BIG-IP® Advanced Routing™
Multicast Configuration Guide

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Table of Contents

Preface

Network administrators and application developers intending to configure ZebOS® multicast protocols should use this Configuration Guide. This guide attempts to make configuration simpler by adding topology illustrations and configuration samples. It covers basic configurations for PIM-SM, PIM-DM, DVMRP, BSR-RP, embedded RP, Anycast RP, and Virtual Routing. Use this guide in conjunction with the PIM-DM, PIM-SM, and VR Command References to get complete information on the commands used in the configurations displayed in this guide.

Conventions

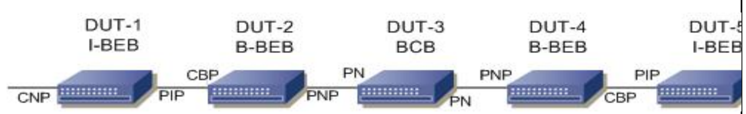
The following table displays the conventions for the syntax and procedures describing how to enter information, and how information displays on the console.

Convention	Description
`command syntax`	The `new courier` font represents command strings entered on a command line, and sample source code.
`UPPERCASE`	A variable parameter. Enter a value according to the descriptions that follow.
`lowercase`	A keyword parameter. Enter lowercase values exactly as shown
`|`	The vertical bar. Delimits choices; select one from the list.
`()`	Parenthesis. Delimits optional parameters. Do not enter parentheses as part of any command.
`[]`	Square brackets: groups parameters and keywords into a single unit. Take all parts within these brackets. Do not enter brackets as part of any command.
`< >`	Angle brackets: enclose a numeric range for a keyword. Do not enter angle brackets as part of any command.
descriptionid	Proportional font gives specific details about a parameter.
=	Equal sign: separates the command syntax from explanatory text.

Note: Unless otherwise stated, press Enter after each command entry.

Configuration Format

The following table describes the configuration format used in this guide.

Format	Description	Example
Scenario Description	This section includes a description of both the topology and the configuration.	**Enabling RIP** This example shows the minimum configuration required for enabling RIP on an interface.
Topology	This section is an illustration of the topology. The figure might include the IP addresses and names of the devices used in the example.	
Configuration	This section has the complete configuration involved in the example. The prompt shows the execution modes of the commands.	`R1` **`ZebOS`**`#configure terminal` **`ZebOS(config)`**`#router rip` **`ZebOS(config-router)`**`#net...` **`ZebOS(config-router)`**`#net...`
Explanation	The grey section next to the configuration provides an explanation of the action performed by a configuration.	Configure interface in bridge group Configure interface mode as `trunk`. Allow all VLANs on interface `eth2`.
Commands Used	This section lists the names of the commands used in the example. Users can look up the details of these commands in the specific command line reference guide. To avoid repetition, this section does not include common commands, such as “configure terminal. “	**Commands Used** router rip, network
Validation Commands	This section has the show commands that display the validation output.	**Validation Commands** show ip rip

Command Line Interface

The ZebOS™ Command Line Interface (CLI) is a text-based interface that is used to interact with systems. Users can utilize many of the commands in scripts to automate many configuration tasks. Each command associates with a specific function or a common function performing a specific task. Multiple users can telnet and issue commands using the Exec mode and the Privileged Exec mode. The VTY shell, described in the ZebOS VTY Shell User Guide, gives users and administrators the ability to issue commands to several daemons from a single telnet session.

Command Line Help

The ZebOS CLI contains a text-based help facility. Access this help by typing in the full or partial command string, then typing "?". The ZebOS CLI displays the command keywords or parameters plus a short description. For example, at the CLI command prompt, type `show` ? (the CLI does not display the question mark). The CLI displays this keyword list with short descriptions for each keyword:

```
bgpd#show
  access-list                    List IP access lists
  bfd                            Bidirectional Forwarding Detection (BFD)
  bgp                            Border Gateway Protocol (BGP)
  cli                            Show CLI tree of current mode
  clns                           Connectionless-Mode Network Service (CLNS)
  debugging                      Debugging functions (see also 'undebug')
  faults                         Show recorded faults
  history                        Display the session command history
  interface                      Interface status and configuration
  ip                             Internet Protocol (IP)
  ipv6                           Internet Protocol version 6 (IPv6)
  isis                           Intermediate System-Intermediate System
  list                           Show command lists
  mrib                           MRIB
  nsm                            NSM
  privilege                      Show current privilege level
  proc-names                     Show process names
  process                        Process
  route-map                      route-map information
  router-id                      Router ID
  running-config                 Current Operating configuration
```

Syntax Help

The ZebOS CLI can complete the spelling of command or parameter keywords. Begin typing the command or parameter, then press TAB. At the CLI command prompt, type `sh`:

```
Router> sh
```

Press TAB. The CLI shows:

```
Router> show
```

If the command or parameter partial spelling is ambiguous, the CLI displays the choices that match the abbreviation. Type `show i`. Press TAB. The CLI shows:

```
Router> show i
interface ip
Router> show i
```

The CLI displays the `interface` and `ip` keywords. Type `n` to select `interface` and press TAB. The CLI shows:

```
Router> show in
Router> show interface
```

Now type ? and the CLI shows a list of parameters for the `show interface` command.

```
 [IFNAME] Interface name
Router> show interface
```

Command Abbreviations

The CLI accepts abbreviations for commands. For example, the following is an abbreviation for `show interface.`

```
sh in
```

Command line errors

If the router does not recognize the command after ENTER is pressed, it displays this message:

```
% Invalid input detected at '^' marker.
```

If a command is incomplete, it displays this message:

```
% Incomplete command.
```

Some commands are too long for the display line, and can wrap in mid-parameter or mid-keyword, if necessary:

```
area 10.10.0.18 virtual-link 10.10.0.19 authentication-key 57393
```

Command Modes

The commands available for each protocol separate into several modes (nodes) arranged in a hierarchy; Exec is the lowest. Each mode has its own special commands; in some modes, commands from a lower mode are available.

Modes Common to Protocols

Mode	Description
Exec	Also called the View mode, use this mode to perform basic commands, such as, show, exit, quit, help, list, and enable. This is the initial mode when users log in to any ZebOS CLI.
Privileged Exec	Also called the Enable mode, this mode allows users to perform debugging commands, write commands (for saving and viewing the configuration), and show commands.
Configure	Also called the Configure Terminal, this mode includes configuration commands and serves as a gateway to other configuration modes, including Interface, Router, Line, Route Map, Key Chain and Address Family modes. All ZebOS daemons have this mode.
Interface	Use this mode to configure protocol-specific settings for a particular interface. Any attribute configured in this mode overrides an attribute configured in the router mode.
Line	Use this mode to make access-class commands available.

Modes Specific to Protocols

The following command modes are specific to a variety of protocols. The command used to enter these modes is different for each protocol.

Mode	Description
Router	Known as the Configure Router mode, this mode is available for the LDP, BGP, OSPF, RSVP-TE and RIP protocols. It provides access to router and routing command.
Route-map	Use this mode to set route metric, route-length and cost data. It is available for the BGP, OSPF, and RIP protocols.
Address Family	Use this mode for multiprotocol BGP extension. It includes address family-specific commands.

Mode	Description
Key Chain	Use this mode to manage the key chain. It is available for the RIP and ISIS protocols.
Trunk	Use this mode to create or modify RSVP trunks. A trunk is the static definition for a Labeled Switch Path (LSP).
Path	Use this mode to create or modify RSVP paths.

CHAPTER 1 PIM Sparse Mode Configuration

The Protocol Independent Multicasting-Sparse Mode (PIM-SM) is a multicast routing protocol designed to operate efficiently across Wide Area Networks (WANs) with sparsely distributed groups. It helps geographically dispersed to network nodes to conserve bandwidth and reduce traffic by simultaneously delivering a single stream of information to multiple locations. PIM-SM uses the IP multicast model of receiver-initiated membership, supporting both shared and shortest-path trees, and uses soft-state mechanisms to adapt to changing network conditions. It relies on a topology-gathering protocol to populate a multicast routing table with routes.

This chapter provides the following topics:

- "Terminology"
- "Data Flow from Source to Receivers in PIM-SM Network Domain"
- "PIM-SM Configuration"
- "Anycast-RP Configuration"
- "Embedded RP Configuration"

Terminology

Following is a brief description of terms and concepts used to describe the PIM-SM protocol:

Rendezvous Point

A Rendezvous Point (RP) router is configured as the root of a non-source-specific distribution tree for a multicast group. Join messages from receivers for a group are sent towards the RP. Data from senders is sent to the RP so that receivers can discover who the senders are, and receive traffic destined for the group.

Multicast Routing Information Base

The Multicast Routing Information Base (MRIB) is a multicast topology table derived from the unicast routing table. In PIM-SM, the MRIB decides where to send Join/Prune messages. It also provides routing metrics for destination addresses. These metrics are used when sending and processing Assert messages.

Reverse Path Forwarding

Reverse Path Forwarding (RPF) is an optimized form of flooding, in which the router accepts a packet from `SourceA` through Interface `IF1`, only if `IF1` is the interface the router uses to reach `SourceA`. To determine if the interface is correct, it consults its unicast routing tables. The packet that arrives through interface `IF1` is forwarded because the routing table lists this interface as the shortest path. The router's unicast routing table determines the shortest path for the multicast packets. Because a router accepts a packet from only one neighbor, it floods the packet only once, meaning that (assuming point-to-point links) each packet is transmitted over each link, once in each direction.

Tree Information Base

The Tree Information Base (TIB) is a collection of states at a PIM router storing the state of all multicast distribution trees at that router. The TIB is created by receiving Join/Prune messages, Assert messages, and IGMP information from local hosts.

Upstream

Upstream indicates that traffic is going towards the root of the tree. The root of the tree might be either the Source or the RP.

Downstream

Downstream indicates that traffic is going away from the root of the tree. The root of tree might be either the Source or the RP.

Source-Based Trees

In Source-Based Trees, the forwarding paths are based on the shortest unicast path to the source. If the unicast routing metric used is `hop counts`, the branches of the multicast Source-Based Trees are minimum hop. If the metric used is `delay`, the branches are minimum delay. A corresponding multicast tree directly connects the source to all receivers for every multicast source. All traffic to the members of an associated group passes along the tree made for their source. Source-Based Trees have two entries with a list of outgoing interfaces -- the source address and the multicast group.

Shared Trees

Shared trees, or RP trees (RPT), rely on a central router called the Rendezvous Point (RP) that receives all traffic from the sources, and forwards that traffic to the receivers. There is a single tree for each multicast group, regardless of the number of sources. Only the routers on the tree know about the group, and information is sent only to interested receivers. With an RP, receivers have a place to join, even if no source exists. The shared tree is unidirectional, and information flows only from the RP to the receivers. If a host other than the RP has to send data on the tree, the data must first be tunneled to the RP, then multicast to the members. This means that even if a receiver is also a source, it can only use the tree to receive packets from the RP, and not to send packets to the RP (unless the source is located between the RP and the receivers).

Note: Not all hosts are receivers.

Bootstrap Router

When a new multicast sender starts sending data packets, or a new receiver starts sending Join messages towards the RP for that multicast group, the sender needs to know the next-hop router towards the RP. The bootstrap router (BSR) provides group-to-RP mapping information to all the PIM routers in a domain, allowing them to map to the correct RP address.

Data Flow from Source to Receivers in PIM-SM Network Domain

1. Sending out Hello Messages

PIM routers periodically send Hello messages to discover neighboring PIM routers. Hello messages are multicast using the address, 224.0.0.13 (`ALL-PIM-ROUTERS` group). Routers do not send any acknowledgement that a Hello message was received. A `holdtime` value determines the length of time for which the information is valid. In PIM-SM, a downstream receiver must join a group before traffic is forwarded on the interface.

2. Electing a Designated Router

In a multi-access network with multiple routers connected, one of the routers is selected to act as a designated router (DR) for a given period. The DR is responsible for sending Join/Prune messages to the RP for local members.

3. Determining the Rendezvous Point

PIM-SM uses a BSR to originate bootstrap messages, and to disseminate RP information. The messages are multicast to the group on each link. If the BSR is not apparent, the routers flood the domain with advertisements. The router with the highest priority (if priorities are same, the higher IP address applies) is selected to be the RP. Routers receive and store bootstrap messages originated by the BSR. When a DR gets a membership indication from IGMP for (or a data packet from) a directly connected host, for a group for which it has no entry, the designated router (DR) maps the group address to one of the candidate RPs that can service that group. The DR then sends a Join/Prune message towards that RP. In a small domain, the RP can also be configured statically.

4. Joining the Shared Tree

To join a multicast group, a host sends an IGMP message to its upstream router, after which the router can accept multicast traffic for that group. The router sends a Join message to its upstream PIM neighbor in the direction of the RP. When a router receives a Join message from a downstream router, it checks to see if a state exists for the group in its multicast routing table. If a state already exists, the Join message has reached the shared tree, and the interface from which the message was received is entered in the Outgoing Interface list. If no state exists, an entry is created, the interface is entered in the Outgoing Interface list, and the Join message is again sent towards the RP.

5. Registering with the RP

A DR can begin receiving traffic from a source without having a Source or a Group state for that source. In this case, the DR has no information on how to get multicast traffic to the RP through a tree. When the source DR receives the initial multicast packet, it encapsulates it in a Register message, and unicasts it to the RP for that group. The RP de-encapsulates each Register message, and forwards the extracted data packet to downstream members on the RPT. Once the path is established from the source to the RP, the DR begins sending traffic to the RP as standard IP multicast packets, as well as encapsulated within Register messages. The RP temporarily receives packets twice. When the RP detects the normal multicast packets, it sends a Register-Stop message to the source DR, meaning it should stop sending register packets.

6. Sending Register-Stop Messages

When the RP begins receiving traffic from the source, both as Register messages and as unencapsulated IP packets, it sends a Register-Stop message to the DR. This notifies the DR that the traffic is now being received as standard IP multicast packets on the SPT. When the DR receives this message, it stops encapsulating traffic in Register messages.

7. Pruning the Interface

Routers attached to receivers send Prune messages to the RP to disassociate the source from the RP. When an RP receives a Prune message, it no longer forwards traffic from the source indicated in the Prune message. If all members of a multicast group are pruned, the IGMP state of the DR is deleted, and the interface is removed from the Source and Group lists of the group.

8. Forwarding Multicast Packets

PIM-SM routers forward multicast traffic onto all interfaces that lead to receivers that have explicitly joined a multicast group. Messages are sent to a group address in the local subnetwork, and have a Time to Live (TTL) of 1. The router performs an RPF check, and forwards the packet. If a downstream router has sent a join to this router or is a member of this group, then traffic that arrives on the correct interface is sent to all outgoing interfaces that lead to downstream receivers.

PIM-SM Configuration

PIM-SM is a soft-state protocol. The required steps to configure PIM-SM are the following:

- enable IP multicast on each PIM router (see "Enabling IP Multicast Routing")
- enable PIM-SM on the desired interfaces (see "Enabling PIM-SM")
- configure the RP statically (see "Configuring Rendezvous Point Statically" or dynamically (see "Configuring Rendezvous Point Dynamically Using Bootstrap Router Method") depending on which method you use)

All multicast group states are dynamically maintained as the result of IGMP `Report/Leave` and PIM `Join/Prune` messages.

This section provides the steps to configure the PIM-SM feature. Configuration steps and examples are used for two relevant scenarios. The following figure displays the network topology used in these examples:

Note: For details about the commands used in the following examples, refer to the *ZebOS Network Platform PIM Command Line Interface Reference Guide.*

Topology

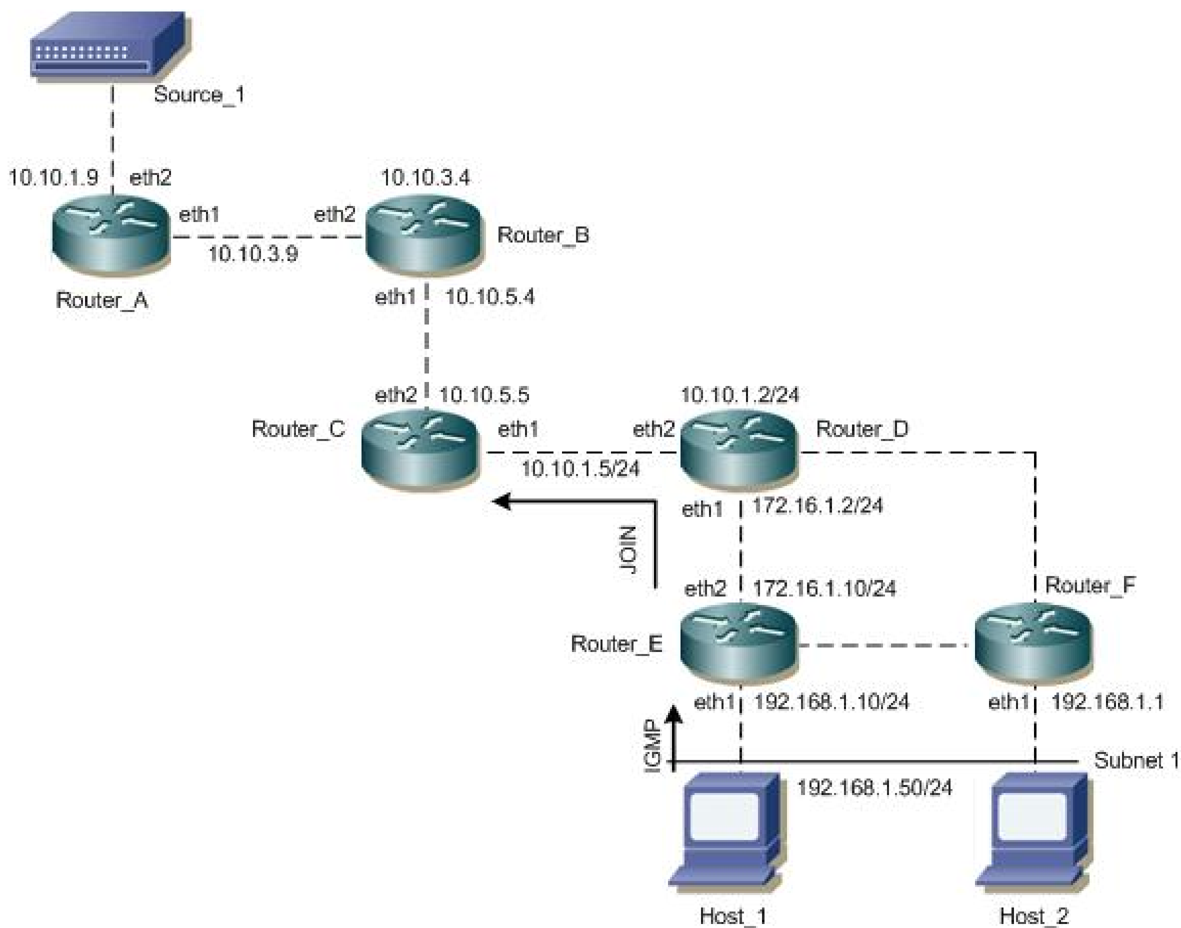


Figure 1: PIM-SM Topology

Enabling IP Multicast Routing

Enable IP multicast routing on all of the PIM routers inside the PIM domain:

Enable IP Multicast Routing

`ZebOS#configure terminal`	Enter Configure mode.
`ZebOS((config)#ip multicast-routing`	Enable IP multicast routing.
`ZebOS(config)#exit`	Exit Configure mode.

Enabling PIM-SM

Enable PIM-SM on all participating interfaces within each of routers inside the PIM domain on which you want to run PIM. In the following sample configuration, both eth1 and eth2 are enabled for PIM-SM on the router.

Enable PIM-SM on an Interface

`ZebOS#configure terminal`	Enter Configure mode.
`ZebOS(config)#interface eth1`	Specify the interface (`eth1`) to be configured and enter the Interface mode.
`ZebOS((config-if)#ip pim sparse-mode`	Enable PIM sparse mode on the interface.
`ZebOS(config-if)#exit`	Exit Interface mode.
`ZebOS(config)#interface eth2`	Specify the interface (`eth2`) to be configured and enter the Interface mode.
`ZebOS((config-if)#ip pim sparse-mode`	Enable PIM sparse mode on the interface.
`ZebOS(config-if)#exit`	Exit Interface mode.

Configuring Rendezvous Point Statically

Every PIM multicast group needs to be associated with the IP address of a Rendezvous Point (RP), which is a router that resides in a multicast network domain. The address of the RP is used as the root of a group-specific distribution tree. All nodes in the domain that want to receive traffic sent to the group are aware of the address of the RP. For all senders to reach all receivers within a group, all routers in the domain must be able to map to the RP address configured for the group. There can be several RPs configured in a network deploying PIM-SM, each serving a different group.

You can statically configure an RP by specifying the RP address in every router in the PIM domain. The use of statically configured RPs is ideal for small network environments or ones that do not require many RPs and/or require changing the assignment of the RPs often. Changing the assignment of an RP requires the reconfiguration of the RP address in all of the routers in the PIM domain.

In static RP configurations, RP failover is not available.

When configuring the RP statically, do the following:

- On every router, include the `ip pim rp-address A.B.C.D` statement even if a router does not have any source or group member attached to it
- Assign only one RP address for a multicast group in the PIM domain

Using the topology depicted in Figure 1, `Router_C` is the RP, and all routers are statically configured with RP information. Host_1 and Host_2 join group 224.0.1.3 for all the sources. They send the IGMP membership report to Subnet 1. Two routers are attached to Subnet 1, `Router_E` and `Router_F`; both have default DR priority on `eth1`. Since `Router_E` has a higher IP address on interface `eth1`, it becomes the Designated Router, and is responsible for sending Join messages to the RP (`Router_C`).

Configure Static RP

`ZebOS#configure terminal`	Enter Configure mode.
`ZebOS((config)#ip pim rp-address 10.10.1.5`	Statically configure an RP address for multicast groups.
`ZebOS(config)#exit`	Exit Configure mode.

Here is the sample configuration for `Router_D`:

```
hostname Router_D
!
interface eth0
!
interface eth1
 ip pim sparse-mode
!
interface eth2
 ip pim sparse-mode
!
interface lo
!
!
ip multicast-routing
ip pim rp-address 10.10.1.5
!
```

Commands Used

ip pim rp-address

Validation

Enter the commands listed in this section to confirm the previous configurations.

RP Details

At Router_D, the `show ip pim rp mapping` command shows that `10.10.1.5` is the RP for all multicast groups `224.0.0.0/4`, and is statically configured. All other routers will have a similar output:

```
Router_D#sh ip pim rp mapping
PIM Group-to-RP Mappings
Override RP cnt: 0
Group(s): 224.0.0.0/4, Static
    RP: 10.10.1.5
         Uptime: 00:01:45
```

At Router_D, use the `show ip pim rp-hash` command to display the selected RP for a specified group (224.0.1.3):

```
Router_D#show ip pim rp-hash 224.0.1.3 RP: 10.10.5.37
```

Interface Details

The `show ip pim interface` command displays the interface details for `Router_E`, and shows that `Router_E` is the Designated Router on `Subnet 1`.

```
Router_E#show ip pim interface
Address          Interface VIFindex Ver/   Nbr      DR    DR
                                    Mode   Count   Prior
192.168.1.10      eth1      0       v2/S   1         1     192.168.1.10
172.16.1.10       eth2      2       v2/S   1         1     172.16.1.10
```

IP Multicast Routing Table

Note: The multicast routing table displays for an RP router are different from other routers.

The `show ip pim mroute` command displays the IP multicast routing table. In this table, the following fields are defined:

`RPF nbr` Displays the unicast next-hop to reach RP.
and mask length.

`RPF idx` Displays the incoming interface for this (*, G) state.

`RP` Displays the IP address for the RP router

`The leading dots ....`
Stand for VIF index

```
Router_E#show ip pim mroute
IP Multicast Routing Table

(*,*,RP) Entries: 0
(*,G) Entries: 1
(S,G) Entries: 0
(S,G,rpt) Entries: 0
(*, 224.0.1.3)
RP: 10.10.1.5
RPF nbr: 172.16.1.2
RPF idx: eth2
Upstream State: JOINED
 Local     ................................
 Joined    j...............................
 Asserted  ................................
 Outgoing  o...............................
```

At `Router_E`, `eth2` is the incoming interface of the (*, G) entry, and `eth1` is on the outgoing interface list of the (*, G) entry. This means that there is a group member through `eth1`, and the RP is reachable through `eth2`.

The 0 position on this 32-bit index is for `eth1` (as illustrated in the interface display above). The `j` on the 0 index indicates that the `Join` has come from `eth1`.

Since `Router_C` is the RP, and the root of this multicast tree, the `show ip pim mroute` command on `Router_C` shows `RPF nbr` as 0.0.0.0 and `RPF idx` as none.

```
Router_C#show ip pim mroute
IP Multicast Routing Table

(*,*,RP) Entries: 0
(*,G) Entries: 1
```

```
(S,G) Entries: 0
(S,G,rpt) Entries: 0
(*, 224.0.1.3)
RP: 10.10.1.5
RPF nbr: 0.0.0.0
RPF idx: None
Upstream State: JOINED
 Local     ...............................
 Joined    j..............................
 Asserted  ...............................
 Outgoing  o..............................
```

Configuring Rendezvous Point Dynamically Using Bootstrap Router Method

A static RP configuration works for a small, stable PIM network domain; however, it is not practical for a large and/or complex one. In such a network, if the RP fails or you have to change the assignment of the RP, you are required to reconfigure the static configurations on all PIM routers. Also, if you have several multicast groups mapped to several RPs, there are many repetitive configurations you are required to perform, which can be time consuming and laborious. Thus when it comes configuring RP in large and/or complex networking environments, configuring it dynamically is the best and most scalable method to use. Bootstrap router (BSR) configuration is one method of configuring the RP dynamically.

The BSR mechanism in a PIM domain uses the concept of a RP as a way for receivers to discover the sources that send to a particular multicast group. The BSR mechanism gives a way for a multicast router to learn the set of group-to-RP mappings required in order to function. The BSR's function is to broadcast the RP set to all routers in the domain.

Some of the PIM routers within a PIM domain are configured as Candidate-RPs (C-RPs). A subset of the C-RPs is eventually used as the actual RPs for the domain. An RP configured with a lower value in the priority field has a higher priority.

Some of the PIM routers in the domain are configured to be Candidate-BSRs (C-BSR). One C-BSR is selected to be the BSR for the domain, and all PIM routers in the domain learn the result of this election through Bootstrap messages (BSM). The C-BSR with highest value in the priority field is elected to be the BSR. The C-RPs then report their candidacies to the elected BSR, which chooses a subset of the C-RPs, and distributes corresponding group-to-RP mappings to all the routers in the domain using Bootstrap messages.

This section provides 2 examples to illustrate the BSR configuration for configuring RP dynamically.

Example 1

For this example, refer to Figure 1 for the topology.

To dynamically configure the RP, `Router_C` on `eth1` and `Router_D` on `eth1` are configured as a Candidate RP using the `ip pim rp-candidate` command. `Router_D` on `eth1` is also configured as the Candidate BSR. Since no other router has been configured as the candidate BSR, `Router_D` becomes the BSR router and is responsible for sending group-to-RP-mapping information to all other routers in this PIM domain.

The highest priority router (configured with lowest priority value) is chosen as the RP. If two or more routers have the same priority, a hash function in the BSR mechanism is used to choose the RP to ensure that all routers in the PIM-domain have the same RP for the same group.

To change the default priority of any candidate RP, use the `ip pim rp-candidate IFNAME PRIORITY` command. At `Router_D`, the `show ip pim rp mapping` command shows that `Router_C` is chosen as the RP for a specified group.

Configure RP Dynamically for Router C

`ZebOS#configure terminal`	Enter Configure mode.
`ZebOS((config)#ip pim rp-candidate eth1 priority 2`	Give this router the candidate RP status using the IP address of the specified interface.

Configure RP Dynamically for Router D

`ZebOS#configure terminal`	Enter Configure mode.
`ZebOS((config)#ip pim bsr-candidate eth1`	Give this router the candidate BSR status using the name the interface.
`ZebOS((config)#ip pim rp-candidate eth1 priority 2`	Give this router the candidate RP status using the IP address of the specified interface.

The following output displays the complete configuration at `Router_C` and `Router_D`:

```
Router_D#show running-config
!
interface eth0
!
interface eth1
 ip pim sparse-mode
!
interface eth2
 ip pim sparse-mode
!
interface lo
!
ip multicast-routing
ip pim bsr-candidate eth1
ip pim rp-candidate eth1 priority 2
!

Router_C#show running-config
interface eth0
!
interface eth1
 ip pim sparse-mode
!
interface eth2
 ip pim sparse-mode
!
interface lo
!
!
ip multicast-routing
ip pim rp-candidate eth1
```

Commands Used

ip pim bsr-candidate, ip pim bsr rp-candidate

Validation

This section provides the steps to verify the RP configuration, interface details, and multicast routing table.

PIM Group-to-RP Mappings

The `show ip pim rp mapping` command displays the group-to-RP mapping details and displays information about RP candidates. There are two RP candidates for the group range, 224.0.0.0/4. RP Candidate 10.10.1.5 has a default priority of 192, whereas, RP Candidate 172.16.1.2 has been configured to have a priority of 2. Since RP candidate 172.16.1.2 has a higher priority, it is selected as RP for the multicast group, 224.0.0.0/4.

```
Router_D#show ip pim rp mapping
This system is the Bootstrap Router (v2)
Group(s): 224.0.0.0/4
  RP: 10.10.1.5
    Info source: 172.16.1.2, via bootstrap, priority 192
         Uptime: 00:00:13, expires: 00:02:29
  RP: 172.16.1.2
    Info source: 172.16.1.2, via bootstrap, priority 2
         Uptime: 00:34:42, expires: 00:01:49
```

RP Details

To display information about the RP router for a particular group, use the following command. This output displays that 172.16.1.2 has been chosen as the RP for the multicast group 224.0.1.3.

```
Router_D#show ip pim rp-hash 224.0.1.3
Group(s): 224.0.0.0/4
    RP: 172.16.1.2
    Info source: 172.16.1.2, via bootstrap
```

After RP information reaches all PIM routers in the domain, various state machines maintain all routing states, as a result of Join/Prune from group membership. To display information on interface details and the multicast routing table, refer to the *Configuring Rendezvous Point Statically* section.

Example 2

For this example, refer to Figure 2 for the topology.

To dynamically configure the RP, `Router_2` on `eth1` is configured as a Candidate RP using the `ip pim rp-candidate` command. Since no other router is configured as C-RP, `Router_2` becomes the RP. `Router_1` on `eth1` and `Router_2` on `eth1` are configured as the Candidate BSRs. Since `Router_1` has a higher priority value than `Router_2`, `Router_1` becomes the BSR router and is responsible for sending group-to-RP-mapping information to all other routers in this PIM domain.

Topology

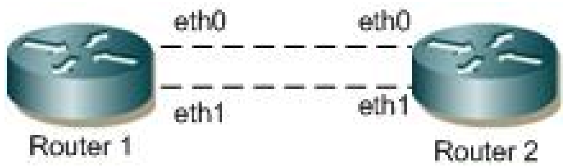


Figure 2: Boostrap Router Topology

Router 1

`ZebOS#configure terminal`	Enter Configure mode for `eth1`.
`ZebOS(config)#ip pim bsr-candidate eth1`	Configure `eth1` of Router 1 as C-BSR. The default priority is 64, so it is not necessary to designate a priority.
`ZebOS(config)#exit`	Exit Configure mode.

Router 2

`ZebOS#configure terminal`	Enter the Configure mode.
`ZebOS(config)#ip pim bsr-candidate eth1 10 25`	Configure `eth1` of Router 2 as C-BSR with a hash mask length of 10, and a priority of 25.
`ZebOS(config)#ip pim rp-candidate eth1 priority 0`	Configure interface `eth1` as C-RP with a priority of 0.
`ZebOS(config)#exit`	Exit Configure mode.

Router 2 Unicast BSM

When the `ip pim unicast-bsm` command is configured on an interface that is a DR for a network, then that interface unicasts the stored copy of BSM to the new or rebooting router.

`ZebOS#configure terminal`	Enter Configure mode.
`ZebOS(config)#interface eth1`	Enter the Interface mode for `eth1`.
`ZebOS(config-if)#ip pim dr-priority 10`	Configure `eth1` as DR
`ZebOS(config-if)#ip pim unicast-bsm`	Enable sending and receiving of Unicast BSM for backward compatibility.
`ZebOS config-if)#exit`	Exit Interface mode.

Commands Used

ip pim bsr-candidate, ip pim bsr rp-candidate, ip pim dr-priority, ip pim unicast-bsm

Validation

1. Verify the C-BSR state on Router 1.

```
ZebOS#show ip pim bsr-router
      PIMv2 Bootstrap information
      This system is the Bootstrap Router (BSR)
        BSR address: 20.0.1.21
        Uptime:      00:37:12, BSR Priority: 64, Hash mask length: 10
        Next bootstrap message in 00:00:04
        Role: Candidate BSR
        State: Elected BSR
```

2. Verify the C-BSR state on Router 2.

   The initial state of C-BSR is P-BSR before transitioning to C-BSR. The two states are illustrated in the sample outputs from the `show ip pim bsr-router` command below.

```
ZebOS#show ip pim bsr-router
PIMv2 Bootstrap information
  BSR address: 20.0.1.21
  Uptime:      00:02:39, BSR Priority: 64, Hash mask length: 10
  Expires:     00:00:03
  Role: Candidate BSR
  State: Pending BSR

ZebOS#show ip pim bsr-router
PIMv2 Bootstrap information
 BSR address: 20.0.1.21
 Uptime:      00:40:20, BSR Priority: 64, Hash mask length: 10
 Expires:     00:02:07
 Role: Candidate BSR
 State: Candidate BSR
```

3. Verify RP-set information on E-BSR.

```
ZebOS#show ip pim rp mapping
PIM Group-to-RP Mappings
This system is the Bootstrap Router (v2)
Group(s): 224.0.0.0/4
 RP: 20.0.1.11
 Info source: 20.0.1.11, via bootstrap, priority 0
 Uptime: 00:00:30, expires: 00:02:04
```

4. Verify RP-set information on C-BSR.

```
ZebOS#show ip pim rp mapping
PIM Group-to-RP Mappings
Group(s): 224.0.0.0/4
RP: 20.0.1.11
Info source: 20.0.1.21, via bootstrap, priority 0
Uptime: 00:00:12, expires: 00:02:18
```

5. Verify RP information for BIDIR group range at BSR.
   - Configure BIDIR RP for a group range by sending C-RP Adv packet from a C-RP with B bit set in the group range.
   - Verify the group-to-mapping information.

```
ZebOS#show ip pim rp mapping
PIM Group-to-RP Mappings
This system is the Bootstrap Router (v2)
Group(s): 224.0.0.0/4
 RP: 20.0.1.11, Bidir
 Info source: 20.0.1.11, via bootstrap, priority 0
 Uptime: 00:02:17, expires: 00:02:16
```

6. Verify the RP information for BIDIR group range at non-BSR. Send the BSM with the B bit set for a group range from BSR. Verify the BIDIR RP at Non-BSR.

```
ZebOS#show ip pim rp mapping
PIM Group-to-RP Mappings
Group(s): 224.0.0.0/4
RP: 20.0.1.11, Bidir
```

```
Info source: 20.0.1.21, via bootstrap, priority 0
Uptime: 00:00:12, expires: 00:02:18
```

Anycast-RP Configuration

The Anycast-RP feature provides load balancing among active RPs and redundancy in a PIM-SM network domain. In a PM-SM configuration, only a single active RP for each multicast group within a domain is permitted. However, in an Anycast-RP configuration, this restriction is removed with the support of multiple active RPs for each group in a domain.

ZebOS supports Anycast-RP using the PIM implementation. In PIM Anycast-RP, Multicast Source Discovery Protocol (MSDP) is not employed to share information about active sources. Instead the Register mechanism in PIM is extended to provide this same function.

The following describes Anycast-RP in PIM-SM:

- A Unicast IP address is used as the RP address. The address is statically configured, and associated with all PIM routers throughout the domain.
- A set of routers in the domain is chosen to act as RPs for this RP address. These routers are called the Anycast-RP set.
- Each router in the Anycast-RP set is configured with a loopback address. The loopback address is configured on all RPs for the loopback interface, then configured as the RP address (static RP), and injected into OSPF using redistribute connected. The ZebOS PIM-SM implementation uses only the first non-loopback address configured on the loopback interface. Therefore, it is important to be sure that the Anycast-RP address is configured with the first non-loopback address.
- Each router in the Anycast-RP set also needs a separate IP address, which is used for communication between the RPs.
- The RP address, or a prefix that includes the RP address, is injected into the unicast routing system inside the domain.
- Each router in the Anycast-RP set is configured with the addresses of all other routers in the Anycast-RP set. This must be consistently configured in all RPs in the set.

Topology

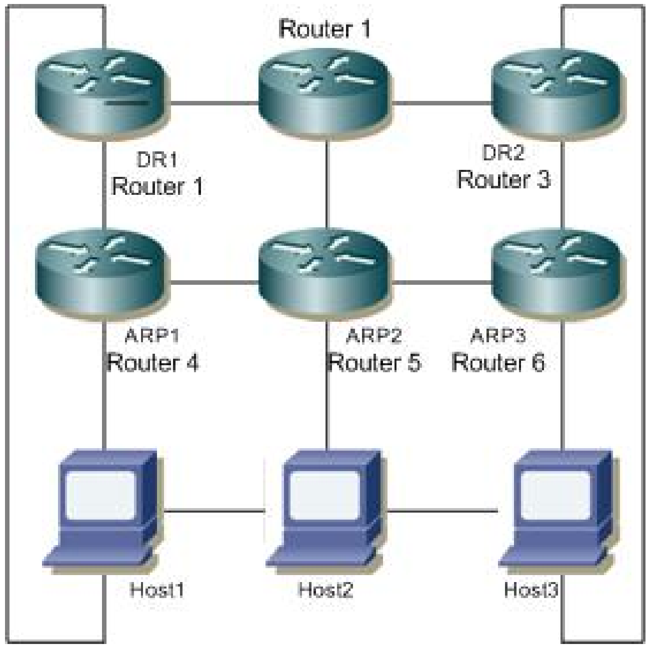


Figure 3: Anycast RP Topology

Host1 and Host3 act as hosts and sources for sending join and multicast data packets; Host2 acts as a host.

ARP1, ARP2 and ARP3

`ZebOS#configure terminal`	Enter the Configure mode.
`ZebOS(config)#interface lo`	Enter the loopback interface.
`ZebOS(config)#ip address 1.1.1.152/32`	Configure the IP address for loopback
`ZebOS(config)#exit`	Exit the Configure mode.
`ZebOS(config)#ip pim rp-address 1.1.1.152`	Configure the static RP with the address of the loopback.
`ZebOS(config)#ip pim anycast-rp 1.1.1.152 4.4.4.5`	Configure the member RP address. In this example, `4.4.4.5` is the member RP in ARP2. It is the address used for communication between all RPs.
`ZebOS(config)#ip pim anycast-rp 1.1.1.152 7.7.7.1`	Configure the member RP address. In this example, `7.7.7.1` is the member RP in ARP3. It is the address used for communication between all RPs.
`ZebOS(config)#ip pim anycast-rp 1.1.1.152 23.23.23.1`	Configure the member RP address. In this example, `23.23.23.1` is the member RP in ARP1. It is the address used for communication between all RPs.
`ZebOS(config)#exit`	Exit the Configure mode.

Disable Anycast-RP

`ZebOS#configure terminal`	Enter Configure mode.
`ZebOS(config)#no ip pim anycast-rp 1.1.1.152`	Disable Anycast-RP.
`ZebOS(config)#no ip pim rp-address 1.1.1.152`	Disable static RP.
`ZebOS(config)#exit`	Exit Configure mode.

Commands Used

ip address, ip pim rp-address, ip pim anycast-rp, no ip pim anycast-rp, no ip pim rp-address

Validation

1. Verify RP-mapping in ARP1.

```
ZebOS#show ip pim rp mapping
      PIM Group-to-RP Mappings
      Group(s): 224.0.0.0/4, Static
          RP: 1.1.1.152
               Uptime: 20:20:29
```

2. Verify RP-mapping in ARP1 after disabling anycast-RP and RP-address.

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

Embedded RP Configuration

RFC 3956 describes a multicast address allocation policy, in which the address of the Rendezvous Point (RP) is encoded in the IPv6 multicast group address, and specifies a PIM-SM group-to-RP mapping to use the encoding, leveraging and extending unicast-prefix-based addressing.

Embedded RP Multicast Group Address Format

RFC 3956 specifies a modification to the unicast-prefix-based address format by specifying the second high-order bit (R-bit), as follows:

```
|    8   | 4  | 4  | 4  | 4  | 8  |       64       |    32    |
|11111111|flgs|scop|rsvd|RIID|plen| network prefix | group ID |
```

The `flgs` is a set of four flags: |0|R|P|T|

When the highest-order bit is 0, flag R = 1, which indicates a multicast address that embeds the address on the RP. In this case, P must be set to 1, and T must be set to 1. In effect, this implies the prefix `FF70::/12,` which means that the last 4 bits of the previously reserved field are interpreted as the embedded RP interface ID.

RP Address in Embedded RP Multicast Address

The address of the RP can only be embedded in unicast prefix-based Any Source Multicast (ASM) addresses. To identify whether an address is an embedded RP multicast address, and should be processed any further, an address must satisfy all of the following criteria:

- It must be a multicast address with `flgs` set to 0111, that is, to be of the prefix FF70::/12; or `flgs` set to 1111, for example, FFF0::/12
- `plen` must not be 0 (Source-Specific Multicast or SSM)
- `plen` must not be greater than 64

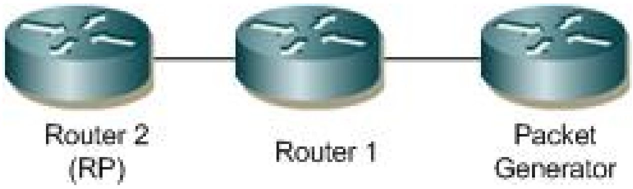


Figure 4: Topology

Enable Embedded RP

`ZebOS#configure terminal`	Enter Configure mode.
`ZebOS(config)#ipv6 pim rp embedded`	Enable embedded RP-to-group mapping.
`ZebOS(config)#ipv6 access-list embedrp1 permit ff7e:240:3ffe:172:31:12::/96`	Configure an access-list to permit the multicast group.
`ZebOS(config)#ipv6 pim rp-address 3ffe:172:31:12::2 embedrp1`	Configure a static RP, and limit the valid groups using an access list.
`ZebOS(config)#exit`	Exit Configure mode.

Disable Embedded RP

`ZebOS#configure terminal`	Enter Configure mode.
`ZebOS(config)#no ipv6 pim rp embedded`	Disable embedded RP-to-group mapping.
`ZebOS(config)#exit`	Exit Configure mode.

Plen bits and the RP Interface ID (RIID) from the embedded-RP group address form the embedded-RP address. Therefore, the global IPv6 address should look like the following example

```
3ffe:192:168:1::1/64 (to)
3ffe:192:168:1::15/64
```

The static-RP configuration should limit the valid groups via an access list as in this example:

```
ipv6 access-list embedrp permit ff7e:0240:3ffe:192:168:1::/96
ipv6 pim rp-address 3ffe:192:168:1::2 embedrp
```

Packets should be generated in the group range <`ff7e:0240:3ffe:192:168:1::/96`>.

Commands Used

ipv6 pim rp embedded, ipv6 access-list, ipv6 pim rp-address, no ipv6 pim rp embedded

Validation

The group-to-RP mapping for embedded-RP addresses is created when the group is first seen at a PIM router. This can be due to the MLD local receiver report, Join/Prune and Register message processing.

1. Verify RP-mapping in RP router.

```
ZebOS#show ipv6 pim rp mapping
PIM Group-to-RP Mappings
Group(s): ff7e:240:3ffe:172:31:12::/96, Static
    RP: 3ffe:172:31:12::2
         Uptime: 00:04:12
```

```
Embedded RP Groups:
Group(s): ff7e:240:3ffe:172:31:12::/96
    RP: 3ffe:172:31:12::2, Uptime: 00:00:33
```

2. Verify RP-mapping in non-RP router.

```
ZebOS#show ipv6 pim rp mapping
PIM Group-to-RP Mappings
Embedded RP Groups:
Group(s): ff7e:240:3ffe:172:31:12::/96
    RP: 3ffe:172:31:12::2, Uptime: 00:00:27
```

CHAPTER 2 PIM-DM Configuration

Protocol Independent Multicast - Dense Mode (PIM-DM) is a data-driven multicast routing protocol that builds source-based multicast distribution trees that operate on the flood-and-prune principle. It requires unicast-reachability information, but it does not depend on a specific unicast routing protocol.

Terminology

Following is a brief description of terms and concepts used to describe the PIM-DM protocol:

Reverse Path Forwarding

Reverse Path Forwarding (RPF) is an optimized form of flooding, in which the router accepts a packet from `SourceA` through Interface `IF1`, only when `IF1` is the interface the router would use in order to reach `SourceA`. It determines whether the interface is correct by consulting its unicast routing tables. The packet that arrives through interface `IF1` is forwarded because the routing table lists this interface as the shortest path to the network. The router's unicast routing table determines the shortest path for the multicast packets. Because a router accepts a packet from only one neighbor, it floods the packet only once, meaning that (assuming point-to-point links) each packet is transmitted over each link once in each direction.

Forwarding Multicast Packets

PIM-DM routers forward multicast traffic to all interfaces that lead to receivers that have explicitly joined a multicast group. Messages are sent to a group address in the local subnetwork. The router performs an RPF check, and forwards the packet. Traffic that arrives on the correct interface is sent to all outgoing interfaces that lead to downstream receivers, if the downstream router is a member of this group.

Upstream

Upstream traffic is traffic that is going towards the source.

Downstream

Downstream traffic is anything other than the upstream interface for that group.

Nexthop

PIM-DM does periodic lookups for prefixes to check router reachability. The ZebOS nexthop lookup mechanism avoids periodic lookup. During start-up, PIM-DM notifies NSM (Network Services Manager) about the prefixes that pertain to them. NSM notifies the protocols if a better nexthop is available, or if a nexthop becomes unavailable. In this way, PIM-DM does not expend resources to do periodic lookups, because NSM is proactive in their maintenance.

PIM-DM Configuration

Configuring PIM-DM requires the following steps:

- enable IP multicast on each PIM router (see “Enabling IP Multicast Routing”)
- enable PIM-DM on the desired interfaces (see “Enabling PIM-DM”)

This section provides the configuration steps for configuring PIM-DM and examples for a relevant scenario.

Topology

In this network topology, the Source_1 address is 10.10.1.52 and the group address is set to 224.0.1.3.

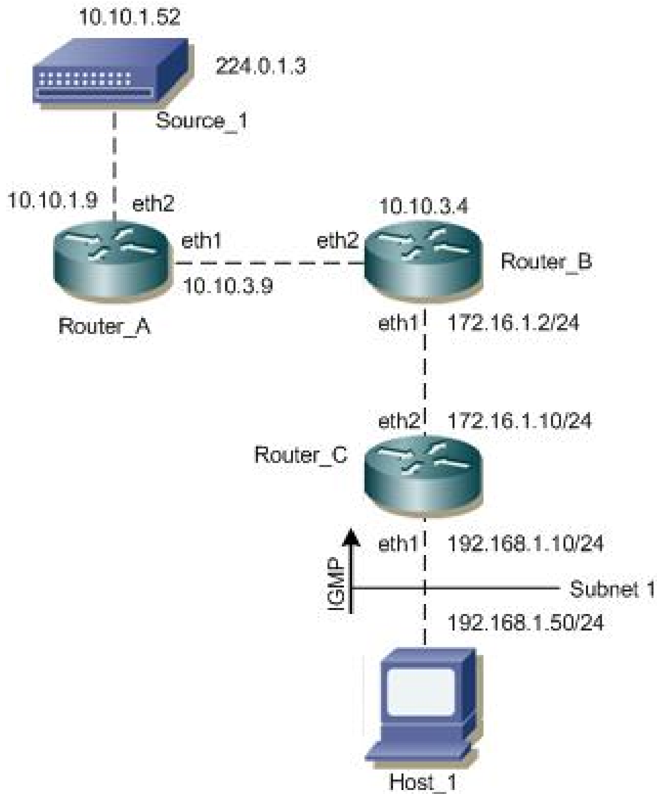


Figure 5: PIM-DM Configuration Topology

In this example, all routers are running PIM-DM.

1. Host_1 sends an IGMP membership report to Subnet 1.
2. After Router_C receives this report, it associates its receiving interface, `eth1`, with the group reported in the IGMP message, for example, group1.
3. Source_1 then sends a data packet for group1.
4. Every router creates an (S,G) entry in the multicast routing table.
5. When the data packet reaches `Router_C`, it forwards via the interface, `eth1`, because there is a local member on this interface for this group. `Router_C` has a downstream receiver, so it does not send a prune message to its upstream neighbor router, `Router_B`.

Enabling IP Multicast Routing

Enable IP multicast routing on all of the PIM routers inside the PIM domain:

Enable IP Multicast Routing

`ZebOS#configure terminal`	Enter Configure mode.

`ZebOS((config)#ip multicast-routing`	Enable IP multicast routing.
`ZebOS(config)#exit`	Exit Configure mode.

Enabling PIM-DM

Enable PIM-DM on all participating interfaces within each of routers inside the PIM domain on which you want to run PIM.

Enable PIM Dense Mode on an Interface

`ZebOS#configure terminal`	Enter Configure mode.
`ZebOS(config)#interface eth1`	Specify the interface (`eth1`) to be configured and enter the Interface mode.
`ZebOS((config-if)#ip pim dense-mode`	Enable PIM dense mode on the interface.
`ZebOS(config-if)#exit`	Exit Interface mode.
`ZebOS(config)#interface eth2`	Specify the interface (`eth2`) to be configured and enter the Interface mode.
`ZebOS((config-if)#ip pim dense-mode`	Enable PIM dense mode on the interface.
`ZebOS(config-if)#exit`	Exit Interface mode.

The following is a sample configuration for `Router_C`:

```
hostname Router_C
!
interface eth0
!
interface eth1
 ip pim dense-mode
!
interface eth2
 ip pim dense-mode
!
interface lo
!
!
ip multicast-routing
!
```

Validation

Use the following commands to validate the interface details and multicast routing table.

Note: For details on the commands used in the following example, refer to the *PIM Command Reference.*

Interface Details

The `show ip pim dense-mode interface` command displays the interface details for `Router_C.`

```
Router_C#show ip pim dense-mode interface
```

```
Address          Interface VIFindex Ver/   Nbr
                                    Mode   Count
192.168.1.10      eth1      0       v2/D   0
172.16.1.10       eth2      2       v2/D   1
```

IP Multicast Routing Table

The `show ip mroute` command displays the IP multicast routing table.

```
Router_C#show ip mroute
IP Multicast Routing Table
Flags: I - Immediate Stat, T - Timed Stat, F - Forwarder installed
Timers: Uptime/Stat Expiry
Interface State: Interface (TTL)
(10.10.1.52, 224.0.1.3), uptime 00:00:15
Owner PIM-DM, Flags: F
 Incoming interface: eth2
 Outgoing interface list:
    eth1 (1)
```

IP PIM-DM Multicast Routing Table

The `show ip pim dense-mode mroute` displays the IP PIM-DM multicast routing table.

```
Router_C#show ip pim dense-mode mroute
PIM-DM Multicast Routing Table
(10.10.1.52, 224.0.1.3)
 RPF Neighbor: 172.16.1.2, Nexthop: 172.16.1.2, eth2
 Upstream IF: eth2
    Upstream State: Forwarding
    Assert State: NoInfo
 Downstream IF List:
    eth1, in 'olist':
      Downstream State: NoInfo
      Assert State: NoInfo
```

CHAPTER 3 DVMRP Configuration

Distance Vector Multicast Routing Protocol (DVMRP) is a multicast routing protocol that provides an efficient mechanism for connectionless datagram delivery to a group of hosts across an internetwork. It is a distributed protocol that dynamically generates IP multicast delivery trees using a technique called Reverse Path Multicasting.

Terminology

Following is a brief description of terms and concepts used to describe the DVMRP protocol.

DRIB. ZebOS DVMRP is a separate daemon serviced by the NSM daemon. It maintains the DVMRP Routing Information Base (DRIB). The DRIB contains the table of routes for multicast sources learned through DVMRP route exchanges. Both the upstream and the downstream parts of a route-state reside physically in a combined, single DRIB node. A DRIB node is called a DVMRP Routing Table (DRT) entry.

The DRT entry contains a vector of downstream interfaces; each vector slot position represents a virtual interface (VIF). It is used to store all required information for the state to decide ultimately the set of forwarding interfaces for corresponding multicasting data packets. DVMRP requires a per-source network Designated Forwarder (DF) on each downstream interface, i.e., DF(S, I). DF election is based on the metric toward the source network. If DF(S,I) changes for an interface, ZebOS updates the outgoing VIF list (Olist) for all prune(S,G) states and their corresponding forwarding caches.

VIF Table. The VIF table is a tree of virtualized physical and tunnel interfaces indexed by a virtual interface number.

Neighbor Table. The Neighbor table is a list of detected DVMRP neighbors on an interface. Neighbors announce themselves using the Probe message.

Route Report Arrays of Lists. Because route reporting is done by grouping together all routes that belong to the same mask, a Route Report Array of Lists (AOL) is used to expedite general route reporting.

DVMRP Configuration

The required steps to configure DVMRP are the following:

- enable IP multicast on each PIM router (see “Enabling IP Multicast Routing”)
- enable DVMRP on the desired interfaces (see “Enabling DVMRP”)

This section provides the configuration steps for configuring DVMRP and a configuration example for a relevant scenario.

Topology

In this configuration topology, the Source_1 address is 10.10.1.52, and the group address is set to 224.0.1.3.

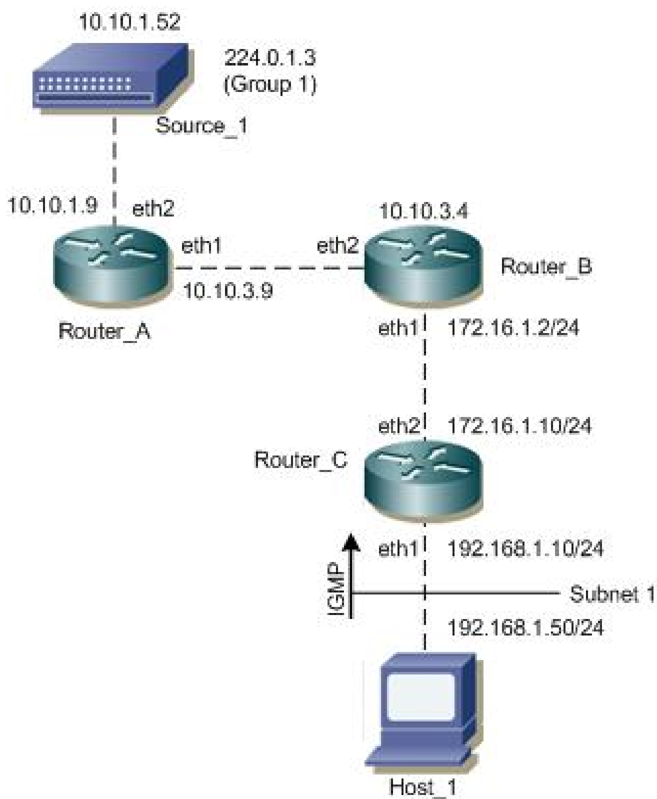


Figure 6: Configuration Topology

In this example, all routers are running DVMRP.

1. Host_1 sends an IGMP membership report to Subnet 1.
2. After Router_C receives this report, it associates its receiving interface, eth1, with the group reported in the IGMP message, for example, Group 1.
3. Source_1 then sends a data packet for Group 1.
4. Every router creates an (S,G) entry in the multicast routing table.
5. When the data packet reaches Router_C, it forwards via the interface, eth1, because there is a local member on this interface for this group. Router_C has a downstream receiver; hence, it does not send a prune message to its upstream neighbor router, Router_B.

Enabling IP Multicast Routing

Enable IP multicast routing on all of the PIM routers inside the PIM domain:

Enable IP Multicast Routing

`ZebOS#configure terminal`	Enter Configure mode.

`ZebOS((config)#ip multicast-routing`	Enable IP multicast routing.
`ZebOS(config)#exit`	Exit Configure mode.

Enabling DVMRP

Enable DVMRP on all participating interfaces within each of routers:

Enable IP Multicast Routing

`ZebOS#configure terminal`	Enter Configure mode.
`ZebOS(config)#interface eth1`	Specify the interface (`eth1`) to be configured and enter the Interface mode.
`ZebOS((config-if)#ip dvmrp enable`	Enable DVMRP on the interface.
`ZebOS(config-if)#exit`	Exit Interface mode.
`ZebOS(config)#interface eth2`	Specify the interface (`eth2`) to be configured and enter the Interface mode.
`ZebOS((config-if)#ip dvmrp enable`	Enable DVMRP on the interface.
`ZebOS(config-if)#exit`	Exit Interface mode.

The following is a sample configuration at `Router_C`:

```
hostname Router_C
!
interface eth1
 ip dvmrp enable
!
interface eth2
 ip dvmrp enable
!
interface lo
!
!
ip multicast-routing
!
```

Validation

Use the following commands to verify interface, neighbor, route, prune, and DVMRP global state information.

Note: For details on the commands used in the following example, refer to the *DVMRP Command Reference.*

Interface Information

The `show ip dvmrp interface` command displays the interface information for `Router_C.` For example:

```
Router_C#sh ip dvmrp interface
Address          Interface    Vif    Ver.    Nbr   Type     Remote
                              Index          Cnt            Address
192.168.1.10     eth1         1      v3.ff   0     BCAST    N/A
172.16.1.10      eth2         0      v3.ff   1     BCAST    N/A
```

Neighbor Information

The show `ip dvmrp neighbor` command displays the neighbor details for `Router_C`. For example:

```
Router_C#sh ip dvmrp neighbor
Neighbor          Interface   Uptime/Expires      Maj  Min  Cap
Address                                           Ver  Ver  Flg
172.16.1.2        eth2        00:01:03/00:00:32   3    255  2
```

Route Information

The show `ip dvmrp route` command displays the route information for `Router_C`. For example:

```
Router_C#sh ip dvmrp route
Flags: N = New, D = DirectlyConnected, H = Holddown
Network            Flags Nexthop   Nexthop             Metric Uptime   Exptime
                         Xface     Neighbor
10.10.3.0/24      ...   eth2      172.16.1.2          2      00:01:27 00:02:01
172.16.1.0/24      .D.   eth2      Directly Connected  1      00:01:37 00:00:00
10.10.1.0/24      ...   eth2      172.16.1.2          3      00:01:27 00:02:01
192.168.1.0/24     .D.   eth1      Directly Connected  1      00:01:52 00:00:00
```

DVMRP Prune Information

The show `ip dvmrp prune` command displays DVMRP prune information for `Router_C`. For example:

```
Router_C#show ip dvmrp prune
```

DVMRP Global State

The show `ip dvmrp` command displays the global DVMRP state for `Router_C`. For example:

```
Router_C#sh ip dvmrp interface
Address           Interface   Vif    Ver.    Nbr   Type     Remote
                              Index          Cnt            Address
192.168.1.10      eth1        1      v3.ff   0     BCAST    N/A
172.16.1.10       eth2        0      v3.ff   1     BCAST    N/A
```

CHAPTER 4 PIM Sparse-Dense Mode Configuration

PIM-SMDM is an integrated protocol which handles both sparse groups and dense groups at the same time. In sparse-dense mode, if the group is in dense mode, the interface will be treated as dense mode. If the group is in sparse mode, the interface will be treated in sparse mode. The group is sparse if the router knows about an RP for that group.

This chapter provides the following topics:

- "PIM-SMDM Configuration"
- PIM-DM

Note: PIM-SMDM feature is not supported for ZebIC releases.

PIM-SMDM Configuration

The required steps to configure PIM-SMDM are the following:

- enable IP multicast on each PIM router (see "Enabling IP Multicast Routing")
- enable PIM-SMDM on the desired interfaces (see "Enabling PIM-SMDM")
- example for the group operating in sparse-mode having Static RP (see "Configuring Rendezvous Point Statically for PIM-SMDM"
- example for the group operating in dense-mode having no RP

All multicast group states are dynamically maintained as the result of IGMP `Report/Leave` and PIM `Join/Prune` messages.

This section provides the steps to configure the PIM-SMDM feature. Configuration steps and examples are used for two relevant scenarios. The following figure displays the network topology used in these examples:

> Note: For details about the commands used in the following examples, refer to the *ZebOS-XP Network Platform PIM Command Reference.*

Enabling IP Multicast Routing

Enable IP multicast routing on all of the PIM routers inside the PIM domain:

Enable IP Multicast Routing

`ZebOS-XP#configure terminal`	Enter Configure mode.
`ZebOS-XP((config)#ip multicast-routing`	Enable IP multicast routing.
`ZebOS-XP(config)#exit`	Exit Configure mode.

Enabling PIM-SMDM

Enable PIM-SMDM on all participating interfaces within each of routers inside the PIM domain on which you want to run PIM. In the following sample configuration, both eth1 and eth2 are enabled for PIM-SMDM on the router.

Enable PIM-SMDM on an Interface

`ZebOS-XP#configure terminal`	Enter Configure mode.
`ZebOS-XP(config)#interface eth1`	Specify the interface (`eth1`) to be configured and enter the Interface mode.
`ZebOS-XP((config-if)#ip pim sparse-dense-mode`	Enable PIM sparse-dense mode on the interface.
`ZebOS-XP(config-if)#exit`	Exit Interface mode.
`ZebOS-XP(config)#interface eth2`	Specify the interface (`eth2`) to be configured and enter the Interface mode.
`ZebOS-XP((config-if)# ip pim sparse-dense-mode`	Enable PIM sparse -dense mode on the interface.
`ZebOS-XP(config-if)#exit`	Exit Interface mode.

Here is the sample configuration for `Router_C`:

```
hostname Router_C
!
interface eth0
!
interface eth1
 ip pim sparse-dense-mode
!
interface eth2
 ip pim sparse-dense-mode
!
interface lo
!
!
ip multicast-routing
```

Validation

Use the following commands to validate the interface details and multicast routing table.

Note: For details about the commands used in the following examples, refer to the *ZebOS-XP Network Platform PIM Command Reference.*

The `show ip pim interface` command displays the interface details for Router_C.

```
Router_C#show ip pim interface

Address            Interface         VIFindex Ver/  Nbr
                                              Mode  Count
192.168.1.10        eth1               0      v2/SD  0
172.16.1.10         eth2               2      v2/SD  1
```

The following examples differentiates the group operating in the sparse mode when RP is present and the group operating in the dense mode when there is no RP for the group

- Sparse-dense mode operates as Sparse-mode when the RP is present for the Group

- Sparse-dense mode operates as dense-mode when there is no RP for the Group

Sparse-dense mode operates as Sparse-mode when the RP is present for the Group

Configuring Rendezvous Point Statically for PIM-SMDM

Every PIM multicast group needs to be associated with the IP address of a Rendezvous Point (RP), which is a router that resides in a multicast network domain. The address of the RP is used as the root of a group-specific distribution tree. All nodes in the domain that want to receive traffic sent to the group are aware of the address of the RP. For all senders to reach all receivers within a group, all routers in the domain must be able to map to the RP address configured for the group. There can be several RPs configured in a network deploying PIM-SM, each serving a different group.

You can statically configure a RP by specifying the RP address in every router in the PIM domain. The use of statically configured RPs is ideal for small network environments or ones that do not require many RPs and/or require changing the assignment of the RPs often. Changing the assignment of an RP requires the re-configuration of the RP address in all of the routers in the PIM domain.

In static RP configurations, RP failover is not available.

When configuring the RP statically, do the following:

- On every router, include the `ip pim rp-address A.B.C.D` statement even if a router does not have any source or group member attached to it
- Assign only one RP address for a multicast group in the PIM domain

Using the topology depicted in Figure 7, `Router_C` is the RP, and all routers are statically configured with RP information. Host_1 and Host_2 join group 224.0.1.3 for all the sources. They send the IGMP membership report to Subnet 1. Two routers are attached to Subnet 1, `Router_E` and `Router_F`; both have default DR priority on `eth1`. Since `Router_E` has a higher IP address on interface `eth1`, it becomes the Designated Router, and is responsible for sending Join messages to the RP (`Router_C`).

Topology

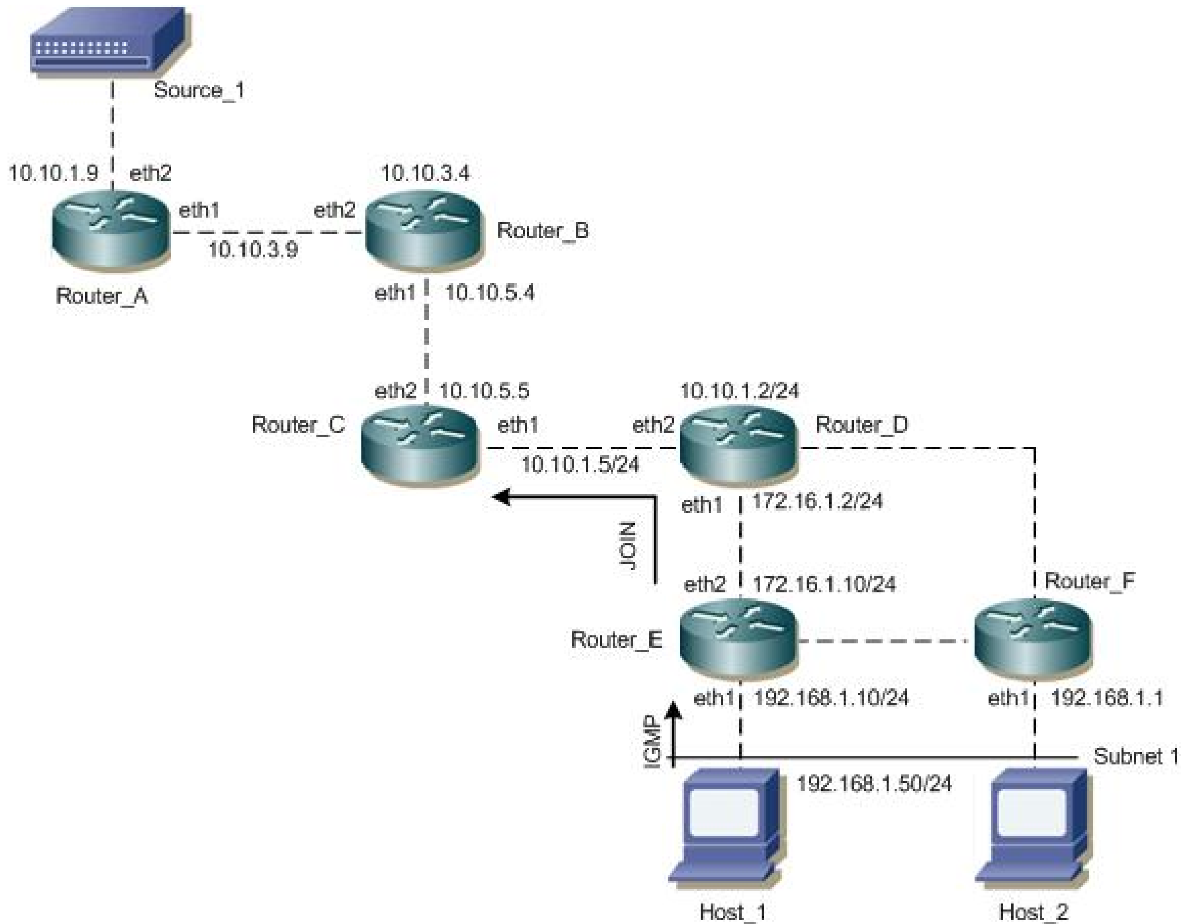


Figure 7: PIM-SMDM Configuration Topology(a)

Configure Static RP

`ZebOS-XP#configure terminal`	Enter Configure mode.
`ZebOS-XP((config)#ip pim rp-address 10.10.1.5`	Statically configure an RP address for multicast groups.
`ZebOS-XP(config)#exit`	Exit Configure mode.

Here is the sample configuration for `Router_D`:

```
hostname Router_D
!
interface eth0
!
interface eth1
 ip pim sparse-dense-mode
!
interface eth2
 ip pim sparse-dense-mode
!
interface lo
```

```
!
!
ip multicast-routing
ip pim rp-address 10.10.1.5
!
```

Commands Used

ip pim rp-address

Validation

Enter the commands listed in this section to confirm the previous configurations.

RP Details

At Router_D, the `show ip pim rp mapping` command shows that `10.10.1.5` is the RP for all multicast groups `224.0.0.0/4`, and is statically configured. All other routers will have a similar output:

```
Router_D#sh ip pim rp mapping
PIM Group-to-RP Mappings
Override RP cnt: 0
Group(s): 224.0.0.0/4, Static
    RP: 10.10.1.5
         Uptime: 00:01:45
```

At Router_D, use the `show ip pim rp-hash` command to display the selected RP for a specified group (224.0.1.3):

```
Router_D#show ip pim rp-hash 224.0.1.3
RP: 10.10.5.37
```

Interface Details

The `show ip pim interface` command displays the interface details for `Router_E`, and shows that `Router_E` is the Designated Router on `Subnet 1.`

```
Router_E#show ip pim interface
Address          Interface VIFindex Ver/   Nbr      DR    DR
                                    Mode   Count   Prior
192.168.1.10      eth1      0       v2/SD   1         1     192.168.1.10
172.16.1.10       eth2      2       v2/SD   1         1     172.16.1.10
```

IP Multicast Routing Table

Note: The multicast routing table displays for an RP router are different from other routers.

The `show ip pim mroute` command displays the IP multicast routing table. In this table, the following fields are defined:

`RPF nbr`	Displays the unicast next-hop to reach RP.
	and mask length.
`RPF idx`	Displays the incoming interface for this (*, G) state.
`RP`	Displays the IP address for the RP router
`B`	Displays the bidirectional pim mode
`The leading dots ....`	
	Stand for VIF index

```
Router_E#show ip pim mroute
IP Multicast Routing Table

(*,*,RP) Entries: 0
(*,G) Entries: 1
(S,G) Entries: 0
(S,G,rpt) Entries: 0
(*, 224.0.1.3)
RP: 10.10.1.5
RPF nbr: 172.16.1.2
RPF idx: eth2
Upstream State: JOINED
 Local     ................................
 Joined    j...............................
 Asserted  ................................
 Outgoing  o...............................
```

At `Router_E`, `eth2` is the incoming interface of the (*, G) entry, and `eth1` is on the outgoing interface list of the (*, G) entry. This means that there is a group member through `eth1`, and the RP is reachable through `eth2`.

The 0 position on this 32-bit index is for `eth1` (as illustrated in the interface display above). The `j` on the 0 index indicates that the `Join` has come from `eth1`.

Since `Router_C` is the RP, and the root of this multicast tree, the `show ip pim mroute` command on `Router_C` shows `RPF nbr` as 0.0.0.0 and `RPF idx` as none.

```
Router_C#show ip pim mroute
IP Multicast Routing Table

(*,*,RP) Entries: 0
(*,G) Entries: 1
(S,G) Entries: 0
(S,G,rpt) Entries: 0
(*, 224.0.1.3)
RP: 10.10.1.5
RPF nbr: 0.0.0.0
RPF idx: None
Upstream State: JOINED
 Local     ................................
 Joined    j...............................
 Asserted  ................................
 Outgoing  o...............................
```

For configuring Rendezvous point dynamically refer "Configuring Rendezvous Point Dynamically Using Bootstrap Router Method" and "Configuring Rendezvous Point Statically"

Sparse-dense mode operates as dense-mode when there is no RP for the Group

Topology

In this network topology, the Source_1 address is 10.10.1.52 and the group address is set to 224.0.1.3.

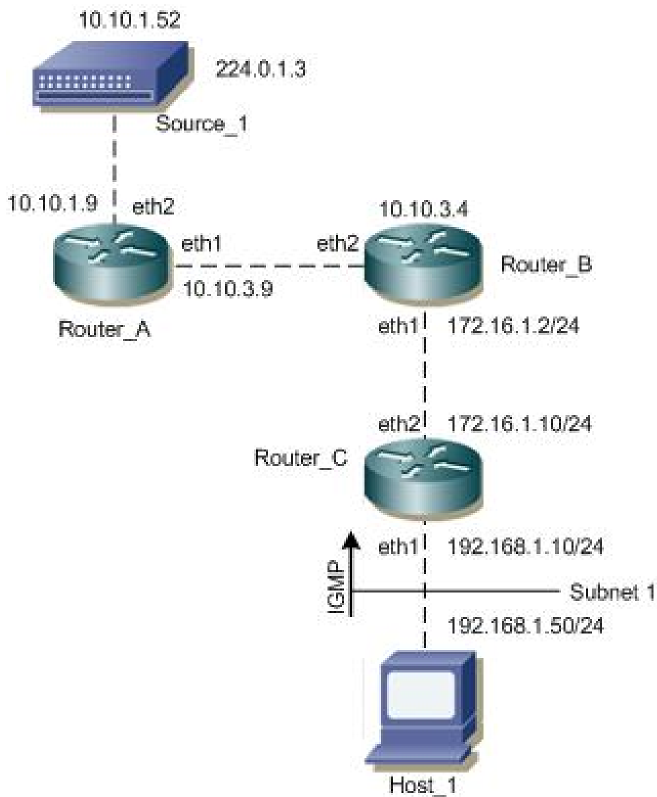


Figure 8: PIM-SMDM Configuration Topology(b)

In this network topologym teh Source_1 address is 10.10.1.52 and the group address is set to 224.0.1.3

In this example all routers are running PIM-SMDM

1. Host_1 sends an IGMP membership report to Subnet 1
2. After Router_C receives this report, it associates its receiving interface, eth1, with the group reported in the IGMP message, for example, group1.
3. Source_1 then sends a data packet for group1.
4. Every router creates an (S,G) entry in the multicast routing table.
5. When the data packet reaches Router_C, it forwards via the interface, eth1, because there is a local member on this interface for this group. Router_C has a downstream receiver, so it does not send a prune message to its upstream neighbor router, Router_B.

Validation

Enter the commands listed in this section to confirm the previous configurations.

IP Multicast Routing Table

The `show ip pim mroute` command displays the IP multicast routing table.

```
Router_C#show ip mroute
IP Multicast Routing Table
Flags: I - Immediate Stat, T - Timed Stat, F - Forwarder installed
Timers: Uptime/Stat Expiry Interface State:
Interface (TTL) (10.10.1.52,   224.0.1.3), uptime 00:00:15
Owner PIM-DM, Flags: F
Incoming interface: eth2
Outgoing interface list:
eth1 (1)
```

IP PIM-SMDM Multicast Routing Table

The `show ip pim dense-mode mroute` command displays the IP PIM-DM multicast routing table

```
Router_C#show ip pim mroute
PIM-DM Multicast Routing Table (10.10.1.52, 224.0.1.3)
RPF Neighbor: 172.16.1.2, Nexthop: 172.16.1.2, eth2
Upstream IF: eth2
Upstream State: Forwarding
Assert State: NoInfo
Downstream IF List:
eth1, in 'olist': Downstream State: NoInfo Assert State: NoInfo
```

CHAPTER 5 IGMP Configuration

This chapter describes how to configure Internet Group Management Protocol (IGMP).

The Internet Group Management Protocol (IGMP) is used by IP hosts to report their multicast group memberships to any immediately-neighboring multicast routers

Using the information obtained through IGMP, the router maintains a list of multicast group on a per-interface basis. The routers that receive these IGMP packets send multicast data that they receive for requested groups out the network segment of the known receivers.

By default, when PIM is enabled on an interface, igmp version 3 is enabled. IGMP can be enabled on an interface explicitly.

IGMP Versions

Zebos supports IGMPv2 and IGMPv3, as well as IGMPv1 report reception.By default, Zebos enables IGMPv3 when PIM is enabled on an interface. IGMPv3 includes the following key changes from IGMPv2:

- Support for Source-Specific Multicast (SSM), which builds shortest path trees from each receiver to the source, through the following features:
    - Host messages that can specify both the group and the source.
    - The multicast state that is maintained for groups and sources, not just for groups as in IGMPv2.

- Hosts no longer perform report suppression, which means that hosts always send IGMP membership reports when an IGMP query message is received.

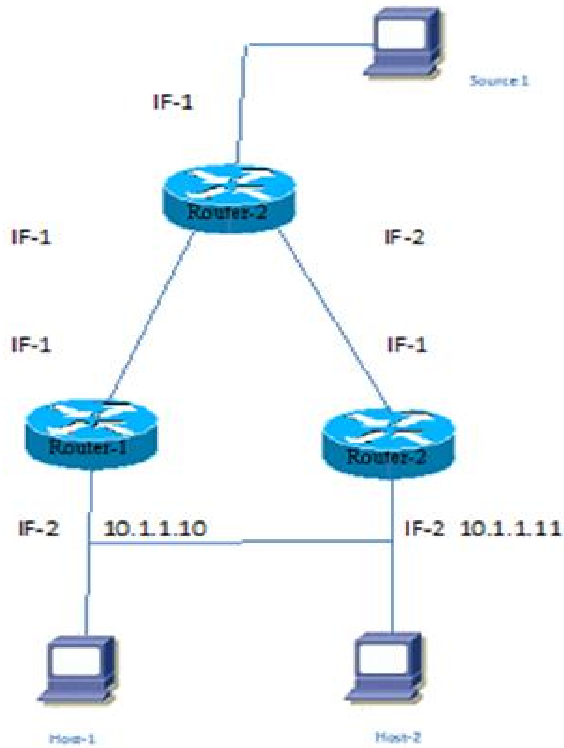


Figure 9: IGMP Topology

IGMP Operation

IGMP works on the premise of three major packets exchange between igmp enabled routers and hosts, interested in joining a particular group.

IGMP Query Operation

Once igmp is enabled or pim is enabled (which enables igmpv3), on any interface it starts sending Query message, which is called general query to the all-hosts multicast group at 224.0.0.1 periodically to discover whether any hosts want to receive multicast data.

Zebos elects a router as the IGMP querier on a subnet if it has the lowest IP address. As long as a router continues to receive query messages from a router with a lower IP address, it resets a timer that is based on its querier timeout value. If the querier timer of a router expires, it becomes the designated querier. If that router later receives a host query message from a router with a lower IP address, it drops its role as the designated querier and sets its querier timer again.

In the figure above Router-1 IF-2sends query every query-interval. Since Router1-IF-2 ip address is less than Router-2 IF-2, Router-1 IF-2 becomes querier on the LAN.

IGMP Membership Report Operation

When a host receives a query from the local router it sends a Host Membership Reportfor all the multicast groups for which it wants to receive multicast traffic. This is called solicited membership report.

When a host joins a new group, the host immediately sends a Membership Report to inform a local router that it wants to receive multicast traffic for the group it has just joined without waiting to receive a Query. This is called unsolicited membership report.

In the figure above Host-1 and Host-2 sends membership reports to Router-1 IF-2for all the multicast groups for which they want to receive multicast traffic. Upon reception of membership report Router-1 maintains an igmp group table containing multicast group-address, interface name on which it receives the report.

IGMP Leave Operation

When a multicast host leaves a group, a host that runs IGMPv2 or later sends an IGMP leave message. To check if this host is the last host to leave the group, the router sends an IGMP query (Called as Group-specific-query) message and starts a timer that you can configure called the last member query response interval. If no reports are received before the timer expires, the software removes the group state. The router continues to send multicast traffic for a group until its state is removed.

In the figure above Host-1 and Host-2 sends leave message to Router-1 IF-2 for all the multicast groups for which they don't want to receive multicast traffic. In response to leave message Router-1 IF-2 sends an group-specific-query message before removing the multicast group address from the igmp table.

Configuring IGMP Version

Configuring IGMP Version

`ZebOS-XP#configureterminal`	Enterconfiguremode.
`ZebOS-XP((config)#Interface Ifname`	Enter interface mode
`ZebOS-XP(config-if)#ip igmp version VersionNumber`	Enable Igmp version
`ZebOS-XP(config-if)#exit`	Exit Interfacemode.
`ZebOS-XP(config)#exit`	Exit configure mode.

Commands Used

`ipigmp version`

Validation

Enter the commands listed in this section to confirm the previous configurations

```
Rtr1#show  running-config
!
no service password-encryption
!
hostname rtr1
!
!
!
ip multicast-routing
!
!
interface eth2
ip address 192.168.10.57/24
no shutdown
```

```
ip ospf cost 10
ip igmp version 2
ip pim sparse-mode
```

Configuring IGMP Parameters

Configuring IGMP parameters

`ZebOS-XP#configureterminal`	Enter configure mode.
`ZebOS-XP((config)#Interface Ifname`	Enter interface mode
`ZebOS-XP(config-if)#ip igmp access-group<access-list>`	Configures a access-list policy to control the multicast groups that hosts on the subnet serviced by an interface can join
`ZebOS-XP(config-if)#ip igmp immediate-leave <Group-list>`	Enables the device to remove the group entry from the multicast routing table immediately upon receiving a leave message for the group
`ZebOS-XP(config-if#ip igmp  join-group<grp-address>`	Statically binds a multicast group to the outgoing interface
`ZebOS-XP(config-if)#ip igmp  last-member-query-count<count>`	Sets the query count used when the software starts up
`ZebOS-XP(config-if)#ipigmp  last-member-query-interval<seconds>`	Sets the query interval used when the software starts up
`ZebOS-XP(config-if)#ip igmplimit<number>`	Configure Max Allowed State on this interface
`ZebOS-XP(config-if)#ip igmp querier-timeout <Seconds>`	Sets the querier timeout that the router uses when deciding to take over as the querier.
`ZebOS-XP(config-if)#ip igmp  query-interval <seconds>`	Sets the frequency at which the router sends IGMP host query messages
`ZebOS-XP(config-if)#ip igmp  query-max-response-time<seconds>`	Sets the response time advertised in IGMP queries
`ZebOS-XP(config-if)#ip igmp  ra-option`	Enable ra-option
`ZebOS-XP(config-if)#ip igmp  robustness-variable<Value>`	Sets the robustness variable
`ZebOS-XP(config-if)#ip igmp startup-query-count<count>`	Sets the query count used when the router starts up
`ZebOS-XP(config-if)#ip igmp startup-query-interval<seconds>`	Sets the query interval used when the router starts up
`ZebOS-XP(config-if)#ip igmp static-group <Grp-address>`	Statically binds a multicast group to the outgoing interface
`ZebOS-XP(cong-if)#exit`	Exit Interface mode.
`ZebOS-XP(config)#exit`	Exit Configure mode.

Commands Used

```
ipigmp access-group
ip igmp immediate-leave
ip igmp  join-group
ip igmp  last-member-query-count
ip igmp  last-member-query-interval
ip igmp limit
ip igmp querier-timeout
ip igmp  query-interval
ip igmp  query-max-response-time
ip igmp  ra-option
ip igmp  robustness-variable
ip igmp startup-query-count
ip igmp startup-query-interval
ip igmp static-group
```

Validation

Enter the commands listed in this section to confirm the previous configurations

```
Rtr1#show  running-config
!
no service password-encryption
!
hostname rtr1
!
!
ip multicast-routing
!
!
interface eth2
ip address 10.1.1.10/24
no shutdown
ip ospf cost 10
ip igmp access-group 1
ip igmp immediate-leave group-list 1
ip igmp last-member-query-count 7
ip igmp limit 100
ip igmp join-group 224.1.1.1
ip igmp static-group 225.1.1.1
ip igmp last-member-query-interval 25500
ip igmp querier-timeout 300
ip igmp query-interval 200
ip igmp query-max-response-time 150
ip igmp startup-query-interval 50
ip igmp startup-query-count 4
ip igmp robustness-variable 4
ip igmp ra-option
ip igmp version 2
ip pim sparse-mode
!!

Rtr1#show  ip igmp   interface  eth2

Interface eth2 (Index 4)
 IGMP Enabled, Active, Querier, Configured for version 2
```

```
 Internet address is 10.1.1.10
  IGMP interface limit is 100
  IGMP interface has 2 group-record states
  IGMP activity: 0 joins, 0 leaves
  IGMP querying router is 0.0.0.0
  IGMP query interval is 200 seconds
  IGMP Startup query interval is 50 seconds
  IGMP Startup query count is 4
  IGMP querier timeout is 300 seconds
  IGMP max query response time is 150 seconds
  Group Membership interval is 950 seconds
  IGMP Last member query count is 7
 Last member query response interval is 25500 milliseconds
```

Here is the sample configuration on Router-1 with all the IGMP related commands configured.

```
Rtr1#show  running-config
!
no service password-encryption
!
hostname rtr1
!
!
debug nsm packet
debug ip pim events
debug ip pim mfc
debug ip pim packet
debug ip pim state
debug ip pim timer
debug ip pim mib
!
ip domain-lookup
no ip icmp-broadcast
!
ip multicast-routing
!
ip pim register-rp-reachability
ip pim crp-cisco-prefix
!
interface lo
ip address 127.0.0.1/8
ip address 1.1.1.57/32 secondary
ipv6 address ::1/128
no shutdown
!
interface eth0
ip address 10.12.48.179/24
no shutdown
!
interface eth1
ip address 192.168.1.27/24
no shutdown
ip ospf cost 10
ip igmp version 3
ip pim sparse-mode
!
interface eth2
ip address 10.1.1.10/24
```

```
no shutdown
ip ospf cost 10
ip igmp access-group 1
ip igmp immediate-leave group-list 1
ip igmp last-member-query-count 7
ip igmp limit 100
ip igmp join-group 224.1.1.1
ip igmp static-group 225.1.1.1
ip igmp last-member-query-interval 25500
ip igmp querier-timeout 300
ip igmp query-interval 200
ip igmp query-max-response-time 150
ip igmp startup-query-interval 50
ip igmp startup-query-count 4
ip igmp robustness-variable 4
ip igmp ra-option
ip igmp version 2
ip pim sparse-mode
!
!
router ospf 100
network 192.168.1.0/24 area 0.0.0.0
network 10.1.1.0/24 area 0.0.0.0
!
line con 0
login
line vty 0 16
exec-timeout 0 0
login
line vty 17 39
login
!
End
```

IGMP GroupTable after IGMPV2 Membership Report is received

Igmp group table is populated at router by virtue of either static join is configured on interface or dynamic report is being received on the interface.

The `showipigmp group` command displays the igmp grouptable.In this table,the following fields are defined.

Group address	Displays the Multicast Group for which report is received.
Interface	Interface name on which Membership report is received.
Uptime	Duration since the report is received.
Expiry	Timeframe in which the multicast group is going to expire.
Last Reporter	Host address from where the report is generated.

```
Rtr1#show  ip igmp groups
IGMP Connected Group Membership
Group Address    Interface            Uptime  Expires  Last Reporter
224.0.1.3       eth2   00:10:06 00:03:43 10.1.1.52
224.1.1.1       eth2 01:54:53   static 0.0.0.0
225.1.1.1       eth200:17:22   static 0.0.0.0

Rtr1#show  ip igmp groups detail
```

```
IGMP Connected Group Membership Details

Flags: (M - SSM Mapping, R - Remote, L - Local,
        SG - Static Group, SS - Static Source)
Interface:      eth2
Group:          224.0.1.3
Flags:          R
Uptime:      00:10:06
Group mode:     Exclude (Expires: 00:03:43)
Last reporter:  10.1.1.52
Source list is empty

Flags: (M - SSM Mapping, R - Remote, L - Local,
        SG - Static Group, SS - Static Source)
Interface:      eth2
Group:          224.1.1.1
Flags:          L
Uptime:         01:54:59
Group mode:     Exclude (Static)
Last reporter:  0.0.0.0
Source list is empty

Flags: (M - SSM Mapping, R - Remote, L - Local,
        SG - Static Group, SS - Static Source)
Interface:      eth2
Group:          225.1.1.1
Flags:          SG
Uptime:         00:17:28
Group mode:     Exclude (Static)
Last reporter:  0.0.0.0
Source list is empty
```

IGMPv3

Internet Group Management Protocol (IGMP) is the protocol used by IPv4 devices to report their IP multicast group memberships to neighboring multicast devices. Version 3 (v3) of IGMP adds support for source filtering. Source filtering enables a multicast receiver host to signal from which groups it wants to receive multicast traffic, and from which sources this traffic is expected. That information may be used by multicast routing protocols to avoid delivering multicast packets from specific sources to networks where there are no interested receivers.

Configuring IGMP Version 3

`ZebOS-XP#configureterminal`	Enter configuremode.
`ZebOS-XP((config)#Interface Ifname`	Enter interface mode
`ZebOS-XP(config-if)#ip igmp version VersionNumber`	Enable Igmp version
`ZebOS-XP(config-if)#exit`	Exit Interfacemode.
`ZebOS-XP(config)#exit`	Exit configure mode.

Commands Used

```
ipigmp version
```

Validation

Enter the commands listed in this section to confirm the previous configurations

```
Rtr1#show  running-config
!
no service password-encryption
!
hostname rtr1
!
!
!
ip multicast-routing
!
!
interface eth2
ip address 192.168.10.57/24
no shutdown
ip ospf cost 10
ip igmp version 3
```

Configuring IGMP parameters in IGMPV3 is similar to IGMPV2 as shown in the IGMP section.

IGMP GroupTable after IGMPV3 Membership report is received

Igmp group table is populated at router by virtue of either static join is configured on interface or dynamic report is being received on the interface.

The `show ip igmp group` command displays the igmp group table.In this table, the following fields are defined.

Group address	Displays the Multicast Group for which report is r
Interface	Interface name on which Membership report is recei
Uptime	Duration since the report is received.
Expiry	Timeframe in which the multicast group is going to
Last Reporter	Host address from where the report is generated.

Group mode	Can be either INCLUDE or EXCLUDE. The Group mode is based on the type of membership report(s) received on the interface for the group. In the output for the show ip igmp groups detail command, the EXCLUDE mode also shows the "Expires:" field for the group entry (not shown in the output).
Group source list	Provides details of which sources have been requested by the multicast group.
Source Address	IP address of the source.
Flags	Information about the entry

IGMPV3 GroupTable in Exclude mode

```
rtr6#show  ip igmp  groups
IGMP Connected Group Membership
Group Address    Interface            Uptime   Expires  Last Reporter
224.0.1.3        eth2               00:08:50 00:02:10 192.168.10.52
rtr6#show  ip igmp  groups detail
IGMP Connected Group Membership Details

Flags: (M - SSM Mapping, R - Remote, L - Local,
        SG - Static Group, SS - Static Source)
Interface:      eth2
Group:          224.0.1.3
Flags:          R
Uptime:         00:08:50
Group mode:     Exclude (Expires: 00:04:57)
Last reporter:  192.168.10.52
Group source list: (R - Remote, M - SSM Mapping, S - Static, L - Local)

Exclude Source List :
  Source Address  Uptime    v3 Exp    Fwd  Flags
  1.2.3.4         00:08:50  stopped   No   R

For IGMPV3 report source list specifies which source to be included or exclude
based on the membership report sent by the hosts.

In the above show command, Source address 1.2.3.4 is excluded to send
Multicast traffic for group 224.0.1.3
```

IGMPV3 GroupTable in Include Mode

```
rtr6#show  ip igmp  groups
IGMP Connected Group Membership
Group Address    Interface            Uptime   Expires  Last Reporter
224.0.1.3        eth2               00:08:50 00:02:10 192.168.10.52
rtr6#show  ip igmp  groups detail
IGMP Connected Group Membership Details

Flags: (M - SSM Mapping, R - Remote, L - Local,
        SG - Static Group, SS - Static Source)
Interface:      eth2
Group:          224.0.1.3
```

```
Flags:          R
Uptime:         00:08:50
Group mode:     Include (Expires: 00:04:57)
Last reporter:  192.168.10.52
Group source list: (R - Remote, M - SSM Mapping, S - Static, L - Local)

Include Source List :
  Source Address  Uptime    v3 Exp    Fwd  Flags
  1.2.3.4         00:08:50  stopped   No   R
```

For IGMPV3 report source list specifies which source to be included or exclude based on the membership report sent by the hosts.

In the above show command, Source address 1.2.3.4 is in included mode implies host is interested in receiving multicast traffic from source 1.2.3.4.

Appendix A Tunnel Interface

To tunnel multicast traffic through intermediate routers which do not support multicast routing, a multicast tunnel can be created between two multicast routers (PIM-SM, PIM-DM, or DVMRP) in IP-in-IP (IPIP) or Generic Routing Encapsulation (GRE) tunnel encapsulation mode. The following provides examples to create this tunnel.

Note: Tunnel interfaces are currently supported only on Linux.

Configuring Interface Tunnel between Two PIM-SM Routers

The following shows the commands to create an interface tunnel between two PIM-SM routers in IPIP mode. Refer to the *ZebOS Network Platform NSM Command Line Interface Reference Guide* and the *ZebOS Network Platform PIM Command Line Interface Reference Guide* for details about the commands below.

Configure Interface Tunnel between Two PIM-SM Routers

`ZebOS#configure terminal`	Enter Configure mode.
`ZebOS(config)#interface tunnel 2`	Create a new tunnel interface and enter the Interface mode.
`ZebOS(config-if)#tunnel source 10.10.1.52`	Specify the tunnel source address.
`ZebOS(config-if)#tunnel destination 10.10.3.35`	Specify the tunnel destination address.
`ZebOS(config-if)#tunnel ttl 23`	Set the time-to-live for the tunnel to 23.
`ZebOS(config-if)#tunnel mode ipip`	Configure the tunnel mode.
`ZebOS(config-if)#ip pim sparse-mode`	Enable PIM sparse mode on the interface.

PIM-DM

The following shows commands to create an interface tunnel between two PIM-DM routers in GRE mode. Refer to the *ZebOS Network Platform NSM Command Line Interface Reference Guide* and the *ZebOS Network Platform PIM Command Line Interface Reference Guide* for details about the commands below.

Configure Interface Tunnel between Two PIM-DM Routers

`ZebOS#configure terminal`	Enter Configure mode.
`ZebOS(config)#interface tunnel 2`	Create a new tunnel interface and enter the Interface mode.
`ZebOS(config-if)#tunnel source 10.10.1.52`	Specify the tunnel source address.
`ZebOS(config-if)#tunnel destination 10.10.3.35`	Specify the tunnel destination address.
`ZebOS(config-if)#tunnel ttl 23`	Set the time-to-live for the tunnel to 23.

`ZebOS(config-if)#tunnel mode gre`	Configure the tunnel in Generic Routing Encapsulation (GRE) mode. Configure a Generic Routing Encapsulation (GRE) tunnel mode.
`ZebOS(config-if)#ip pim dense-mode`	Enable PIM dense mode on the interface.

DVMRP

The following shows commands to create an interface tunnel between two DVMRP routers in IPIP mode. Refer to the *ZebOS Network Platform NSM Command Line Interface Reference Guide* and the *ZebOS Network Platform DVMRP Command Line Interface Reference Guide* for details about the commands below.

Configure Interface Tunnel between Two DVMRP Routers

`ZebOS#configure terminal`	Enter Configure mode.
`ZebOS(config)#interface tunnel 2`	Create a new tunnel interface and enter the Interface mode.
`ZebOS(config-if)#tunnel source 10.10.1.52`	Specify the tunnel source address.
`ZebOS(config-if)#tunnel destination 10.10.3.35`	Specify the tunnel destination address.
`ZebOS(config-if)#tunnel ttl 23`	Set the time-to-live for the tunnel to 23.
`ZebOS(config-if)#tunnel mode ipip`	Configure the tunnel in IPIP mode.
`ZebOS(config-if)#ip dvmrp enable`	Enable DVMRP mode on the interface.

Index

N

P

R

S

T

V