Protocol Independent Multicast - Sparse Mode
Student Objectives

Upon successful completion of this module, you will be able to:

- Describe Protocol Independent Multicast - Sparse Mode (PIM-SM).
- Describe the PIM-SM processes and how they work.
- Enable PIM-SM.
- Configure PIM-SM timers.
- Configure the Candidate Bootstrap Router (CBSR) and Candidate Rendezvous Point (CRP) parameters.
- Verify the PIM-SM configuration.
Protocol Independent Multicast

- **PIM**
  - Protocol independent
  - No separate multicast routing protocol
  - Operates in one of two modes

- **PIM – Dense Mode**
  - Push model assumes there are multicast group members at all points in the network
  - Suitable for densely populated multicast groups
  - Flood and prune behavior

- **PIM – Sparse Mode**
  - Explicit join behavior
  - Multicast path constructed around a Rendezvous Point
  - Pull model assumes there are few, if any, multicast group members in the network
PIM – Sparse Mode Overview

- Suitable for networks with minimal multicast deployment and close router proximity.
- Builds shared trees based on a common Rendezvous Point.
  - Source trees can also be used.
- Reverse Path Forwarding (RPF) check depends on tree type.
  - Shared trees use the Rendezvous Point (RP) address.
  - Source trees use the Source address.
- Explicit join messages required
  - Sources register with the Rendezvous Point.
  - Receivers send join messages to the Rendezvous Point.
Designated Router Asserts

- Designated Routers set up multicast route entries and issue join and prune messages on behalf of directly connected sources and receivers.
- If more than one router is on a subnet, the routers receive multicast packets on an outgoing interface. They then send an Assert Message to elect a forwarder.
The Bootstrap Router

- A PIM domain is configured to operate within a specified boundary.

- The BSR generates bootstrap messages that:
  - Distribute Rendezvous Point information.
  - Are propagated throughout the domain.
  - Conduct BSR elections if required.

- Routers within the domain are configured as Candidate BSRs (CBSRs).
  - The election process selects a single router as the BSR.

- PIM Multicast Border Routers have some interfaces within the PIM domain and other interfaces outside the PIM domain.
BSR Election

- Candidates transmit bootstrap messages
- Messages contain weighting.
- Highest value elects the BSR.
Rendezvous Point Description

- The Rendezvous Point (RP) is a router to which all:
  - Sources register.
  - Receivers join.
  - Receivers hear of new sources.

- The Rendezvous Point (RP) is the root of a shared tree.

- Routers within the domain are configured as Candidate RPs (CRPs).
  - CRPs are usually the same routers that were configured as CBSRs.
1. Source 1 multicasts.

2. Router A encapsulates multicast in a unicast register message towards the RP.

3a. The RP (Router C) multicasts the de-encapsulated multicast traffic.

3b. The RP sends a join message towards source 1.

4. The RP sends a register-stop message back to router A.
1. Router B receives an IGMP message.

2a. Router B creates a *,G state entry in the multicast routing table.

2b. Router B issues a PIM (*,G) join message towards the RP (Router C).

3. The RP creates *,G state entry in its multicast routing table.

4. The group G multicast traffic can now be sent.
PIM – SM Prune Messages

1. Router B is receiving multicast traffic.
2. Router B no longer has active group members.
3. Router B sends a *,G Prune message to remove source S1.
Shortest Path Tree Switchover

1. Router B receives multicast traffic from RP (Router C).
2. SPT threshold exceeded. Router B sends S,G join to the source.
3. Router B sends a S,G Prune message to RP (Router C).
Configuring PIM-SM Overview

1. Configure VLANs, router interfaces, a dynamic routing protocol, and enable IP forwarding.
2. Verify that IGMP and IGMP snooping are enabled.
3. Enable IP Multicast forwarding.
4. Enable PIM-SM on VLANs.
5. Configure the PIM-SM Candidate Rendezvous Point.
6. Configure the Candidate Bootstrap Router.
7. Configure the Source Path Tree threshold.
8. Start the multicast stream at the source.
9. Initiate a receiver Join.
10. Verify that the leaf workstations receive the multicast stream.
Enabling IPMC Forwarding

- To enable IP multicast forwarding:
  ```
  enable ipmcforwarding {vlan <name>}
  ```
- If no VLANs are specified, all configured IP interfaces are affected.
- When new IP interfaces are added, IPMC forwarding is disabled by default.
- IP forwarding must be enabled before enabling IPMC forwarding.
Enabling PIM

- To enable PIM on an IP router interface:
  ```
  configure pim add vlan [<vlan_name> | all] {dense | sparse} {passive}
  ```
- PIM is disabled by default.
- To enable PIM globally:
  ```
  enable PIM
  ```
Configuring a Candidate Rendezvous Point (RP)

- To configure a Candidate Rendezvous Point:
  ```
  configure pim crp vlan <vlan_name> [none | <policy>] {<priority>}
  ```

- To configure the candidate rendezvous point advertising interval:
  ```
  configure pim crp timer <crp_adv_interval>
  ```
Configuring a Static RP

- Static RP is a simpler configuration.
- All switches in the PIM domain must be configured with the same RP address for the same multicast group(s).

To configure a static Rendezvous Point:

```
configure pim crp static <ip_address> [none | <policy>] {<priority>}
```

To verify the RP:

```
show pim rp-set
```

<table>
<thead>
<tr>
<th>London.10</th>
<th># show pim rp-set</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
<td>Mask</td>
</tr>
<tr>
<td>239.2.4.70</td>
<td>255.255.255.0</td>
</tr>
</tbody>
</table>

```
London.11 #
London.11 #
```
Creating a Multicast Group Policy File

- The policy file is a container for a list of multicast group addresses for which the RP is being configured.
- The policy file can be created on the switch using the vi-like edit command or using a simple text editor and downloading it to the switch using the tftp command.

```plaintext
edit policy mgroup.pol
entry anyname {
    if match any { }
    then { nlri 239.2.4.0/24 ; }
}
```
Configuring a CBSR

► The BSR generates bootstrap messages that distribute Rendezvous Point information.

► To configure a Candidate Bootstrap Router:

```bash
configure pim cbsr [{vlan} <vlan_name> {<priority [0-254]} | none]
```
Configuring the Register Suppress Interval

- Register packets encapsulate multicast data from the source.
- Null register packets are sent periodically for efficiency.
- Null register packets are sent at the register suppress interval minus the register probe interval.
- To configure the register suppress and register probe interval:
  ```bash
  configure pim register-suppress-interval <reg-interval>
  register-probe-interval <probe_interval>
  ```
- To configure the initial interval for sending null-register messages:
  ```bash
  configure pim register-rate-limit-interval <interval>
  ```
Configuring the SPT Threshold

- To configure the Source Path Tree switchover threshold:
  `configure pim spt-threshold <leaf-threshold>`
- On leaf routers, the setting is based on kbps of data packets.
- On the RP, the setting is based on kbps of register packets.
PIM–SM Example

OSPF Area 0.0.0.0

R1

10.0.3.2

10.0.3.1

ABR 1

163.12.12.2

163.12.12.1

OSPF Area 3.0.0.0

ABR 2

186.12.119.2

186.12.119.1

OSPF Area 4.0.0.0

R2

10.0.2.2

10.0.2.1

blue

black

green

orange

10.0.2.1
PIM–SM Example Commands:

Use the following commands to configure VLANs blue, black, green, and orange IP addresses for PIM-SM:

```
enable ipforwarding
configure ospf routerid 1.1.1.1
configure ospf add vlan black area 0.0.0.0
configure ospf add vlan blue area 0.0.0.0
configure ospf add vlan green area 4.0.0.0
configure ospf add vlan orange area 3.0.0.0
enable ospf
enable ipmcforwarding
configure pim add vlan all sparse
configure pim crp vlan green mgroup 10
configure pim cbsr vlan green 3
enable pim
```
Verifying the PIM-SM Configuration

```
show pim
```

```
CaIRO.2 # show pim
PIM Enabled. Version 2
PIM CRP Enabled on 1 interfaces
BSR state: CANDIDATE
BSR Hash Mask Length: 255.255.255.252
Current BSR Info : 11.0.0.2 (Priority 10) expires after 111 sec
Configured BSR Info : 12.0.0.2 (Priority 4) in vlan orange
CRP Adv Interval : 60 sec ; CRP Holdtime: 150
BSR Interval : 60 sec ; BSR Timeout : 130
Cache Timer : 210 sec ; Prune Timer : 210
Assert Timeout : 210 sec ; Register Suppression Timeout.Probe: 60, 5
Generation Id : 0x4511d2d7
Threshold for Last Hop Routers: 0 kbps
Threshold for RP : 0 kbps
Register-Rate-Limit-Interval : Always active
PIM SSM address range : None
Register Checksum to include data
Active Sparse Ckts 3 Dense Ckts 0

Global Packet Statistics (In/Out)
C-RP-Adv 5 67
Registrars 0 0
RegisterStops 0 0

<table>
<thead>
<tr>
<th>VLAN</th>
<th>Cid IP Address</th>
<th>Designated Flags</th>
<th>Hello</th>
<th>J/P</th>
<th>Nbrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>brown</td>
<td>3 13.0.0.2 /24 13.0.0.2</td>
<td>rifms----</td>
<td>30</td>
<td>60</td>
<td>1</td>
</tr>
<tr>
<td>gray</td>
<td>1 104.0.0.1 /24 104.0.0.1</td>
<td>rifms----</td>
<td>30</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>orange</td>
<td>2 12.0.0.2 /24 12.0.0.2</td>
<td>rifms---</td>
<td>30</td>
<td>60</td>
<td>1</td>
</tr>
<tr>
<td>red</td>
<td>4 15.0.0.2 /24 15.0.0.2</td>
<td>rifms----</td>
<td>30</td>
<td>60</td>
<td>0</td>
</tr>
</tbody>
</table>

Legend: J/P Int: Join/Prune Interval
Flags: r - Router PIM Enabled, i - Interface PIM Enabled, f - Interface Forwarding Enabled, s - Sparse mode, d - Dense mode, c - CRP enabled,
------ - Trusted Gateway configured, m - Multinetted VLAN,
p - Passive Mode, S - Source Specific Multicast.
```
Verifying the PIM Cache

```
Cairo.4 # show pim cache detail
Index  Dest Group  Source          InVlan  Origin
[0000] 239.2.4.70  11.0.0.1 (WR)  brown  Sparse
        Entry timer is not run; UpstNbr: 13.0.0.1
        EgressIfList = gray(0)(FW)(SM)(I)

[0001] 239.2.4.70  101.0.0.2 (S)  orange  Sparse
        Expires after 189 secs UpstNbr: 12.0.0.1
        RP: 11.0.0.1 via 13.0.0.1 in brown
        EgressIfList = gray(0)(FW)(SM)(I)

Number of multicast cache = 2

Entry flags :-
Egress/Pruned interface flags :-
SM: Sparse Mode  DM: Dense Mode
FW: Forwarding  PP: Prune pending
AI: Assert Loser  N: Neighbor present
I: IGMP member present  S: (s,g) join received
Z: (*,g) join received  Y: (*,*,rp) join received
```

Cairo.5 #
Verifying the PIM RP Set

```
Newyork.2 # show pim rp-set
Group    Mask         C-RP          Origin    Priority
239.2.4.0 255.255.255.0 11.0.0.1    Bootstrap 1
239.2.4.0 255.255.255.0 11.0.0.2    Bootstrap 3
239.2.4.0 255.255.255.0 12.0.0.1    Bootstrap 10
239.2.4.0 255.255.255.0 12.0.0.2    Bootstrap 4
Newyork.3 #
```
Summary

You should now be able to:

- Describe Protocol Independent Multicast - Sparse Mode (PIM-SM).
- Describe the PIM-SM processes and how they work.
- Enable PIM-SM.
- Configure PIM-SM timers.
- Configure the Candidate Bootstrap Router (CBSR) and Candidate Rendezvous Point (CRP) parameters.
- Verify the PIM-SM configuration.