1.4
   candidate-paths
    preference 100
     explicit segment-list SIDLIST3
    !
   !
  !
```

Verification

```
Router# show segment-routing traffic-eng policy name srte_c_20_ep_1.1.1.4
Sat Jul  8 12:25:34.114 UTC
SR-TE policy database
---------------------
Name: P1 (Color: 20, End-point: 1.1.1.4)
  Status:
    Admin: up  Operational: up for 00:06:21 (since Jul  8 12:19:13.198)
  Candidate-paths:
    Preference 10:
      Explicit: segment-list SIDLIST1 (active)
        Weight: 2
          400102 [Prefix-SID, 2.1.1.1]
          400106
      Explicit: segment-list SIDLIST2 (active)
```

```
      Weight: 2
        400222 [Prefix-SID, 22.11.1.1]
        400106
Attributes:
  Binding SID: 15001
    Allocation mode: explicit
    State: programmed
    Policy selected: yes
  Forward Class: 0
```

Configuring Explicit Path with Affinity Constraint Validation

To fully configure SR-TE flexible name-based policy constraints, you must complete these high-level tasks in order:

1. Assign Color Names to Numeric Values
2. Associate Affinity-Names with SR-TE Links
3. Associate Affinity Constraints for SR-TE Policies

```
/* Enter the global configuration mode and assign color names to numeric values
Router# configure
Router(config)# segment-routing
Router(config-sr)# traffic-eng
Router(config-sr-te)# affinity-map
Router(config-sr-te-affinity-map)# blue bit-position 0
Router(config-sr-te-affinity-map)# green bit-position 1
Router(config-sr-te-affinity-map)# red bit-position 2
Router(config-sr-te-affinity-map)# exit
```

```
/* Associate affinity-names with SR-TE links
Router(config-sr-te)# interface Gi0/0/0/0
Router(config-sr-te-if)# affinity
Router(config-sr-te-if-affinity)# blue
Router(config-sr-te-if-affinity)# exit
Router(config-sr-te-if)# exit
Router(config-sr-te)# interface Gi0/0/0/1
Router(config-sr-te-if)# affinity
Router(config-sr-te-if-affinity)# blue
Router(config-sr-te-if-affinity)# green
Router(config-sr-te-if-affinity)# exit
Router(config-sr-te-if)# exit
Router(config-sr-te)#
```

```
/* Associate affinity constraints for SR-TE policies
Router(config-sr-te)# segment-list name SIDLIST1
Router(config-sr-te-sl)# index 10 address ipv4 1.1.1.2
Router(config-sr-te-sl)# index 20 address ipv4 2.2.2.23
Router(config-sr-te-sl)# index 30 address ipv4 1.1.1.4
Router(config-sr-te-sl)# exit
Router(config-sr-te)# segment-list name SIDLIST2
Router(config-sr-te-sl)# index 10 address ipv4 1.1.1.2
Router(config-sr-te-sl)# index 30 address ipv4 1.1.1.4
Router(config-sr-te-sl)# exit
Router(config-sr-te)# segment-list name SIDLIST3
Router(config-sr-te-sl)# index 10 address ipv4 1.1.1.5
```

```
Router(config-sr-te-sl)# index 30 address ipv4 1.1.1.4
Router(config-sr-te-sl)# exit

Router(config-sr-te)# policy POLICY1
Router(config-sr-te-policy)# color 20 end-point ipv4 1.1.1.4
Router(config-sr-te-policy)# binding-sid mpls 1000
Router(config-sr-te-policy)# candidate-paths
Router(config-sr-te-policy-path)# preference 200
Router(config-sr-te-policy-path-pref)# constraints affinity exclude-any red
Router(config-sr-te-policy-path-pref)# explicit segment-list SIDLIST1
Router(config-sr-te-pp-info)# exit
Router(config-sr-te-policy-path-pref)# explicit segment-list SIDLIST2
Router(config-sr-te-pp-info)# exit
Router(config-sr-te-policy-path-pref)# exit
Router(config-sr-te-policy-path)# preference 100
Router(config-sr-te-policy-path-pref)# explicit segment-list SIDLIST3
```

Running Configuration

```
Router# show running-configuration
segment-routing
 traffic-eng

  interface GigabitEthernet0/0/0/0
   affinity
    blue
   !
  !
  interface GigabitEthernet0/0/0/1
   affinity
    blue
    green
   !
  !


  segment-list name SIDLIST1
   index 10 address ipv4 1.1.1.2
   index 20 address ipv4 2.2.2.23
   index 30 address ipv4 1.1.1.4
  !
  segment-list name SIDLIST2
   index 10 address ipv4 1.1.1.2
   index 30 address ipv4 1.1.1.4
  !
  segment-list name SIDLIST3
   index 10 address ipv4 1.1.1.5
   index 30 address ipv4 1.1.1.4
  !
  policy POLICY1
   binding-sid mpls 1000
   color 20 end-point ipv4 1.1.1.4
   candidate-paths
    preference 100
     explicit segment-list SIDLIST3
     !
    !
    preference 200
     explicit segment-list SIDLIST1
     !
     explicit segment-list SIDLIST2
```

```
     !
     constraints
      affinity
       exclude-any
        red
       !
      !
     !
    !
   !
   affinity-map
    blue bit-position 0
    green bit-position 1
    red bit-position 2
   !
  !
!
```

Explicit Path with Affinity Constraint Validation for Anycast SIDs

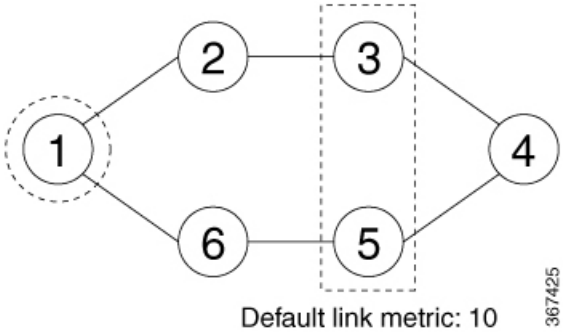
Note For information about configuring Anycast SIDs, see Configuring a Prefix-SID on the IS-IS Enabled Loopback Interface or Configuring a Prefix-SID on the OSPF-Enabled Loopback Interface.

Routers that are configured with the same Anycast SID, on the same Loopback address and with the same SRGB, advertise the same prefix SID (Anycast).

The shortest path with the lowest IGP metric is then verified against the affinity constraints. If multiple nodes have the same shortest-path metric, all their paths are validated against the affinity constraints. A path that is not the shortest path is not validated against the affinity constraints.

Affinity Support for Anycast SIDs: Examples

In the following examples, nodes 3 and 5 advertise the same Anycast prefix (1.1.1.8) and assign the same prefix SID (16100).



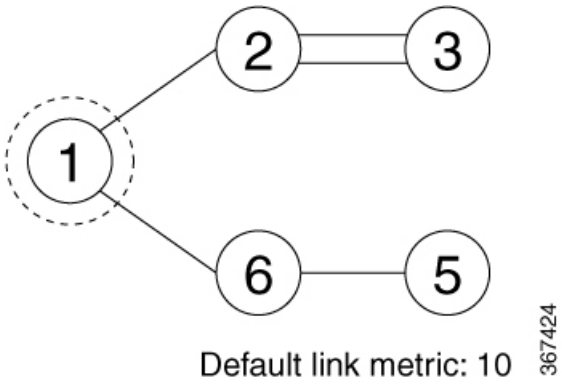
Node 1 uses the following SR-TE policy:

```
segment-routing
 traffic-eng
  policy POLICY1
   color 20 end-point ipv4 1.1.1.4
   binding-sid mpls 1000
```

```
  candidate-paths
   preference 100
    explicit segment-list SIDLIST1
    constraints
     affinity
      exclude-any
       red
segment-list name SIDLIST1
 index 10 address ipv4 100.100.100.100
 index 20 address ipv4 4.4.4.4
```

Affinity Constraint Validation With ECMP Anycast SID: Example

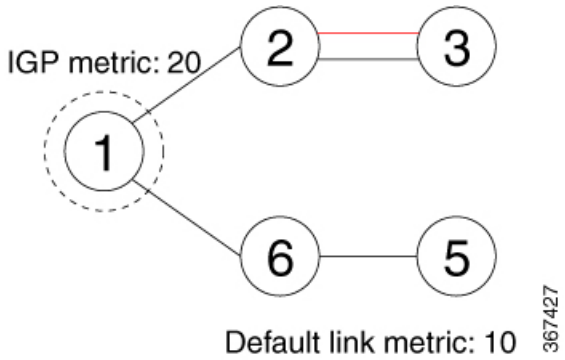
In this example, the shortest path to both node 3 and node 5 has an equal accumulative IGP metric of 20. Both paths are validated against affinity constraints.




```
Name: POLICY1 (Color: 2, End-point: 198.51.100.6)
  Status:
    Admin: up  Operational: up for 00:03:52 (since Jan 24 01:52:14.215)
  Candidate-paths:
    Preference 100:
      Constraints:
        Affinity:
          exclude-any: red
      Explicit: segment-list SIDLIST1 (active)
        Weight: 0, Metric Type: IGP
          16100 [Prefix-SID, 1.1.1.8]
          16004 [Prefix-SID, 4.4.4.4]
```

Affinity Constraint Validation With Non-ECMP Anycast SID: Example

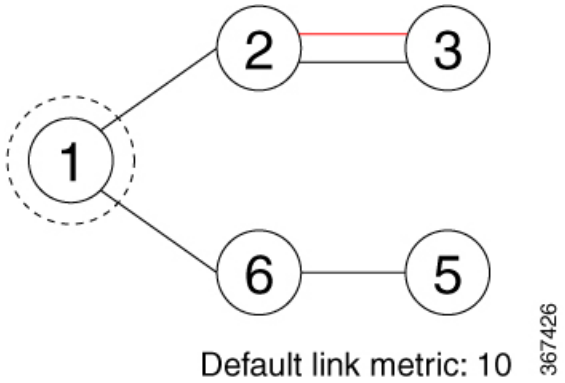
In this example, the shortest path to node 5 has an accumulative IGP metric of 20, and the shortest path to node 3 has an accumulative IGP metric of 30. Only the shortest path to node 5 is validated against affinity constraints.



Note Even though parallel link (23) is marked with red, it is still considered valid since anycast traffic flows only on the path to node 5.

Invalid Path Based on Affinity Constraint: Example

In this example, parallel link (23) is marked as red, so the path to anycast node 3 is invalidated.




```
SR-TE policy database
---------------------
Name: POLICY1 (Color: 2, End-point: 198.51.100.6)
  Status:
    Admin: up  Operational: up for 00:03:52 (since Jan 24 01:52:14.215)
  Candidate-paths:
    Preference 100:
      Constraints:
        Affinity:
          exclude-any: red
      Explicit: segment-list SIDLIST1 (inactive)
      Inactive Reason: Link [2.2.21.23,2.2.21.32] failed to satisfy affinity exclude-any
constraint=0x00000008, link attributes=0x0000000A
```

Protocols

Path Computation Element Protocol

The path computation element protocol (PCEP) describes a set of procedures by which a path computation client (PCC) can report and delegate control of head-end label switched paths (LSPs) sourced from the PCC to a PCE peer. The PCE can request the PCC to update and modify parameters of LSPs it controls. The stateful model also enables a PCC to allow the PCE to initiate computations allowing the PCE to perform network-wide orchestration.

BGP SR-TE

SR-TE can be used by data center (DC) operators to provide different levels of Service Level Assurance (SLA). Setting up SR-TE paths using BGP (BGP SR-TE) simplifies DC network operation without introducing a new protocol for this purpose.

Explicit BGP SR-TE

Explicit BGP SR-TE uses an SR-TE policy (identified by a unique color ID) that contains a list of explicit paths with SIDs that correspond to each explicit path. A BGP speaker signals an explicit SR-TE policy to a remote peer, which triggers the setup of an SR-TE policy with specific characteristics and explicit paths. On the receiver side, an SR-TE policy that corresponds to the explicit path is setup by BGP. The packets for the destination mentioned in the BGP update follow the explicit path described by the policy. Each policy can include multiple explicit paths, and TE will create a policy for each path.

IPv4 and IPv6 SR policies can be advertised over BGPv4 or BGPv6 sessions between the SR-TE controller and the SR-TE headend. The Cisco IOS-XR implementation supports the following combinations:

- IPv4 SR policy advertised over BGPv4 session
- IPv6 SR policy advertised over BGPv4 session
- IPv6 SR policy advertised over BGPv6 session

Configure Explicit BGP SR-TE

Perform this task to configure explicit BGP SR-TE:

SUMMARY STEPS

1. **configure**
2. **router bgp** *as-number*
3. **bgp router-id** *ip-address*
4. **address-family** {**ipv4** | **ipv6**} **sr-policy**
5. **exit**
6. **neighbor** *ip-address*
7. **remote-as** *as-number*
8. **address-family** {**ipv4** | **ipv6**} **sr-policy**

9. **route-policy** *route-policy-name* {**in** | **out**}

DETAILED STEPS

	Command or Action	Purpose
Step 1	**configure**	
Step 2	**router bgp** *as-number* **Example:** `RP/0/RSP0/CPU0:router(config)# router bgp 65000`	Specifies the BGP AS number and enters the BGP configuration mode, allowing you to configure the BGP routing process.
Step 3	**bgp router-id** *ip-address* **Example:** `RP/0/RSP0/CPU0:router(config-bgp)# bgp router-id 1.1.1.1`	Configures the local router with a specified router ID.
Step 4	**address-family** {**ipv4**	**ipv6**} **sr-policy** **Example:** `RP/0/RSP0/CPU0:router(config-bgp)# address-family ipv4 sr-policy`	Specifies either the IPv4 or IPv6 address family and enters address family configuration submode.
Step 5	**exit**	
Step 6	**neighbor** *ip-address* **Example:** `RP/0/RSP0/CPU0:router(config-bgp)# neighbor 10.10.0.1`	Places the router in neighbor configuration mode for BGP routing and configures the neighbor IP address as a BGP peer.
Step 7	**remote-as** *as-number* **Example:** `RP/0/RSP0/CPU0:router(config-bgp-nbr)# remote-as 1`	Creates a neighbor and assigns a remote autonomous system number to it.
Step 8	**address-family** {**ipv4**	**ipv6**} **sr-policy** **Example:** `RP/0/RSP0/CPU0:router(config-bgp-nbr)# address-family ipv4 sr-policy`	Specifies either the IPv4 or IPv6 address family and enters address family configuration submode.
Step 9	**route-policy** *route-policy-name* {**in**	**out**} **Example:**	Applies the specified policy to IPv4 or IPv6 unicast routes.

	Command or Action	Purpose
	`RP/0/RSP0/CPU0:router(config-bgp-nbr-af)#` **`route-policy pass out`**	

Example: BGP SR-TE with BGPv4 Neighbor to BGP SR-TE Controller

The following configuration shows the an SR-TE head-end with a BGPv4 session towards a BGP SR-TE controller. This BGP session is used to signal both IPv4 and IPv6 SR policies.

```
router bgp 65000
bgp router-id 1.1.1.1
 !
 address-family ipv4 sr-policy
 !
 address-family ipv6 sr-policy
 !
 neighbor 10.1.3.1
  remote-as 10
  description *** eBGP session to BGP SRTE controller ***
  address-family ipv4 sr-policy
   route-policy pass in
   route-policy pass out
  !
  address-family ipv6 sr-policy
   route-policy pass in
   route-policy pass out
  !
 !
!
```

Example: BGP SR-TE with BGPv6 Neighbor to BGP SR-TE Controller

The following configuration shows an SR-TE head-end with a BGPv6 session towards a BGP SR-TE controller. This BGP session is used to signal IPv6 SR policies.

```
router bgp 65000
bgp router-id 1.1.1.1
 address-family ipv6 sr-policy
 !
 neighbor 3001::10:1:3:1
  remote-as 10
  description *** eBGP session to BGP SRTE controller ***
  address-family ipv6 sr-policy
   route-policy pass in
   route-policy pass out
  !
 !
!
```

Traffic Steering

Automated Steering

Automated steering (AS) refers to the functionality where BGP service traffic is automatically steered on the right SLA path programmed by an SR policy. The decision to steer traffic into an SR policy is based on intent (color) and next-hop of the service route, regardless of the instantiation method of a policy (pushed by BGP-TE,

provisioned manually, automatically instantiate on-demand [SR-ODN], or pushed by PCEP). AS provides per-destination steering. A matching SR policy can already be present at the head-end router or can be instantiated on-demand (SR-ODN) when receiving the service route update.

Using Binding Segments

The binding segment is a local segment identifying an SR-TE policy. Each SR-TE policy is associated with a binding segment ID (BSID). The BSID is a local label that is automatically allocated for each SR-TE policy when the SR-TE policy is instantiated.

Note In Cisco IOS XR 6.3.2 and later releases, you can specify an explicit BSID for an SR-TE policy. See the following **Explicit Binding SID** section.

BSID can be used to steer traffic into the SR-TE policy and across domain borders, creating seamless end-to-end inter-domain SR-TE policies. Each domain controls its local SR-TE policies; local SR-TE policies can be validated and rerouted if needed, independent from the remote domain's head-end. Using binding segments isolates the head-end from topology changes in the remote domain.

Packets received with a BSID as top label are steered into the SR-TE policy associated with the BSID. When the BSID label is popped, the SR-TE policy's SID list is pushed.

BSID can be used in the following cases:

- Multi-Domain (inter-domain, inter-autonomous system)—BSIDs can be used to steer traffic across domain borders, creating seamless end-to-end inter-domain SR-TE policies.
- Large-Scale within a single domain—The head-end can use hierarchical SR-TE policies by nesting the end-to-end (edge-to-edge) SR-TE policy within another layer of SR-TE policies (aggregation-to-aggregation). The SR-TE policies are nested within another layer of policies using the BSIDs, resulting in seamless end-to-end SR-TE policies.
- Label stack compression—If the label-stack size required for an SR-TE policy exceeds the platform capability, the SR-TE policy can be seamlessly stitched to, or nested within, other SR-TE policies using a binding segment.
- BGP SR-TE Dynamic—The head-end steers the packet into a BGP-based FIB entry whose next hop is a binding-SID.

Explicit Binding SID

Use the **binding-sid mpls** *label* command in SR-TE policy configuration mode to specify the explicit BSID. Explicit BSIDs are allocated from the segment routing local block (SRLB) or the dynamic range of labels. A best-effort is made to request and obtain the BSID for the SR-TE policy. If requested BSID is not available (if it does not fall within the available SRLB or is already used by another application or SR-TE policy), the policy stays down.

Use the **binding-sid explicit** {**fallback-dynamic** | **enforce-srlb**} command to specify how the BSID allocation behaves if the BSID value is not available.

- Fallback to dynamic allocation – If the BSID is not available, the BSID is allocated dynamically and the policy comes up:

```
Router# configure
Router(config)# segment-routing
Router(config-sr)# traffic-eng
Router(config-sr-te)# binding-sid explicit fallback-dynamic
```

- Strict SRLB enforcement – If the BSID is not within the SRLB, the policy stays down:

```
Router# configure
Router(config)# segment-routing
Router(config-sr)# traffic-eng
Router(config-sr-te)# binding-sid explicit enforce-srlb
```

This example shows how to configure an SR policy to use an explicit BSID of 1000. If the BSID is not available, the BSID is allocated dynamically and the policy comes up.

```
segment-routing
 traffic-eng
  binding-sid explicit fallback-dynamic
  policy goo
   binding-sid mpls 1000
  !
 !
!
```

Stitching SR-TE Polices Using Binding SID: Example

In this example, three SR-TE policies are stitched together to form a seamless end-to-end path from node 1 to node 10. The path is a chain of SR-TE policies stitched together using the binding-SIDs of intermediate policies, providing a seamless end-to-end path.

Figure 1: Stitching SR-TE Polices Using Binding SID

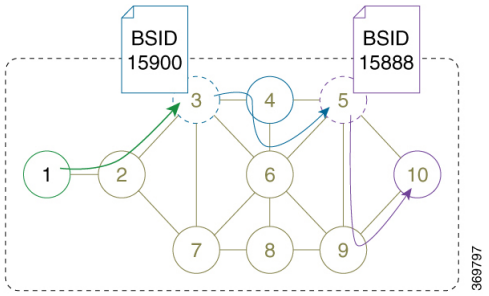


Table 1: Router IP Address

Router	Prefix Address	Prefix SID/Adj-SID
3	Loopback0 - 1.1.1.3	Prefix SID - 16003
4	Loopback0 - 1.1.1.4 Link node 4 to node 6 - 10.4.6.4	Prefix SID - 16004 Adjacency SID - dynamic
5	Loopback0 - 1.1.1.5	Prefix SID - 16005

Router	Prefix Address	Prefix SID/Adj-SID
6	Loopback0 - 1.1.1.6 Link node 4 to node 6 - 10.4.6.6	Prefix SID - 16006 Adjacency SID - dynamic
9	Loopback0 - 1.1.1.9	Prefix SID - 16009
10	Loopback0 - 1.1.1.10	Prefix SID - 16010

Step 1 On node 5, do the following:

a) Define an SR-TE policy with an explicit path configured using the loopback interface IP addresses of node 9 and node 10.

b) Define an explicit binding-SID (**mpls label 15888**) allocated from SRLB for the SR-TE policy.

Example:

Node 5

```
segment-routing
 traffic-eng
  segment-list PATH-9_10
   index 10 address ipv4 1.1.1.9
   index 20 address ipv4 1.1.1.10
  !
  policy foo
   binding-sid mpls 15888
   color 777 end-point ipv4 1.1.1.10
   candidate-paths
    preference 100
     explicit segment-list PATH5-9_10
     !
    !
   !
  !
 !
!

RP/0/RSP0/CPU0:Node-5# show segment-routing traffic-eng policy color 777

SR-TE policy database
---------------------

Color: 777, End-point: 1.1.1.10
  Name: srte_c_777_ep_1.1.1.10
  Status:
    Admin: up  Operational: up for 00:00:52 (since Aug 19 07:40:12.662)
  Candidate-paths:
    Preference: 100 (configuration) (active)
      Name: foo
      Requested BSID: 15888
      PCC info:
        Symbolic name: cfg_foo_discr_100
        PLSP-ID: 70
      Explicit: segment-list PATH-9_10 (valid)
        Weight: 1, Metric Type: TE
          16009 [Prefix-SID, 1.1.1.9]
          16010 [Prefix-SID, 1.1.1.10]
  Attributes:
    Binding SID: 15888 (SRLB)
```

```
    Forward Class: 0
    Steering BGP disabled: no
    IPv6 caps enable: yes
```

Step 2 On node 3, do the following:

a) Define an SR-TE policy with an explicit path configured using the following:

- Loopback interface IP address of node 4
- Interface IP address of link between node 4 and node 6
- Loopback interface IP address of node 5
- Binding-SID of the SR-TE policy defined in Step 1 (**mpls label 15888**)

Note This last segment allows the stitching of these policies.

b) Define an explicit binding-SID (**mpls label 15900**) allocated from SRLB for the SR-TE policy.

Example:

Node 3

```
segment-routing
 traffic-eng
  segment-list PATH-4_4-6_5_BSID
   index 10 address ipv4 1.1.1.4
   index 20 address ipv4 10.4.6.6
   index 30 address ipv4 1.1.1.5
   index 40 mpls label 15888
  !
  policy baa
   binding-sid mpls 15900
   color 777 end-point ipv4 1.1.1.5
   candidate-paths
    preference 100
     explicit segment-list PATH-4_4-6_5_BSID
     !
    !
   !
  !
 !
!

RP/0/RSP0/CPU0:Node-3# show segment-routing traffic-eng policy color 777

SR-TE policy database
---------------------

Color: 777, End-point: 1.1.1.5
  Name: srte_c_777_ep_1.1.1.5
  Status:
    Admin: up  Operational: up for 00:00:32 (since Aug 19 07:40:32.662)
  Candidate-paths:
    Preference: 100 (configuration) (active)
      Name: baa
      Requested BSID: 15900
      PCC info:
        Symbolic name: cfg_baa_discr_100
        PLSP-ID: 70
      Explicit: segment-list PATH-4_4-6_5_BSID (valid)
        Weight: 1, Metric Type: TE
          16004 [Prefix-SID, 1.1.1.4]
```

```
            80005 [Adjacency-SID, 10.4.6.4 - 10.4.6.6]
            16005 [Prefix-SID, 1.1.1.5]
            15888
      Attributes:
        Binding SID: 15900 (SRLB)
        Forward Class: 0
        Steering BGP disabled: no
        IPv6 caps enable: yes
```

Step 3 On node 1, define an SR-TE policy with an explicit path configured using the loopback interface IP address of node 3 and the binding-SID of the SR-TE policy defined in step 2 (**mpls label 15900**). This last segment allows the stitching of these policies.

Example:

Node 1

```
segment-routing
 traffic-eng
  segment-list PATH-3_BSID
   index 10 address ipv4 1.1.1.3
   index 20 mpls label 15900
  !
  policy bar
   color 777 end-point ipv4 1.1.1.3
   candidate-paths
    preference 100
     explicit segment-list PATH-3_BSID
     !
    !
   !
  !
 !
!

RP/0/RSP0/CPU0:Node-1# show segment-routing traffic-eng policy color 777

SR-TE policy database
---------------------

Color: 777, End-point: 1.1.1.3
  Name: srte_c_777_ep_1.1.1.3
  Status:
    Admin: up  Operational: up for 00:00:12 (since Aug 19 07:40:52.662)
  Candidate-paths:
    Preference: 100 (configuration) (active)
      Name: bar
      Requested BSID: dynamic
      PCC info:
        Symbolic name: cfg_bar_discr_100
        PLSP-ID: 70
      Explicit: segment-list PATH-3_BSID (valid)
        Weight: 1, Metric Type: TE
          16003 [Prefix-SID, 1.1.1.3]
          15900
  Attributes:
    Binding SID: 80021
    Forward Class: 0
    Steering BGP disabled: no
    IPv6 caps enable: yes
```

L2VPN Preferred Path

EVPN VPWS Preferred Path over SR-TE Policy feature allows you to set the preferred path between the two end-points for EVPN VPWS pseudowire (PW) using SR-TE policy.

L2VPN VPLS or VPWS Preferred Path over SR-TE Policy feature allows you to set the preferred path between the two end-points for L2VPN Virtual Private LAN Service (VPLS) or Virtual Private Wire Service (VPWS) using SR-TE policy.

Refer to the EVPN VPWS Preferred Path over SR-TE Policy and L2VPN VPLS or VPWS Preferred Path over SR-TE Policy sections in the "L2VPN Services over Segment Routing for Traffic Engineering Policy" chapter of the *L2VPN and Ethernet Services Configuration Guide*.