PIM-SM Multicast Routing

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Outline

- IP Multicast review
- Multicast forwarding review
- DVMRP and PIM-DM
- PIM-SM
- XORP

IP Multicast Review

- Many-to-many communication model
- Multicast group address
  - Only as destination address
  - IPv4 224.0.0.0/4
  - IPv6 ff00::/8
- Group management mechanism
  - IGMP (IPv4)
  - MLD (IPv6)

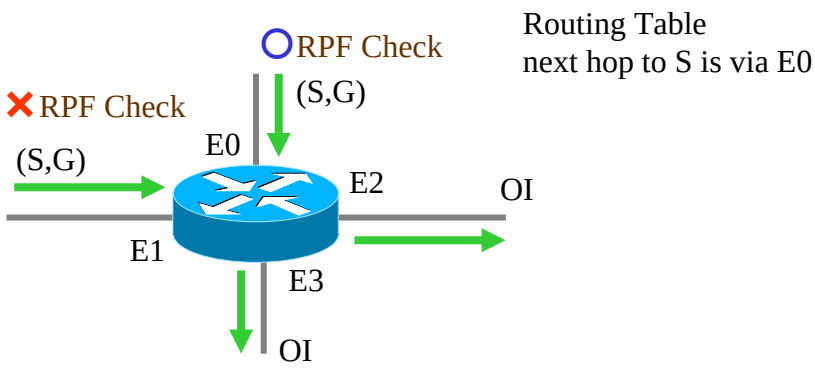
Multicast Forwarding Review

- Multicast router forward packet to outgoing interfaces
- Where does the packet come from?
  - Do not forward to the incoming interface.
- Reverse Path Forwarding
  - Does the packet come from the correct interface?

Reverse Path Forwarding

- RPF
  - A router forwards a packet only if received from the upstream interface to the source
- RPF Check
  - Check the source address of multicast packets against a unicast routing table
  - If arrived on the interface to reach the source address, RPF check passes
  - Otherwise, RPF check fails

RPF Check Illustration

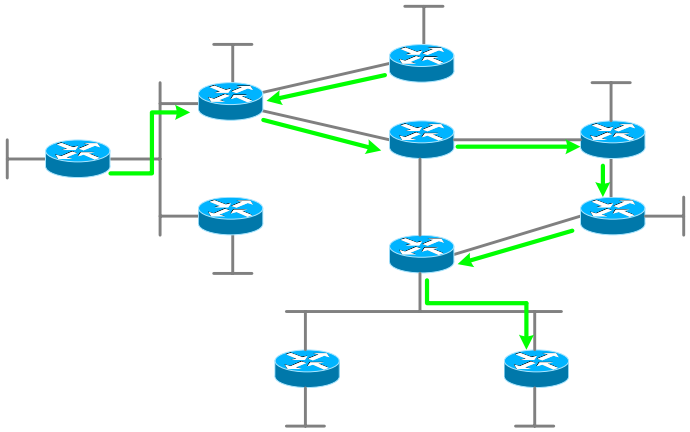


Routing Table
next hop to S is via E0

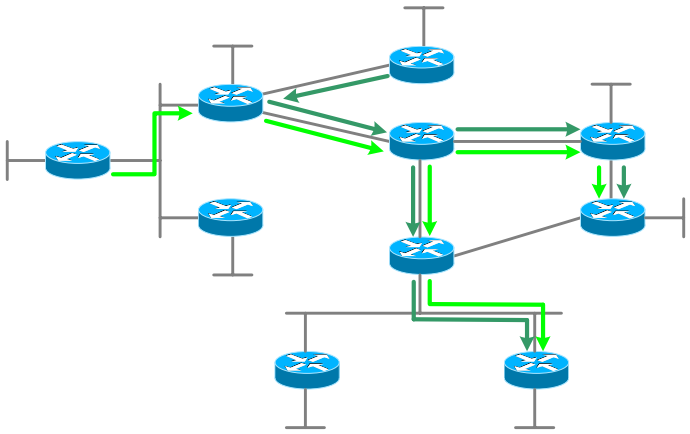
Multicast Distribution Tree

- Shared Tree
  - Rooted at a Rendezvous Point
  - Likely to be non-optimal
- Shortest-Path Tree
  - Each multicast source is root
  - Optimal tree (shortest hop, (and delay))

Shared Tree



Shortest-Path Tree



Multicast Forwarding State

- Routers keep multicast forwarding state for each group
  - Join
  - Pruned
- State structure
  - (S, G)
  - Outgoing interfaces

Source 1

Multicast Routing Protocols

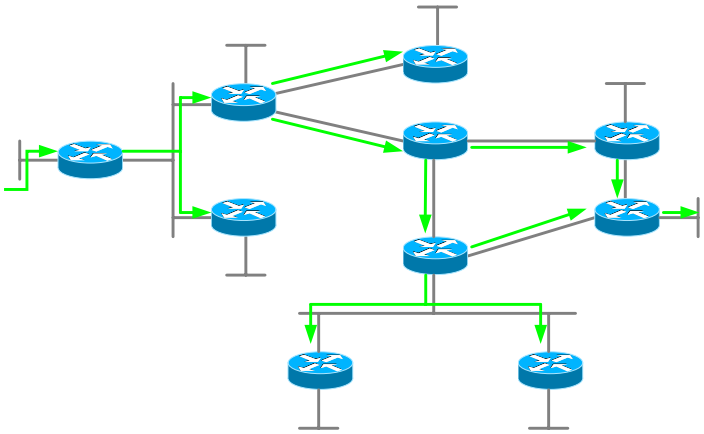
- DVMRP (based on Bellman-Ford algorithm)
- PIM-DM (dense mode)
- PIM-SM (sparse mode)
- CBT
- MOSPF

- BGMP
- MSDP

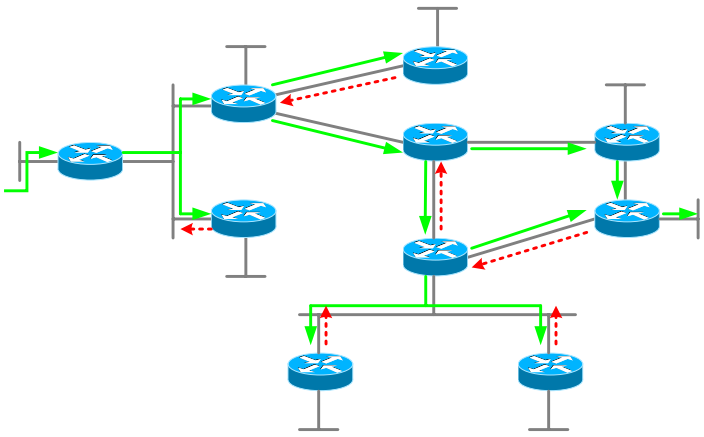
Dense Mode

- Flood-prune mechanism
- Suites networks with many receivers compared to #routers

DM: Flooding

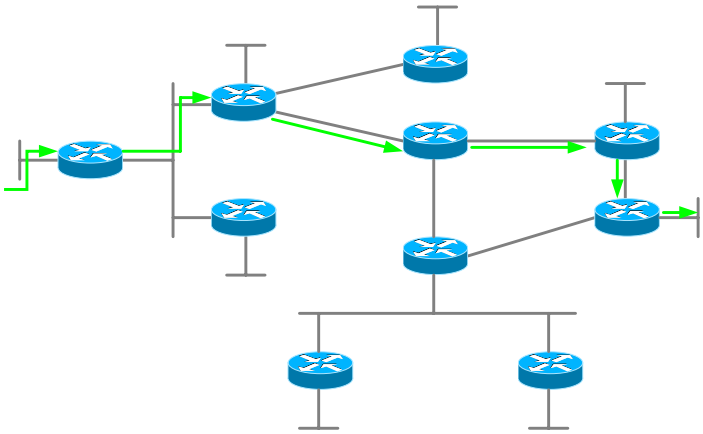


DM: Prune Unwanted Traffic



Source

DM: Final Tree



PIM-SM Overview

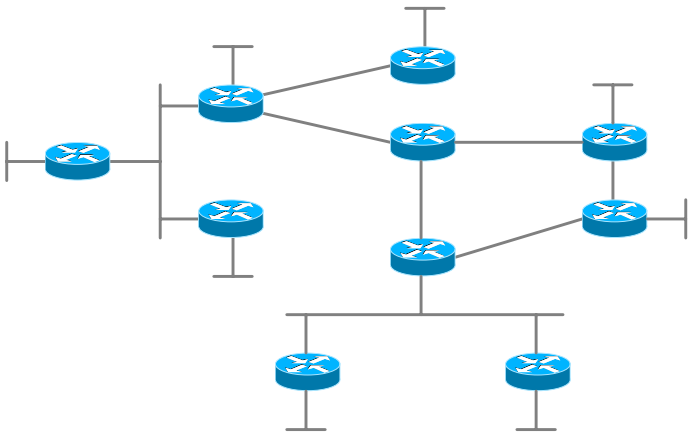
- Sparse mode multicast routing protocol
  - uses explicit Join and Prune
  - small #receivers compared to #routers
- Uses the available routing protocol to populate routing table
  - Protocol independent
- *de-facto* multicast routing protocol

Source

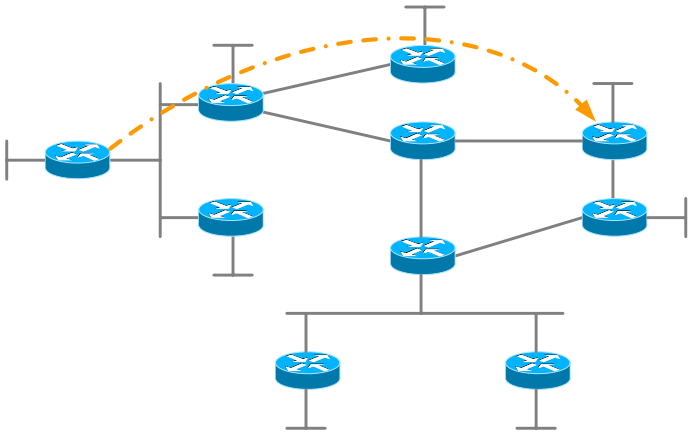
Building Distribution Tree in PIM-SM

- RP-tree
  - Shared tree rooted at RP
  - Receiver sends Join messages toward RP
  - DR sends Register-encapsulated multicast packets toward RP
- Register stop
  - RP builds SPT to receive native multicast packets from S
  - RP stops receiving Register messages
- Shortest path tree
  - Leaf-router initiates switch to SPT; send Join messages toward S
  - Prune RP-tree after the first message from SPT arrived

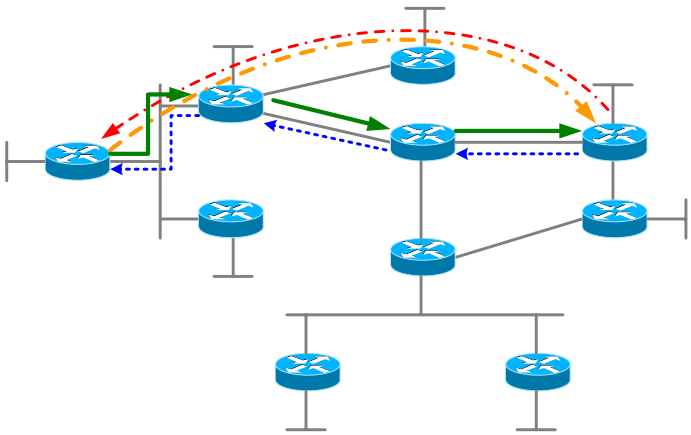
PIM-SM: Initial Condition



PIM-SM: Sender Registering



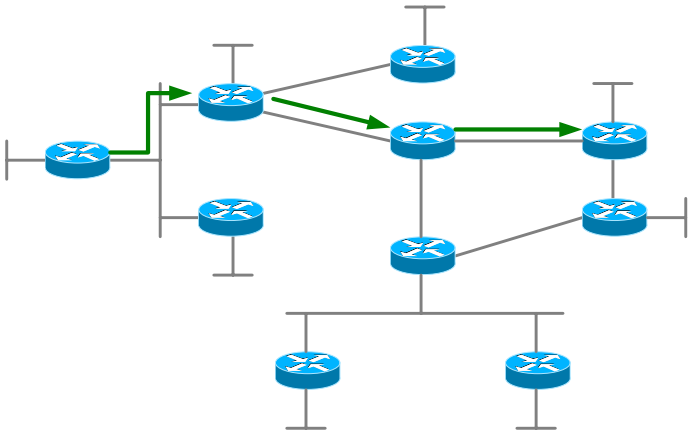
PIM-SM: RP Initiates Register-Stop



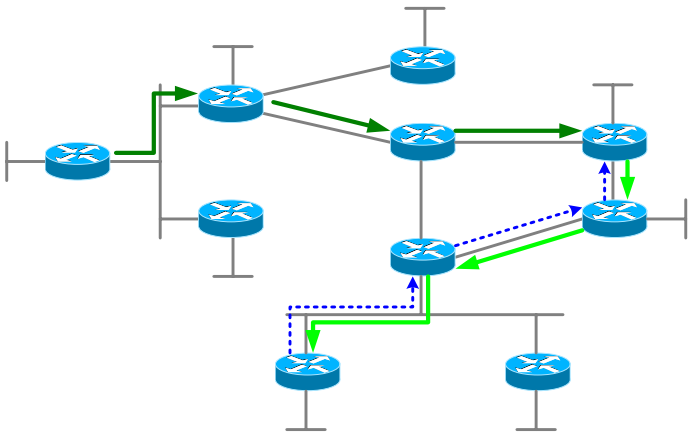
(S,G

Source

PIM-SM: Register-Stop Completed

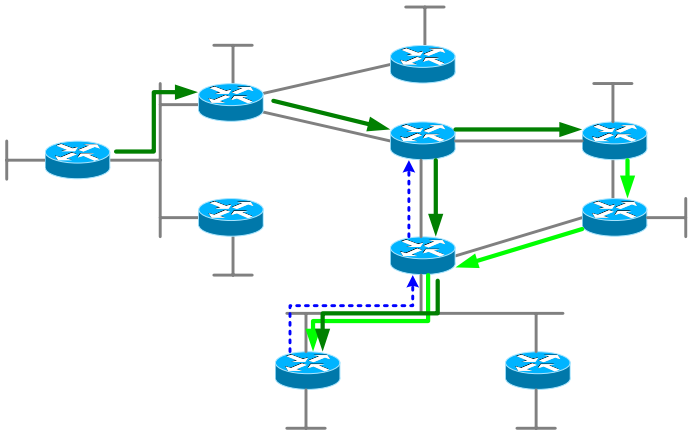


PIM-SM: Receiver Joins RPT

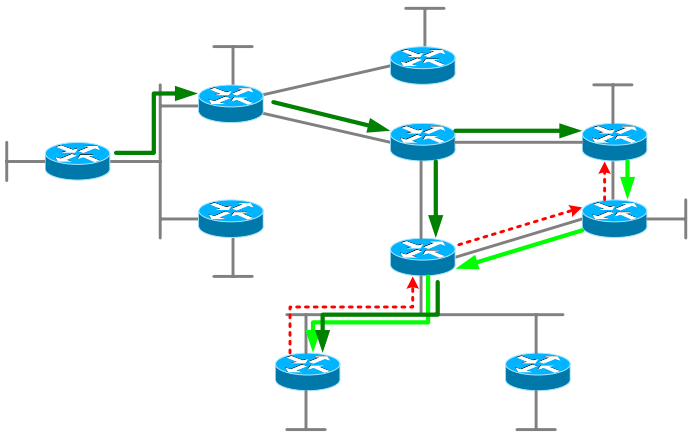


Source

PIM-SM: Leaf Router Initiates SPT Switch-over

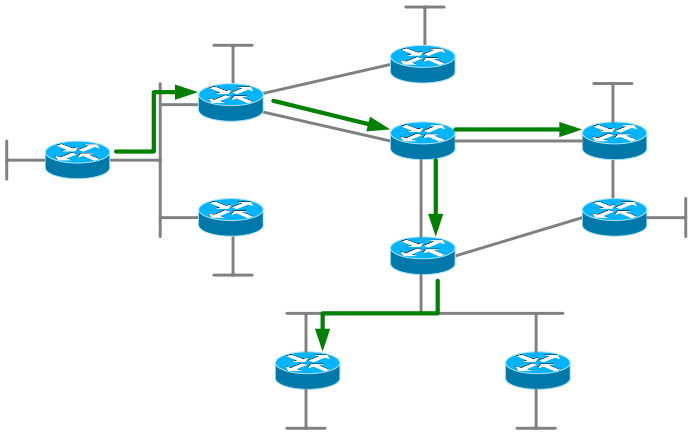


PIM-SM: Leaf Router Prunes RP-Tree



Source

PIM-SM: SP-Tree Completed



Rendezvous Point

- Every multicast router within a PIM domain must be able to map a multicast group to the same RP
- Methods:
  - Static
  - Dynamic, via bootstrap router mechanism

Source

PIM Bootstrap and RP Discovery

- Bootstrap Router mechanism: a dynamic way to discover RPs
- A router advertises itself as BSR-candidate
- BSR elected based on priority
- Candidate-RP advertises itself to BSR
- BSR computes RP-set and floods RP-set to PIM domain
  - RP-set: the collection of all group-to-RP mappings known to a router

Designated Router

- A DR is elected among PIM routers on a link
  - DR priority
  - DR IP address
- DR represents the link
- DR register-encapsulates multicast traffic from sources on its link

PIM Assert

- On multi-access link, multicast packets may be forwarded-in by more than one router
- PIM elects a single forwarder
- Assert winner precedence:
  - Router with (S,G) over (*,G)
  - Better metric toward S between routers with (S,G)
- Assert-winner keeps Join state
- Assert-losers issue Prune messages to its upstream

PIM-SM on FreeBSD

- FreeBSD 4.x before 4.9-RELEASE
  - Kernel patch + recompile
- FreeBSD 4.9-RELEASE ~
  - recompile

```
options MROUTING
options PIM
```

Multicast Routing Table

- to be correct: Multicast Forwarding Cache

```
% netstat -ng
```

- See the difference between IPv4 and IPv6!

Interface Table and MFC

```
Virtual Interface Table
 Vif   Thresh   Rate   Local-Address   Remote-Address    Pkts-In   Pkts-Out
  0         1      0   10.20.1.1                           18871       5255
  1         1      0   10.1.1.100                           5255      12740
  2         1      0   10.20.1.1                               0       2532

IPv4 Multicast Forwarding Cache
 Origin          Group            Packets In-Vif  Out-Vifs:Ttls
 10.20.1.20      239.18.100.100       208    0    2:1

IPv6 Multicast Interface Table
 Mif   Rate   PhyIF   Pkts-In   Pkts-Out
   0      0    fxp0     23834      10097
   1      0    fxp1     10097      12066
   2      0    reg0         0       9833

IPv6 Multicast Forwarding Cache
 Origin                       Group              Packets Waits In-Mif  Out-Mifs
 2001:d30:13:e001:7172:2b1c:36 ff85::100             209     0    0    2
```

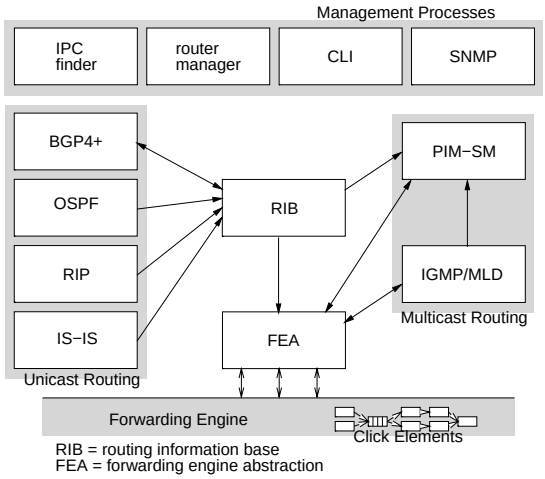
Running PIM-SM Routing on FreeBSD

- pimd
  - PIM-SM for IPv4
  - Early implementation, not maintained anymore
- pim6sd
  - PIM-SM for IPv6 implementation by KAME
  - based on pimd code
- XORP
  - new project: unicast & multicast, IPv4 & IPv6
  - Release 1.0 just out
  - conform with the latest draft specs
  - need get updated via CVS

XORP

- eXtensible Open Router Platform
  (read: ZORP)
- http://www.xorp.org/
- Open source

XORP Process Model



Installing XORP

- Requirements:
  - GNU make
  - Net-SNMP
- Unix group name: xorp
- The usual procedure:

```
tar zxpvf xorp-1.0.tar.gz
cd xorp-1.0
./configure
gmake
gmake install
```

LAB WORK

Exercise 1

XORP Installation Structure

- Default base dir:
  `/usr/local/xorp`
- Configuration file:
  `/usr/local/xorp/config.boot`
- Router manager:
  `/usr/local/xorp/bin/xorp_rtrmgr`
- XORP shell:
  `/usr/local/xorp/bin/xorpsh`

Recompile Kernel

- Add the below options (page 33 on Handout)

```
options MROUTING
options PIM
```