

CCIE Routing & Switching Lab Guide

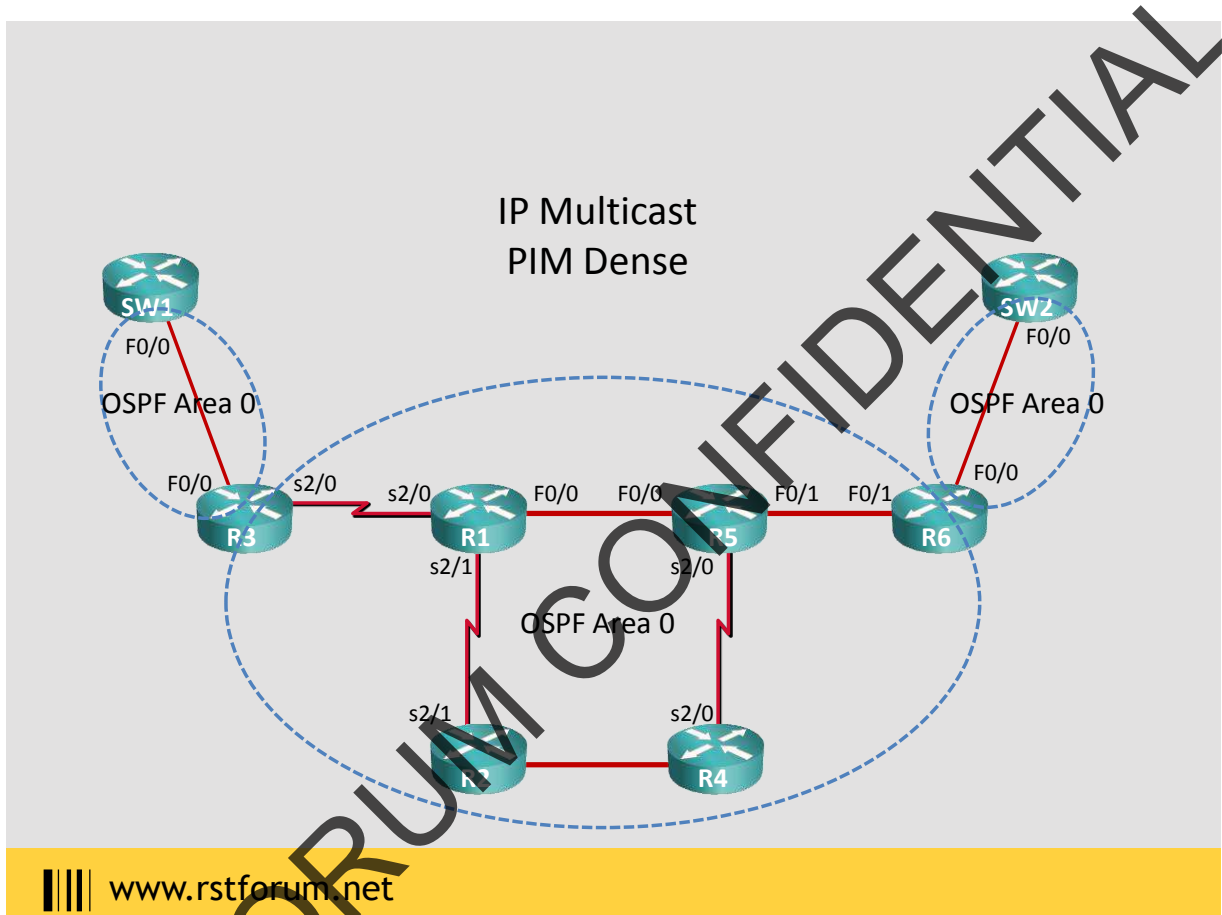
Disclaimer

This CCIE Routing & Switching Lab Guide is designed to assist candidates in the preparation for Cisco Systems' CCIE Routing & Switching Lab exam. While every effort has been made to ensure that all material is as complete and accurate as possible, the enclosed material is presented on an "as is" basis. Neither the authors nor Forum assume any liability or responsibility to any person or entity with respect to loss or damages incurred from the information contained in this workbook. This workbook was developed by Forum. Any similarities between material presented in this workbook and actual CCIE TM lab material or any other material is completely coincidental.



IP Multicast

Configure IP Multicast with PIM Dense Mode throughout the OSPF domain so that multicast traffic sent from SW1 can be received by SW2.



Configuration:

```
R1:
ip multicast-routing
!
interface Loopback0
ip address 150.1.1.1 255.255.255.255
!
interface FastEthernet0/0
ip address 150.1.15.1 255.255.255.0
ip pim dense-mode
```

Configuration:

```
interface Serial2/0
ip address 150.1.13.1 255.255.255.0
ip pim dense-mode
!
interface Serial2/1
ip address 150.1.12.1 255.255.255.0
ip pim dense-mode
!
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
```

```
R2:
ip multicast-routing
!
interface Loopback0
ip address 150.1.2.2 255.255.255.255
!
interface FastEthernet0/0
ip address 150.1.24.2 255.255.255.0
ip pim dense-mode
!
interface Serial2/1
ip address 150.1.12.2 255.255.255.0
ip pim dense-mode
!
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
```

```
R3:
ip multicast-routing
!
interface Loopback0
ip address 150.1.3.3 255.255.255.255
!
interface FastEthernet0/0
ip address 10.1.37.3 255.255.255.0
ip pim dense-mode
!
interface Serial2/0
ip address 150.1.13.3 255.255.255.0
ip pim dense-mode
!
```

Configuration:

```
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
```

R4:

```
ip multicast-routing
!
interface Loopback0
ip address 150.1.4.4 255.255.255.255
!
interface FastEthernet0/0
ip address 150.1.24.4 255.255.255.0
ip pim dense-mode
!
interface Serial2/0
ip address 150.1.45.4 255.255.255.0
ip pim dense-mode
!
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
```

R5:

```
ip multicast-routing
!
interface Loopback0
ip address 150.1.5.5 255.255.255.255
!
interface FastEthernet0/0
ip address 150.1.15.5 255.255.255.0
ip pim dense-mode
!
interface FastEthernet0/1
ip address 150.1.56.5 255.255.255.0
ip pim dense-mode
!
interface Serial2/0
ip address 150.1.45.5 255.255.255.0
ip pim dense-mode
!
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
```

Configuration:

R6:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.6.6 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.68.6 255.255.255.0  
ip pim dense-mode  
!  
interface FastEthernet0/1  
ip address 150.1.56.6 255.255.255.0  
ip pim dense-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```

SW1:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.7.7 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.37.7 255.255.255.0  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```

SW2:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.8.8 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.68.8 255.255.255.0  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```

Verification:

R1#show ip pim neighbor

PIM Neighbor Table

Neighbor Address	Interface	Uptime/Expires Prio/Mode	Ver	DR
150.1.15.5	FastEthernet0/0	00:55:51/00:01:26	v2	1 / DR P
150.1.13.3	Serial2/0	00:55:55/00:01:28	v2	1 / P
150.1.12.2	Serial2/1	00:30:06/00:01:42	v2	1 / P

R2#show ip pim neighbor

PIM Neighbor Table

Neighbor Address	Interface	Uptime/Expires Prio/Mode	Ver	DR
150.1.24.4	FastEthernet0/0	01:01:40/00:01:41	v2	1 / DR P
150.1.12.1	Serial2/1	00:35:47/00:01:24	v2	1 / P

R3#show ip pim neighbor

PIM Neighbor Table

Neighbor Address	Interface	Uptime/Expires Prio/Mode	Ver	DR
150.1.13.1	Serial2/0	01:04:54/00:01:39	v2	1 / P

R4#show ip pim neighbor

PIM Neighbor Table

Neighbor Address	Interface	Uptime/Expires Prio/Mode	Ver	DR
150.1.24.2	FastEthernet0/0	00:23:37/00:01:37	v2	1 / P
150.1.45.5	Serial2/0	00:29:24/00:01:24	v2	1 / P

R5#show ip pim neighbor

PIM Neighbor Table

Neighbor Address	Interface	Uptime/Expires Prio/Mode	Ver	DR
150.1.15.1	FastEthernet0/0	01:08:04/00:01:22	v2	1 / P
150.1.56.6	FastEthernet0/1	01:07:39/00:01:22	v2	1 / DR P
150.1.45.4	Serial2/0	00:30:34/00:01:41	v2	1 / P

R6#show ip pim neighbor

PIM Neighbor Table

Neighbor Address	Interface	Uptime/Expires Prio/Mode	Ver	DR
150.1.56.5	FastEthernet0/1	01:09:00/00:01:21	v2	1 / P

Verification:

SW1: Originate multicast feed from source SW1:

```
SW1#conf t
SW1(config)#rtr 1
SW1(config-rtr)#type udpEcho dest-ipaddr 224.1.1.1 dest-port 12345
                    source-ipaddr 10.1.37.7 control disable
SW1(config-rtr)#frequency 5
SW1(config-rtr)#exit
SW1(config)#rtr schedule 1 start now
SW1(config)#end
```

(10.1.37.7,224.1.1.1) is flooded throughout the network to R6 and pruned back to R3 as there are no receivers:

```
R6#debug ip pim
PIM(0): Insert (10.1.37.7,224.1.1.1) prune in nbr 150.1.56.5's queue
PIM(0): Building join/Prune packet for nbr 150.1.56.5
PIM(0): Adding v2 (10.1.37.7/32, 224.1.1.1) Prune
PIM(0): Send v2 join/prune to 150.1.56.5 (FastEthernet0/1)
```

```
R3#debug ip pim
PIM(0): Received v2 Join/Prune on Serial2/0 from 150.1.13.1, to us
PIM(0): Prune-list: (10.1.37.7/32, 224.1.1.1)
PIM(0): Prune Serial2/0/224.1.1.1 from (10.1.37.7/32, 224.1.1.1)
```

R1#show ip mroute 224.1.1.1

```
<output omitted>
(*, 224.1.1.1), 00:07:30/stopped, RP 0.0.0.0, flags: D
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial2/1, Forward/Dense, 00:07:30/00:00:00
    Serial2/0, Forward/Dense, 00:07:30/00:00:00
    FastEthernet0/0, Forward/Dense, 00:07:30/00:00:00
```

```
(10.1.37.7, 224.1.1.1), 00:04:05/00:02:00, flags: PT
  Incoming interface: Serial2/0, RPF nbr 150.1.13.3
```

Outgoing interface list:

```
FastEthernet0/0, Prune/Dense, 00:01:00/00:01:59
Serial2/1, Prune/Dense, 00:00:56/00:02:03
```

Verification:

R2#show ip mroute 224.1.1.1

<output omitted>

(* , 224.1.1.1), 00:12:46/stopped, RP 0.0.0.0, flags: D

Incoming interface: Null, RPF nbr 0.0.0.0

Outgoing interface list:

Serial2/1, Forward/Dense, 00:12:46/00:00:00

FastEthernet0/0, Forward/Dense, 00:12:47/00:00:00

(10.1.37.7, 224.1.1.1), 00:00:45/00:02:14, flags: PT

Incoming interface: Serial2/1, RPF nbr 150.1.12.1

Outgoing interface list:

FastEthernet0/0, Prune/Dense, 00:00:40/00:02:19, A

R3#show ip mroute 224.1.1.1

<output omitted>

(* , 224.1.1.1), 00:35:12/stopped, RP 0.0.0.0, flags: D

Incoming interface: Null, RPF nbr 0.0.0.0

Outgoing interface list:

Serial2/0, Forward/Dense, 00:35:12/00:00:00

(10.1.37.7, 224.1.1.1), 00:03:02/00:00:07, flags: PT

Incoming interface: FastEthernet0/0, RPF nbr 0.0.0.0

Outgoing interface list:

Serial2/0, Prune/Dense, 00:02:57/00:00:02

R4#show ip mroute 224.1.1.1

<output omitted>

(* , 224.1.1.1), 00:37:43/stopped, RP 0.0.0.0, flags: D

Incoming interface: Null, RPF nbr 0.0.0.0

Outgoing interface list:

Serial2/0, Forward/Dense, 00:37:43/00:00:00

FastEthernet0/0, Forward/Dense, 00:37:43/00:00:00

(10.1.37.7, 224.1.1.1), 00:02:43/00:00:23, flags: PT

Incoming interface: Serial2/0, RPF nbr 150.1.45.5

Outgoing interface list:

FastEthernet0/0, Prune/Dense, 00:02:42/00:00:17

Verification:

```
R5#show ip mroute 224.1.1.1
<output omitted>
```

```
(* , 224.1.1.1), 00:39:27/stopped, RP 0.0.0.0, flags: D
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
  Serial2/0, Forward/Dense, 00:39:27/00:00:00
  FastEthernet0/1, Forward/Dense, 00:39:27/00:00:00
  FastEthernet0/0, Forward/Dense, 00:39:27/00:00:00
```

```
(10.1.37.7, 224.1.1.1), 00:01:07/00:01:59, flags: PT
Incoming interface: FastEthernet0/0, RPF nbr 150.1.15.1
Outgoing interface list:
  FastEthernet0/1, Prune/Dense, 00:01:07/00:01:52
  Serial2/0, Prune/Dense, 00:01:07/00:01:52
```

```
R6#show ip mroute 224.1.1.1
<output omitted>
```

```
(* , 224.1.1.1), 00:44:31/stopped, RP 0.0.0.0, flags: D
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
  FastEthernet0/1, Forward/Dense, 00:44:31/00:00:00
```

```
(10.1.37.7, 224.1.1.1), 00:02:41/00:00:18, flags: PT
Incoming interface: FastEthernet0/1, RPF nbr 150.1.56.5
Outgoing interface list: Null
```

SW2: Sends join message to requests traffic from the group 224.1.1.1:

```
SW2#conf t
SW2(config)#int FastEthernet0/0
SW2(config-if)#ip igmp join-group 224.1.1.1
SW2(config-if)#end
```

Verification:

R6 sends PIM dense graft to add itself to the tree for 224.1.1.1:

R6#debug ip pim

02:57:27: PIM(0): Building Graft message for 224.1.1.1, FastEthernet0/1:
10.1.37.7/32
02:57:27: PIM(0): Send v2 Graft to 150.1.56.5 (FastEthernet0/1)
02:57:27: PIM(0): Received v2 Graft-Ack on FastEthernet0/1 from 150.1.56.5
02:57:27: Group 224.1.1.1:
10.1.37.7/32

R5 receives graft request from R6 and continues forwarding request upstream toward source:

02:56:57: PIM(0): Received v2 Graft on FastEthernet0/1 from 150.1.56.6
02:56:57: PIM(0): Join-list: (10.1.37.7/32, 224.1.1.1)
02:56:57: PIM(0): Add FastEthernet0/1/0.0.0.0 to (10.1.37.7, 224.1.1.1), Forward state, by PIM Graft
02:56:57: PIM(0): Send v2 Graft-Ack on FastEthernet0/1 to 150.1.56.6
02:56:57: PIM(0): Building Graft message for 224.1.1.1, Serial2/0: no entries
02:56:57: PIM(0): Building Graft message for 224.1.1.1, FastEthernet0/1: no entries
02:56:57: PIM(0): Building Graft message for 224.1.1.1, FastEthernet0/0:
10.1.37.7/32
02:56:57: PIM(0): Send v2 Graft to 150.1.15.1 (FastEthernet0/0)
02:56:58: PIM(0): Received v2 Graft-Ack on FastEthernet0/0 from 150.1.15.1
02:56:58: Group 224.1.1.1:
10.1.37.7/32

Dense tree is built back to the source and traffic begins to flow:

R3#show ip mroute 224.1.1.1

<output omitted>

(* 224.1.1.1), 00:10:42/stopped, RP 0.0.0.0, flags: D

Incoming interface: Null, RPF nbr 0.0.0.0

Outgoing interface list:

Serial2/0, Forward/Dense, 00:10:42/00:00:00

(10.1.37.7, 224.1.1.1), 00:10:42/00:02:51, flags: T

Incoming interface: FastEthernet0/0, RPF nbr 0.0.0.0

Outgoing interface list:

Serial2/0, Forward/Dense, 00:10:20/00:00:00

Verification:

```
R1#show ip mroute 224.1.1.1
```

```
<output omitted>
```

```
(* , 224.1.1.1), 00:15:27/stopped, RP 0.0.0.0, flags: D
```

```
Incoming interface: Null, RPF nbr 0.0.0.0
```

```
Outgoing interface list:
```

```
Serial2/1, Forward/Dense, 00:15:27/00:00:00
```

```
Serial2/0, Forward/Dense, 00:15:27/00:00:00
```

```
FastEthernet0/0, Forward/Dense, 00:15:27/00:00:00
```

```
(10.1.37.7, 224.1.1.1), 00:15:27/00:02:59, flags: T
```

```
Incoming interface: Serial2/0, RPF nbr 150.1.13.3
```

```
Outgoing interface list:
```

```
FastEthernet0/0, Forward/Dense, 00:15:05/00:00:00
```

```
Serial2/1, Prune/Dense, 00:02:47/00:00:12
```

Traffic is still pruned through R2 and R4 as they are not in the SPT from SW1 to SW2:

```
R2#show ip mroute 224.1.1.1
```

```
<output omitted>
```

```
(* , 224.1.1.1), 00:18:47/stopped, RP 0.0.0.0, flags: D
```

```
Incoming interface: Null, RPF nbr 0.0.0.0
```

```
Outgoing interface list:
```

```
Serial2/1, Forward/Dense, 00:18:47/00:00:00
```

```
FastEthernet0/0, Forward/Dense, 00:18:47/00:00:00
```

```
(10.1.37.7, 224.1.1.1), 00:03:02/00:00:06, flags: PT
```

```
Incoming interface: Serial2/1, RPF nbr 150.1.12.1
```

```
Outgoing interface list:
```

```
FastEthernet0/0, Prune/Dense, 00:02:58/00:00:01, A
```

```
R4#show ip mroute 224.1.1.1
```

```
<output omitted>
```

```
(* , 224.1.1.1), 00:20:34/stopped, RP 0.0.0.0, flags: D
```

```
Incoming interface: Null, RPF nbr 0.0.0.0
```

```
Outgoing interface list:
```

```
Serial2/0, Forward/Dense, 00:20:34/00:00:00
```

```
FastEthernet0/0, Forward/Dense, 00:20:34/00:00:00
```

```
(10.1.37.7, 224.1.1.1), 00:01:39/00:01:27, flags: PT
```

```
Incoming interface: Serial2/0, RPF nbr 150.1.45.5
```

```
Outgoing interface list:
```

```
FastEthernet0/0, Prune/Dense, 00:01:39/00:01:20
```

Verification:

R5#show ip mroute 224.1.1.1

<output omitted>

(* , 224.1.1.1), 00:23:50/stopped, RP 0.0.0.0, flags: D

Incoming interface: Null, RPF nbr 0.0.0.0

Outgoing interface list:

Serial2/0, Forward/Dense, 00:23:50/00:00:00

FastEthernet0/1, Forward/Dense, 00:23:50/00:00:00

FastEthernet0/0, Forward/Dense, 00:23:50/00:00:00

(10.1.37.7, 224.1.1.1), 00:23:50/00:02:52, flags: T

Incoming interface: FastEthernet0/0, RPF nbr 150.1.15.1

Outgoing interface list:

FastEthernet0/1, Forward/Dense, 00:23:28/00:00:00

Serial2/0, Prune/Dense, 00:01:45/00:01:14

R6#show ip mroute 224.1.1.1

<output omitted>

(* , 224.1.1.1), 00:28:19/stopped, RP 0.0.0.0, flags: DC

Incoming interface: Null, RPF nbr 0.0.0.0

Outgoing interface list:

FastEthernet0/0, Forward/Dense, 00:26:22/00:00:00

FastEthernet0/1, Forward/Dense, 00:28:19/00:00:00

(10.1.37.7, 224.1.1.1), 00:26:43/00:02:51, flags: T

Incoming interface: FastEthernet0/1, RPF nbr 150.1.56.5

Outgoing interface list:

FastEthernet0/0, Forward/Dense, 00:26:22/00:00:00

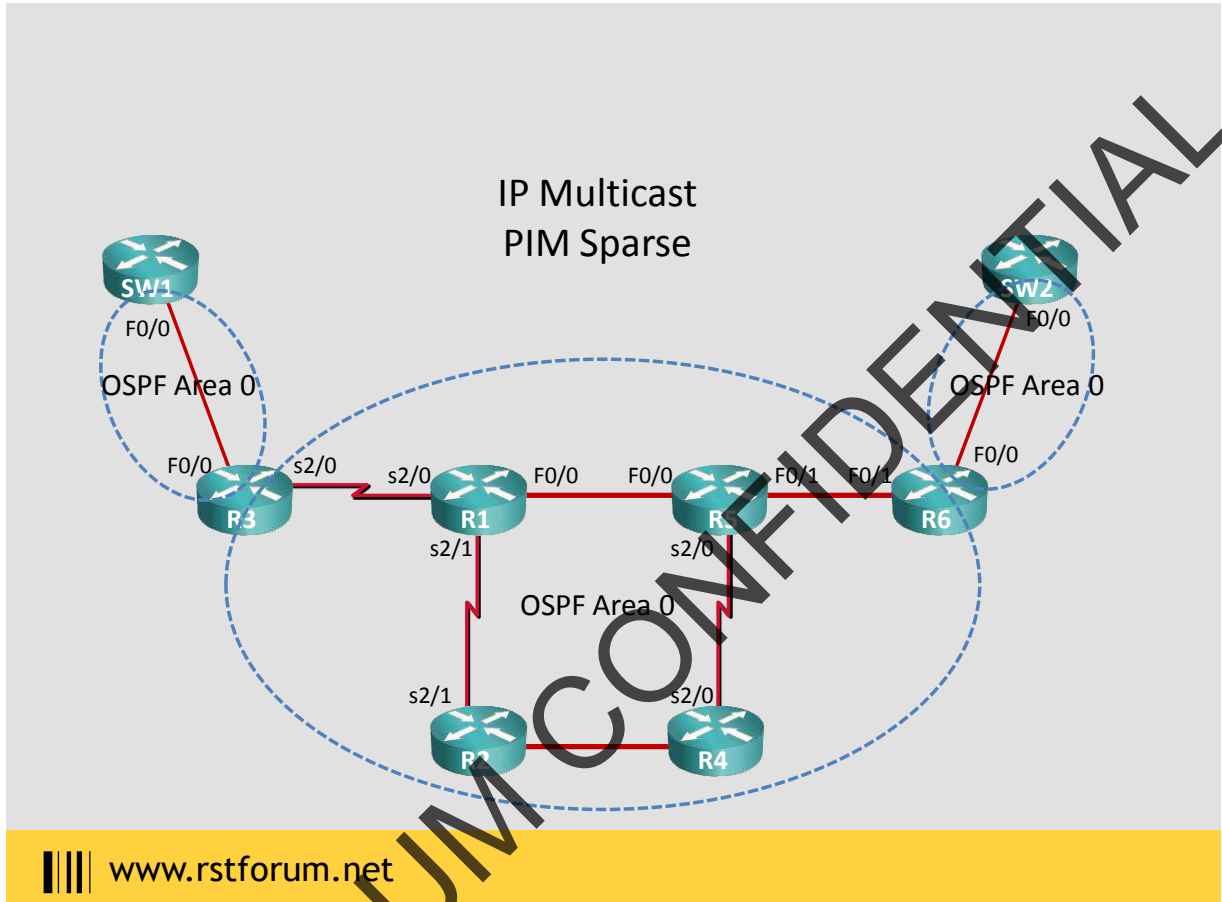
Traffic flows from SW1 to SW2:

R6#debug ip mpacket

04:06:25: IP(0): s=10.1.37.7 (FastEthernet0/1) d=224.1.1.1 (FastEthernet0/0) len 44,

mforward

Configure IP Multicast with PIM Sparse Mode throughout the OSPF domain with R2 as Rendezvous point so that multicast traffic sent from SW1 can be received by SW2.



Configuration:

```
R1:
ip multicast-routing
!
interface Loopback0
ip address 150.1.1.1 255.255.255.255
!
interface FastEthernet0/0
ip address 150.1.15.1 255.255.255.0
ip pim sparse-mode
```

Configuration:

```
interface Serial2/0
 ip address 150.1.13.1 255.255.255.0
 ip pim sparse-mode
!
interface Serial2/1
 ip address 150.1.12.1 255.255.255.0
 ip pim sparse-mode
!
router ospf 1
 network 0.0.0.0 255.255.255.255 area 0
!
 ip pim rp-address 150.1.2.2
```

R2:

```
 ip multicast-routing
!
interface Loopback0
 ip address 150.1.2.2 255.255.255.255
!
interface FastEthernet0/0
 ip address 150.1.24.2 255.255.255.0
 ip pim sparse-mode
!
interface Serial2/1
 ip address 150.1.12.2 255.255.255.0
 ip pim sparse-mode
!
router ospf 1
 network 0.0.0.0 255.255.255.255 area 0
!
 ip pim rp-address 150.1.2.2
```

R3:

```
 ip multicast-routing
!
interface Loopback0
 ip address 150.1.3.3 255.255.255.255
!
interface FastEthernet0/0
 ip address 10.1.37.3 255.255.255.0
 ip pim sparse-mode
!
interface Serial2/0
 ip address 150.1.13.3 255.255.255.0
 ip pim sparse-mode
```

Configuration:

```
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
!
ip pim rp-address 150.1.2.2
```

R4:

```
ip multicast-routing
!
interface Loopback0
ip address 150.1.4.4 255.255.255.255
!
interface FastEthernet0/0
ip address 150.1.24.4 255.255.255.0
ip pim sparse-mode
!
interface Serial2/0
ip address 150.1.45.4 255.255.255.0
ip pim sparse-mode
!
```

```
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
!
ip pim rp-address 150.1.2.2
```

R5:

```
ip multicast-routing
!
interface Loopback0
ip address 150.1.5.5 255.255.255.255
!
interface FastEthernet0/0
ip address 150.1.15.5 255.255.255.0
ip pim sparse-mode
!
```

```
interface FastEthernet0/1
ip address 150.1.56.5 255.255.255.0
ip pim sparse-mode
!
```

```
interface Serial2/0
ip address 150.1.45.5 255.255.255.0
ip pim sparse-mode
!
```

```
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
!
ip pim rp-address 150.1.2.2
```

Configuration:

R6:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.6.6 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.68.6 255.255.255.0  
ip pim sparse-mode  
!  
interface FastEthernet0/1  
ip address 150.1.56.6 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!  
ip pim rp-address 150.1.2.2
```

SW1:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.7.7 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.37.7 255.255.255.0  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```

SW2:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.8.8 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.68.8 255.255.255.0  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```


Verification:

R1#show ip pim neighbor

PIM Neighbor Table

Neighbor Address	Interface	Uptime/Expires Prio/Mode	Ver	DR
150.1.15.5	FastEthernet0/0	00:55:51/00:01:26	v2	1 / DR P
150.1.13.3	Serial2/0	00:55:55/00:01:28	v2	1 / P
150.1.12.2	Serial2/1	00:30:06/00:01:42	v2	1 / P

R2#show ip pim neighbor

PIM Neighbor Table

Neighbor Address	Interface	Uptime/Expires Prio/Mode	Ver	DR
150.1.24.4	FastEthernet0/0	01:01:40/00:01:41	v2	1 / DR P
150.1.12.1	Serial2/1	00:35:47/00:01:24	v2	1 / P

R3#show ip pim neighbor

PIM Neighbor Table

Neighbor Address	Interface	Uptime/Expires Prio/Mode	Ver	DR
150.1.13.1	Serial2/0	01:04:54/00:01:39	v2	1 / P

R4#show ip pim neighbor

PIM Neighbor Table

Neighbor Address	Interface	Uptime/Expires Prio/Mode	Ver	DR
150.1.24.2	FastEthernet0/0	00:23:37/00:01:37	v2	1 / P
150.1.45.5	Serial2/0	00:29:24/00:01:24	v2	1 / P

R5#show ip pim neighbor

PIM Neighbor Table

Neighbor Address	Interface	Uptime/Expires Prio/Mode	Ver	DR
150.1.15.1	FastEthernet0/0	01:08:04/00:01:22	v2	1 / P
150.1.56.6	FastEthernet0/1	01:07:39/00:01:22	v2	1 / DR P
150.1.45.4	Serial2/0	00:30:34/00:01:41	v2	1 / P

R6#show ip pim neighbor

PIM Neighbor Table

Neighbor Address	Interface	Uptime/Expires Prio/Mode	Ver	DR
150.1.56.5	FastEthernet0/1	01:09:00/00:01:21	v2	1 / P

Verification:

SW1: Originate multicast feed from source SW1:

```
SW1#conf t
SW1(config)#rtr 1
SW1(config-rtr)#type udpEcho dest-ipaddr 224.1.1.1 dest-port 12345
source-ipaddr 10.1.37.7 control disable
SW1(config-rtr)#frequency 5
SW1(config-rtr)#exit
SW1(config)#rtr schedule 1 start now
SW1(config)#end
```

(10.1.37.7,224.1.1.1) is flooded throughout the network to R6 and pruned back to R3 as there are no receivers:

R3: The PIM DR, sends unicast register message to R2, the RP

```
R3#debug ip pim
PIM debugging is on
R3#
00:04:51: PIM(0): Send v2 Register to 150.1.2.2 for 10.1.37.7, group 224.1.1.1
00:04:52: PIM(0): Received v2 Register-Stop on Serial2/0 from 150.1.2.2
00:04:52: PIM(0): for source 10.1.37.7, group 224.1.1.1
00:04:52: PIM(0): Clear register flag to 150.1.2.2 for (10.1.37.7/32, 224.1.1.1)
```

R3 and R2 have the (*,G) and (S,G) entry for 224.1.1.1.

Other devices do not have these entries since there are no receivers:

```
R3#show ip mroute 224.1.1.1
<output omitted>
```

```
(* , 224.1.1.1), 00:23:45/stopped, RP 150.1.2.2, flags: SPF
Incoming interface: Serial2/0, RPF nbr 150.1.13.1
Outgoing interface list: Null
```

```
(10.1.37.7) 224.1.1.1), 00:26:13/00:02:52, flags: PFT
Incoming interface: FastEthernet0/0, RPF nbr 0.0.0.0
Outgoing interface list: Null
```

Verification:

R2#show ip mroute 224.1.1.1
<output omitted>

(* , 224.1.1.1), 00:31:29/00:00:38, RP 150.1.2.2, flags: SP
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list: Null

(10.1.37.7, 224.1.1.1), 00:27:40/00:01:22, flags: PT
Incoming interface: Serial2/1, RPF nbr 150.1.12.1
Outgoing interface list: Null

R1#show ip mroute 224.1.1.1
Group 224.1.1.1 not found

R4#show ip mroute 224.1.1.1
Group 224.1.1.1 not found

R5#show ip mroute 224.1.1.1
Group 224.1.1.1 not found

R6#show ip mroute 224.1.1.1
Group 224.1.1.1 not found

SW2: Sends join message to requests traffic from the group 224.1.1.1:

SW2#conf t
SW2(config)#int FastEthernet0/0
SW2(config-if)#ip igmp join-group 224.1.1.1
SW2(config-if)#end

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Verification:

R6: Forwards the PIM join message upstream towards the RP:

R6#debug ip pim

01:31:12: PIM(0): Check RP 150.1.2.2 into the (*, 224.1.1.1) entry
01:31:12: PIM(0): Building Triggered Join/Prune message for 224.1.1.1
01:31:12: PIM(0): Insert (*,224.1.1.1) join in nbr 150.1.56.5's queue
01:31:12: PIM(0): Building Join/Prune packet for nbr 150.1.56.5
01:31:12: PIM(0): Adding v2 (150.1.2.2/32, 224.1.1.1), WC-bit, RPT-bit, S-bit Join
01:31:12: PIM(0): **Send v2 join/prune to 150.1.56.5 (FastEthernet0/1)**

Shortest Path Tree is built from SW1 to R3, R1, R5, R6, SW2:

R3#show ip mroute

<output omitted>

(*, 224.1.1.1), 00:01:20/stopped, RP 150.1.2.2, flags: SPF
Incoming interface: Serial2/0, RPF nbr 150.1.13.1
Outgoing interface list: Null

(10.1.37.7, 224.1.1.1), 00:00:50/00:03:25, flags: FT
Incoming interface: FastEthernet0/0, RPF nbr 0.0.0.0
Outgoing interface list:
Serial2/0, Forward/Sparse, 00:00:29/00:03:01

R1#show ip mroute

<output omitted>

(*, 224.1.1.1), 00:00:29/stopped, RP 150.1.2.2, flags: SP
Incoming interface: Serial2/1, RPF nbr 150.1.12.2
Outgoing interface list: Null

(10.1.37.7, 224.1.1.1), 00:00:29/00:03:16, flags: T
Incoming interface: Serial2/0, RPF nbr 150.1.13.3
Outgoing interface list:
FastEthernet0/0, Forward/Sparse, 00:00:19/00:03:10

Verification:

R5#show ip mroute
<output omitted>

(* , 224.1.1.1), 00:07:27/00:02:56, RP 150.1.2.2, flags: S
Incoming interface: Serial2/0, RPF nbr 150.1.45.4
Outgoing interface list:
FastEthernet0/1, Forward/Sparse, 00:07:27/00:02:56

(10.1.37.7, 224.1.1.1), 00:07:18/00:03:23, flags: T
Incoming interface: FastEthernet0/0, RPF nbr 150.1.15.1
Outgoing interface list:
FastEthernet0/1, Forward/Sparse, 00:07:18/00:02:56

R6#show ip mroute
<output omitted>

(* , 224.1.1.1), 00:01:25/stopped, RP 150.1.2.2, flags: SJC
Incoming interface: FastEthernet0/1, RPF nbr 150.1.56.5
Outgoing interface list:
FastEthernet0/0, Forward/Sparse, 00:01:25/00:02:30

(10.1.37.7, 224.1.1.1), 00:00:20/00:02:58, flags: JT
Incoming interface: FastEthernet0/1, RPF nbr 150.1.56.5
Outgoing interface list:
FastEthernet0/0, Forward/Sparse, 00:00:20/00:02:39

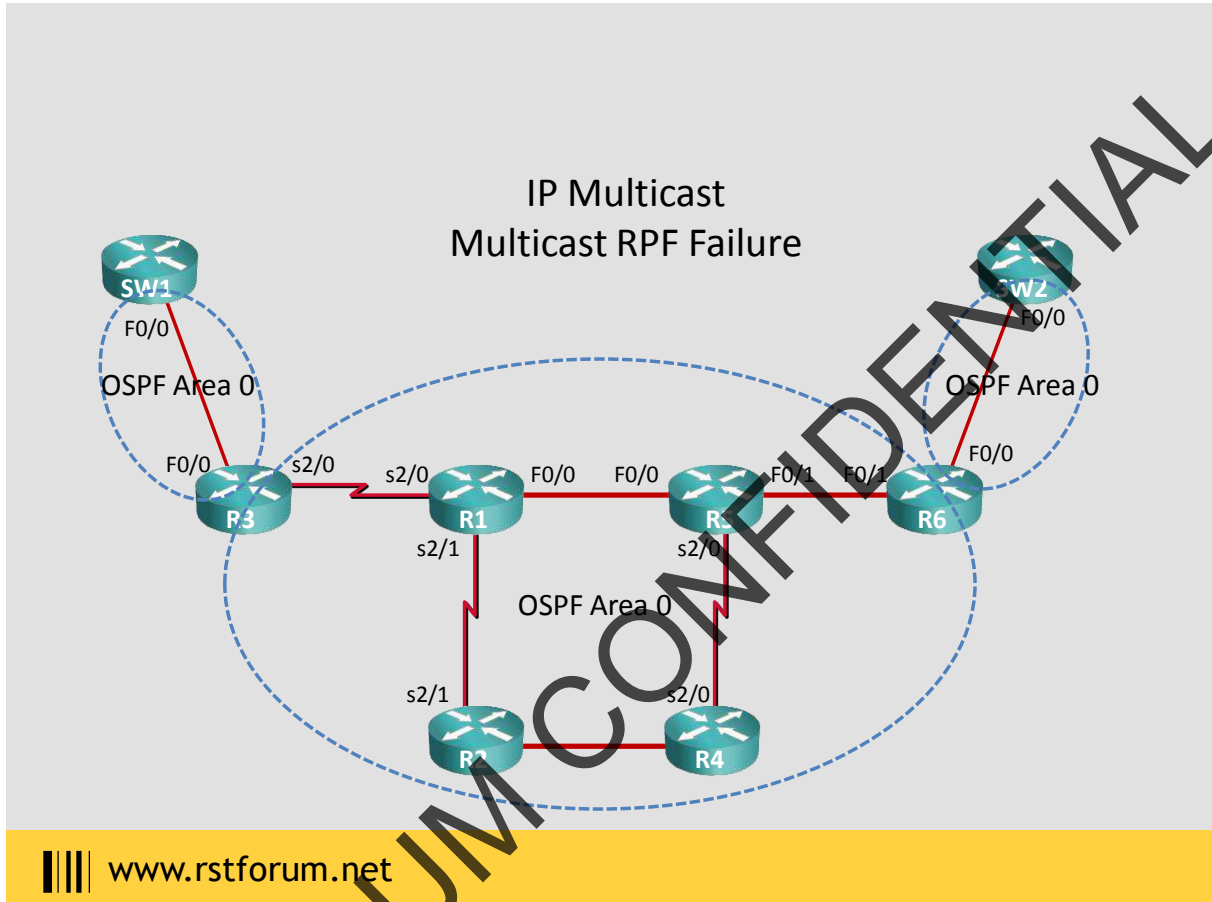
R6: Forwards multicast feed to SW2:

R6(config)#int FastEthernet0/1
R6(config-if)#no ip mroute-cache
R6(config-if)#do debug ip mpacket

IP multicast packets debugging is on

00:14:46: IP(0): s=10.1.37.7 (FastEthernet0/1) d=224.1.1.1 (FastEthernet0/0) len 44,
mforward

Configure IP Multicast with PIM Dense Mode throughout the OSPF domain except between R1 and R5. Configure static multicast routes so that multicast traffic sent from SW1 can be received by SW2.



Configuration:

```
R1:
ip multicast-routing
!
interface Loopback0
ip address 150.1.1.1 255.255.255.255
!
interface FastEthernet0/0
ip address 150.1.15.1 255.255.255.0
```

Configuration:

```
interface Serial2/0
 ip address 150.1.13.1 255.255.255.0
 ip pim dense-mode
!
interface Serial2/1
 ip address 150.1.12.1 255.255.255.0
 ip pim dense-mode
!
router ospf 1
 network 0.0.0.0 255.255.255.255 area 0
```

```
R2:
 ip multicast-routing
!
interface Loopback0
 ip address 150.1.2.2 255.255.255.255
!
interface FastEthernet0/0
 ip address 150.1.24.2 255.255.255.0
 ip pim dense-mode
!
interface Serial2/1
 ip address 150.1.12.2 255.255.255.0
 ip pim dense-mode
!
router ospf 1
 network 0.0.0.0 255.255.255.255 area 0
```

```
R3:
 ip multicast-routing
!
interface Loopback0
 ip address 150.1.3.3 255.255.255.255
!
interface FastEthernet0/0
 ip address 10.1.37.3 255.255.255.0
 ip pim dense-mode
!
interface Serial2/0
 ip address 150.1.13.3 255.255.255.0
 ip pim dense-mode
```

Configuration:

```
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
```

R4:

```
ip multicast-routing
!
interface Loopback0
ip address 150.1.4.4 255.255.255.255
!
interface FastEthernet0/0
ip address 150.1.24.4 255.255.255.0
ip pim dense-mode
!
interface Serial2/0
ip address 150.1.45.4 255.255.255.0
ip pim dense-mode
!
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
!
ip mroute 10.1.37.0 255.255.255.0 150.1.24.2
```

R5:

```
ip multicast-routing
!
interface Loopback0
ip address 150.1.5.5 255.255.255.255
!
interface FastEthernet0/0
ip address 150.1.15.5 255.255.255.0
ip pim dense-mode
!
interface FastEthernet0/1
ip address 150.1.56.5 255.255.255.0
ip pim dense-mode
!
interface Serial2/0
ip address 150.1.45.5 255.255.255.0
ip pim dense-mode
!
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
!
ip mroute 10.1.37.0 255.255.255.0 150.1.45.4
```


Configuration:

R6:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.6.6 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.68.6 255.255.255.0  
ip pim dense-mode  
!  
interface FastEthernet0/1  
ip address 150.1.56.6 255.255.255.0  
ip pim dense-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!
```

SW1:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.7.7 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.37.7 255.255.255.0  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```

SW2:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.8.8 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.68.8 255.255.255.0  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```

Verification:

SW1: Originate multicast feed from source SW1:

```
SW1#conf t
SW1(config)#rtr 1
SW1(config-rtr)#type udpEcho dest-ipaddr 224.1.1.1 dest-port 12345
                    source-ipaddr 10.1.37.7 control disable
SW1(config-rtr)#frequency 5
SW1(config-rtr)#exit
SW1(config)#rtr schedule 1 start now
SW1(config)#end
```

SW2 requests to traffic for the group 224.1.1.1:

```
SW2#conf t
SW2(config)#int fa0/0
SW2(config-if)#ip igmp join-group 224.1.1.1
SW2(config-if)#end
```

Before static mroute R4 drops traffic due to RPF failure:

```
R4#show ip mroute 224.1.1.1
<output omitted>
```

```
(* , 224.1.1.1), 00:01:09/stopped, RP 0.0.0.0, flags: D
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
  Serial2/0, Forward/Dense, 00:01:09/00:00:00
  FastEthernet0/0, Forward/Dense, 00:01:09/00:00:00
```

Incoming multicast interface is Serial2/0

```
(10.1.37.7, 224.1.1.1), 00:01:09/00:01:51, flags:
Incoming interface: Serial2/0, RPF nbr 150.1.45.5
Outgoing interface list:
  FastEthernet0/0, Forward/Dense, 00:01:09/00:00:00
```

Incoming unicast interface is FastEthernet0/0:

```
R4#sho ip route 10.1.37.7
Routing entry for 10.1.37.0/24
  Known via "ospf 1", distance 110, metric 98, type intra area
  Last update from 150.1.24.2 on FastEthernet0/0, 00:08:31 ago
  Routing Descriptor Blocks:
    * 150.1.45.5, from 150.1.7.7, 00:08:31 ago, via Serial2/0
      Route metric is 98, traffic share count is 1
    150.1.24.2, from 150.1.7.7, 00:08:31 ago, via FastEthernet0/0
      Route metric is 98, traffic share count is 1
```

Verification:

```
R4#conf t
R4(config)#interface FastEthernet0/0
R4(config-if)#no ip mroute-cache
R4(config-if)#do debug ip mpacket
IP multicast packets debugging is on
```

Packets are dropped due to RPF failure:

```
00:18:02: IP(0): s=10.1.37.7 (FastEthernet0/0) d=224.1.1.1 len 60, not RPF interface
```

```
R4#show ip mroute count
```

```
IP Multicast Statistics
```

```
3 routes using 1976 bytes of memory
```

```
2 groups, 0.50 average sources per group
```

```
Forwarding Counts: Pkt Count/Pkts per second/Avg Pkt Size/Kilobits per second
```

```
Other counts: Total/RPF failed/Other drops(OIF-null, rate-limit etc)
```

```
Group: 224.1.1.1, Source count: 1, Group pkt count: 0
```

```
Source: 10.1.37.7/32, Forwarding: 0/0/0/0, Other: 11/11/0
```

Static mroute is configured to bypass RPF check:

```
R4(config)#ip mroute 10.1.37.0 255.255.255.0 150.1.24.2
```

```
R4(config)#end
```

```
00:27:42: IP(0): s=10.1.37.7 (FastEthernet0/0) d=224.1.1.1 (Serial2/0) len 44, mforward
```

R5: expects multicast packet in FastEthernet0/0 from R1 but receives it from R4:

```
R5#debug ip mpacket
```

```
00:32:32: IP(0): s=10.1.37.7 (Serial2/0) d=224.1.1.1 len 48, not RPF interface
```

```
R5#show ip route 10.1.37.7
```

```
Routing entry for 10.1.37.0/24
```

```
Known via "ospf 1", distance 110, metric 50, type intra area
```

```
Last update from 150.1.15.1 on FastEthernet0/0, 00:36:53 ago
```

```
Routing Descriptor Blocks:
```

```
* 150.1.15.1, from 150.1.7.7, 00:36:53 ago, via FastEthernet0/0
```

```
Route metric is 50, traffic share count is 1
```

Verification:

Static mroute overrides RPF check:

```
R5#conf t
R5(config)#ip mroute 10.1.37.0 255.255.255.0 150.1.45.4
```

```
IP(0): s=10.1.37.7 (Serial2/0) d=224.1.1.1 (FastEthernet0/1), len=44(44), mforward
```

Traffic is now delivered to SW2:

```
R6#debug ip mpacket
IP multicast packets debugging is on
00:58:52: IP(0): s=10.1.37.7 (FastEthernet0/1) d=224.1.1.1 (FastEthernet0/0) len 44,
mforward
```

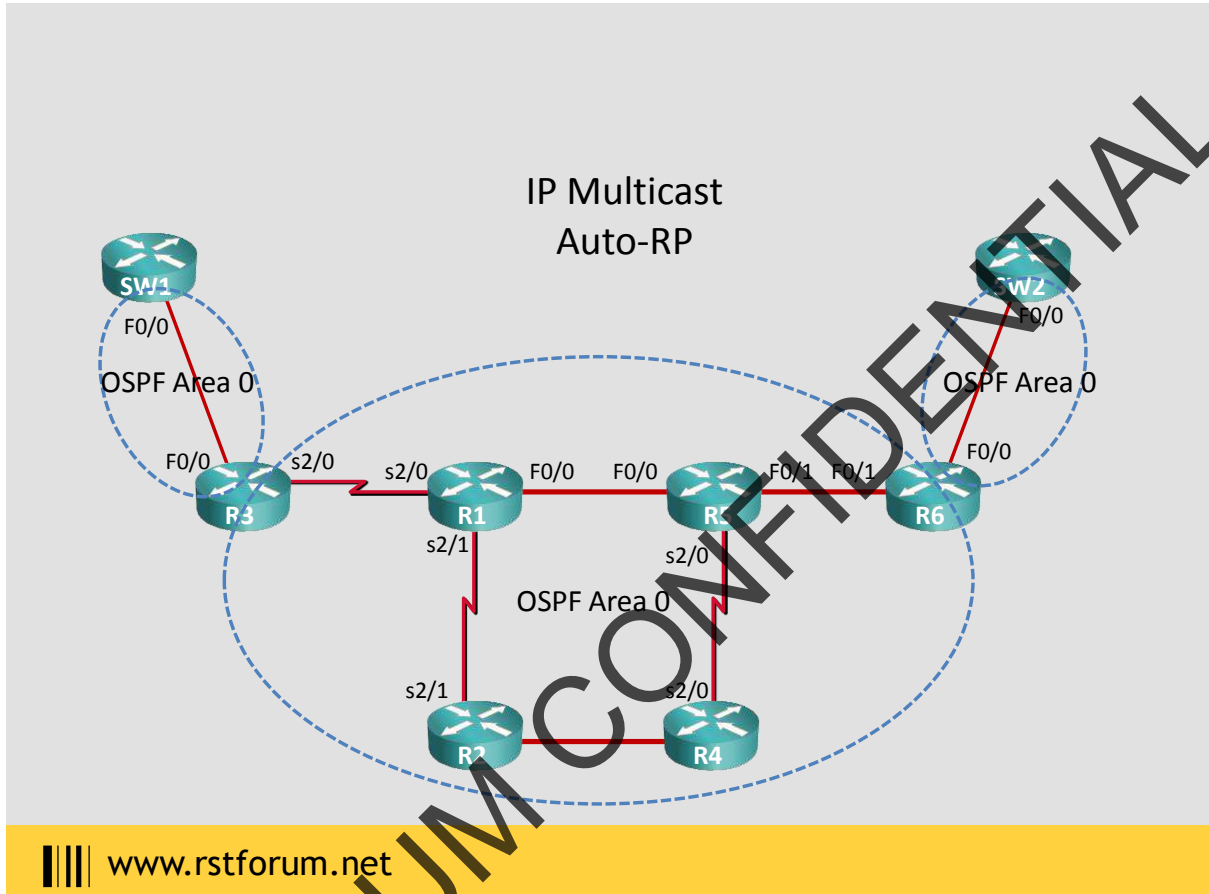
```
R6#show ip mroute 224.1.1.1
<output omitted>
```

```
(* , 224.1.1.1), 00:52:25/stopped, RP 0.0.0.0, flags: DC
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
FastEthernet0/0, Forward/Dense, 00:05:36/00:00:00
FastEthernet0/1, Forward/Dense, 00:17:43/00:00:00
```

```
(10.1.37.7, 224.1.1.1), 00:17:36/00:02:57, flags: T
Incoming interface: FastEthernet0/1, RPF nbr 150.1.56.5
Outgoing interface list:
FastEthernet0/0, Forward/Dense, 00:05:36/00:00:00
```

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Configure IP Multicast with PIM Sparse-Dense and Auto-RP throughout the OSPF domain so that multicast traffic sent from SW1 can be received by SW2. R1 should be RP and R5 should be mapping agent.



Note: In Auto-RP the RP announces itself to discovery agent using address 224.0.0.39 and in turn mapping agent uses 224.0.0.40 to tell other routers. For RP announce and Discovery dense mode is used hence it is recommended to use Ip pim sparse-dense-mode. or you can use ip pim autorp listener that allows the device to listen to and propagate mapping messages even if no RP for the group exists.

Configuration:

```
R1:
ip multicast-routing
!
interface Loopback0
ip address 150.1.1.1 255.255.255.255
ip pim sparse-dense-mode
!
interface FastEthernet0/0
ip address 150.1.15.1 255.255.255.0
ip pim sparse-dense-mode
```

Configuration:

```
interface Serial2/0
 ip address 150.1.13.1 255.255.255.0
 ip pim sparse-dense-mode
!
interface Serial2/1
 ip address 150.1.12.1 255.255.255.0
 ip pim sparse-dense-mode
!
router ospf 1
 network 0.0.0.0 255.255.255.255 area 0
!
 ip pim send-rp-announce Loopback0 scope 16
```

```
R2:
 ip multicast-routing
!
 interface Loopback0
 ip address 150.1.2.2 255.255.255.255
!
 interface FastEthernet0/0
 ip address 150.1.24.2 255.255.255.0
 ip pim sparse-dense-mode
!
 interface Serial2/1
 ip address 150.1.12.2 255.255.255.0
 ip pim sparse-dense-mode
!
 router ospf 1
 network 0.0.0.0 255.255.255.255 area 0
```

```
R3:
 ip multicast-routing
!
 interface Loopback0
 ip address 150.1.3.3 255.255.255.255
!
 interface FastEthernet0/0
 ip address 10.1.37.3 255.255.255.0
 ip pim sparse-dense-mode
!
 interface Serial2/0
 ip address 150.1.13.3 255.255.255.0
 ip pim sparse-dense-mode
```

Configuration:

```
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
```

R4:

```
ip multicast-routing
!
interface Loopback0
ip address 150.1.4.4 255.255.255.255
!
interface FastEthernet0/0
ip address 150.1.24.4 255.255.255.0
ip pim sparse-dense-mode
!
interface Serial2/0
ip address 150.1.45.4 255.255.255.0
ip pim sparse-dense-mode
!
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
```

R5:

```
ip multicast-routing
!
interface Loopback0
ip address 150.1.5.5 255.255.255.255
ip pim sparse-dense-mode
!
interface FastEthernet0/0
ip address 150.1.15.5 255.255.255.0
ip pim sparse-dense-mode
!
interface FastEthernet0/1
ip address 150.1.56.5 255.255.255.0
ip pim sparse-dense-mode
!
interface Serial2/0
ip address 150.1.45.5 255.255.255.0
ip pim sparse-dense-mode
!
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
!
ip pim send-rp-discovery Loopback0 scope 16
```

Configuration:

R6:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.6.6 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.68.6 255.255.255.0  
ip pim sparse-dense-mode  
!  
interface FastEthernet0/1  
ip address 150.1.56.6 255.255.255.0  
ip pim sparse-dense-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!
```

SW1:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.7.7 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.37.7 255.255.255.0  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```

SW2:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.8.8 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.68.8 255.255.255.0  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```


Verification:

R1 advertises itself to the mapping agent via 224.0.1.39:

Note: 224.0.1.39 and 224.0.1.40 use the dense mode for RP announce and Discovery hence we are using PIM Sparse-dense mode

R5#show ip mroute 224.0.1.39
<output omitted>

(* , 224.0.1.39), 00:25:49/stopped, RP 0.0.0.0, flags: DCL
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
Serial2/0, Forward/Sparse-Dense, 00:25:49/00:00:00
FastEthernet0/1, Forward/Sparse-Dense, 00:25:49/00:00:00
FastEthernet0/0, Forward/Sparse-Dense, 00:25:49/00:00:00

(150.1.1.1, 224.0.1.39), 00:25:49/00:02:16, flags: LT
Incoming interface: FastEthernet0/0, RPF nbr 150.1.15.1
Outgoing interface list:
FastEthernet0/1, Forward/Sparse-Dense, 00:24:21/00:00:00
Serial2/0, Forward/Sparse-Dense, 00:24:21/00:00:00

R5 advertises R1 as the RP to all other routers via 224.0.1.40:

R3#show ip mroute 224.0.1.40
<output omitted>

*, 224.0.1.40), 00:03:46/stopped, RP 0.0.0.0, flags: DCL
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
Serial2/0, Forward/Sparse-Dense, 00:03:46/00:00:00
FastEthernet0/0, Forward/Sparse-Dense, 00:03:46/00:00:00

(150.1.5.5, 224.0.1.40), 00:03:24/00:02:39, flags: LT
Incoming interface: Serial2/0, RPF nbr 150.1.13.1
Outgoing interface list:
FastEthernet0/0, Forward/Sparse-Dense, 00:03:24/00:00:00

R1 is assigned as the RP via Auto-RP:

R3#show ip pim rp mapping
PIM Group-to-RP Mappings

Group(s) 224.0.0.0/4
RP 150.1.1.1 (?), v2v1
Info source: 150.1.5.5 (?), elected via Auto-RP
Uptime: 00:21:20, expires: 00:02:29

Verification:

SW1: Originate multicast feed from source SW1; R3 registers the source with the RP:

```
SW1#conf t
SW1(config)#rtr 1
SW1(config-rtr)#type udpEcho dest-ipaddr 224.1.1.1 dest-port 12345
                    source-ipaddr 10.1.37.7 control disable
SW1(config-rtr)#frequency 5
SW1(config-rtr)#exit
SW1(config)#rtr schedule 1 start now
SW1(config)#end
```

```
R3#debug ip pim
00:01:13: PIM(0): Check RP 150.1.1.1 into the (*, 224.1.1.1) entry
00:01:13: PIM(0): Send v2 Register to 150.1.1.1 for 10.1.37.7, group 224.1.1.1
00:01:14: PIM(0): Received v2 Register-Stop on Serial2/0 from 150.1.1.1
00:01:14: PIM(0): for source 10.1.37.7, group 224.1.1.1
00:01:14: PIM(0): Clear register flag to 150.1.1.1 for (10.1.37.7/32, 224.1.1.1)
```

SW2: joins group and R6 sends PIM Join upstream towards RP:

```
SW2(config)#int fa0/0
SW2(config-if)#ip igmp join-group 224.1.1.1

R6#debug ip pim
PIM debugging is on
00:03:42: PIM(0): Insert (10.1.37.7,224.1.1.1) join in nbr 150.1.56.5's queue
00:03:42: PIM(0): Building Join/Prune packet for nbr 150.1.56.5
00:03:42: PIM(0): Adding v2 (10.1.37.7/32, 224.1.1.1), S-bit Join
00:03:42: PIM(0): Send v2 join/prune to 150.1.56.5 (FastEthernet0/1)
```

Multicast traffic flows from SW1 to SW2:

```
R6(config)#int f0/1
R6(config-if)#no ip mroute-cache
R6(config-if)#do debug ip mpacket

IP multicast packets debugging is on
00:14:32: IP(0): s=10.1.37.7 (FastEthernet0/1) d=224.1.1.1 (FastEthernet0/0) len 44,
mforward
```

Verification:

224.0.1.39 and 224.0.1.40 are in PIM Dense mode

All other groups are Sparse:

R6#show ip mroute

IP Multicast Routing Table

Flags: **D - Dense, S - Sparse**, B - Bidir Group, s - SSM Group, C - Connected,

L - Local, P - Pruned, R - RP-bit set, F - Register flag,

T - SPT-bit set, J - Join SPT, M - MSDP created entry,

X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,

U - URD, I - Received Source Specific Host Report,

Z - Multicast Tunnel, z - MDT-data group sender,

Y - Joined MDT-data group, y - Sending to MDT-data group

V - RD & Vector, v - Vector

(* , 224.1.1.1), 00:13:49/stopped, RP 150.1.1.1, flags: **SJC**

Incoming interface: FastEthernet0/1, RPF nbr 150.1.56.5

Outgoing interface list:

FastEthernet0/0, Forward/Sparse-Dense, 00:13:49/00:02:38

(10.1.37.7, 224.1.1.1), 00:13:43/00:02:55, flags: **JT**

Incoming interface: FastEthernet0/1, RPF nbr 150.1.56.5

Outgoing interface list:

FastEthernet0/0, Forward/Sparse-Dense, 00:13:43/00:02:38

(* , 224.0.1.39), 00:17:12/stopped, RP 0.0.0.0, flags: **DC**

Incoming interface: Null, RPF nbr 0.0.0.0

Outgoing interface list:

FastEthernet0/1, Forward/Sparse-Dense, 00:17:12/00:00:00

(150.1.1.1, 224.0.1.39), 00:00:08/00:02:51, flags: **PTX**

Incoming interface: FastEthernet0/1, RPF nbr 150.1.56.5

Outgoing interface list: Null

(* , 224.0.1.40), 00:17:23/stopped, RP 0.0.0.0, flags: **DCL**

Incoming interface: Null, RPF nbr 0.0.0.0

Outgoing interface list:

FastEthernet0/0, Forward/Sparse-Dense, 00:17:23/00:00:00

FastEthernet0/1, Forward/Sparse-Dense, 00:16:54/00:00:00

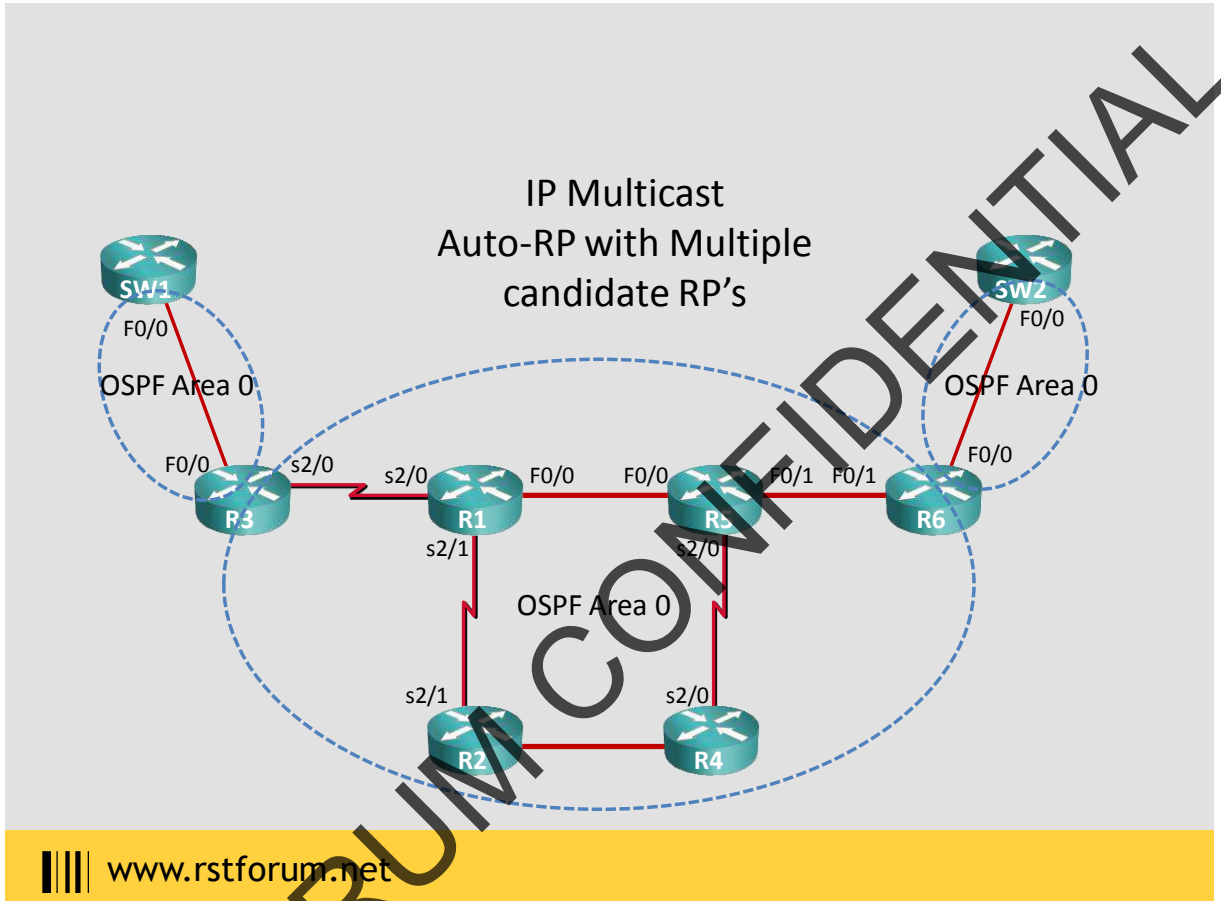
(150.1.5.5, 224.0.1.40), 00:16:15/00:02:41, flags: **LT**

Incoming interface: FastEthernet0/1, RPF nbr 150.1.56.5

Outgoing interface list:

FastEthernet0/0, Forward/Sparse-Dense, 00:16:15/00:00:00

Configure IP Multicast with PIM Sparse-Dense and Auto-RP throughout the OSPF domain so that multicast traffic sent from SW1 can be received by SW2. R2 should be RP for group 224.0.0.0/5 and R4 should be RP for group 232.0.0.0/5. R5 should be mapping agent.



Configuration:

```
R1:
ip multicast-routing
!
interface Loopback0
ip address 150.1.1.1 255.255.255.255
!
interface FastEthernet0/0
ip address 150.1.15.1 255.255.255.0
ip pim sparse-dense-mode
```

Configuration:

```
interface Serial2/0
ip address 150.1.13.1 255.255.255.0
ip pim sparse-dense-mode
!
interface Serial2/1
ip address 150.1.12.1 255.255.255.0
ip pim sparse-dense-mode
!
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
```

R2:

```
ip multicast-routing
!
interface Loopback0
ip address 150.1.2.2 255.255.255.255
ip pim sparse-dense-mode
!
interface FastEthernet0/0
ip address 150.1.24.2 255.255.255.0
ip pim sparse-dense-mode
!
interface Serial2/1
ip address 150.1.12.2 255.255.255.0
ip pim sparse-dense-mode
!
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
!
ip pim send-rp-announce Loopback0 scope 16 group-list 1
access-list 1 permit 224.0.0.0 7.255.255.255
```

R3:

```
ip multicast-routing
!
interface Loopback0
ip address 150.1.3.3 255.255.255.255
!
interface FastEthernet0/0
ip address 10.1.37.3 255.255.255.0
ip pim sparse-dense-mode
!
interface Serial2/0
ip address 150.1.13.3 255.255.255.0
ip pim sparse-dense-mode
```

Configuration:

```
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
```

R4:

```
ip multicast-routing
!
interface Loopback0
ip address 150.1.4.4 255.255.255.255
ip pim sparse-dense-mode
!
interface FastEthernet0/0
ip address 150.1.24.4 255.255.255.0
ip pim sparse-dense-mode
!
interface Serial2/0
ip address 150.1.45.4 255.255.255.0
ip pim sparse-dense-mode
!
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
!
Ip pim send-rp-announce loopback0 scope 16 group-list 1
access-list 1 permit 232.0.0.0 7.255.255.255
```

R5:

```
ip multicast-routing
!
interface Loopback0
ip address 150.1.5.5 255.255.255.255
Ip pim sparse-dense-mode
!
interface FastEthernet0/0
ip address 150.1.15.5 255.255.255.0
ip pim sparse-dense-mode
!
interface FastEthernet0/1
ip address 150.1.56.5 255.255.255.0
ip pim sparse-dense-mode
!
interface Serial2/0
ip address 150.1.45.5 255.255.255.0
ip pim sparse-dense-mode
!
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
!
ip pim send-rp-discovery Loopback0 scope 16
```

Configuration:

R6:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.6.6 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.68.6 255.255.255.0  
ip pim sparse-dense-mode  
!  
interface FastEthernet0/1  
ip address 150.1.56.6 255.255.255.0  
ip pim sparse-dense-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!
```

SW1:

```
ip multicast-routing  
!  
interface Loopback0  
ip address 150.1.7.7 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.37.7 255.255.255.0  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```

SW2:

```
ip multicast-routing  
!  
interface Loopback0  
ip address 150.1.8.8 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.68.8 255.255.255.0  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```

Verification:

R2 and R4 advertises themselves to the mapping agent via 224.0.1.39:

(* , 224.0.1.39), 00:03:56/stopped, RP 0.0.0.0, flags: DCL
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
Loopback0, Forward/Sparse-Dense, 00:02:48/00:00:00
Serial2/0, Forward/Sparse-Dense, 00:03:56/00:00:00
FastEthernet0/1, Forward/Sparse-Dense, 00:03:56/00:00:00
FastEthernet0/0, Forward/Sparse-Dense, 00:03:56/00:00:00

(150.1.2.2, 224.0.1.39), 00:03:01/00:02:58, flags: LT
Incoming interface: Serial2/0, RPF nbr 150.1.45.4
Outgoing interface list:
Loopback0, Forward/Sparse-Dense, 00:02:48/00:00:00
FastEthernet0/0, Forward/Sparse-Dense, 00:00:00/00:00:00
FastEthernet0/1, Forward/Sparse-Dense, 00:03:01/00:00:00

(150.1.4.4, 224.0.1.39), 00:03:07/00:02:55, flags: LT
Incoming interface: Serial2/0, RPF nbr 150.1.45.4
Outgoing interface list:
Loopback0, Forward/Sparse-Dense, 00:02:48/00:00:00
FastEthernet0/0, Forward/Sparse-Dense, 00:03:10/00:00:00
FastEthernet0/1, Forward/Sparse-Dense, 00:03:10/00:00:00

R5 advertises R1 as the RP to all other routers via 224.0.1.40:

R3#show ip mroute 224.0.1.40
<output omitted>

(* , 224.0.1.40), 01:04:58/stopped, RP 0.0.0.0, flags: DCL
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
Serial2/0, Forward/Sparse-Dense, 01:04:28/00:00:00
FastEthernet0/0, Forward/Sparse-Dense, 01:04:58/00:00:00

(150.1.5.5, 224.0.1.40), 00:08:28/00:02:34, flags: LT
Incoming interface: Serial2/0, RPF nbr 150.1.13.1
Outgoing interface list:
FastEthernet0/0, Forward/Sparse-Dense, 00:08:28/00:00:00

Verification:

R2 and R4 are assigned as the RP's via Auto-RP:

```
R3#show ip pim rp mapping
PIM Group-to-RP Mappings
```

Group(s) 224.0.0.0/5

RP 150.1.2.2 (?), v2v1

Info source: 150.1.5.5 (?), elected via Auto-RP

Uptime: 00:42:42, expires: 00:02:55

Group(s) 232.0.0.0/5

RP 150.1.4.4 (?), v2v1

Info source: 150.1.5.5 (?), elected via Auto-RP

Uptime: 00:43:08, expires: 00:02:34

SW1: Originate multicast feed from source SW1;

```
SW1#conf t
```

```
SW1(config)#rtr 1
```

```
SW1(config-rtr)#type udpEcho dest-ipaddr 224.1.1.1 dest-port 12345
source-ipaddr 10.1.37.7 control disable
```

```
SW1(config-rtr)#frequency 5
```

```
SW1(config-rtr)#exit
```

```
SW1(config)#rtr schedule 1 start now
```

```
SW1(config)#end
```

```
SW1(config)#rtr 2
```

```
SW1(config-rtr)#type udpEcho dest-ipaddr 232.1.1.1 dest-port 12345
source-ipaddr 10.1.37.7 control disable
```

```
SW1(config-rtr)#frequency 5
```

```
SW1(config-rtr)#exit
```

```
SW1(config)#rtr schedule 2 start now
```

```
SW1(config)#end
```

Verification:

R3#debug ip pim

01:24:40: PIM(0): Check RP 150.1.2.2 into the (*, 224.1.1.1) entry

01:24:40: PIM(0): Send v2 Register to 150.1.2.2 for 10.1.37.7, group 224.1.1.1

01:24:40: PIM(0): Received v2 Register-Stop on Serial2/0 from 150.1.2.2

01:24:40: PIM(0): for source 10.1.37.7, group 224.1.1.1

01:24:40: PIM(0): Clear register flag to 150.1.2.2 for (10.1.37.7/32, 224.1.1.1)

01:25:26: PIM(0): Check RP 150.1.4.4 into the (*, 232.1.1.1) entry

01:25:26: PIM(0): Send v2 Register to 150.1.4.4 for 10.1.37.7, group 232.1.1.1

01:25:27: PIM(0): Received v2 Register-Stop on Serial2/0 from 150.1.4.4

01:25:27: PIM(0): for source 10.1.37.7, group 232.1.1.1

01:25:27: PIM(0): Clear register flag to 150.1.4.4 for (10.1.37.7/32, 232.1.1.1)

SW2: joins group and R6 sends PIM Join upstream towards RP:

SW2(config)#int fa0/0

SW2(config-if)#ip igmp join-group 224.1.1.1

SW2(config-if)#ip igmp join-group 232.1.1.1

R6#debug ip pim

PIM debugging is on

01:44:14: PIM(0): Adding v2 (10.1.37.7/32, 224.1.1.1), S-bit Join

01:44:14: PIM(0): Send v2 join/prune to 150.1.56.5 (FastEthernet0/1)

01:44:14: PIM(0): Received RP-Reachable on FastEthernet0/1 from 150.1.2.2

01:44:14: for group 224.1.1.1

01:47:13: PIM(0): Adding v2 (10.1.37.7/32, 232.1.1.1), S-bit Join

01:47:13: PIM(0): Send v2 join/prune to 150.1.56.5 (FastEthernet0/1)

01:47:14: PIM(0): Received RP-Reachable on FastEthernet0/1 from 150.1.2.2

01:47:14: for group 224.1.1.1

Multicast traffic flows from SW1 to SW2:

R6(config)#int f0/1

R6(config-if)#no ip mroute-cache

R6(config-if)#do debug ip mpacket

01:56:33: IP(0): s=10.1.37.7 (FastEthernet0/1) d=224.1.1.1 (FastEthernet0/0) len 80, mforward

01:56:34: IP(0): s=10.1.37.7 (FastEthernet0/1) d=232.1.1.1 (FastEthernet0/0) len 80, mforward

Verification:

224.0.1.39 and 224.0.1.40 are in PIM Dense mode

All other groups are Sparse:

R6#show ip mroute

IP Multicast Routing Table

Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,

L - Local, P - Pruned, R - RP-bit set, F - Register flag,

T - SPT-bit set, J - Join SPT, M - MSDP created entry,

X - Proxy Join Timer Running, A - Candidate for MSDP Advertisement,

U - URD, I - Received Source Specific Host Report,

Z - Multicast Tunnel, z - MDT-data group sender,

Y - Joined MDT-data group, y - Sending to MDT-data group

V - RD & Vector, v - Vector

Outgoing interface flags: H - Hardware switched, A - Assert winner

Timers: Uptime/Expires

Interface state: Interface, Next-Hop or VCD, State/Mode

(* , 232.1.1.1), 03:18:06/00:02:59, RP 150.1.4.4, flags: **S**JC

Incoming interface: FastEthernet0/1, RPF nbr 150.1.56.5

Outgoing interface list:

FastEthernet0/0, Forward/Sparse-Dense, 03:18:06/00:02:59

(* , 224.1.1.1), 03:18:09/00:02:56, RP 150.1.2.2, flags: **S**JC

Incoming interface: FastEthernet0/1, RPF nbr 150.1.56.5

Outgoing interface list:

FastEthernet0/0, Forward/Sparse-Dense, 03:18:09/00:02:56

(* , 224.0.1.39), 04:38:26/stopped, RP 0.0.0.0, flags: **D**C

Incoming interface: Null, RPF nbr 0.0.0.0

Outgoing interface list:

FastEthernet0/1, Forward/Sparse-Dense, 04:38:26/00:00:00

(150.1.2.2, 224.0.1.39), 00:00:09/00:02:50, flags: PTX

Incoming interface: FastEthernet0/1, RPF nbr 150.1.56.5

Outgoing interface list: Null

(150.1.4.4, 224.0.1.39), 00:01:09/00:01:50, flags: PTX

Incoming interface: FastEthernet0/1, RPF nbr 150.1.56.5

Outgoing interface list: Null

Verification:

(* , 224.0.1.40), 05:02:17/stopped, RP 0.0.0.0, flags: DCL

Incoming interface: Null, RPF nbr 0.0.0.0

Outgoing interface list:

FastEthernet0/0, Forward/Sparse-Dense, 05:02:17/00:00:00

FastEthernet0/1, Forward/Sparse-Dense, 05:01:48/00:00:00

(150.1.5.5, 224.0.1.40), 04:05:41/00:02:26, flags: LT

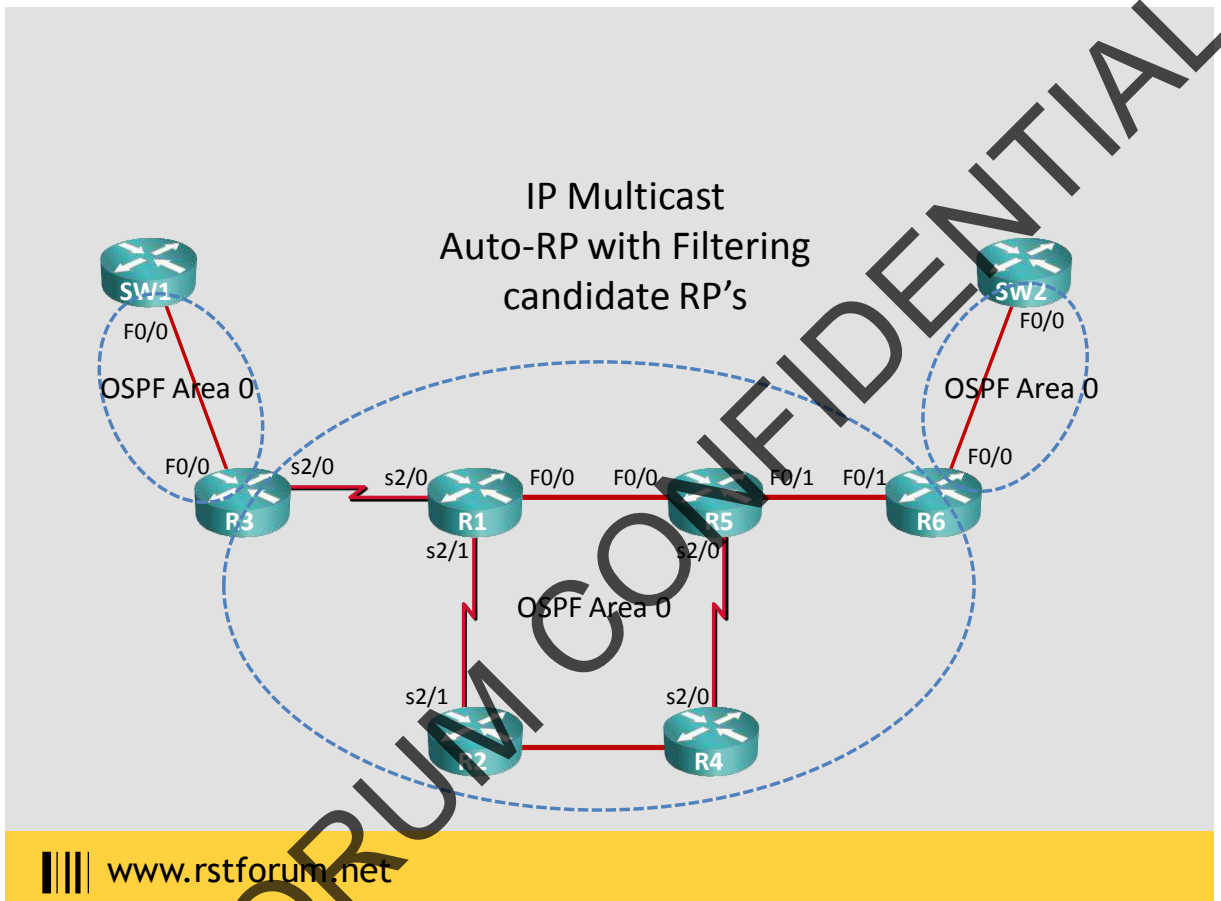
Incoming interface: FastEthernet0/1, RPF nbr 150.1.56.5

Outgoing interface list:

FastEthernet0/0, Forward/Sparse-Dense, 04:05:41/00:00:00

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Configure IP Multicast with PIM Sparse-Dense and Auto-RP throughout the OSPF domain so that multicast traffic sent from SW1 can be received by SW2. R2 should be RP for group 224.0.0.0/5 and R4 should be RP for group 232.0.0.0/5. R5 should be mapping agent and should prevent any additional devices from being elected as RPs.



Configuration:

```
R1:
ip multicast-routing
!
interface Loopback0
ip address 150.1.1.1 255.255.255.255
!
interface FastEthernet0/0
ip address 150.1.15.1 255.255.255.0
ip pim sparse-dense-mode
```

Configuration:

```
interface Serial2/0
 ip address 150.1.13.1 255.255.255.0
 ip pim sparse-dense-mode
!
interface Serial2/1
 ip address 150.1.12.1 255.255.255.0
 ip pim sparse-dense-mode
!
router ospf 1
 network 0.0.0.0 255.255.255.255 area 0
```

R2:

```
ip multicast-routing
!
interface Loopback0
 ip address 150.1.2.2 255.255.255.255
 ip pim sparse-dense-mode
!
interface FastEthernet0/0
 ip address 150.1.24.2 255.255.255.0
 ip pim sparse-dense-mode
!
interface Serial2/1
 ip address 150.1.12.2 255.255.255.0
 ip pim sparse-dense-mode
!
router ospf 1
 network 0.0.0.0 255.255.255.255 area 0
!
ip pim send-rp-announce Loopback0 scope 16 group-list 1
 access-list 1 permit 224.0.0.0 7.255.255.255
```

R3:

```
ip multicast-routing
!
interface Loopback0
 ip address 150.1.3.3 255.255.255.255
!
interface FastEthernet0/0
 ip address 10.1.37.3 255.255.255.0
 ip pim sparse-dense-mode
!
interface Serial2/0
 ip address 150.1.13.3 255.255.255.0
 ip pim sparse-dense-mode
```

Configuration:

```
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
```

R4:

```
ip multicast-routing
!
interface Loopback0
ip address 150.1.4.4 255.255.255.255
ip pim sparse-dense-mode
!
interface FastEthernet0/0
ip address 150.1.24.4 255.255.255.0
ip pim sparse-dense-mode
!
interface Serial2/0
ip address 150.1.45.4 255.255.255.0
ip pim sparse-dense-mode
!
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
!
Ip pim send-rp-announce loopback0 scope 16 group-list 1
access-list 1 permit 232.0.0.0 7.255.255.255
```

R5:

```
ip multicast-routing
!
interface Loopback0
ip address 150.1.5.5 255.255.255.255
Ip pim sparse-dense-mode
!
interface FastEthernet0/0
ip address 150.1.15.5 255.255.255.0
ip pim sparse-dense-mode
!
interface FastEthernet0/1
ip address 150.1.56.5 255.255.255.0
ip pim sparse-dense-mode
!
interface Serial2/0
ip address 150.1.45.5 255.255.255.0
ip pim sparse-dense-mode
!
router ospf 1
network 0.0.0.0 255.255.255.255 area 0
!
```

Configuration:

```
!  
ip pim send-rp-discovery Loopback0 scope 16  
ip pim rp-announce-filter rp-list R2_LOOPBACK group-list R2_GROUPS  
ip pim rp-announce-filter rp-list R4_LOOPBACK group-list R4_GROUPS  
ip pim rp-announce-filter rp-list ALL_OTHER_RPS group-list NO_GROUPS  
!  
ip access-list standard ALL_OTHER_RPS  
deny 150.1.2.2  
deny 150.1.4.4  
permit any  
!  
ip access-list standard NO_GROUPS  
deny 224.0.0.0 3.255.255.255  
!  
ip access-list standard R2_GROUPS  
permit 224.0.0.0 7.255.255.255  
!  
ip access-list standard R2_LOOPBACK  
permit 150.1.2.2  
!  
ip access-list standard R4_GROUPS  
permit 232.0.0.0 7.255.255.255  
!  
ip access-list standard R4_LOOPBACK  
permit 150.1.4.4
```

R6:

```
ip multicast-routing  
!  
interface Loopback0  
ip address 150.1.6.6 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.68.6 255.255.255.0  
ip pim sparse-dense-mode  
!  
interface FastEthernet0/1  
ip address 150.1.56.6 255.255.255.0  
ip pim sparse-dense-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```


Configuration:

SW1:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.7.7 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.37.7 255.255.255.0  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```

SW2:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.8.8 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.68.8 255.255.255.0  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```

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Verification:

R1 and R3 advertise themselves as "rogue" RPs but are filtered by R5:

```
R1(config)#int lo0
R1(config-if)#ip pim sparse-dense-mode
R1(config)#ip pim send-rp-announce loopback0 scope 16
```

```
R3(config)#int lo0
R3(config-if)#ip pim sparse-dense-mode
R3(config)#ip pim send-rp-announce loopback0 scope 16
```

```
R5#debug ip pim auto-rp
PIM Auto-RP debugging is on
01:13:17: Auto-RP(0): Received RP-announce, from 150.1.1.1, RP_cnt 1, ht 181
01:13:17: Auto-RP(0): Filtered 224.0.0.0/4 for RP 150.1.1.1
01:13:23: Auto-RP(0): Received RP-announce, from 150.1.3.3, RP_cnt 1, ht 181
01:13:23: Auto-RP(0): Filtered 224.0.0.0/4 for RP 150.1.3.3
```

R2 and R4 are accepted by the filter on R5:

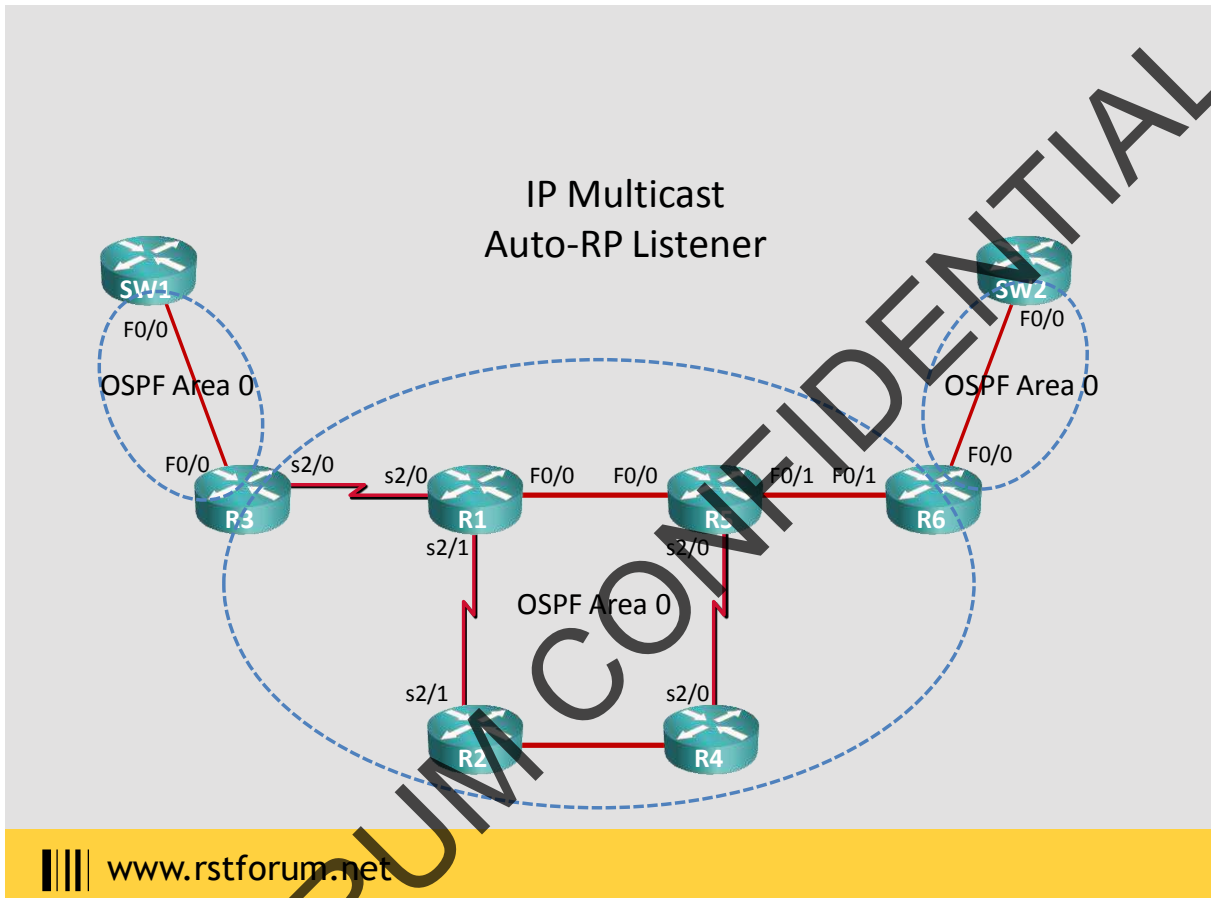
```
R5#debug ip pim auto-rp
PIM Auto-RP debugging is on
01:10:33: Auto-RP(0): Received RP-announce, from 150.1.2.2, RP_cnt 1, ht 181
01:10:33: Auto-RP(0): Update (224.0.0.0/5, RP:150.1.2.2), PIMv2 v1
01:10:39: Auto-RP(0): Received RP-announce, from 150.1.4.4, RP_cnt 1, ht 181
01:10:39: Auto-RP(0): Update (232.0.0.0/5, RP:150.1.4.4), PIMv2 v1
```

```
R5#show ip pim rp mapping
```

```
PIM Group-to-RP Mappings
This system is an RP-mapping agent (Loopback0)
```

```
Group(s) 224.0.0.0/5
RP 150.1.2.2 (?), v2v1
Info source: 150.1.2.2 (?), elected via Auto-RP
Uptime: 01:21:43, expires: 00:02:42
Group(s) 232.0.0.0/5
RP 150.1.4.4 (?), v2v1
Info source: 150.1.4.4 (?), elected via Auto-RP
Uptime: 01:22:56, expires: 00:02:30
```

Configure IP Multicast with PIM Sparse and Auto-RP throughout the OSPF domain so that multicast traffic sent from SW1 can be received by SW2. R2 should be RP for group 224.0.0.0/5. R5 should be mapping agent. Groups outside should not fall back to dense mode.



Note:

The `ip pim autorp listener` is mandatory command in Pim sparse AutoRP mode. This command allows the Group 224.0.0.39 & 224.0.0.40 to be densely flooded. This command is used when pim-dense mode is not configured.

As the RP announces 224.0.0.39 to the mapping agent and the mapping agent announces 224.0.0.40 to all routers part of the group.

when using autoRP to propagate groups to RP mappings you face the following problem:

mapping messages are sent with destination address 224.0.1.40, i.e. for group 224.0.1.40. But if the links are configured with sparse-mode and no RP for 224.0.1.40 exists then this group will not work. (In Auto-RP the two ip's 224.0.0.39 and 224.0.0.40 use the dense mode for RP announce and Discovery hence it is recommended to use **Ip pim sparse-dense-mode**)

- or you can use `ip pim autorp listener` that allows the device to listen to and propagate mapping messages even if no RP for the group exists.

Comments from cisco: "To cause IP multicast traffic for the two Auto-RP groups 224.0.1.39 and 224.0.1.40 to be PIM dense mode flooded across interfaces operating in PIM sparse mode, use the `ip pim autorp listener` command in global configuration mode.

Configuration:

R1:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.1.1 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 150.1.15.1 255.255.255.0  
ip pim sparse-mode  
!  
interface Serial2/0  
ip address 150.1.13.1 255.255.255.0  
ip pim sparse-mode  
!  
interface Serial2/1  
ip address 150.1.12.1 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!  
ip pim autorp listener
```

R2:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.2.2 255.255.255.255  
ip pim sparse-mode  
!  
interface FastEthernet0/0  
ip address 150.1.24.2 255.255.255.0  
ip pim sparse-mode  
!  
interface Serial2/1  
ip address 150.1.12.2 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!  
ip pim send-rp-announce Loopback0 scope 16 group-list 1  
access-list 1 permit 224.0.0.0 7.255.255.255  
!  
ip pim autorp listener
```

Configuration:

R3:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.3.3 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.37.3 255.255.255.0  
ip pim sparse-mode  
!  
interface Serial2/0  
ip address 150.1.13.3 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!  
ip pim autorp listener
```

R4:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.4.4 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 150.1.24.4 255.255.255.0  
ip pim sparse-mode  
!  
interface Serial2/0  
ip address 150.1.45.4 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!  
ip pim autorp listener
```

Configuration:

```
R5:
ip multicast-routing
!
interface Loopback0
 ip address 150.1.5.5 255.255.255.255
Ip pim sparse-mode
!
interface FastEthernet0/0
 ip address 150.1.15.5 255.255.255.0
 ip pim sparse-mode
!
interface FastEthernet0/1
 ip address 150.1.56.5 255.255.255.0
 ip pim sparse-mode
!
interface Serial2/0
 ip address 150.1.45.5 255.255.255.0
 ip pim sparse-mode
!
router ospf 1
 network 0.0.0.0 255.255.255.255 area 0
!
ip pim send-rp-discovery Loopback0 scope 16
!
ip pim autorp listener

R6:
ip multicast-routing
!
interface Loopback0
 ip address 150.1.6.6 255.255.255.255
!
interface FastEthernet0/0
 ip address 10.1.68.6 255.255.255.0
 ip pim sparse-mode
!
interface FastEthernet0/1
 ip address 150.1.56.6 255.255.255.0
 ip pim sparse-mode
!
router ospf 1
 network 0.0.0.0 255.255.255.255 area 0
!
ip pim autorp listener
```

Configuration:

SW1:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.7.7 255.255.255.255  
  
interface FastEthernet0/0  
ip address 10.1.37.7 255.255.255.0  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```

SW2:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.8.8 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.68.8 255.255.255.0  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```

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Verification:

Multicast routers only have an RP for 224.0.0.0/5:

```
R3#show ip pim rp mapping
PIM Group-to-RP Mappings
Group(s) 224.0.0.0/5
RP 150.1.2.2 (?), v2v1
  Info source: 150.1.15.5 (?), elected via Auto-RP
  Uptime: 00:01:19, expires: 00:02:36
```

SW1 generates traffic to 224.1.1.1 and 232.1.1.1:

```
SW1(config)#rtr 1
SW1(config-rtr)#type udpEcho dest-ipaddr 224.1.1.1 dest-port 12345 source-ipaddr
10.1.37.7 control disable
SW1(config-rtr-udp)#frequency 5
```

```
SW1(config)#rtr 2
SW1(config-rtr)#type udpEcho dest-ipaddr 232.1.1.1 dest-port 12345 source-ipaddr
10.1.37.7 control disable
SW1(config-rtr-udp)#frequency 5
```

```
SW1(config)#rtr schedule 1 start after 00:00:05
SW1(config)#rtr schedule 2 start after 00:00:05
SW1(config)#end
```

R3 registers (10.1.37.7,224.1.1.1) but (10.1.37.7,232.1.1.1) is dropped

```
R3#debug ip pim
00:08:31: PIM(0): Check RP 150.1.2.2 into the (*, 224.1.1.1) entry
00:08:31: PIM(0): Send v2 Register to 150.1.2.2 for 10.1.37.7, group 224.1.1.1
00:08:31: PIM(0): Received v2 Register-Stop on Serial2/0 from 150.1.2.2
00:08:31: PIM(0): for source 10.1.37.7, group 224.1.1.1
00:08:31: PIM(0): Clear register flag to 150.1.2.2 for (10.1.37.7/32, 224.1.1.1)
```

Traffic for 224.1.1.1 flows but 232.1.1.1 is dropped:

```
Sw2(config)# int fa0/0
Sw2(config)#ip igmp join 224.1.1.1
Sw2(config)#ip igmp join 232.1.1.1
```

```
R3#conf t
Enter configuration commands, one per line. End with CNTL/Z.
R3(config)#int F0/0
R3(config-if)#no ip mroute-cache
R3(config-if)#do debug ip mpacket
```


Verification:

IP multicast packets debugging is on

```
00:30:20: IP(0): s=10.1.37.7 (FastEthernet0/0) d=224.1.1.1 (Serial2/0) len 44, mforward
00:30:30: IP(0): s=10.1.37.7 (FastEthernet0/0) d=232.1.1.1 len 60, RPF lookup failed for
source or RP
```

Only 224.0.1.39 and 224.0.1.40 are allow to run in dense mode:

```
R3#show ip mroute
```

```
<output omitted>
```

```
(* , 232.1.1.1), 00:00:21/00:02:38, RP 0.0.0.0, flags: SP
```

```
Incoming interface: Null, RPF nbr 0.0.0.0
```

```
Outgoing interface list: Null
```

```
(* , 224.1.1.1), 00:35:10/stopped, RP 150.1.2.2, flags: SPF
```

```
Incoming interface: Serial2/0, RPF nbr 150.1.13.1
```

```
Outgoing interface list: Null
```

```
(10.1.37.7, 224.1.1.1), 00:35:10/00:03:28, flags: FT
```

```
Incoming interface: FastEthernet0/0, RPF nbr 0.0.0.0
```

```
Outgoing interface list:
```

```
Serial2/0, Forward/Sparse, 00:20:19/00:03:03
```

```
(* , 224.0.1.39), 00:40:35/stopped, RP 0.0.0.0, flags: D
```

```
Incoming interface: Null, RPF nbr 0.0.0.0
```

```
Outgoing interface list:
```

```
Serial2/0, Forward/Sparse, 00:40:35/00:00:00
```

```
(150.1.2.2, 224.0.1.39), 00:01:25/00:01:34, flags: PT
```

```
Incoming interface: Serial2/0, RPF nbr 150.1.13.1
```

```
Outgoing interface list: Null
```

```
(* , 224.0.1.40), 00:41:21/stopped, RP 0.0.0.0, flags: DCL
```

```
Incoming interface: Null, RPF nbr 0.0.0.0
```

```
Outgoing interface list:
```

```
Loopback0, Forward/Sparse, 00:41:21/00:00:00
```

```
Serial2/0, Forward/Sparse, 00:41:21/00:00:00
```

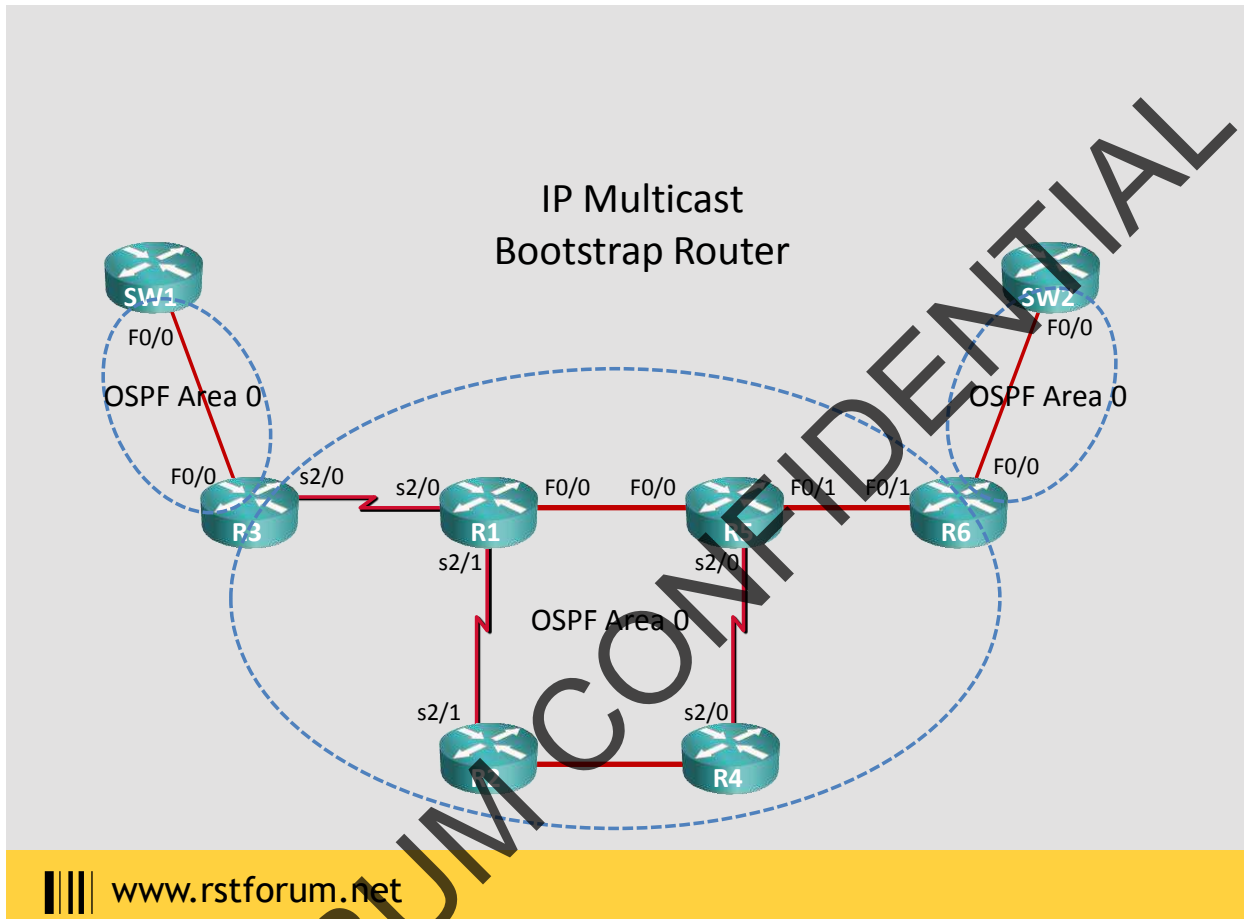
```
(150.1.15.5, 224.0.1.40), 00:40:36/00:02:57, flags: LT
```

```
Incoming interface: Serial2/0, RPF nbr 150.1.13.1
```

```
Outgoing interface list:
```

```
Loopback0, Forward/Sparse, 00:40:36/00:00:00
```

Configure IP Multicast with PIM Sparse and BSR throughout the OSPF domain so that multicast traffic sent from SW1 can be received by SW2. R1 should be RP and R5 should be BSR.



Note: There are two ways to configure the routers to use an RP. 1) To statically define the RP This method has two important administrative problems. If you ever want to change the RP to another router, you have to change it separately in every router, and it lacks the ability to automatically switch to a backup RP in case of failure. 2) The alternative is to configure the network to discover the RP dynamically; there are two ways to accomplish this. One uses a Cisco proprietary method called Auto-RP, and the other called the Bootstrap Router method, which is part of the open PIM-SM standard defined in RFC 4601.

In BSR router there are two important commands that define how it will advertise itself. The first is *ip pim rp-candidate*, which allows the router to advertise itself as a possible RP. If there are several candidate RP routers, the PIM-SM algorithm prefers the one with the highest IP address. Next important command is *ip pim bsr-candidate*, This allows the router to act as BSRs which are responsible for distributing information about all of the known candidate RPs throughout the network

Configuration:

R1:

```
ip multicast-routing
!  
interface Loopback0  
 ip address 150.1.1.1 255.255.255.255  
 ip pim sparse-mode  
!  
interface FastEthernet0/0  
 ip address 150.1.15.1 255.255.255.0  
 ip pim sparse-mode  
!  
interface Serial2/0  
 ip address 150.1.13.1 255.255.255.0  
 ip pim sparse-mode  
!  
interface Serial2/1  
 ip address 150.1.12.1 255.255.255.0  
 ip pim sparse-mode  
!  
router ospf 1  
 network 0.0.0.0 255.255.255.255 area 0  
!  
 ip pim rp-candidate Loopback0
```

R2:

```
ip multicast-routing
!  
interface Loopback0  
 ip address 150.1.2.2 255.255.255.255  
!  
interface FastEthernet0/0  
 ip address 150.1.24.2 255.255.255.0  
 ip pim sparse-mode  
!  
interface Serial2/1  
 ip address 150.1.12.2 255.255.255.0  
 ip pim sparse-mode  
!  
router ospf 1  
 network 0.0.0.0 255.255.255.255 area 0
```

Configuration:

R3:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.3.3 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.37.3 255.255.255.0  
ip pim sparse-mode  
!  
interface Serial2/0  
ip address 150.1.13.3 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```

R4:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.4.4 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 150.1.24.4 255.255.255.0  
ip pim sparse-mode  
!  
interface Serial2/0  
ip address 150.1.45.4 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```

R5:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.5.5 255.255.255.255  
ip pim sparse-mode  
!  
interface FastEthernet0/0  
ip address 150.1.15.5 255.255.255.0  
ip pim sparse-mode  
!
```

Configuration:

```
interface FastEthernet0/1
 ip address 150.1.56.5 255.255.255.0
 ip pim sparse-mode
 !
interface Serial2/0
 ip address 150.1.45.5 255.255.255.0
 ip pim sparse-mode
 !
router ospf 1
 network 0.0.0.0 255.255.255.255 area 0
 !
ip pim bsr-candidate Loopback0
```

```
R6:
 ip multicast-routing
 !
interface Loopback0
 ip address 150.1.6.6 255.255.255.255
 !
interface FastEthernet0/0
 ip address 10.1.68.6 255.255.255.0
 ip pim sparse-mode
 !
interface FastEthernet0/1
 ip address 150.1.56.6 255.255.255.0
 ip pim sparse-mode
 !
router ospf 1
 network 0.0.0.0 255.255.255.255 area 0
```

```
SW1:
 ip multicast-routing
 !
interface Loopback0
 ip address 150.1.7.7 255.255.255.255
 !
interface FastEthernet0/0
 ip address 10.1.37.7 255.255.255.0
 !
router ospf 1
 network 0.0.0.0 255.255.255.255 area 0
```

Configuration:

SW2:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.8.8 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.68.8 255.255.255.0  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```

Verification:

R1 advertises itself to the BSR as an RP Candidate:

```
R5#show ip pim bsr-router
```

PIMv2 Bootstrap information

This system is the Bootstrap Router (BSR)

BSR address: 150.1.5.5 (?)

Uptime: 00:05:12, BSR Priority: 0, Hash mask length: 0

Next bootstrap message in 00:00:48

```
R5#show ip pim rp mapping
```

PIM Group-to-RP Mappings

This system is the Bootstrap Router (v2)

Group(s) 224.0.0.0/4

RP 150.1.1.1 (?), v2

Info source: 150.1.15.1 (?), via bootstrap, priority 0, holdtime 150

Uptime: 00:06:41, expires: 00:01:47

```
R6#show ip pim rp mapping
```

PIM Group-to-RP Mappings

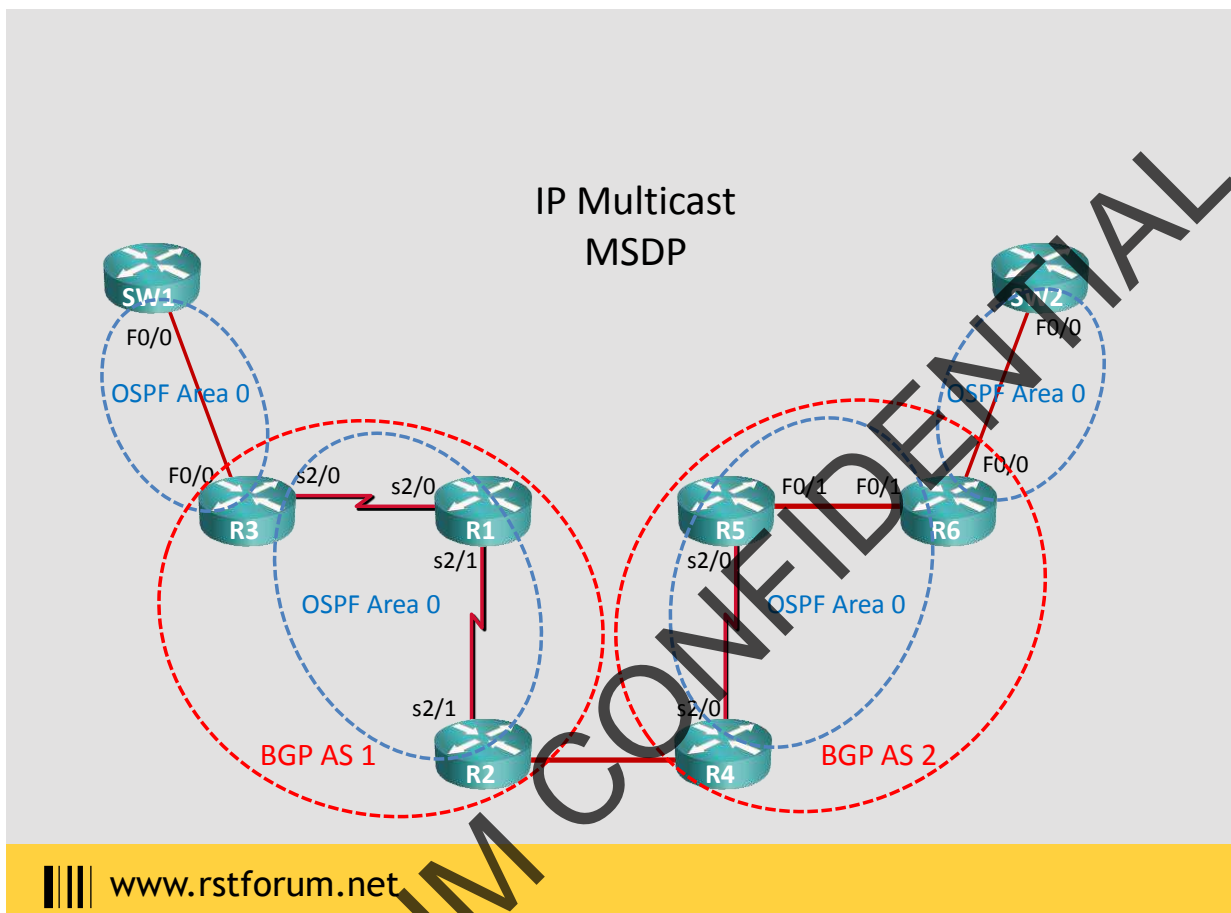
Group(s) 224.0.0.0/4

RP 150.1.1.1 (?), v2

Info source: 150.1.5.5 (?), via bootstrap, priority 0, holdtime 150

Uptime: 00:09:09, expires: 00:01:32

Configure IP Multicast with MSDP between R2 and R4 so that multicast traffic sent from SW1 in AS1 can be received by SW2 in AS2.



Note:

MSDP: Multicast Source Discovery Protocol - MSDP describes a mechanism to connect multiple PIM-SM domains together. Each PIM-SM domain uses its own independent RP(s) and does not have to depend on RPs in other domains. Advantages include:

- No Third-party resource dependencies. PIM-SM domains can rely on their own RPs only.
- Domains with only receivers get data without globally advertising group membership.

MSDP-speaking routers have a MSDP peering relationship with MSDP peers in another domain. Each domain has one or more connections to this virtual topology. The purpose of this topology is to allow domains to discover multicast sources from other domains. If the multicast sources are of interest to a domain which has receivers, the normal source-tree building mechanism in PIM-SM will be used to deliver multicast data over an inter-domain distribution tree.

Configuration:

R1:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.1.1 255.255.255.255  
ip pim sparse-mode  
!  
interface Serial2/0  
ip address 150.1.13.1 255.255.255.0  
ip pim sparse-mode  
!  
interface Serial2/1  
ip address 150.1.12.1 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!  
ip pim rp-address 150.1.24.2
```

R2:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.2.2 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 150.1.24.2 255.255.255.0  
ip pim sparse-mode  
!  
interface Serial2/1  
ip address 150.1.12.2 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!  
router bgp 1  
redistribute ospf 1  
neighbor 150.1.24.4 remote-as 2  
!  
ip pim rp-address 150.1.24.2  
ip msdp peer 150.1.24.4 remote-as 2
```


Configuration:

R3:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.3.3 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.37.3 255.255.255.0  
ip pim sparse-mode  
!  
interface Serial2/0  
ip address 150.1.13.3 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!  
!  
ip pim rp-address 150.1.24.2
```

R4:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.4.4 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 150.1.24.4 255.255.255.0  
ip pim sparse-mode  
!  
interface Serial2/0  
ip address 150.1.45.4 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!  
router bgp 2  
redistribute ospf 1  
neighbor 150.1.24.2 remote-as 1  
!  
ip pim rp-address 150.1.24.4  
ip msdp peer 150.1.24.2
```

Configuration:

R5:

```
ip multicast-routing
!
interface Loopback0
 ip address 150.1.5.5 255.255.255.255
Ip pim sparse-mode
!
interface FastEthernet0/1
 ip address 150.1.56.5 255.255.255.0
ip pim sparse-mode
!
interface Serial2/0
 ip address 150.1.45.5 255.255.255.0
 ip pim sparse-mode
!
router ospf 1
 network 0.0.0.0 255.255.255.255 area 0
!
ip pim rp-address 150.1.24.4
```

R6:

```
ip multicast-routing
!
interface Loopback0
 ip address 150.1.6.6 255.255.255.255
!
interface FastEthernet0/0
 ip address 10.1.68.6 255.255.255.0
 ip pim sparse-mode
!
interface FastEthernet0/1
 ip address 150.1.56.6 255.255.255.0
 ip pim sparse-mode
!
router ospf 1
 network 0.0.0.0 255.255.255.255 area 0
!
ip pim rp-address 150.1.24.4
```

Configuration:

SW1:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.7.7 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.37.7 255.255.255.0  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```

SW2:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.8.8 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.68.8 255.255.255.0  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```

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Verification:

Enable multicast debugging on R2 and R4:

```
R2#debug ip pim
PIM debugging is on
```

```
R2#debug ip msdp peer
MSDP Peer debugging is on
```

```
R2#debug ip msdp routes
MSDP Routes debugging is on
```

```
R2#debug ip msdp detail
MSDP Detail debugging is on
```

```
R4#debug ip pim
PIM debugging is on
```

```
R4#debug ip msdp peer
MSDP Peer debugging is on
```

```
R4#debug ip msdp routes
MSDP Routes debugging is on
```

```
R4#debug ip msdp detail
MSDP Detail debugging is on
```

Generate multicast traffic from SW1:

```
SW1(config)#rtr 1
SW1(config-rtr)#type udpEcho dest-ipaddr 224.1.1.1 dest-port 12345 source-ipaddr
10.1.37.7 control disable
SW1(config-rtr-udp)#frequency 5
SW1(config-rtr-udp)#timeout 0
SW1(config-rtr-udp)#exit
SW1(config)#rtr schedule 1 start after 00:00:05 life forever
```

R3 registers source with R2 and R2 generates MSDP SA message to R4:

```
R2#
00:31:27: PIM(0): Received v2 Register on Serial2/1 from 150.1.13.3
00:31:27:   for 10.1.37.7, group 224.1.1.1
00:31:27: PIM(0): Check RP 150.1.24.2 into the (*, 224.1.1.1) entry

00:31:27: MSDP(0): 150.1.24.4: Send 52-byte SA encapsulated data for (10.1.37.7,
224.1.1.1), RP 150.1.24.2
00:31:27: PIM(0): Send v2 Register-Stop to 150.1.13.3 for 10.1.37.7, group 224.1.1.1
```

Verification:

```
R2#show ip mroute  
<output omitted>
```

```
(10.1.37.7, 224.1.1.1), 00:04:34/00:02:26, flags: PA  
Incoming interface: Serial2/1, RPF nbr 150.1.12.1  
Outgoing interface list: Null
```

R4 receives SA message from R2:

```
R4#  
00:38:54: MSDP(0): Received 20-byte TCP segment from 150.1.24.2  
00:38:54: MSDP(0): Append 20 bytes to 0-byte msg 42 from 150.1.24.2, qs 1  
00:38:54: MSDP(0): 150.1.24.2: Received 20-byte msg 42 from peer  
00:38:54: MSDP(0): 150.1.24.2: SA TLV, len: 20, ec: 1, RP: 150.1.24.2  
00:38:54: MSDP(0): 150.1.24.2: Peer RPF check passed for single peer  
00:38:54: MSDP(0): (10.1.37.7/32, 224.1.1.1), accepted
```

R4 does not have mroute entry for group 224.1.1.1

```
R4#show ip mroute  
(* , 224.0.1.40), 00:40:04/00:02:51, RP 150.1.24.4, flags: SJCL  
Incoming interface: Null, RPF nbr 0.0.0.0  
Outgoing interface list:  
Serial2/0, Forward/Sparse, 00:39:33/00:03:20  
FastEthernet0/0, Forward/Sparse, 00:39:58/00:02:51
```

Configure SW2 to receive traffic for the multicast group:

```
SW2(config)#int fa0/0  
SW2(config-if)#ip igmp join-group 224.1.1.1
```

R4 receives PIM Join from R5 for 224.1.1.1 and builds the RPF tree

```
R4#  
00:42:38: PIM(0): Received v2 Join/Prune on Serial2/0 from 150.1.45.5, to us  
00:42:38: PIM(0): Join-list: (*, 224.1.1.1), RPT-bit set, WC-bit set, S-bit set  
00:42:38: PIM(0): Check RP 150.1.24.4 into the (*, 224.1.1.1) entry  
00:42:38: PIM(0): Add Serial2/0/150.1.45.5 to (*, 224.1.1.1), Forward state, by PIM *G  
Join  
00:42:38: PIM(0): Insert (10.1.37.7,224.1.1.1) join in nbr 150.1.24.2's queue  
00:42:38: PIM(0): Update Serial2/0/150.1.45.5 to (10.1.37.7, 224.1.1.1), Forward state,  
by PIM *G Join  
00:42:38: PIM(0): Building Join/Prune packet for nbr 150.1.24.2  
00:42:38: PIM(0): Adding v2 (10.1.37.7/32, 224.1.1.1), S-bit Join  
00:42:38: PIM(0): Send v2 join/prune to 150.1.24.2 (FastEthernet0/0)  
00:42:42: PIM(0): Received v2 Join/Prune on Serial2/0 from 150.1.45.5, to us  
00:42:42: PIM(0): Join-list: (10.1.37.7/32, 224.1.1.1), S-bit set  
00:42:42: PIM(0): Update Serial2/0/150.1.45.5 to (10.1.37.7, 224.1.1.1), Forward state,  
by PIM SG Join
```

Verification:

R4 Builds mroute entry for group 224.1.1.1

R4#show ip mroute

<output omitted>

(* , 224.1.1.1), 00:06:37/00:02:45, RP 150.1.24.4, flags: S

Incoming interface: Null, RPF nbr 0.0.0.0

Outgoing interface list:

Serial2/0, Forward/Sparse, 00:06:37/00:02:45

(10.1.37.7, 224.1.1.1), 00:06:37/00:03:29, flags: MT

Incoming interface: FastEthernet0/0, RPF nbr 150.1.24.2

Outgoing interface list:

Serial2/0, Forward/Sparse, 00:06:37/00:02:45

R6 forwards multicast feed to SW2:

R6(config)#int F0/0

R6(config-if)#no ip mroute-cache

R6#debug ip mpacket

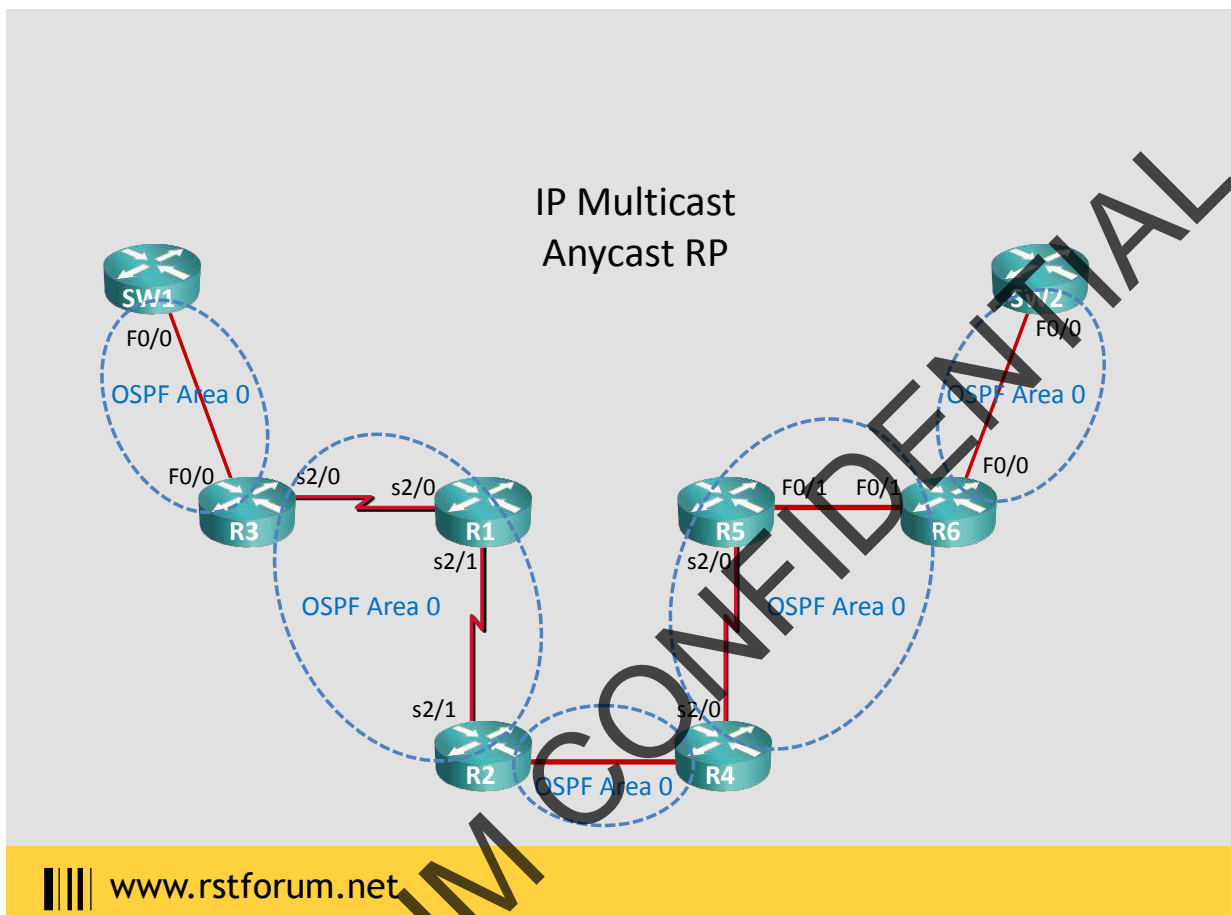
IP multicast packets debugging is on

02:27:27: IP(0): s=10.1.37.7 (FastEthernet0/1) d=224.1.1.1 (FastEthernet0/0) len 44,

mforward

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Configure R1 and R5 with the duplicate addresses 150.1.255.255/32 for Anycast RP within the PIM Sparse-Mode domain.



Note: Anycast RP is an application of MSDP. Originally developed for interdomain multicast applications, MSDP used for Anycast RP is an intradomain feature that provides redundancy and load-sharing capabilities. Typically Anycast RP is used for configuring a PIM-SM network to meet fault tolerance requirements within a single multicast domain.

In Anycast RP, two or more RPs are configured with the same IP address on loopback interfaces. The Anycast RP loopback address should be configured with a 32-bit mask. All routers should be configured to “know” that the Anycast RP loopback address is the IP address of their local RP. IP routing will automatically select the topologically closest RP for each source and receiver.

Because a source may register with one RP and receivers may join to a different RP, a method is needed for the RPs to exchange information about active sources. This information exchange is done with MSDP. In Anycast RP, all the RPs are configured to be MSDP peers of each other. When a source registers with one RP, an SA message will be sent to the other RPs informing them that there is an active source for a particular group. The result is that each RP will know about the active sources in the area of the other RPs. If any of the RPs were to fail, IP routing would converge and one of the RPs would become the active RP in more than one area. New sources would register with the backup RP. Receivers would join toward the new RP and connectivity would be maintained.

Configuration:

R1:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.1.1 255.255.255.255  
ip pim sparse-mode  
!  
interface Loopback1  
ip address 150.1.255.255 255.255.255.255  
!  
interface Serial2/0  
ip address 150.1.13.1 255.255.255.0  
ip pim sparse-mode  
!  
interface Serial2/1  
ip address 150.1.12.1 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!  
ip pim rp-address 150.1.255.255  
ip msdp peer 150.1.5.5 connect-source Loopback0
```

R2:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.2.2 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 150.1.24.2 255.255.255.0  
ip pim sparse-mode  
!  
interface Serial2/1  
ip address 150.1.12.2 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!  
ip pim rp-address 150.1.255.255
```


Configuration:

R3:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.3.3 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.37.3 255.255.255.0  
ip pim sparse-mode  
!  
interface Serial2/0  
ip address 150.1.13.3 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!  
ip pim rp-address 150.1.255.255
```

R4:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.4.4 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 150.1.24.4 255.255.255.0  
ip pim sparse-mode  
!  
interface Serial2/0  
ip address 150.1.45.4 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!  
ip pim rp-address 150.1.255.255
```

Configuration:

R5:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.5.5 255.255.255.255  
Ip pim sparse-mode  
!  
interface Loopback1  
ip address 150.1.255.255 255.255.255.255  
!  
interface FastEthernet0/1  
ip address 150.1.56.5 255.255.255.0  
ip pim sparse-mode  
!  
interface Serial2/0  
ip address 150.1.45.5 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!  
ip pim rp-address 150.1.255.255  
ip msdp peer 150.1.1.1 connect-source loopback0
```

R6:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.6.6 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.68.6 255.255.255.0  
ip pim sparse-mode  
!  
interface FastEthernet0/1  
ip address 150.1.56.6 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!  
ip pim rp-address 150.1.255.255
```

Configuration:

SW1:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.7.7 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.37.7 255.255.255.0  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```

SW2:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.8.8 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 10.1.68.8 255.255.255.0  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0
```

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Verification:

Enable multicast debugging on R1 and R5:

```
R1#debug ip pim
PIM debugging is on
```

```
R1#debug ip msdp peer
MSDP Peer debugging is on
```

```
R1#debug ip msdp routes
MSDP Routes debugging is on
```

```
R1#debug ip msdp detail
MSDP Detail debugging is on
```

```
R5#debug ip pim
PIM debugging is on
```

```
R5#debug ip msdp peer
MSDP Peer debugging is on
```

```
R5#debug ip msdp routes
MSDP Routes debugging is on
```

```
R5#debug ip msdp detail
MSDP Detail debugging is on
```

Generate multicast traffic from SW1:

```
SW1(config)#rtr 1
SW1(config-rtr)#type udpEcho dest-ipaddr 224.1.1.1 dest-port 12345 source-ipaddr
10.1.37.7 control disable
SW1(config-rtr-udp)#frequency 5
SW1(config-rtr-udp)#timeout 0
SW1(config-rtr-udp)#exit
SW1(config)#rtr schedule 1 start after 00:00:05 life forever
```

R3 registers source with R1 and R1 generates MSDP SA message to R5:

```
R1#
00:30:23: PIM(0): Received v2 Register on Serial2/0 from 150.1.13.3
00:30:23:   for 10.1.37.7, group 224.1.1.1
00:30:23: PIM(0): Check RP 150.1.255.255 into the (*, 224.1.1.1) entry
00:30:23: MSDP(0): 150.1.5.5: Send 52-byte SA encapsulated data for (10.1.37.7,
224.1.1.1), RP 150.1.255.255
```

Verification:

R5 receives SA message from R1:

```
R5#
00:42:39: MSDP(0): Received 20-byte TCP segment from 150.1.1.1
00:42:39: MSDP(0): Append 20 bytes to 0-byte msg 31 from 150.1.1.1, qs 1
00:42:39: MSDP(0): 150.1.1.1: Received 20-byte msg 31 from peer
00:42:39: MSDP(0): 150.1.1.1: SA TLV, len: 20, ec: 1, RP: 150.1.255.255
00:42:39: MSDP(0): 150.1.1.1: Peer RPF check passed for single peer
00:42:39: MSDP(0): (10.1.37.7/32, 224.1.1.1), accepted
```

Configure SW2 to receive traffic for the multicast group:

```
SW2#conf t
Enter configuration commands, one per line. End with CNTL/Z.
SW2(config)#int fa0/0
SW2(config-if)#ip igmp join-group 224.1.1.1
```

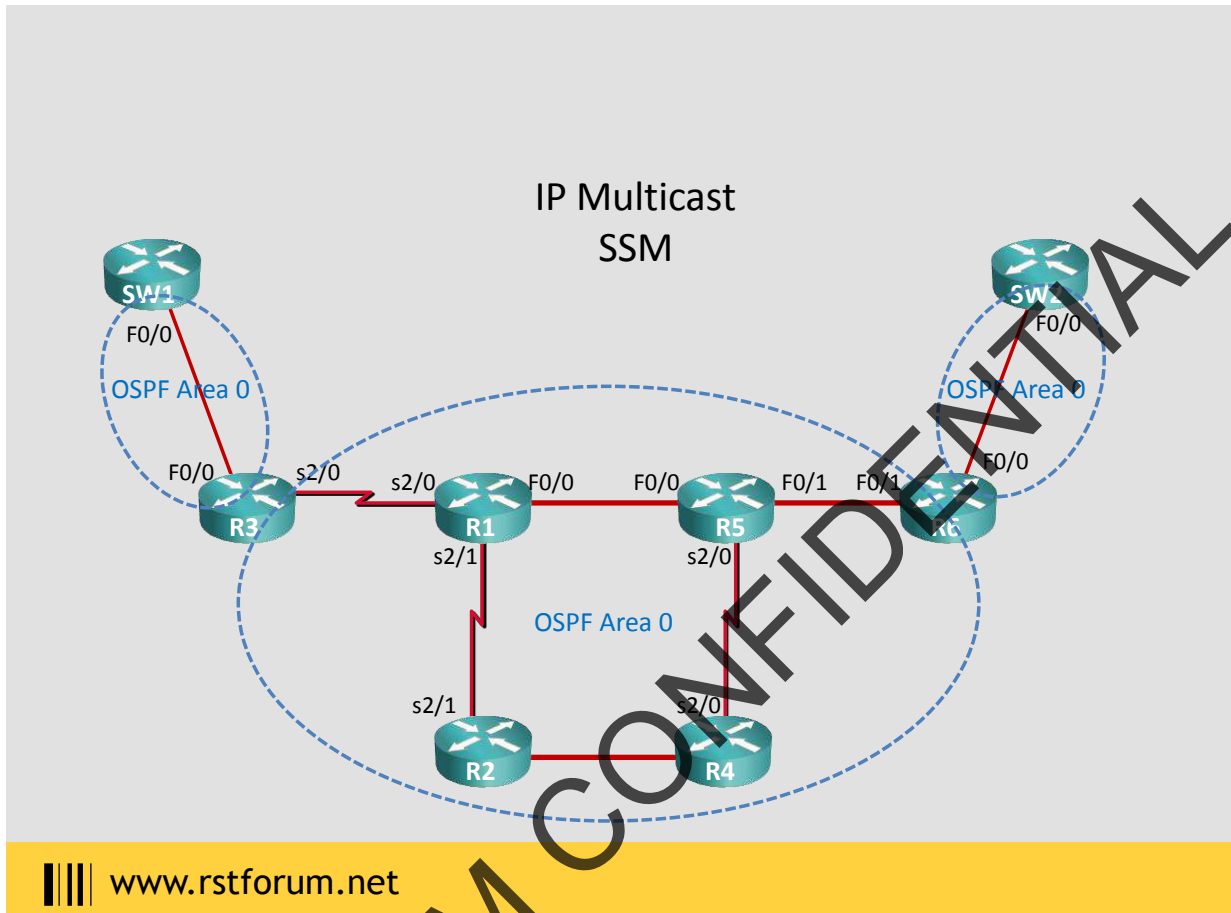
R5 receives PIM Join from R6 for 224.1.1.1 and builds the RPF tree

```
R5#
00:47:30: PIM(0): Received v2 Join/Prune on FastEthernet0/1 from 150.1.56.6, to us
00:47:30: PIM(0): Join-list: (*, 224.1.1.1), RPF-bit set, WC-bit set, S-bit set
00:47:30: PIM(0): Update FastEthernet0/1/150.1.56.6 to (*, 224.1.1.1), Forward state,
by PIM *G Join
00:47:30: PIM(0): Update FastEthernet0/1/150.1.56.6 to (10.1.37.7, 224.1.1.1), Forward
state, by PIM *G Join
00:47:30: PIM(0): Join-list: (10.1.37.7/32, 224.1.1.1), S-bit set
00:47:30: PIM(0): Update FastEthernet0/1/150.1.56.6 to (10.1.37.7, 224.1.1.1), Forward
state, by PIM SG Join
```

R6 forwards multicast feed to SW2:

```
R6(config)#int F0/0
R6(config-if)#no ip mroute-cache
R6#debug ip mpacket
IP multicast packets debugging is on
00:53:14: IP(0): s=10.1.37.7 (FastEthernet0/1) d=224.1.1.1 (FastEthernet0/0) len 44,
mforward
```

Configure Source Specific Multicast within the PIM Sparse-Mode domain.



Note: Traditional multicast forwarding is performed using multicast group addresses. A group address is a single IP address taken from a reserved range (224.0.0.0/4 for IPv4, FF00::/8 for IPv6) to uniquely identify a group of hosts desiring to receive certain traffic. Any host within the multicast domain can be a source for a group, sending traffic to the group's IP address. Each multicast packet sent by the source is replicated by the network infrastructure so that each host belonging to the multicast group receives a copy. Because any host can act a source, this multicast implementation is deemed Any Source Multicast (ASM).

Source-Specific Multicast (SSM), defined in RFC 4607, extends this concept to identify a set of multicast hosts not only by group address but also by source. An SSM group, called a channel, is identified as (S,G) where S is the source address and G is the group address. This is in contrast to the definition of an ASM multicast route written as (*,G). IANA has reserved for SSM the IPv4 address range 232.0.0.0/8 and the IPv6 range FF3x::/32.

Note: SSM brings several important benefits over ASM. Because an SSM channel is defined by both a source and a group address, group addresses can be re-used by multiple sources while keeping channels unique. For instance, the SSM channel (192.168.45.7, 232.7.8.9) is different than (192.168.3.104, 232.7.8.9), and hosts subscribed to one will not receive traffic from the other. This allows for greater flexibility in choosing a multicast group while also protecting against denial of service attacks; hosts will only receive traffic from explicitly requested sources.

One of the biggest advantages SSM holds over ASM is that it does not rely on the designation of a rendezvous point (RP) to establish a multicast tree. Because the source of an SSM channel is always known in advance, multicast trees are efficiently built from channel hosts toward the source (based on the unicast routing topology) without the need for an RP to join a source and shared multicast tree. The corollary of this, which may be undesirable in some multicast implementations, is that the multicast source(s) must be learned in advance via some external method (e.g. manual configuration).

SSM can be implemented using a subset of Protocol Independent Multicast (PIM) derived from PIM sparse mode (PIM-SM), dubbed PIM-SSM.

SSM works with IGMP version 3. There are no shared tree and there are no need for RP for SSM.

Multicast client subscribes to group (S,G) instead of (*,G).

PIM-SSM Configuration

Once you have PIM-SM running, PIM-SSM is trivial to enable. This is done by specifying a range of addresses for which PIM-SSM will be used. Generally, you will want to enable PIM-SSM for its default group range (232.0.0.0/8).

IP version 4 (IPv4) addresses in the 232/8 (232.0.0.0 to 232.255.255.255) range are designated as source-specific multicast (SSM) destination addresses and are reserved for use by source-specific applications and protocols. For IP version 6 (IPv6), the address prefix FF3x::/32 is reserved for source-specific multicast use.

A router that receives an IP datagram with a source-specific destination address MUST silently drop it unless a neighboring host or router has communicated a desire to receive packets sent from the source and to the destination address of the received packet.

Task: 1) Configure SW2 such that it will accept multicast feed from SW1 for group 232.1.1.1 only if it is sourced from SW1's loopback0.

2) Configure R6 such that it will accept multicast feed from R3 for group 232.1.1.1 only if it is sourced from R3's loopback0.

Configuration:

R1:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.1.1 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 150.1.15.1 255.255.255.0  
ip pim sparse-mode  
!  
interface Serial2/0  
ip address 150.1.13.1 255.255.255.0  
ip pim sparse-mode  
!  
interface Serial2/1  
ip address 150.1.12.1 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!  
ip pim rp-address 150.1.2.2  
ip pim ssm range 1  
!  
access-list 1 permit 232.0.0.0 0.255.255.255
```

R2:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.2.2 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 150.1.24.2 255.255.255.0  
ip pim sparse-mode  
!  
interface Serial2/1  
ip address 150.1.12.2 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!  
ip pim rp-address 150.1.2.2  
ip pim ssm range 1  
!  
access-list 1 permit 232.0.0.0 0.255.255.255
```


Configuration:

R3:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.3.3 255.255.255.255  
ip pim sparse-mode  
!  
interface FastEthernet0/0  
ip address 10.1.37.3 255.255.255.0  
ip pim sparse-mode  
!  
interface Serial2/0  
ip address 150.1.13.3 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!  
ip pim rp-address 150.1.2.2  
ip pim ssm range 1  
!  
access-list 1 permit 232.0.0.0 0.255.255.255
```

R4:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.4.4 255.255.255.255  
!  
interface FastEthernet0/0  
ip address 150.1.24.4 255.255.255.0  
ip pim sparse-mode  
!  
interface Serial2/0  
ip address 150.1.45.4 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!  
ip pim rp-address 150.1.2.2  
ip pim ssm range 1  
!  
access-list 1 permit 232.0.0.0 0.255.255.255
```

Configuration:

R5:

```
ip multicast-routing
!  
interface Loopback0  
 ip address 150.1.5.5 255.255.255.255  
!  
interface FastEthernet0/0  
 ip address 150.1.15.5 255.255.255.0  
 ip pim sparse-mode  
!  
interface FastEthernet0/1  
 ip address 150.1.56.5 255.255.255.0  
 ip pim sparse-mode  
!  
interface Serial2/0  
 ip address 150.1.45.5 255.255.255.0  
 ip pim sparse-mode  
!  
router ospf 1  
 network 0.0.0.0 255.255.255.255 area 0  
!  
ip pim rp-address 150.1.2.2  
ip pim ssm range 1  
!  
access-list 1 permit 232.0.0.0 0.255.255.255
```

R6:

```
ip multicast-routing
!  
interface Loopback0  
 ip address 150.1.6.6 255.255.255.255  
 ip pim sparse-mode  
!  
interface FastEthernet0/0  
 ip address 10.1.68.6 255.255.255.0  
 ip pim sparse-mode  
!  
interface FastEthernet0/1  
 ip address 150.1.56.6 255.255.255.0  
 ip pim sparse-mode  
!  
router ospf 1  
 network 0.0.0.0 255.255.255.255 area 0  
!  
ip pim rp-address 150.1.2.2  
ip pim ssm range 1  
!  
access-list 1 permit 232.0.0.0 0.255.255.255
```

Configuration:

SW1:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.7.7 255.255.255.255  
ip pim sparse-mode  
!  
interface FastEthernet0/0  
ip address 10.1.37.7 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!  
ip pim rp-address 150.1.2.2  
ip pim ssm range 1  
!  
access-list 1 permit 232.0.0.0 0.255.255.255
```

SW2:

```
ip multicast-routing
!  
interface Loopback0  
ip address 150.1.8.8 255.255.255.255  
ip pim sparse-mode  
!  
interface FastEthernet0/0  
ip address 10.1.68.8 255.255.255.0  
ip pim sparse-mode  
!  
router ospf 1  
network 0.0.0.0 255.255.255.255 area 0  
!  
ip pim rp-address 150.1.2.2  
ip pim ssm range 1  
!  
access-list 1 permit 232.0.0.0 0.255.255.255
```

Verification:

Generate multicast traffic for group 232.1.1.1 from SW1's loopback interface 150.1.7.7:

```
SW1(config)#rtr 1
SW1(config-rtr)#type udpEcho dest-ipaddr 232.1.1.1 dest-port 12345 source-ipaddr
150.1.7.7 control disable
SW1(config-rtr-udp)#frequency 5
SW1(config-rtr-udp)#timeout 0
SW1(config-rtr-udp)#exit
SW1(config)#rtr schedule 1 start after 00:00:05 life forever
```

Generate multicast traffic for group 232.1.1.1 from R3's loopback interface 150.1.3.3:

```
R3(config)#rtr 1
R3(config-rtr)#type udpEcho dest-ipaddr 232.1.1.1 dest-port 12345 source-ipaddr
150.1.5.5 control disable
R3(config-rtr-udp)#frequency 5
R3(config-rtr-udp)#timeout 0
R3(config-rtr-udp)#exit
R3(config)#rtr schedule 1 start after 00:00:05 life forever
```

Enable multicast debugging on SW1, R3 and R5:

```
#debug ip pim
PIM debugging is on
```

SW1:

Multicast feed for group 232.1.1.1 on Sw1 does not register with RP as this feed is for SSM range (232.0.0.0-255.255.255)

Note: There is no register message for group 232.1.1.1 sent to RP (150.1.2.2)

```
00:55:38: PIM(0): Received RP-Reachable on FastEthernet0/0 from 150.1.2.2
00:55:38: PIM(0): Received RP-Reachable on FastEthernet0/0 from 150.1.2.2
00:55:38:   for group 224.0.1.40
00:56:05: PIM(0): Building Periodic (*,G) Join / (S,G,RP-bit) Prune message for
224.0.1.40
00:56:05: PIM(0): Insert (*,224.0.1.40) join in nbr 10.1.37.3's queue
00:56:05: PIM(0): Building Join/Prune packet for nbr 10.1.37.3
00:56:05: PIM(0): Adding v2 (150.1.2.2/32, 224.0.1.40), WC-bit, RPT-bit, S-bit Join
00:56:05: PIM(0): Send v2 join/prune to 10.1.37.3 (FastEthernet0/0)
```

R3:

Multicast feed for group 232.1.1.1 on R3 does not register with RP as this feed is for SSM range (232.0.0.0 0.255.255.255)

Note: There is no register message for group 232.1.1.1 sent to RP (150.1.2.2)

01:28:48: PIM(0): Received v2 Join/Prune on FastEthernet0/0 from 10.1.37.7, to us
01:28:48: PIM(0): Join-list: (*, 224.0.1.40), RPT-bit set, WC-bit set, S-bit set
01:28:48: PIM(0): Update FastEthernet0/0/10.1.37.7 to (*, 224.0.1.40), Forward state, by PIM *G Join
01:28:50: PIM(0): Building Periodic (*,G) Join / (S,G,RP-bit) Prune message for 224.0.1.40
01:28:50: PIM(0): Insert (*,224.0.1.40) join in nbr 150.1.13.1's queue
01:28:50: PIM(0): Building Join/Prune packet for nbr 150.1.13.1
01:28:50: PIM(0): Adding v2 (150.1.2.2/32, 224.0.1.40), WC-bit, RPT-bit, S-bit Join
01:28:50: PIM(0): Send v2 join/prune to 150.1.13.1 (Serial2/0)
01:28:51: PIM(0): Received RP-Reachable on Serial2/0 from 150.1.2.2
01:28:51: PIM(0): Received RP-Reachable on Serial2/0 from 150.1.2.2
01:28:51: for group 224.0.1.40
01:28:51: PIM(0): Forward RP-reachability for 224.0.1.40 on FastEthernet0/0

R2:

Note: There is no register message for group 232.1.1.1 received on RP (150.1.2.2)

01:27:01: PIM(0): Send RP-reachability for 224.0.1.40 on FastEthernet0/0
01:27:01: PIM(0): Send RP-reachability for 224.0.1.40 on Serial2/1
01:27:19: PIM(0): Received v2 Join/Prune on Serial2/1 from 150.1.12.1, to us
01:27:19: PIM(0): Join-list: (*, 224.0.1.40), RPT-bit set, WC-bit set, S-bit set
01:27:19: PIM(0): Update Serial2/1/150.1.12.1 to (*, 224.0.1.40), Forward state, by PIM *G Join
01:27:26: PIM(0): Received v2 Join/Prune on FastEthernet0/0 from 150.1.24.4, to us
01:27:26: PIM(0): Join-list: (*, 224.0.1.40), RPT-bit set, WC-bit set, S-bit set
01:27:26: PIM(0): Update FastEthernet0/0/150.1.24.4 to (*, 224.0.1.40), Forward state, by PIM *G Join
01:27:34: PIM(0): Building Periodic (*,G) Join / (S,G,RP-bit) Prune message for 224.0.1.40
01:28:18: PIM(0): Received v2 Join/Prune on Serial2/1 from 150.1.12.1, to us
01:28:18: PIM(0): Join-list: (*, 224.0.1.40), RPT-bit set, WC-bit set, S-bit set
01:28:18: PIM(0): Update Serial2/1/150.1.12.1 to (*, 224.0.1.40), Forward state, by PIM *G Join
01:28:26: PIM(0): Received v2 Join/Prune on FastEthernet0/0 from 150.1.24.4, to us
01:28:26: PIM(0): Join-list: (*, 224.0.1.40), RPT-bit set, WC-bit set, S-bit set
01:28:26: PIM(0): Update FastEthernet0/0/150.1.24.4 to (*, 224.0.1.40), Forward state, by PIM *G Join

R2:

Note: There is no entry for group 232.1.1.1 as the SSM range does not register with RP.

R2#Show ip mroute

IP Multicast Routing Table

(*, 224.0.1.40), 00:00:02/00:02:57, RP 150.1.2.2, flags: SPL

Incoming interface: Null, RPF nbr 0.0.0.0

Outgoing interface list: Null

Configure R6 to receive traffic for the multicast group 232.1.1.1 from source 150.1.3.3:

R6#conf t

Enter configuration commands, one per line. End with CNTL/Z.

R6(config)#int Loopback0

R6(config-if)#ip igmp join-group 232.1.1.1 source 150.1.3.3

R3 receives PIM Join from R6 for 232.1.1.1 and builds the RPF tree

03:00:25: PIM(0): Received v2 Join/Prune on Serial2/0 from 150.1.13.1, to us

03:00:25: PIM(0): Join-list: (150.1.3.3/32, 232.1.1.1), S-bit set

03:00:25: PIM(0): Update Serial2/0/150.1.13.1 to (150.1.3.3, 232.1.1.1), Forward state, by PIM SG Join

mroute is created from R3 - R1 - R5 - R6

R6#sho ip mroute

IP Multicast Routing Table

(150.1.3.3, 232.1.1.1), 00:14:52/00:02:58, flags: sLTI

Incoming interface: FastEthernet0/1, RPF nbr 150.1.56.5

Outgoing interface list:

Loopback0, Forward/Sparse, 00:08:28/00:02:07

(*, 224.0.1.40), 00:36:01/00:02:16, RP 150.1.2.2, flags: SJCL

Incoming interface: FastEthernet0/1, RPF nbr 150.1.56.5

Outgoing interface list:

FastEthernet0/0, Forward/Sparse, 00:35:11/00:02:45

R1#show ip mroute

IP Multicast Routing Table

(150.1.3.3, 232.1.1.1), 00:16:49/00:03:27, flags: sT
Incoming interface: Serial2/0, RPF nbr 150.1.13.3
Outgoing interface list:
FastEthernet0/0, Forward/Sparse, 00:10:26/00:03:27

R5#show ip mroute

IP Multicast Routing Table

(150.1.3.3, 232.1.1.1), 00:18:58/00:03:29, flags: sT
Incoming interface: FastEthernet0/0, RPF nbr 150.1.15.1
Outgoing interface list:
FastEthernet0/1, Forward/Sparse, 00:12:34/00:03:19

R6#show ip mroute

IP Multicast Routing Table

(150.1.3.3, 232.1.1.1), 00:14:52/00:02:58, flags: sLTl
Incoming interface: FastEthernet0/1, RPF nbr 150.1.56.5
Outgoing interface list:
Loopback0, Forward/Sparse, 00:08:28/00:02:07

(* , 224.0.1.40), 00:36:01/00:02:16, RP 150.1.2.2, flags: SJCL
Incoming interface: FastEthernet0/1, RPF nbr 150.1.56.5
Outgoing interface list:
FastEthernet0/0, Forward/Sparse, 00:35:11/00:02:45

R2: RP

Note: There is no entry for group 232.1.1.1 as the SSM range does not register with RP.

R2#Show ip mroute

IP Multicast Routing Table

(* , 224.0.1.40), 00:00:02/00:02:57, RP 150.1.2.2, flags: SPL
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list: Null

Request for multicast feed from SW2 for 232.1.1.1 group from new source 150.1.7.7

Configure SW2 to receive traffic for the multicast group 232.1.1.1 from source 150.1.7.7:

```
SW2#conf t
Enter configuration commands, one per line. End with CNTL/Z.
SW2(config)#int Loopback0
SW2(config-if)#ip igmp join-group 232.1.1.1 source 150.1.7.7
```

SW1 receives PIM Join from SW1 for 232.1.1.1 and builds the RPF tree

```
03:33:53: PIM(0): Received v2 Join/Prune on FastEthernet0/0 from 10.1.37.3, to us
03:33:53: PIM(0): Join-list: (150.1.7.7/32, 232.1.1.1), S-bit set
03:33:53: PIM(0): Update FastEthernet0/0/10.1.37.3 to (150.1.7.7, 232.1.1.1), Forward
state, by PIM SG Join
```

mroute is created from SW1-R3 – R1 - R5 -R6 – SW2

SW2#sho ip mroute

IP Multicast Routing Table

```
(150.1.7.7, 232.1.1.1), 00:15:14/00:02:58, flags: sLTI
Incoming interface: FastEthernet0/0, RPF nbr 10.1.68.6
Outgoing interface list:
Loopback0, Forward/Sparse, 00:15:14/00:02:32
```

```
(*, 224.0.1.40), 03:21:58/00:02:16, RP 150.1.2.2, flags: SJCL
Incoming interface: FastEthernet0/0, RPF nbr 10.1.68.6
Outgoing interface list:
Loopback0, Forward/Sparse, 03:21:58/00:01:46
```

R3#show ip mroute

IP Multicast Routing Table

```
(150.1.3.3, 232.1.1.1), 00:30:49/00:03:25, flags: sT
Incoming interface: Loopback0, RPF nbr 0.0.0.0
Outgoing interface list:
Serial2/0, Forward/Sparse, 00:30:22/00:02:47
```

```
(150.1.7.7, 232.1.1.1), 00:09:30/00:03:22, flags: sT
```

```
Incoming interface: FastEthernet0/0, RPF nbr 10.1.37.7
Outgoing interface list:
Serial2/0, Forward/Sparse, 00:09:30/00:02:53
```


R1#show ip mroute

IP Multicast Routing Table

(150.1.3.3, 232.1.1.1), 00:50:35/00:03:29, flags: sT

Incoming interface: Serial2/0, RPF nbr 150.1.13.3

Outgoing interface list:

FastEthernet0/0, Forward/Sparse, 00:44:12/00:03:14

(150.1.7.7, 232.1.1.1), 00:12:52/00:03:29, flags: sT

Incoming interface: Serial2/0, RPF nbr 150.1.13.3

Outgoing interface list:

FastEthernet0/0, Forward/Sparse, 00:12:52/00:03:26

R5#show ip mroute

IP Multicast Routing Table

(150.1.3.3, 232.1.1.1), 00:51:34/00:03:25, flags: sT

Incoming interface: FastEthernet0/0, RPF nbr 150.1.15.1

Outgoing interface list:

FastEthernet0/1, Forward/Sparse, 00:45:10/00:03:18

(150.1.7.7, 232.1.1.1), 00:13:50/00:03:27, flags: sT

Incoming interface: FastEthernet0/0, RPF nbr 150.1.15.1

Outgoing interface list:

FastEthernet0/1, Forward/Sparse, 00:13:50/00:03:27

R6#show ip mroute

IP Multicast Routing Table

(150.1.3.3, 232.1.1.1), 00:52:11/00:02:58, flags: sLTI

Incoming interface: FastEthernet0/1, RPF nbr 150.1.56.5

Outgoing interface list:

Loopback0, Forward/Sparse, 00:45:47/00:02:57

(150.1.7.7, 232.1.1.1), 00:14:28/00:03:22, flags: sT

Incoming interface: FastEthernet0/1, RPF nbr 150.1.56.5

Outgoing interface list:

FastEthernet0/0, Forward/Sparse, 00:14:28/00:02:52

Note: There is no entry for group 232.1.1.1 as the SSM range does not register with RP.

R2#Show ip mroute

IP Multicast Routing Table

(* , 224.0.1.40), 00:00:02/00:02:57, RP 150.1.2.2, flags: SPL

Incoming interface: Null, RPF nbr 0.0.0.0

Outgoing interface list: Null