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| **Segment Routing** |

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| Segment Routing (SR) is a network architecture that is similar to source-routing . In this |

architecture, the ingress router adds a list of segments, known as SIDs, to the packet as

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| it enters the network. These segments represent different portions of the network path |

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| that the packet will take. |

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| The SR segments are portions of the network path taken by the packet, and are called |

SIDs. At each node, the first SID of the list is read, executed as a forwarding function,

and may be popped to let the next node read the next SID of the list. The SID list

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| completely determines the path where the packet is forwarded. |

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| Segment Routing can be applied to an existing MPLS-based data plane and defines a |

control plane network architecture. In MPLS networks, segments are encoded as MPLS

labels and are added at the ingress router. These MPLS labels are then exchanged and

populated by Interior Gateway Protocols (IGPs) like IS-IS or OSPF which are running on

most ISPs.

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| **Note** |

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| Segment routing defines a control plane network architecture and can be applied to an |

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| existing MPLS based dataplane. In the MPLS networks, segments are encoded as MPLS |

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| labels and are imposed at the ingress router. MPLS labels are exchanged and populated |

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| by IGPs like IS-IS.Segment Routing as per RFC8667 for MPLS dataplane. It supports |

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| IPv4, IPv6 and ECMP and has been tested against Cisco & Juniper routers.however,this |

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| deployment is still EXPERIMENTAL for FRR. |
| **IS-IS SR Configuration** |

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| Segment routing (SR) is used by the IGP protocols to interconnect network devices, |

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| below configuration shows how to enable SR on IS-IS: |

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| **Note** |

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| |  | | --- | | Known limitations: | |

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| No support for level redistribution (L1 to L2 or L2 to L1) |

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| No support for binding SID |

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| No support for SRLB |

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| Only one SRGB and default SPF Algorithm is supported |
| **set protocols isis segment-routing global-block high-label-value <label-value>** |

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| Set the Segment Routing Global Block i.e. the label range used by MPLS to store label in |

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| --- |
| the MPLS FIB for Prefix SID. Note that the block size may not exceed 65535. |

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| --- |
| **set protocols isis segment-routing global-block low-label-value <label-value>** |

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| --- |
| Set the Segment Routing Global Block i.e. the low label range used by MPLS to store |

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| --- |
| label in the MPLS FIB for Prefix SID. Note that the block size may not exceed 65535. |

|  |
| --- |
| **set protocols isis segment-routing local-block high-label-value <label-value>** |

|  |
| --- |
| Set the Segment Routing Local Block i.e. the label range used by MPLS to store label in |

|  |
| --- |
| the MPLS FIB for Prefix SID. Note that the block size may not exceed 65535.Segment |

|  |
| --- |
| Routing Local Block, The negative command always unsets both. |

|  |
| --- |
| **set protocols isis segment-routing local-block <low-label-value <label-value>** |

|  |
| --- |
| Set the Segment Routing Local Block i.e. the low label range used by MPLS to store label |

|  |
| --- |
| in the MPLS FIB for Prefix SID. Note that the block size may not exceed 65535.Segment |

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| --- |
| Routing Local Block, The negative command always unsets both. |

|  |
| --- |
| **set protocols isis segment-routing maximum-label-depth <1-16>** |

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| --- |
| Set the Maximum Stack Depth supported by the router. The value depend of the MPLS |

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| dataplane. |

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| --- |
| **set protocols isis segment-routing prefix <address> index value <0-65535>** |

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| --- |
| A segment ID that contains an IP address prefix calculated by an IGP in the service |

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| provider core network. Prefix SIDs are globally unique, this value indentify it |

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| --- |
| **set protocols isis segment-routing prefix <address> index <no-php-flag | explicit-null| n-flag-clear>** |

this option allows to configure prefix-sid on SR. The ‘no-php-flag’ means NO Penultimate

Hop Popping that allows SR node to request to its neighbor to not pop the label. The

‘explicit-null’ flag allows SR node to request to its neighbor to send IP packet with the

EXPLICIT-NULL label. The ‘n-flag-clear’ option can be used to explicitly clear the Node

flag that is set by default for Prefix-SIDs associated to loopback addresses. This option is

necessary to configure Anycast-SIDs.

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| --- |
| **show isis segment-routing node** |

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| --- |
| Show detailed information about all learned Segment Routing Nodes |

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| --- |
| **show isis route prefix-sid** |

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| --- |
| Show detailed information about prefix-sid and label learned |

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| **Note** |

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| more information related IGP - IS-IS |
| **OSPF SR Configuration** |

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| Segment routing (SR) is used by the IGP protocols to interconnect network devices, |

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| below configuration shows how to enable SR on OSPF: **set protocols ospf parameters opaque-lsa** |

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| Enable the Opaque-LSA capability (rfc2370), necessary to transport label on IGP |

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| --- |
| **set protocols ospf segment-routing global-block high-label-value <label-value>** |

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| --- |
| Set the Segment Routing Global Block i.e. the label range used by MPLS to store label in |

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| --- |
| the MPLS FIB for Prefix SID. Note that the block size may not exceed 65535. |

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| --- |
| **set protocols ospf segment-routing global-block low-label-value <label-value>** |

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| --- |
| Set the Segment Routing Global Block i.e. the low label range used by MPLS to store |

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| --- |
| label in the MPLS FIB for Prefix SID. Note that the block size may not exceed 65535. |

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| --- |
| **set protocols ospf segment-routing local-block high-label-value <label-value>** |

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| --- |
| Set the Segment Routing Local Block i.e. the label range used by MPLS to store label in |

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| --- |
| the MPLS FIB for Prefix SID. Note that the block size may not exceed 65535.Segment |

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| --- |
| Routing Local Block, The negative command always unsets both. |

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| --- |
| **set protocols ospf segment-routing local-block <low-label-value <label-value>** |

|  |
| --- |
| Set the Segment Routing Local Block i.e. the low label range used by MPLS to store label |

|  |
| --- |
| in the MPLS FIB for Prefix SID. Note that the block size may not exceed 65535.Segment |

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| --- |
| Routing Local Block, The negative command always unsets both. |

|  |
| --- |
| **set protocols ospf segment-routing maximum-label-depth <1-16>** |

|  |
| --- |
| Set the Maximum Stack Depth supported by the router. The value depend of the MPLS |

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| dataplane. |

|  |
| --- |
| **set protocols ospf segment-routing prefix <address> index value <0-65535>** |

|  |
| --- |
| A segment ID that contains an IP address prefix calculated by an IGP in the service |

|  |
| --- |
| provider core network. Prefix SIDs are globally unique, this value indentify it |

|  |
| --- |
| **set protocols ospf segment-routing prefix <address> index <no-php-flag | explicit-null| n-flag-clear>** |

this option allows to configure prefix-sid on SR. The ‘no-php-flag’ means NO Penultimate

Hop Popping that allows SR node to request to its neighbor to not pop the label. The

‘explicit-null’ flag allows SR node to request to its neighbor to send IP packet with the

EXPLICIT-NULL label. The ‘n-flag-clear’ option can be used to explicitly clear the Node

flag that is set by default for Prefix-SIDs associated to loopback addresses. This option is

necessary to configure Anycast-SIDs.

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| **Note** |

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| more information related IGP - OSPF |
| **Configuration Example** |

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| we described the configuration SR ISIS / SR OSPF using 2 connected with them to share |

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| label information. |

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| **Enable IS-IS with Segment Routing (Experimental)** |

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| **Node 1:** |

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| --- |
| set interfaces loopback lo address '192.168.255.255/32' set interfaces ethernet eth1 address '192.0.2.1/24' |

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| set protocols isis interface eth1 |

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| --- |
| set protocols isis interface lo  set protocols isis net '49.0001.1921.6825.5255.00'  set protocols isis segment-routing global-block high-label-value '599'  set protocols isis segment-routing global-block low-label-value '550'  set protocols isis segment-routing prefix 192.168.255.255/32 index value '1' set protocols isis segment-routing prefix 192.168.255.255/32 index explicit-null set protocols mpls interface 'eth1' |

|  |
| --- |
| **Node 2:** |

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| --- |
| set interfaces loopback lo address '192.168.255.254/32' set interfaces ethernet eth1 address '192.0.2.2/24' |

|  |
| --- |
| set protocols isis interface eth1  set protocols isis interface lo  set protocols isis net '49.0001.1921.6825.5254.00'  set protocols isis segment-routing global-block high-label-value '599'  set protocols isis segment-routing global-block low-label-value '550'  set protocols isis segment-routing prefix 192.168.255.254/32 index value '2' set protocols isis segment-routing prefix 192.168.255.254/32 index explicit-null set protocols mpls interface 'eth1' |

|  |
| --- |
| This gives us MPLS segment routing enabled and labels for far end loopbacks: |

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| --- |
| Node-1@vyos:~$ show mpls table  Inbound Label Type Nexthop Outbound Label  ----------------------------------------------------------------------  552 SR (IS-IS) 192.0.2.2 IPv4 Explicit Null <-- Node-2 loopback learned on Node-1 15000 SR (IS-IS) 192.0.2.2 implicit-null  15001 SR (IS-IS) fe80::e87:6cff:fe09:1 implicit-null  15002 SR (IS-IS) 192.0.2.2 implicit-null  15003 SR (IS-IS) fe80::e87:6cff:fe09:1 implicit-null |

|  |
| --- |
| Node-2@vyos:~$ show mpls table  Inbound Label Type Nexthop Outbound Label  ---------------------------------------------------------------------  551 SR (IS-IS) 192.0.2.1 IPv4 Explicit Null <-- Node-1 loopback learned on Node-2 15000 SR (IS-IS) 192.0.2.1 implicit-null  15001 SR (IS-IS) fe80::e33:2ff:fe80:1 implicit-null  15002 SR (IS-IS) 192.0.2.1 implicit-null  15003 SR (IS-IS) fe80::e33:2ff:fe80:1 implicit-null |

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| --- |
| Here is the routing tables showing the MPLS segment routing label operations: |

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| Node-1@vyos:~$ show ip route isis  Codes: K - kernel route, C - connected, S - static, R - RIP,  O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,  T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,  f - OpenFabric,  > - selected route, \* - FIB route, q - queued, r - rejected, b - backup t - trapped, o - offload failure |

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| --- |
| I 192.0.2.0/24 [115/20] via 192.0.2.2, eth1 inactive, weight 1, 00:07:48  I>\* 192.168.255.254/32 [115/20] via 192.0.2.2, eth1, label IPv4 Explicit Null, weight 1, 00:03:39 |

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| --- |
| Node-2@vyos:~$ show ip route isis  Codes: K - kernel route, C - connected, S - static, R - RIP, O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP, T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR, f - OpenFabric, |

|  |
| --- |
| > - selected route, \* - FIB route, q - queued, r - rejected, b - backup t - trapped, o - offload failure |

|  |
| --- |
| I 192.0.2.0/24 [115/20] via 192.0.2.1, eth1 inactive, weight 1, 00:07:46  I>\* 192.168.255.255/32 [115/20] via 192.0.2.1, eth1, label IPv4 Explicit Null, weight 1, 00:03:43 |

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| **Enable OSPF with Segment Routing (Experimental):** |

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| **Node 1** |

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| --- |
| set interfaces loopback lo address 10.1.1.1/32  set interfaces ethernet eth0 address 192.168.0.1/24  set protocols ospf area 0 network '192.168.0.0/24'  set protocols ospf area 0 network '10.1.1.1/32'  set protocols ospf parameters opaque-lsa  set protocols ospf parameters router-id '10.1.1.1'  set protocols ospf segment-routing global-block high-label-value '1100' set protocols ospf segment-routing global-block low-label-value '1000' set protocols ospf segment-routing prefix 10.1.1.1/32 index explicit-null set protocols ospf segment-routing prefix 10.1.1.1/32 index value '1' |

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| --- |
| **Node 2** |

|  |
| --- |
| set interfaces loopback lo address 10.1.1.2/32  set interfaces ethernet eth0 address 192.168.0.2/24  set protocols ospf area 0 network '192.168.0.0/24'  set protocols ospf area 0 network '10.1.1.2/32'  set protocols ospf parameters opaque-lsa  set protocols ospf parameters router-id '10.1.1.2'  set protocols ospf segment-routing global-block high-label-value '1100' set protocols ospf segment-routing global-block low-label-value '1000' set protocols ospf segment-routing prefix 10.1.1.2/32 index explicit-null set protocols ospf segment-routing prefix 10.1.1.2/32 index value '2' |

|  |
| --- |
| This gives us MPLS segment routing enabled and labels for far end loopbacks: |

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| --- |
| Node-1@vyos:~$ show mpls table  Inbound Label Type Nexthop Outbound Label  -----------------------------------------------------------  1002 SR (OSPF) 192.168.0.2 IPv4 Explicit Null <-- Node-2 loopback learned on Node-1 15000 SR (OSPF) 192.168.0.2 implicit-null  15001 SR (OSPF) 192.168.0.2 implicit-null |

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| --- |
| Node-2@vyos:~$ show mpls table  Inbound Label Type Nexthop Outbound Label  -----------------------------------------------------------  1001 SR (OSPF) 192.168.0.1 IPv4 Explicit Null <-- Node-1 loopback learned on Node-2 15000 SR (OSPF) 192.168.0.1 implicit-null  15001 SR (OSPF) 192.168.0.1 implicit-null |

|  |
| --- |
| Here is the routing tables showing the MPLS segment routing label operations: |

|  |
| --- |
| Node-1@vyos:~$ show ip route ospf  Codes: K - kernel route, C - connected, S - static, R - RIP,  O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,  T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,  f - OpenFabric,  > - selected route, \* - FIB route, q - queued, r - rejected, b - backup |

|  |
| --- |
| t - trapped, o - offload failure |

|  |
| --- |
| O 10.1.1.1/32 [110/0] is directly connected, lo, weight 1, 00:03:43  O>\* 10.1.1.2/32 [110/1] via 192.168.0.2, eth0, label IPv4 Explicit Null, weight 1, 00:03:32 O 192.168.0.0/24 [110/1] is directly connected, eth0, weight 1, 00:03:43 |

|  |
| --- |
| Node-2@vyos:~$ show ip route ospf  Codes: K - kernel route, C - connected, S - static, R - RIP,  O - OSPF, I - IS-IS, B - BGP, E - EIGRP, N - NHRP,  T - Table, v - VNC, V - VNC-Direct, A - Babel, F - PBR,  f - OpenFabric,  > - selected route, \* - FIB route, q - queued, r - rejected, b - backup t - trapped, o - offload failure |

|  |
| --- |
| O>\* 10.1.1.1/32 [110/1] via 192.168.0.1, eth0, label IPv4 Explicit Null, weight 1, 00:03:36 O 10.1.1.2/32 [110/0] is directly connected, lo, weight 1, 00:03:51  O 192.168.0.0/24 [110/1] is directly connected, eth0, weight 1, 00:03:51 |

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