

● ● ● Transforming communications  
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# IPv6 Multicast Tutorial

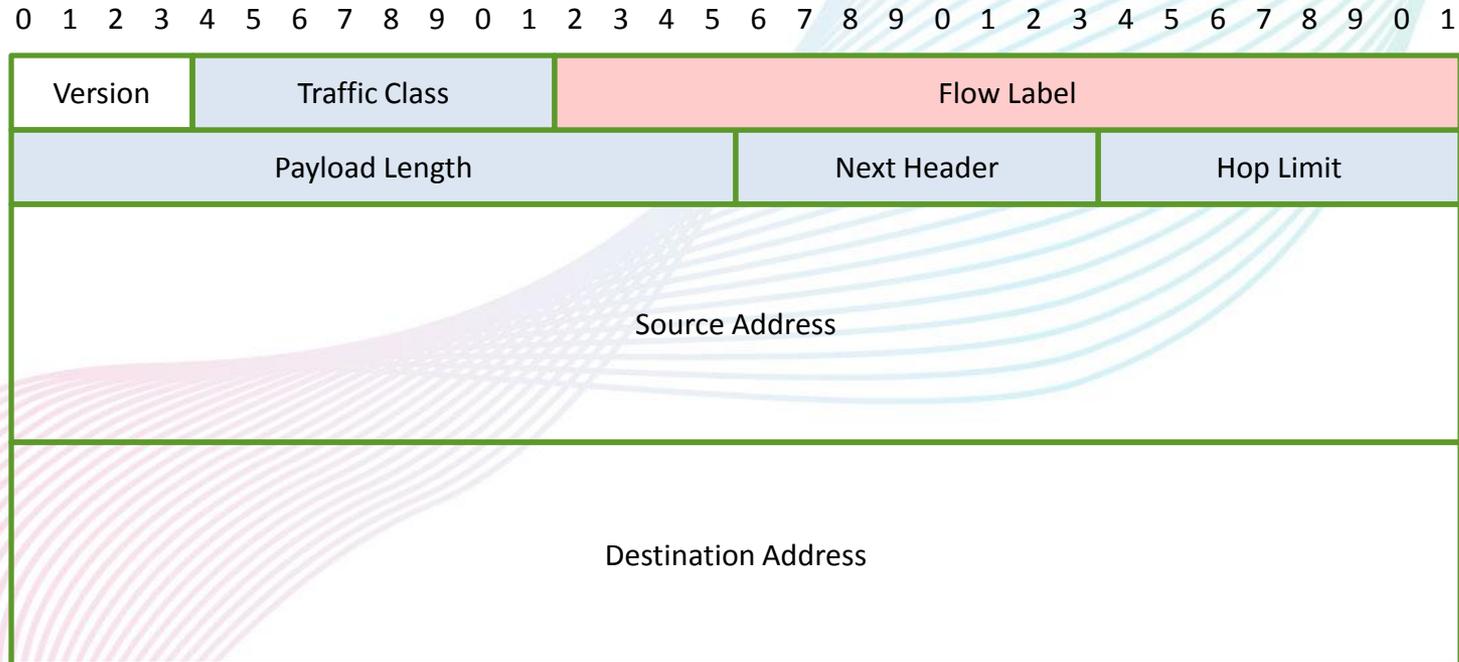
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# Agenda

- IPv6 Basics: header format/addressing
- What is multicast ?
- MLDv1/v2
- Multicast Forwarding and PIM
  - PIM-SM (ASM: Any Source Multicast)
  - PIM-SSM (SSM: Source Specific Multicast)
- MLD Snooping
- IPv6 Multicast Configuration and Show commands, Trouble shooting
- Failure case study
- Consideration in deploying IPv6 multicast to SP network

# IPv6 Basics

# IPv6 Header Format



**# header length is fixed in IPv6**



Newly defined field in IPv6



Field name is changed in IPv6

# IPv6 Address notation

## ◆ IPv4 address notation

#please refer also “draft-kawamura-ipv6-text-representation”

Binary digit notation(32bits)

```
11000000 10101000 00000000 00000001
```

- For every 8bits, display in decimal number and separate with “.”

```
192.168.0.1
```

## ◆ IPv6 address notation

Binary digit notation(128bits)

```
0010000000000001 0000110110111000 1011111011101111 1100101011111110  
0000000000000000 0000000000000000 0000000000000000 0001001000110100
```

- For every 16bits, display in Hex number and separate with “:”

```
2001:0db8:beef:cafe:0000:0000:0000:1234
```

- Leading zero in 16bits field can be abbreviated.

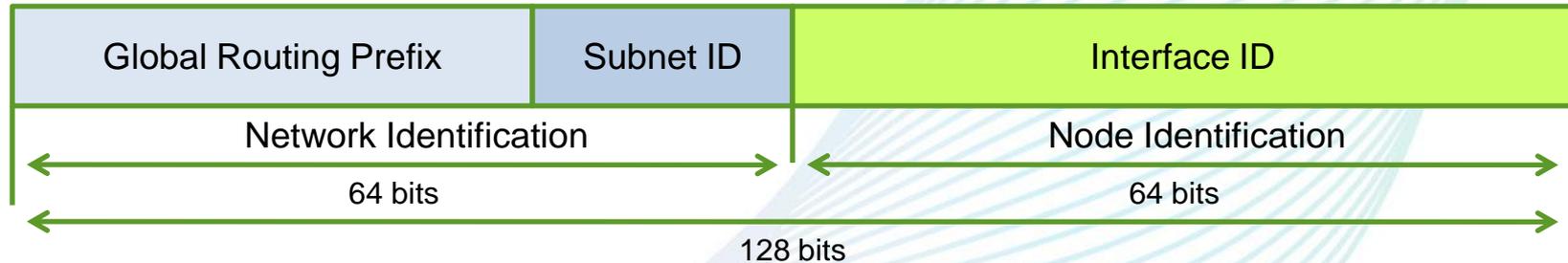
```
2001:db8:beef:cafe:0:0:0:1234
```

- Compress the zeros with “::”

```
2001:db8:beef:cafe::1234
```

# IPv6 Address

## ◆ IPv6 Address Architecture



### ● Prefix

Upper 64 bits with Global Routing Prefix + Subnet ID

## ◆ IPv6 Address categories

- Unicast Address one to one communication  
the Address for each network interface  
Global Address, Link-local Address, Unique Local Address
- Multicast Address one(or Many) to Many communication  
receiving hosts are identified by Group Address  
Also used as alternative way of IPv4's broadcast as well
- Anycast Address one to one of many communication  
can be configured on multiple interfaces/nodes. Assigned for "feature".

# Unicast Address Format

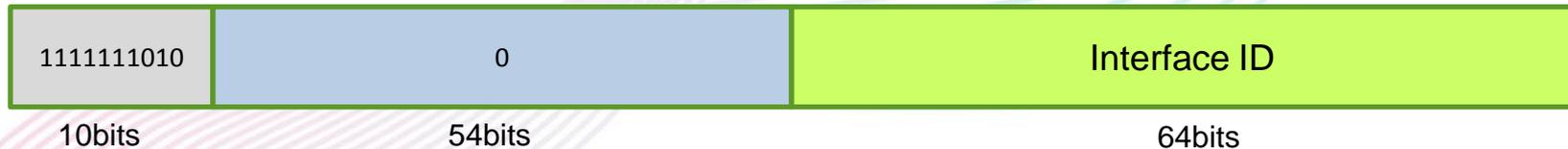
## ◆ Global Unicast Address



(3bits) 48bits 16bits 64bits

- Global address (ex) 2001:db8::1

## ◆ Link-local Unicast Address



10bits 54bits 64bits

Unique within one Link (fe80::/10)

It is used for the communication within the link.

## ◆ Unique Local Unicast Address(ULA) [RFC4193]



8bits 40bits 16bits 64bits

L bit: 0 future use 1 Locally assigned pseudo-random Global ID

# Multicast Address Format

## ◆ Multicast Address



Flag	
T Flag	0: permanently-assigned ("well-known") multicast address, assigned by IANA <b>1: non-permanently-assigned multicast address</b>
P Flag	<b>1: Unicast-Prefix-based multicast address (RFC3306) #when P=1, T must be 1</b>
R Flag	1: multicast address that RP address is embedded (RFC3956) #when R=1, P/T must be 1

### Scope: limit the scope of the multicast group

0000(0)	reserved	0101(5)	site-local scope
0001(1)	interface-local scope	1000(8)	organizational-local scope
0010(2)	link-local scope	1110(E)	global scope
0100(4)	admin-local scope	1111(F)	reserved

### ◆ ex):

**PIM-SM(ASM) multicast address** **FF15::1234**

**PIM-SSM multicast address** **FF38::abcd**

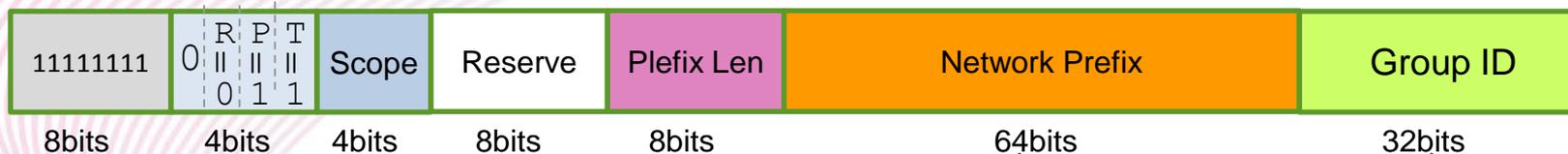
# Multicast Address Format

## ◆ permanently-assigned multicast address: mainly used for control packets

FF02:0:0:0:0:0:1	Link local All IPv6 Nodes
FF02:0:0:0:0:0:2	Link local All IPv6 routers
FF02:0:0:0:0:0:C	Link local DHCP server/relay agent
FF02:0:0:0:0:1:FFxx:xxxx	Solicited node multicast address(xx:xxxx represents lower 24bits of node's unicast/anycast address. )

## ◆ RFC3306 Unicast-Prefix-based multicast address

If the user has global unicast IPv6 prefix, the user can have globally unique multicast prefix that global unicast prefix is embedded in multicast prefix.



◆ ex):

**FF3E:0040:2001:0123:c001:1100:0000:abcd**  
 Plen=64      Unicast prefix      groupID

When the User has Unicast Prefix = 2001:0123:c001:1100::/64.

# Multicast MAC Address for IPv6

128 Bits

FF3E:0040:2001:0123:c001:1100:0000:abcd

33-33-00-00-ab-cd

16 Bits

32 Bits

48 Bits

FF3E:0040:2001:0123:c001:1100:0000:abcd and

FF18:0040:2001:0234:1002:0010:0000:abcd

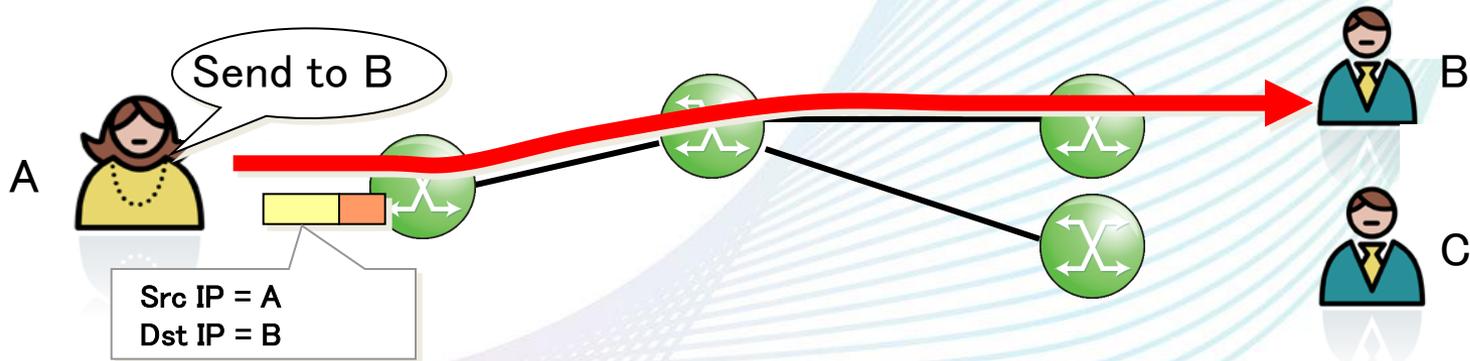
will have same multicast MAC address(L2-dest-address).

L2-switch may not be able to differentiate those IPv6 multicast address.

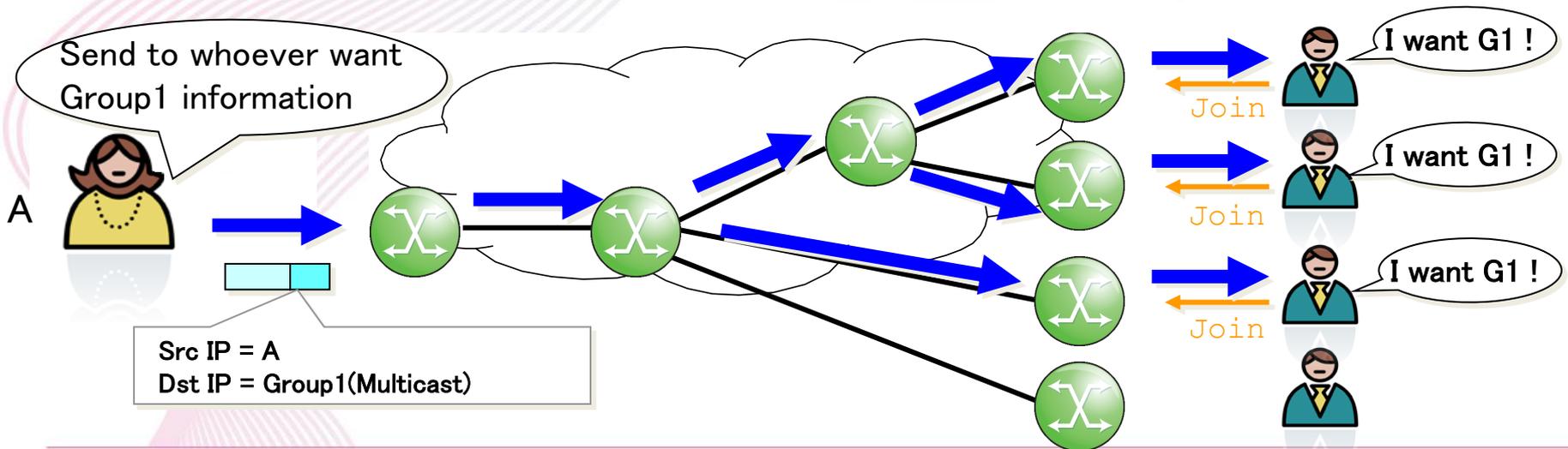
# What is Multicast ?

# Difference between Unicast and Multicast

## ◆ Unicast: one to one communication



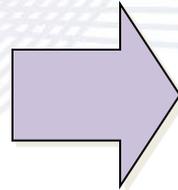
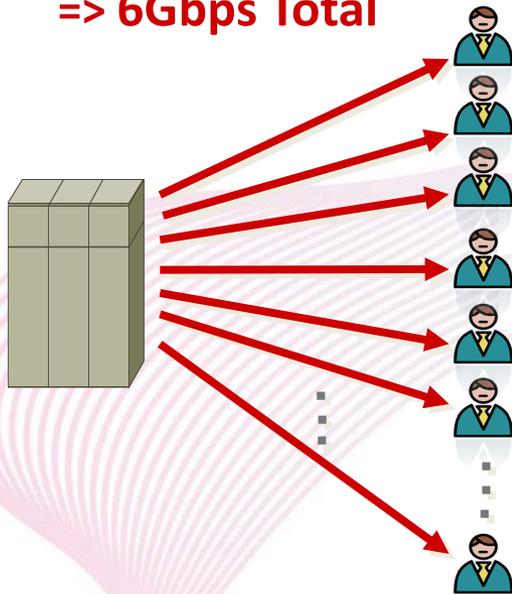
## ◆ Multicast: one(or Many) to Many that joined to the group



# Advantage of Multicast

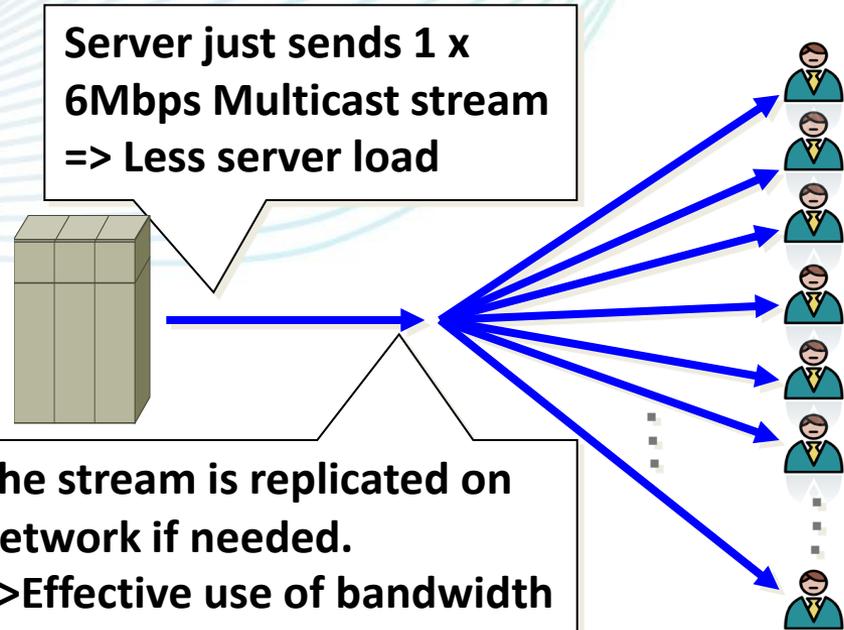
- ◆ Reduce the server load while sending same contents to many receivers
- ◆ Effective use of network bandwidth

**6Mbps x 1000 receivers  
=> 6Gbps Total**



**Server just sends 1 x  
6Mbps Multicast stream  
=> Less server load**

**The stream is replicated on  
network if needed.  
=> Effective use of bandwidth**



# Multicast applicability

- ◆ **Residential Broadband**  
IP/TV, Live Streaming  
Gaming, Contents download
- ◆ **Enterprise network**  
E-Learning, broadcasting  
Application delivery  
Multipoint conference  
Sensor network in Factory
- ◆ **Financial**  
Hoot and Holler  
Financial systems(Stock exchange, etc)
- ◆ **Public**  
Video Surveillance for river, highway  
information broadcasting(voice, disaster information)  
information distribution in local town

# IPv6 multicast service example

## ◆IPv6 multicast broadcasting system(i-InproV6)

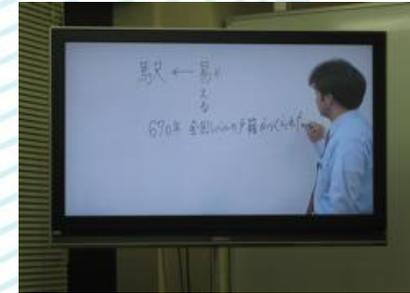
### ●Remote class in preparatory schools

Cost is 1/10 to compare with satellite broadcasting

- Initial cost: \$several million => about \$200k
- running cost: \$100k/month => \$10k/month

Popular teacher's class is broadcasted to all areas.  
same quality in all areas, more per class profit

Remote Class



<http://becare.co.jp/service/case01.html>

## ◆Emergency Earthquake information distribution service(OCN)

●Emergency Earthquake information/Alert from Meteorological biz support center is distributed to users with urgency/realtime/efficiency.

Receiver Application



<http://www.ntt.com/jishinsokuho/index.html>

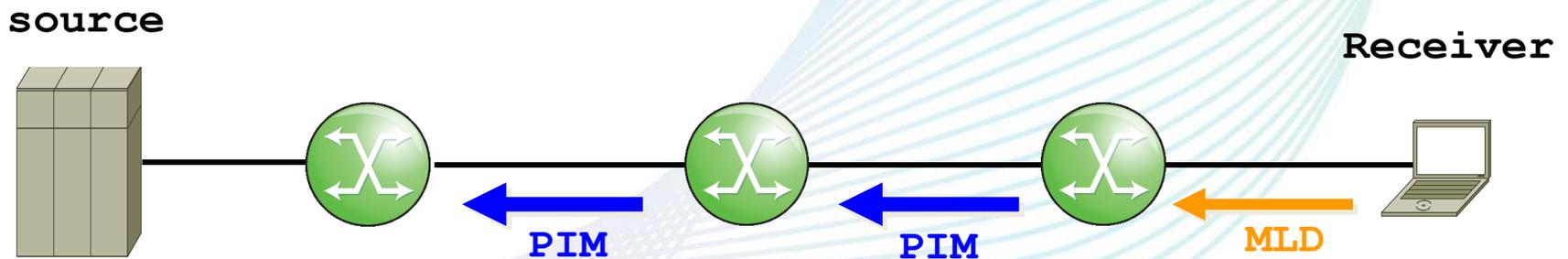
## ◆contents distribution for kiosk hosts at convenience stores. (FamilyMart)

- 6,000 stores are dual-stack-ed
- change from satellite to broadband with multicast
- Distributing large volumes of data by multicast like New product Add/manual for employee

Kiosk Host(Fami-port)



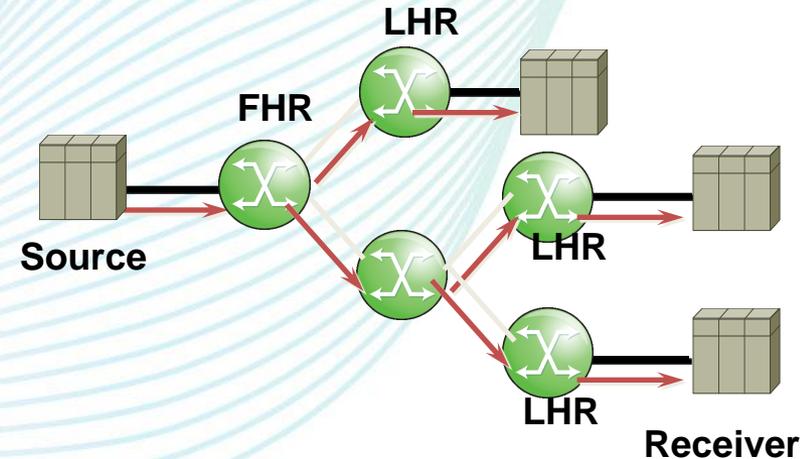
# Multicast Protocols



**MLD: for Signaling between Receiver and Router**  
**PIM: for Signaling between Routers to build multicast distribution tree**

# Terminologies

- Source/Sender
  - The host/server sending multicast traffic
- Receiver/Listener
  - The host that receives multicast traffic
- Upstream
  - The direction traffic comes in
- Downstream
  - The direction traffic goes out
- RP (Rendezvous Point)
  - In PIM-SM, The router that “rendezvous” source and receiver info
- First Hop Router (FHR)
  - The router that source is connected
- Last Hop Router (LHR)
  - The router that receiver is connected
- (\*,G)
  - \*:any source, G:group address
- (S,G)
  - S:source address of multicast traffic, G:group address



# Terminologies

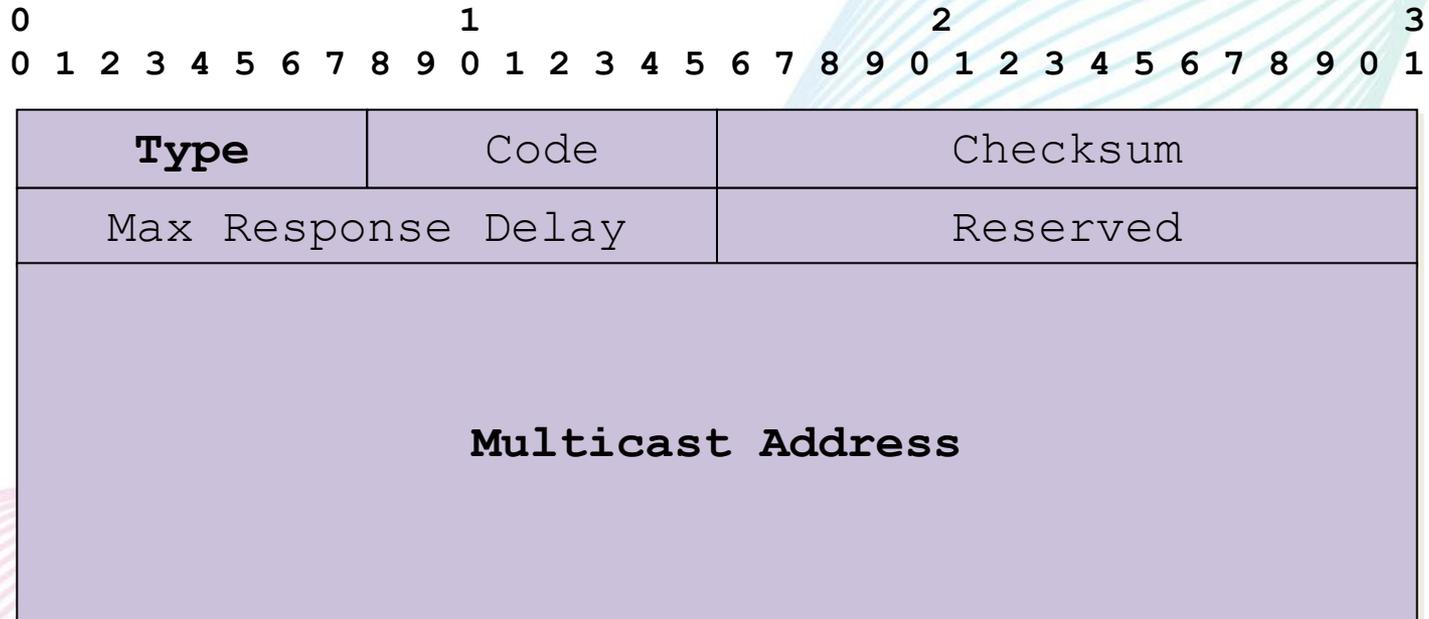
- Multicast Group Address
  - Destination address for multicast traffic
- Multicast Group
  - The group consist of sender and receiver
- MDT (Multicast Distribution Tree)
  - The tree used to distribute multicast traffic on the routers
  - Shortest Path Tree(Source Tree), Shared Tree(RP tree)
- Join
  - Joining to the multicast group to receive the traffic
- Leave(MLD)/Prune(PIM)
  - Leave from the multicast group to stop receiving the traffic
- ASM (Any Source Multicast)
  - Multicast service that only specifies group address(does not specify source address)
- SSM (Source Specific Multicast)
  - Multicast service that specifies group and source address

# MLD(Multicast Listener Discovery) v1/ v2

# MLDv1 (RFC2710)

- ◆ Used for signaling between Multicast Listener(Receiver) and First Hop Router to inform/confirm the existence of multicast listener.
- ◆ Receiver sends “Report” to the router when join to the group.
- ◆ Receiver sends “Done” to the router when leave from the group.
- ◆ Router periodically sends MLD General Query to receiver side, and confirm the existence of listener.
- ◆ When the listener leave from the group, router sends Multicast Address Specific Query to confirm no any other listener is there.
- ◆ MLD is subset of ICMPv6 protocol

# MLDv1 Packet Format



## Type Field:

- 130 : Multicast Listener Query**
  - General Query
  - Multicast-Address-Specific Query
- 131 : Multicast Listener Report**
- 132 : Multicast Listener Done**

## Multicast Address Field:

- Report : Target Multicast Address
- General Query : zero
- Multicast-Address-Specific Query :Target Multicast Address

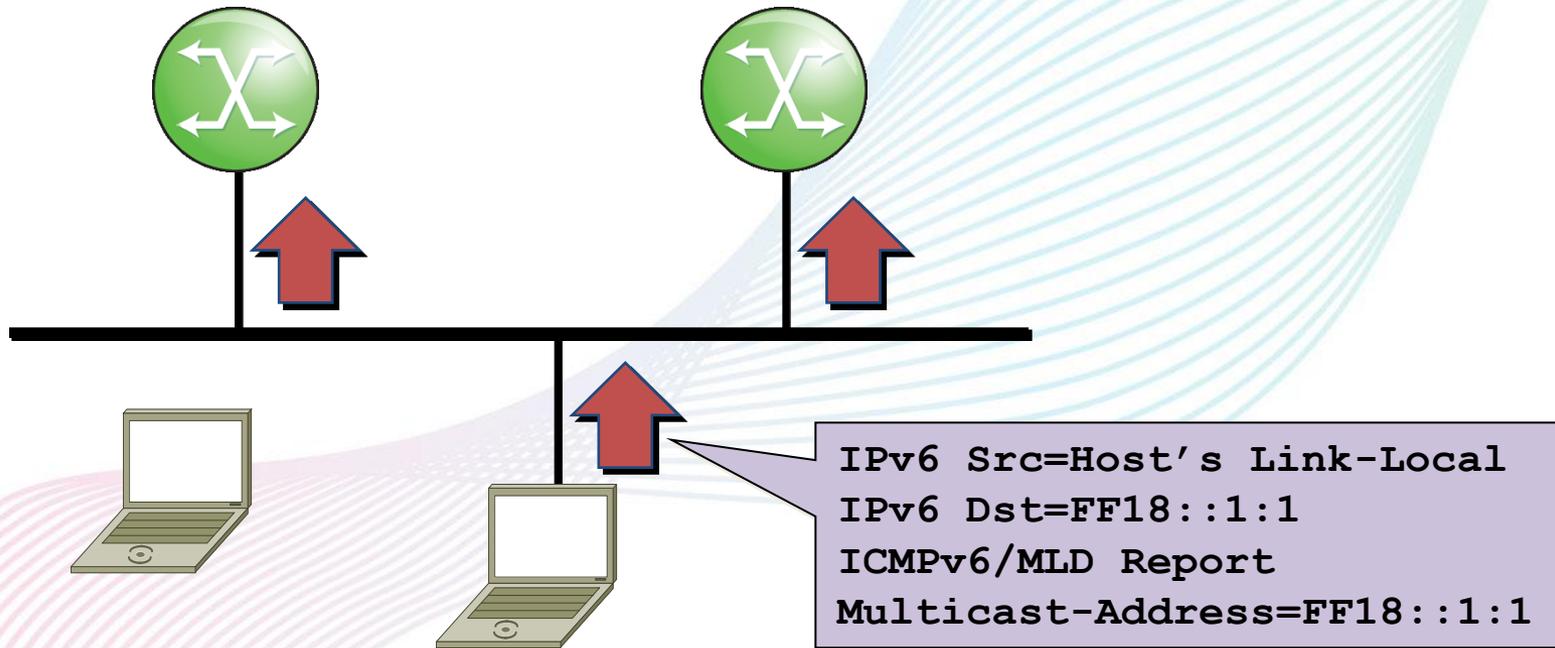
# Destination address, MLDv1 timers/variable

<b>Message Types</b>	<b>IPv6 destination Address</b>
General Query	link-scope all-nodes (FF02::1)
Multicast-Address-Specific Query	Target multicast address
Report	Target multicast address
Done	link-scope all-routers (FF02::2)

## Default Timer/Variable

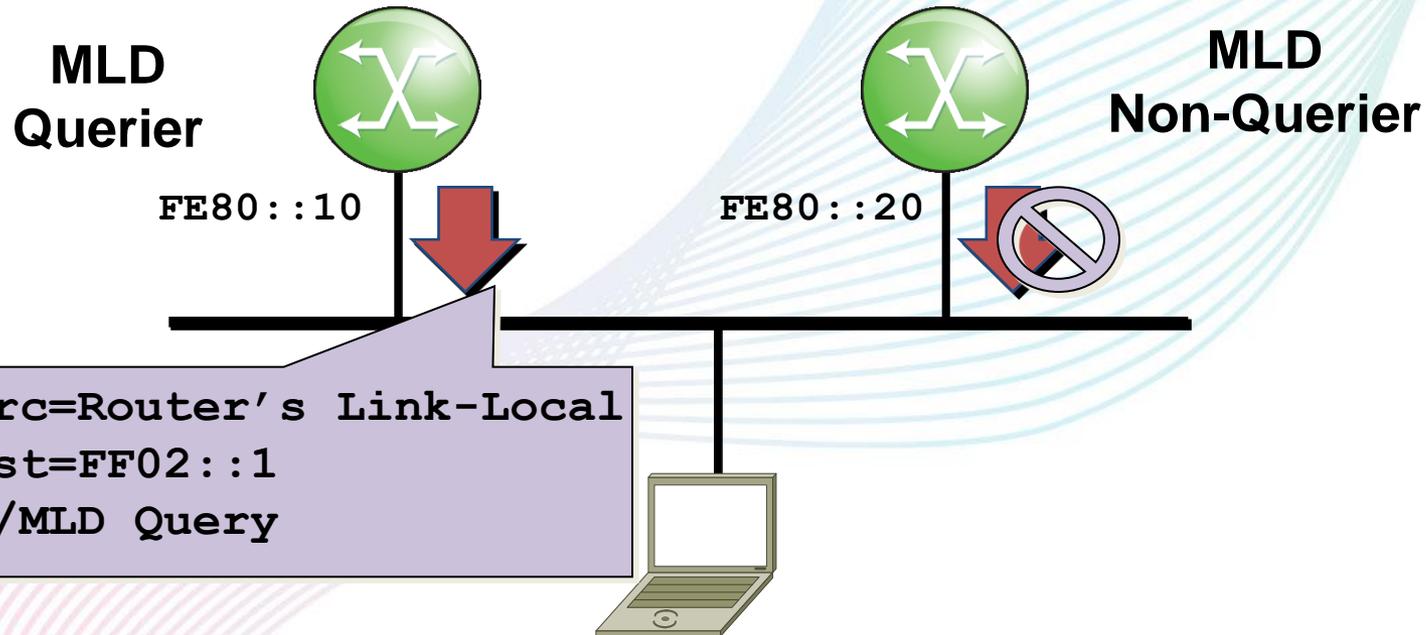
Query Interval	125 Sec
Maximum Response Delay	10000mSec
Multicast Listener Interval (expire timer on router side)	$[\text{Query Interval}] * 2 + 10\text{Sec} = 260 \text{ Sec}$
Other querier Present interval	$[\text{Query Interval}] * 2 + 5\text{Sec} = 255 \text{ Sec}$
Unsolicited Report Interval	10Sec
Last Listener Query Count(Robustness Variable)	2
Last Listener Query Interval	1Sec

# MLDv1 Joining to the group



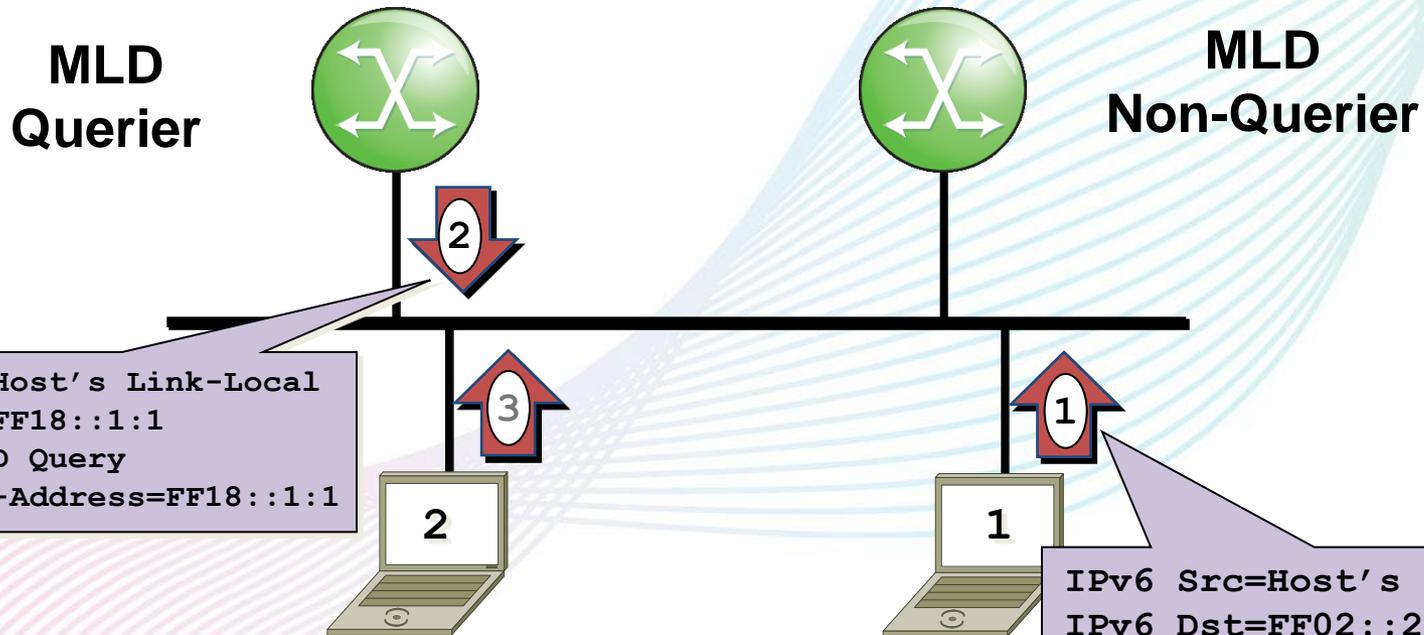
- Receiver sends MLD Report to Router for joining to the group.

# MLD Querier election



- When MLD routers become online, all routers start sending Query.
- If the router receives the query from other router that has more smaller source address, the router stop sending query(become non-querier).
- The router that has the most smallest IPv6 address become MLD querier.

# MLDv1 Leave from the Group

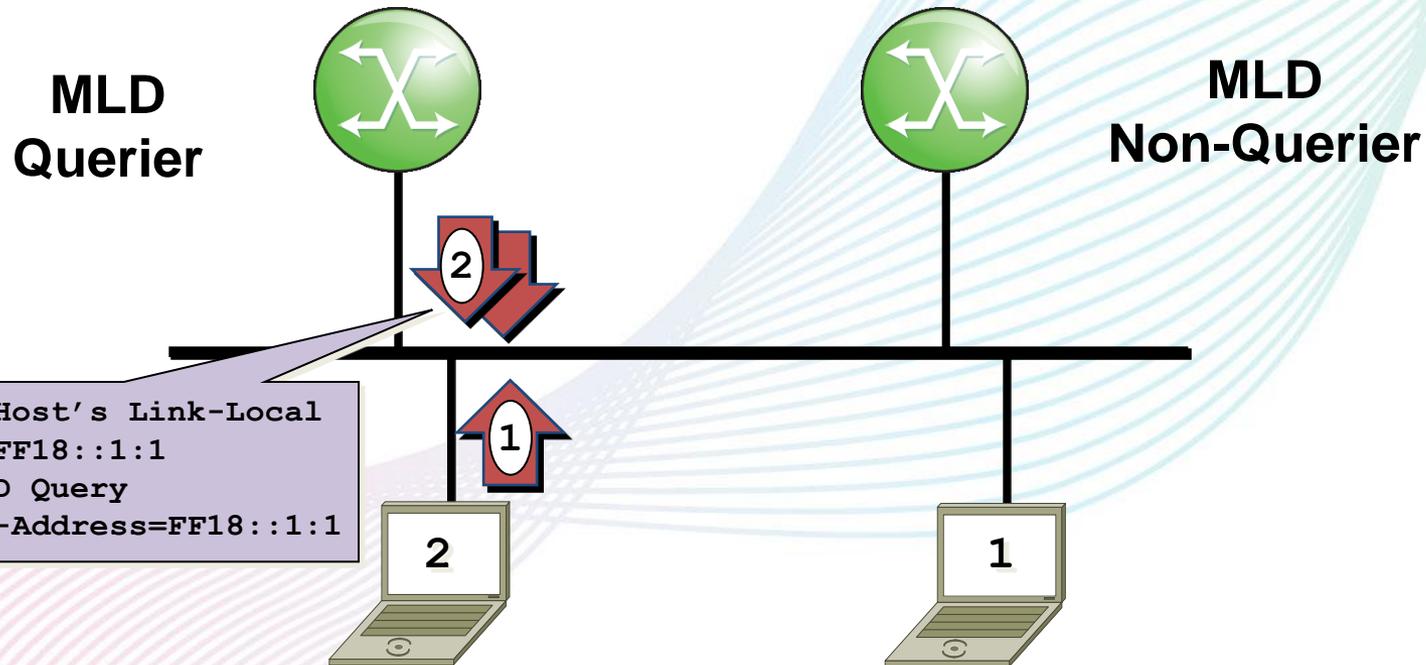


IPv6 Src=Host's Link-Local  
IPv6 Dst=FF18::1:1  
ICMPv6/MLD Query  
Multicast-Address=FF18::1:1

IPv6 Src=Host's Link-Local  
IPv6 Dst=FF02::2  
ICMPv6/MLD Done  
Multicast-Address=FF18::1:1

1. Host1 sends MLD-done to “all-routers”.
2. MLD Querier sends Multicast-Address-Specific-Query to target Group Address.
3. If Host2 still joining to the group, Host2 must send MLD report within “Last Listener Query Interval”.

# MLDv1 Leave from the Group



1. Host2 sends MLD-done to “all-routers”
2. MLD Querier sends Multicast-Address-Specific-Query to target Group Address. (send 2\*queries with Timeout=1sec)
3. After timeout, routers delete MLD entry.

# MLDv2(RFC3810)

- ◆ MLDv2 enables host join/leave to Source and Group(for PIM-SSM)
- ◆ Adding Include/Exclude Source-List
- ◆ It has backward compatibility with MLDv1.
- ◆ All MLDv2 packets use same destination IPv6 address “FF02::16” in all types of messages.

# MLDv2 Report Packet Format



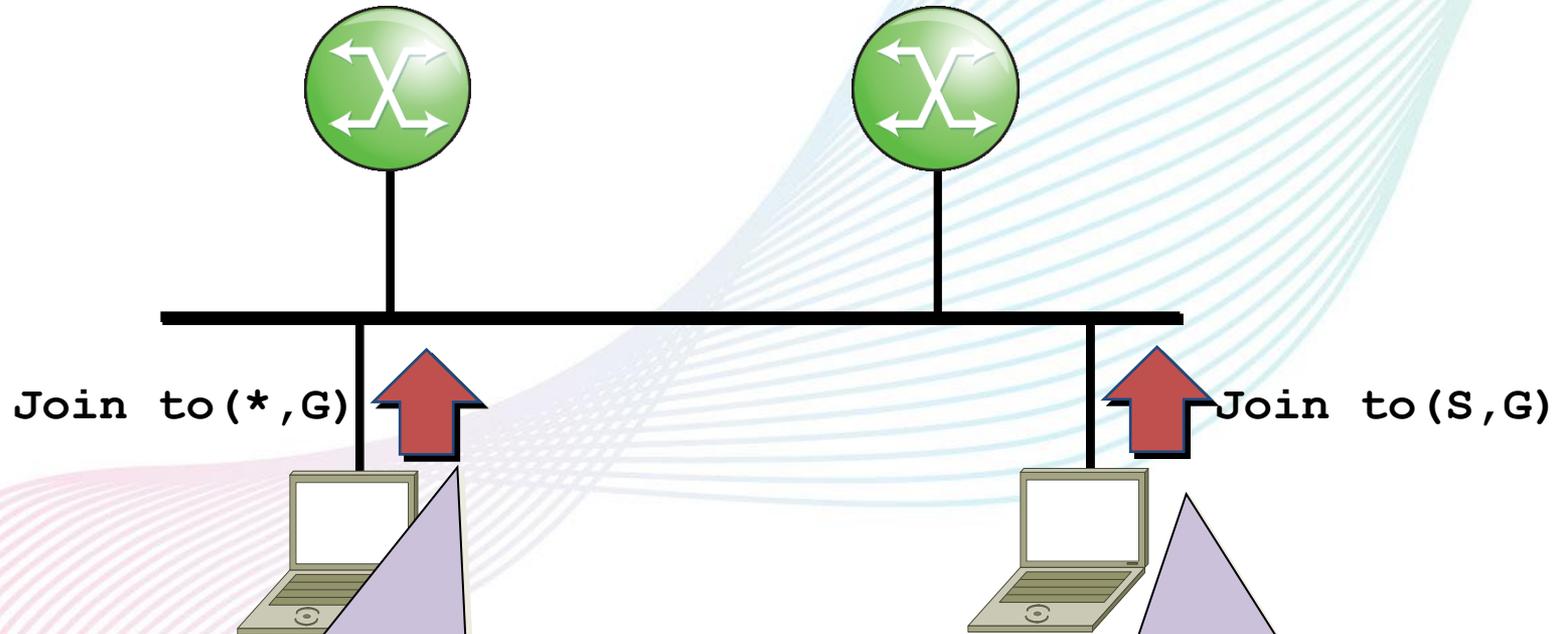
# MLDv2 Multicast Address Record Format

Record Type	Aux Data Len	Number of Sources (N)
Multicast Address		
Source Address [1]		
...		
Source Address [N]		

## Record Type:

1. `MODE_IS_INCLUDE - IS_IN ({S},G)`
2. `MODE_IS_EXCLUDE - IS_EX ({S},G)`
3. `CHANGE_TO_INCLUDE_MODE - TO_IN ({S},G)`
4. `CHANGE_TO_EXCLUDE_MODE - TO_EX ({S},G)`
5. `ALLOW_NEW_SOURCES - ALLOW ({S},G) [join (S,G)]`
6. `BLOCK_OLD_SOURCES - BLOCK ({S},G) [Leave (S,G)]`

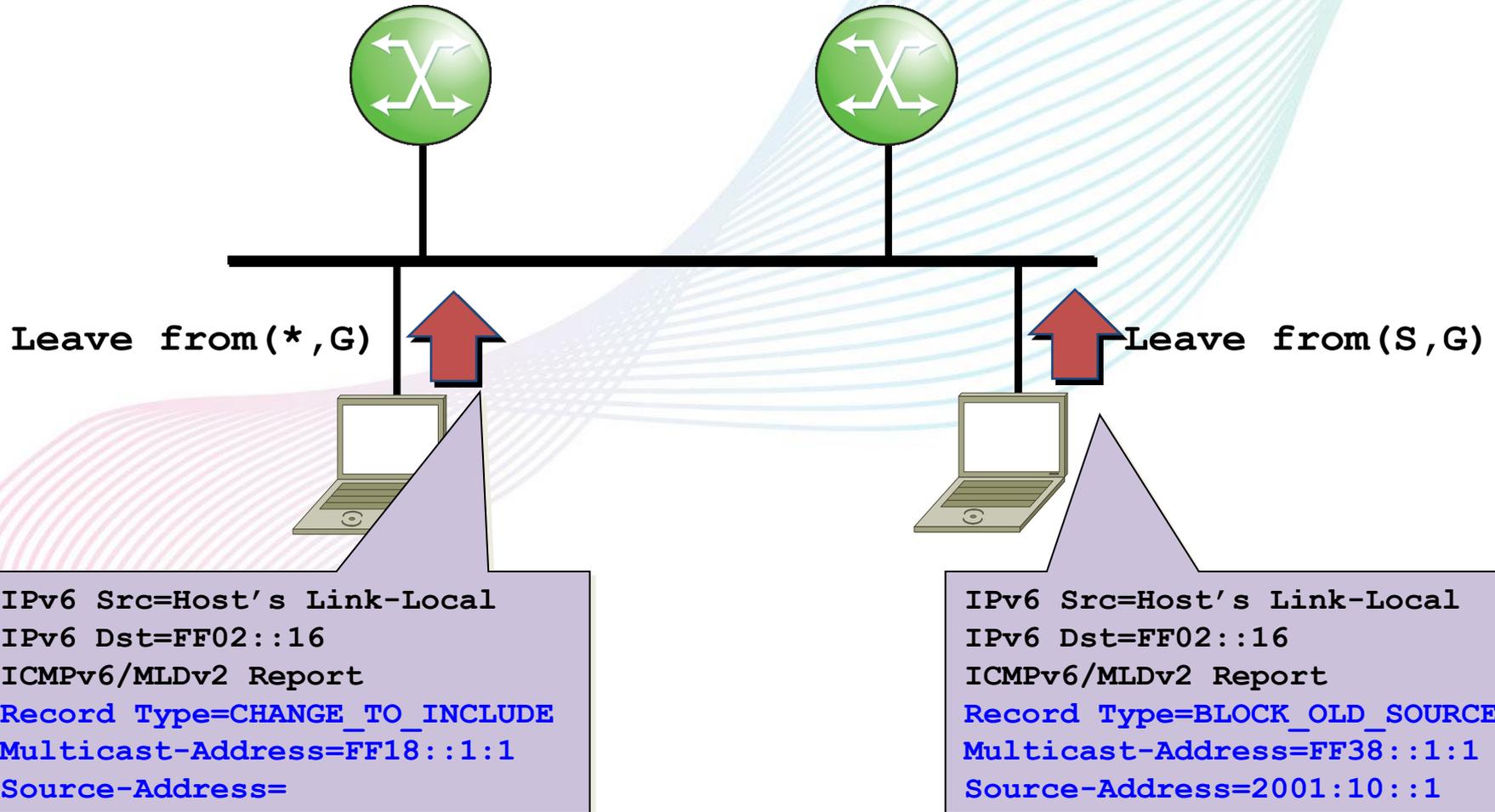
# MLDv2 Join to (\*,G)/(S,G)



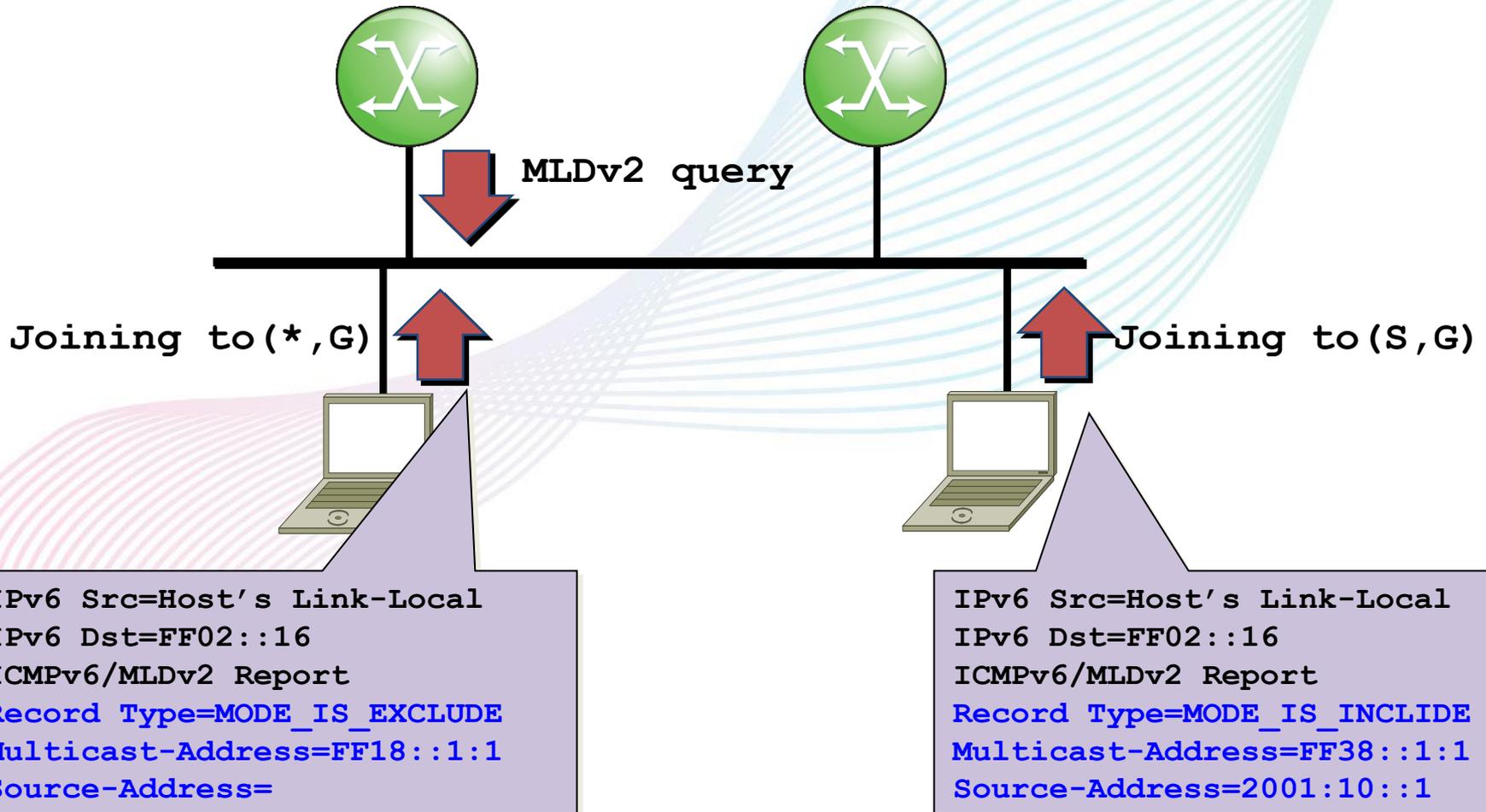
IPv6 Src=Host's Link-Local  
IPv6 Dst=FF02::16  
ICMPv6/MLDv2 Report  
Record Type=CHANGE\_TO\_EXCLUDE  
Multicast-Address=FF18::1:1  
Source-Address=

IPv6 Src=Host's Link-Local  
IPv6 Dst=FF02::16  
ICMPv6/MLDv2 Report  
Record Type=ALLOW\_NEW\_SOURCES  
Multicast-Address=FF38::1:1  
Source-Address=2001:10::1

# MLDv2 Leave from (\*,G)/(S,G)



# MLDv2 Reply to the Query



# Multicast Forwarding and PIM (Protocol Independent Multicast)

# Multicast Distribution Tree(MDT)

Multicast Traffic is forwarded over the distribution tree that is built by PIM, **from Upstream to Downstream.**

- **Shortest Path Tree/Source Tree/ (S,G) Tree**
  - The top of Shortest Path Tree is **Source**
  - (S,G) based forwarding
  - shortest path **from Receiver to Source**
- **Shared Tree / RP Tree / (\*,G) Tree**
  - The top of Shared Tree is **RP**
  - (\*,G) based forwarding
  - shortest path **from Receiver to RP**

# Reverse Path Forwarding (RPF)

- **RPF interface (Incoming interface)**

Each router selects the interface as upstream interface for Source/RP. Selection of the upstream interface is based on Unicast Routing information or routing information only for Multicast like BGP-mcast-addr-family/static-mroute.

- **Outgoing interface (List)**

Downstream interface that received Join.OIF/OIL

- **RPF Neighbor**

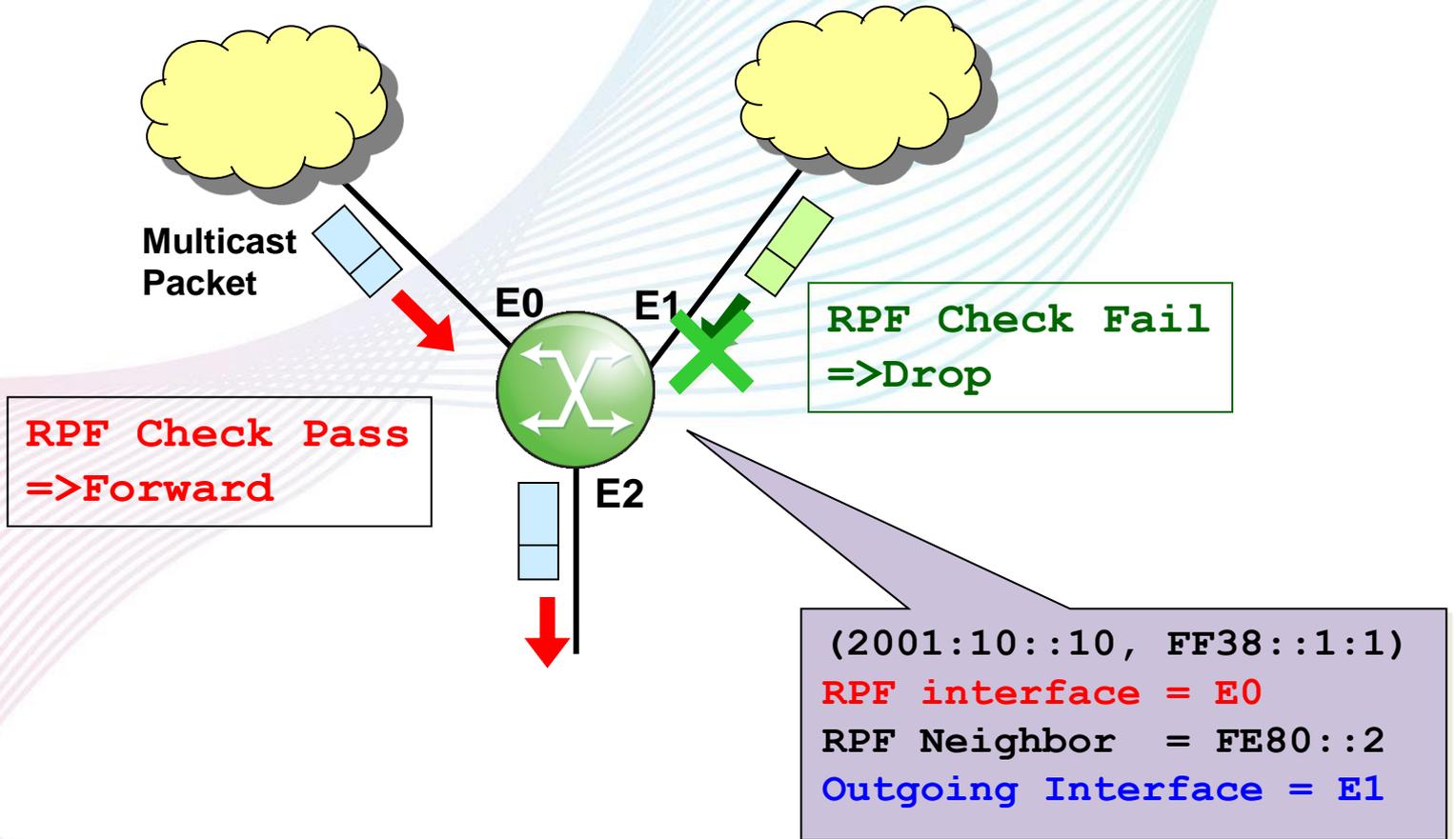
Next hop router (address) on RPF interface (upstream side) towards source/RP. Each  $(*,G)/(S,G)$  entry will select each RPF neighbor. PIM Join/Prune must be sent out to RPF Neighbor.

- **RPF Check**

If the multicast packet for  $(*,G)/(S,G)$  is received on RPF interface, that packet is forwarded to OIFs.

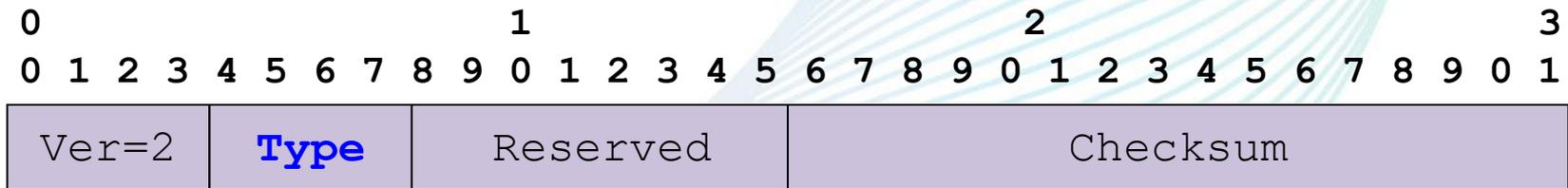
If the multicast packet is received on non-RPF interface, that packet is discarded.

# RPF Check



# PIM Header Packet Format

IPv6 Source Addr = Router Link-Local address  
 IPv6 Destination Addr = depends of message type  
 IPv6 NextHeader = 103 (0x67)



Message Types	IPv6 destination Address
0 = Hello	ALL-PIM-ROUTERS (FF02::D)
1 = Register	RP Address
2 = Register-Stop	First Hop Router (source of register)
3 = Join/Prune	ALL-PIM-ROUTERS (FF02::D)
4 = Bootstrap	ALL-PIM-ROUTERS (FF02::D)
5 = Assert	ALL-PIM-ROUTERS (FF02::D)
8 = Candidate-RP-Advertisement	BSR address

# PIM Hello/PIM Neighbor

- ◆ PIM Routers periodically send PIM hello packet on the link, and each Router recognize other routers as PIM Neighbor.
- ◆ If RPF neighbor is recognized as PIM Neighbor, router can send PIM Join/Prune to RPF neighbor.
- ◆ When there are multiple PIM routers on same Subnet(Link), one PIM DR(Designated-Router) is selected on the link based on PIM-DR-Priority (if routers have same DR-priority, biggest address is selected as DR.)

# PIM Neighbor Discovery

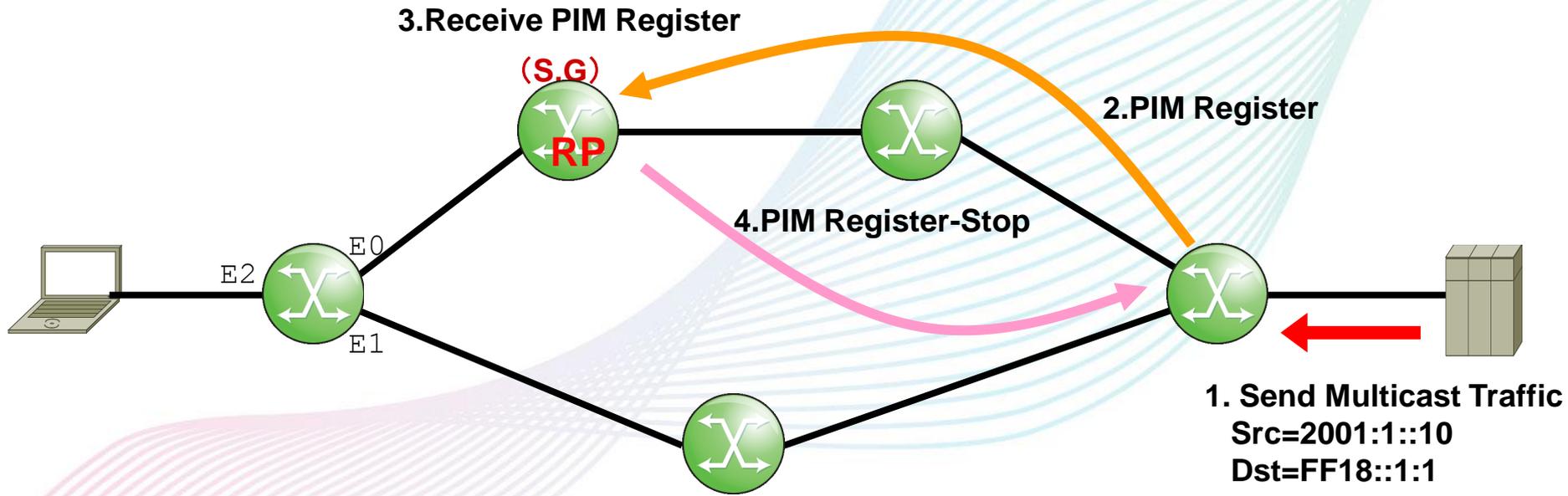


- ◆ The router that has most highest DR-priority is elected as DR on that link. (If DR-priority is same, most biggest address wins).
- ◆ Router periodically sends PIM Hello to “FF02::D”(All-PIM-ROUTERS)  
Default Timer Value
  - Hello Interval = 30 Sec
  - Holdtime = 30 x 3.5 = 105 sec
- ◆ When DR is Timeout, new DR is elected.
- ◆ Only DR can do the PIM Join/Prune activity by receiving MLD Join/Leave. (Non-DR can not start any PIM action)

# PIM SM(RFC4601)

- ◆ **Requires RP(Rendezvous Point)**
- ◆ **Source information is registered on RP(by first hop router). Join request is sent toward to RP by Hop-by-Hop.RP is managing (S,G) information in that multicast domain.**
- ◆ **Effective for “one to many” or “many to many” communication.**

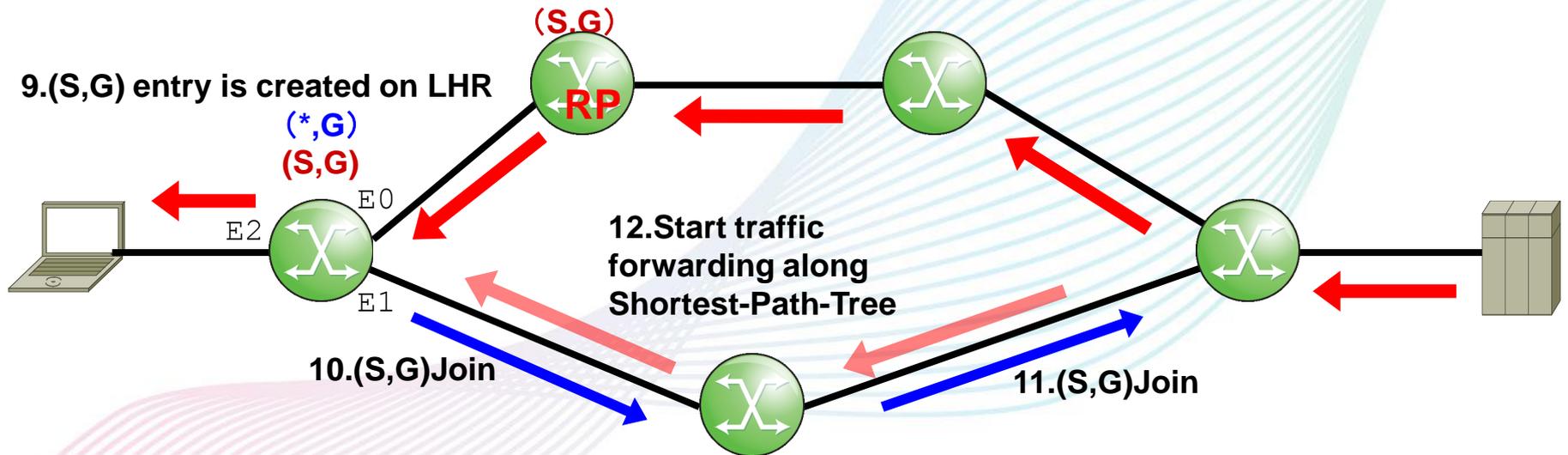
# PIM-SM Sequence (1)



1. Source starts sending Multicast Traffic (2001:1::10, FF18::1:1).
2. First Hop Router sends PIM Register to RP in Unicast.  
Original multicast packet is encapsulated in PIM packet.
3. RP receives Register, and create (S,G) info on RP.
4. RP sends back PIM Register-Stop to First Hop Router.  
First Hop Router stop sending PIM Register.



# PIM-SM Sequence (3)



9. By receiving source traffic, (S,G) entry is created on LHR.

In above case, (\*,G) RPF-IF = E0

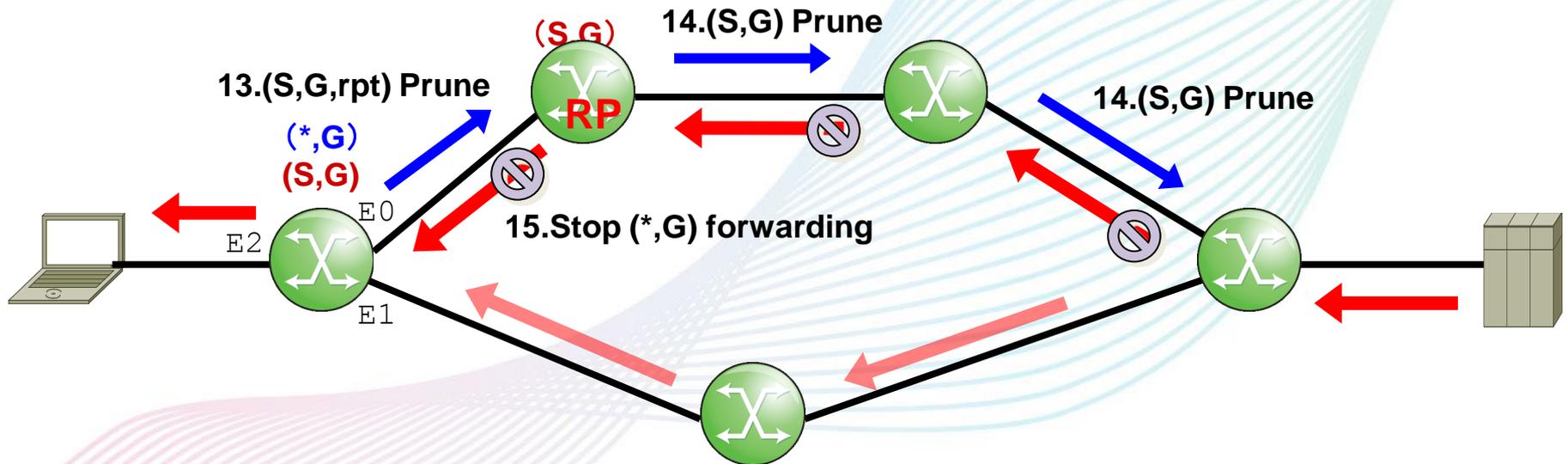
(S,G) RPF-IF = E1

10. LHR sends (S,G) Join towards RPF interface for Source.

11. Router sends (S,G) Join towards RPF interface for Source to build Shortest-Path-Tree.

12. Start traffic forwarding along Shortest-Path-Tree.

# PIM-SM Sequence (4)



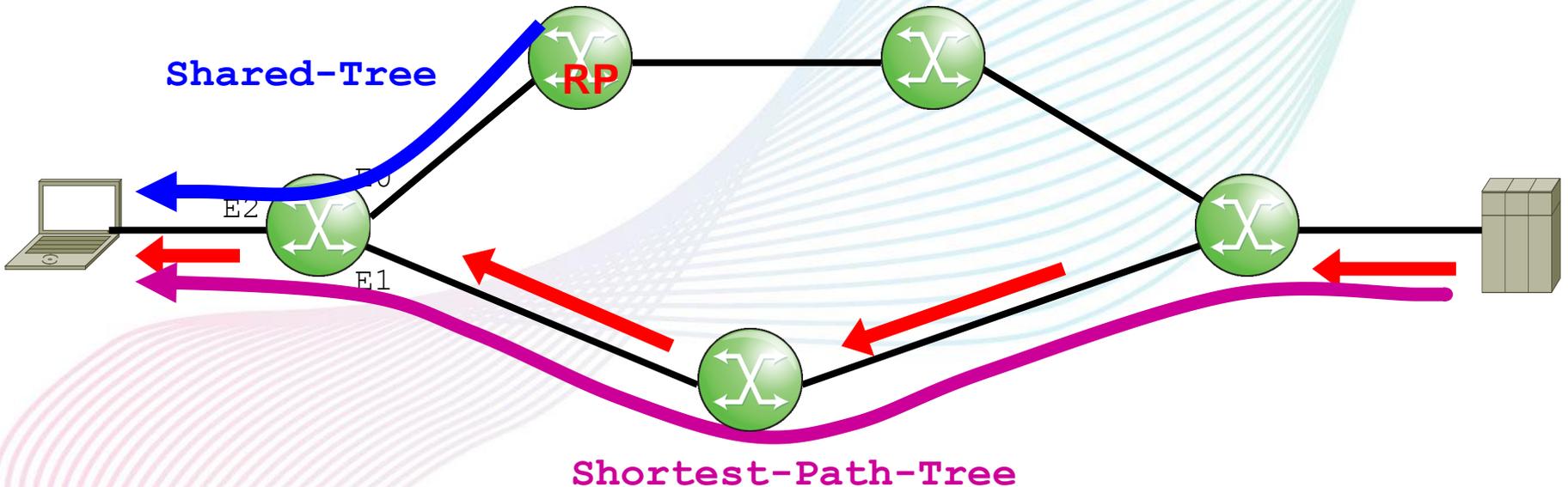
13.LHR start receiving traffic on Shortest-Path-Tree, LHR sends (S,G,rpt)prune towards RP because the traffic via RP is not necessary any more.

$(*,G)RPF-IF \neq (S,G)RPF-IF$

14.Stop Shared-Tree based forwarding.

15. (S,G) prune is sent from RP towards source, and traffic from source to RP is stopped.

# PIM-SM Sequence (5)



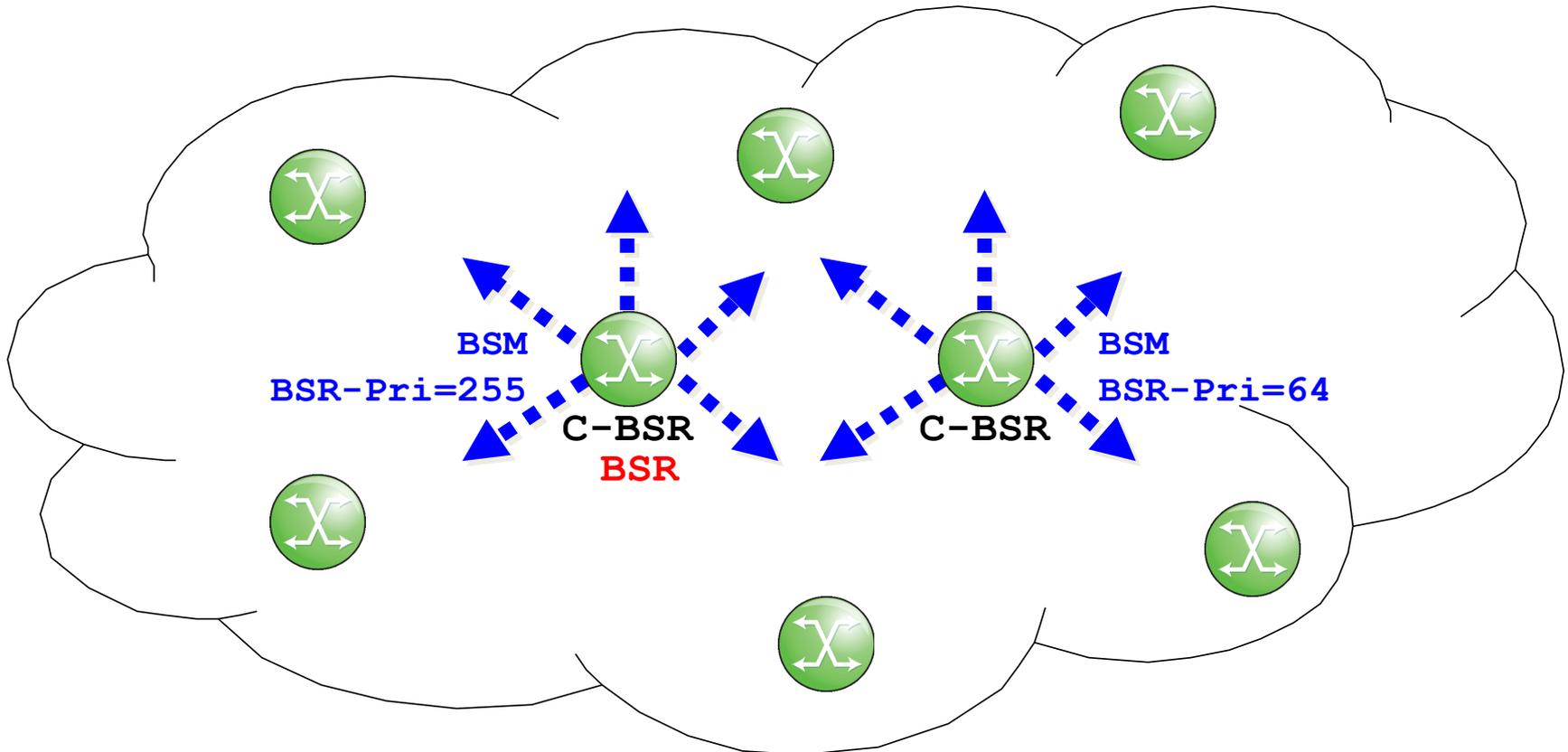
Finally traffic is forwarded only along shortest-path-tree. (SPT switchover)

After SPT is built, Shared-Tree is maintained but not used for traffic forwarding.

# Defining RP

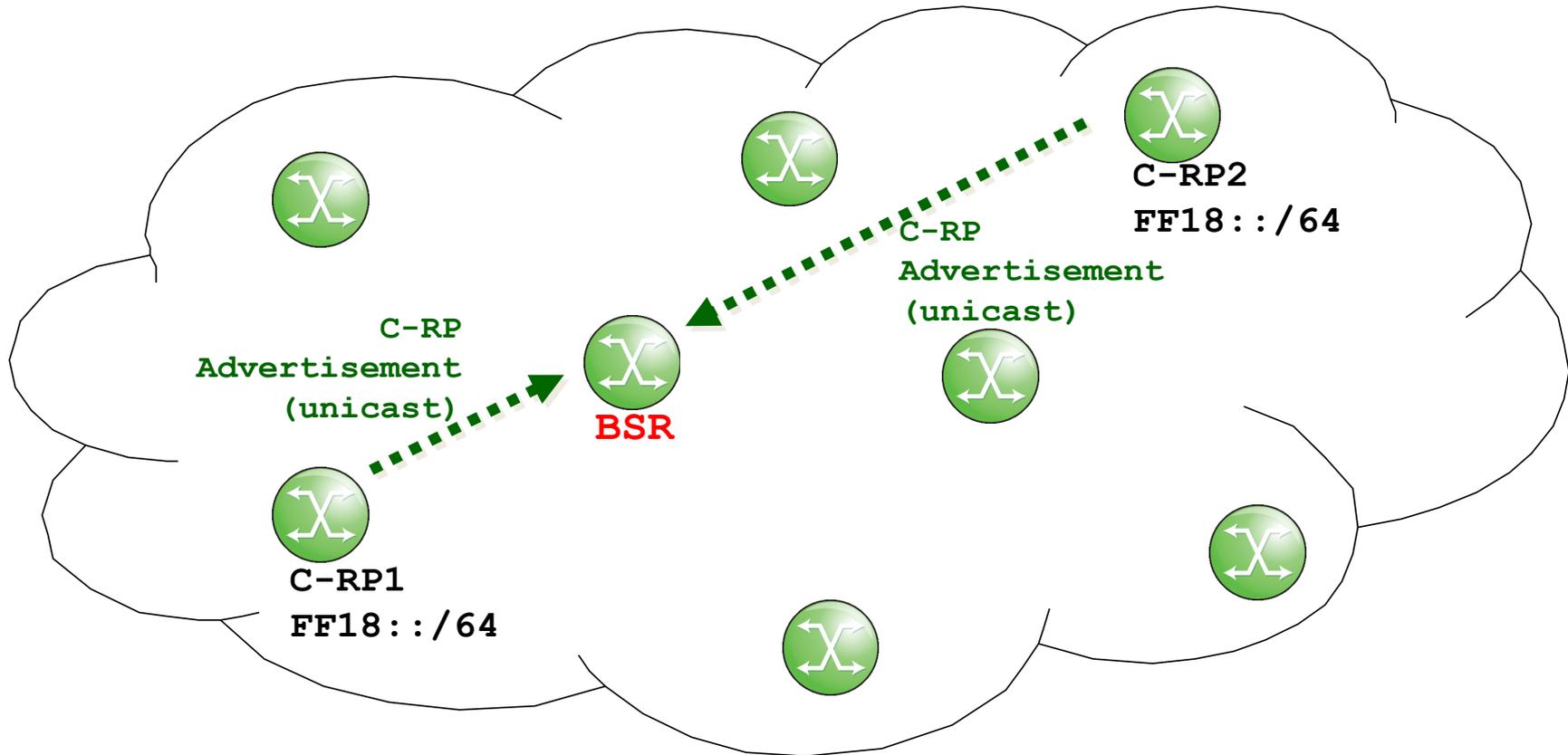
- ◆ **Static-RP: Statically configuring RP address.  
All routers need configuration.**
- ◆ **BSR(Bootstrap Router):  
Candidate-RPs information is distributed to all routers,  
and RP is automatically elected from Candidate-RPs  
based on priority/hash.**
- ◆ **Embedded-RP  
RP address is embedded in Multicast Address.  
mainly used for PIM-SM Inter-domain connection.**

# PIM BSR



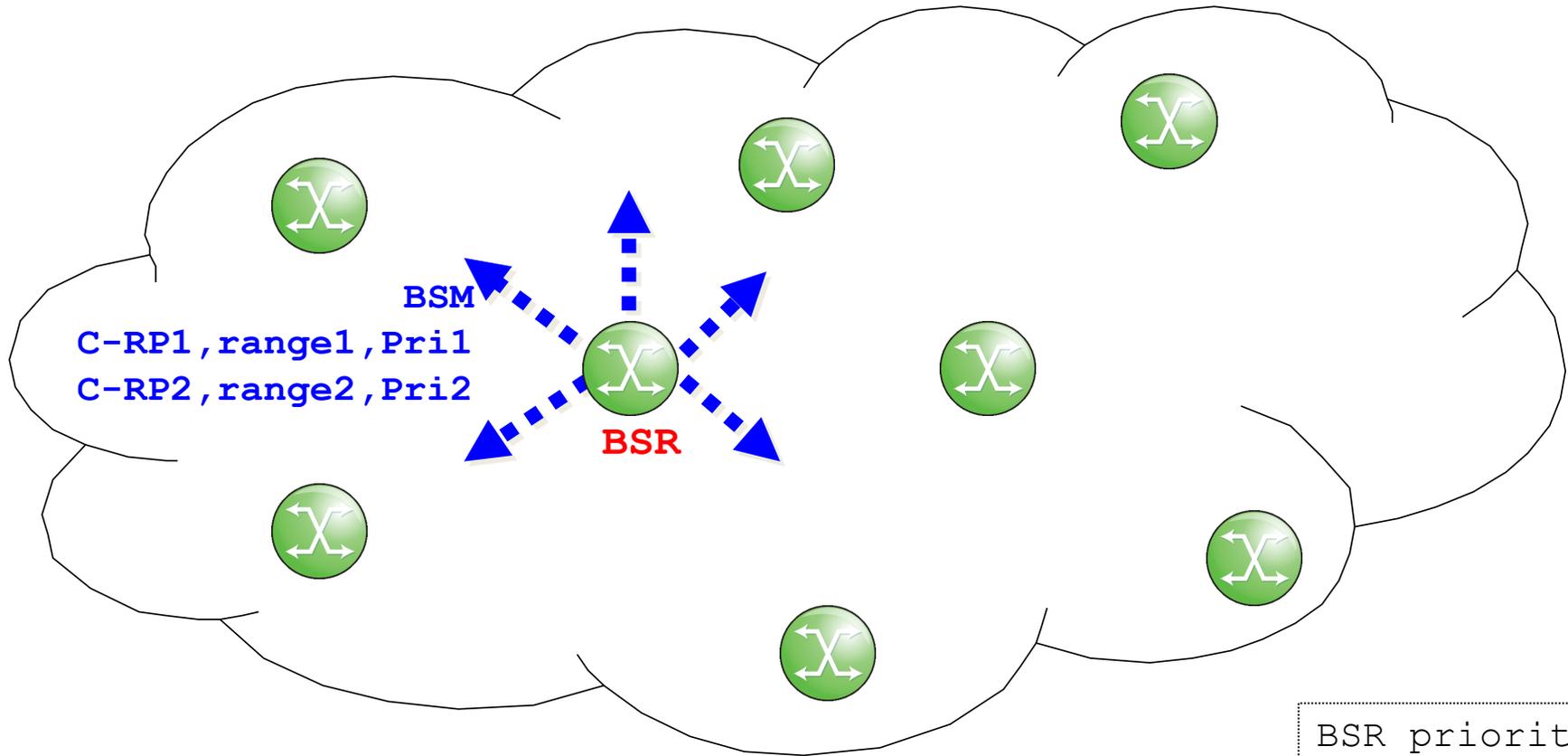
Candidate-BSR (C-BSR) floods Bootstrap Message (BSM) to all routers by Hop-by-Hop.  
C-BSR that has most highest BSR Priority is elected as BSR.

# PIM BSR



Candidate-RPs (C-RP) send C-RP-Advertisement to BSR in Unicast. (C-RP-Advertisement includes C-RP-Addr, Group-range, RP-Priority information.)

# PIM BSR



**BSR floods all C-RPs information by BSM.  
All other routes receive this BSM, and elect RP.**

BSR priority
255 > 0
RP priority
0 > 255

# Embedded-RP(RFC3956)

- Based on "Unicast-Prefix based Multicast Address".
- RP address is embedded in Multicast Address.
- Router can know RP address from Multicast Address.
- Mainly used for PIM-SM inter-domain multicast.



◆ example:

**FF78** : **0140** : **2001:0123:c001:1100** : **0000:0001**

**Unicast prefix** **groupID**

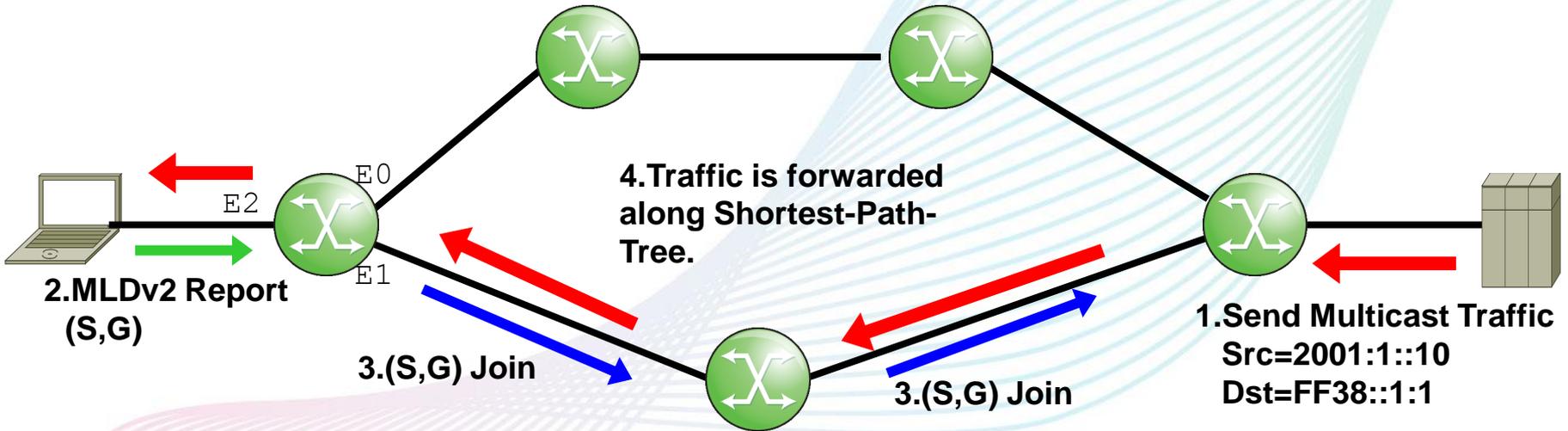
**Embedded RP Address = 2001:0123:c001:1100::1**

# PIM SSM (RFC4601/3569/4607)

---

- ◆ **No RP required**
- ◆ **Receiver join to (S,G)**
- ◆ **more simpler than PIM-SM**
- ◆ **subset of PIM-SM**

# PIM-SSM Sequence

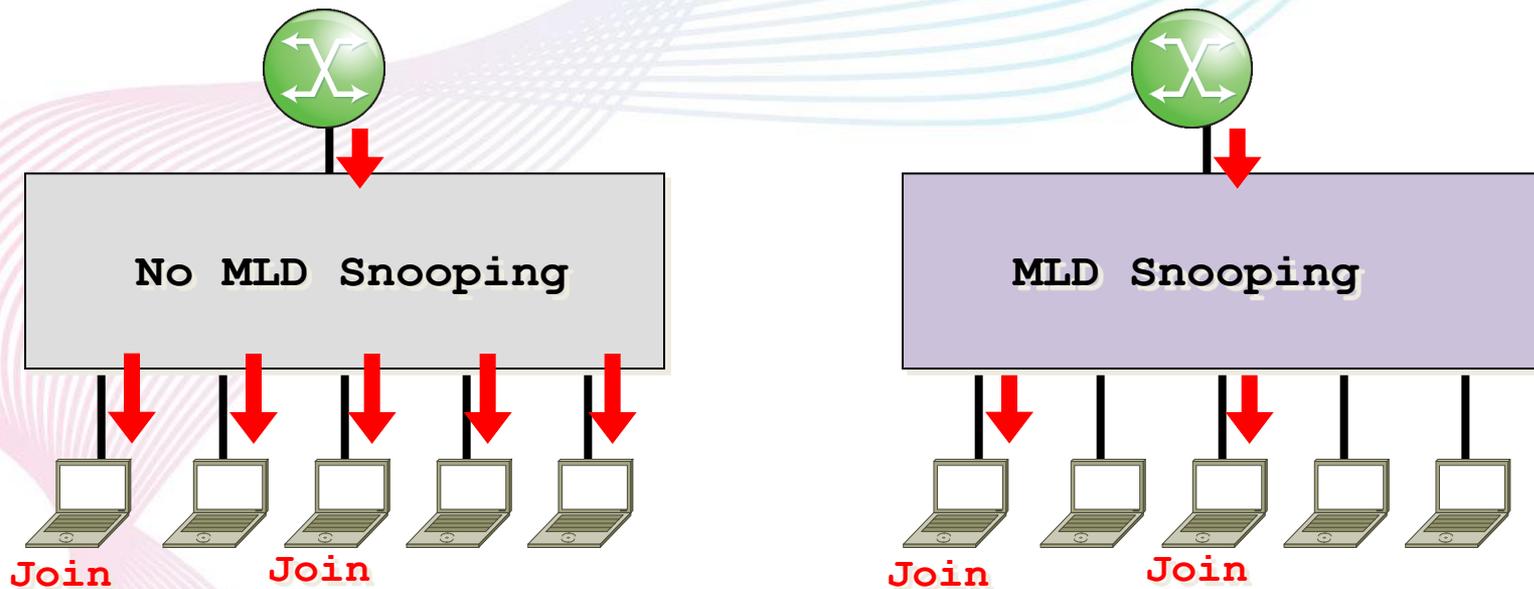


1. Source starts sending Multicast Traffic (2001:1::10, FF38::1:1).
2. Receiver send MLDv2 report for the Group/Source.  
(2001:1::10, FF38::1:1)
3. Last Hop Router sends PIM (S,G) Join towards source.  
Shortest-Path-Tree is built.
4. Multicast traffic is forwarded from Source to receiver along.  
Shortest-Path-Tree.

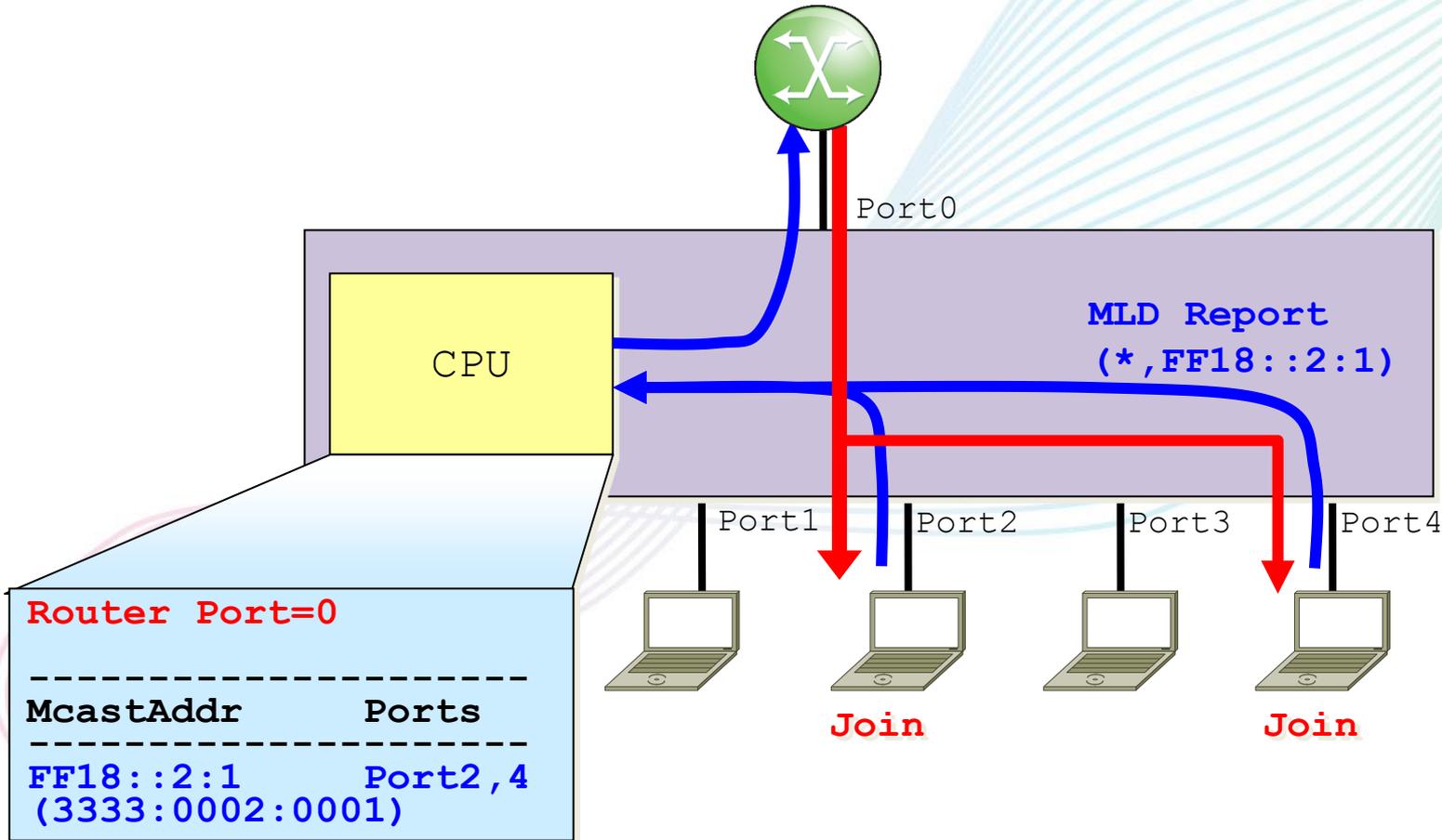
# MLD Snooping

# Necessity of MLD Snooping

- ◆ On Non-MLD-aware L2-switch, all multicast traffic is flooded to all ports in the vlan.
- ◆ With MLD-snooping enabled, multicast traffic is forwarded only to the ports that receiver joined.

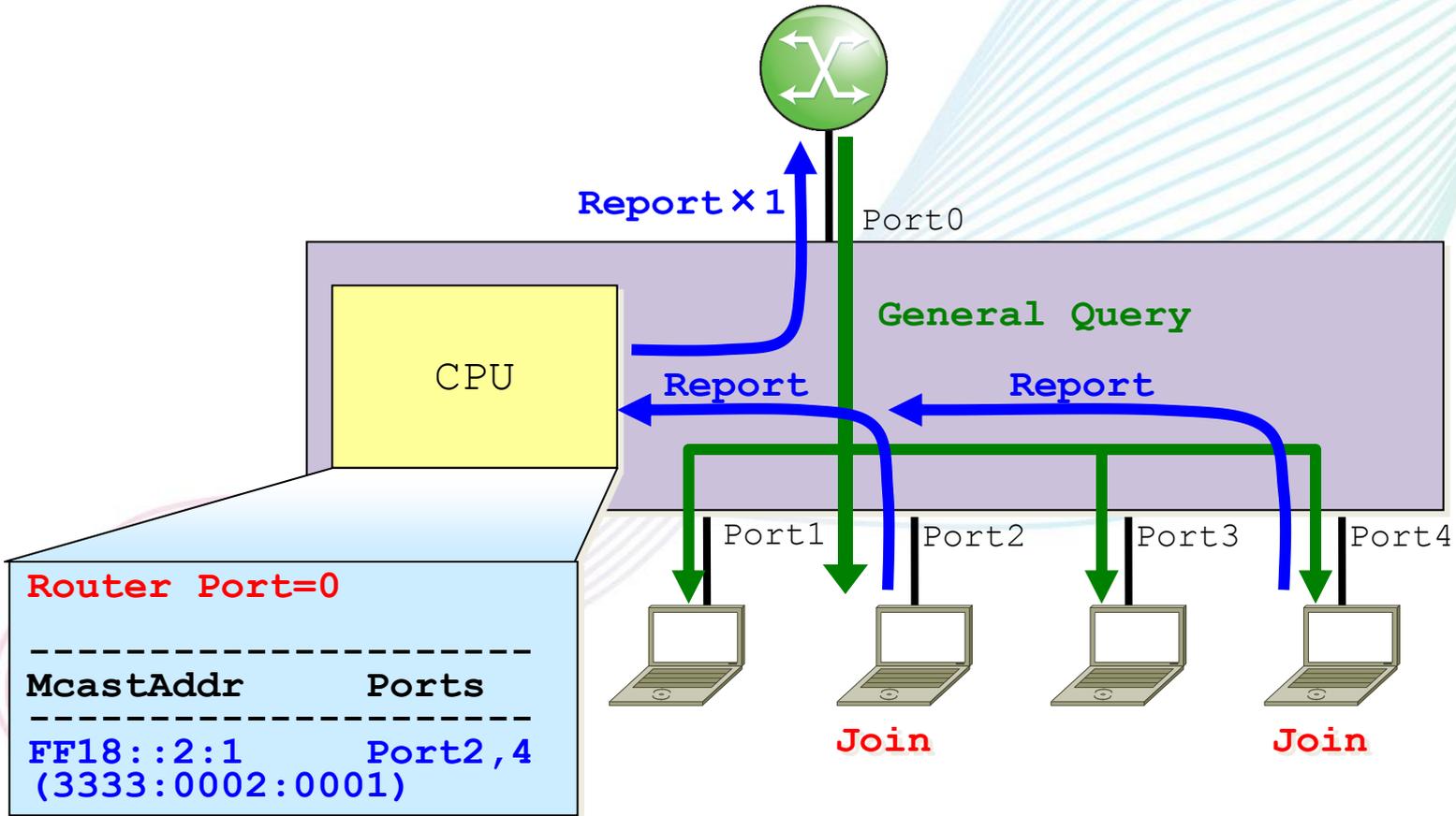


# MLD Snooping: Join to the Group



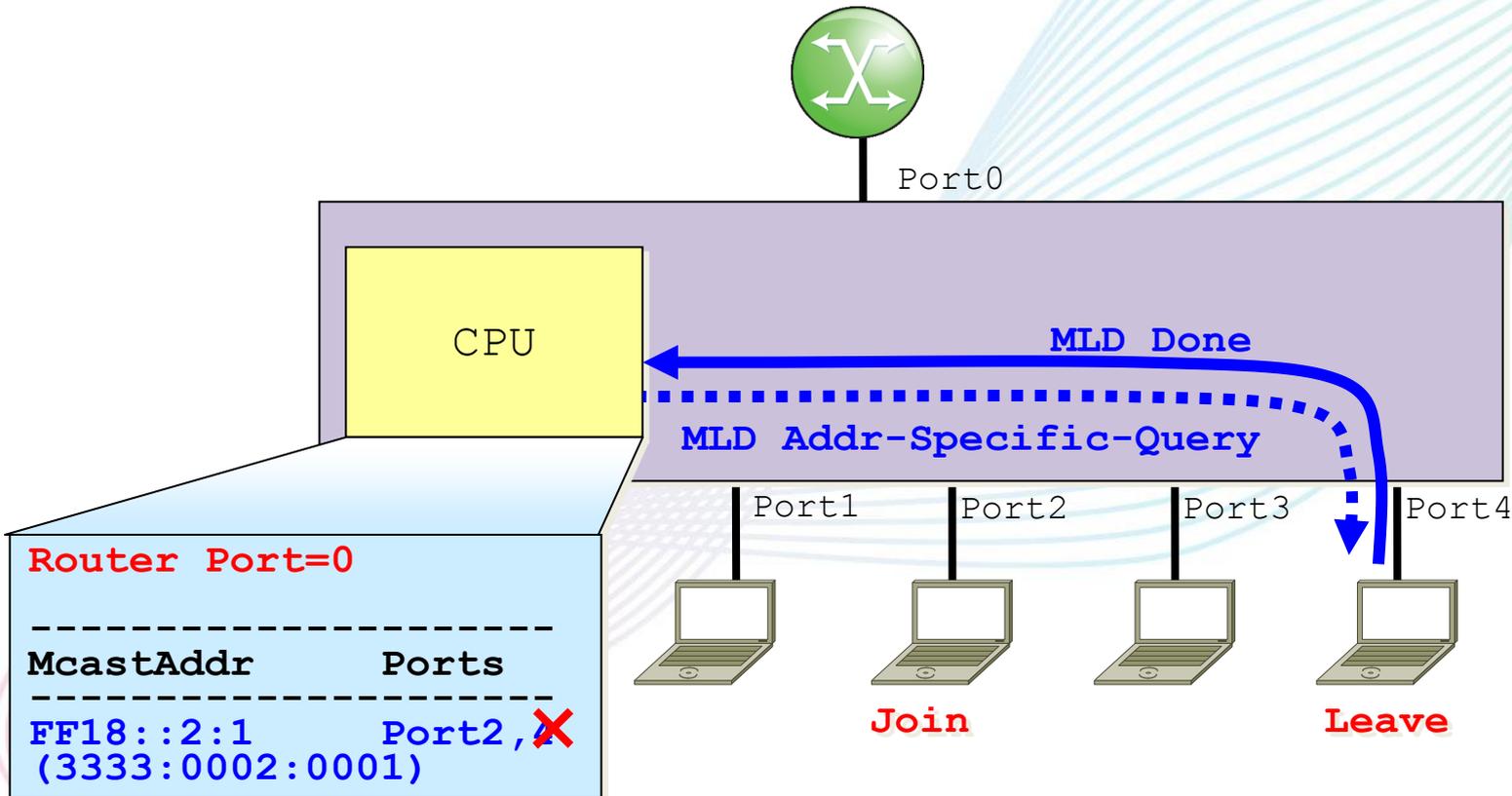
The switch snoops MLD Packet, and create L2 forwarding table based on the request of MLD packet. After that,MLD packet is forwarded to the router.

# MLD Snooping: Maintaining MLD-snooping Entry



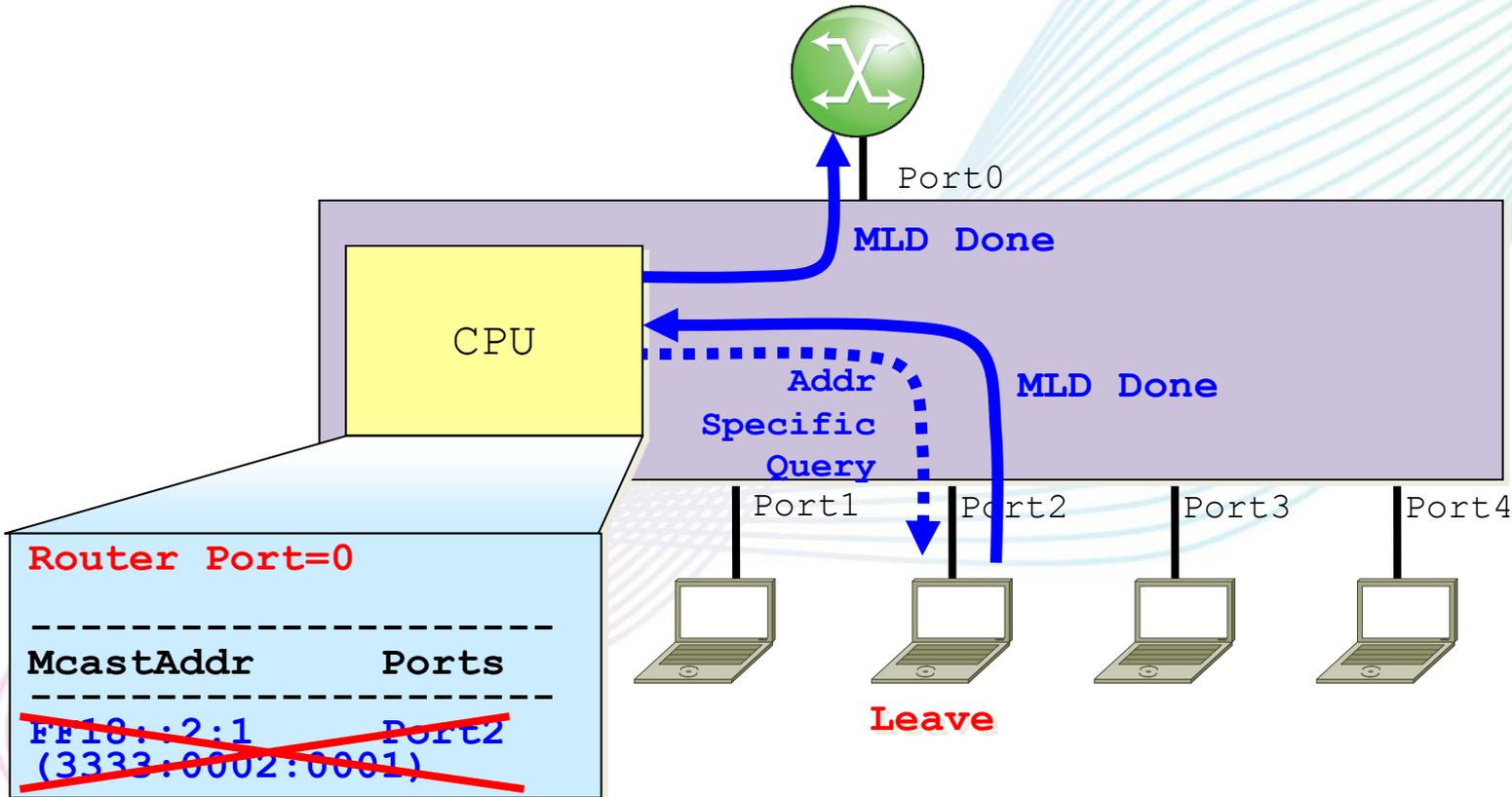
MLD General Query from the router is flooded to all ports. Joined hosts send back MLD report and each MLD snooping entry is maintained. only one MLD report is forwarded to the router.

# MLD Snooping: Leave from the Group (1)



When one host leaves from the group, switch sends multicast-address-specific-query to that port, and after timeout of the query, switch deletes that port from MLD snooping entry. When still there is any other host joining to that group, switch does not send MLD done to the router.

# MLD Snooping: Leave from the Group



When Last listener leave from the group, switch sends multicast-Addr-Specific-Query to that port. After the query timeout, switch deletes MLD entry for that group and send MLD done to the router.

# MLD Snooping: others

- ◆ **Router Port identification:**  
MLD Snooping does work correctly only when Router Port exists or there is MLD Querier on the vlan. Router Port can be identified automatically by receiving MLD Query/PIM Hello packet, or need static configuration.(depends on switch's implementation.)
- ◆ **The role of Router Port:**  
Receiver side: MLD packet is forwarded to Router Port  
Sender side: Multicast Traffic is forwarded to Router Port
- ◆ **MAC address duplication:**  
If the switch identify the multicast group based on MAC address only, the switch may not be able to differentiate multiple groups that has same MAC address.(source address identification of MLDv2 snooping has same issue.)

# MLD Snooping: immediately Stopping traffic

In IP/TV or video-surveillance environment, listener frequently Join/Leave to the group, router should shorten the time to stop forwarding traffic after receiving leave.

## ◆ MLD Fast-Leave :

When the router/switch receives the leave, immediately stop the traffic without sending multicast-address-specific query. In this case, it must be 1host/1port.

## ◆ MLD Host-tracking :

Router/switch is tracking all listener's address that joining to the group, and last listener leave from the group on that port, immediately stop the traffic.

# IPv6 multicast configuration and show command, Trouble shooting

# Enable MLD router and confirm MLD router status

```
ALU# configure router mld interface "e-1/3/1"
```

```
ALU# show router mld status
```

```
MLD Status
```

```
Admin State           : Up
Oper State             : Up
Query Interval         : 125
Last Listener Query Interval : 1
Query Response Interval : 10
Robust Count           : 2
```

```
ALU# show router mld interface
```

```
MLD Interfaces
```

Interface	Adm	Oper	Cfg/Opr	Num	Policy
Querier			Version	Groups	
e-1/3/1	Up	Up	2/2	0	none
FE80::216:4DFF:FE56:25DB					

```
Interfaces : 1
```

# Enable PIMv6 on interfaces

```
ALU # configure router pim  
ALU >config>router>pim# no ipv6-multicast-disable  
ALU >config>router>pim# interface ge-1/1/1  
ALU >config>router>pim>if# exit  
ALU >config>router>pim# interface ge-1/1/2  
ALU >config>router>pim>if# exit  
ALU >config>router>pim# interface e-1/3/1  
ALU >config>router>pim>if# exit
```

# Confirm PIM interfaces status

```
ALU # show router pim interface ipv6
```

```
=====
PIM Interfaces ipv6
=====
Interface                               Adm  Opr  DR Prty          Hello Intvl  Mcast Send
DR
-----
ge-1/1/1                                Up   Up   1              30          auto
FE80::216:4DFF:FE56:25DB
ge-1/1/2                                Up   Up   1              30          auto
FE80::216:4DFF:FE9B:A0FA
e-1/3/1                                 Up   Up   1              30          auto
FE80::216:4DFF:FE56:25DB
-----
Interfaces : 3
=====
```

# Confirm PIM Neighbor entry

```
ALU # show router pim neighbor ipv6
```

```
=====
PIM Neighbor ipv6
=====
Interface                Nbr DR Prty      Up Time          Expiry Time      Hold Time
  Nbr Address
-----
ge-1/1/1                  1                0d 06:07:32     0d 00:01:43     105
  FE80::216:4DFF:FE1D:D1B8
ge-1/2/1                  1                0d 05:54:21     0d 00:01:24     105
  FE80::216:4DFF:FE9B:A0FA
-----
Neighbors : 2
=====
```

# Configuring static RP for PIM-ASM

```
ALU # configure router pim
ALU >config>router>pim# rp ipv6
ALU >config>router>pim>rp>ipv6# static address 2001::2
<Configure RP address as “2001::2” statically>
ALU >config>router>pim>rp>ipv6>static>address# override
<prioritize static-RP configuration over BSR RP info>
ALU >config>router>pim>rp>ipv6>static>address# group-prefix FF18::/16
<configure group-range for RP=2001::2>
```

# Confirm RP to Group mapping

```
ALU # show router pim rp ipv6
```

```
=====
```

```
PIM RP Set ipv6
```

```
=====
```

Group Address	RP Address	Type	Prio	Hold Time	Expiry Time
FF18::/16	2001::2	Static	1	N/A	N/A

```
-----
```

```
Group Prefixes : 1
```

```
=====
```

# Configuring PIM-SSM

```
ALU # configure router pim  
ALU >config>router>pim# ssm-groups  
ALU >config>router>pim>ssm# group-range FF38::/16  
<configure FF38::/16 as group-address-range for PIM-SSM>
```

# Configuring MLD-Snooping

```
ALU# configure service vpls 3  
ALU >config>service>vpls# mld-snooping no shutdown  
<Enable MLD-snooping on VPLS 3(VLAN3) >
```

# Confirm MLD Snooping status

```
ALU # show service id 10 mld-snooping base
```

```
=====
```

```
MLD Snooping Base info for service 10
```

```
=====
```

```
Admin State : Up
```

```
Querier      : FE80::216:4DFF:FE56:25DB on SAP 1/8/2
```

```
-----
```

Sap/Sdp Id	Oper State	MRtr Port	Send Queries	Max Num Groups	MVR From-VPLS	Num Groups
sap:1/8/2	Up	Yes	Disabled	No Limit	Local	0
sap:1/8/3	Up	No	Disabled	No Limit	Local	0

```
=====
```

# Confirm MLD Entry (MLDv1)

```
ALU # show router mld group
```

```
=====
MLD Groups
=====

(*,FF18::1:1)
  Up Time : 0d 00:00:14
  Fwd List : e-1/8/1
-----
(*,G)/(S,G) Entries : 1
=====
```

# Confirm PIM group Entry (PIM-SM)

```
ALU # show router pim group ipv6
```

```
=====
```

```
PIM Groups ipv6
```

```
=====
```

Group Address	Type	Spt Bit	Inc	Intf	No.Oifs
FF18::1:1	(* ,G)			ge-1/1/1	1
*	2001::2				
FF18::1:1	(S,G)	spt		ge-1/2/1	1
2001:1:10::10	2001::2				

```
-----
```

```
Groups : 2
```

```
=====
```

# Confirm RPF

```
ALU # show router route-table 2001::2
```

```
=====  
IPv6 Route Table (Router: Base)  
=====
```

Dest Prefix Next Hop[Interface Name]	Type	Proto	Age	Pref Metric
2001::2/128 FE80::216:4DFF:FE1D:D1B8-"ge-1/1/1"	Remote	OSPF3	01d00h39m	10 101

```
-----  
No. of Routes: 1  
=====
```

```
ALU# show router route-table 2001:1:10::10
```

```
=====  
IPv6 Route Table (Router: Base)  
=====
```

Dest Prefix Next Hop[Interface Name]	Type	Proto	Age	Pref Metric
2001:1:10::/64 FE80::216:4DFF:FE9B:A0FA-"ge-1/2/1"	Remote	OSPF3	01d00h37m	10 201

```
-----  
No. of Routes: 1  
=====
```

# Debug example at Last Hop Router(PIM-SM)

## Receiving MLD report and send (\*,G) Join to RPF Neighbor for RP

```
ALU #
[029 22:22:48.660] MLD interface e-1/8/1
[ifIndex 4] V2 PDU: :: -> FF02::16 pduLen 28
  Type: V2 REPORT maxrespCode 0x0 checksum 0x6e74
  Num Group Records: 1
    Group Record 0
      Type: CHG_TO_EXCL, AuxDataLen 0, Num Sources 0
      Mcast Addr: FF18::1:1
      Source Address List

51 2009/11/07 16:24:45.49 JST MINOR: DEBUG #2001 Base PIM[Instance 1 Base]
"PIM[Instance 1 Base]: pimSendJoinPrunePdu
pimSendJoinPrunePdu: if 2, adj FE80::216:4DFF:FE1D:D1B8"

52 2009/11/07 16:24:45.49 JST MINOR: DEBUG #2001 Base PIM[Instance 1 Base]
"PIM[Instance 1 Base]: pimSGEncodeGroupSet
pimEncodeGroupSet: encoding groupset for group FF18::1:1, numJoinedSrcs 1, numPrunedSrcs 0"

53 2009/11/07 16:24:45.49 JST MINOR: DEBUG #2001 Base PIM[Instance 1 Base]
"PIM[Instance 1 Base]: pimSGEncodeGroupSet
pimEncodeGroupSet: Encoding Join for (*,G) RP = 2001::2"
```

# Debug example at Last Hop Router(PIM-SM)

## Send (S,G) Join to the RPF Neighbor for source

```
57 2009/11/07 16:24:45.53 JST MINOR: DEBUG #2001 Base PIM[Instance 1 Base]
"PIM[Instance 1 Base]: pimSendJoinPrunePdu
pimSendJoinPrunePdu: if 3, adj FE80::216:4DFF:FE9B:A0FA"

58 2009/11/07 16:24:45.53 JST MINOR: DEBUG #2001 Base PIM[Instance 1 Base]
"PIM[Instance 1 Base]: pimSGEncodeGroupSet
pimEncodeGroupSet: encoding groupset for group FF18::1:1, numJoinedSrcs 1, numPrunedSrcs 0"

59 2009/11/07 16:24:45.54 JST MINOR: DEBUG #2001 Base PIM[Instance 1 Base]
"PIM[Instance 1 Base]: pimSGEncodeGroupSet
pimEncodeGroupSet: Encoding Join for source 2001:1:10::10"

60 2009/11/07 16:24:45.54 JST MINOR: DEBUG #2001 Base PIM[Instance 1 Base]
"PIM[Instance 1 Base]: pimSGEncodeGroupSet
pimEncodeGroupSet: num joined srcs 1, num pruned srcs 0"
```

# Debug example at Last Hop Router(PIM-SM)

## Send (S,G)RPT-Prune to the RPF neighbor for RP

```
64 2009/11/07 16:24:45.55 JST MINOR: DEBUG #2001 Base PIM[Instance 1 Base]
"PIM[Instance 1 Base]: pimSendJoinPrunePdu
pimSendJoinPrunePdu: if 2, adj FE80::216:4DFF:FE1D:D1B8"

65 2009/11/07 16:24:45.55 JST MINOR: DEBUG #2001 Base PIM[Instance 1 Base]
"PIM[Instance 1 Base]: pimSGEncodeGroupSet
pimEncodeGroupSet: encoding groupset for group FF18::1:1, numJoinedSrcs 0, numPrunedSrcs 1"

66 2009/11/07 16:24:45.55 JST MINOR: DEBUG #2001 Base PIM[Instance 1 Base]
"PIM[Instance 1 Base]: pimSGEncodeGroupSet
pimEncodeGroupSet: Encoding RPT Prune for source 2001:1:10::10"

67 2009/11/07 16:24:45.55 JST MINOR: DEBUG #2001 Base PIM[Instance 1 Base]
"PIM[Instance 1 Base]: pimSGEncodeGroupSet
pimEncodeGroupSet: num joined srcs 0, num pruned srcs 1"

68 2009/11/07 16:24:45.56 JST MINOR: DEBUG #2001 Base PIM[Instance 1 Base]
"PIM[Instance 1 Base]: pimSendJoinPrunePdu
pimSendJoinPrunePdu2: sending JP PDU with 1 groups."
```

# Confirm MLD entry (MLDv2)

```
ALU# show router mld group ff38::2:1
```

```
=====
```

```
MLD Groups
```

```
=====
```

```
(2001:1:10::10, FF38::2:1)
```

```
  Up Time   : 0d 00:00:21
```

```
  Fwd List  : e-1/8/1
```

```
-----
```

```
(* ,G) / (S ,G) Entries : 1
```

```
=====
```

# Confirm PIM group entry (PIM-SSM)

```
ALU # show router pim group ff38::2:1
```

```
=====
```

```
PIM Groups ipv6
```

```
=====
```

Group Address	Type	Spt Bit	Inc	Intf	No.Oifs
Source Address	RP				
FF38::2:1	(S,G)			ge-1/2/1	1
2001:1:10::10					

```
-----
```

```
Groups : 1
```

```
=====
```

# Useful command

```
ALU # show router pim group ff38::2:1 detail
```

```
<snip>
```

```
Group Address      : FF38::2:1  
Source Address    : 2001:1:10::10
```

```
<snip>
```

```
Curr Fwding Rate  : 6920.7 kbps  
Forwarded Packets : 71223           Discarded Packets : 0  
Forwarded Octets  : 98002848       RPF Mismatches    : 0  
Spt threshold    : 0 kbps           ECMP opt threshold : 7  
Admin bandwidth  : 1 kbps
```

```
-----  
Groups : 1  
=====
```

# Confirm MLD snooping entry

```
ALU # show service id 3 mld-snooping proxy-db
```

```
Group Address
```

```
Mode Up Time Num Sources
```

```
-----  
FF18::1:1
```

```
exclude 0d 00:11:40 0
```

```
FF38::2:1
```

```
include 0d 00:11:40 1  
-----
```

```
Number of groups: 2  
=====
```

```
ALU # show service id 3 mld-snooping port-db sap 1/8/3
```

```
Group Address
```

```
Mode Type From-VPLS Up Time Expires Num MC  
Src Stdby
```

```
-----  
FF18::1:1
```

```
exclude dynamic local 0d 00:11:41 143s 0
```

```
FF38::2:1
```

```
include dynamic local 0d 00:11:41 0s 1  
-----
```

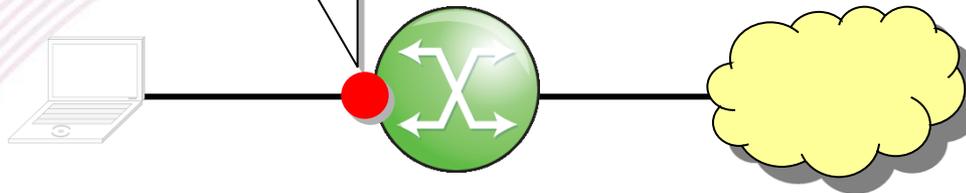
```
Number of groups: 2  
=====
```

# Useful command : static MLD join

Configure joined status statically on the interface

```
ALU # configure router mld
ALU>config>router>mld# interface e-1/3/1
ALU>config>router>mld>if# static group ff18::1:1 starg
<static join for (*,G) >
ALU>config>router>mld>if# static group ff38::2:1 source 2001:1:10::10
<static join for (S,G) >
```

By configuring static join,  
Router emulates MLD joined  
status statically.

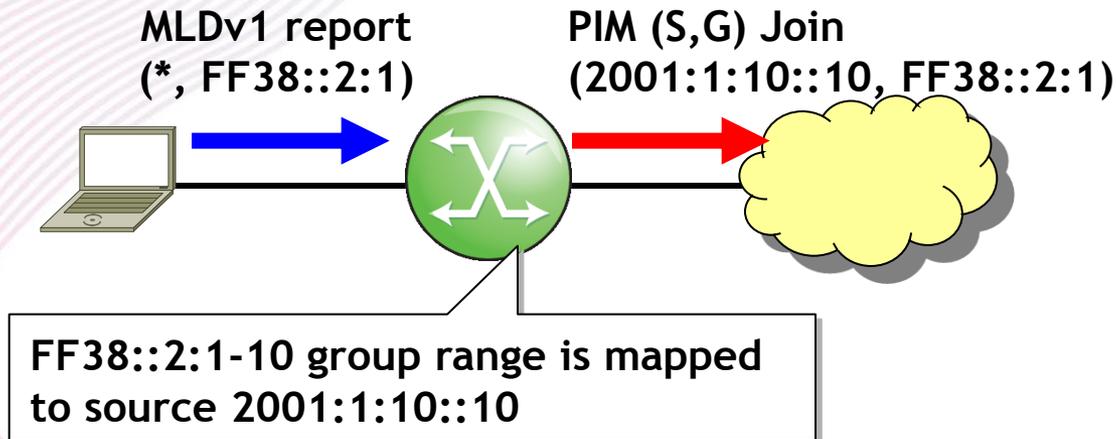


# Useful command : SSM Mapping

Configure the mapping information for group and source.  
With this configuration PIM-SSM can be used even if there is only MLDv1 client.

#need to configure mapping information on all edge routers.

```
ALU # configure router mld
ALU >config>router>mld# ssm-translate grp-range ff38::2:1 ff38::2:10 source
2001:1:10::10
```

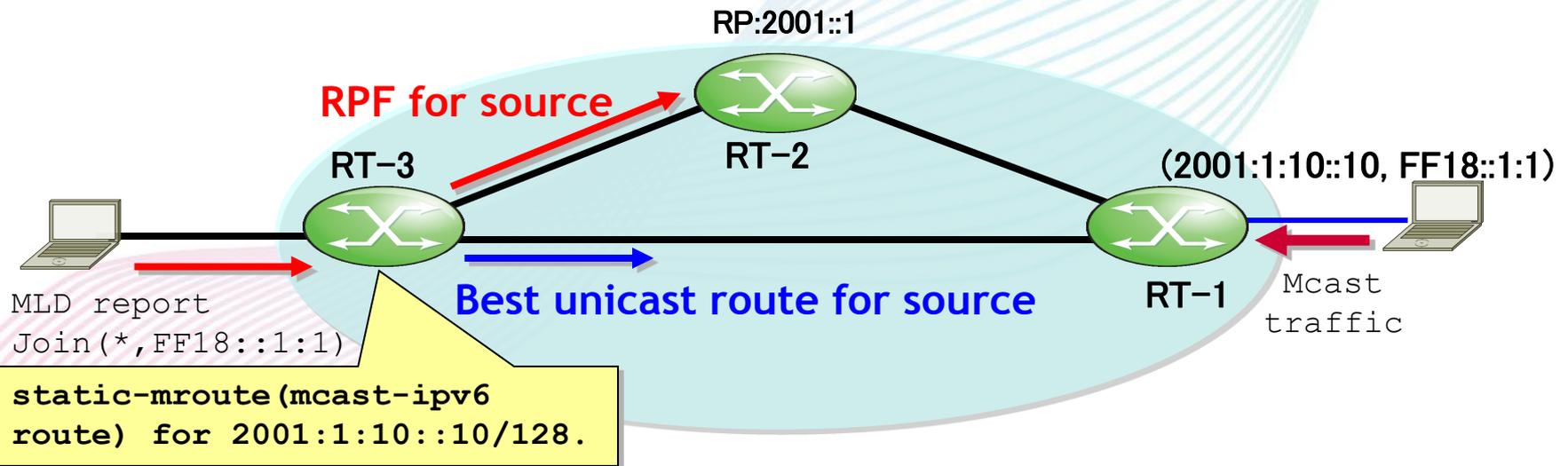


# Useful command : static route only for multicast

Static route configuration used only for RPF in multicast.

It does not affect unicast routing information.

Useful when change RPF neighbor without unicast routing change.



```
ALU # configure router static-route 2001:1:10::10/128 next-hop 2001:2:10::2
mcast-ipv6
```

# Trouble shooting for multicast

First, check the source is sending multicast traffic correctly.

- Hop-limit(TTL) is not “1”, have enough value ?
- Source/Group Address is correct ?

Check the status from Receiver side towards Source/RP

- LHR has MLD Entry correctly ?
- LHR recognizes PIM Neighbor correctly ?
- LHR has PIM Entry(mroute) correctly ?
- LHR's RPF Neighbor/Interface is expected one ?
- LHR is sending Join/Prune to RPF Neighbor ?



- Upstream router has PIM Entry correctly ?
- Upstream router's RPF Neighbor/Interface is expected one ?
- Upstream router is sending PIM Join/Prune to RPF Neighbor ?



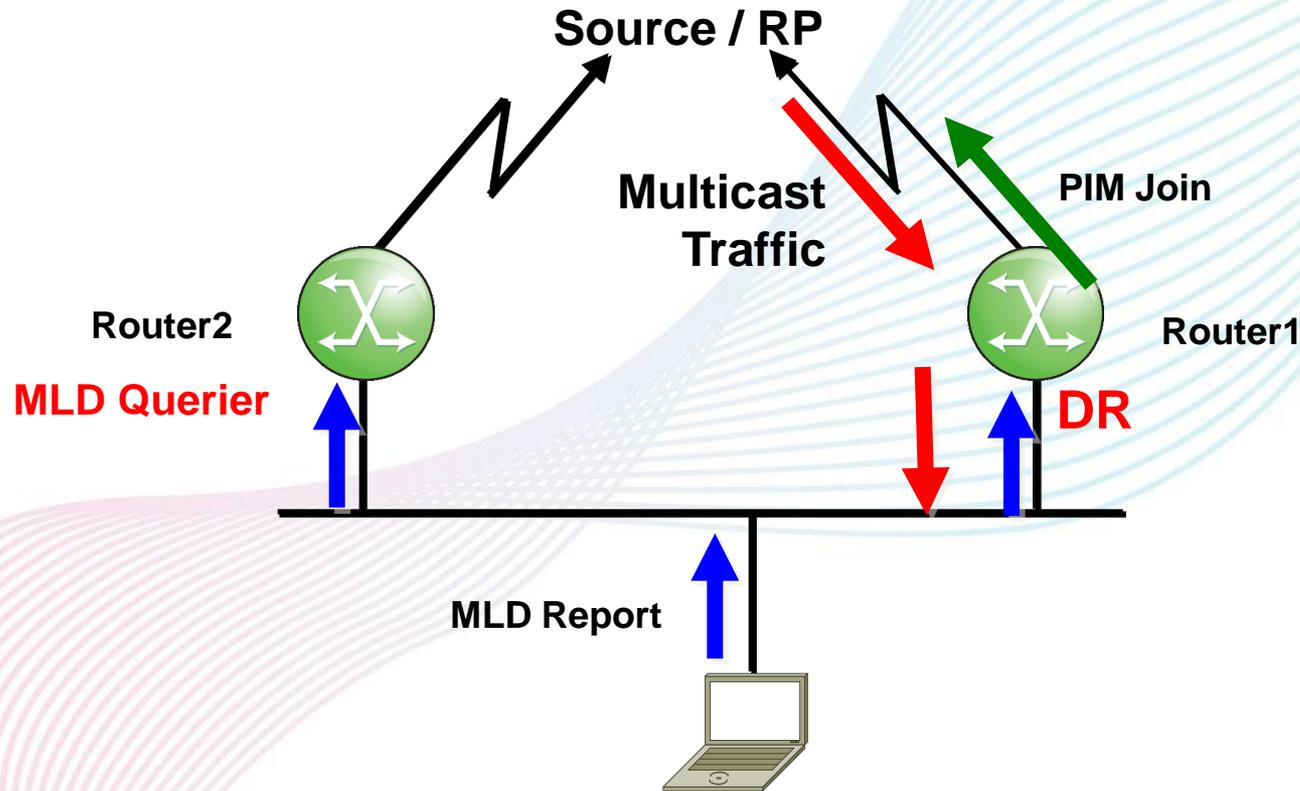
Repeat those check towards Source

# Debug commands

```
ALU # debug router pim jp  
ALU # debug router pim packet  
ALU # debug router pim db  
ALU # debug router mld packet
```

# Failure Case Study

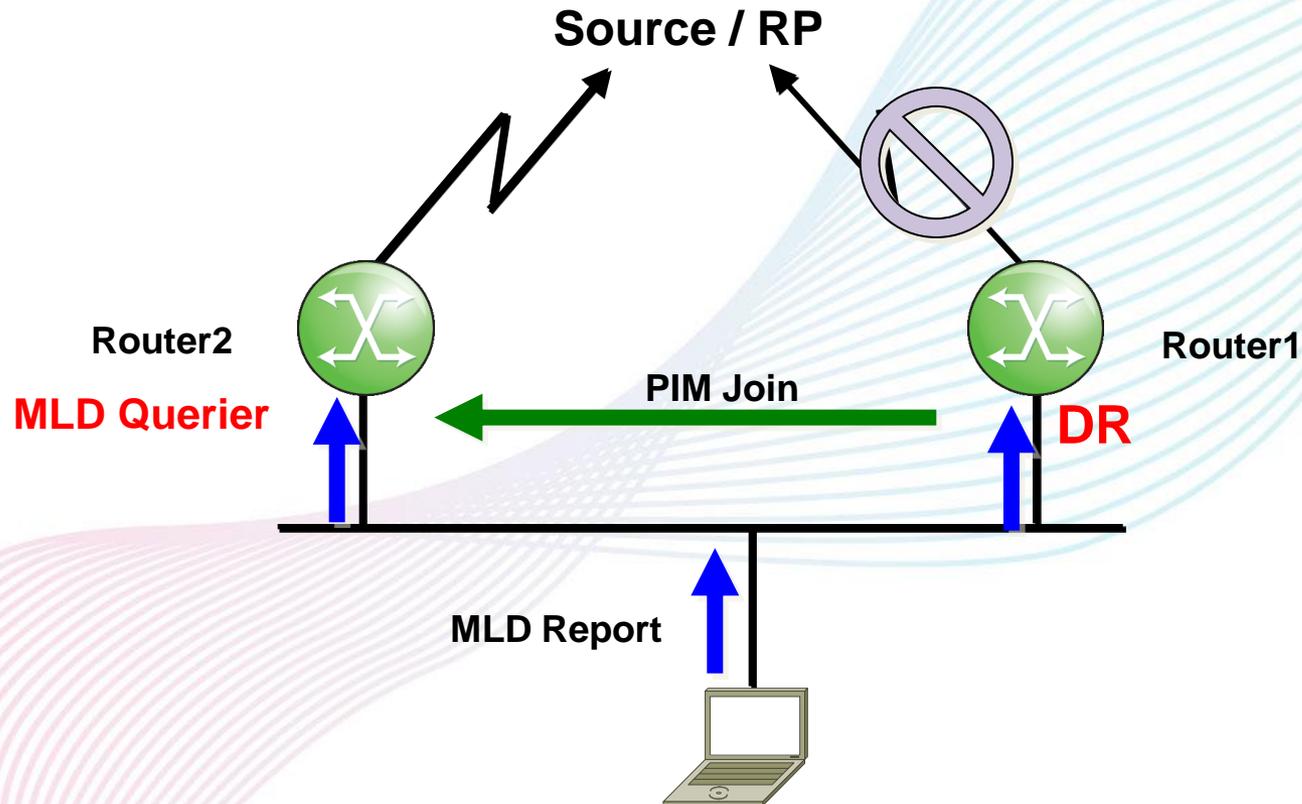
# DR on Receiver Side



User expects that Router2 as Primary Multicast Forwarder on that segment, but Router1 has become DR unexpectedly and Router1 become forwarder.

=> Need to configure DR-Priority or Link-Local Address

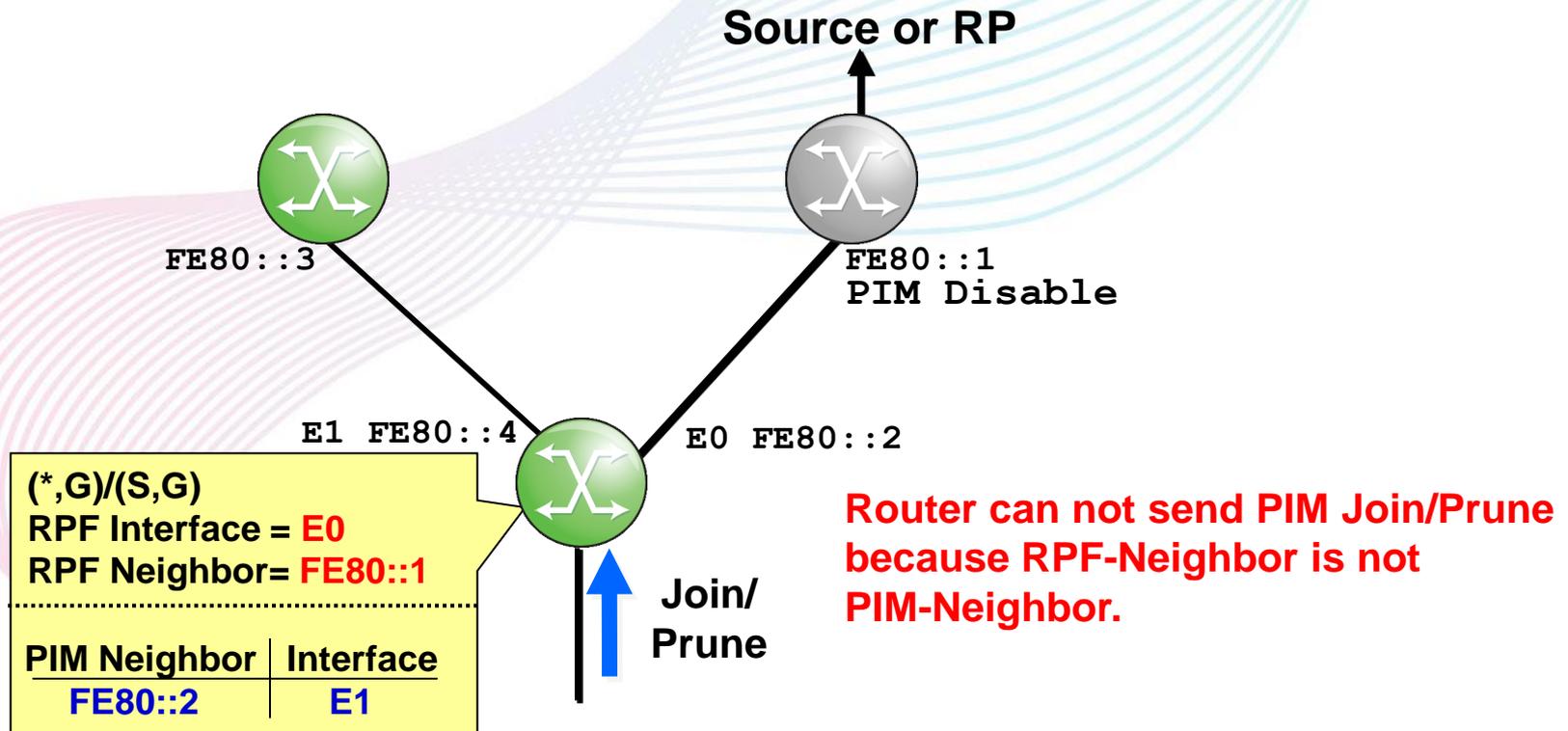
# DR on Receiver Side



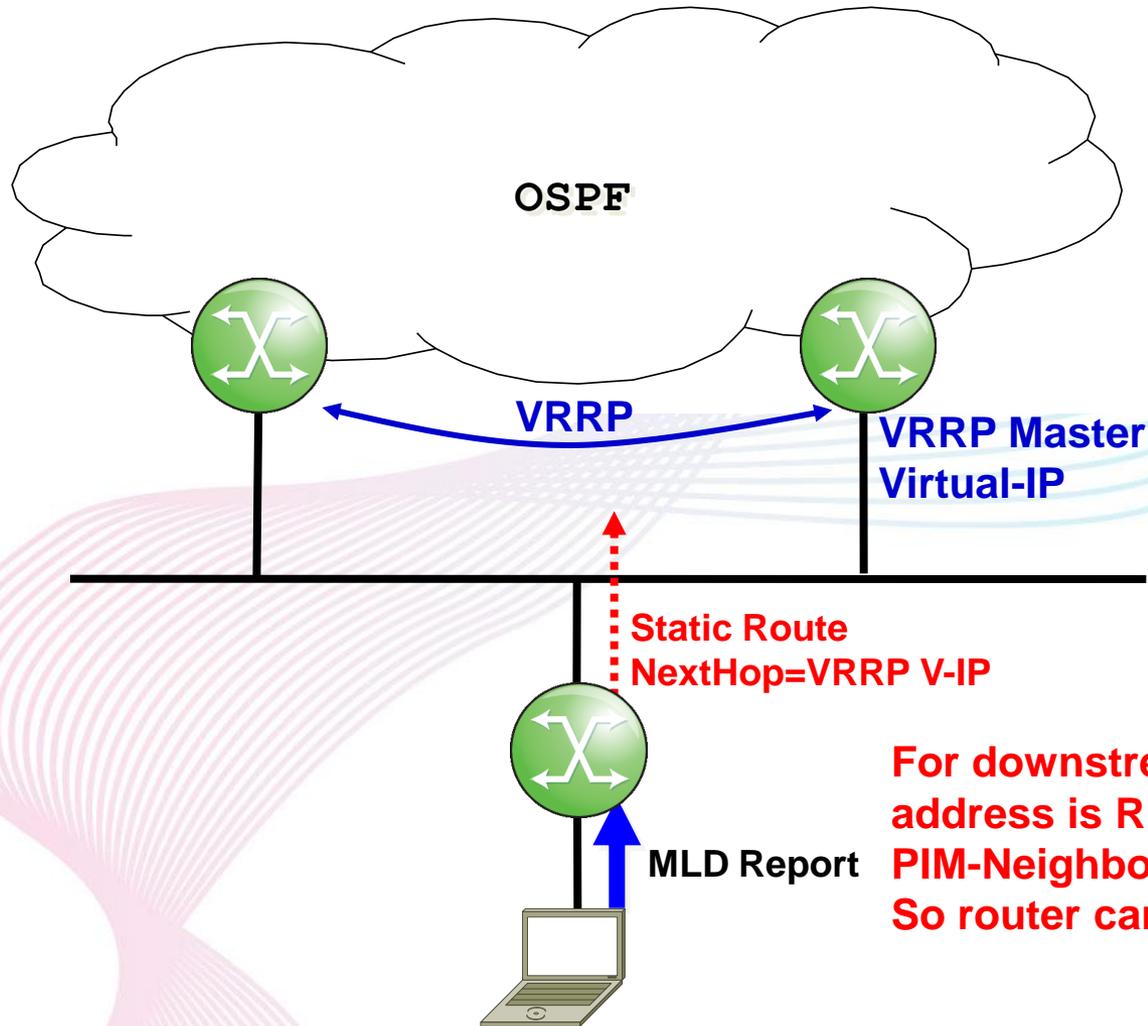
In above topology and uplink on Router1 become down, Router1 need to know alternative route via Router2. (generally LAN segment is configured as " passive") In some PIM implementation, above failover scenario does not work.

# PIM-Neighbor

When the router find RPF Neighbor based on unicast routing info, Router can not send PIM-Join/Prune to the RPF neighbor if that RPF Neighbor is not recognized as PIM-Neighbor.  
=> PIM should be enabled on all links in the network

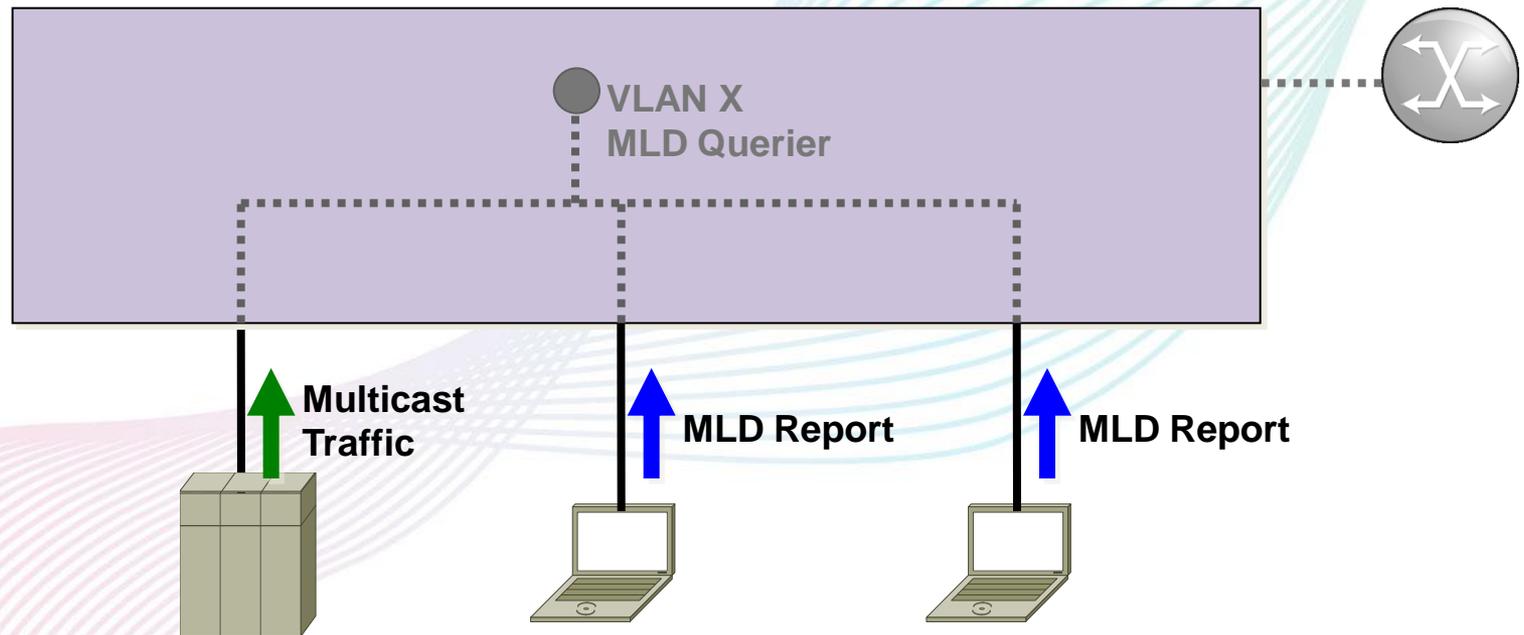


# VRRP and PIM



**For downstream router, VRRP virtual address is RPF Neighbor, but it is not PIM-Neighbor.  
So router can not send any PIM messages.**

# L2 Switch only environment



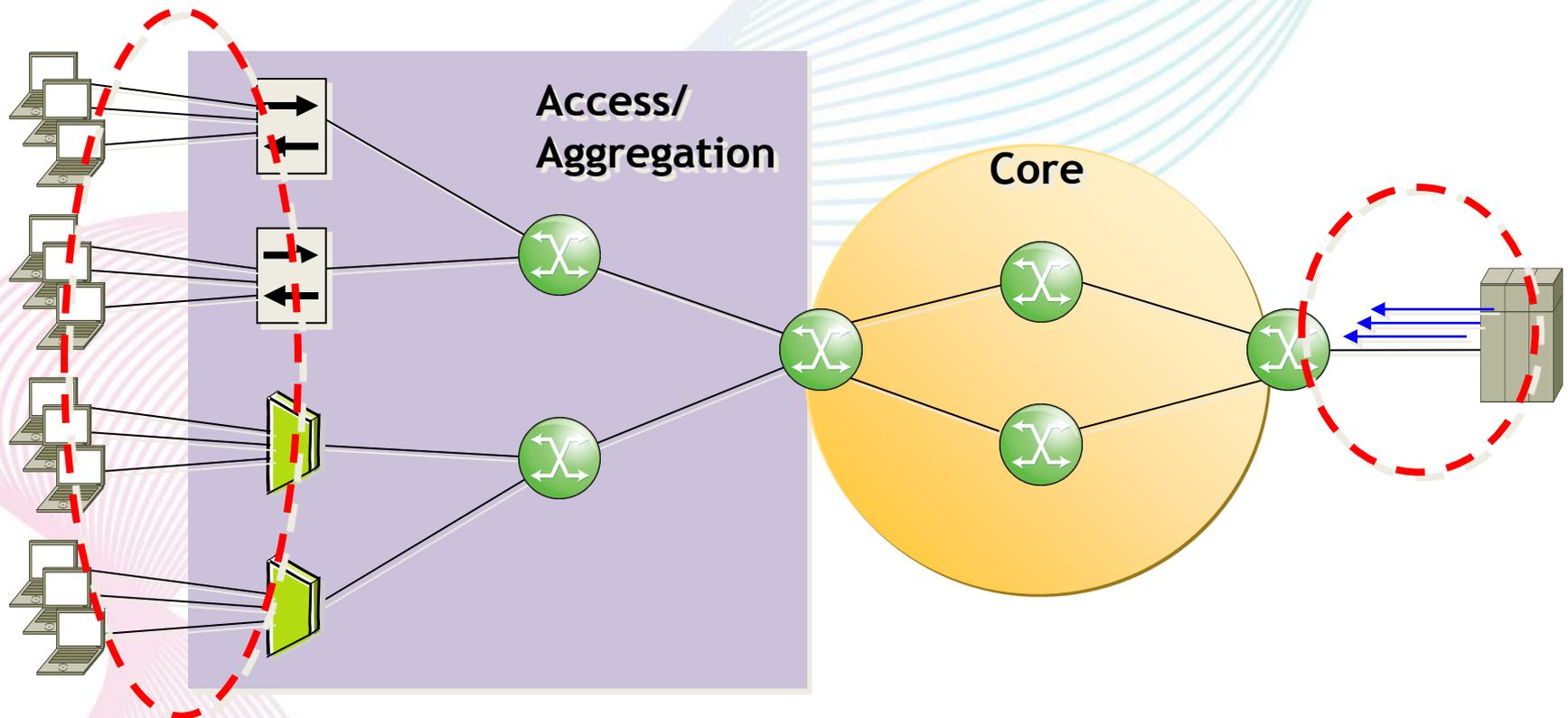
There is no MLD querier in the vlan, MLD-snooping does not work without router port.

=> Need to connect MLD Router, or need to configure MLD querier

# Considerations in deploying IPv6 multicast to SP network

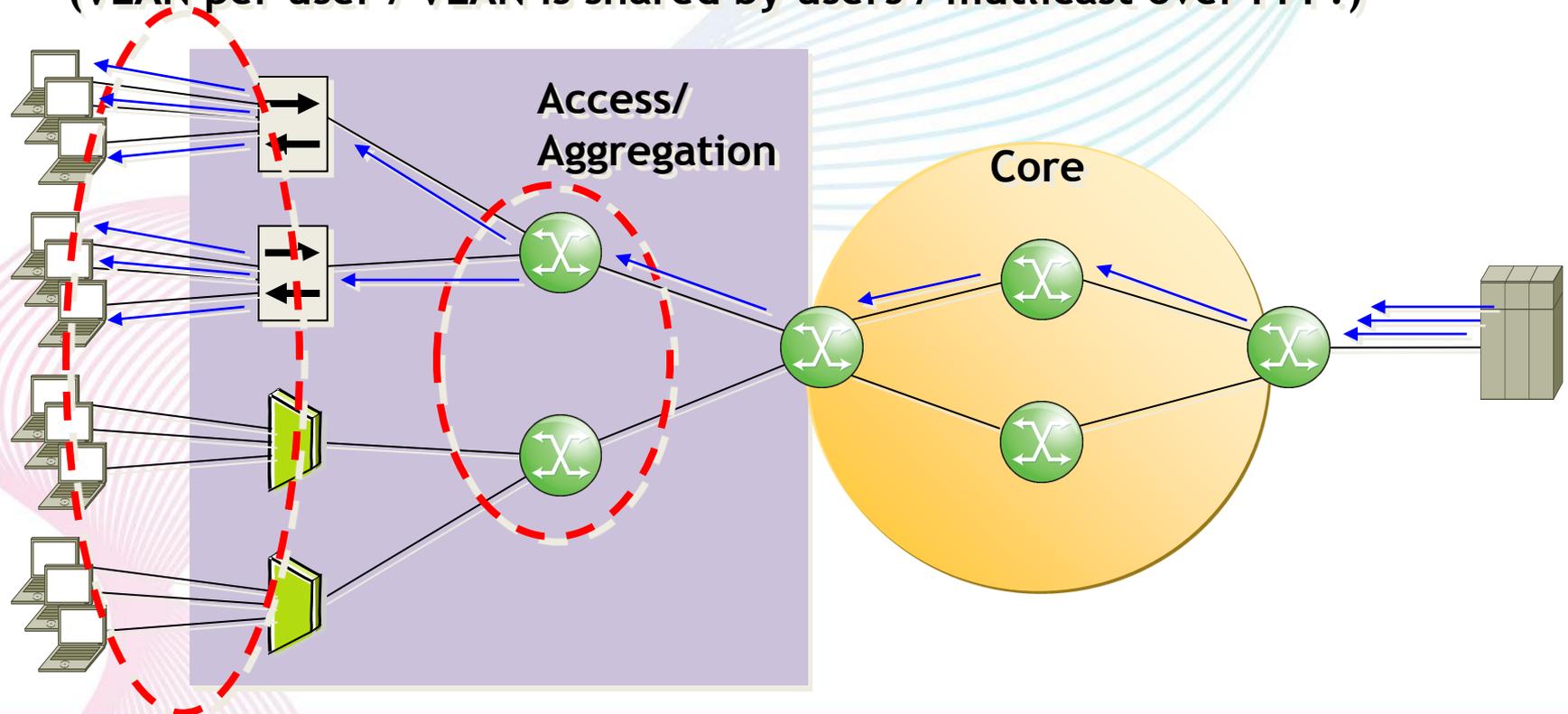
# Considerations in deploying IPv6 multicast(1)

- 1.How many groups(multicast streams) ?
- 2.Each stream's Bandwidth ?
- 3.How much bandwidth available in access network ?



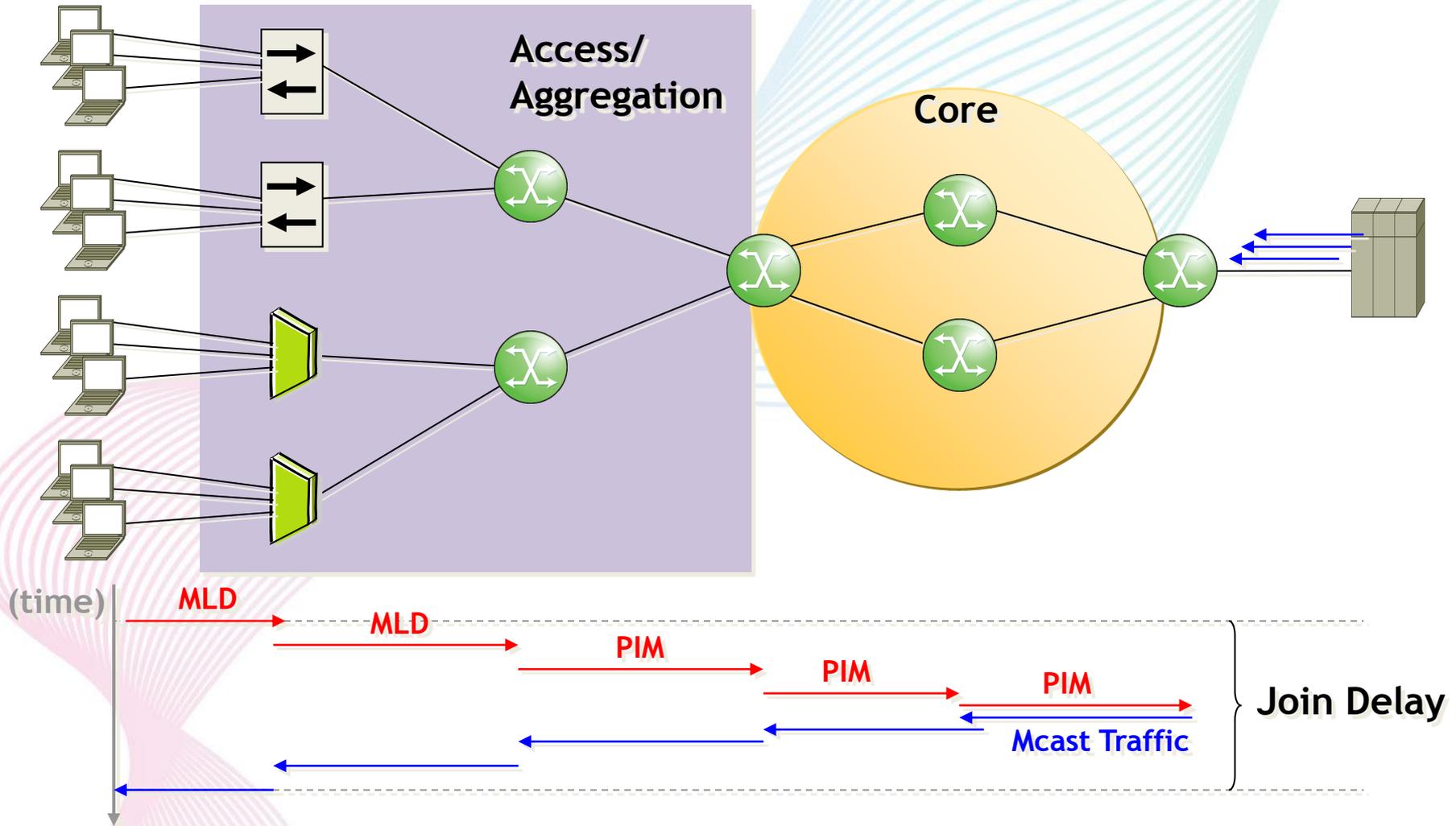
# Considerations in deploying IPv6 multicast(2)

4. How many subscribers on one L2-edge-device ?
5. Max join rate(# of MLD joins/sec) L2-edge-device receiving ?
6. How many subscribers on one L3-edge-device ?
7. Max join rate(# of MLD joins/sec) L3-edge-device receiving ?
8. Max # of replication(Fan out) on L2/L3-device ?  
(VLAN per user / VLAN is shared by users / mutlicast over PPP?)



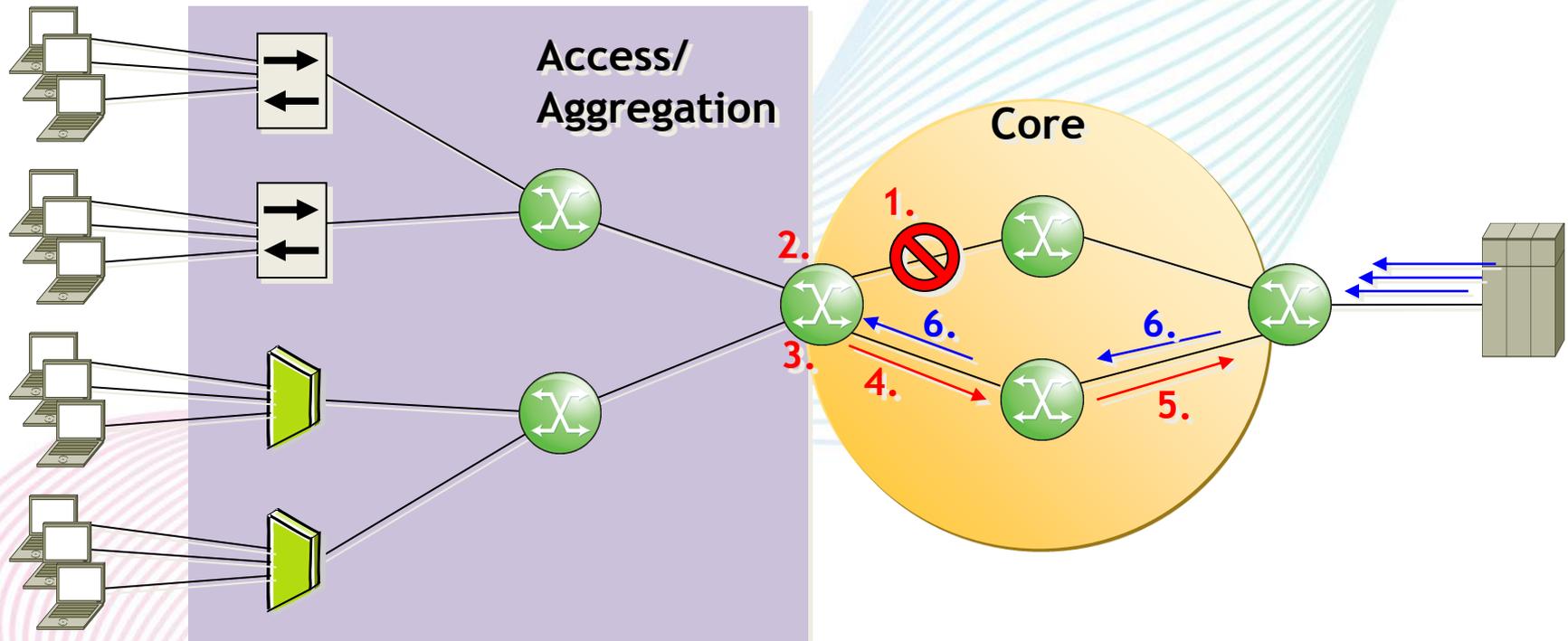
# Considerations in deploying IPv6 multicast(3)

## 9. What is the acceptable Join delay ?



# Considerations in deploying IPv6 multicast(3)

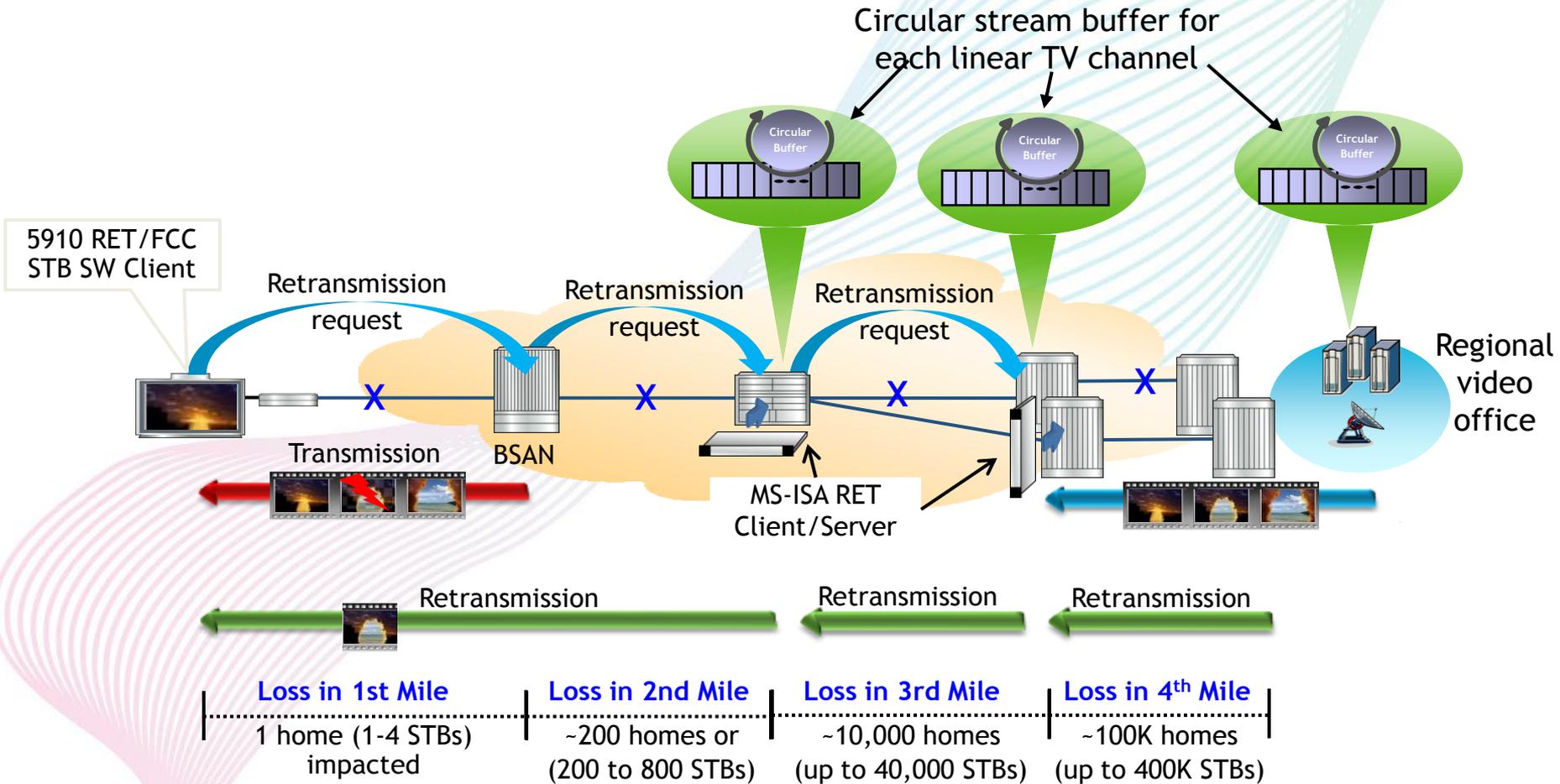
## 9. What is the required failover time ?



1. Network down detected
2. Unicast Routing convergence
3. Multicast routing detects unicast change, RPF Neighbor is changed
4. Send PIM join to new RPF neighbor
5. PIM Join towards to source
6. Traffic forwarded on new Tree

<reference>

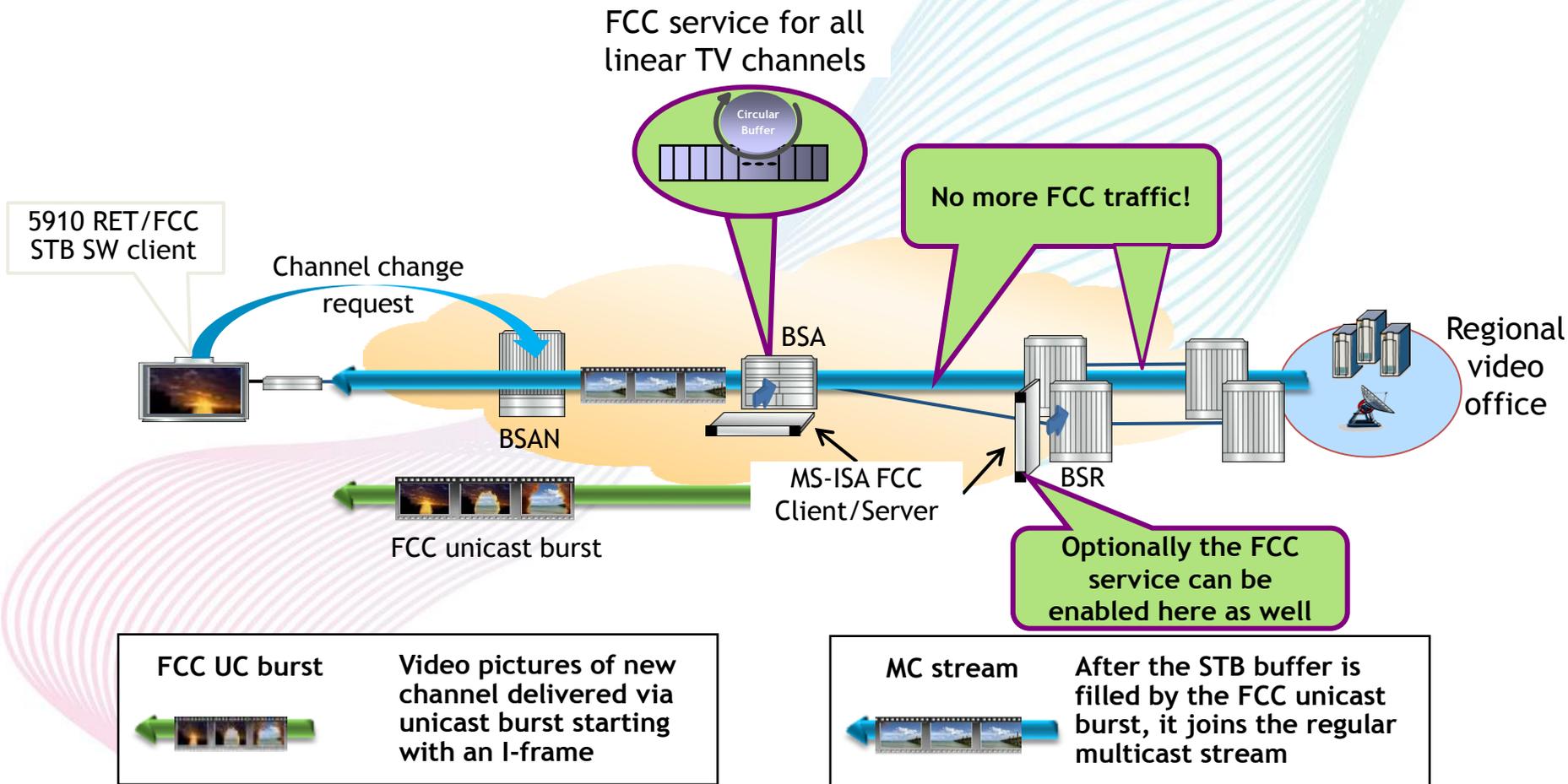
# Distributed and integrated video packet retransmission



Hierarchical deployment limits impact of packet loss and reduces retransmission traffic  
Linear per-channel scaling yields superior performance with far lower traffic overhead

<reference>

# Distributed & integrated fast channel change support



Hierarchical deployment optimizes efficiency for both popular and less popular content  
Integrated FCC functions yield superior performance with far lower traffic overhead



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