

Chapter 2

IP Multicasting

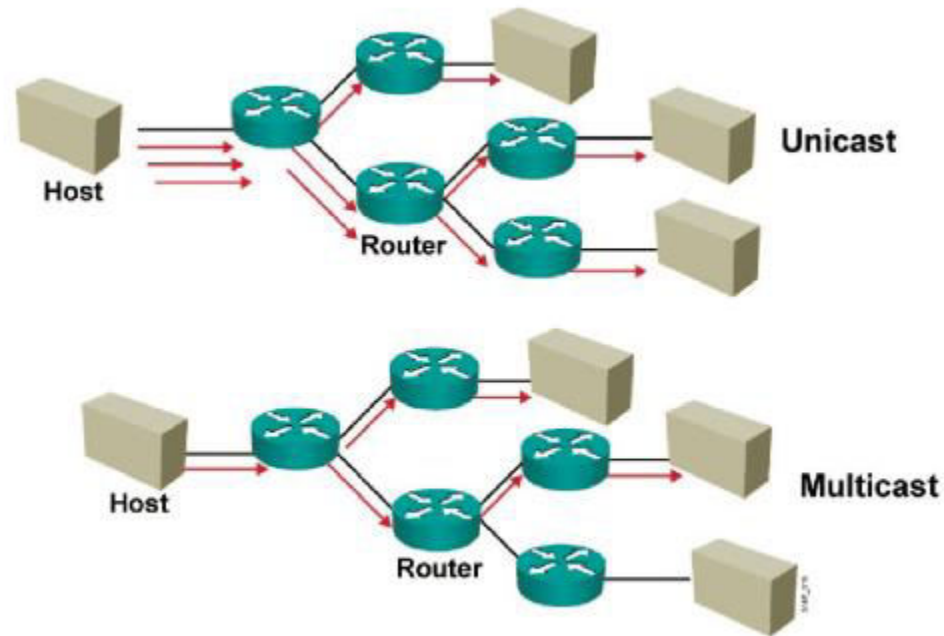
Multicasting

- Multicasting Introduction
- How multicasting works
- Multicast IP addresses
- IGMP (v1/v2/v3)
- IP multicast Routing (PIM introduction)
- Source Tree/ shared Tree
- LAB : IP PIM Dense-mode
- RPF check
- PIM Sparse-mode
- LAB : PIM Sparse-Mode
- LAB : Sparse -dense-mode
- Rendezvous point

- 
- LAB : Auto RP:
 - PIM Bootstrap Router
 - LAB : PIM Bootstrap Router:
 - Auto-RP with Multiple RP (redundancy & Load-balancing)
 - Bi-directional PIM
 - LAB : PIM-Bidirectional
 - Source Specific Multicast
 - LAB : Source Specific Multicast
 - Anycast RP/MSDP
 - LAB : Anycast & MSDP
 - Layer 2 Multicast
 - IGMP Snooping

IP MULTICASTING

- What is Multicasting
- Sending a message from a single source to selected multiple destinations



IP MULTICASTING

Live TV and Radio Broadcast
to the Desktop

Distance Learning

Multicast File Transfer
Data and File Replication



Real-Time Data Delivery—Financial

Corporate Broadcasts



Training

Whiteboard/Collaboration

Videoconferencing

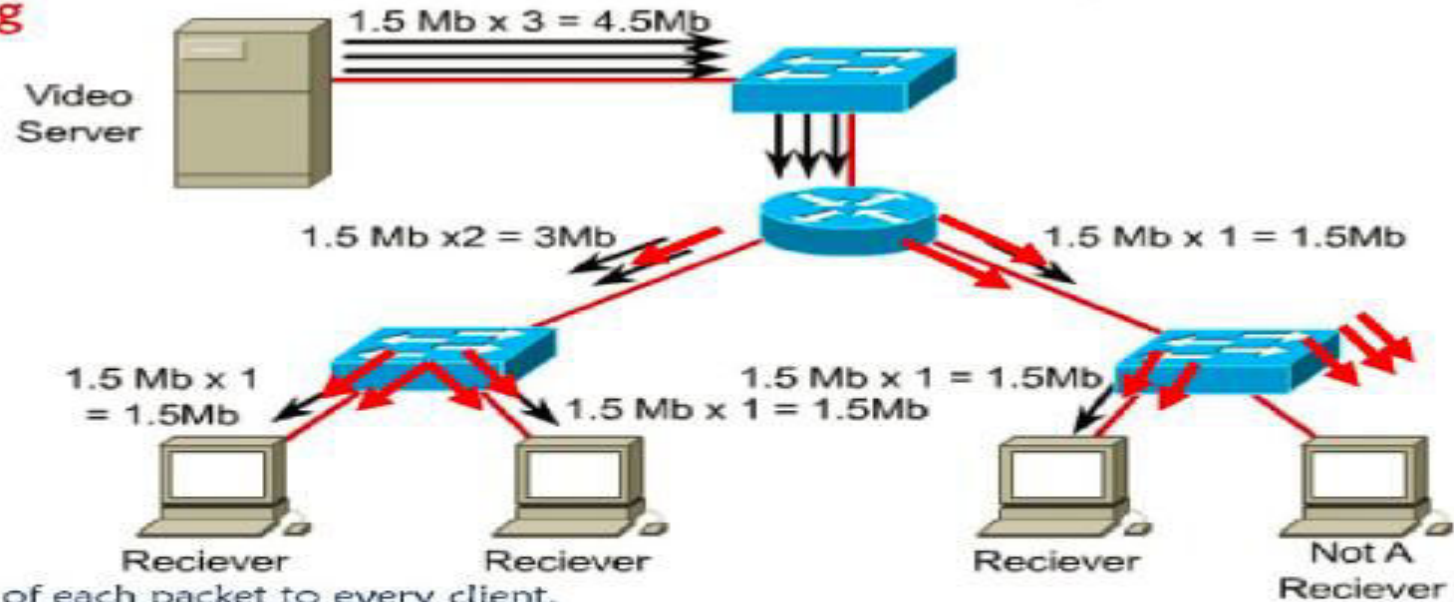
Video-on-Demand

Multimedia traffic using Unicast

Multimedia traffic using Unicast

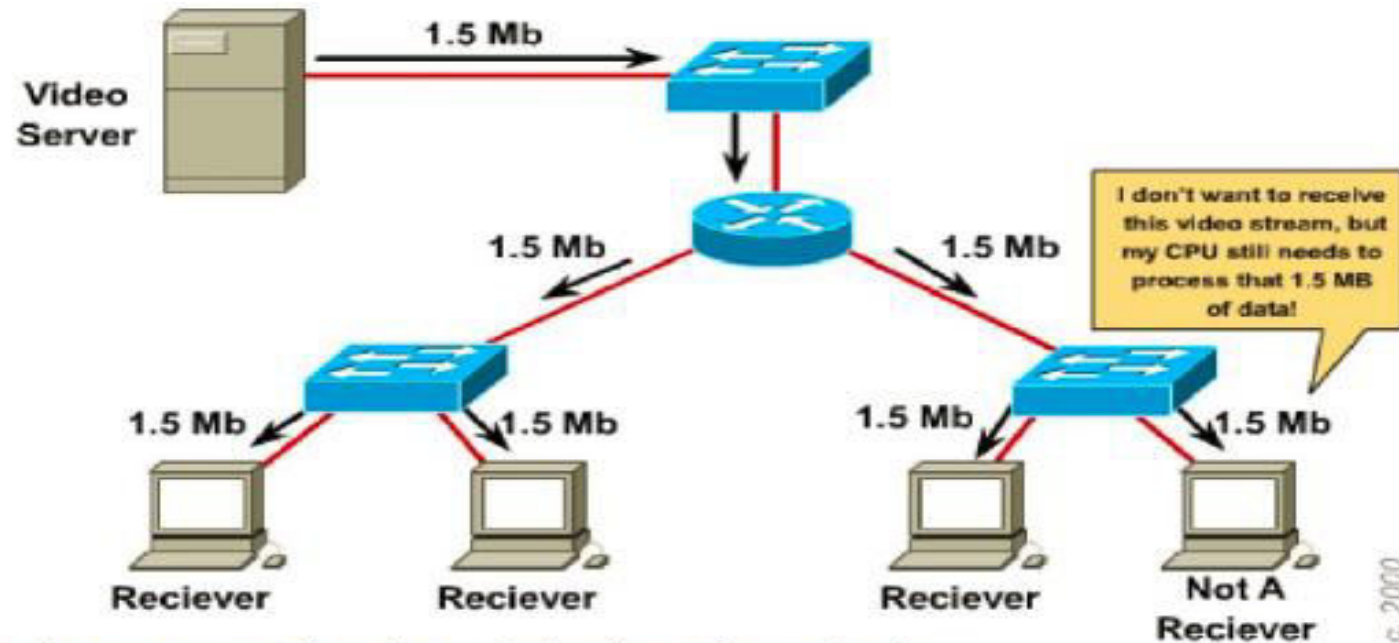
Best case: known unicasts

Worst case: unknown unicasts



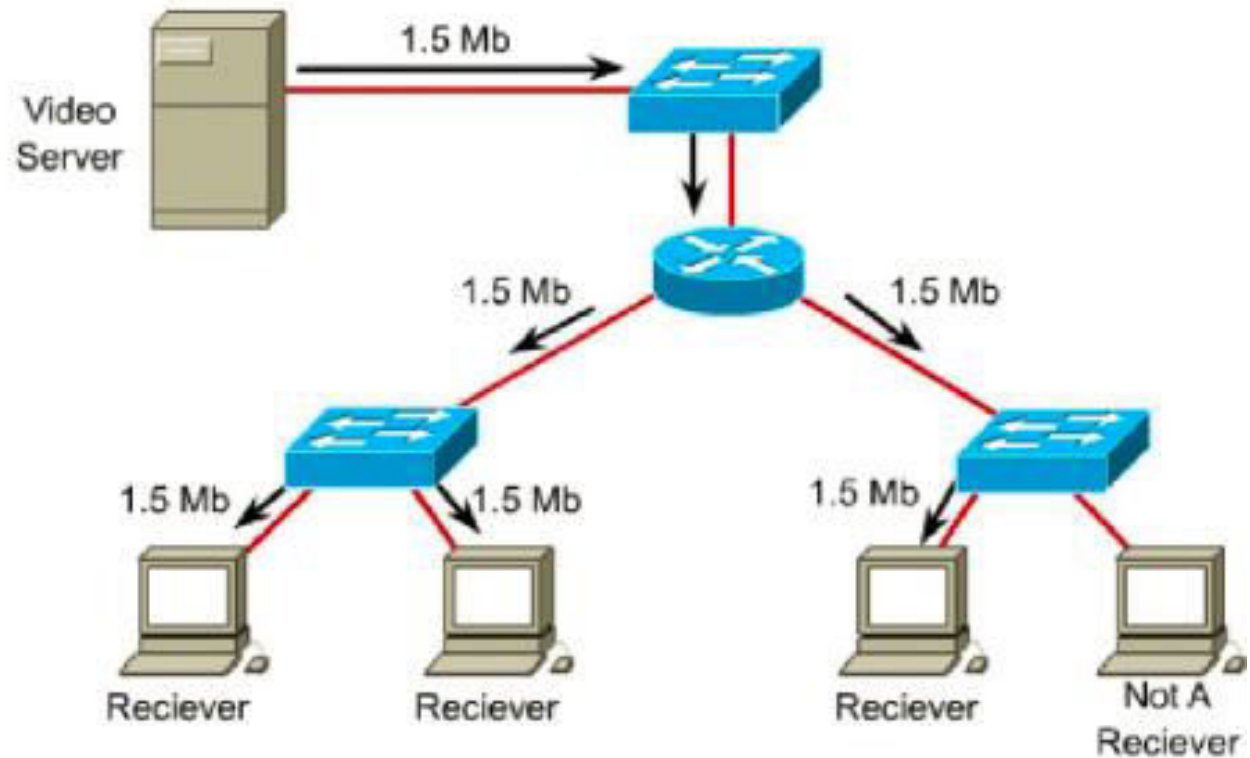
- ▶ Application sends one copy of each packet to every client.
- ▶ Used when only few clients need to access the application.
- ▶ If the message has to be sent to a large group, the same information has to be carried multiple times, even on the same link.
- ▶ Bandwidth usage is proportional to number of users.
- ▶ Router makes individual routing decision based on each pair of source & Destination

Multimedia traffic using Broadcast



- ▶ Application sends only one copy of each packet using a broadcast.
- ▶ All end hosts need to process even if they don't want.
- ▶ **Not recommended** implementation for applications delivering data, voice, or video to multiple receivers.

Multimedia traffic using Multicast

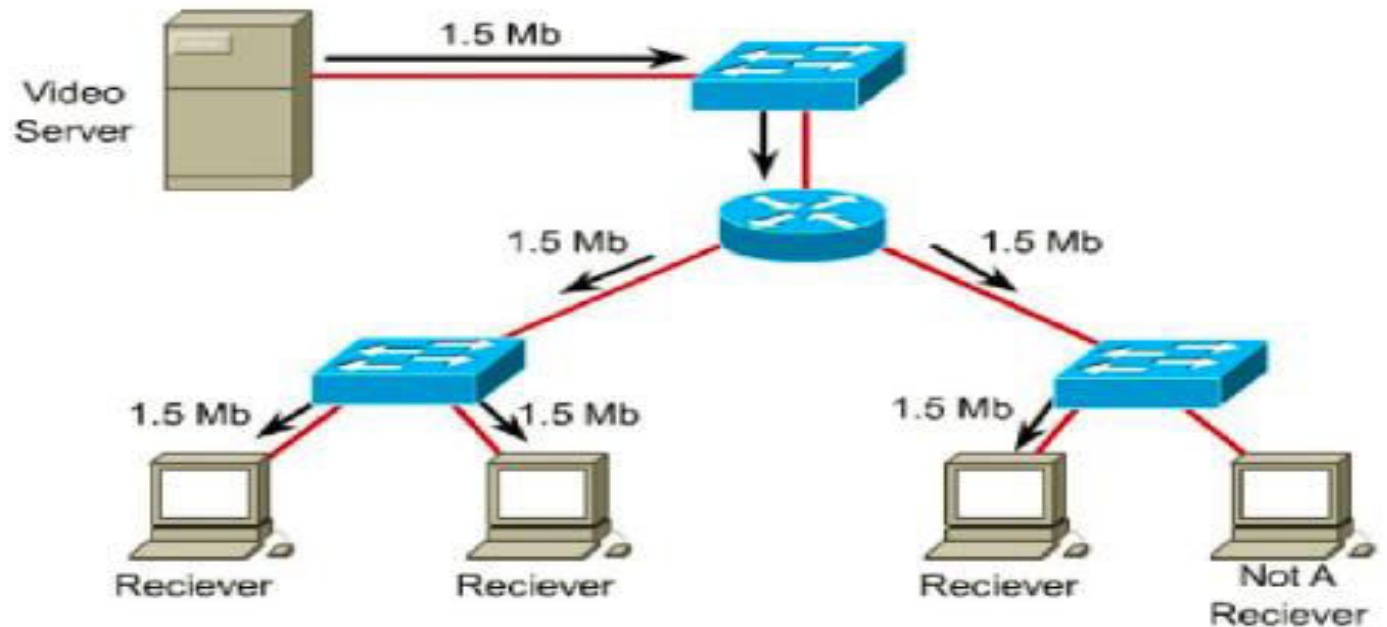


- ▶ The most efficient solution – in between broadcast and unicast.
- ▶ Server sends one copy of each packet to a special address that represents multiple clients.
- ▶ Server sends out a single data stream to multiple clients.

Multimedia traffic using Multicast

Reduces

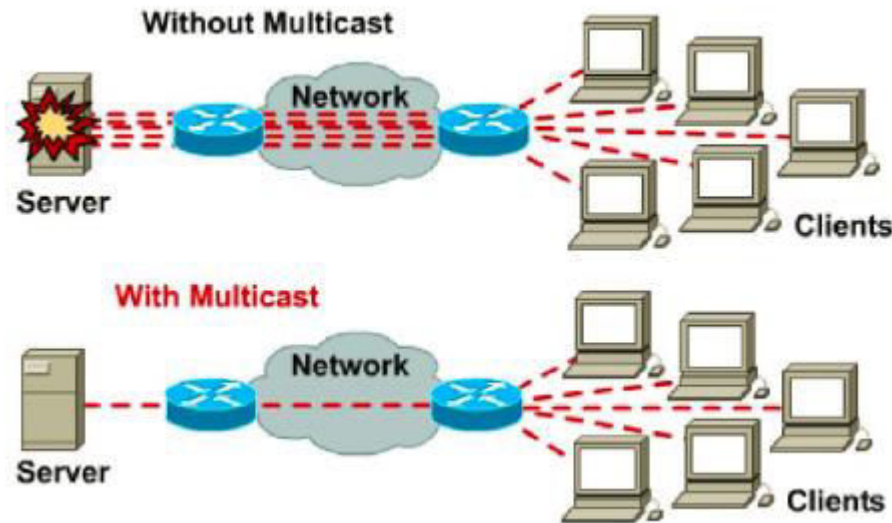
- ▶ Sending Server processing
- ▶ Better bandwidth utilization.
- ▶ Less host/router processing.



- ▶ **Saves bandwidth** and controls network traffic by forcing the network to replicate packets only when necessary.
- ▶ **Reduces network bandwidth consumption** and host processing.
- ▶ Cisco switches can process IP multicast packets and deliver those packets only to requesting receivers at both Layer 2 and Layer 3.

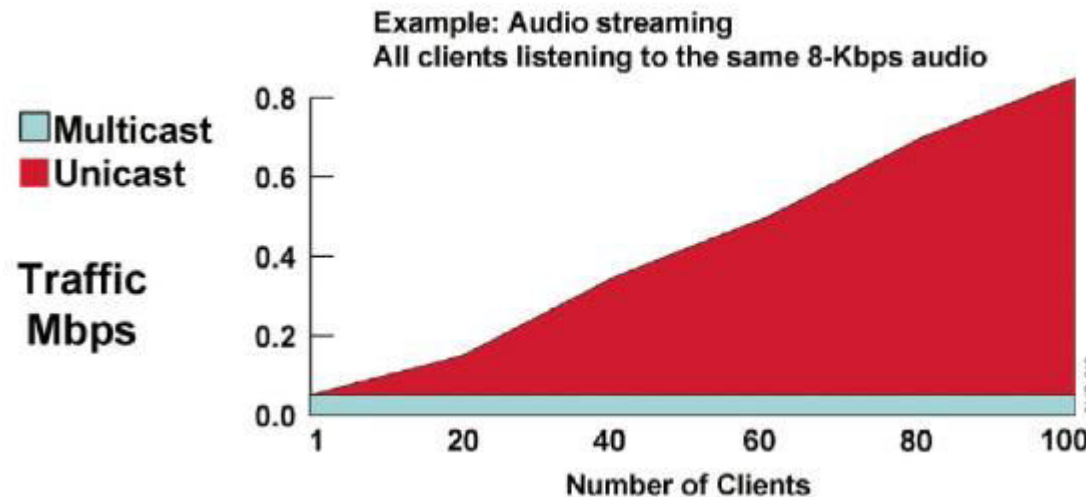
How Multicast helps in saving Resources

- Server generate single Data feed for all interested receivers.
- the sender, or source of multicast traffic does not have to know the unicast addresses of the receiver, (sends to Multicast Group address)
- The routers perform packet multiplication and delivery to the receivers.
- Uninterested hosts will not receive packets



Multicast Advantages

- Enhanced efficiency: Controls network traffic and reduces server and CPU loads
- **Reduces Sending Server processing , Better bandwidth utilization. Less host/router processing**

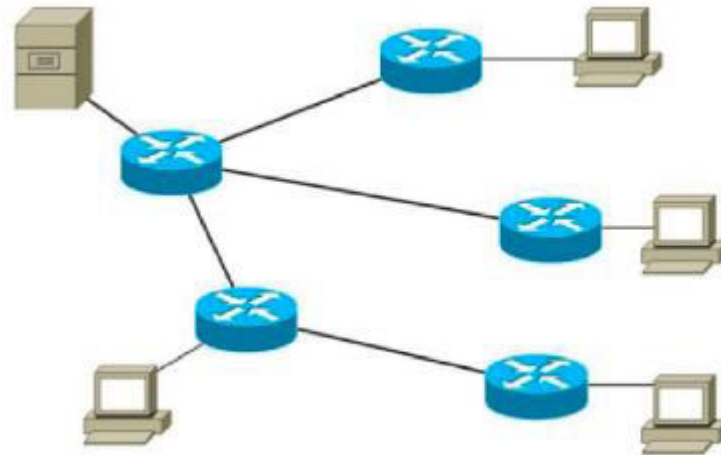


Multicast Disadvantages

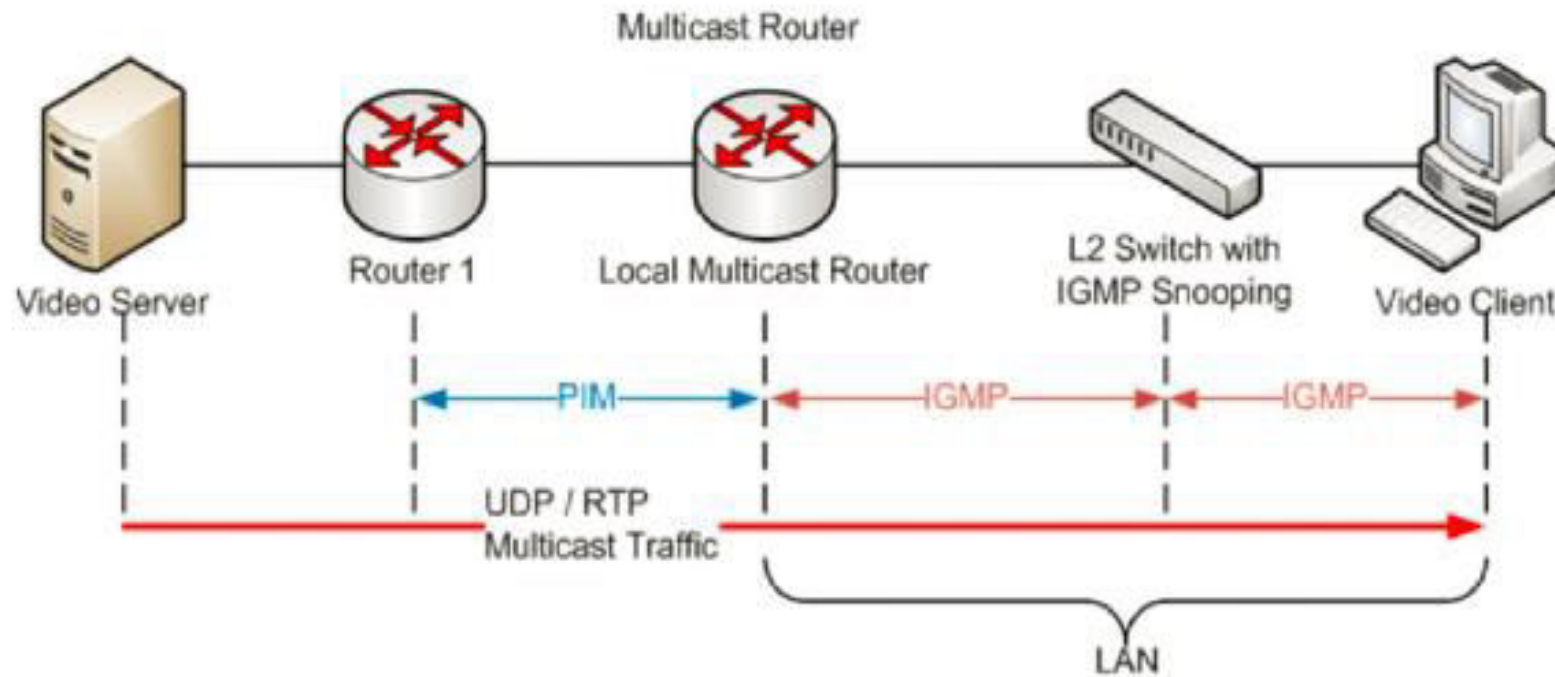
- Multicast is UDP-based.
- Best-effort delivery: (no acknowledgements)
- No congestion avoidance:
- Duplicates (possible during network convergence)
- Out-of-sequence delivery

How Multicast works

- Multicast Server Application configured with Layer 3 addresses (CLASS - D)
- Multi cast Application installed on all the hosts .
- Indicate Router that they want to receive Multicast traffic for group (1GMP)
- multicast routing protocol forward multicast Server. (P3M)
- Calculate Layer 2 Multicast MAC address (IGMP Snooping /CGMP)

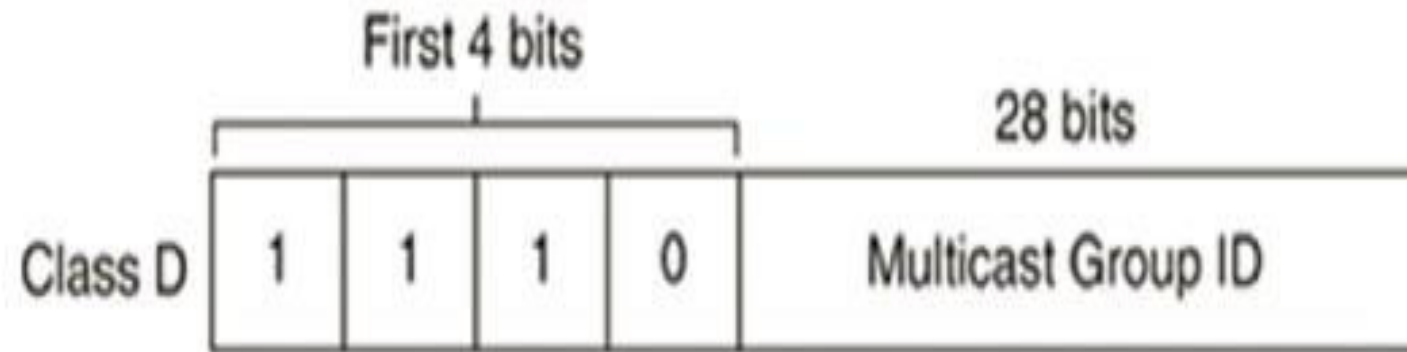


How Multicast works



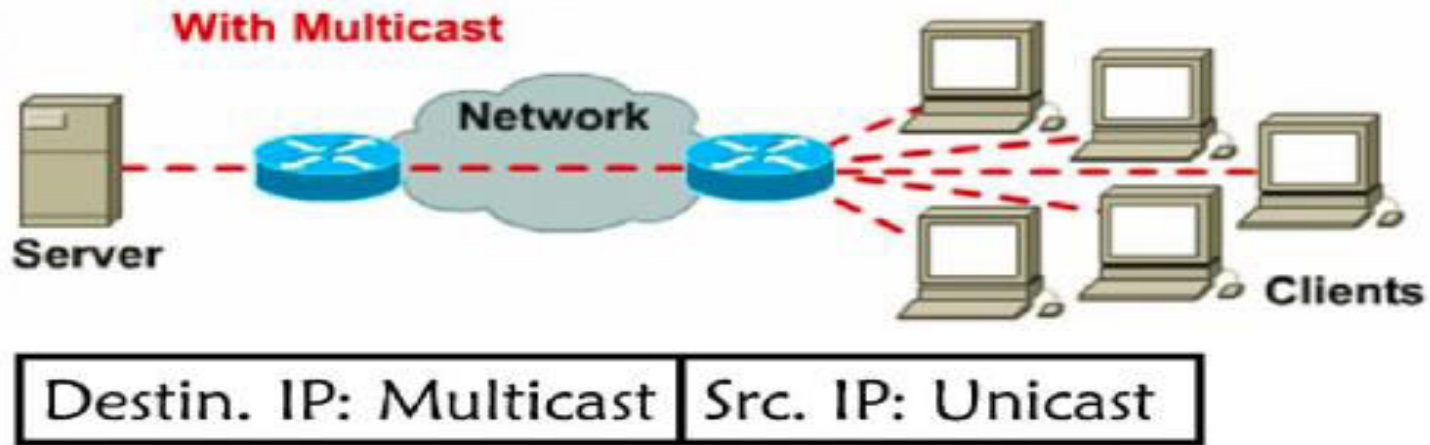
Multicast IP Address Structure

- The Internet Assigned Numbers Authority (IANA) has assigned class D IP addresses to multicast



224.0.0.0 to 239.255.255.255

Multicast IP Address Structure



- ▶ The Class D address range is used only for the group address or destination address of IP multicast traffic.
- ▶ The source address for multicast datagrams is always the unicast source address.

Multicast IP Address Structure

Permanent multicast groups

- in the range 224.0.0.0–224.0.1.255
- Non routed purpose range (Reserved Multicast Addresses)
 - 224.0.0.0 through 224.0.0.255.
- Routed purpose range
 - 224.0.1.0 through 224.0.1.255.

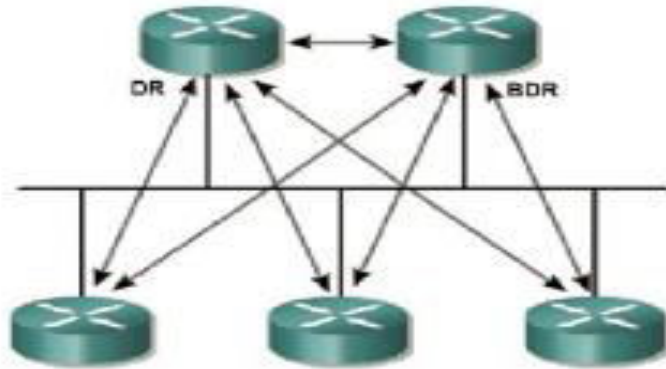
Source-Specific Multicast (SSM)

- in the range 232.0.0.0– 232.255.255.255

Private multicast addresses

- in the range 239.0.0.0–239.255.255.255

Reserved Link Local Addresses



224.0.0.1 - All multicast-capable hosts on the segment
224.0.0.2 - All multicast-capable routers on the segment
224.0.0.4 - All DVMRP routers on the segment
224.0.0.5 - All OSPF routers
224.0.0.6 - All OSPF designated routers
224.0.0.9 - All RIPv2 routers
224.0.0.13 - All PIM routers

- ▶ 224.0.0.0 to 224.0.0.255 (link local destination addresses) to be used by network protocols on a local network segment.
- ▶ Routers do not forward packets in this address range.
- ▶ Typically sent with a **Time-to-Live (TTL) value of 1**.
- ▶ Network protocols use these addresses for **automatic router discovery** and to **communicate important routing information**.
- ▶ For example, OSPF uses the IP addresses 224.0.0.5 and 224.0.0.6 to exchange link-state information.
 - 224.0.0.5, All SPF Routers
 - 224.0.0.6 ALL DR Routers

IP MULTICASTING

Address **224.0.0.1** identifies the **all-hosts group**.

- ° Every multicast-capable host must join this group when initializing its IP stack.
- ° If you send an ICMP echo request to this address, all multicast-capable hosts on the network answer the request with an ICMP echo reply.

Address 224.0.0.2 identifies the **all-routers group**.

- ° Multicast routers join this group on all multicast-enabled interfaces

```
C:\>ping 224.0.0.1  
  
Pinging 224.0.0.1 with 32 bytes of data:  
  
Reply from 10.11.5.58: bytes=32 time=3ms TTL=64  
Reply from 10.11.5.58: bytes=32 time=2ms TTL=64  
Reply from 10.11.5.58: bytes=32 time=2ms TTL=64  
Reply from 10.11.5.58: bytes=32 time=1ms TTL=64
```

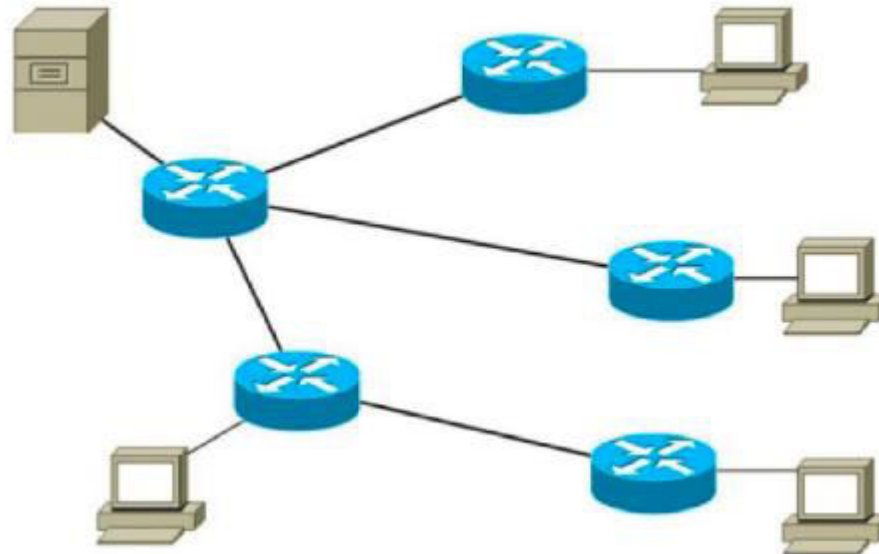
Protocols used for Multicasting

IGMP - Internet Group Management Protocol

- ° End Host to Router Communication

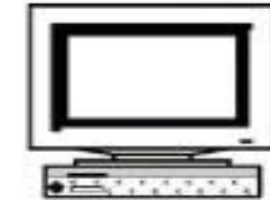
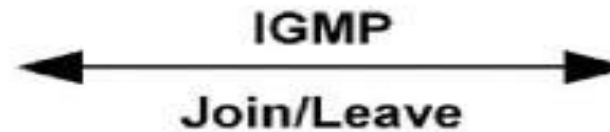
PIM - protocol Independent Multicast

- ° router to Router Communication



ICMP - Internet Group Management Protocol

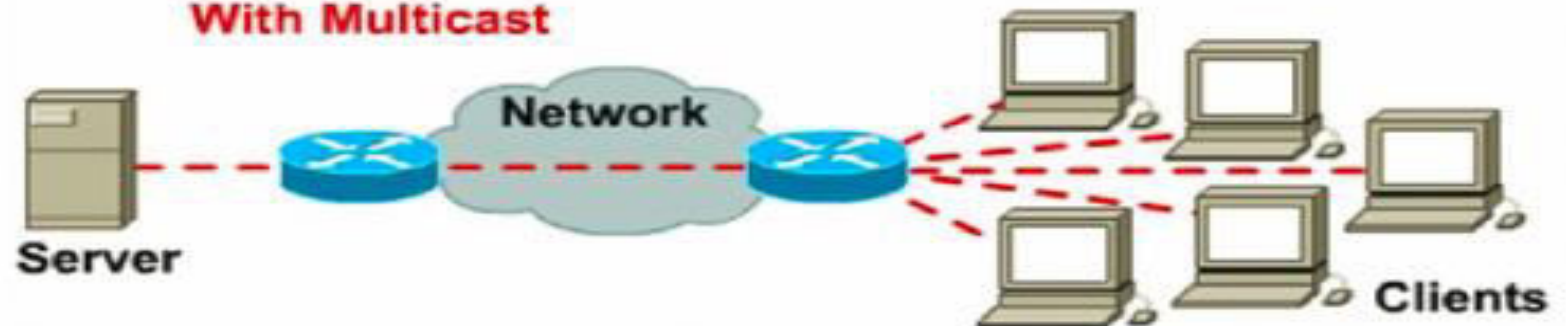
IGMP



Receiver

- ▶ Enable communication between a router and connected hosts.
- ▶ The two most important goals of IGMP are as follows:
 1. To inform a local multicast router that a host wants to receive multicast traffic for a specific group
 2. To inform local multicast routers that a host wants to leave a multicast group.

With Multicast



IGMP versions

- IGMP VI
- IGMPV2 (default)
- IGMP V3

IGMP v1

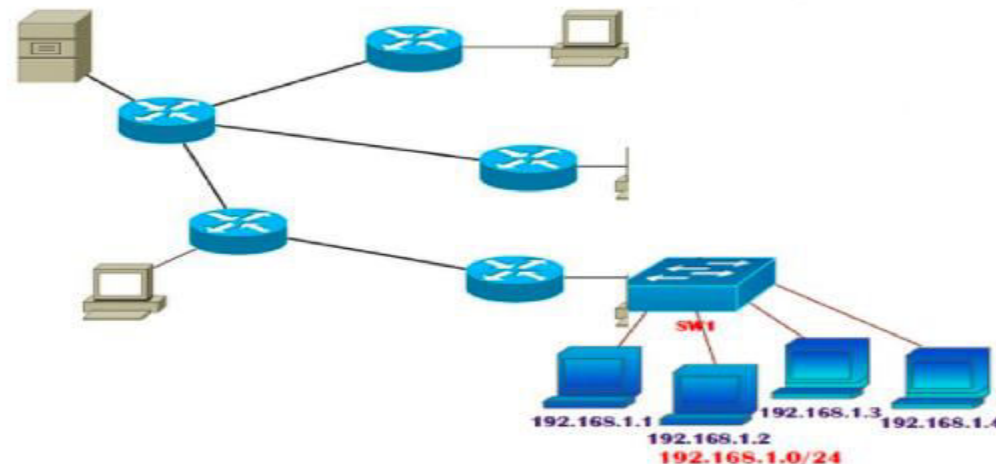
uses two specific message structures

Report Messages :

used by the client to join the group

Query Messages

- used by router to see if the members of the group still exist
- * always sent to 224.0.0.1 by multicast routers.



IGMPv1 (Contd)

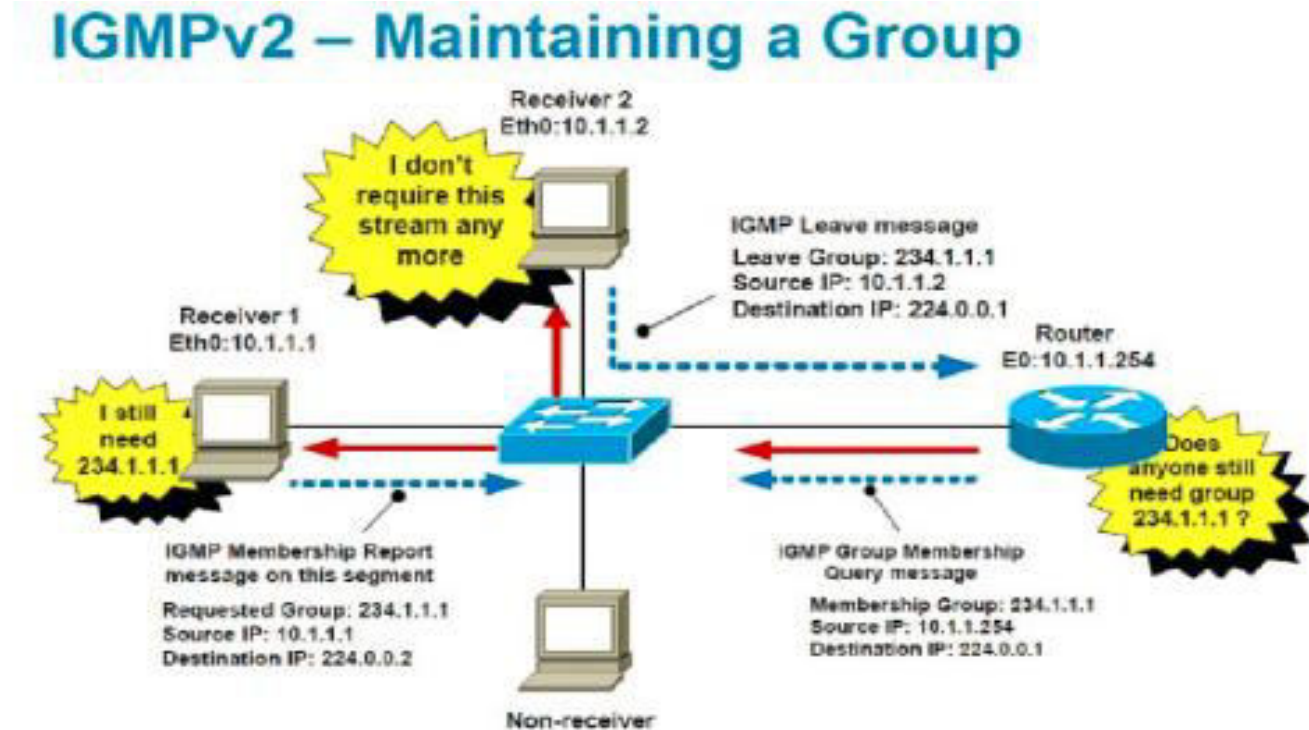
- R1 sends periodic IGMP queries to the 224.0.0.1 address.
- If only one member per group per subnet sends the IGMP report message to the
- router— in this case, H2
- while the other hosts H1 and H3 suppress theirs.
- IGMP query interval is 60 seconds and 180 delay Timer.



IGMP v2

IGMPv2 brought a number of improvements.

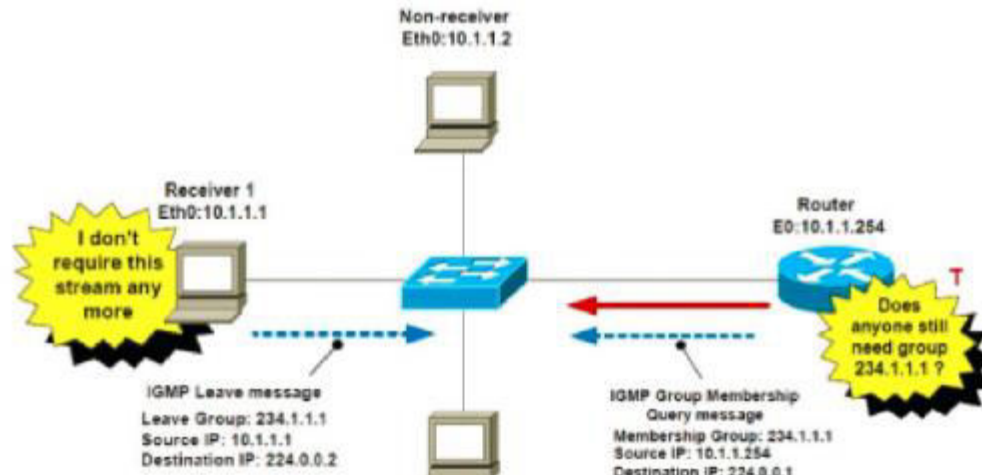
1. Leave Group message from host to the Router (apart from report and query)
2. Tunable Timers
3. Querier election
4. Group Specific Queries



IGMP Leave Group

- When a client want to leave the group they will send a “ **IGMP Leave Msg**’ to **224.0.0.2**
- Then router will query “ **IGMP Query Msg**” to **224.0.0.1 (All-Host multicast address)**.
- As long as at least one client is in this group, switch will forward IGMP Membership report back to first hop router

IGMPv2 – Leaving a Group

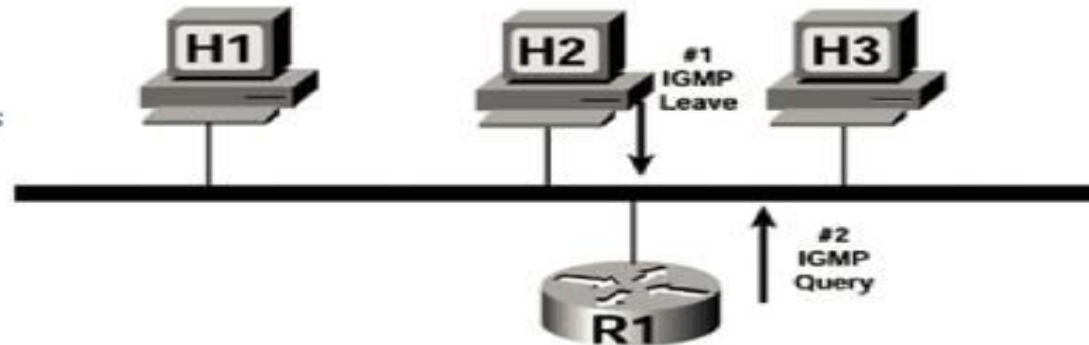


IGMP Leave Group



Group Specific Queries

- ▶ In version 1 Query send to all hosts on 224.0.0.1
- ▶ In version 2 Query generated to only devices to that specific group

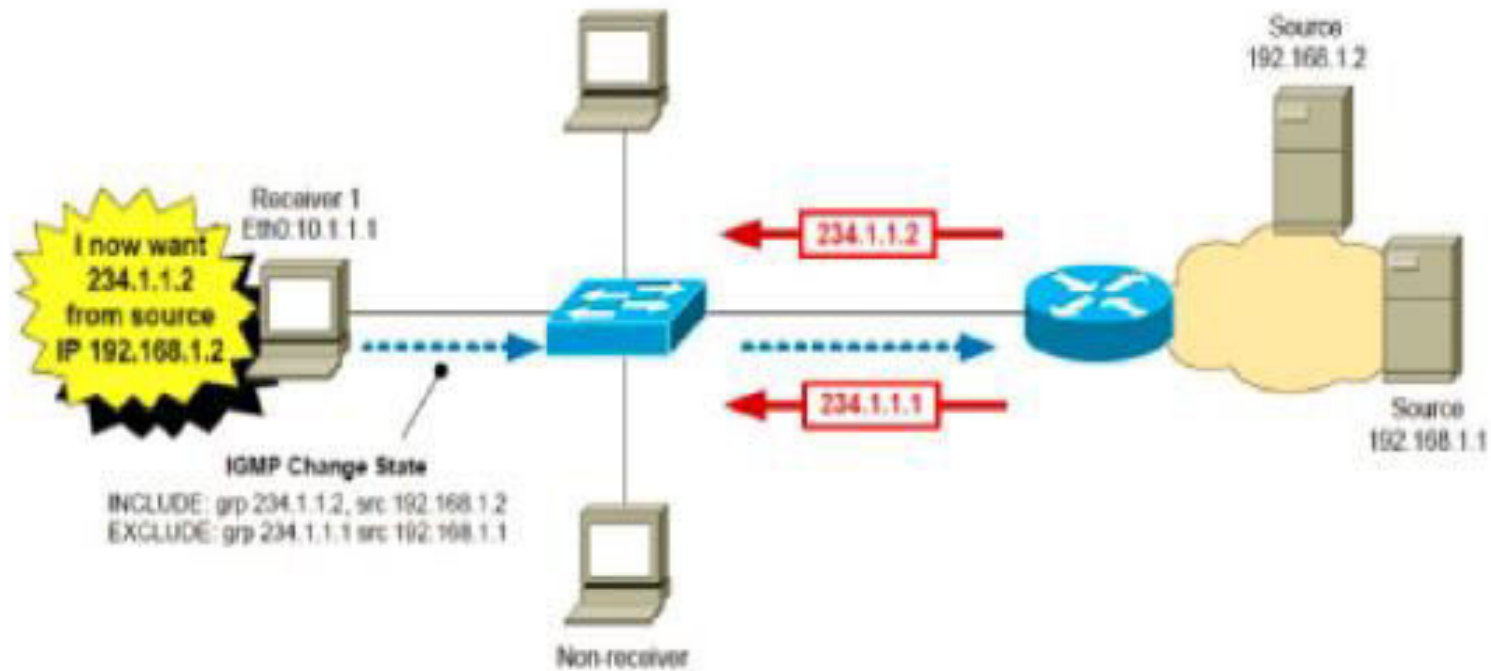


IGMP v3

- Allows us to do Source Specific multicast.
- v1/v2 only support group specific multicast (*,G) join any source /specific Group)
- V3 support Source specific multicast (S.G) join.



IGMPv3- Changing a Group



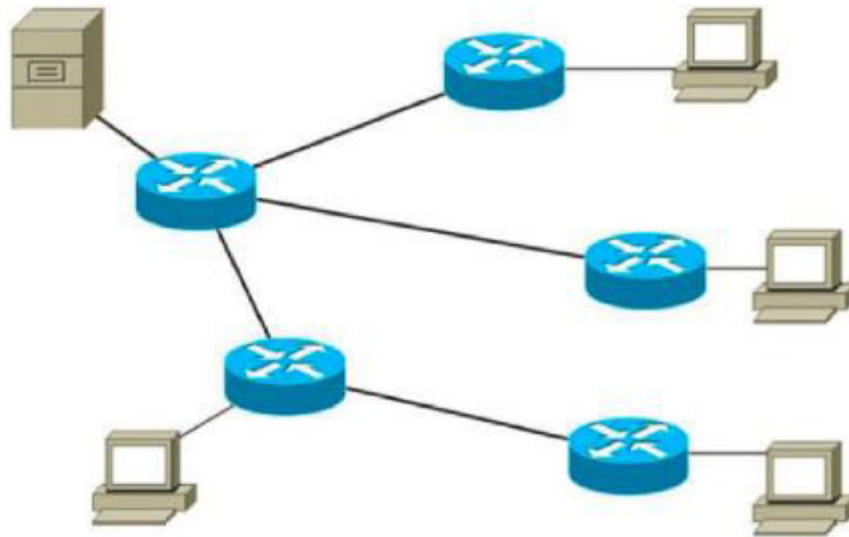
IP MULTICASTING

IP Multicast Routing

PIM Dense-Mode, PIM Sparse-Mode

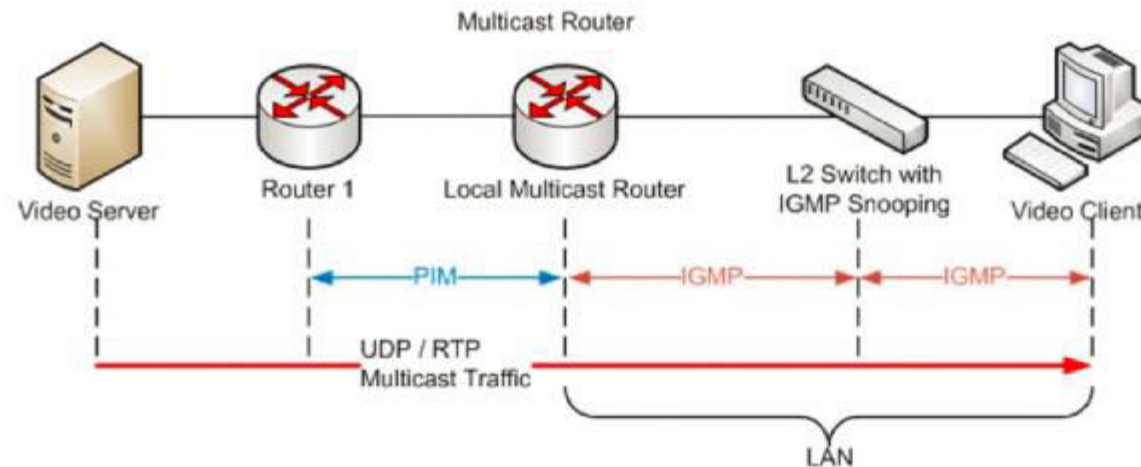
IP Multicast Routing

- Distance Vector Multicast Routing Protocol (DVMRP) (legacy)
- Multicast OSPF (MOSPF) (legacy)
- Protocol-Independent Multicast (PIM)



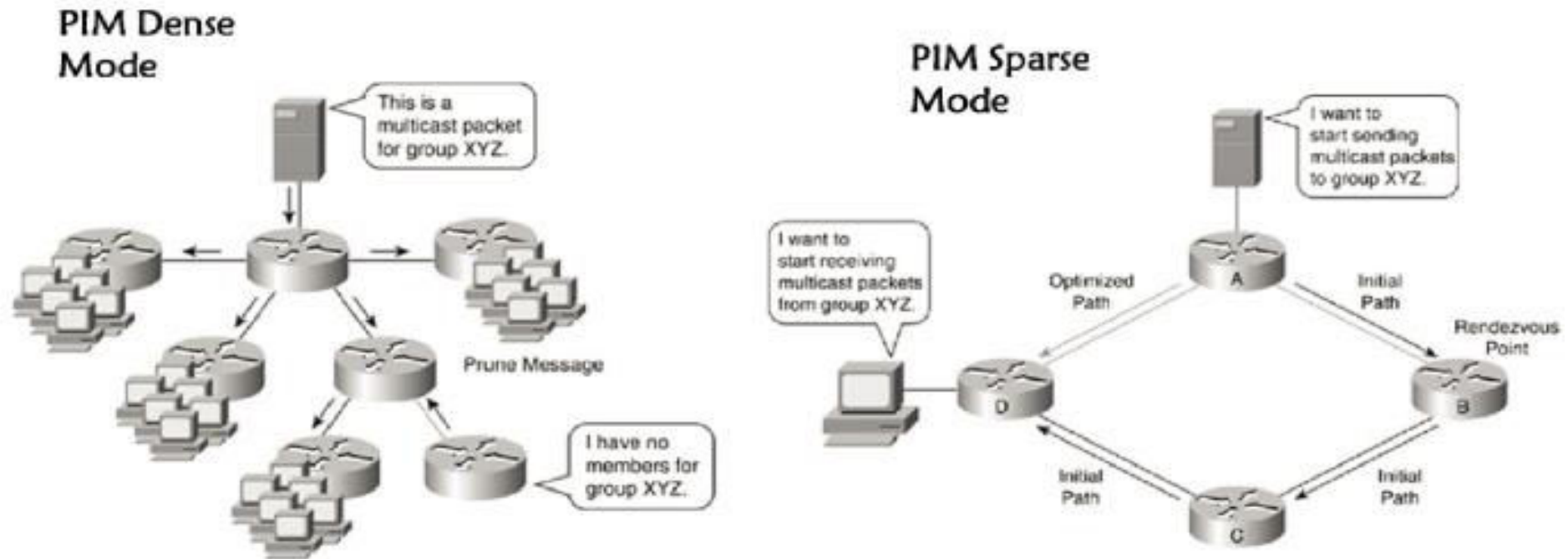
PIM

- Protocol independent Multicast
- Provides loop free router to router communication
- Rely on IGP to figure out the network is loop free (using RPF Check)
- Do not advertise the routes through out the network(like IGP)



PIM Modes

Tells how the multicast tree is build from sender to receiver

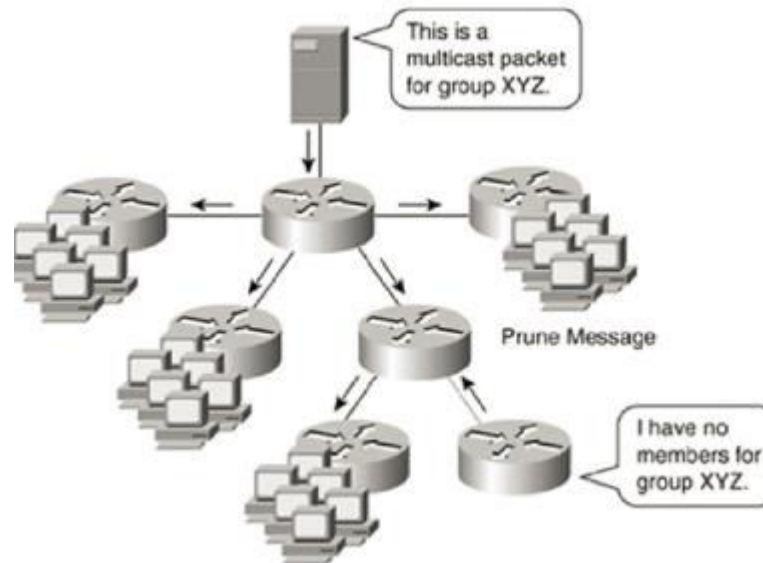


PIM Mode will decide how the tree is built , and who will receive traffic

Dense Mode

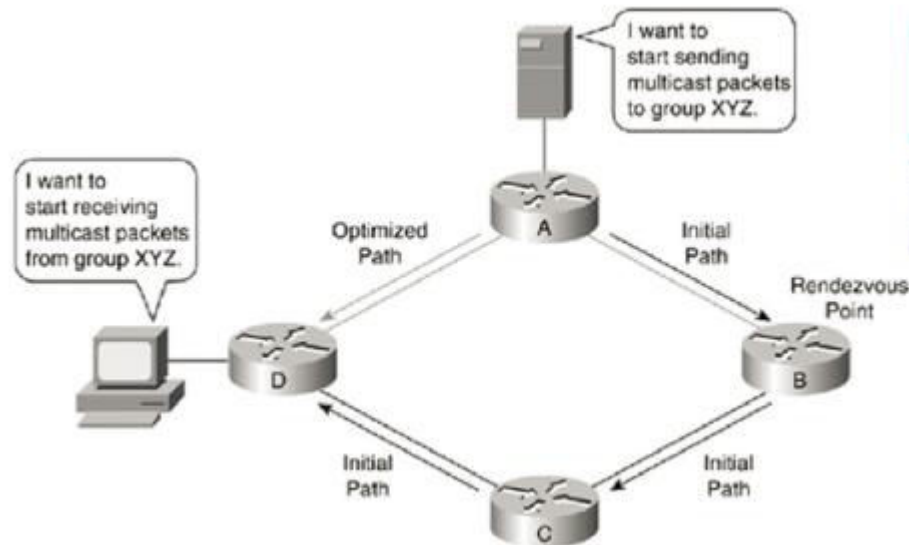
Dense Mode

- Considered as implicit join
- Uses flood and prune behavior



Sparse Mode

- Considered as explicit join
- Uses RP to process join requests



Source Tree vs Shared Tree

Multicast Tree will decide how the traffic is routed from sender to receiver*

Source Tree:

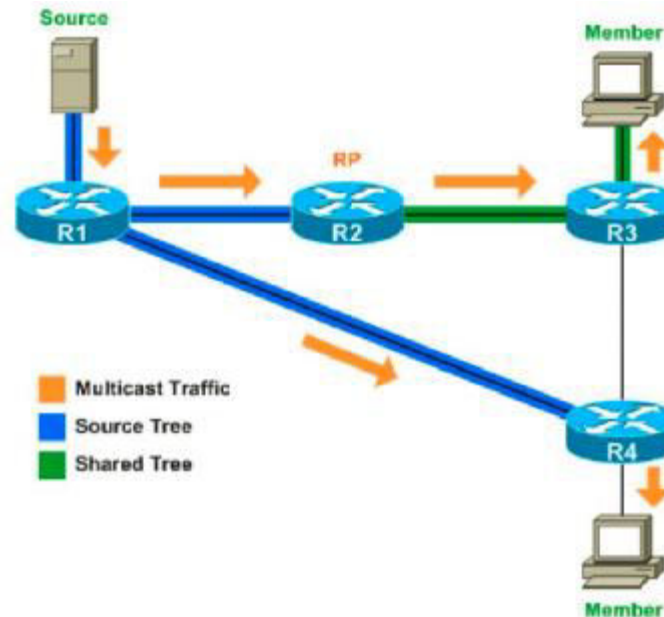
- ° Uses the shortest IGP path from sender to Receiver
- ° Dense-mode /Sparse-mode

Shared Tree :

- ° Uses shortest path from Sender to RP
- ° Shortest path from RP to Receiver
- ° Sparse-mode only
- ° Used to eliminate flooding &. pruning and makes Routing more scalable

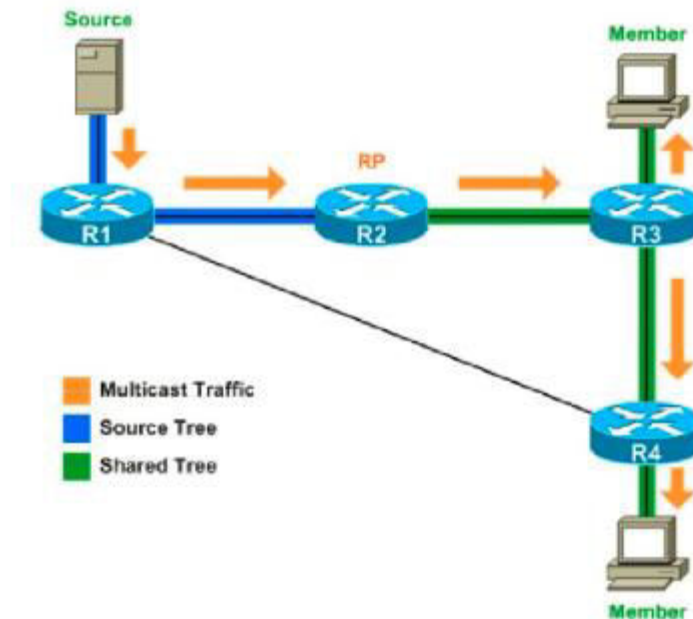
Source Tree

- ° Uses the shortest IGP path from sender to Receiver
- ° Dense-mode / Sparse-mode



Shared Tree

- Uses shortest path from Sender to RP
- Shortest path from RP to Receiver
- Sparse-mode only
- Used to eliminate flooding & pruning and makes Routing more scalable



Source Tree V/s Shared Tree

Source Tree

Advantages :

- ▶ The Shortest path between the source and the receivers.
- ▶ guarantees the minimum amount of network latency for forwarding multicast traffic.

Disadvantages :

- ▶ additional overhead because the routers maintain path information for each source.

Shared Tree

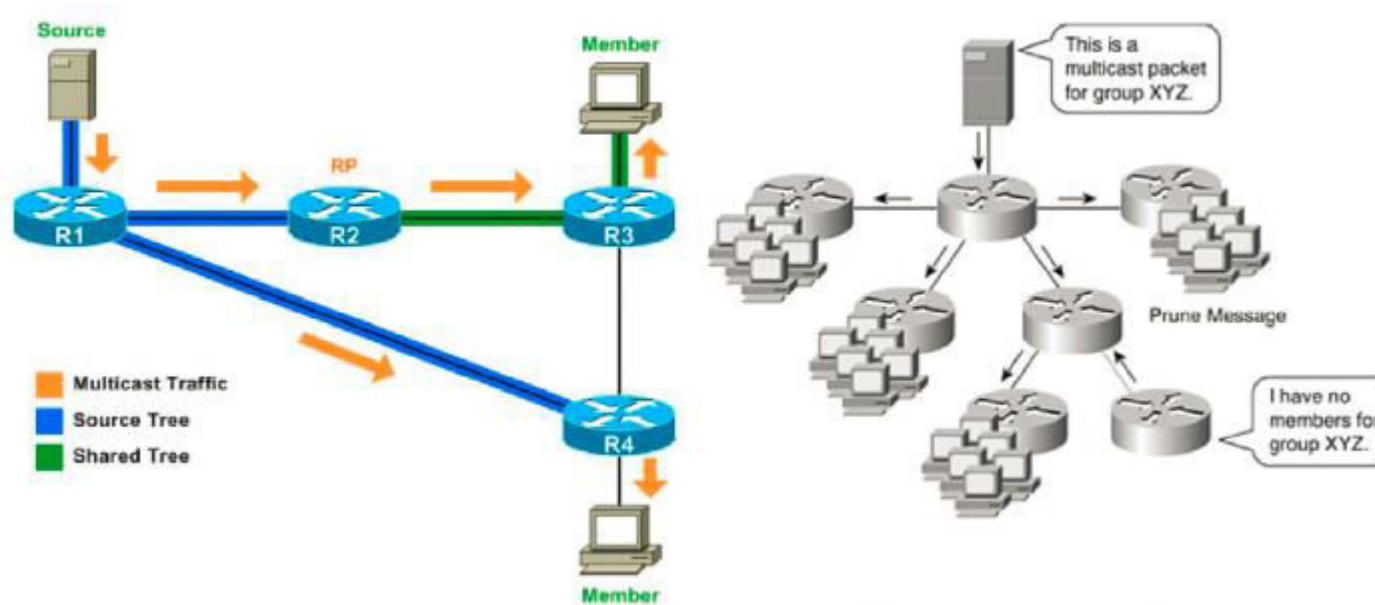
Advantages :

- ▶ minimum amount of state information in each router.
- ▶ lowers the overall memory requirements and complexity for a network

Disadvantages :

- ▶ the paths between the source and receivers might not be the optimal paths
- ▶ May overuse some links and leave others unused
- ▶ carefully consider the placement of the RP

- Uses implicit Join. (get traffic even if not asked)
- Also Called as flood and prune .
- Suitable for small multicast implementations

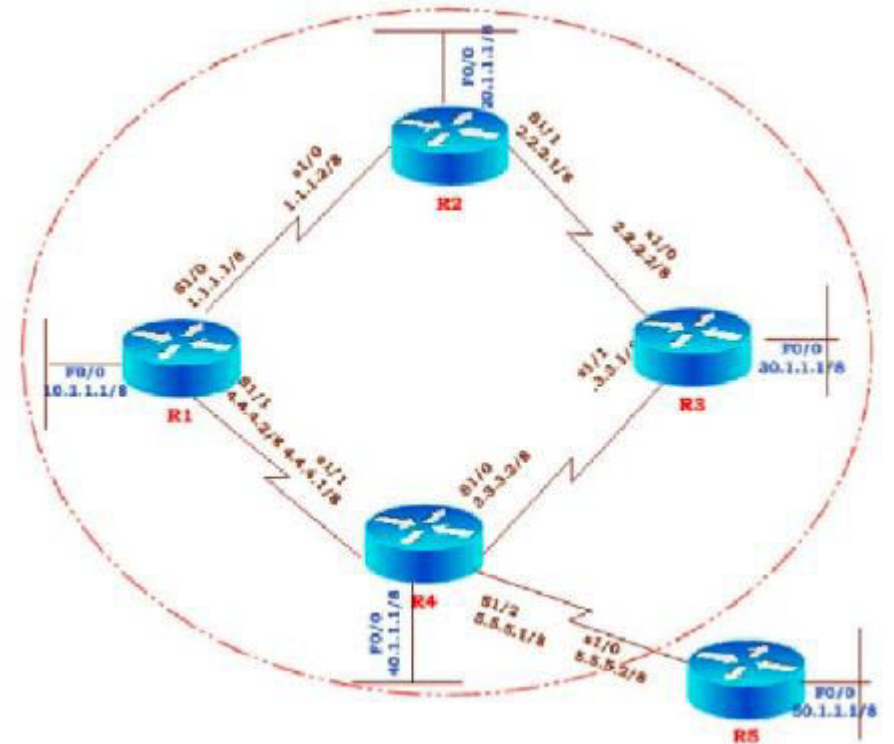


IP PIM Dense Mode configuration

```

R1(config) # ip multicast-routing
R1(config)# intfO/O
R1(config-jf) # ip pim dense-mode
R1(config-if)# intsl/0
R1(config-if)# ip pim dense-mode
R1(config-if)# intsl/t
R1(config-if} # ip pim dense-mode

```

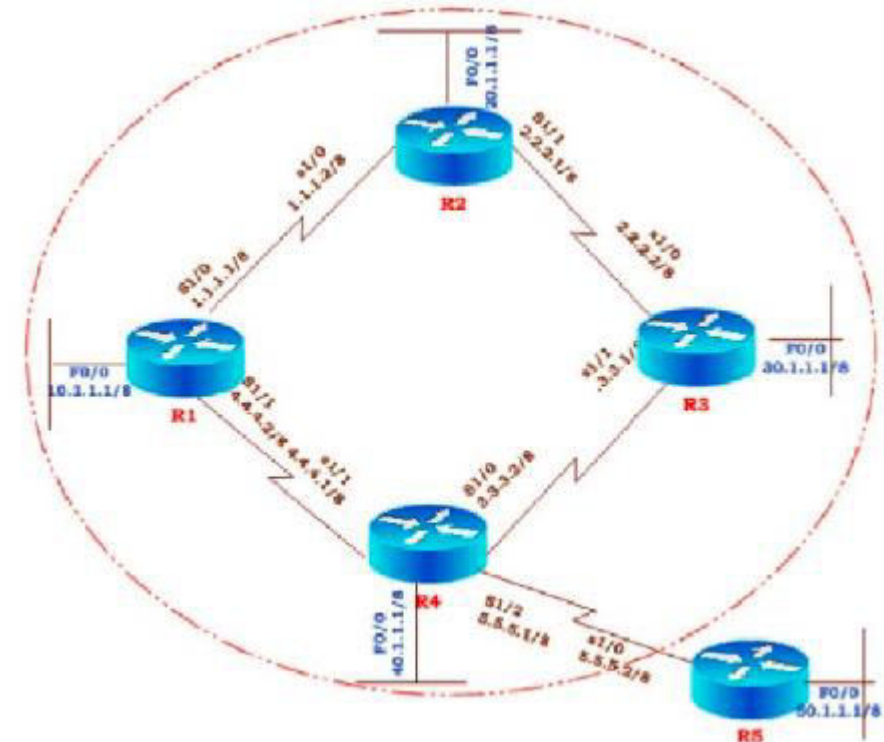


R4#sh ip pim interface

Address	Interface	Ver/	Nbr	Query	DR	DR Mode	Count	Intvl	Prior
40.1.1.1	FastEthernet0/0	v2/D	0	30	1	40.1.1.1			
3.3.3.2	Serial1/0	v2/D	1	30	1	0.0.0.0			
4.4.4.1	Serial1/1	v2/D	1	30	1	0.0.0.0			
5.5.5.1	Serial1/2	v2/D	1	30	1	0.0.0.0			

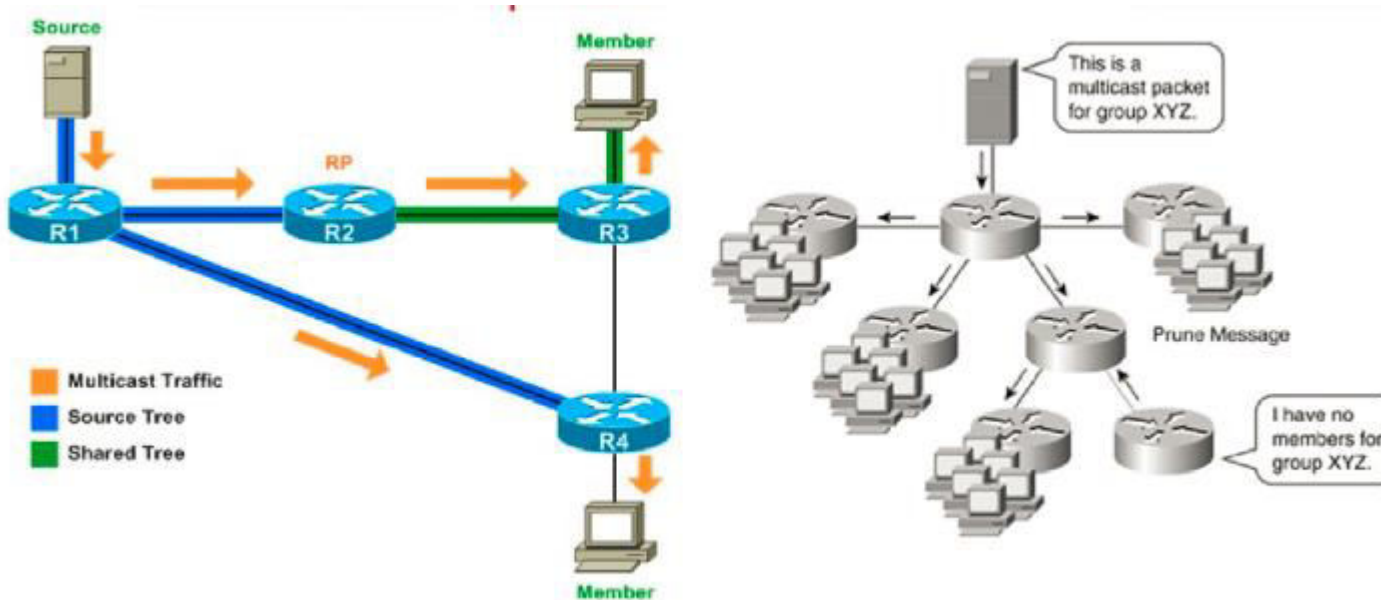
PIM Neighbors

- using hello messages to the **ALL-PIM Routers**
- **(224.0.0.13)**
- **Default hello = 30 sec & dead = 90 sec**



PIM Dense Mode Operation

- Discover PIM neighbors (uses 224,0.0.13)
- Flood all the multicast traffic on all PIM enabled Interfaces
- Prune unwanted traffic
- Maintains multicast Table



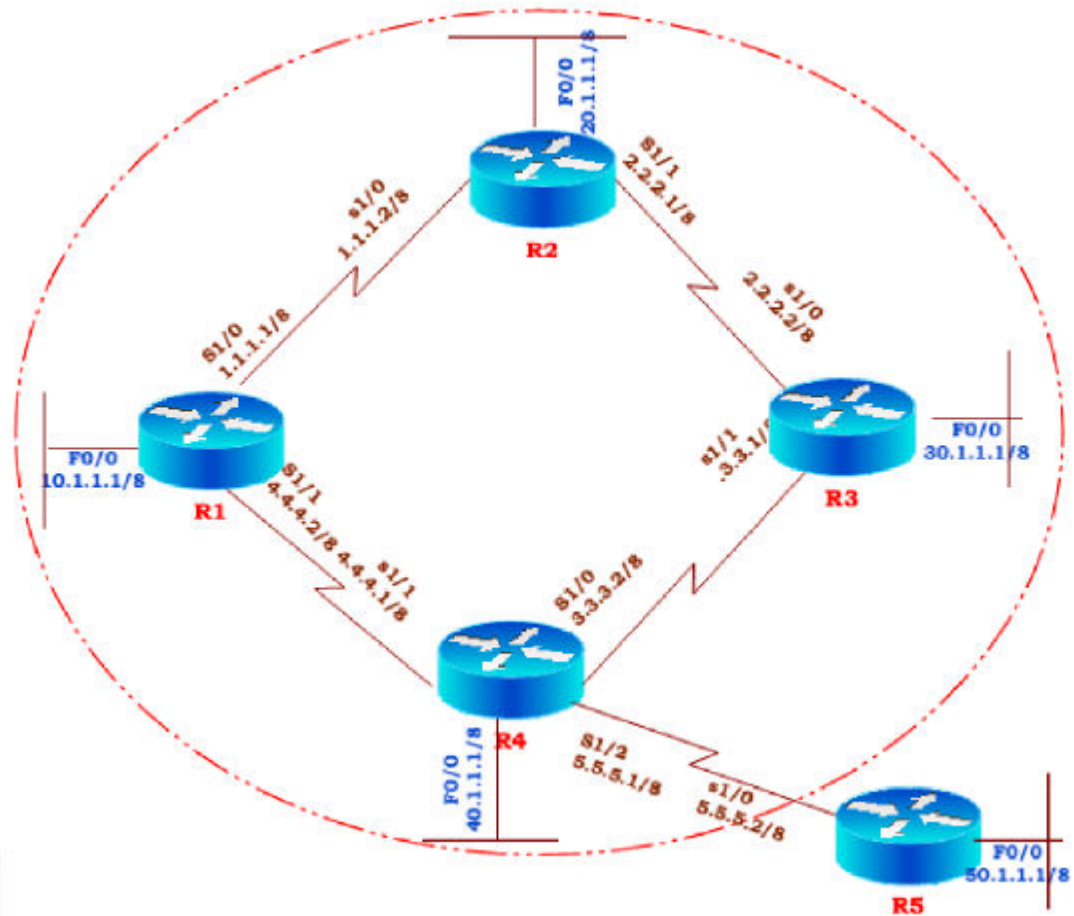
PIM Dense Mode Summary

PIM floods the multimedia packet to all routers in the network and then prunes routers that do not service members of that particular multicast group.

- PIM-DM is most useful in the following cases:
 1. Senders and receivers are in close proximity to one another.
 2. There are few senders and many receivers.
 3. The volume of multicast traffic is high.
 4. The stream of multicast traffic is constant.

Nevertheless, PIM-DM is not the method of choice for enterprise and service provider customers because of its scalability and flooding properties.

LAB : IP PIM Dense-mode



LAB : IP PIM Dense-mode

TASK :

- Configure IGP as OSPF area 0
- advertise all connected interfaces as per the diagram

```
R1(config)#router ospf 1
```

```
R1(config-router)#network 1.1.1.1 0.0.0.0 area 0
```

```
R1(config-router)#network 4.4.4.2 0.0.0.0 area 0
```

```
R1(config-router)#network 10.0.0.0 0.255.255.255 area 0
```

```
R1(config-router)#exit
```

LAB : IP PIM Dense-mode

```
R2(config)#router ospf 1
```

```
R2(config-router)#network 1.1.1.2 0.0.0.0 area 0
```

```
R2(config-router)#network 2.2.2.1 0.0.0.0 area 0
```

```
R2(config-router)#network 20.0.0.0 0.255.255.255 area 0
```

```
R2(config-router)#end
```

```
R3(config)#router ospf 1
```

```
R3(config-router)# network 30.0.0.0 0.255.255.255 area 0
```

```
R3(config-router)#network 3.3.3.1 0.0.0.0 area 0
```

```
R3(config-router)#end
```

LAB : IP PIM Dense-mode

```
R4(config)# router ospf 1
```

```
R4(config-router)# network 40.0.0.0 0.255.255.255 area 0
```

```
R4(config-router)# network 3.3.3.2 0.0.0.0 area 0
```

```
R4(config-router)# network 4.4.4.1 0.0.0.0 area 0
```

```
R4(config-router)# network 5.5.5.1 0.0.0.0 area 0
```

```
R4(config-router)#end
```

```
R5(config)#router ospf 1
```

```
R5(config-router)#network 50.0.0.0 0.255.255.255 area 0
```

```
R5(config-router)#network 5.5.5.2 0.0.0.0 area 0
```

```
R5(config-router)#end
```

LAB : IP PIM Dense-mode

```
R4#sh ip os neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
50.1.1.1	0	FULL/ -	00:00:31	5.5.5.2	Serial5/2
10.1.1.1	0	FULL/ -	00:00:39	4.4.4.2	Serial5/1
30.1.1.1	0	FULL/ -	00:00:30	3.3.3.1	Serial5/0

```
R4#
```

```
R2#sh ip os neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
30.1.1.1	0	FULL/ -	00:00:39	2.2.2.2	Serial5/1
10.1.1.1	0	FULL/ -	00:00:33	1.1.1.1	Serial5/0

```
R2#
```

LAB : IP PIM Dense-mode

```
R1#sh ip rou os
      50.0.0.0/24 is subnetted, 1 subnets
0       50.1.1.0 [110/129] via 4.4.4.1, 00:01:31, Serial5/1
      2.0.0.0/24 is subnetted, 1 subnets
0       2.2.2.0 [110/128] via 1.1.1.2, 00:01:31, Serial5/0
      3.0.0.0/24 is subnetted, 1 subnets
0       3.3.3.0 [110/128] via 4.4.4.1, 00:01:31, Serial5/1
      20.0.0.0/24 is subnetted, 1 subnets
0       20.1.1.0 [110/65] via 1.1.1.2, 00:01:31, Serial5/0
      5.0.0.0/24 is subnetted, 1 subnets
0       5.5.5.0 [110/128] via 4.4.4.1, 00:01:31, Serial5/1
      40.0.0.0/24 is subnetted, 1 subnets
0       40.1.1.0 [110/65] via 4.4.4.1, 00:01:31, Serial5/1
      30.0.0.0/24 is subnetted, 1 subnets
0       30.1.1.0 [110/129] via 4.4.4.1, 00:01:31, Serial5/1
              [110/129] via 1.1.1.2, 00:01:31, Serial5/0
R1#
```

LAB : IP PIM Dense-mode

TASK :

- Configure IP multicast on all the interfaces using IP pim dense-mode
- To test configurations configure R5 f0/0 interfaces to join multicast group 224.5.5.5
- ensure that all the routers should ping to this multicast group on R5..

LAB : IP PIM Dense-mode

```
R1(config)# ip multicast-routing
R1(config)# int f0/0
R1(config-if)# ip pim dense-mode
R1(config-if)# int s1/0
R1(config-if)# ip pim dense-mode
R1(config-if)# int s1/1
R1(config-if)# ip pim dense-mode
R1(config-if)#end
```

LAB : IP PIM Dense-mode

```
R2(config)# ip multicast-routing
```

```
R2(config)# int f0/0
```

```
R2(config-if)# ip pim dense-mode
```

```
R2(config-if)# int s1/0
```

```
R2(config-if)# ip pim dense-mode
```

```
R2(config-if)# int s1/1
```

```
R2(config-if)# ip pim dense-mode
```

LAB : IP PIM Dense-mode

```
R3(config)#ip multicast-routing
```

```
R3(config)# int f0/0
```

```
R3(config-if)# ip pim dense-mode
```

```
R3(config-if)# int s1/0
```

```
R3(config-if)# ip pim dense-mode
```

```
R3(config-if)# int s1/1
```

```
R3(config-if)# ip pim dense-mode
```

```
R3(config-if)#
```

LAB : IP PIM Dense-mode

```
R4(config)#ip multicast-routing
```

```
R4(config)# int f0/0
```

```
R4(config-if)# ip pim dense-mode
```

```
R4(config-if)# int s1/0
```

```
R4(config-if)# ip pim dense-mode
```

```
R4(config-if)# int s1/1
```

```
R4(config-if)# ip pim dense-mode
```

```
R4(config-if)#int s1/2
```

```
R4(config-if)# ip pim dense-mode
```

```
R4(config-if)#end
```

LAB : IP PIM Dense-mode

```
R5(config)#ip multicast-routing
```

```
R5(config)#int s1/O
```

```
R5(config-if)#ip pim dense-mode
```

```
R5(config-if)#int f0/O
```

```
R5(config-if)#ip pim dense-mode
```

```
R5(config-if)#end
```

LAB : IP PIM Dense-mode

```
R5#sh ip pim inter
```

Address	Interface	Ver/ Mode	Nbr Count	Query Intvl	DR Prior	DR
50.1.1.1	GigabitEthernet4/0	v2/D	0	30	1	50.1.1.1
5.5.5.2	Serial5/2	v2/D	1	30	1	0.0.0.0

```
R5#
```

```
R4#sh ip pim interface
```

Address	Interface	Ver/ Mode	Nbr Count	Query Intvl	DR Prior	DR
40.1.1.1	GigabitEthernet4/0	v2/D	0	30	1	40.1.1.1
3.3.3.2	Serial5/0	v2/D	1	30	1	0.0.0.0
4.4.4.1	Serial5/1	v2/D	1	30	1	0.0.0.0
5.5.5.1	Serial5/2	v2/D	1	30	1	0.0.0.0

```
R4#
```

LAB : IP PIM Dense-mode

```
R4#sh ip pim neighbor
```

```
PIM Neighbor Table
```

```
Mode: B - Bidir Capable, DR - Designated Router, N - Default DR Priority,  
      S - State Refresh Capable
```

Neighbor Address	Interface	Uptime/Expires	Ver	DR Prio/Mode
3.3.3.1	Serial5/0	00:03:15/00:01:26	v2	1 / S
4.4.4.2	Serial5/1	00:03:14/00:01:27	v2	1 / S
5.5.5.2	Serial5/2	00:03:14/00:01:28	v2	1 / S

```
R4#
```

```
R2#sh ip pim interface
```

Address	Interface	Ver/ Mode	Nbr Count	Query Intvl	DR Prior	DR
20.1.1.1	GigabitEthernet4/0	v2/D	0	30	1	20.1.1.1
1.1.1.2	Serial5/0	v2/D	1	30	1	0.0.0.0
2.2.2.1	Serial5/1	v2/D	1	30	1	0.0.0.0

```
R2#
```

LAB : IP PIM Dense-mode

```
R5#sh ip igmp group
IGMP Connected Group Membership
Group Address      Interface          Uptime    Expires    Last Reporter    Group Accounted
224.0.1.40         GigabitEthernet4/0 00:05:28  00:02:30   50.1.1.1
R5#
```

- In some situations it is desirable to manually configure multicast group membership on a router interface, particularly during testing and in the absence of IGMP-capable recipients.
- IOS provides command to designate group membership on an interface
- The join-group command makes the router behave as a member of the specified group

LAB : IP PIM Dense-mode

```
R5(config)#int f0/0
```

```
R5(config-if)#ip igmp join-group 224.5.5.5
```

```
R5(config-if)#end
```

- Here in this example we wish to forward multicast traffic for the 224.5.5.5 group to the subnet 50.0.0.0/8 on f0/0 interface of R5
- To do this, we apply ip igmp join-group 224.5.5.5 to R5's Gig4/0 interface

Now check on R1,R2,R3,R4

```
R1#sh ip mroute
R1#sh ip mroute 224.5.5.5
Group 224.5.5.5 not found
R1#
```

LAB : IP PIM Dense-mode

```
R5#sh ip mroute 224.5.5.5
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
Outgoing interface flags: H - Hardware switched, A - Assert winner
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.5.5.5), 00:02:33/00:02:23, RP 0.0.0.0, flags: DCL
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial5/2, Forward/Dense, 00:02:33/00:00:00
    GigabitEthernet4/0, Forward/Dense, 00:02:33/00:00:00

R5#
```

LAB : IP PIM Dense-mode

- Generate ping messages to group 224.5.5.5(which R5 is reciever) and verify the mroute table:

```
R1#ping 224.5.5.5 repeat 100

Type escape sequence to abort.
Sending 100, 100-byte ICMP Echos to 224.5.5.5, timeout is 2 seconds:

Reply to request 0 from 5.5.5.2, 52 ms
Reply to request 1 from 5.5.5.2, 52 ms
Reply to request 2 from 5.5.5.2, 116 ms
Reply to request 3 from 5.5.5.2, 52 ms
Reply to request 4 from 5.5.5.2, 60 ms
Reply to request 5 from 5.5.5.2, 116 ms
Reply to request 6 from 5.5.5.2, 72 ms
Reply to request 7 from 5.5.5.2, 48 ms
Reply to request 8 from 5.5.5.2, 56 ms
Reply to request 9 from 5.5.5.2, 20 ms
Reply to request 10 from 5.5.5.2, 28 ms
Reply to request 11 from 5.5.5.2, 20 ms
Reply to request 12 from 5.5.5.2, 12 ms
Reply to request 13 from 5.5.5.2, 8 ms
Reply to request 14 from 5.5.5.2, 32 ms
Reply to request 15 from 5.5.5.2, 16 ms
```

LAB : IP PIM Dense-mode

```
R5#sh ip mroute 224.5.5.5
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
Outgoing interface flags: H - Hardware switched, A - Assert winner
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.5.5.5), 00:06:55/stopped, RP 0.0.0.0, flags: DCL
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
  Serial5/2, Forward/Dense, 00:06:55/00:00:00
  GigabitEthernet4/0, Forward/Dense, 00:06:55/00:00:00

(4.4.4.2, 224.5.5.5), 00:01:15/00:02:58, flags: LT
Incoming interface: Serial5/2, RPF nbr 5.5.5.1
Outgoing interface list:
  GigabitEthernet4/0, Forward/Dense, 00:01:15/00:00:00

R5#
```

LAB : IP PIM Dense-mode

```
Outgoing interface flags: H - Hardware switched, A - Assert winner
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.5.5.5), 00:02:03/stopped, RP 0.0.0.0, flags: D
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial5/2, Forward/Dense, 00:02:03/00:00:00
    Serial5/1, Forward/Dense, 00:02:03/00:00:00
    Serial5/0, Forward/Dense, 00:02:03/00:00:00

(1.1.1.1, 224.5.5.5), 00:02:03/00:00:57, flags:
  Incoming interface: Serial5/1, RPF nbr 4.4.4.2
  Outgoing interface list:
    Serial5/0, Forward/Dense, 00:02:03/00:00:00
    Serial5/2, Forward/Dense, 00:02:03/00:00:00

(4.4.4.2, 224.5.5.5), 00:02:03/00:02:50, flags: T
  Incoming interface: Serial5/1, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial5/0, Forward/Dense, 00:02:03/00:00:00
    Serial5/2, Forward/Dense, 00:02:03/00:00:00

R4#
```

LAB : IP PIM Dense-mode

```
(* , 224.5.5.5), 00:02:45/stopped, RP 0.0.0.0, flags: D
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial5/1, Forward/Dense, 00:02:45/00:00:00
    Serial5/0, Forward/Dense, 00:02:45/00:00:00

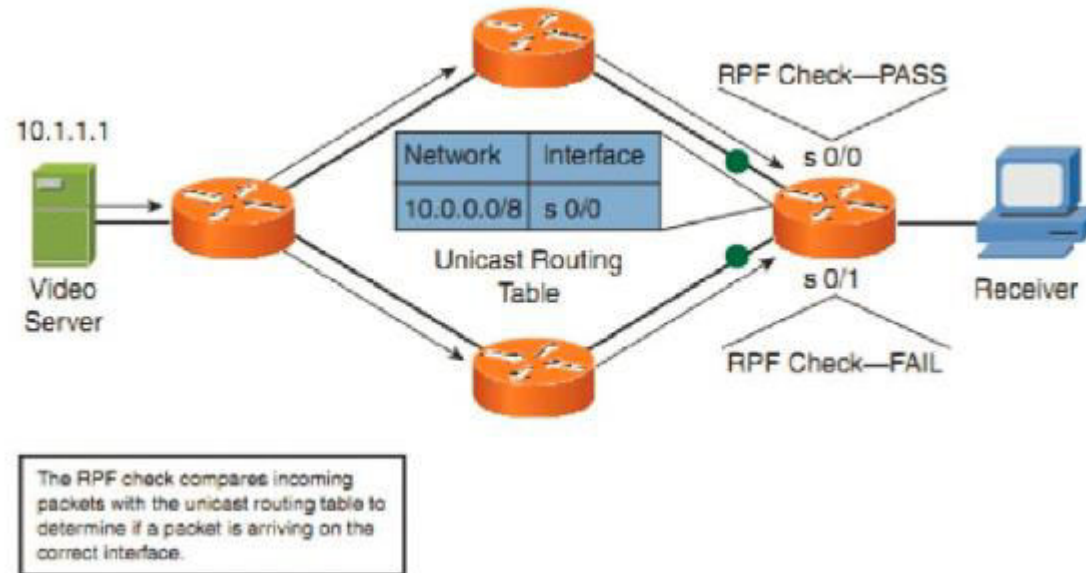
(1.1.1.1, 224.5.5.5), 00:02:45/00:02:55, flags: T
  Incoming interface: Serial5/1, RPF nbr 2.2.2.1
  Outgoing interface list:
    Serial5/0, Forward/Dense, 00:02:45/00:00:00

(4.4.4.2, 224.5.5.5), 00:02:45/00:02:55, flags: T
  Incoming interface: Serial5/0, RPF nbr 3.3.3.2
  Outgoing interface list:
    Serial5/1, Forward/Dense, 00:02:45/00:00:00

(* , 224.0.1.40), 00:17:34/00:02:19, RP 0.0.0.0, flags: DCL
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial5/1, Forward/Dense, 00:17:05/00:00:00
    Serial5/0, Forward/Dense, 00:17:21/00:00:00
    GigabitEthernet4/0, Forward/Dense, 00:17:35/00:00:00
```

R3#

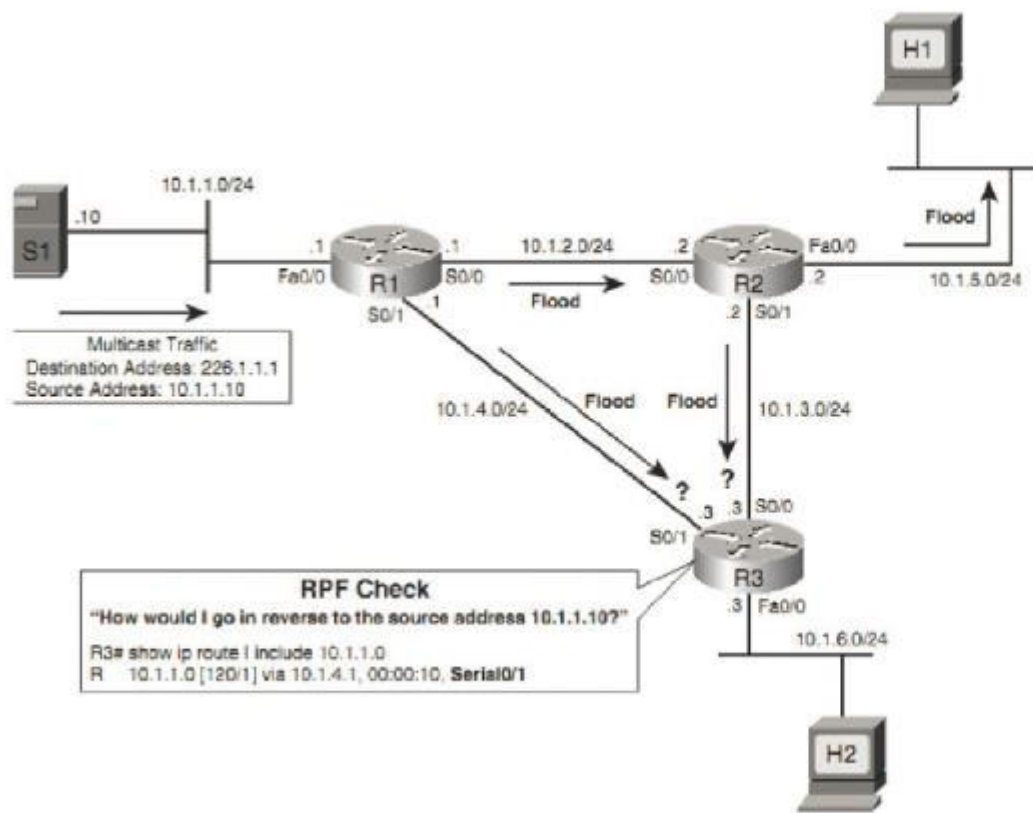
RPF Check



- To Overcome the issue of receiving duplicate packets, Cisco routers perform a Reverse Path Forwarding (RPF)
- check to determine whether a multicast packet is entering a router on the correct interface

RPF Check

- R3 Performs the RPF Check



- ▶ An RPF check examines the source address of an incoming packet and checks it against the router's unicast routing table to see what interface should be used to get back to the source network.
- ▶ If the incoming multicast packet is using that interface, the RPF check passes, and the packet is forwarded.
- ▶ If the multicast packet is coming in a different interface, the RPF check fails, and the packet is discarded.

LAB : Reverse path Forwarding :

TASK :

- Continue with the same configs done in the previous lab
- Disable PIM on S5/1 interface between R1- R4:
- Ensure that R1 can still ping to 224.5.5.5 group address on R5

R5#traceroute 10.1.1.1

R1/R4

Rx(config)#int s1/1

Rx(config-if)#no ip pirn dense-mode

```
R5#traceroute 10.1.1.1
```

```
Type escape sequence to abort.  
Tracing the route to 10.1.1.1
```

```
 1 5.5.5.1 12 msec 24 msec 40 msec
```

```
 2 4.4.4.2 40 msec 36 msec 20 msec
```

```
R5#
```

LAB : Reverse path Forwarding :

```
R4#sh ip pim interface
```

Address	Interface	Ver/ Mode	Nbr Count	Query Intvl	DR Prior	DR
40.1.1.1	GigabitEthernet4/0	v2/D	0	30	1	40.1.1.1
3.3.3.2	Serial5/0	v2/D	1	30	1	0.0.0.0
5.5.5.1	Serial5/2	v2/D	1	30	1	0.0.0.0

```
R4#
```

```
R4#sh ip pim nei
```

```
R4#sh ip pim neighbor
```

```
PIM Neighbor Table
```

Mode: B - Bidir Capable, DR - Designated Router, N - Default DR Priority,
S - State Refresh Capable

Neighbor Address	Interface	Uptime/Expires	Ver	DR Prio/Mode
3.3.3.1	Serial5/0	00:48:20/00:01:40	v2	1 / S
5.5.5.2	Serial5/2	00:48:20/00:01:15	v2	1 / S

```
R4#
```

LAB : Reverse path Forwarding :

```
R4#sh ip mroute 224.5.5.5
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
Outgoing interface flags: H - Hardware switched, A - Assert winner
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.5.5.5), 00:00:15/stopped, RP 0.0.0.0, flags: D
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial5/2, Forward/Dense, 00:00:15/00:00:00
    Serial5/0, Forward/Dense, 00:00:15/00:00:00

(1.1.1.1, 224.5.5.5), 00:00:15/00:02:44, flags:
  Incoming interface: Null, RPF nbr 4.4.4.2
  Outgoing interface list:
    Serial5/0, Forward/Dense, 00:00:15/00:00:00
    Serial5/2, Forward/Dense, 00:00:16/00:00:00

R4#
```

LAB : Reverse path Forwarding :

```
R5#traceroute 10.1.1.1

Type escape sequence to abort.
Tracing the route to 10.1.1.1

 1 5.5.5.1 32 msec 16 msec 20 msec
 2 4.4.4.2 44 msec 68 msec 52 msec
R5#
```

LAB : Reverse path Forwarding :

To fix this :

1. enable PIM on R1- R4 interface:
2. change IGP cost to use alternate route where PIM is enabled (shutdown/change cost)
3. configure Multicast static route to use alternate route

```
R4(config)#int s1/1
```

```
R4(config-if)#shutdown
```

```
R4(config)#int s1/1
```

```
R4(config-if)#no shutdown
```

```
R4(config)#ip mroute 0.0.0.0 0.0.0.0 3.3.3.1
```

LAB : Reverse path Forwarding :

```
R1#ping 224.5.5.5  repeat 10
```

```
Type escape sequence to abort.
```

```
Sending 10, 100-byte ICMP Echos to 224.5.5.5, timeout is 2 seconds:
```

```
Reply to request 0 from 5.5.5.2, 48 ms
```

```
Reply to request 1 from 5.5.5.2, 24 ms
```

```
Reply to request 2 from 5.5.5.2, 48 ms
```

```
Reply to request 3 from 5.5.5.2, 48 ms
```

```
Reply to request 4 from 5.5.5.2, 108 ms
```

```
Reply to request 5 from 5.5.5.2, 44 ms
```

LAB : Reverse path Forwarding :

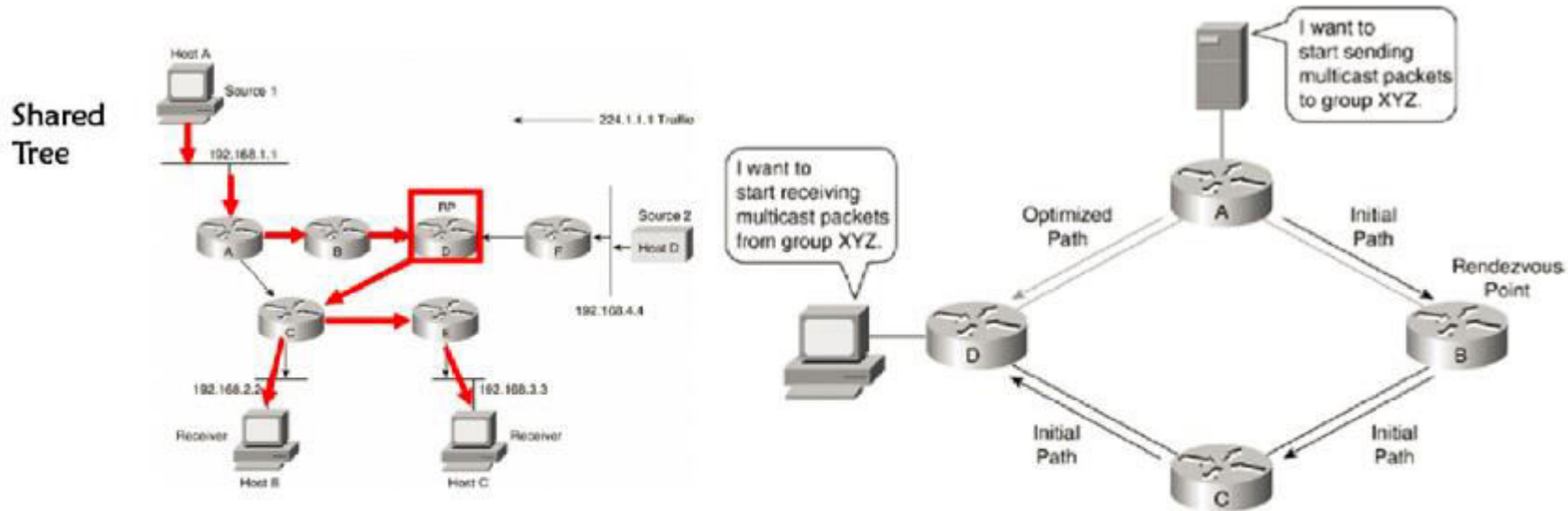
```
R4#sh ip mroute 224.5.5.5
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group, C - Connected,
       L - Local, P - Pruned, R - RP-bit set, F - Register flag,
       T - SPT-bit set, J - Join SPT, M - MSDP created entry,
       X - Proxy Join Timer Running, A - 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
Outgoing interface flags: H - Hardware switched, A - Assert winner
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.5.5.5), 00:06:19/stopped, RP 0.0.0.0, flags: D
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial5/2, Forward/Dense, 00:06:19/00:00:00
    Serial5/0, Forward/Dense, 00:06:19/00:00:00

(1.1.1.1, 224.5.5.5), 00:03:17/00:02:18, flags: T
  Incoming interface: Serial5/0, RPF nbr 3.3.3.1, Mroute
  Outgoing interface list:
    Serial5/2, Forward/Dense, 00:03:17/00:00:00

R4#
```

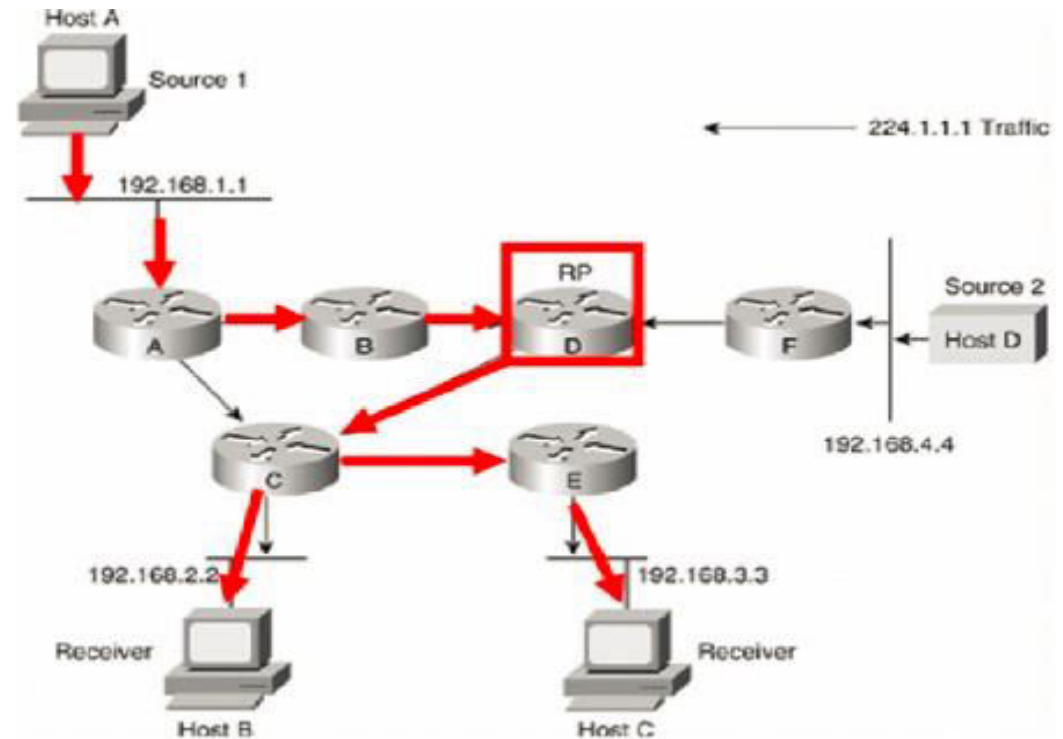
PIM Sparse Mode



- ▶ Uses Explicit Join (not receive unless you ask for)
- ▶ Uses both shared Tree & Source Tree
- ▶ More Scalable

PIM Sparse-Mode Operation

1. Discover PIM Neighbors
2. Discover the Root of the tree (RP).
3. RP listens to Source (PIM register)
4. RP listens to Destination (PIM join)
5. Builds Shared tree from Sender to Receiver through RP
6. Joins the Shortest path



PIM Sparse-Mode Operation

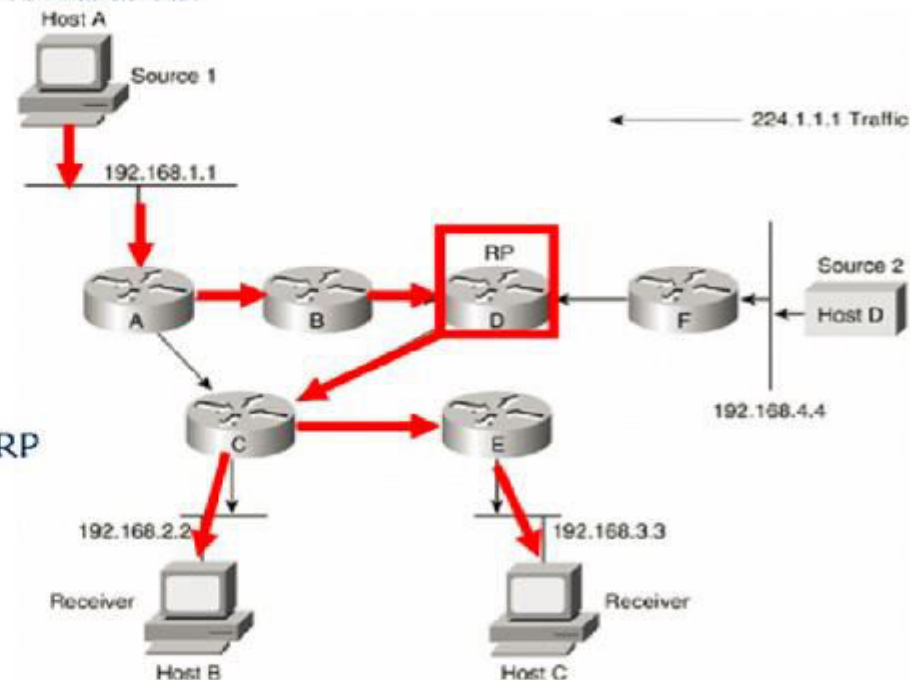
- ▶ Reference Point for the root of the shared tree
- ▶ RP learns about source using PIM register messages
 - (RP ack with Register stop and add (S,G))
- ▶ RP learns about destination using PIM join messages.
- ▶ Merge two trees together.
- ▶ Joining shortest path to source and Prune towards RP.

Rendezvous Point

What if there is no RP

1. Source cannot register
2. Joins can't be processed

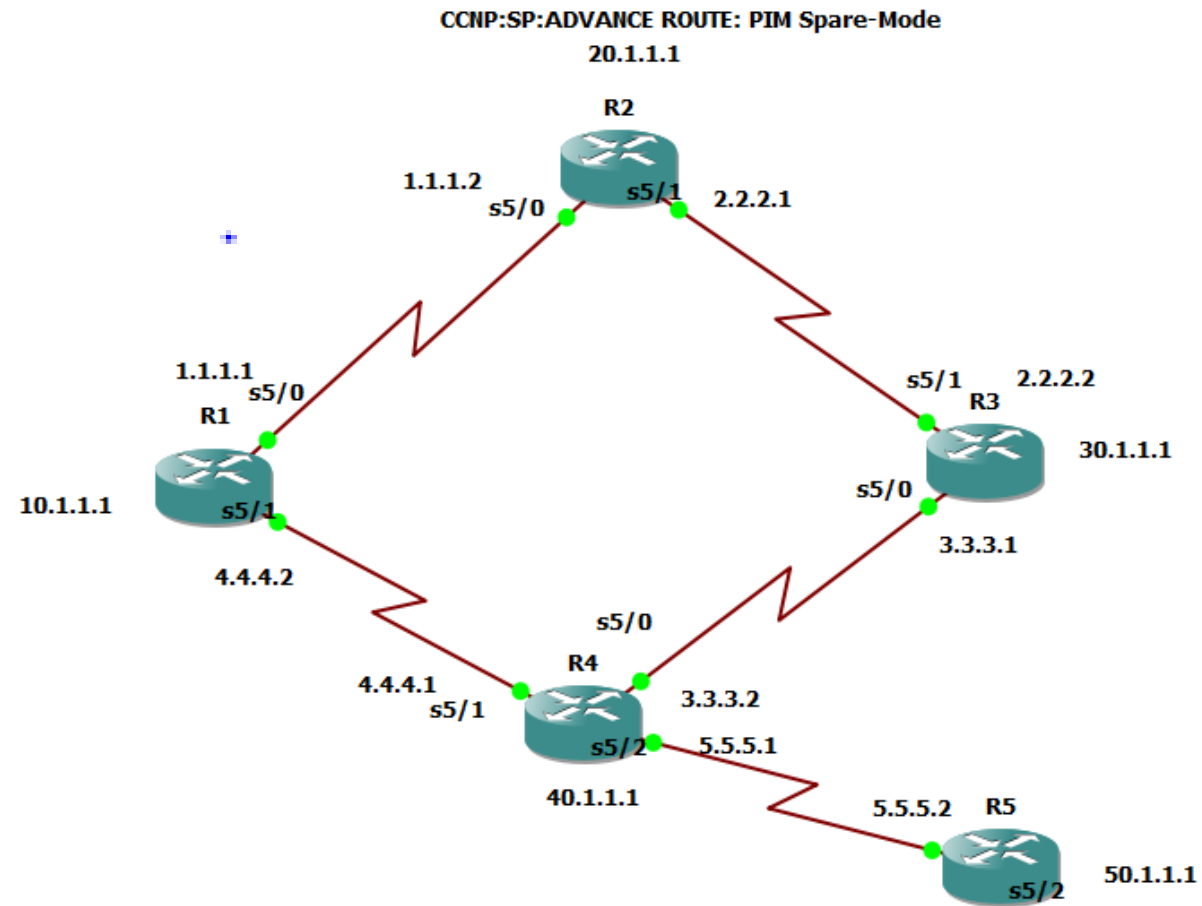
All the routers must agree on the common RP



PIM Sparse-mode Configuration

```
R4(config)#ip multicast-routing
R4(config)#int f0/0
R4(config-if)# ip pim sparse-mode
R4(config-if)# int sl/0
R4(config-if)# ip pim sparse-mode
R4(config-if)# int sl/T
R4(config-if)# ip pim sparse-mode
R4(config-if)# int sl/2
R4(config-if)# ip pim sparse-mode
R4(config-if)#end
Rx(config)#ip pim rp-address 13.0.0.1
```

LAB : PIM Sparse-Mode



LAB : PIM Sparse-Mode

TASK:

- Reconfigure the network using IP pim sparse -mode
- Remove the Mroute configured on R4
- R5 should only join group 224.5.5.5 on f0/0 for testing. (already configured)

```
R4(config)#no ip mroute 0.0.0.0 0.0.0.0 3.3.3.1
```

```
R5(config)# int f0/0
```

```
R5(config-if)# no ip pim dense-mode
```

```
R5(config-if)# ip pim sparse-mode
```

```
R5(config-if)# int f0/0
```

```
R5(config-if)# no ip pim dense-mode
```

```
R5(config-if)# ip pim sparse-mode
```

LAB : PIM Sparse-Mode

R4(config)#int f0/0

R4(config-if)# no ip pim dense-mode

R4(config-if)# ip pim sparse-mode

R4(config-if)# int s1/0

R4(config-if)# no ip pim dense-mode

R4(config-if)# ip pim sparse-mode

R4(config-if)# int s1/1

R4(config-if)# no ip pim dense-mode

R4(config-if)# ip pim sparse-mode

LAB : PIM Sparse-Mode

```
R4(config-if)# int sl/2
R4(config-if)# no ip pim dense-mode
R4(config-if)# ip pim sparse-mode
R4(config-if)#end
R3(config)#int f0/0
R3(config-if)# no ip pim dense-mode
R3(config-if)# ip pim sparse-mode
R3(config-if)# int sl/O
R3(config-if)# no ip pim dense-mode
R3(config-if)# ip pim sparse-mode
```

LAB : PIM Sparse-Mode

```
R3(config-if)# int sl/1
```

```
R3(config-if)# no ip pim dense-mode
```

```
R3(config-if)# ip pim sparse-mode
```

```
R3(config-if)#end
```

```
R2(config)#int f0/0
```

```
R2(config-if)# no ip pim dense-mode
```

```
R2(config-if)# ip pim sparse-mode
```

```
R2(config-if)# int sl/0
```

```
R2(config-if)# no ip pim dense-mode
```

```
R2(config-if)# ip pim sparse-mode
```

```
R2(config-if)#
```

LAB : PIM Sparse-Mode

```
R2(config-if)# int sl/1
```

```
R2(config-if)# no ip pim dense-mode
```

```
R2(config-if)# ip pim sparse-mode
```

```
R1(config)#int f0/0
```

```
R1(config-if)# no ip pim dense-mode
```

```
R1(config-if)# ip pim sparse-mode
```

```
R1(config-if)# int sl/0
```

```
R1(config-if)# no ip pim dense-mode
```

```
R1(config-if)# ip pim sparse-mode
```

```
R1(config-if)# int sl/1
```

```
R1(config-if)# no ip pim dense-mode
```

```
R1(config-if)# ip pim sparse-mode
```

LAB : PIM Sparse-Mode

```
R4#sh ip pim interface
```

Address	Interface	Ver/ Mode	Nbr Count	Query Intvl	DR Prior	DR
40.1.1.1	GigabitEthernet4/0	v2/S	0	30	1	40.1.1.1
4.4.4.1	Serial5/1	v2/S	1	30	1	0.0.0.0
3.3.3.2	Serial5/0	v2/S	1	30	1	0.0.0.0
5.5.5.1	Serial5/2	v2/S	1	30	1	0.0.0.0

```
R4#
```

```
R4#sh ip pim nei
```

```
R4#sh ip pim neighbor
```

```
PIM Neighbor Table
```

Mode: B - Bidir Capable, DR - Designated Router, N - Default DR Priority,
S - State Refresh Capable

Neighbor Address	Interface	Uptime/Expires	Ver	DR Prio/Mode
4.4.4.2	Serial5/1	00:00:35/00:01:38	v2	1 / S
3.3.3.1	Serial5/0	00:06:59/00:01:39	v2	1 / S
5.5.5.2	Serial5/2	00:07:46/00:01:20	v2	1 / S

```
R4#
```

LAB : PIM Sparse-Mode

TASK :

- Configure R3loopback 0 (13.0.0.1) as static RP on all routers
- Ensure that R3 loopback0 advertised in IGP with exact mask (/24 instead of /32)

```
R3#sh run int loopback 0
Building configuration...

Current configuration : 62 bytes
!
interface Loopback0
 ip address 13.0.0.1 255.255.255.0
end

R3#
```

LAB : PIM Sparse-Mode

```
R3(config)#router ospf 1
```

```
R3(config-router)#network 13.0.0.0 0.0.0.255 area 0
```

```
R3(config-router)#end
```

```
R2#sh ip route 13.0.0.0
Routing entry for 13.0.0.0/32, 1 known subnets
O        13.0.0.1 [110/65] via 2.2.2.2, 00:00:21, Serial5/1
R2#
```

```
R3(config)#int loop 0
```

```
R3(config-if)#ip ospf network point-to-point
```

```
R3(config-if)#end
```

```
R2#sh ip route 13.0.0.0
Routing entry for 13.0.0.0/24, 1 known subnets
O        13.0.0.0 [110/65] via 2.2.2.2, 00:00:14, Serial5/1
R2#
```

LAB : PIM Sparse-Mode

on all routers: (R1 to R5)

Rx(config)#ip pim rp-address 13.0.0.1

```
R5#sh ip pim rp mapping
PIM Group-to-RP Mappings

Group(s): 224.0.0.0/4, Static
          RP: 13.0.0.1 (?)
R5#
R5#
R5#sh run int gig4/0
Building configuration...

Current configuration : 139 bytes
!
interface GigabitEthernet4/0
 ip address 50.1.1.1 255.255.255.0
 ip pim sparse-mode
 ip igmp join-group 224.5.5.5
 negotiation auto
end
R5#
```

LAB : PIM Sparse-Mode

- Check on All Routers # sh ip mroute 224.5.5.5

```
R5#sh ip mroute 224.5.5.5
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
Outgoing interface flags: H - Hardware switched, A - Assert winner
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.5.5.5), 00:46:22/00:02:50, RP 13.0.0.1, flags: SJCL
  Incoming interface: Serial5/2, RPF nbr 5.5.5.1
  Outgoing interface list:
    GigabitEthernet4/0, Forward/Sparse, 00:46:22/00:02:50

R5#
```

LAB : PIM Sparse-Mode

Check on All Routers # sh ip mroute 224.5.5.5

```
R1#ping 224.5.5.5 repeat 10

Type escape sequence to abort.
Sending 10, 100-byte ICMP Echos to 224.5.5.5, timeout is 2 seconds:

Reply to request 0 from 5.5.5.2, 80 ms
Reply to request 0 from 5.5.5.2, 128 ms
Reply to request 0 from 5.5.5.2, 128 ms
Reply to request 1 from 5.5.5.2, 8 ms
Reply to request 1 from 5.5.5.2, 52 ms
Reply to request 1 from 5.5.5.2, 44 ms
Reply to request 2 from 5.5.5.2, 20 ms
Reply to request 2 from 5.5.5.2, 144 ms
Reply to request 3 from 5.5.5.2, 84 ms
Reply to request 3 from 5.5.5.2, 84 ms
Reply to request 4 from 5.5.5.2, 36 ms
Reply to request 4 from 5.5.5.2, 84 ms
Reply to request 5 from 5.5.5.2, 48 ms
Reply to request 5 from 5.5.5.2, 96 ms
Reply to request 6 from 5.5.5.2, 12 ms
Reply to request 6 from 5.5.5.2, 28 ms
Reply to request 7 from 5.5.5.2, 32 ms
Reply to request 7 from 5.5.5.2, 44 ms
```

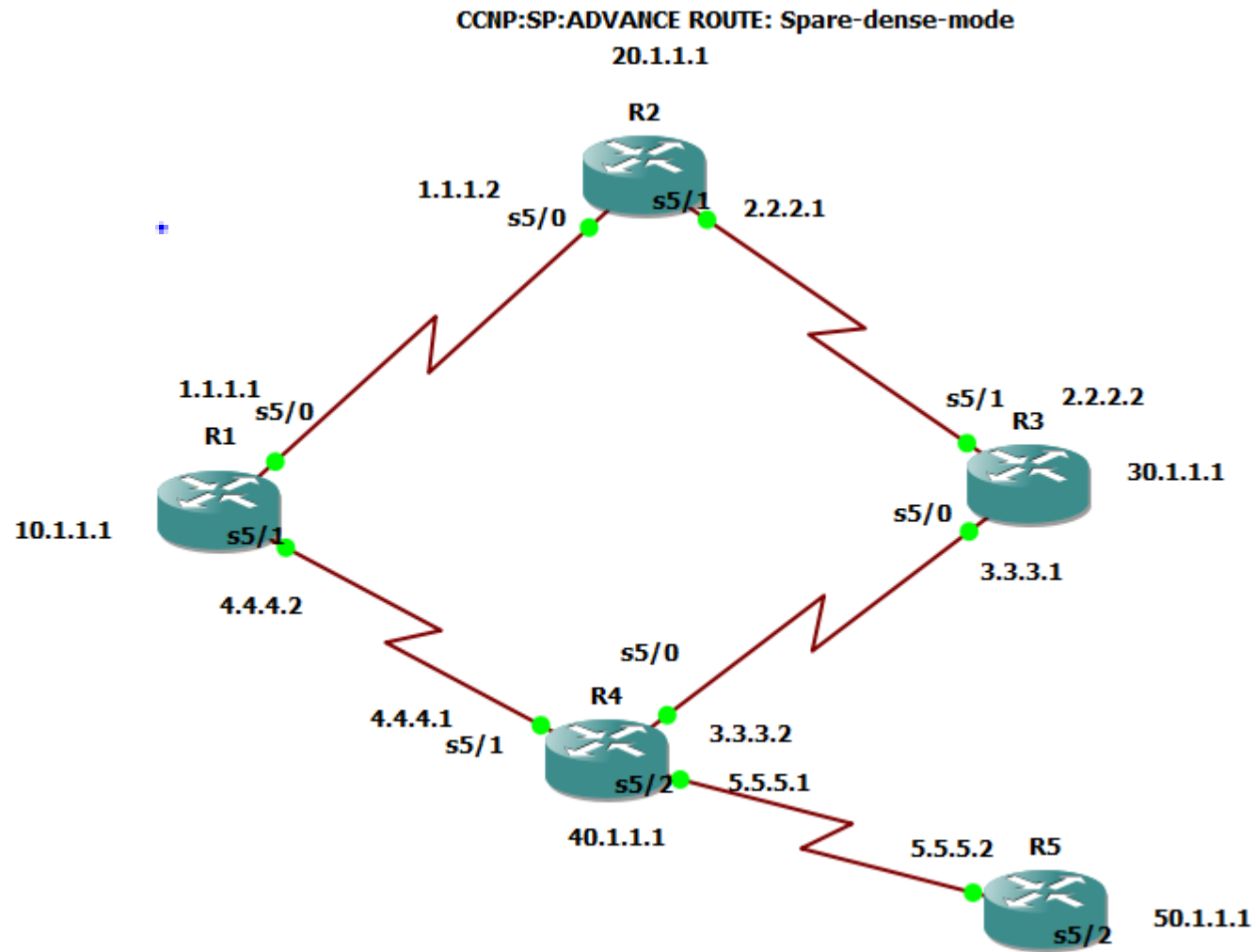
LAB : PIM Sparse-Mode

Check on All Routers # sh ip mroute 224.5.5.5

```
Interface state: Interface, Next-Hop or VCD, State/Mode
(*, 224.5.5.5), 01:43:57/stopped, RP 13.0.0.1, flags: SJCL
  Incoming interface: Serial5/2, RPF nbr 5.5.5.1
  Outgoing interface list:
    GigabitEthernet4/0, Forward/Sparse, 01:43:57/00:02:23
(1.1.1.1, 224.5.5.5), 00:00:17/00:02:58, flags: LJT
  Incoming interface: Serial5/2, RPF nbr 5.5.5.1
  Outgoing interface list:
    GigabitEthernet4/0, Forward/Sparse, 00:00:17/00:02:42
(4.4.4.2, 224.5.5.5), 00:00:17/00:02:58, flags: LJT
  Incoming interface: Serial5/2, RPF nbr 5.5.5.1
  Outgoing interface list:
    GigabitEthernet4/0, Forward/Sparse, 00:00:17/00:02:42
(10.1.1.1, 224.5.5.5), 00:00:17/00:02:54, flags: LJT
  Incoming interface: Serial5/2, RPF nbr 5.5.5.1
  Outgoing interface list:
    GigabitEthernet4/0, Forward/Sparse, 00:00:17/00:02:42
```

R5#

LAB : Sparse -dense-mode:



LAB : Sparse -dense-mode:

TASK :

- Reconfigure all the interfaces to run sparse-dense-mode.
- Modify the RP configuration ensure that R3 should be RP only for group 224.5.5.5

```
R5(config)# access-list 5 permit host 224.5.5.5
```

```
R5(config)# no ip pim rp-address 13.0.0.1
```

```
R5(config)#ip pim rp-address 13.0.0.1 5
```

```
R5(config)#int f0/0
```

```
R5(config-if)#no ip pim sparse-mode
```

```
R5(config-if)#ip pim sparse-dense-mode
```

```
R5(config-if)#int s1/0
```

```
R5(config-if)#no ip pim sparse-mode
```

```
R5(config-if)#ip pim sparse-dense-mode
```

LAB : Sparse -dense-mode:

```
R4(config)# access-list 5 permit host 224.5.5.5
```

```
R4(config)# no ip pim rp-address 13.0.0.1
```

```
R4(config)# ip pim rp-address 13.0.0.1 5
```

```
R4(config)# int f0/0
```

```
R4(config-if)# no ip pim sparse-mode
```

```
R4(config-if)# ip pim sparse-dense-mode
```

```
R4(config-if)#
```

```
R4(config-if)# int sl/0
```

```
R4(config-if)# no ip pim sparse-mode
```

```
R4(config-if)# ip pim sparse-dense-mode
```

```
R4(config-if)# int sl/1
```

```
R4(config-if)# no ip pim sparse-mode
```

```
R4(config-if)# ip pim sparse-dense-mode
```

LAB : Sparse -dense-mode:

```
R4(config-if)# int sl/2
R4(config-if)# no ip pim sparse-mode
R4(config-if)# ip pim sparse-dense-mode
R4(config-if)#end
R3(config-if)# access-list 5 permit host 224.5.5.5
R3(config)# no ip pim rp-address 13.0.0.1
R3(config)# ip pim rp-address 13.0.0.1 5
R3(config)# int f0/0
R3(config-if)# no ip pim sparse-mode
R3(config-if)# ip pim sparse-dense-mode
R3(config-if)# int sl/0
R3(config-if)# no ip pim sparse-mode
R3(config-if)# ip pim sparse-dense-mode
```

LAB : Sparse -dense-mode:

```
R3(config-if)# int sl/1
```

```
R3(config-if)# no ip pim sparse-mode
```

```
R3(config-if)# ip pim sparse-dense-mode
```

```
R3(config-if)#end
```

```
R2(config)# access-list 5 permit host 224.5.5.5
```

```
R2(config)# no ip pim rp-address 13.0.0.1
```

```
R2(config)# ip pim rp-address 13.0.0.1 5
```

```
R2(config)# int f0/0
```

```
R2(config-if)# no ip pim sparse-mode
```

```
R2(config-if)# ip pim sparse-dense-mode
```

LAB : Sparse -dense-mode:

```
R2(config-if)# int sl/0
R2(config-if)# no ip pim sparse-mode
R2(config-if)# ip pim sparse-dense-mode
R2(config-if)# int sl/1
R2(config-if)# no ip pim sparse-mode
R2(config-if)# ip pim sparse-dense-mode
R2(config-if)#end
R1(config)# access-list 5 permit host 224.5.5.5
R1(config)# no ip pim rp-address 13.0.0.1
R1(config)# ip pim rp-address 13.0.0.1 5
```

LAB : Sparse -dense-mode:

```
R1(config)# int f0/0
R1(config-if)# no ip pim sparse-mode
R1(config-if)# ip pim sparse-dense-mode
R1(config-if)#
R1(config-if)# int s1/0
R1(config-if)# no ip pim sparse-mode
R1(config-if)# ip pim sparse-dense-mode
R1(config-if)# int s1/1
R1(config-if)# no ip pim sparse-mode
R1(config-if)# ip pim sparse-dense-mode
R1(config-if)#end
```

LAB : Sparse -dense-mode:

TASK:

- Configure R5 to join group 224.50.50.50 and ensure that R1 should be able to ping the multicast group 224.50.50.50 without RP.

```
R5(config)#int f0/0
```

```
R5(config-if)#ip igmp join-group 224.50.50.50
```

```
R5(config-if)#end
```

LAB : Sparse -dense-mode:

```
R1#ping 224.5.5.5 re 5
```

```
Type escape sequence to abort.
```

```
Sending 5, 100-byte ICMP Echos to 224.5.5.5, timeout is 2 seconds:
```

```
Reply to request 0 from 5.5.5.2, 128 ms
```

```
Reply to request 0 from 5.5.5.2, 152 ms
```

```
Reply to request 0 from 5.5.5.2, 140 ms
```

```
Reply to request 1 from 5.5.5.2, 28 ms
```

```
Reply to request 1 from 5.5.5.2, 52 ms
```

```
Reply to request 1 from 5.5.5.2, 28 ms
```

```
Reply to request 2 from 5.5.5.2, 28 ms
```

```
Reply to request 2 from 5.5.5.2, 40 ms
```

```
Reply to request 3 from 5.5.5.2, 44 ms
```

```
Reply to request 3 from 5.5.5.2, 56 ms
```

```
Reply to request 4 from 5.5.5.2, 40 ms
```

```
Reply to request 4 from 5.5.5.2, 96 ms
```

```
R1#
```

LAB : Sparse -dense-mode

Check on All Routers # sh ip mroute 224.5.5.5

```
Outgoing interface flags: H - Hardware switched, A - Assert winner
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.5.5.5), 00:01:55/stopped, RP 13.0.0.1, flags: SPF
  Incoming interface: Serial5/1, RPF nbr 4.4.4.1
  Outgoing interface list: Null

(1.1.1.1, 224.5.5.5), 00:01:55/00:01:42, flags: FT
  Incoming interface: Serial5/0, RPF nbr 0.0.0.0, Registering
  Outgoing interface list:
    Serial5/1, Forward/Sparse-Dense, 00:01:55/00:02:33

(10.1.1.1, 224.5.5.5), 00:01:55/00:01:42, flags: FT
  Incoming interface: GigabitEthernet4/0, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial5/1, Forward/Sparse-Dense, 00:01:55/00:02:34

R1#
```

LAB : Sparse -dense-mode

Ping from R1# 224.50.50.50

```
R1#ping 224.50.50.50 re 10

Type escape sequence to abort.
Sending 10, 100-byte ICMP Echos to 224.50.50.50, timeout is 2 seconds:

Reply to request 0 from 5.5.5.2, 48 ms
Reply to request 1 from 5.5.5.2, 36 ms
Reply to request 2 from 5.5.5.2, 56 ms
Reply to request 3 from 5.5.5.2, 24 ms
Reply to request 4 from 5.5.5.2, 20 ms
Reply to request 5 from 5.5.5.2, 20 ms
Reply to request 6 from 5.5.5.2, 16 ms
Reply to request 7 from 5.5.5.2, 56 ms
Reply to request 8 from 5.5.5.2, 52 ms
Reply to request 9 from 5.5.5.2, 20 ms
R1#
```

IP MULTICASTING

- Check on All Routers # sh ip mroute 224.5.5.5

```
R5#sh ip mroute 224.50.50.50
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
Outgoing interface flags: H - Hardware switched, A - Assert winner
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.50.50.50), 00:06:45/stopped, RP 0.0.0.0, flags: DCL
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial5/2, Forward/Sparse-Dense, 00:06:45/00:00:00
    GigabitEthernet4/0, Forward/Sparse-Dense, 00:06:45/00:00:00

(4.4.4.2, 224.50.50.50), 00:01:22/00:02:07, flags: LT
  Incoming interface: Serial5/2, RPF nbr 5.5.5.1
  Outgoing interface list:
    GigabitEthernet4/0, Forward/Sparse-Dense, 00:01:22/00:00:00
```

IP Multicast Routing - Rendezvous point (Static, Auto RP, BSR)

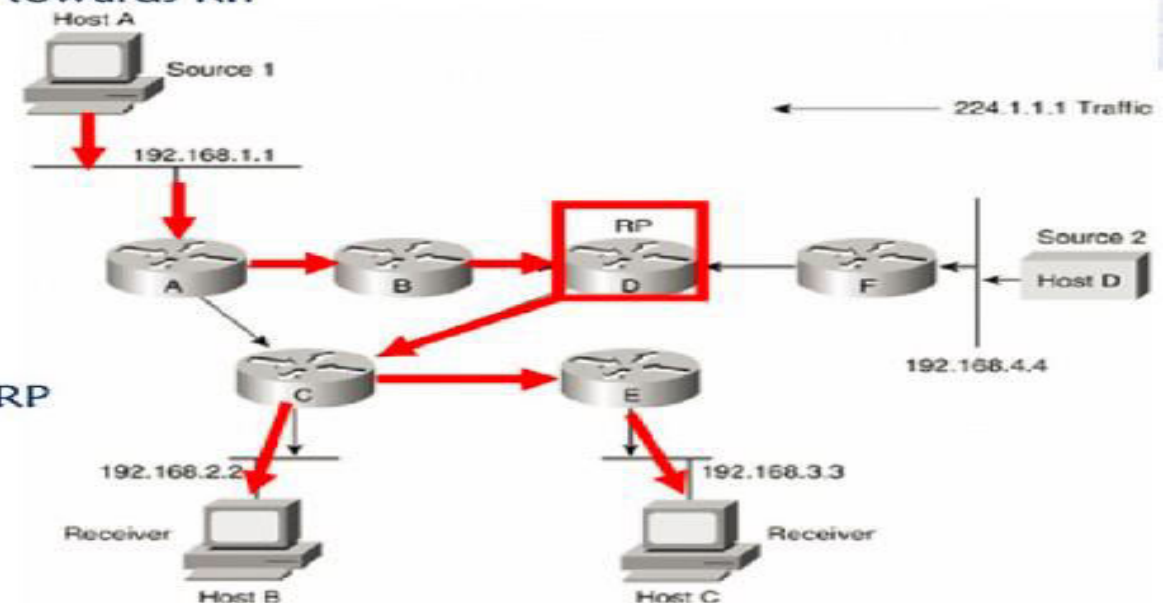
- ▶ Reference Point for the root of the shared tree
- ▶ RP learns about source using PIM register messages
 - (RP ack with Register stop and add (S,G))
- ▶ RP learns about destination using PIM join messages.
- ▶ Merge two trees together.
- ▶ Joining shortest path to source and Prune towards RP.

Rendezvous Point

What if there is no RP

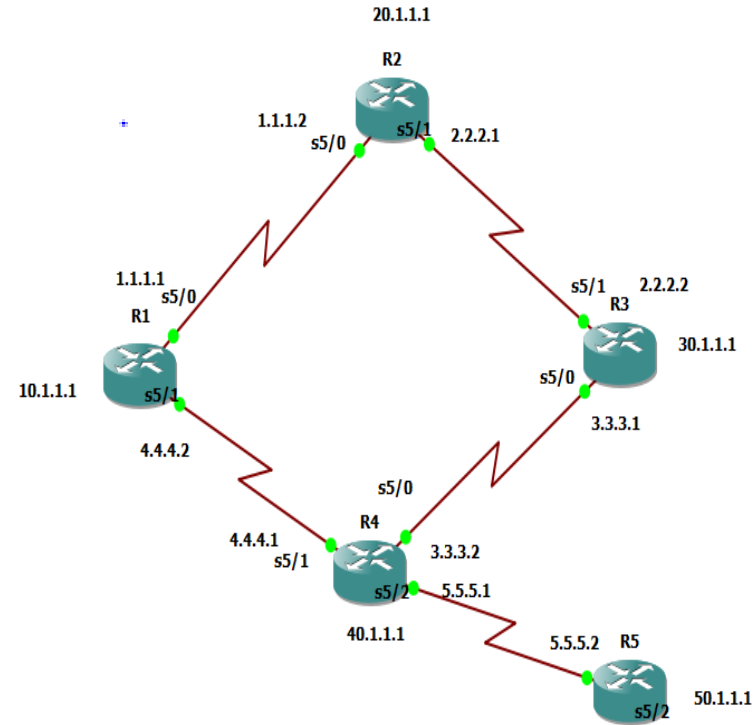
1. Source cannot register
2. Joins can't be processed

All the routers must agree on the common RP



Configuring RP

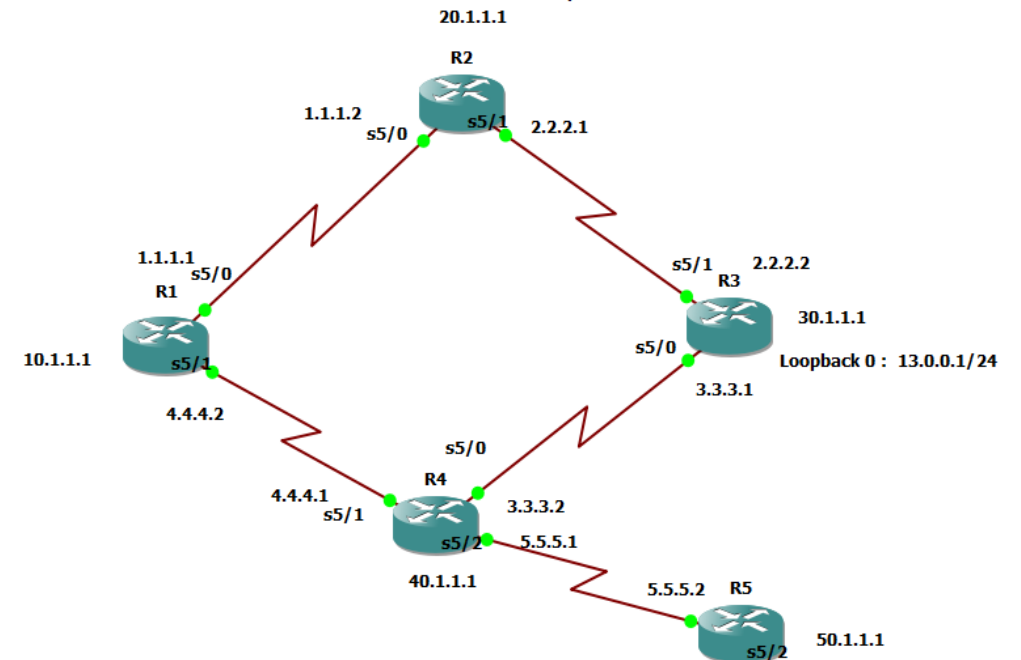
1. Statically
2. Dynamically
 1. Auto-RP
 2. BSR



Static RP

- ° Manual RP address must be configured on every router
- ° All routers must have the same RP address
- ° RP fail-over not possible

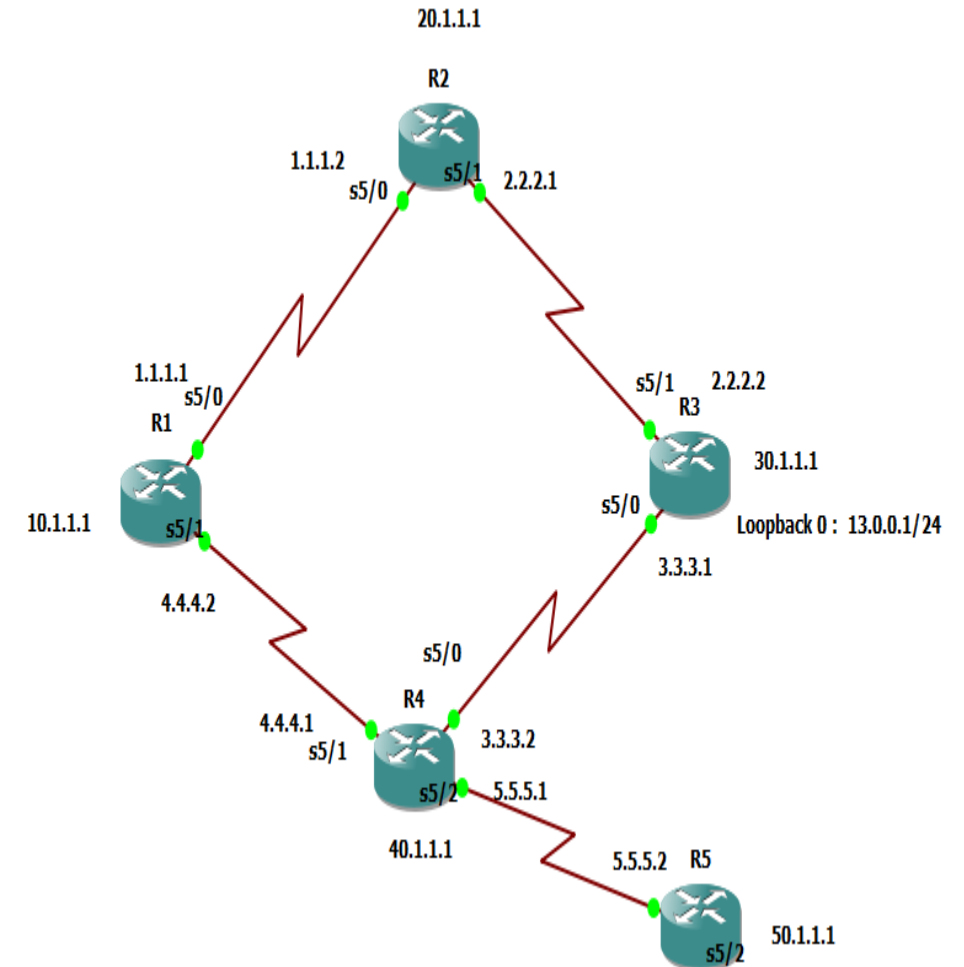
Rx(config)#ip pim rp-address 13.0.0.1



PIM Sparse-mode Configuration

```
R4(config)#ip multicast-routing
R4(config)#int f0/0
R4(config-if)# ip pim sparse-mode
R4(config-if)# int s1/0
R4(config-if)# ip pim sparse-mode
R4(config-if)# int s1/1
R4(config-if)# ip pim sparse-mode
R4(config-if)# int s1/2
R4(config-if)# ip pim sparse-mode
R4(config-if)#end

Rx(config)#ip pim rp-address 13.0.0.1
```



Auto-RP

- Legacy cisco proprietary method of Learning RP information
- All routers automatically learn RP address
- No configuration necessary except on:
 - **Candidate RPs (Device willing to become RP)**
 - **Mapping Agents (chooses the RP and relays this information to rest of the PIM Domain)**
- Permits backup RP's to be configured

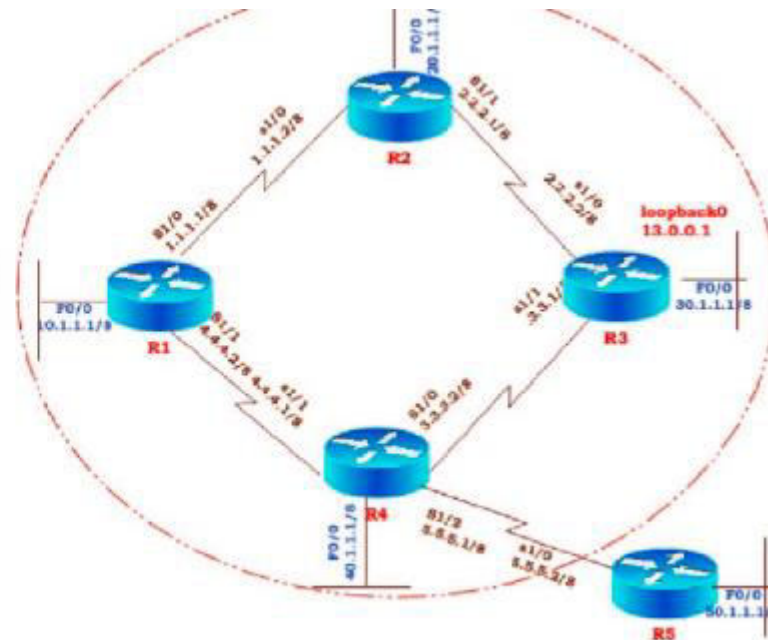
Auto RP Configuration

```
R3(config)#ip pim send-rp-announce loopback 0 scope 10
```

```
R3(config)#ip pim send-rp-discovery loopback 0 scope 10
```

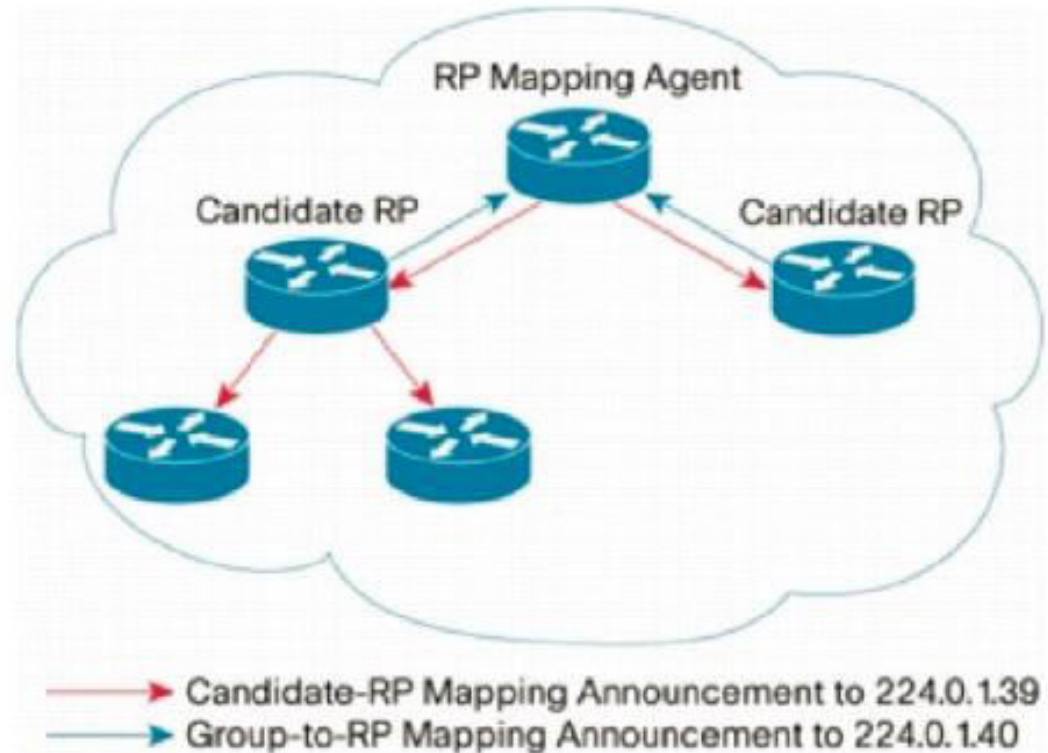
```
R3#sh ip pim rp mapping
PIM Group-to-RP Mappings
This system is an RP (Auto-RP)
This system is an RP-mapping agent (Loopback0)

Group(s) 224.0.0.0/4
RP 13.0.0.1 (?), v2v1
Info source: 13.0.0.1 (?), elected via Auto-RP
Uptime: 00:01:02, expires: 00:02:54
```



How Auto-RP works

1. Candidate RP generate advertisements using (S, 224.0.1.39) and Groups with group information
2. Mapping Agent listens for (*,224.0.1.39) to learn about RP mappings.
3. Mapping Agent generate Advertisement using (S, 224.0.1.40) to distribute RP mapping information.

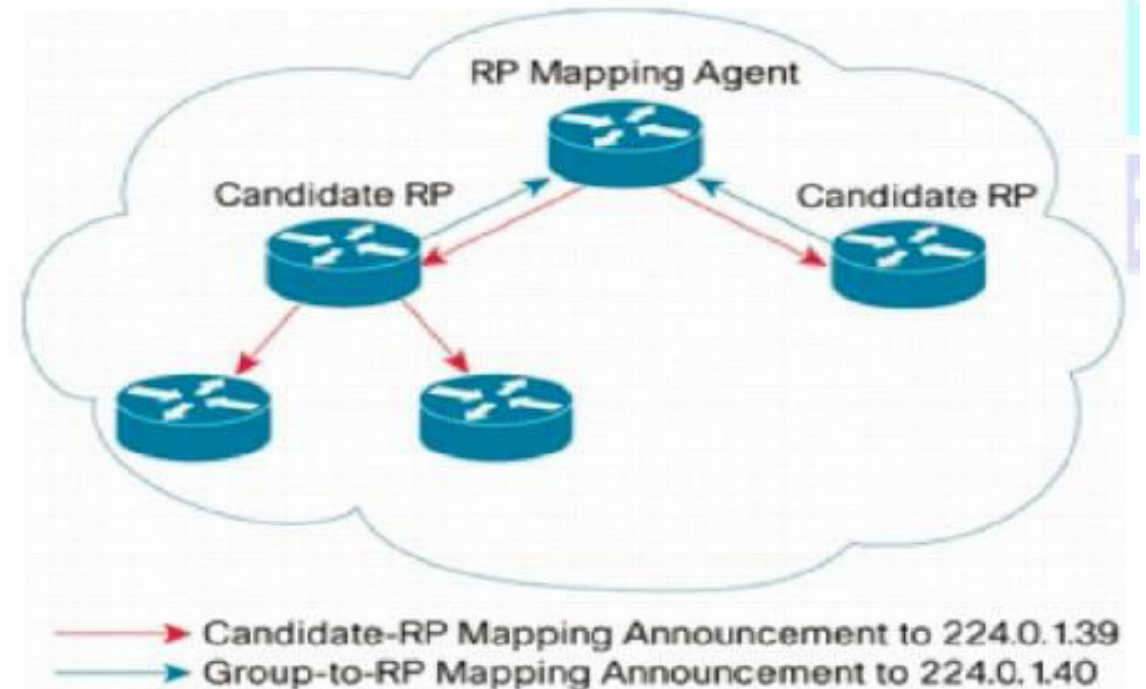


How Auto-RP works (Cont.)

- ▶ Every Router must join 224.0.1.39 & 224.0.1.40 for learning information from mapping agent
- ▶ by default using sparse-mode other routers cannot join 224.0.1.40 (mapping agent)

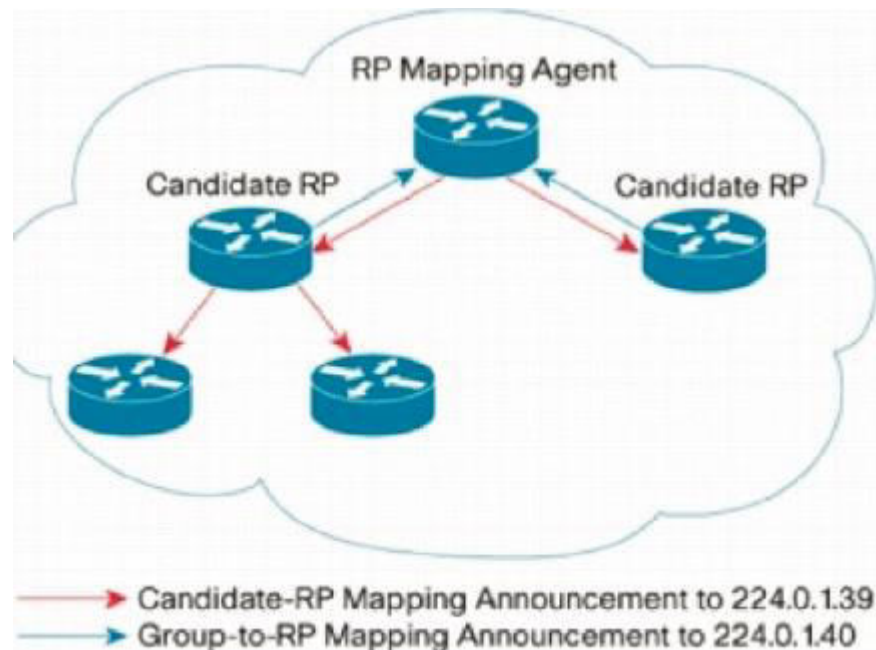
possible solutions:

1. use PIM Sparse-dense-mode
2. default static RP assignment for 224.0.1.39 & 224.0.1.40
3. Auto-RP listener



Auto -RP with Multiple RP

- Provides Redundancy & load sharing
- ACL can be applied to control which RP server which group
- If multiple RP configured mapping agent selects the best highest IP
- Cannot use two RP same time for same group



Auto RP with multiple RP Configuration

R2(Config)# access-list TO permit host 224.2.2.2

R2(Config)# ip pirn send-rp-announce LoopbackO scope 32 group-list 10

R2(Config) # ip pirn send-rp-discovery LoopbackO scope 32

R3(Config)# access-list T1 permit host 224.3.3.3

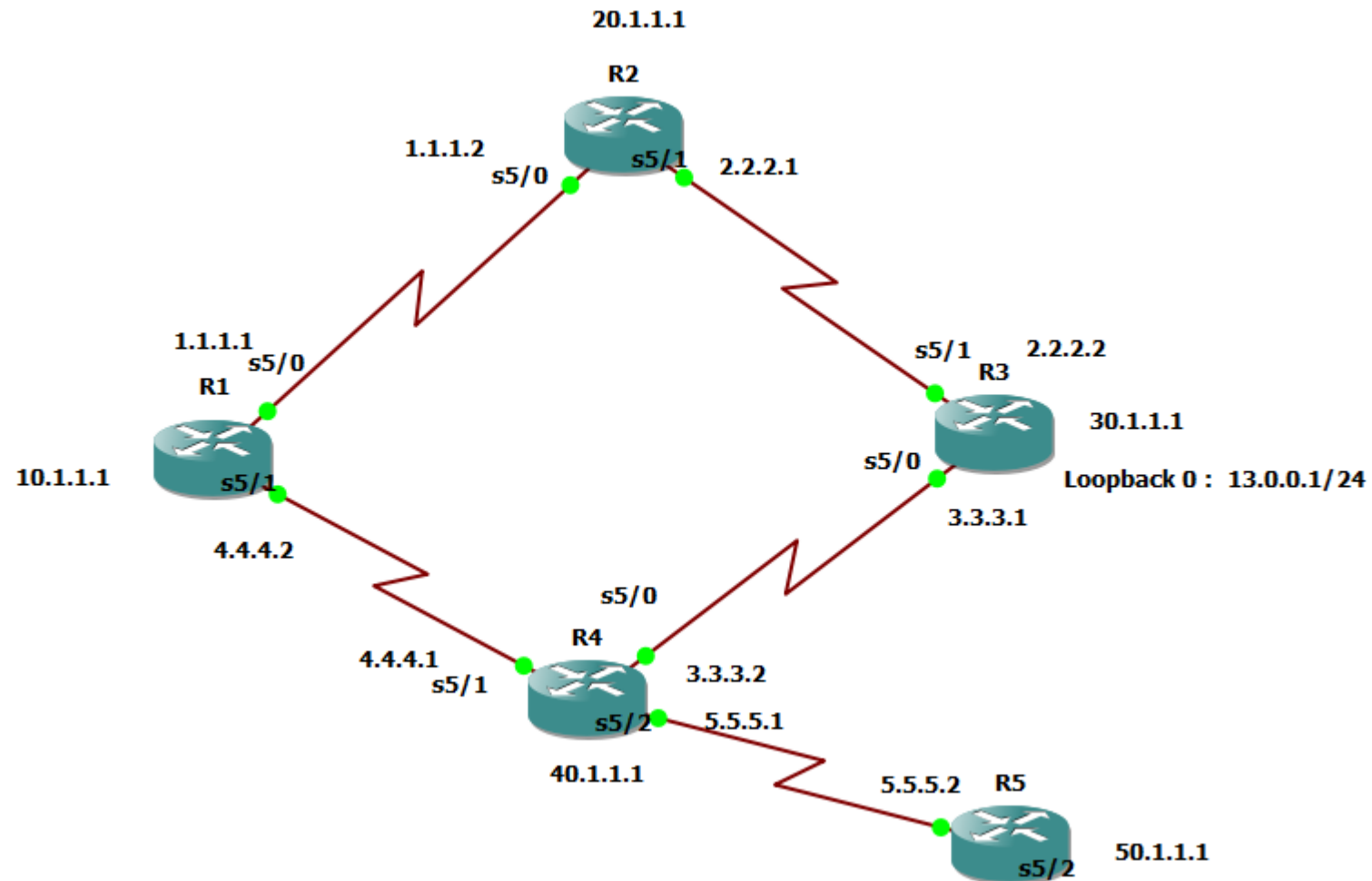
R3(Config)# ip pim send-rp-announce LoopbackO scope 32 group-list 11

R3(Config)# ip pim send-rp-discovery LoopbackO scope 32

Drawbacks of Auto-RP

- Cisco proprietary.
- Need to learn about 224.0.1.39/40
- Not used in IPv6 Multicast.

LAB : Auto RP



LAB : Auto RP

TASK:

- Remove ACL & sparse-dense mode and reconfigure using sparse-mode on all interfaces.
- Remove the static RP configuration.
- For Testing R5 is already configured with join group for 224.5.5.5 & 224.50.50.50

LAB : Auto RP

```
R5(config)#no access-list 5
R5(config)#no ip pirn rp-address 13.0.0.1 5
R5(config)# int f0/0
R5(config-if)#no ip pirn sparse-dense-mode
R5(config-if)# ip pirn sparse-mode
R5(config-if)#exit
R5(config)# int s1/0
R5(config-if)#no ip pirn sparse-dense-mode
R5(config-if)# ip pirn sparse-mode
R5(config-if)#end
```

LAB : Auto RP

```
R4(config)#no access-list 5
```

```
R4(config)#no ip pirn rp-address 13.0.0.1 5
```

```
R4(config)#
```

```
R4(config)# int f0/0
```

```
R4(config-if)#no ip pirn sparse-dense-mode
```

```
R4(config-if)# ip pirn sparse-mode
```

```
R4(config-if)#
```

LAB : Auto RP

R4(config-if)# int sl/O

R4(config-if)#no ip pim sparse-dense-mode

R4(config-if)# ip pim sparse-mode

R4(config-if)# int sl/1

R4(config-if)#no ip pim sparse-dense-mode

R4(config-if)# ip pim sparse-mode

R4(config-if)# int sl/2

R4(config-if)#no ip pim sparse-dense-mode

R4(config-if)# ip pim sparse-mode

LAB : Auto RP

```
R3(config)#no access-list 5
R3(config)#no ip pim rp-address 13.0.0.1 5
R3(config)# int f0/0
R3(config-if)#no ip pim sparse-dense-mode
R3(config-if)# ip pim sparse-mode
R3(config-if)# int s1/0
R3(config-if)#no ip pim sparse-dense-mode
R3(config-if)# ip pim sparse-mode
R3(config-if)# int s1/1
R3(config-if)#no ip pim sparse-dense-mode
R3(config-if)# ip pim sparse-mode
R3(config-if)#end
```

LAB : Auto RP

```
R2(config)#no access-list 5
R2(config)#no ip pim rp-address 13.0.0.1 5
R2(config)# int f0/0
R2(config-if)#no ip pim sparse-dense-mode
R2(config-if)# ip pim sparse-mode
R2(config-if)# int s1/0
R2(config-if)#no ip pim sparse-dense-mode
R2(config-if)# ip pim sparse-mode
R2(config-if)# int s1/1
R2(config-if)#no ip pim sparse-dense-mode
R2(config-if)# ip pim sparse-mode
R2(config-if)#end
```

LAB : Auto RP

```
R1(config)#no access-list 5
R1(config)#no ip pim rp-address 13.0.0.1 5
R1(config)# int f0/0
R1(config-if)#no ip pim sparse-dense-mode
R1(config-if)# ip pim sparse-mode
R1(config-if)#
R1(config-if)# int s1/0
R1(config-if)#no ip pim sparse-dense-mode
R1(config-if)# ip pim sparse-mode
R1(config-if)#
R1(config-if)# int s1/1
R1(config-if)#no ip pim sparse-dense-mode
R1(config-if)# ip pim sparse-mode
```

LAB : Auto RP

```
R4#sh ip pim interface
```

Address	Interface	Ver/ Mode	Nbr Count	Query Intvl	DR Prior	DR
40.1.1.1	GigabitEthernet4/0	v2/S	0	30	1	40.1.1.1
3.3.3.2	Serial5/0	v2/S	1	30	1	0.0.0.0
4.4.4.1	Serial5/1	v2/S	1	30	1	0.0.0.0
5.5.5.1	Serial5/2	v2/S	1	30	1	0.0.0.0

```
R4#
```

```
R4#sh ip pim nei
```

```
PIM Neighbor Table
```

```
Mode: B - Bidir Capable, DR - Designated Router, N - Default DR Priority,  
      S - State Refresh Capable
```

Neighbor Address	Interface	Uptime/Expires	Ver	DR Prio/Mode
3.3.3.1	Serial5/0	00:03:08/00:01:34	v2	1 / S
4.4.4.2	Serial5/1	00:00:50/00:01:23	v2	1 / S
5.5.5.2	Serial5/2	00:04:25/00:01:44	v2	1 / S

```
R4#
```

LAB : Auto RP

```
R2#sh ip pim interface
```

Address	Interface	Ver/ Mode	Nbr Count	Query Intvl	DR Prior	DR
20.1.1.1	GigabitEthernet4/0	v2/S	0	30	1	20.1.1.1
1.1.1.2	Serial5/0	v2/S	1	30	1	0.0.0.0
2.2.2.1	Serial5/1	v2/S	1	30	1	0.0.0.0

```
R2#
```

```
R2#sh ip pim nei
```

```
R2#sh ip pim neighbor
```

```
PIM Neighbor Table
```

Mode: B - Bidir Capable, DR - Designated Router, N - Default DR Priority,
S - State Refresh Capable

Neighbor Address	Interface	Uptime/Expires	Ver	DR Prio/Mode
1.1.1.1	Serial5/0	00:02:31/00:01:41	v2	1 / S
2.2.2.2	Serial5/1	00:03:29/00:01:41	v2	1 / S

```
R2#
```

LAB : Auto RP

```
R1#ping 224.5.5.5 re 5
```

```
Type escape sequence to abort.
```

```
Sending 5, 100-byte ICMP Echos to 224.5.5.5, timeout is 2 seconds:
```

```
.....
```

```
R1#
```

LAB : Auto RP

TASK:

- Configure R3 loopback0 to be RP and mapping agent for all multicast groups..
- R3 loopback 0 is already advertised in IGP for reachability.

```
R3(config)#int loop 0
```

```
R3(config-if)#ip pirn sparse-mode
```

```
R3(config-if)#exit
```

```
R3(config)#ip pirn send-rp-announce loopback 0 scope 10
```

```
R3(config)#ip pirn send-rp-discovery loopback 0 scope 10
```

```
R3(config)#end
```

LAB : Auto RP

- What is Multicasting
- Sending a message from a single source to selected multiple destinations

LAB : Auto RP

```
R3#sh ip pim rp mapping
PIM Group-to-RP Mappings
This system is an RP (Auto-RP)
This system is an RP-mapping agent (Loopback0)

R3#
```

LAB : Auto RP

Check on All Routers # sh ip mroute 224.5.5.5

```
Outgoing interface flags: H - Hardware switched, A - Assert winner
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.0.1.39), 00:02:19/stopped, RP 0.0.0.0, flags: DCL
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
  Loopback0, Forward/Sparse, 00:02:08/00:02:50
  Serial5/1, Forward/Sparse, 00:02:08/00:01:40
  Serial5/0, Forward/Sparse, 00:02:08/00:01:40
  GigabitEthernet4/0, Forward/Sparse, 00:02:08/00:02:48

(13.0.0.1, 224.0.1.39), 00:02:19/00:02:40, flags: LT
Incoming interface: Loopback0, RPF nbr 0.0.0.0
Outgoing interface list:
  Serial5/1, Forward/Sparse, 00:02:08/00:01:40
  Serial5/0, Forward/Sparse, 00:02:08/00:01:40
  GigabitEthernet4/0, Forward/Sparse, 00:02:08/00:02:48

(*, 224.0.1.40), 00:04:01/stopped, RP 0.0.0.0, flags: DCL
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
```

LAB : Auto RP

by default using sparse-mode other routers cannot join 224.0.1.40 (mapping agent)
possible solutions:

- 1) use PIM Sparse-dense-mode
- 2) default static RP assignment for 224.0.1.39 & 224.0.1.40
- 3) Auto-RP listener

On all routers :

```
Rx(config)#access-list 40 permit 224.0.1.39
```

```
Rx(config)#access-list 40 permit 224.0.1.40
```

```
Rx(config)#ip pirn rp-address 13.0.0.1 40
```

LAB : Auto RP

```
R1#sh ip pim rp mapping
PIM Group-to-RP Mappings

Acl: 40, Static
    RP: 13.0.0.1 (?)
R1#
```

```
R5#sh ip pim rp mapping
PIM Group-to-RP Mappings

Group(s) 224.0.0.0/4
    RP 13.0.0.1 (?), v2v1
        Info source: 13.0.0.1 (?), elected via Auto-RP
        Uptime: 00:00:49, expires: 00:02:10
Acl: 40, Static
    RP: 13.0.0.1 (?)
R5#
```

LAB : Auto RP

```
R1#ping 224.5.5.5 re 10
```

```
Type escape sequence to abort.
```

```
Sending 10, 100-byte ICMP Echos to 224.5.5.5, timeout is 2 seconds:
```

```
Reply to request 0 from 5.5.5.2, 28 ms
Reply to request 0 from 5.5.5.2, 72 ms
Reply to request 0 from 5.5.5.2, 60 ms
Reply to request 1 from 5.5.5.2, 32 ms
Reply to request 1 from 5.5.5.2, 64 ms
Reply to request 1 from 5.5.5.2, 64 ms
Reply to request 1 from 5.5.5.2, 32 ms
Reply to request 2 from 5.5.5.2, 32 ms
Reply to request 2 from 5.5.5.2, 72 ms
Reply to request 2 from 5.5.5.2, 60 ms
Reply to request 3 from 5.5.5.2, 36 ms
Reply to request 3 from 5.5.5.2, 120 ms
Reply to request 4 from 5.5.5.2, 28 ms
Reply to request 4 from 5.5.5.2, 84 ms
Reply to request 5 from 5.5.5.2, 72 ms
Reply to request 5 from 5.5.5.2, 72 ms
Reply to request 6 from 5.5.5.2, 68 ms
```

LAB : Auto RP

TASK:

- Remove The Static RP configured in the previous task
- Ensure that all routers can listen to Auto-RP announcements and able to reach the receiver 224.5.5.5 on R5

Auto-RP listener

- is another solution designed to allow using Auto-RP without risking any groups falling back to dense mode forwarding.
- This feature works with PIM sparse mode enabled on all interfaces (not PIM SM/DM).
- However, two Auto-RP multicast groups 224.0.1.39 and 224.0.1.40 are flooded in dense mode.
- No other groups are allowed to use dense mode and thus dangerous flooding fallback is eliminated.

LAB : Auto RP

Check on All Routers # sh ip mroute 224.5.5.5

```
R3#sh ip pim rp mapping
PIM Group-to-RP Mappings
This system is an RP (Auto-RP)
This system is an RP-mapping agent (Loopback0)

Group(s) 224.0.0.0/4
  RP 13.0.0.1 (?), v2v1
    Info source: 13.0.0.1 (?), elected via Auto-RP
      Uptime: 00:09:14, expires: 00:02:44
Acl: 40, Static
  RP: 13.0.0.1 (?)
R3#
```

IP MULTICASTING

on all routers

Rx(config)#ip pirn autorp listener

Check on All Routers # sh ip mroute 224.5.5.5

```
R5#sh ip pim rp mapping
PIM Group-to-RP Mappings

Group(s) 224.0.0.0/4
  RP 13.0.0.1 (?), v2v1
    Info source: 13.0.0.1 (?), elected via Auto-RP
      Uptime: 00:06:23, expires: 00:02:32
Acl: 40, Static
  RP: 13.0.0.1 (?)
R5#
```

LAB : Auto RP

- TASK: remove R3 as Mapping agent and Reconfigure R2 :

```
R3#sh run | in pim
ip pim sparse-mode
ip pim sparse-mode
ip pim sparse-mode
ip pim sparse-mode
ip pim rp-address 13.0.0.1 40
ip pim autorp listener
ip pim send-rp-announce Loopback0 scope 10
ip pim send-rp-discovery Loopback0 scope 10
R3#
```

LAB : Auto RP

```
R3(config)#no ip pirn send-rp-discovery Loopback0 scope 10
```

```
R2(config)#router ospf 1
```

```
R2(config-router)#network 12.0.0.0 0.0.0.255 area 0
```

```
R2(config-router)#exit
```

```
R2(config)#int loop 0
```

```
R2(config-if)#ip pirn sparse-mode
```

```
R2(config-if)#exit
```

```
R2(config-if)#ip pirn send-rp-discovery Loopback0 scope 10
```

```
R2(config)#end
```

LAB : Auto RP

```
R2#sh ip pim rp mapping
PIM Group-to-RP Mappings
This system is an RP-mapping agent

Group(s) 224.0.0.0/4
  RP 13.0.0.1 (?), v2v1
    Info source: 13.0.0.1 (?), elected via Auto-RP
    Uptime: 00:19:09, expires: 00:01:59
Acl: 40, Static
  RP: 13.0.0.1 (?)
R2#
```

```
R3#sh ip pim rp mapping
PIM Group-to-RP Mappings
This system is an RP (Auto-RP)
This system is an RP-mapping agent (Loopback0)

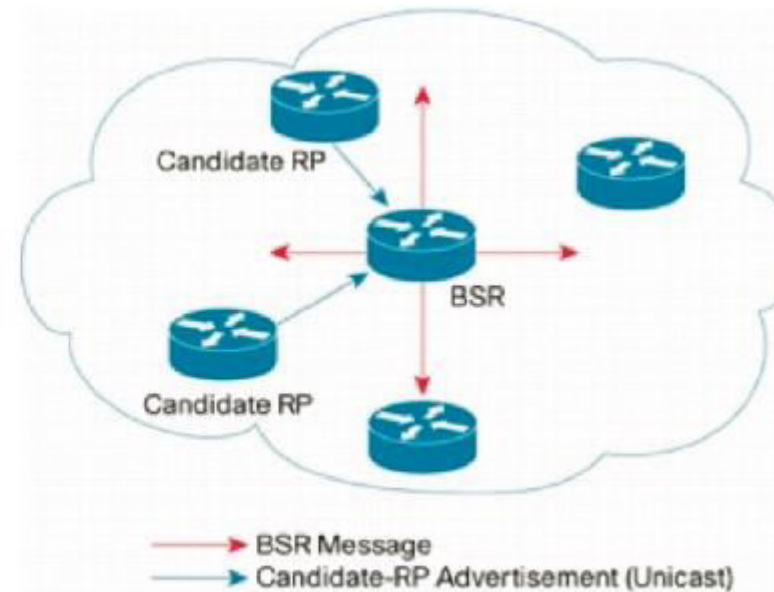
Group(s) 224.0.0.0/4
  RP 13.0.0.1 (?), v2v1
    Info source: 13.0.0.1 (?), elected via Auto-RP
    Uptime: 00:21:35, expires: 00:02:31
Acl: 40, Static
  RP: 13.0.0.1 (?)
R3#
```

PIM -Bootstrap router (BSR)

- ▶ Functionality is similar to Auto-RP.
- ▶ Standard-based protocol
- ▶ Bootstrap Router part of PIMv2 standard
- ▶ Support IPv6 Multicast.

Defines two roles in BSR domain

- ▶ **RP Candidate :**
 - same as Candidate RP in Auto-RP
 - Uses unicast PIM to advertise itself to BSR.
- ▶ **Bootstrap Router**
 - Same as Mapping agent in Auto-RP
 - Advertises RP information to all the other routers hop by hop in the actual PIM messages



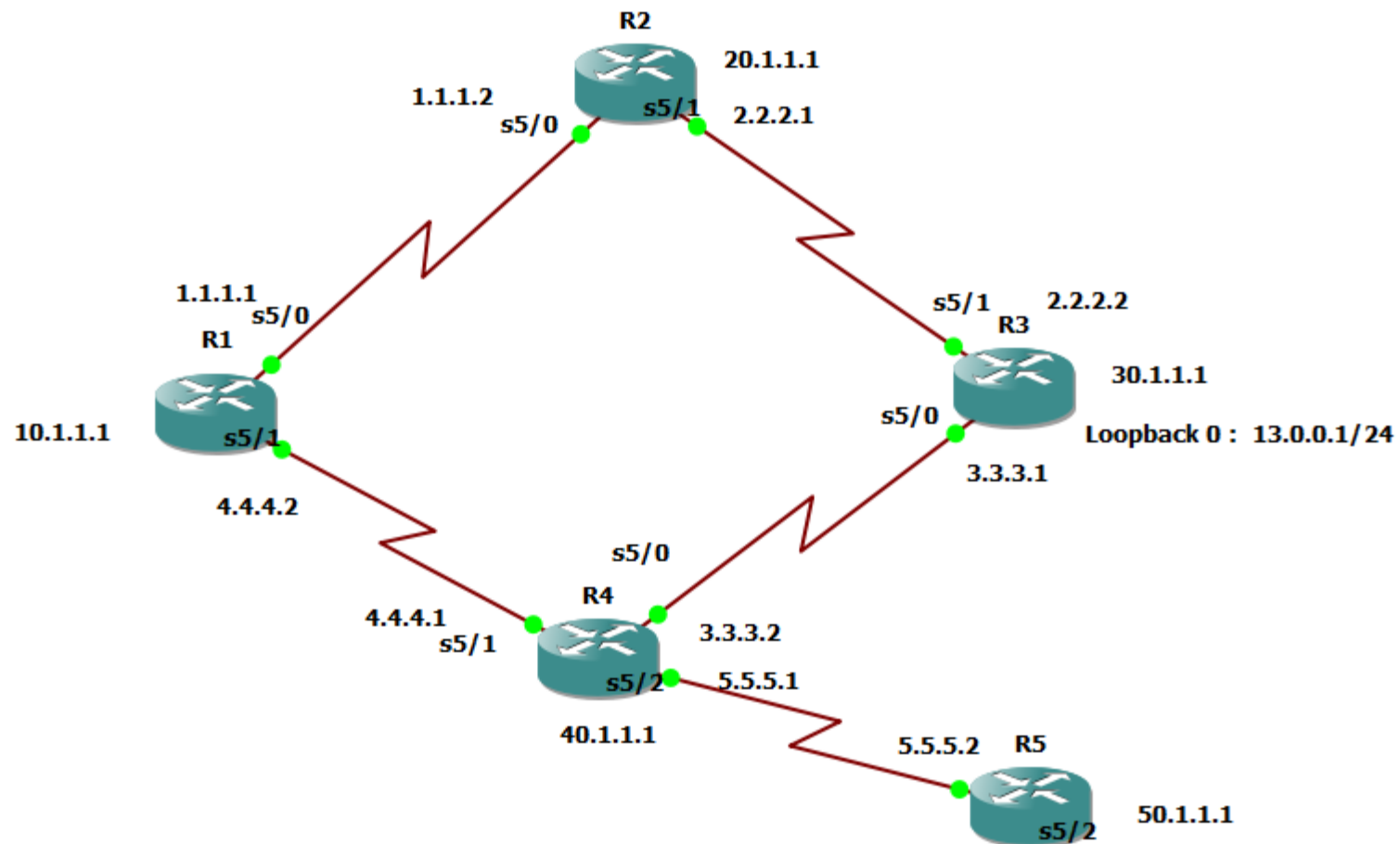
PIM -Bootstrap router (BSR)

BSR Configuration

```
R3(config)#ip pim rp-candidate loopback 0
```

```
R3(config)#ip pim bsr-candidate loopback 0
```

LAB : P1M Bootstrap Router



LAB : P1M Bootstrap Router

TASK :

- Remove the Auto-RP configuration on all routers.
- R5 on f0/0 interface is preconfigured to join group 224.5.5.5
- Configure R3 to advertise itself as RP for all multicast Groups using standard protocol

on all routers:

```
R1(config)#no ip pirn autorp listener
```

LAB : P1M Bootstrap Router

on R2

```
R2(config)#no ip pirn send-rp-discovery Loopback0 scope 10
```

on R3

```
R3(config)#no ip pirn send-rp-announce Loopback0 scope 10
```

```
R5#sh run int gi4/0
Building configuration...

Current configuration : 172 bytes
!
interface GigabitEthernet4/0
 ip address 50.1.1.1 255.255.255.0
 ip pim sparse-mode
 ip igmp join-group 224.5.5.5
 ip igmp join-group 224.50.50.50
 negotiation auto
end

R5#
```

LAB : P1M Bootstrap Router

```
R3(config)#do sh run | s ospf
ip ospf network point-to-point
router ospf 1
log-adjacency-changes
network 2.2.2.2 0.0.0.0 area 0
network 3.3.3.1 0.0.0.0 area 0
network 13.0.0.0 0.0.0.255 area 0
network 30.0.0.0 0.255.255.255 area 0
R3(config)#
```

LAB : P1M Bootstrap Router

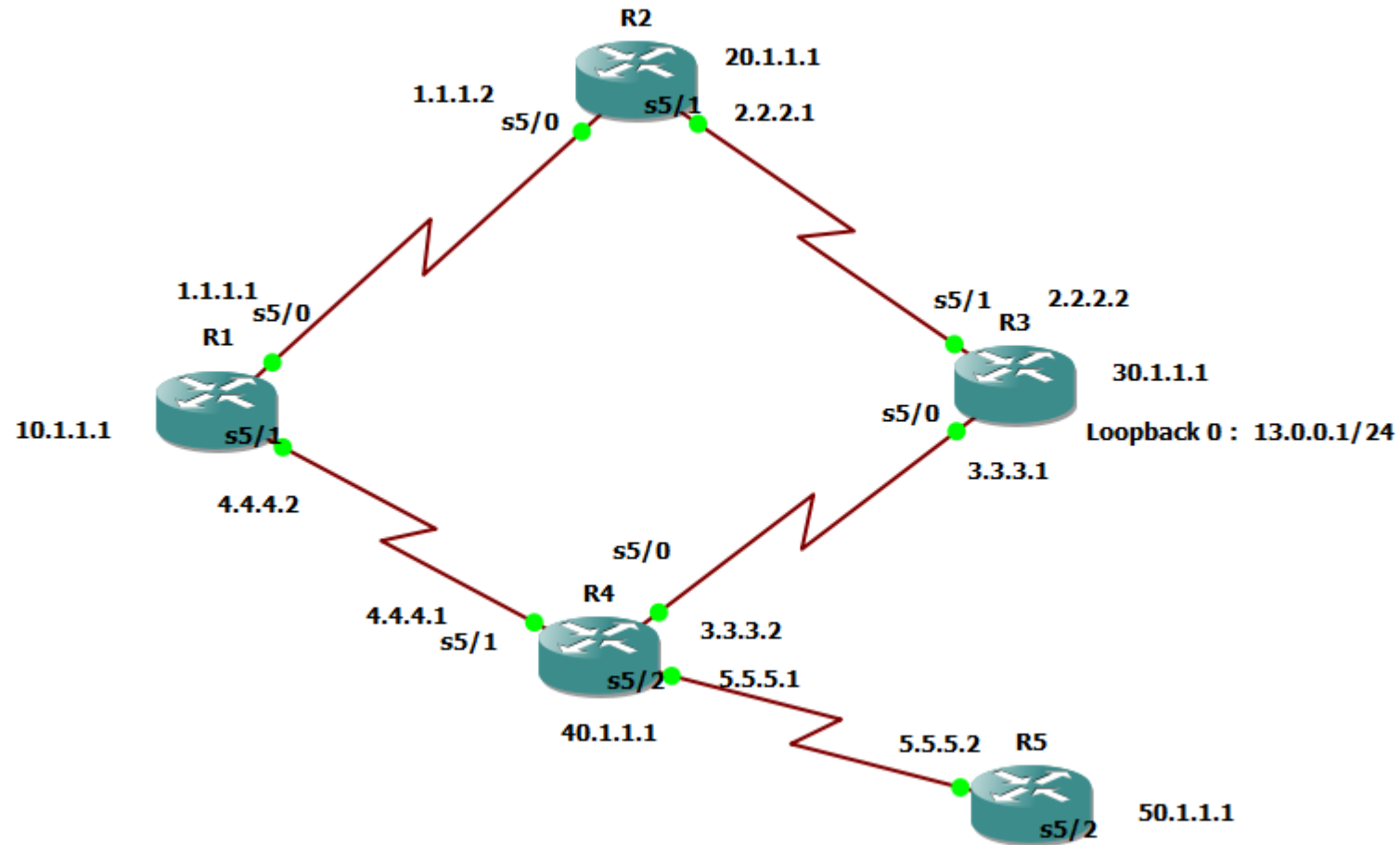
```
R3(config)#do s ip pim rp mapping
PIM Group-to-RP Mappings
This system is a candidate RP (v2)
This system is an RP-mapping agent (Loopback0)
This system is the Bootstrap Router (v2)

Acl: 40, Static
    RP: 13.0.0.1 (?)
R3(config)#
```

```
R1#sh ip pim rp mapping
PIM Group-to-RP Mappings

Group(s) 224.0.0.0/4
  RP 13.0.0.1 (?), v2
    Info source: 13.0.0.1 (?), via bootstrap, priority 0, holdtime 150
    Uptime: 00:00:13, expires: 00:02:21
Acl: 40, Static
    RP: 13.0.0.1 (?)
R1#
```

Lab: Auto-RP with Multiple RP (redundancy & Load-balancing)



Lab: Auto-RP with Multiple RP (redundancy & Load-balancing)

TASK:

- Configure OSPF Area 0 as IGP protocol
- enable PIM Sparse-mode on all connected interfaces as per the diagram.

```
RI (config)#router ospf 1
```

```
R1(config-router)#network 10.0.0.0 0.255.255.255 a 0
```

```
R1(config-router)#network 1.0.0.0 0.255.255.255 a 0
```

```
RI (config-router)#network 4.0.0.0 0.255.255.255 a 0
```

```
R1(config-router)#exit
```

Lab: Auto-RP with Multiple RP (redundancy & Load-balancing)

```
R2(config)#router ospf 1
```

```
R2(config-router)#network 20.0.0.0 0.255.255.255 area 0
```

```
R2(config-router)#network 2.0.0.0 0.255.255.255 area 0
```

```
R2(config-router)#network 1.0.0.0 0.255.255.255 area 0
```

```
R2(config-router)#end
```

```
R3(config)#router ospf 1
```

```
R3(config-router)#network 30.0.0.0 0.255.255.255 area 0
```

```
R3(config-router)#network 3.0.0.0 0.255.255.255 area 0
```

```
R3(config-router)#network 2.0.0.0 0.255.255.255 area 0
```

```
R3(config-router)#exit
```

Lab: Auto-RP with Multiple RP (redundancy & Load-balancing)

```
R4(config)#router ospf 1
```

```
R4(config-router)#network 40.0.0.0 0.255.255.255 area 0
```

```
R4(config-router)#network 4.0.0.0 0.255.255.255 area 0
```

```
R4(config-router)#network 3.0.0.0 0.255.255.255 area 0
```

```
R4(config-router)#network 5.0.0.0 0.255.255.255 area 0
```

```
R4(config-router)#exit
```

```
R5(config)#router ospf 1
```

```
R5(config-router)#network 50.0.0.0 0.255.255.255 area 0
```

```
R5(config-router)#network 5.0.0.0 0.255.255.255 area 0
```

```
R5(config-router)#end
```

Lab: Auto-RP with Multiple RP (redundancy & Load-balancing)

```
R4#sh ip os neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
50.1.1.1	0	FULL/ -	00:00:37	5.5.5.2	Serial5/2
10.1.1.1	0	FULL/ -	00:00:35	4.4.4.2	Serial5/1
13.0.0.1	0	FULL/ -	00:00:36	3.3.3.1	Serial5/0

```
R4#
```

```
R4#sh ip rou os
```

```
1.0.0.0/24 is subnetted, 1 subnets
O      1.1.1.0 [110/128] via 4.4.4.2, 01:41:54, Serial5/1
50.0.0.0/24 is subnetted, 1 subnets
O      50.1.1.0 [110/65] via 5.5.5.2, 01:41:54, Serial5/2
2.0.0.0/24 is subnetted, 1 subnets
O      2.2.2.0 [110/128] via 3.3.3.1, 01:41:54, Serial5/0
20.0.0.0/24 is subnetted, 1 subnets
O      20.1.1.0 [110/129] via 4.4.4.2, 01:41:54, Serial5/1
        [110/129] via 3.3.3.1, 01:41:54, Serial5/0
10.0.0.0/24 is subnetted, 1 subnets
O      10.1.1.0 [110/65] via 4.4.4.2, 01:41:54, Serial5/1
13.0.0.0/24 is subnetted, 1 subnets
O      13.0.0.0 [110/65] via 3.3.3.1, 01:41:54, Serial5/0
30.0.0.0/24 is subnetted, 1 subnets
O      30.1.1.0 [110/65] via 3.3.3.1, 01:41:54, Serial5/0
```

```
R4#
```

Lab: Auto-RP with Multiple RP (redundancy & Load-balancing)

```
R2#sh ip rou os
 50.0.0.0/24 is subnetted, 1 subnets
O       50.1.1.0 [110/193] via 2.2.2.2, 01:49:16, Serial5/1
         [110/193] via 1.1.1.1, 01:49:16, Serial5/0
 3.0.0.0/24 is subnetted, 1 subnets
O       3.3.3.0 [110/128] via 2.2.2.2, 01:49:16, Serial5/1
 4.0.0.0/24 is subnetted, 1 subnets
O       4.4.4.0 [110/128] via 1.1.1.1, 01:49:16, Serial5/0
 5.0.0.0/24 is subnetted, 1 subnets
O       5.5.5.0 [110/192] via 2.2.2.2, 01:49:16, Serial5/1
         [110/192] via 1.1.1.1, 01:49:16, Serial5/0
40.0.0.0/24 is subnetted, 1 subnets
O      40.1.1.0 [110/129] via 2.2.2.2, 01:49:16, Serial5/1
         [110/129] via 1.1.1.1, 01:49:16, Serial5/0
10.0.0.0/24 is subnetted, 1 subnets
O      10.1.1.0 [110/65] via 1.1.1.1, 01:49:16, Serial5/0
13.0.0.0/24 is subnetted, 1 subnets
O      13.0.0.0 [110/65] via 2.2.2.2, 01:49:16, Serial5/1
30.0.0.0/24 is subnetted, 1 subnets
O      30.1.1.0 [110/65] via 2.2.2.2, 01:49:16, Serial5/1
```

```
R2#sh ip os nei
```

```
R2#sh ip os neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
13.0.0.1	0	FULL/ -	00:00:32	2.2.2.2	Serial5/1
10.1.1.1	0	FULL/ -	00:00:33	1.1.1.1	Serial5/0

```
R2#
```

Lab: Auto-RP with Multiple RP (redundancy & Load-balancing)

R1/R2/R3

```
Rx(config)#ip multicast-routing
```

```
Rx(config)#int f0/0
```

```
Rx(config-if)#ip pim sparse-mode
```

```
Rx(config-if)#int s1/0
```

```
Rx(config-if)#ip pim sparse-mode
```

```
Rx(config-if)#int s1/1
```

```
Rx(config-if)#ip pim sparse-mode
```

```
Rx(config-if)#end
```

Lab: Auto-RP with Multiple RP (redundancy & Load-balancing)

```
R4#sh ip pim neighbor
PIM Neighbor Table
Mode: B - Bidir Capable, DR - Designated Router, N - Default DR Priority,
      S - State Refresh Capable
Neighbor          Interface                Uptime/Expires    Ver    DR
Address                                     Prio/Mode
3.3.3.1           Serial5/0                02:18:43/00:01:23 v2      1 / S
4.4.4.2           Serial5/1                02:18:43/00:01:26 v2      1 / S
5.5.5.2           Serial5/2                02:18:21/00:01:16 v2      1 / S
```

R4#

R4#

```
R4#sh ip pim int
```

```
R4#sh ip pim interface
```

Address	Interface	Ver/ Mode	Nbr Count	Query Intvl	DR Prior	DR
40.1.1.1	GigabitEthernet4/0	v2/S	0	30	1	40.1.1.1
3.3.3.2	Serial5/0	v2/S	1	30	1	0.0.0.0
4.4.4.1	Serial5/1	v2/S	1	30	1	0.0.0.0
5.5.5.1	Serial5/2	v2/S	1	30	1	0.0.0.0

R4#

Lab: Auto-RP with Multiple RP (redundancy & Load-balancing)

TASK : Configure Auto-RP Using a Cisco proprietary technology

- Configure R2 & R3 loopback 0 as RP , R4 as the Mapping Agent.
- use loopback 0 interfaces for respective routers and advertise them In IGP
- Ensure that all devices still hear Auto-RP announcements. (Auto-RP listener).

on all routers :

```
Rx(config)#ip pim autorp listener
```

Lab: Auto-RP with Multiple RP (redundancy & Load-balancing)

R4: (mapping-Agent)

R4(config)#router ospf 1

R4(config-router)#network 14.0.0.0 0.0.0.255 area 0

R4(config-router)#exit

R4(config)#int loop 0

R4(config-if)#ip pim sparse-mode

R4(config-if)#exit

R4(config)#ip pim send-rp-discovery loopback 0 scope 10

R4(config)#exit

Lab: Auto-RP with Multiple RP (redundancy & Load-balancing)

```
R4#sh ip pim rp mapping
PIM Group-to-RP Mappings
This system is an RP-mapping agent

Group(s) 224.0.0.0/4
  RP 13.0.0.1 (?), v2
    Info source: 13.0.0.1 (?), via bootstrap, priority 0, holdtime 150
    Uptime: 01:00:10, expires: 00:02:25
Acl: 40, Static
  RP: 13.0.0.1 (?)
R4#
```

Lab: Auto-RP with Multiple RP (redundancy & Load-balancing)

```
R3#sh ip pim rp mapping
PIM Group-to-RP Mappings
This system is an RP (Auto-RP)
This system is a candidate RP (v2)
This system is an RP-mapping agent (Loopback0)
This system is the Bootstrap Router (v2)

Group(s) 224.0.0.0/4
  RP 13.0.0.1 (?), v2v1
    Info source: 13.0.0.1 (?), elected via Auto-RP, via bootstrap, priority 0, holdtime 150
    Uptime: 01:06:02, expires: 00:02:44
  RP 12.0.0.1 (?), v2v1
    Info source: 12.0.0.1 (?), via Auto-RP
    Uptime: 00:00:58, expires: 00:02:00
Acl: 40, Static
  RP: 13.0.0.1 (?)
R3#
```

Lab: Auto-RP with Multiple RP (redundancy & Load-balancing)

```
R1#sh ip pim rp mapping
PIM Group-to-RP Mappings

Group(s) 224.0.0.0/4
  RP 13.0.0.1 (?), v2v1
    Info source: 4.4.4.1 (?), elected via Auto-RP, via bootstrap, priority 0, holdtime 150
      Uptime: 01:07:25, expires: 00:02:21
  RP 12.0.0.1 (?), v2v1
    Info source: 4.4.4.1 (?), via Auto-RP, via bootstrap, priority 0, holdtime 181
      Uptime: 00:02:21, expires: 00:00:38
Acl: 40, Static
  RP: 13.0.0.1 (?)
R1#
```

```
R1#clear ip pim rp-mapping
R1#
R1#
R1#sh ip pim rp map
R1#sh ip pim rp mapping
PIM Group-to-RP Mappings

Acl: 40, Static
  RP: 13.0.0.1 (?)
```

Lab: Auto-RP with Multiple RP (redundancy & Load-balancing)

NOTE :

If there are multiple RP configured for redundancy, the one with the highest IP address will be selected by the Mapping Agent.

```
R3(config)#int loop 0
```

```
R3(config-if)#shutdown
```

```
R3(config-if)#exit
```

```
R1#clear ip pim rp-mapping
R1#sh ip pim rp mapping
PIM Group-to-RP Mappings

Group(s) 224.0.0.0/4
  RP 13.0.0.1 (?), v2v1
    Info source: 4.4.4.1 (?), elected via Auto-RP
      Uptime: 00:00:06, expires: 00:02:49
Acl: 40, Static
RP: 13.0.0.1 (?)
```

Lab: Auto-RP with Multiple RP (redundancy & Load-balancing)

```
R3(config)#int loop 0
```

```
R3(config-if)#no shutdown
```

```
R3(config-if)#end
```

```
R4#sh ip pim rp mapping
PIM Group-to-RP Mappings
This system is an RP-mapping agent

Acl: 40, Static
    RP: 13.0.0.1 (?)
R4#
```

```
R1#sh ip pim rp mapping
PIM Group-to-RP Mappings

Acl: 40, Static
    RP: 13.0.0.1 (?)
R1#
```

Lab: Auto-RP with Multiple RP (redundancy & Load-balancing)

TASK: Auto-RP Load-Balancing:

- Re-Configure Auto-RP Using a Cisco proprietary technology
- Configure R2 loopback 0 as RP for multicast group 224.2.2.2 & R3- RP for 224.3.3.3 only.
- Configure R4 as the Mapping Agent
- use loopback 0 interfaces for respective routers and advertise them In IGP

```
R2#sh run | in pim
ip pim sparse-mode
ip pim sparse-mode
ip pim sparse-mode
ip pim sparse-mode
ip pim rp-address 13.0.0.1 40
ip pim autorp listener
ip pim send-rp-announce Loopback0 scope 10
R2#
```

Lab: Auto-RP with Multiple RP (redundancy & Load-balancing)

```
R2(config)#no ip pirn send-rp-announce Loopback0 scope 10
```

```
R3(config)#no ip pirn send-rp-announce Loopback0 scope 10
```

```
R4#clear ip pirn rp-mapping
```

```
R2(config)#access-list 2 permit host 224.2.2.2
```

```
R2(config)#ip pirn send-rp-announce loopback 0 scope 10 group-list 2
```

```
R3(config)#access-list 3 permit host 224.3.3.3
```

```
R3(config)#ip pirn send-rp-announce loopback 0 scope 10 group-list 3
```

```
R3(config)#end
```

```
R4(config)# ip pirn send-rp-discovery loopback 0 scope 10
```

Lab: Auto-RP with Multiple RP (redundancy & Load-balancing)

```
R4#sh ip pim rp mapping
PIM Group-to-RP Mappings
This system is an RP-mapping agent

Group(s) 224.0.0.0/4
  RP 13.0.0.1 (?), v2
    Info source: 13.0.0.1 (?), via bootstrap, priority 0, holdtime 150
    Uptime: 00:05:51, expires: 00:01:42
Group(s) 224.2.2.2/32
  RP 12.0.0.1 (?), v2v1
    Info source: 12.0.0.1 (?), elected via Auto-RP, via bootstrap, priority 0, holdtime 181
    Uptime: 00:09:50, expires: 00:02:10
Group(s) 224.3.3.3/32
  RP 13.0.0.1 (?), v2v1
    Info source: 13.0.0.1 (?), elected via Auto-RP, via bootstrap, priority 0, holdtime 181
    Uptime: 00:08:43, expires: 00:02:14
Acl: 40, Static
  RP: 13.0.0.1 (?)
R4#
```

Lab: Auto-RP with Multiple RP (redundancy & Load-balancing)

```
R1#sh ip pim rp mapping
PIM Group-to-RP Mappings

Group(s) 224.0.0.0/4
  RP 13.0.0.1 (?), v2
    Info source: 13.0.0.1 (?), via bootstrap, priority 0, holdtime 150
    Uptime: 00:08:12, expires: 00:02:19
Group(s) 224.2.2.2/32
  RP 12.0.0.1 (?), v2v1
    Info source: 13.0.0.1 (?), elected via Auto-RP, via bootstrap, priority 0, holdtime 181
    Uptime: 00:12:10, expires: 00:02:43
Group(s) 224.3.3.3/32
  RP 13.0.0.1 (?), v2v1
    Info source: 13.0.0.1 (?), elected via Auto-RP, via bootstrap, priority 0, holdtime 181
    Uptime: 00:11:03, expires: 00:02:46
Acl: 40, Static
  RP: 13.0.0.1 (?)
R1#
```

Lab: Auto-RP with Multiple RP (redundancy & Load-balancing)

```
R5#sh ip pim rp mapping
PIM Group-to-RP Mappings

Group(s) 224.0.0.0/4
  RP 13.0.0.1 (?), v2
    Info source: 13.0.0.1 (?), via bootstrap, priority 0, holdtime 150
    Uptime: 00:09:15, expires: 00:02:19
Group(s) 224.2.2.2/32
  RP 12.0.0.1 (?), v2v1
    Info source: 5.5.5.1 (?), elected via Auto-RP, via bootstrap, priority 0, holdtime 181
    Uptime: 00:13:14, expires: 00:02:41
Group(s) 224.3.3.3/32
  RP 13.0.0.1 (?), v2v1
    Info source: 5.5.5.1 (?), elected via Auto-RP, via bootstrap, priority 0, holdtime 181
    Uptime: 00:12:06, expires: 00:02:42
Acl: 40, Static
  RP: 13.0.0.1 (?)
R5#
```

Lab: Auto-RP with Multiple RP (redundancy & Load-balancing)

TASK :

- Configure R5 f0/0 as receivers to join group for both Multicast groups (224.2.2.2 & 224.3.3.3)
- Ensure that you should be able to reach from R1 (server)

```
R5(config)#int f0/0
```

```
R5(config-if)#ip igmp join-group 224.2.2.2
```

```
R5(config-if)#ip igmp join-group 224.3.3.3
```

```
R5(config-if)#end
```

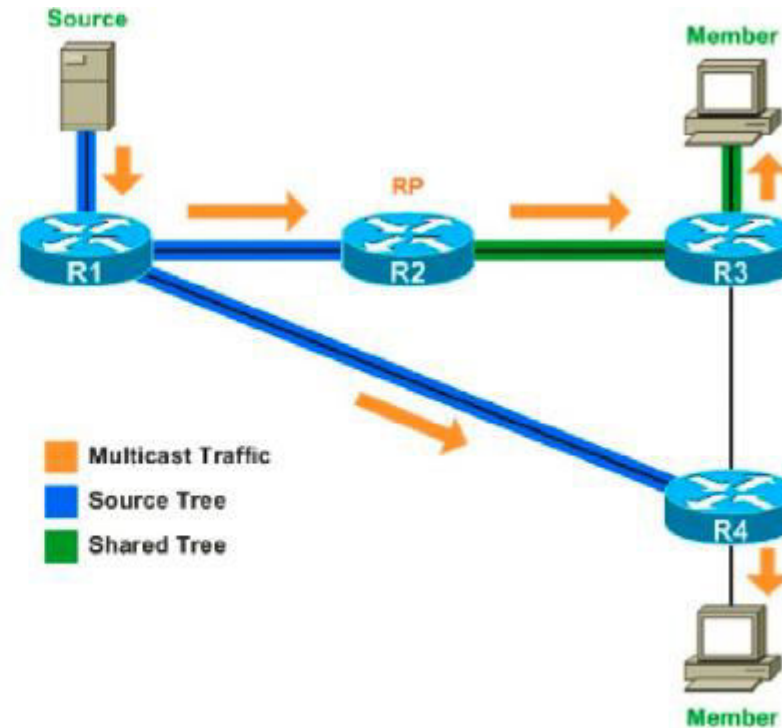
```
R1#ping 224.3.3.3
Type escape sequence to abort.
Sending 1, 100-byte ICMP Echos to 224.3.3.3, timeout is 2 seconds:
.
R1#ping 224.2.2.2
Type escape sequence to abort.
Sending 1, 100-byte ICMP Echos to 224.2.2.2, timeout is 2 seconds:
```

Bidirectional PIM

Traditional PIM for two Trees

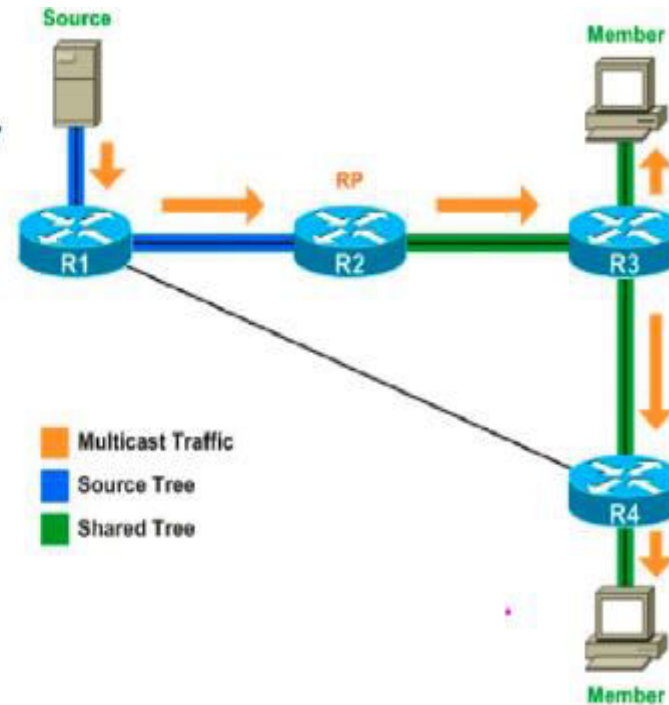
1. Unidirectional SPT from source to RP creates (S,G) entries
2. Unidirectional Shared tree from RP to receivers. creates (*,G) entries

For many to many Applications this is not scalable.



Bidirectional PIM

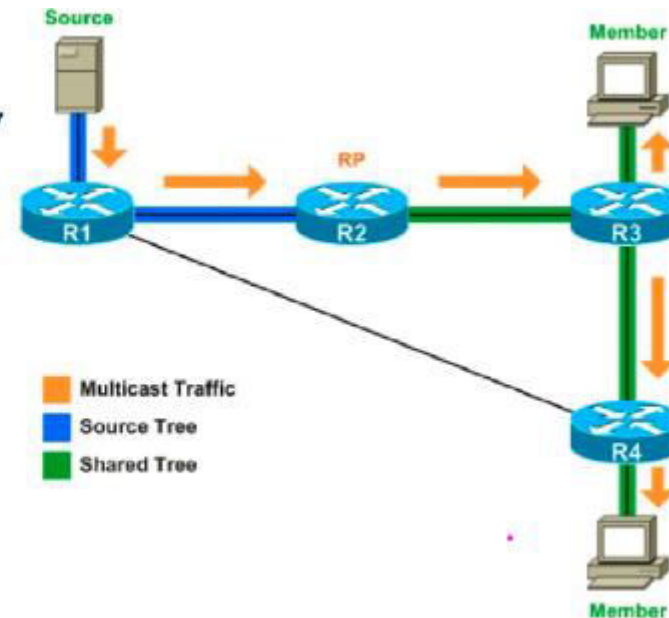
- › Bidirectional PIM solves this issues by using only Shared Tree (*,G)
- › never uses the shortest Path tree(S,G).



How Bidirectional P1M works

- Enable Bi-directional PIM for PIM RP and Group range
- Build $O\backslash G$ tree towards RP
- Remove the PIM Register messages
- Uses Designated Forwarder (DF) for loop prevention

- ▶ Bidirectional PIM solves this issues by using only Shared Tree $(*,G)$
- ▶ never uses the shortest Path tree (S,G) .



Bidirectional PIM Configuration

On all routers

```
(config)#ip pim bidir-enable
```

Static RP (on all routers)

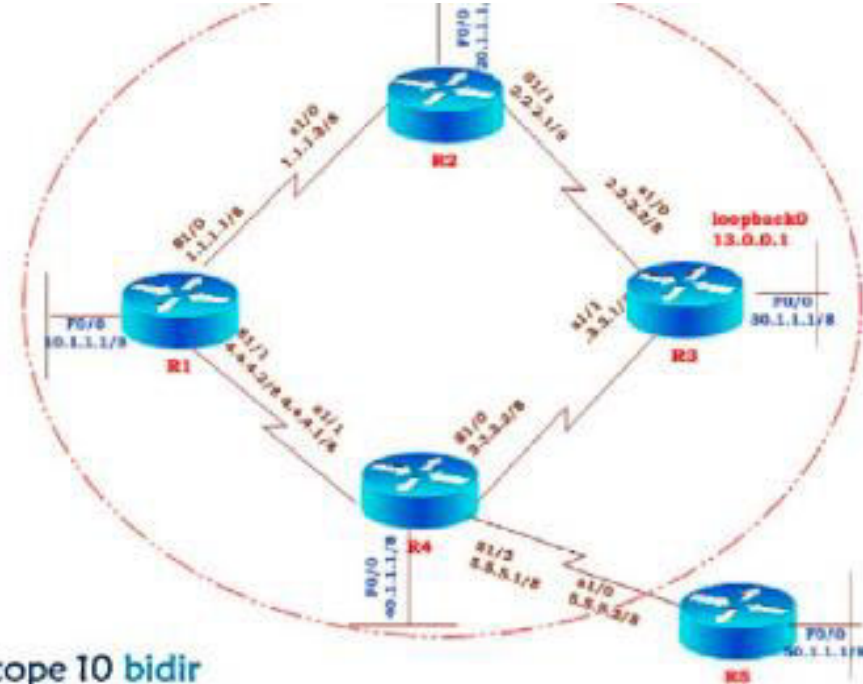
```
(config)#ip pim rp-address 13.0.0.1 bidir
```

Auto-RP (only on RP)

```
(config)#ip pim send-rp-announce loopback 0 scope 10 bidir
```

PIM Bootstrap Router (only on RP)

```
RP(config)#ip pim rp-candidate loopback 0 bidir
```

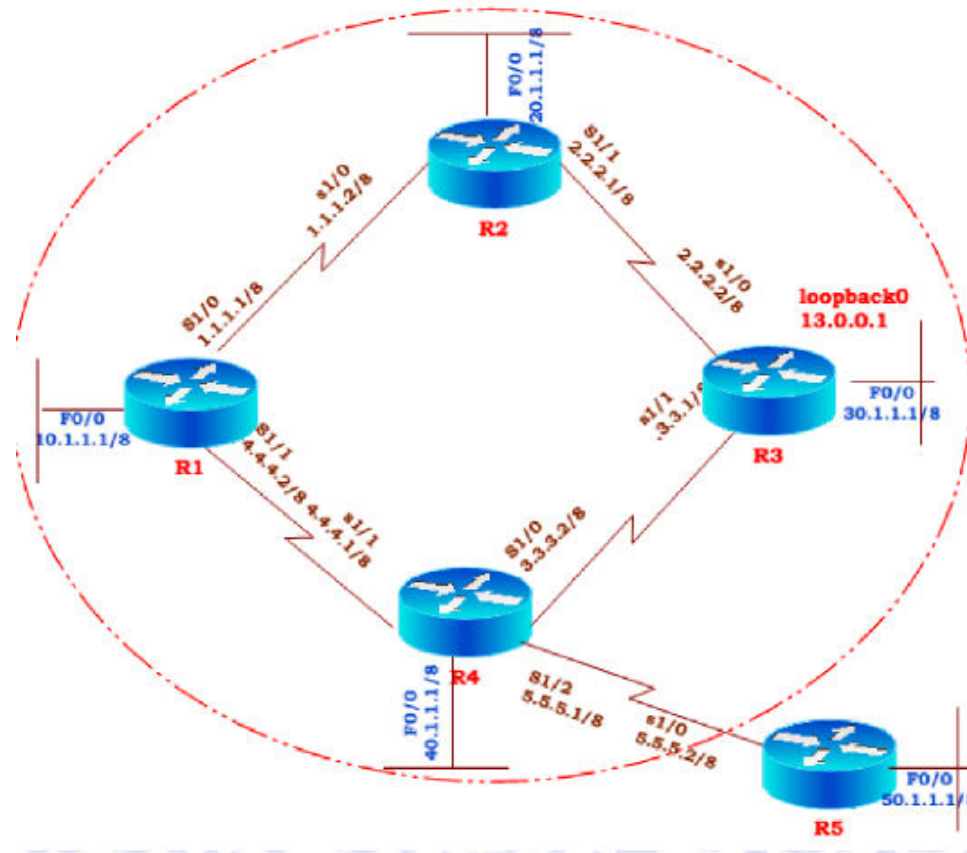


LAB:PIM-Bidirectional

PIM-Bidir is more efficient and more scalable than PIM-SM for large number of multicast sources.

- The DF (Designated Forwarder) is elected on each segment or point-to-point link to establish loop-free SPT with RP as the root.
- (S,G) join messages are dropped on routers that supports only Bidir-PIM.
- RP never join back a path to the source (no (S,G) tree) nor send any register-stop.
- PIM-Bidir is capable of sending and receiving multicast traffic for the same group along the same shared-tree.

LAB:PIM-Bidirectional



LAB:PIM-Bidirectional

TASK :

- Configure OSPF area 0
- enable IP Pim Sparse-mode on all connected interfaces.
- Configure R3 loop 0 as RP using standard based PIM.
- configure R5 f0/0 to simulate receivers for group 224.5.5.5
- verify the reachability by testing from Source from R1.

LAB:PIM-Bidirectional

```
R1(config)#router ospf 1
```

```
R1(config-router)#network 10.0.0.0 0.255.255.255 area 0
```

```
R1(config-router)#network 1.0.0.0 0.255.255.255 area 0
```

```
R1(config-router)#network 4.0.0.0 0.255.255.255 area 0
```

```
R1(config-router)#exit
```

```
R2(config)# router ospf 1
```

```
R2(config-router)# network 20.0.0.0 0.255.255.255 area 0
```

```
R2(config-router)# network 1.0.0.0 0.255.255.255 area 0
```

```
R2(config-router)# network 2.0.0.0 0.255.255.255 area 0
```

LAB:PIM-Bidirectional

```
R3(config)# router ospf 1
```

```
R3(config-router)# network 30.0.0.0 0.255.255.255 area 0
```

```
R3(config-router)# network 2.0.0.0 0.255.255.255 area 0
```

```
R3(config-router)# network 3.0.0.0 0.255.255.255 area 0
```

```
R3(config-router)# exit
```

```
R4(config)# router ospf 1
```

```
R4(config-router)# network 40.0.0.0 0.255.255.255 area 0
```

```
R4(config-router)# network 3.0.0.0 0.255.255.255 area 0
```

```
R4(config-router)# network 4.0.0.0 0.255.255.255 area 0
```

```
R4(config-router)# network 5.0.0.0 0.255.255.255 area 0
```

LAB:PIM-Bidirectional

```
R5(config)# router ospf 1
```

```
R5(config-router)# network 50.0.0.0 0.255.255.255 area 0
```

```
R5(config-router)# network 5.0.0.0 0.255.255.255 area 0
```

```
R5(config-router)# exit
```

```
R5(config)#
```

LAB:PIM-Bidirectional

```
R2(config-router)#do sh ip os nei
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
13.0.3.1	0	FULL/ -	00:00:35	2.2.2.2	Serial1/1
11.0.3.1	0	FULL/ -	00:00:33	1.1.1.1	Serial1/0

```
R2(config-router)#
```

```
R4#sh ip os neighbor
```

Neighbor ID	Pri	State	Dead Time	Address	Interface
50.1.1.1	0	FULL/ -	00:00:34	5.5.5.2	Serial1/2
11.0.3.1	0	FULL/ -	00:00:33	4.4.4.2	Serial1/1
13.0.3.1	0	FULL/ -	00:00:39	3.3.3.1	Serial1/0

```
R4#
```

LAB:PIM-Bidirectional

```
R4#sh ip rou os
0    1.0.0.0/8 [110/128] via 4.4.4.2, 00:00:46, Serial1/1
0    50.0.0.0/8 [110/74] via 5.5.5.2, 00:00:46, Serial1/2
0    2.0.0.0/8 [110/128] via 3.3.3.1, 00:00:46, Serial1/0
    4.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
0      4.4.4.0/24 [110/128] via 4.4.4.2, 00:00:46, Serial1/1
0    20.0.0.0/8 [110/138] via 4.4.4.2, 00:00:46, Serial1/1
      [110/138] via 3.3.3.1, 00:00:46, Serial1/0
0    10.0.0.0/8 [110/74] via 4.4.4.2, 00:00:46, Serial1/1
0    30.0.0.0/8 [110/74] via 3.3.3.1, 00:00:46, Serial1/0
R4#
```

LAB:PIM-Bidirectional

```
R4(config-if)#do sh ip pim nei
PIM Neighbor Table
Mode: B - Bidir Capable, DR - Designated Router, N - Default DR Priority,
      S - State Refresh Capable
Neighbor          Interface                Uptime/Expires    Ver    DR
Address                                     Prio/Mode
3.3.3.1            Serial1/0                00:03:34/00:01:38 v2      1 / S
4.4.4.2            Serial1/1                00:03:32/00:01:40 v2      1 / S
R4(config-if)#
```

```
R4(config-if)#do sh ip pim int

Address          Interface                Ver/   Nbr   Query  DR    DR
                  Mode      Count  Intvl Prior
40.1.1.1         FastEthernet0/0        v2/S    0     30     1     40.1.1.1
3.3.3.2          Serial1/0              v2/S    1     30     1     0.0.0.0
4.4.4.1          Serial1/1              v2/S    1     30     1     0.0.0.0
R4(config-if)#
```

LAB:PIM-Bidirectional

```
R3#sh ip pim rp mapping
```

```
PIM Group-to-RP Mappings
```

```
This system is a candidate RP (v2)
```

```
This system is the Bootstrap Router (v2)
```

```
Group(s) 224.0.0.0/4
```

```
RP 13.0.0.1 (?), v2
```

```
Info source: 13.0.0.1 (?), via bootstrap, priority 0, holdtime 150
```

```
Uptime: 00:00:10, expires: 00:02:17
```

LAB:PIM-Bidirectional

```
R1#sh ip pim rp mapping
PIM Group-to-RP Mappings

Group(s) 224.0.0.0/4
  RP 13.0.0.1 (?), v2
    Info source: 13.0.0.1 (?), via bootstrap, priority 0, holdtime 150
    Uptime: 00:01:09, expires: 00:02:24
R1#
R1#ping 224.5.5.5

Type escape sequence to abort.
Sending 1, 100-byte ICMP Echos to 224.5.5.5, timeout is 2 seconds:
.
R1#
```

LAB:PIM-Bidirectional

```
R1#sh ip mroute 224.5.5.5
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
Outgoing interface flags: H - Hardware switched, A - Assert winner
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.5.5.5), 00:00:45/stopped, RP 13.0.0.1, flags: SPF
  Incoming interface: Serial1/1, RPF nbr 4.4.4.1
  Outgoing interface list: Null

(10.1.1.1, 224.5.5.5), 00:00:45/00:02:18, flags: PFT
  Incoming interface: FastEthernet0/0, RPF nbr 0.0.0.0
  Outgoing interface list: Null

R1#
```

By default uses the shortest path tree once it learns the information via RP.

LAB:PIM-Bidirectional

TASK : Configure Bi-directional PIM

Configure the network so that this group uses a single shared tree for multicast traffic delivery. Use BSR for this purpose.

Configuring PIM BiDir is relatively simple. You just need to enable BiDir PIM on all multicast routers by using the command `ip pim bidir-enable` and designate particular RP/Group combinations as bi-directional. You can do this in the following ways:

- Using a static RP configuration with the command `ip pim rp-address <IP> <ACL> bidir .`

LAB:PIM-Bidirectional

- Using BSR or RP information dissemination, you may flag particular group/RP combinations as bi-directional using the syntax `ip pim rp-candidate <interface> group-list <ACL> bidir .`
- Using Auto-RP for RP information dissemination, you may flag particular group/RP combinations as bidirectional using the syntax `ip pim send-rp-announce <interface> scope <TTL> group-list <ACL> bidir`

LAB:PIM-Bidirectional

on allrouters :

```
Rx(config)#ip pimn bidir-enable
```

on RP only :

```
R3(config)#ip pim rp-candidate loopback 0 bidir
```

on allrouters :

```
Rx#clear ip mroute *
```

LAB:PIM-Bidirectional

```
R1#sh 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
Outgoing interface flags: H - Hardware switched, A - Assert winner
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.0.1.40), 00:00:26/00:02:33, RP 0.0.0.0, flags: DCL
Incoming interface: Null, RPF nbr 0.0.0.0
Outgoing interface list:
  FastEthernet0/0, Forward/Sparse, 00:00:26/00:02:33

R1#sh ip mrou
R1#sh ip mroute 224.5.5.5
Group 224.5.5.5 not found
R1#
```

LAB:PIM-Bidirectional

```
R1#ping 224.5.5.5

Type escape sequence to abort.
Sending 1, 100-byte ICMP Echos to 224.5.5.5, timeout is 2 seconds:
.
R1#sh ip mro
R1#sh ip mroute 224.5.5.5
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
Outgoing interface flags: H - Hardware switched, A - Assert winner
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.5.5.5), 00:00:11/00:02:53, RP 13.0.0.1, flags: BP
  Bidir-Upstream: Serial1/1, RPF nbr 4.4.4.1
  Outgoing interface list:
    Serial1/1, Bidir-Upstream/Sparse, 00:00:11/00:00:00

R1#
```

LAB:PIM-Bidirectional

- Note that since the RP is now a P1MBiDir RP, there is no source registration procedure via P1M register/Register-Stop messages. In Sparse-Mode, P1MRegister Tunnels were automatically created on all PIM routers in order to unicast the PIM register messages to the RP.
- These Tunnels are not created when PIM BiDir is in use. The RP does not need to decapsulate/encapsulate unicast register messages when running BiDir, so these dynamic tunnels are not needed:

LAB:PIM-Bidirectional

```
R2#sh ip mroute 224.5.5.5
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
Outgoing interface flags: H - Hardware switched, A - Assert winner
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.5.5.5), 00:01:55/00:01:04, RP 13.0.0.1, flags: BP
  Bidir-Upstream: Serial1/1, RPF nbr 2.2.2.2
  Outgoing interface list:
    Serial1/1, Bidir-Upstream/Sparse, 00:01:55/00:00:00
```

LAB:PIM-Bidirectional

```
R3#sh ip mroute 224.5.5.5
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
Outgoing interface flags: H - Hardware switched, A - Assert winner
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.5.5.5), 00:02:06/00:00:53, RP 13.0.0.1, flags: BP
  Bidir-Upstream: Null, RPF nbr 0.0.0.0
  Outgoing interface list: Null
```

Source Specific Multicast

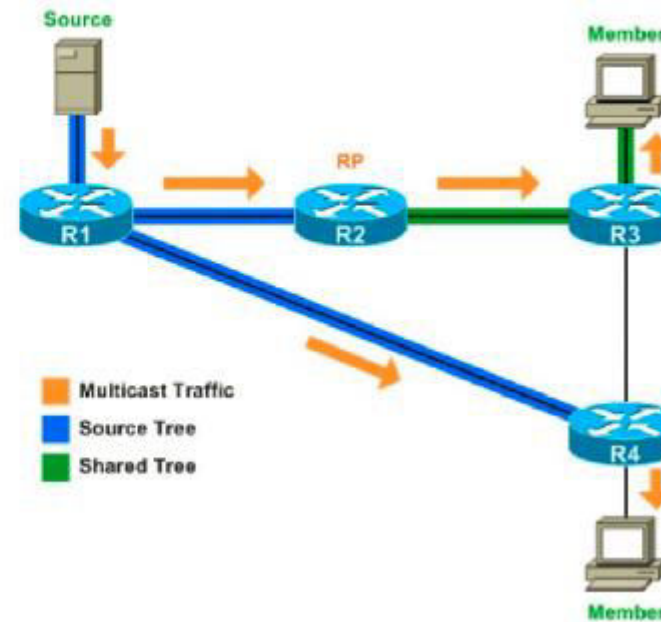
- Any Source Multicast
- Uses IGMPv2 &. PIM-Sparse-mode /Dense-mode
- Sparse-mode uses an RP
- Receivers do not know who the source is (*,G)
- Senders & Receivers know each other via RP
- Build shared tree (*,G) and source Tree (S,G)

Issues with Any Source Multicast

- ▶ Receivers do not know about source initially $(*,G)$
- ▶ Learns via RP $(*,G)$
- ▶ If RP fails the new trees cannot be built.

Solution :

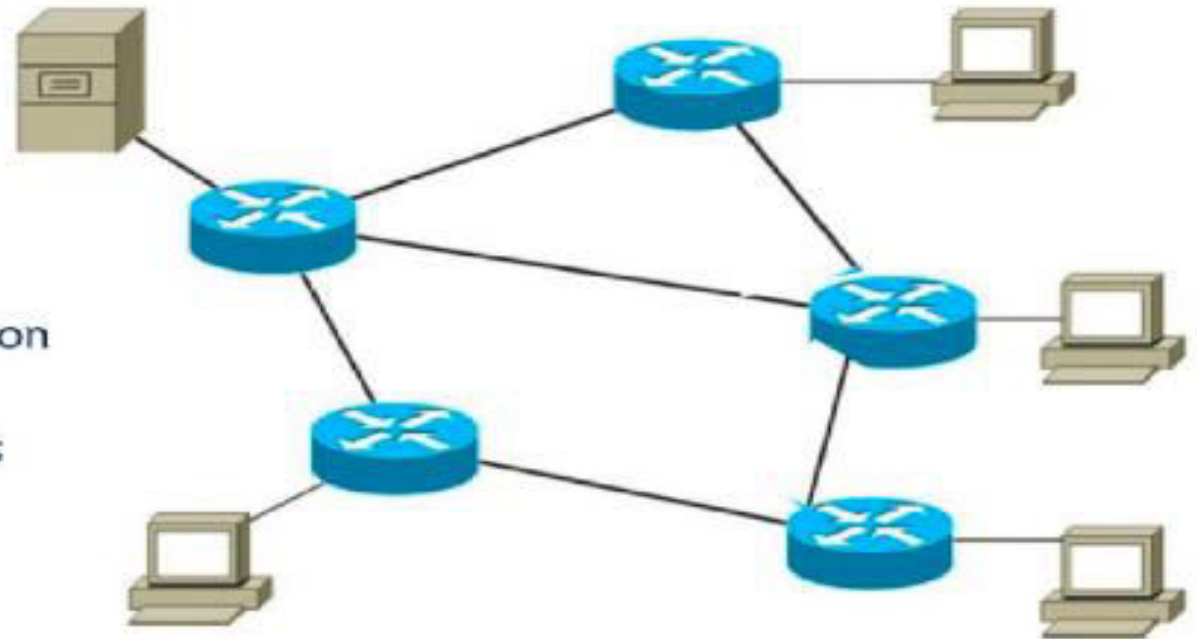
- ▶ Receivers to learn about the source (S,G)
- ▶ Send (S,G) join instead of $(*,G)$ join



Source Specific Multicast

- ▶ Uses a group range of 232.0.0.0/8
- ▶ Receivers know the application source before it sends membership.
- ▶ Receivers uses IGMPv3 to send join source (S,G) .

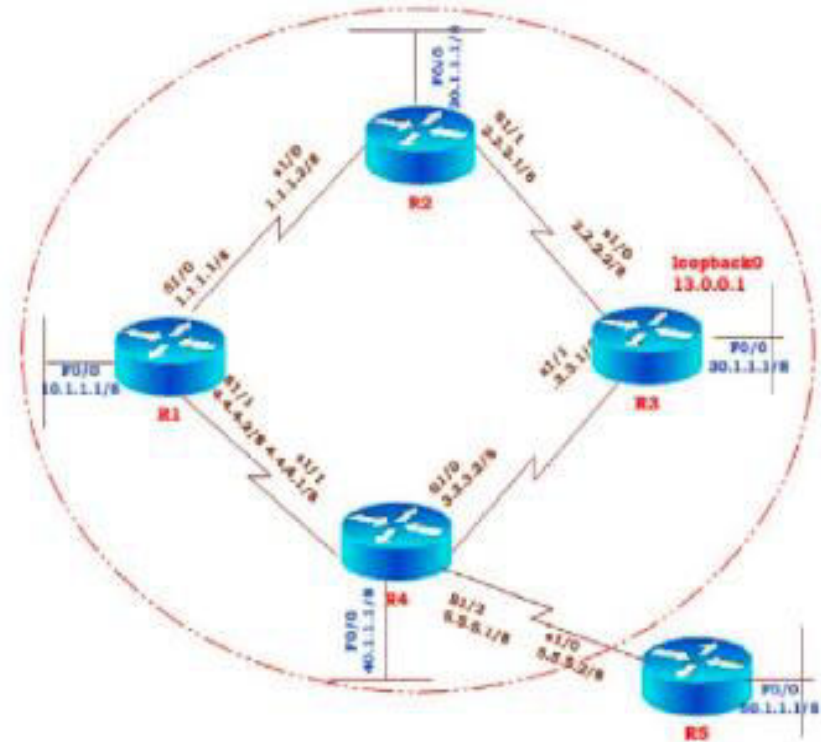
- ▶ Removes the need for the RP (application already know about the source)
- ▶ Last hop router uses (S,G) join messages towards the source
- ▶ SSM uses only (S,G) entries only.



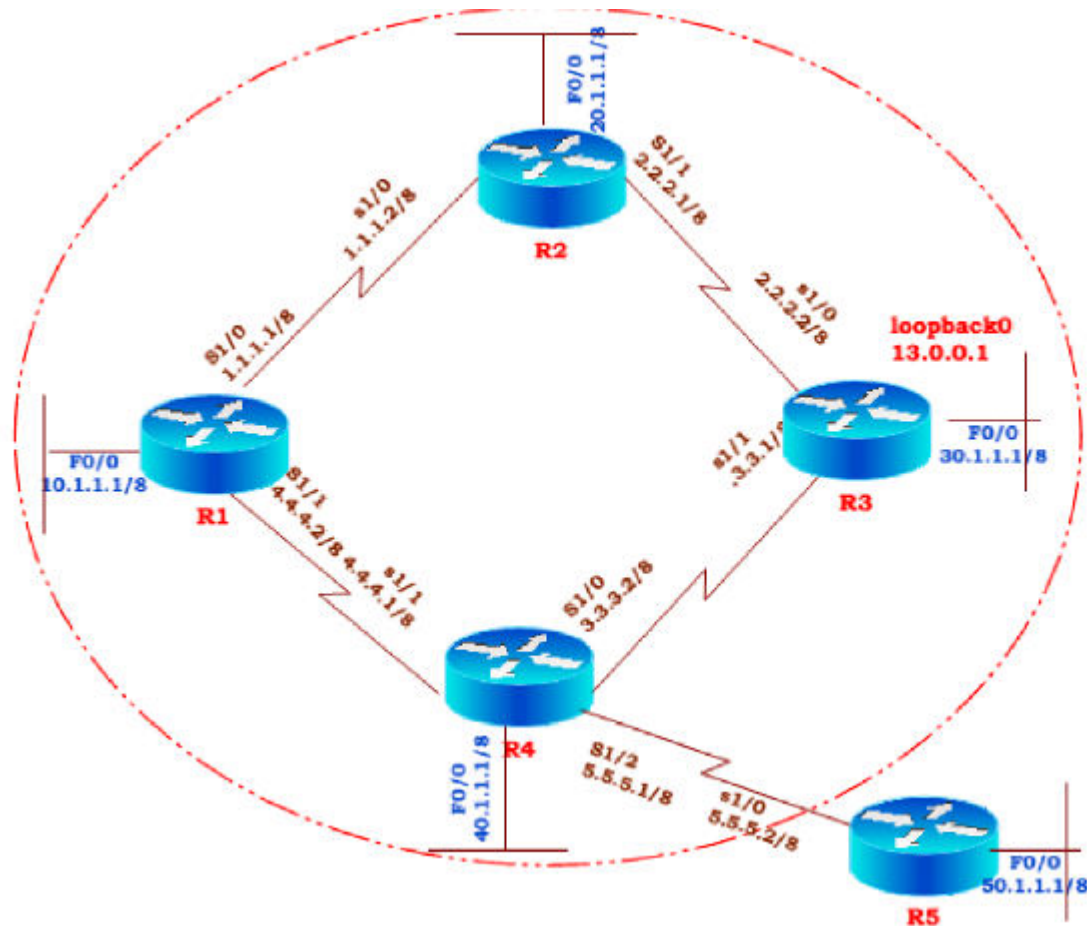
SSM Configuration

```
Rx(config)#ip pim ssm default
```

```
R5(config)# int f0/0  
R5(config-if)# ip igmp version 3  
R5(config-if)# ip igmp join-group 232.5.5.5 source 11.0.0.1
```



LAB : Source Specific Multicast



LAB : Source Specific Multicast

TASK :

- Configure OSPF area 0
- Enable PIM sparse-mode multicast delivery from R1 to R5
- Using the default multicast group range, enable PIM SSM functionality on your network.
- R5 should join the multicast feed (11.0.0.1,232.5.5.5). R1- loop 0 should be the source

LAB : Source Specific Multicast

R1 (config)#router ospf 1

R1(config-router)#network 10.0.0.0 0.255.255.255 area 0

R1(config-router)#network 1.0.0.0 0.255.255.255 area 0

R1(config-router)#network 4.0.0.0 0.255.255.255 area 0

R1 (config-router)#exit

R2(config)# router ospf 1

R2(config-router)# network 20.0.0.0 0.255.255.255 area 0

R2(config-router)# network 1.0.0.0 0.255.255.255 area 0

R2(config-router)# network 2.0.0.0 0.255.255.255 area 0

R2(config-router)# exit

LAB : Source Specific Multicast

```
R3(config)# router ospf 1
```

```
R3(config-router)# network 30.0.0.0 0.255.255.255 area 0
```

```
R3(config-router)# network 2.0.0.0 0.255.255.255 area 0
```

```
R3(config-router)# network 3.0.0.0 0.255.255.255 area 0
```

```
R3(config-router)# exit
```

```
R4(config)# router ospf 1
```

```
R4(config-router)# network 40.0.0.0 0.255.255.255 area 0
```

```
R4(config-router)# network 3.0.0.0 0.255.255.255 area 0
```

```
R4(config-router)# network 4.0.0.0 0.255.255.255 area 0
```

```
R4(config-router)# network 5.0.0.0 0.255.255.255 area 0
```

LAB : Source Specific Multicast

```
R5(config)# router ospf 1
```

```
R5(config-router)# network 50.0.0.0 0.255.255.255 area 0
```

```
R5(config-router)# network 5.0.0.0 0.255.255.255 area 0
```

```
R5(config-router)# exit
```

LAB : Source Specific Multicast

```
R4#sh ip pim nei
PIM Neighbor Table
Mode: B - Bidir Capable, DR - Designated Router, N - Default DR Priority,
      S - State Refresh Capable
Neighbor          Interface              Uptime/Expires    Ver   DR
Address                                     Prio/Mode
3.3.3.1            Serial1/0                01:22:16/00:01:19 v2     1 / B S
4.4.4.2            Serial1/1                00:04:27/00:01:44 v2     1 / B S
R4#
```

LAB : Source Specific Multicast

R1/R2/R3

Rx(config)# ip multicast-routing

Rx(config)# int f0/0

Rx(config-if)# ip pirn sparse-mode

Rx(config-if)# int sl/0

Rx(config-if)# ip pirn sparse-mode

Rx(config-if)# int sl/1

Rx(config-if)# ip pirn sparse-mode

Rx(config-if)#end

LAB : Source Specific Multicast

```
R4(config)# ip multicast-routing
```

```
R4(config)# int f0/0
```

```
R4(config-if)# ip pim sparse-mode
```

```
R4(config-if)# int sl/0
```

```
R4(config-if)# ip pim sparse-mode
```

```
R4(config-if)# int sl/1
```

```
R4(config-if)# ip pim sparse-mode
```

```
R4(config-if)# int sl/2
```

```
R4(config-if)# ip pim sparse-mode
```

```
R4(config-if)#end
```

LAB : Source Specific Multicast

```
R5(config)# ip multicast-routing  
R5(config)# int f0/0  
R5(config-if)# ip pim sparse-mode  
R5(config-if)# int s1/0  
R5(config-if)# ip pim sparse-mode  
R5(config-if)#end
```

LAB : Source Specific Multicast

```
R4#sh ip pim nei
PIM Neighbor Table
Mode: B - Bidir Capable, DR - Designated Router, N - Default DR Priority,
      S - State Refresh Capable
Neighbor          Interface                Uptime/Expires    Ver    DR
Address                                     Prio/Mode
3.3.3.1            Serial1/0                01:28:05/00:01:25 v2      1 / B S
4.4.4.2            Serial1/1                00:10:15/00:01:20 v2      1 / B S
R4#sh ip pim inter
R4#sh ip pim interface

Address          Interface                Ver/    Nbr    Query    DR    DR
                  Interface                Mode    Count  Intvl    Prior
40.1.1.1         FastEthernet0/0         v2/S    0      30      1      40.1.1.1
3.3.3.2          Serial1/0               v2/S    1      30      1      0.0.0.0
4.4.4.1          Serial1/1               v2/S    1      30      1      0.0.0.0
R4#
```

LAB : Source Specific Multicast

on all routers :

```
Rx(config)#ip pim ssm default
```

```
Rl(config)#router ospf 1
```

```
Rl(config-router)#network 11.0.0.0 0.0.0.255 area 0
```

```
R1(config-router)#exit
```

```
Rl(config)#int loop 0
```

```
R1(config-if)#ip pim sparse-mode
```

LAB : Source Specific Multicast

```
R5#ping 11.0.0.1
```

```
Type escape sequence to abort.
```

```
Sending 5, 100-byte ICMP Echos to 11.0.0.1, timeout is 2 seconds:
```

```
!!!!
```

```
Success rate is 100 percent (5/5), round-trip min/avg/max = 80/127/168 ms
```

```
R5#
```

LAB : Source Specific Multicast

```
R5(config)# int f0/0
```

```
R5(config-if)# ip igmp version 3
```

```
R5(config-if)# ip igmp join-group 232.5.5.5 source 11.0.0.1
```

```
R5(config-if)#end
```

LAB : Source Specific Multicast

```
R5#sh ip mroute 232.5.5.5
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
Outgoing interface flags: H - Hardware switched, A - Assert winner
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(11.0.0.1, 232.5.5.5), 00:00:13/00:02:47, flags: sLTI
  Incoming interface: Serial1/0, RPF nbr 0.0.0.0
  Outgoing interface list:
    FastEthernet0/0, Forward/Sparse, 00:00:13/00:02:47
```

LAB : Source Specific Multicast

```
R1#ping 232.5.5.5
```

```
Type escape sequence to abort.
```

```
Sending 1, 100-byte ICMP Echos to 232.5.5.5, timeout is 2 seconds:
```

```
.
```

```
R1#
```

```
R1#
```

LAB : Source Specific Multicast

```
R5#sh ip igmp groups 232.5.5.5 detail
```

Flags: L - Local, U - User, SG - Static Group, VG - Virtual Group,
SS - Static Source, VS - Virtual Source,
Ac - Group accounted towards access control limit

Interface: FastEthernet0/0

Group: 232.5.5.5

Flags: L SSM

Uptime: 00:01:53

Group mode: INCLUDE

Last reporter: 50.1.1.1

Group source list: (C - Cisco Src Report, U - URD, R - Remote, S - Static,
V - Virtual, M - SSM Mapping, L - Local,
Ac - Channel accounted towards access control limit)

Source Address	Uptime	v3 Exp	CSR Exp	Fwd	Flags
11.0.0.1	00:01:53	00:02:21	stopped	Yes	RL

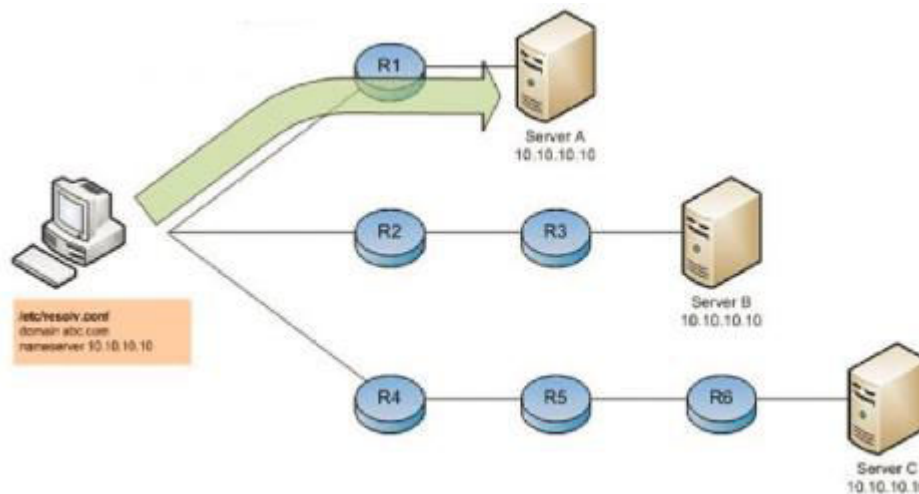
```
R5#
```

LAB : Source Specific Multicast

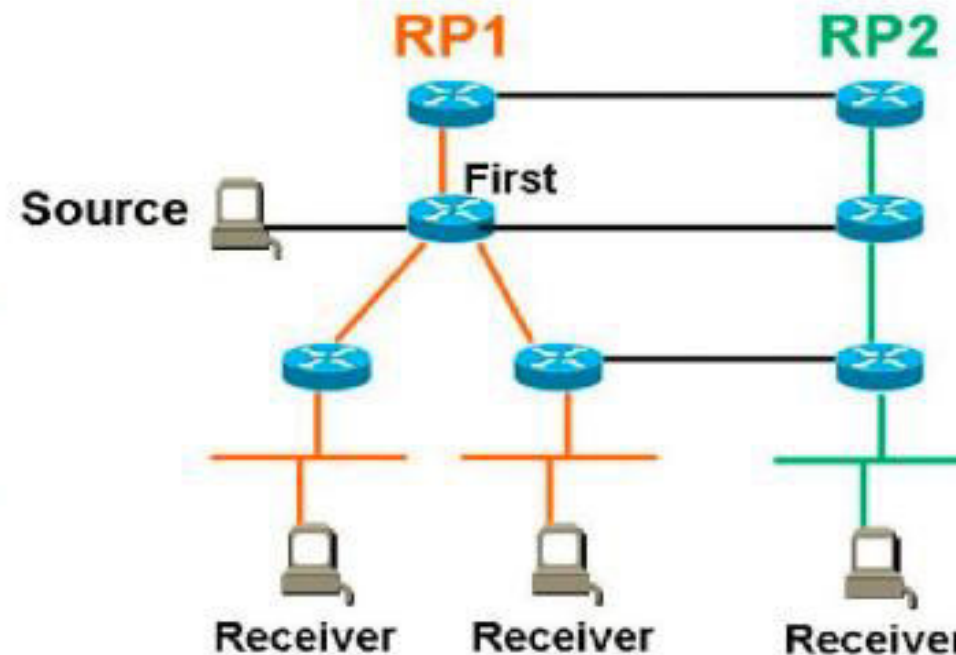
- The major difference between ASM and SSM multicast is that the IGMPv3 join triggers state throughout the PIM network all the way up to the source.
- In ASM, IGMP triggered state up to the RP, not directly to the source. If we source multicast packets destined to 232.5.5.5 from any interface other than RTs Loopback0 (11.0.0.1), R5 will not respond to these packet because it is only listening to multicast packets sourced from 11.0.0.1 and destined to 232.5.5.5

Concept of Anycast

- Identify multiple devices using the same address
- But sends to anyone which ever is nearest (find first) .
- Provides Load Balancing & High Availability
- Each device assigns the same IPv4/v6 address and advertise ,
- Send to anyone based on shortest path (IGP/BGP) .
- If anyone fails, sends to next nearest based on routing table



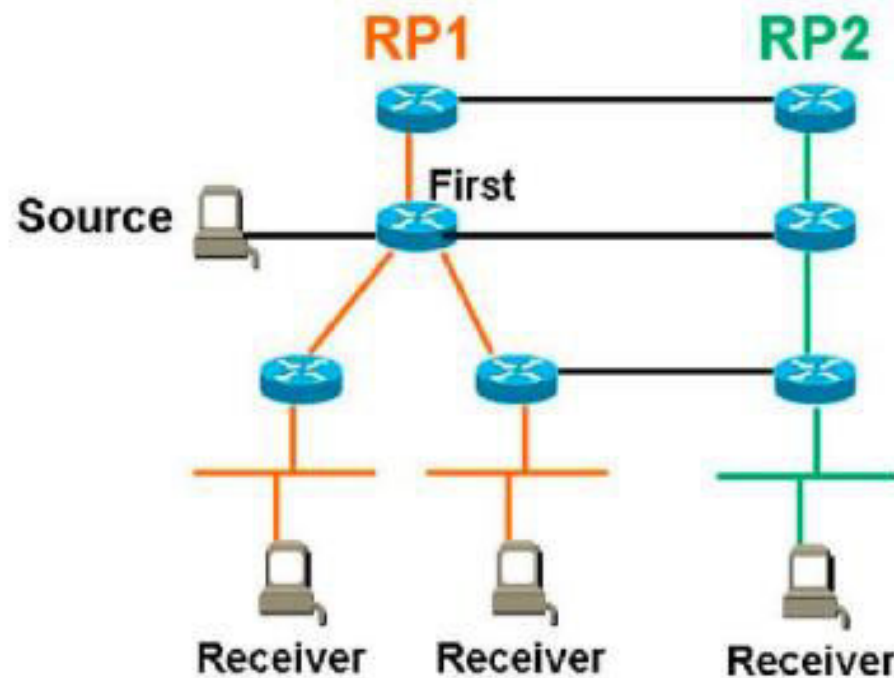
- ▶ a mechanism to provide fast RP failover and RP load-sharing.
- ▶ Idea is to get (at least) 2 routers playing the role of RP simultaneously.
- ▶ If one RP goes down, convergence is up to IGP to send to next nearest RP.
- ▶ All RPs in the multicast domain shared the same IP address and the PIM join/prune as well as the source registration
- ▶ messages are sent to the closest RP based on the unicast routing table.



Anycast RP issues

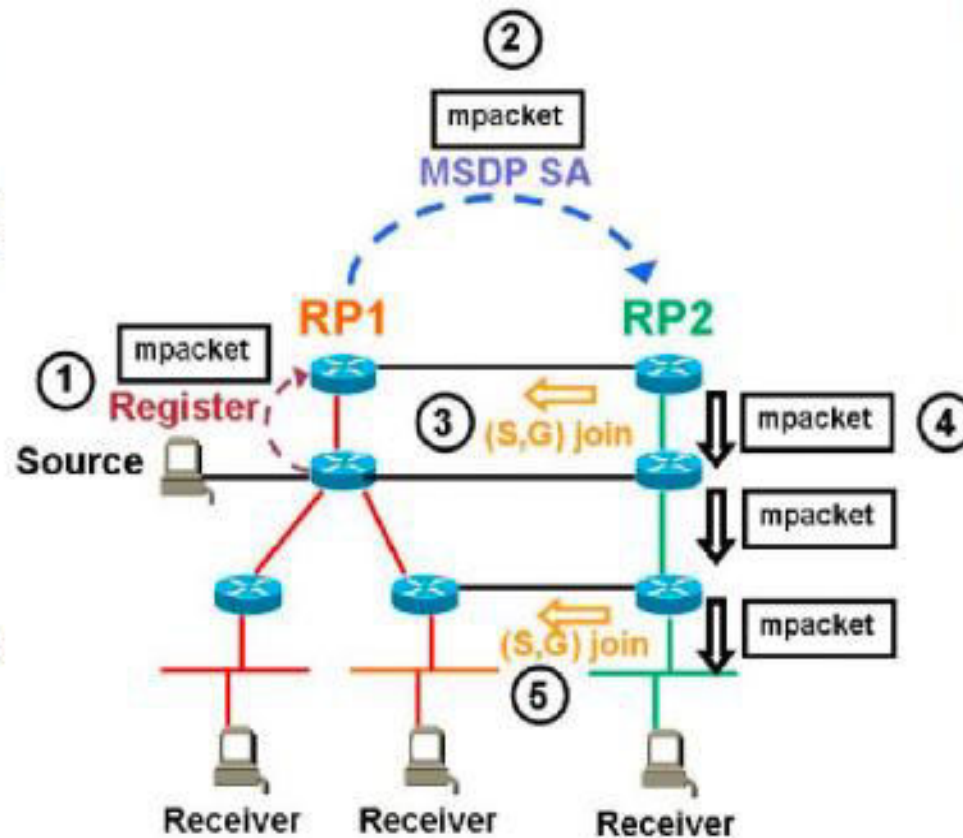
- ▶ All the RP must share the same information about sender & receiver
- ▶ There are 2 RPs for the same group, they use same IP address
- ▶ Receivers on the left have a shorter path towards RP1 so they are connected to the shared tree of RP1
- ▶ Receiver on the right is closer to RP2 so it's connected to the shared tree of RP2.
- ▶ RP must know about the source and Receiver.

Solution : MSDP



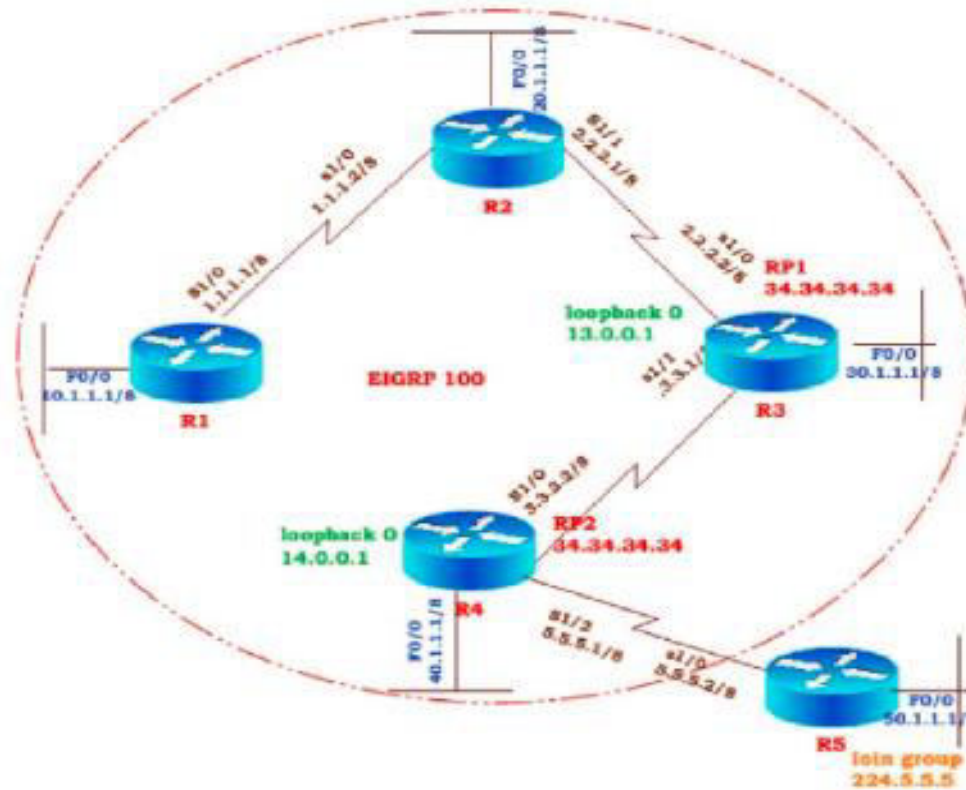
Multicast Source Discovery protocol

- ▶ Used to advertise (S,G) pairs between RP's
- ▶ Listen PIM Register messages (S,G) tells the other RP using MSDP Source active message
- ▶ Allows PIM domains to use independent RP's
- ▶ Originally designed for inter-AS multicast
- ▶ Here, we are using for anycast intra-AS multicast



How Anycast RP works

- ▶ Assign duplicate IP address on both RP's and Advertise in IGP
- ▶ All the routers point to any one of the nearest RP (anycast)
- ▶ MSDP peering between RP using unique address.
- ▶ MSDP SA messages to MSDP peer.



LAB: Anycast -MSDP Configuration

R3/R4

```
Rx(config)# ip pim rp-candidate loopback 34
```

```
Rx(config)# ip pim bsr-candidate loopback 34
```

R5(config)#int f0/0

```
R5(config-if)#ip igmp join-group 224.5.5.5
```

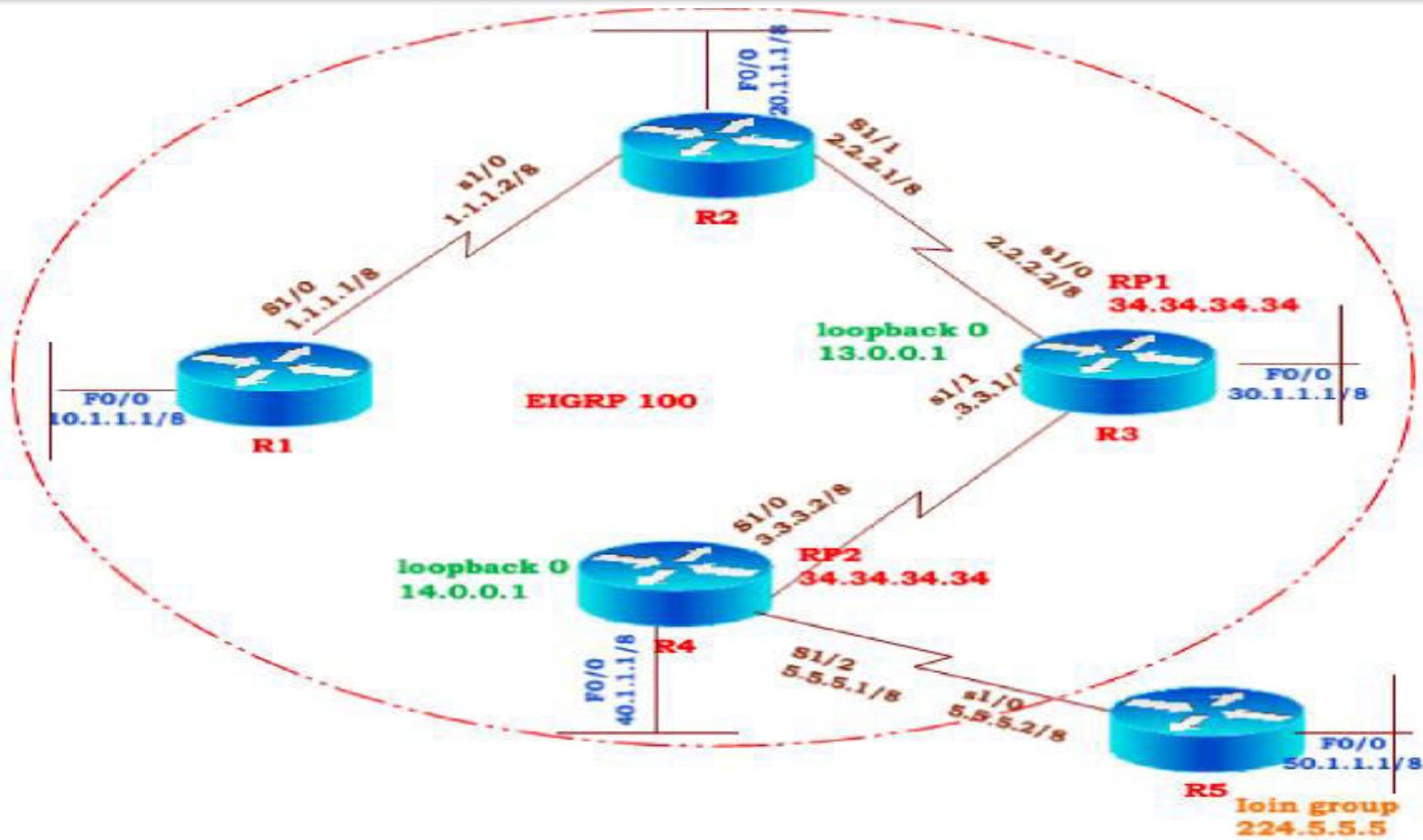
```
R3(config)# ip msdp peer 14.0.0.1 connect-source loopback 0
```

```
R3(config)# ip msdp originator-id loopback 0
```

```
R4(config)#ip msdp peer 13.0.0.1 connect-source loopback 0 224.5.5.5
```

```
R4(config)#ip msdp originator-id loopback 0
```

LAB: Anycast -MSDP Configuration



LAB: Anycast -MSDP Configuration

TASK :

- Create loopback 34 on both R4/R3
- Configure EIGRP 100 and advertise all connected interfaces as per the diagram.

```
R1(config)#router eigrp 100
```

```
RI (config-router)#no auto-summary
```

```
RI (config-router)#network 10.0.0.0
```

```
RI (config-router)#network 1.0.0.0
```

```
R1(config-router)#exit
```

LAB: Anycast -MSDP Configuration

```
R2(config)#router eigrp 100
```

```
R2(config-router)#no auto-summary
```

```
R2(config-router)#network 1.0.0.0
```

```
R2(config-router)#network 2.0.0.0
```

```
R2(config-router)#network 20.0.0.0
```

```
R2(config-router)#exit
```

```
R3(config)#router eigrp 100
```

```
R3(config-router)#network 30.0.0.0
```

```
R3(config-router)#network 3.0.0.0
```

```
R3(config-router)#network 2.0.0.0
```

```
R3(config-router)#exit
```

LAB: Anycast -MSDP Configuration

```
R4(config)#router eigrp 100
```

```
R4(config-router)#network 5.0.0.0
```

```
R4(config-router)#network 3.0.0.0
```

```
R4(config-router)#network 40.0.0.0
```

```
R4(config-router)#exit
```

```
R5(config)#router eigrp 100
```

```
R5(config-router)#no auto-summary
```

```
R5(config-router)#network 50.0.0.0
```

```
R5(config-router)#network 5.0.0.0
```

```
R5(config-router)#exit
```

LAB: Anycast -MSDP Configuration

```
R4(config-router)#do sh ip ei nei
IP-EIGRP neighbors for process 100
H   Address                Interface          Hold Uptime    SRTT   RTO   Q   Seq
                               (sec)          (ms)          Cnt  Num
1   5.5.5.2                  Se1/2             13 00:00:11    35   315   0    3
0   3.3.3.1                  Se1/0             11 00:00:31    12   200   0   13

R4(config-router)#do sh ip rou ei
D    1.0.0.0/8 [90/3193856] via 3.3.3.1, 00:00:38, Serial1/0
D    50.0.0.0/8 [90/2195456] via 5.5.5.2, 00:00:17, Serial1/2
D    2.0.0.0/8 [90/2681856] via 3.3.3.1, 00:00:38, Serial1/0
D    20.0.0.0/8 [90/2707456] via 3.3.3.1, 00:00:38, Serial1/0
D    10.0.0.0/8 [90/3219456] via 3.3.3.1, 00:00:38, Serial1/0
D    30.0.0.0/8 [90/2195456] via 3.3.3.1, 00:00:38, Serial1/0
R4(config-router)#
```

LAB: Anycast -MSDP Configuration

TASK:

- Configure IP Pim sparse-mode
- R3 and R4 as RP and mapping-agent using loopback 34

```
R1(config)#ip multicast-routing
```

```
R1(config)#int s1/0
```

```
R1(config-if)#ip pim sparse-mode
```

```
R1(config-if)#int f0/0
```

```
R1(config-if)#ip pim sparse-mode
```

```
R1(config-if)#exit
```

LAB: Anycast -MSDP Configuration

```
R2(config)# ip multicast-routing
```

```
R2(config)# int s1/0
```

```
R2(config-if)# ip pim sparse-mode
```

```
R2(config-if)# int f0/0
```

```
R2(config-if)# ip pim sparse-mode
```

```
R2(config-if)# int s1/1
```

```
R2(config-if)# ip pim sparse-mode
```

```
R2(config-if)#end
```

LAB: Anycast -MSDP Configuration

```
R3(config)#ip multicast-routing
R3(config)# int s1/0
R3(config-if)# ip pim sparse-mode
R3(config-if)# int f0/0
R3(config-if)# ip pim sparse-mode
R3(config-if)# int s1/1
R3(config-if)# ip pim sparse-mode
R3(config-if)# end
```

LAB: Anycast -MSDP Configuration

```
R4(config)# ip multicast-routing
R4(config)# int s1/0
R4(config-if)# ip pim sparse-mode
R4(config-if)#int f0/0
R4(config-if)# ip pim sparse-mode
R4(config-if)#int se1/2
R4(config-if)# ip pim sparse-mode
R4(config-if)#end
```

LAB: Anycast -MSDP Configuration

```
R5(config)#ip multicast-routing
```

```
R5(config-if)#int fa0/0
```

```
R5(config-if)#ip pim sparse-mode
```

```
R5(config-if)#int sl/O
```

```
R5(config-if)#ip pim sparse-mode
```

```
R5(config-if)#end
```

```
R4(config-if)#do sh ip pim nei
PIM Neighbor Table
Mode: B - Bidir Capable, DR - Designated Router, N - Default DR Priority,
      S - State Refresh Capable
Neighbor          Interface                Uptime/Expires    Ver   DR
Address                                     Prio/Mode
3.3.3.1            Serial1/0                04:07:54/00:01:37 v2     1 / B S
4.4.4.2            Serial1/1                02:50:05/00:01:20 v2     1 / B S
5.5.5.2            Serial1/2                00:01:09/00:01:35 v2     1 / B S
R4(config-if)#
```

LAB: Anycast -MSDP Configuration

R3/R4

```
Rx(config)# int loop 34
```

```
Rx(config-if)# ip address 34.34.34.34 255.255.255.255
```

```
Rx(config-if)# exit
```

```
Rx(config)# router eigrp 100
```

```
Rx(config-router)# network 34.34.34.34 0.0.0.0
```

```
Rx(config-router)# exit
```

LAB: Anycast -MSDP Configuration

```
Rx(config)# line vty 0 4
```

```
Rx(config-line)# no login
```

```
Rx(config-line)# exit
```

```
Rx(config)# int loop 34
```

```
Rx(config-if)# ip pim sparse-mode
```

```
Rx(config-if)# exit
```

LAB: Anycast -MSDP Configuration

R3/R4

```
Rx(config)# ip pim rp-candidate loopback 34
```

```
Rx(config)# ip pim bsr-candidate loopback 34
```

```
Rx(config)# exit
```

```
R1#sh ip pim rp mapping
PIM Group-to-RP Mappings

Group(s) 224.0.0.0/4
  RP 34.34.34.34 (?), v2
    Info source: 34.34.34.34 (?), via bootstrap, priority 0, holdtime 150
    Uptime: 00:01:44, expires: 00:01:42
  RP 13.0.0.1 (?), v2
    Info source: 34.34.34.34 (?), via bootstrap, priority 0, holdtime 150
    Uptime: 00:01:44, expires: 00:01:44
R1#tel
R1#telnet 34.34.34.34
Trying 34.34.34.34 ... Open
```

LAB: Anycast -MSDP Configuration

```
R1#sh ip pim rp mapping
PIM Group-to-RP Mappings

Group(s) 224.0.0.0/4
  RP 34.34.34.34 (?), v2
    Info source: 34.34.34.34 (?), via bootstrap, priority 0, holdtime 150
    Uptime: 00:03:03, expires: 00:02:24
  RP 13.0.0.1 (?), v2
    Info source: 34.34.34.34 (?), via bootstrap, priority 0, holdtime 150
    Uptime: 00:03:03, expires: 00:02:24
R1#
```

LAB: Anycast -MSDP Configuration

```
R5#sh ip pim rp mapping
PIM Group-to-RP Mappings

Group(s) 224.0.0.0/4
  RP 34.34.34.34 (?), v2
    Info source: 34.34.34.34 (?), via bootstrap, priority 0, holdtime 150
    Uptime: 00:04:12, expires: 00:02:27
R5#tel
R5#telnet 34.34.34.34
Trying 34.34.34.34 ... Open

R4>
```

LAB: Anycast -MSDP Configuration

TASK :

- Configure R5 to join group 224.5.5.5 (simulating reciveres forgroup 224.5.5.5)
- Configure R1 to simulate hosts sending traffic for group 224.5.5.5 (use ping 224.5.5.5)
- Verify the PIM Register and join messages using Show ip mroute.

```
R5(config)#int f0/0
```

```
R5(config-if)#ip igmp join-group 224.5.5.5
```

```
R5(config-if)#exit
```

LAB: Anycast -MSDP Configuration

```
R5#sh ip mroute 224.5.5.5
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
Outgoing interface flags: H - Hardware switched, A - Assert winner
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.5.5.5), 04:06:55/stopped, RP 34.34.34.34, flags: SJCL
Incoming interface: Serial1/0, RPF nbr 5.5.5.1
Outgoing interface list:
  FastEthernet0/0, Forward/Sparse, 04:06:55/00:01:45
```

LAB: Anycast -MSDP Configuration

```
R4#sh ip mroute 224.5.5.5
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
Outgoing interface flags: H - Hardware switched, A - Assert winner
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.5.5.5), 00:07:19/00:03:02, RP 34.34.34.34, flags: S
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial1/2, Forward/Sparse, 00:07:19/00:03:02

R4#
```

LAB: Anycast -MSDP Configuration

```
R1#ping 224.5.5.5
```

```
Type escape sequence to abort.
```

```
Sending 1, 100-byte ICMP Echos to 224.5.5.5, timeout is 2 seconds:
```

```
.
```

```
R1#
```

```
R1#sh ip mroute 224.5.5.5
```

```
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
```

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

```
Timers: Uptime/Expires
```

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

```
(*, 224.5.5.5), 00:00:10/stopped, RP 34.34.34.34, flags: SPF
```

```
  Incoming interface: Serial1/0, RPF nbr 1.1.1.2
```

```
  Outgoing interface list: Null
```

```
(10.1.1.1, 224.5.5.5), 00:00:10/00:02:52, flags: PFT
```

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

```
  Outgoing interface list: Null
```

```
(11.0.0.1, 224.5.5.5), 00:00:10/00:02:52, flags: PFT
```

```
  Incoming interface: Loopback0, RPF nbr 0.0.0.0
```

```
  Outgoing interface list: Null
```

```
R1#
```

LAB: Anycast -MSDP Configuration

```
R2#sh ip mroute 224.5.5.5
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
Outgoing interface flags: H - Hardware switched, A - Assert winner
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.5.5.5), 00:01:46/stopped, RP 34.34.34.34, flags: SPF
  Incoming interface: Serial1/1, RPF nbr 2.2.2.2
  Outgoing interface list: Null

(1.1.1.1, 224.5.5.5), 00:01:46/00:01:18, flags: PFT
  Incoming interface: Serial1/0, RPF nbr 0.0.0.0
  Outgoing interface list: Null

R2#
```

LAB: Anycast -MSDP Configuration

```
R3#sh ip mroute 224.5.5.5
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
Outgoing interface flags: H - Hardware switched, A - Assert winner
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.5.5.5), 00:01:55/stopped, RP 34.34.34.34, flags: SP
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list: Null

(1.1.1.1, 224.5.5.5), 00:01:55/00:01:04, flags: P
  Incoming interface: Serial1/0, RPF nbr 2.2.2.1
  Outgoing interface list: Null

(10.1.1.1, 224.5.5.5), 00:01:55/00:01:04, flags: P
  Incoming interface: Serial1/0, RPF nbr 2.2.2.1
  Outgoing interface list: Null

R3#
```

LAB: Anycast -MSDP Configuration

- R1/R2 send PIM Register messages to nearest RP (R3) to create entries (S,G)
- R5 send Pim Join messages to nearest RP (R4).
- Here as the source and Recievers are using nearest RP (different) it will not create shortest path tree from source to reciever

LAB: Anycast -MSDP Configuration

TASK :

- Configure MSDP peering between R3-R4 to ensure that server able to send multicast traffic on R5 Recievers.
- use loopback 0 interface of respective routers for MSDP peering.

```
R3(config)#router eigrp 100
```

```
R3(config-router)#network 13.0.0.0 0.0.0.255
```

```
R3(config-router)#exit
```

LAB: Anycast -MSDP Configuration

```
R3(config)# ip msdp peer 14.0.0.1 connect-source loopback 0
```

```
R3(config)# ip msdp originator-id loopback 0
```

```
R4(config)#router eigrp 100
```

```
R4(config-router)#network 14.0.0.0 0.0.0.255
```

```
R4(config-router)#exit
```

LAB: Anycast -MSDP Configuration

- connect-source is like update-source i.e the address used for establishing the session.
- originator-id is an identifier for the router, just like BGP router ID, or OSPF router ID. It is usually the the highest IP address on loopback interfaces and has to be unique, originator-id is used for solving the issue when the highest loopback IP is the same on routers by assigning different MSDP ID to each one.

If you are running anycast RP then usually you would hardcode the originator-ID so there is no risk of collision. This could happen if MSDP chooses the anycast address as the originator-ID.

```
R4#ping 14.0.0.1 source 14.0.0.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 14.0.0.1, timeout is 2 seconds:
Packet sent with a source address of 14.0.0.1
!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

LAB: Anycast -MSDP Configuration

```
R4(config)#ip msdp peer 13.0.0.1 connect-source loopback 0
```

```
R4(config)#ip msdp originator-id loopback 0
```

LAB: Anycast -MSDP Configuration

```
R4#sh ip msdp peer
MSDP Peer 13.0.0.1 (?), AS ?
  Connection status:
    State: Listen, Resets: 0, Connection source: Loopback0 (14.0.0.1)
    Uptime(Downtime): 00:00:17, Messages sent/received: 0/0
    Output messages discarded: 0
    Connection and counters cleared 00:00:17 ago
  SA Filtering:
    Input (S,G) filter: none, route-map: none
    Input RP filter: none, route-map: none
    Output (S,G) filter: none, route-map: none
    Output RP filter: none, route-map: none
  SA-Requests:
    Input filter: none
  Peer ttl threshold: 0
  SAs learned from this peer: 0
  Input queue size: 0, Output queue size: 0
R4#
```

LAB: Anycast -MSDP Configuration

```
R1#ping 224.5.5.5
```

```
Type escape sequence to abort.
```

```
Sending 1, 100-byte ICMP Echos to 224.5.5.5, timeout is 2 seconds:
```

```
Reply to request 0 from 5.5.5.2, 104 ms
```

```
R1#
```

LAB: Anycast -MSDP Configuration

```
R1#sh ip mroute 224.5.5.5
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
Outgoing interface flags: H - Hardware switched, A - Assert winner
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.5.5.5), 00:00:41/stopped, RP 34.34.34.34, flags: SPF
  Incoming interface: Serial1/0, RPF nbr 1.1.1.2
  Outgoing interface list: Null

(10.1.1.1, 224.5.5.5), 00:00:41/00:03:07, flags: FT
  Incoming interface: FastEthernet0/0, RPF nbr 0.0.0.0
  Outgoing interface list:
    Serial1/0, Forward/Sparse, 00:00:41/00:02:48

(11.0.0.1, 224.5.5.5), 00:00:42/00:02:41, flags: PFT
  Incoming interface: Loopback0, RPF nbr 0.0.0.0
  Outgoing interface list: Null

R1#
```

LAB: Anycast -MSDP Configuration

TASK : Shutdown the R3 loopback 34 interface to verify Redundancy.

```
R3(config)#int loop 34
```

```
R3(config-if)#shutdown
```

```
R3(config-if)#exit
```

LAB: Anycast -MSDP Configuration

```
R1#ping 224.5.5.5
```

```
Type escape sequence to abort.
```

```
Sending 1, 100-byte ICMP Echos to 224.5.5.5, timeout is 2 seconds:
```

```
Reply to request 0 from 5.5.5.2, 132 ms
```

```
R1#sh ip pim rp mapping
```

```
PIM Group-to-RP Mappings
```

```
Group(s) 224.0.0.0/4
```

```
RP 34.34.34.34 (?), v2
```

```
Info source: 34.34.34.34 (?), via bootstrap, priority 0, holdtime 150
```

```
Uptime: 00:18:34, expires: 00:02:04
```

```
RP 13.0.0.1 (?), v2
```

```
Info source: 34.34.34.34 (?), via bootstrap, priority 0, holdtime 150
```

```
Uptime: 00:18:34, expires: 00:01:56
```

```
R1#
```

LAB: Anycast -MSDP Configuration

```
R1#telnet 34.34.34.34
Trying 34.34.34.34 ... Open
R4>
```

LAB: Anycast -MSDP Configuration

TASK : Shutdown the R3 loopback 34 interface to verify Redundancy.

```
R3(config)#int loop 34
```

```
R3(config-if)#no shutdown
```

```
R3(config-if)#exit
```

```
R1#clear ip pim rp-mapping
```

```
R1#telnet 34.34.34.34
Trying 34.34.34.34 ... Open
R3>
```

LAB: Anycast -MSDP Configuration

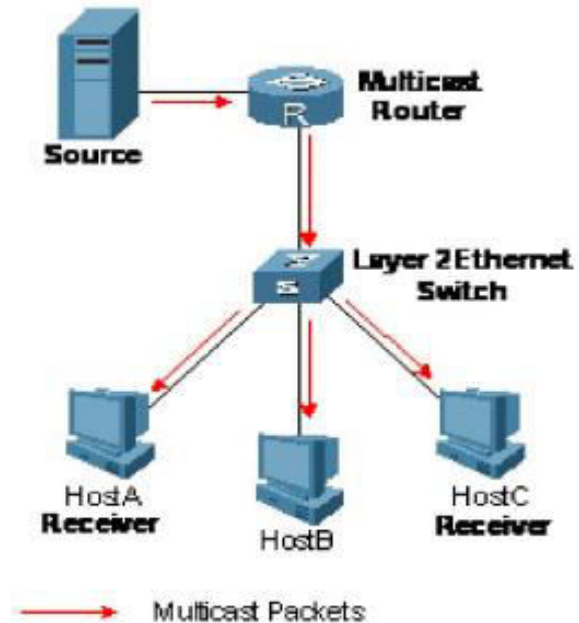
```
R1#telnet 34.34.34.34
Trying 34.34.34.34 ... Open

R3>
R3>
[Connection to 34.34.34.34 closed by foreign host]
R1#
R1#sh ip pim rp map
R1#sh ip pim rp mapping
PIM Group-to-RP Mappings

Group(s) 224.0.0.0/4
  RP 34.34.34.34 (?), v2, bidir
    Info source: 34.34.34.34 (?), via bootstrap, priority 0, holdtime 150
    Uptime: 00:12:15, expires: 00:01:50
  RP 13.0.0.1 (?), v2, bidir
    Info source: 34.34.34.34 (?), via bootstrap, priority 0, holdtime 150
    Uptime: 00:11:59, expires: 00:01:48
R1#
```

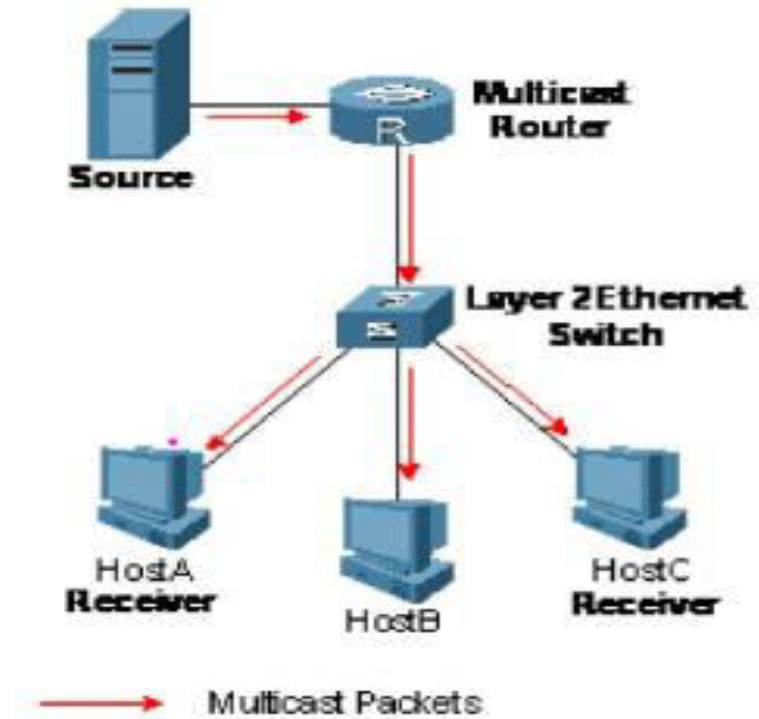
Layer 2 Multicast

- ▶ Layer 2 MAC address
- ▶ IGMP Snooping



Multicast Mac address

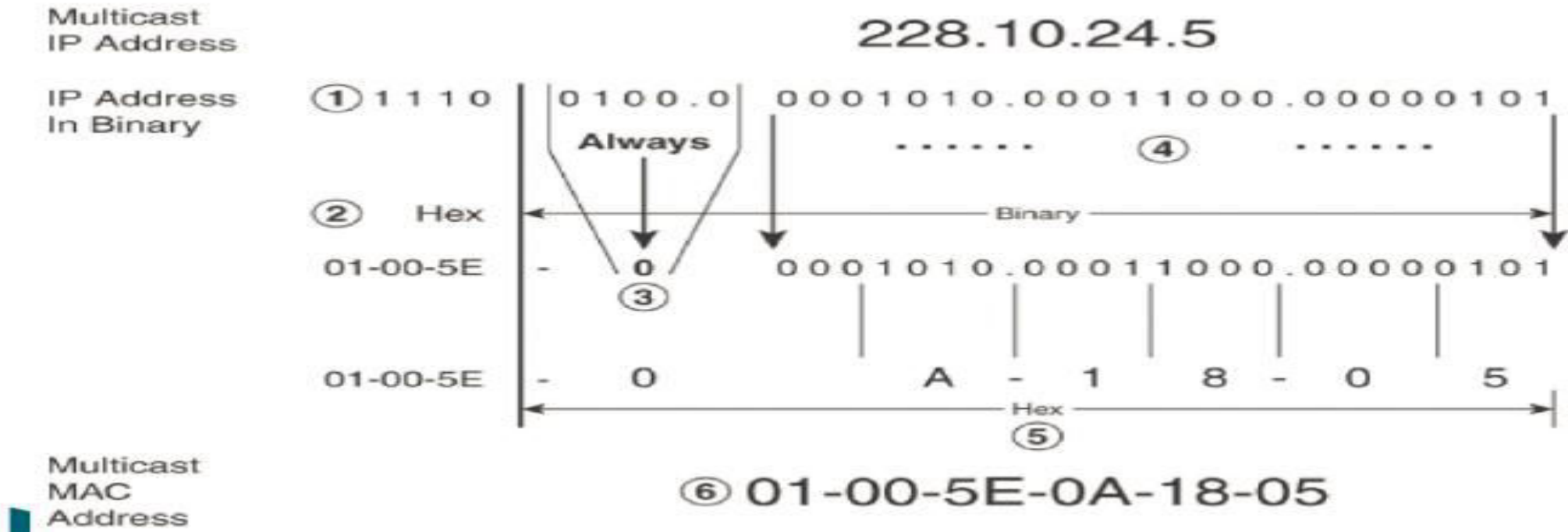
- ▶ Multicast Ethernet MAC addresses start with hexadecimal **01:00:5E**
- ▶ The translation between L3 IP multicast and L2 MAC multicast addresses is achieved
- ▶ Mapping the lower 23 bits



Steps for Multicast mac conversion

1. Convert the IP address to binary .(first 4 bits always 1110)
2. Replace the first 4 bits 1110 of the IP address with the 6 hexadecimal digits (or 24 bits) 01-00-5E
3. Replace the next 5 bits of the binary IP address with one binary 0 in the multicast MAC.
4. Copy the last 23 bits of the binary IP address in the last 23-bit space of the multicast MAC address.
5. Convert the last 24 bits of the multicast MAC address from binary to 6 hexadecimal digits.
6. Combine the first 6 hexadecimal digits 01-00-5E with the last 6 hexadecimal digits, calculated in Step 5, to form a complete multicast MAC address of 12 hexadecimal digits.

Multicast MAC address Conversion

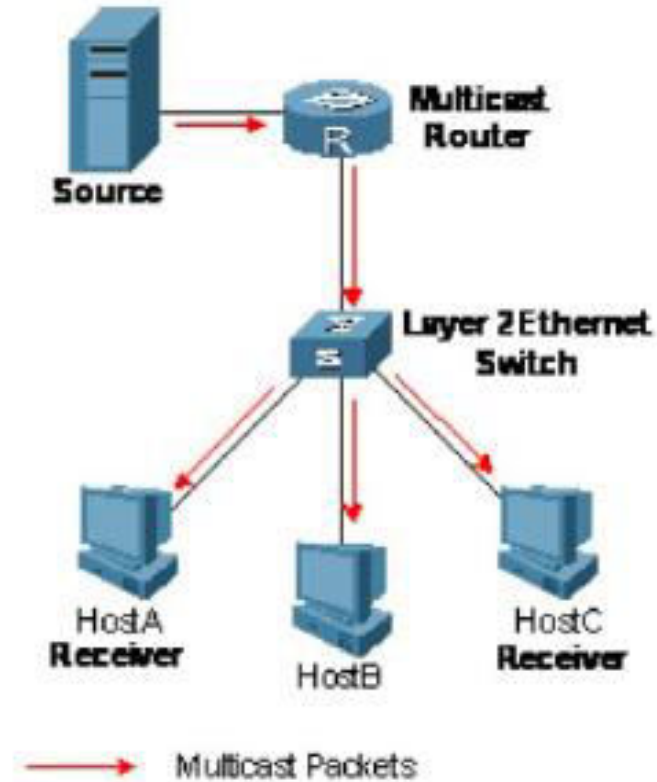


Layer 2 Multicast (broadcast issues)

- ▶ IGMP helps routers to determine how to distribute multicast traffic.
- ▶ IGMP works at Layer 3, and switches do not understand IGMP messages.
- ▶ Switches will never find a multicast MAC address in their CAM table, because a multicast MAC address is never used as a source address.
- ▶ Switches flood multicast traffic to all the hosts in a broadcast domain, which wastes bandwidth.

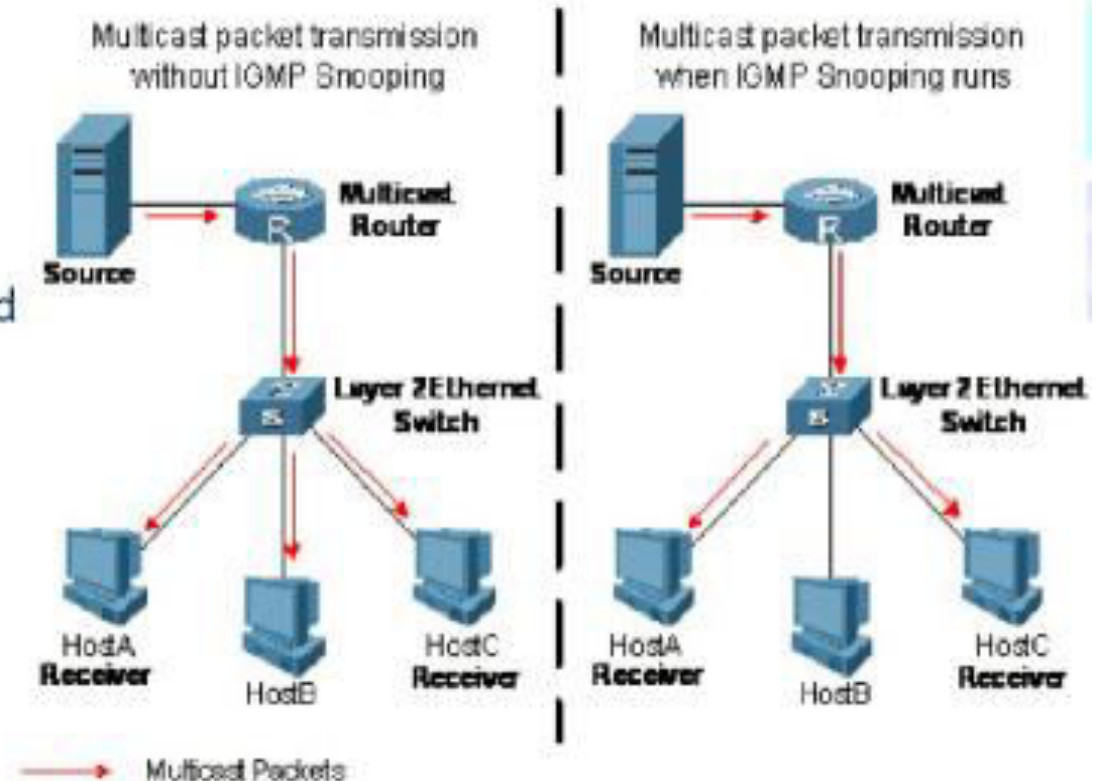
Solution :

- ▶ **IGMP Snooping**
- ▶ **CGMP (Cisco Proprietary)**



IGMP Snooping

- Standard based.
- dynamically determine which hosts connected to a particular VLAN in the switch need to receive a particular multicast transmission.
- The switch examines IGMP messages and learns the location of multicast routers and group members.
- dynamically determine which hosts connected to a particular VLAN in the switch need to receive a particular multicast transmission.



IGMP Snooping

- ICMP snooping is enabled by default on Catalyst multi-layer switches.
- Snooping is enabled globally and on a per-VLAN basis.

```
Router(config)# ip igmp snooping
```

```
Router(config)# ip igmp snooping vlan 10
```

IGMP Snooping

```
SW1#show ip igmp snooping vlan 146
```

```
Global IGMP Snooping configuration:
```

```
IGMP snooping : Enabled
```

```
IGMPv3 snooping (minimal) : Enabled
```

```
Report suppression : Enabled
```

```
TCN solicit query : Disabled
```

```
TCN flood query count : 2
```

```
Robustness variable : 2
```

```
Last member query count : 2
```

```
Last member query interval : 1000
```

```
Vlan 146:
```

```
----- IGMP snooping : Enabled
```

```
CAPWAP enabled : Disabled IGMPv2 immediate leave : Enabled
```

```
Multicast router learning mode : pim-dvmrp
```

```
CGMP interoperability mode : IGMP_ONLY
```

```
Robustness variable : 2
```

```
Last member query count : 2
```

```
Last member query interval : 1000
```



Thank you