



IPv4 EXHAUSTION

IPv6オペレータ育成プログラム

本資料は2009年11月19日に開催されたIPv4アドレス枯渇対応タスクフォース主催の
IPv6ハンズオンセミナー
「マルチキャスト編」(講師:鹿志村康生氏)を元に
し、公開用に資料を編集したものである。

IPv4アドレス枯渇対応タスクフォース
<http://www.kokatsu.jp/>



IPv4
EXHAUSTION

IPv6オペレータ育成プログラム

IPv6ハンズオンセミナー マルチキャスト編

<ハンズオンテキスト>

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Agenda (第2部:ハンズオン)

1. ハンズオン環境について

2. 設定とStatusの確認>

- Enable IPv6 multicast routing
- Enable MLD
- Enable PIM
- Configuring RP for PIM-ASM
- Configuring PIM-SSM
- Configuring MLD Snooping

3. 動作確認

- Streamの送信
- PIM-ASM動作確認
- PIM-SSM動作確認
- MLD-Snooping動作確認
- PIM Route Failover

4. Advanced course

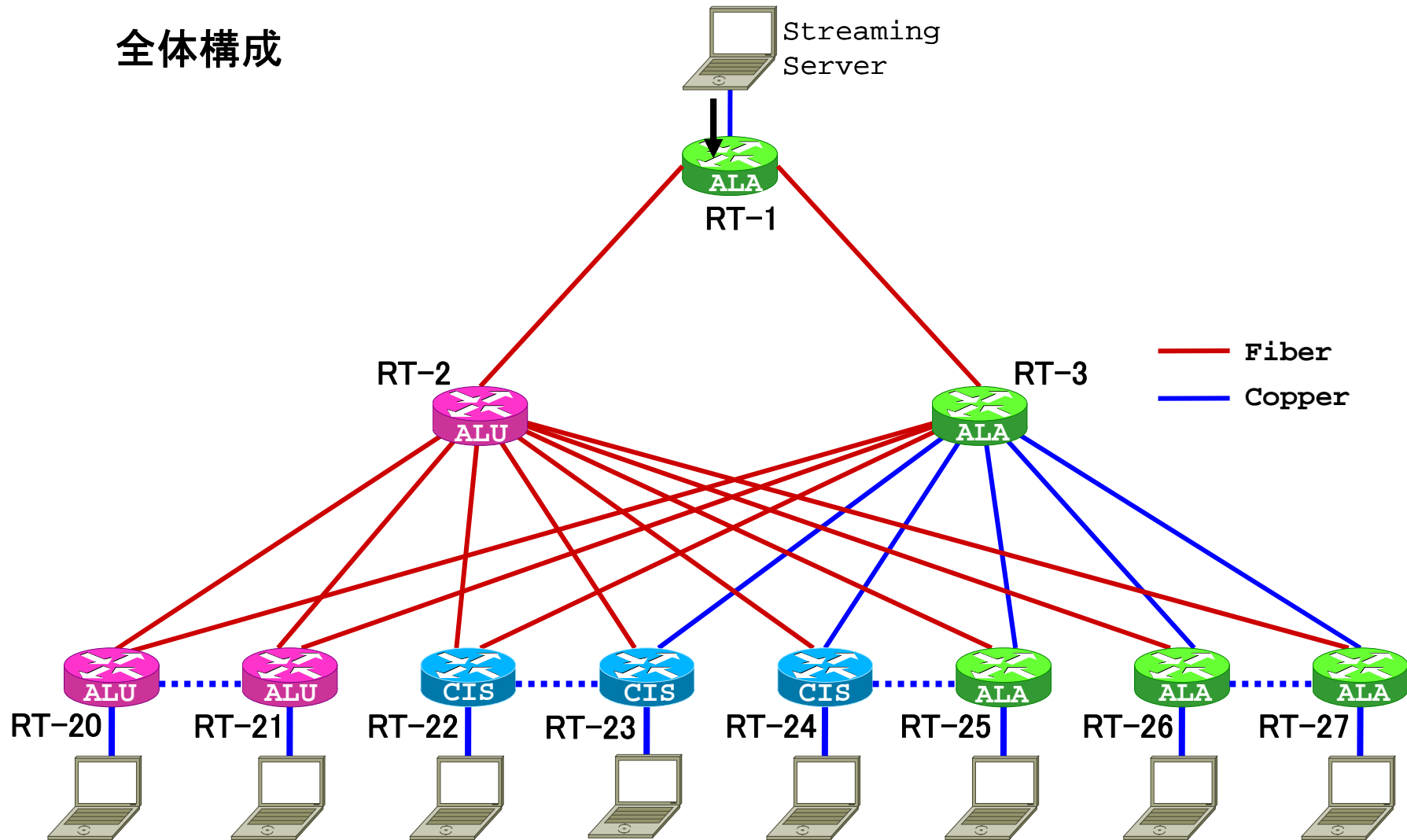
- PIM DRの動作
- Static MLD join
- SSM mapping

5. まとめ

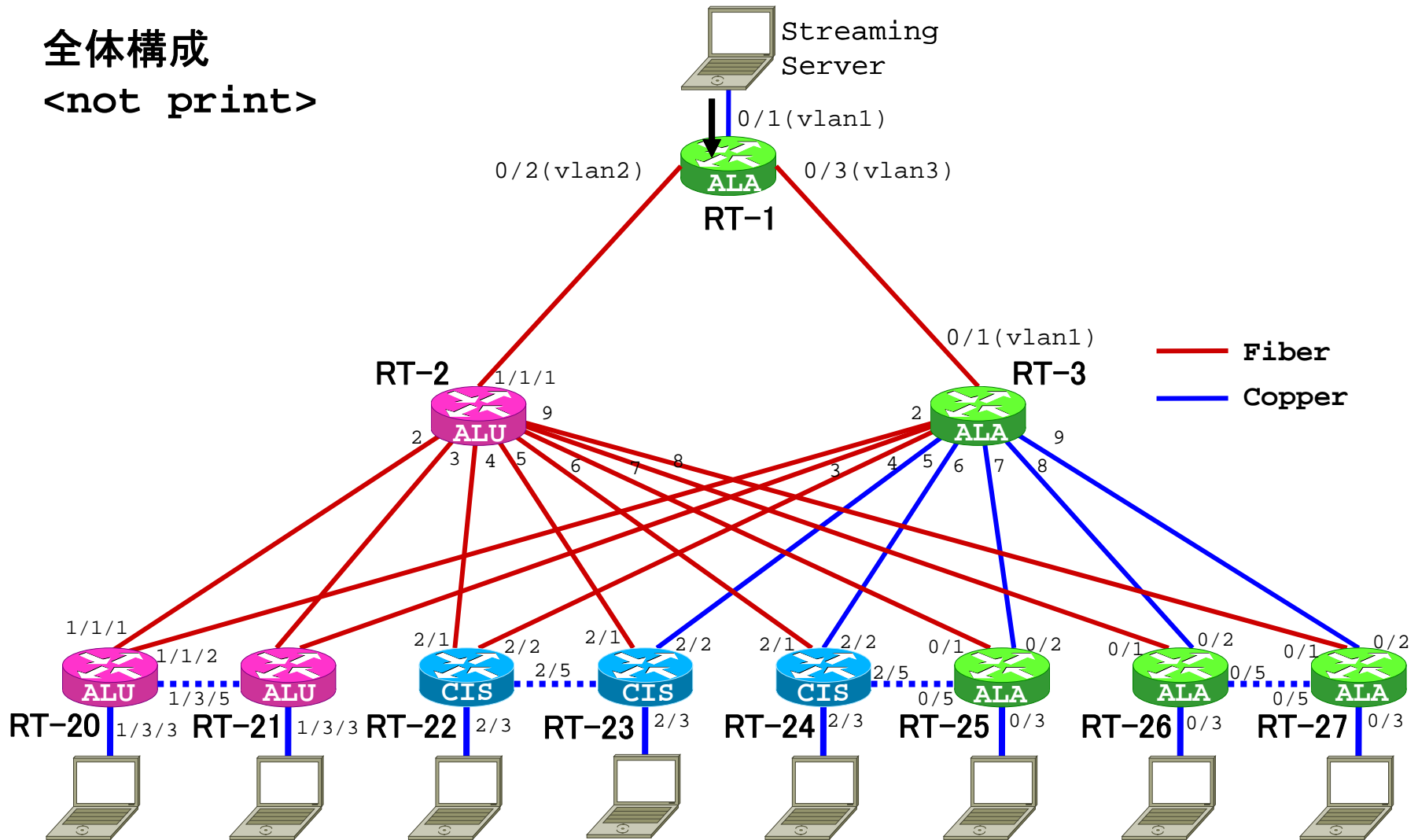
ハンズオン環境について



全体構成



全体構成
<not print>

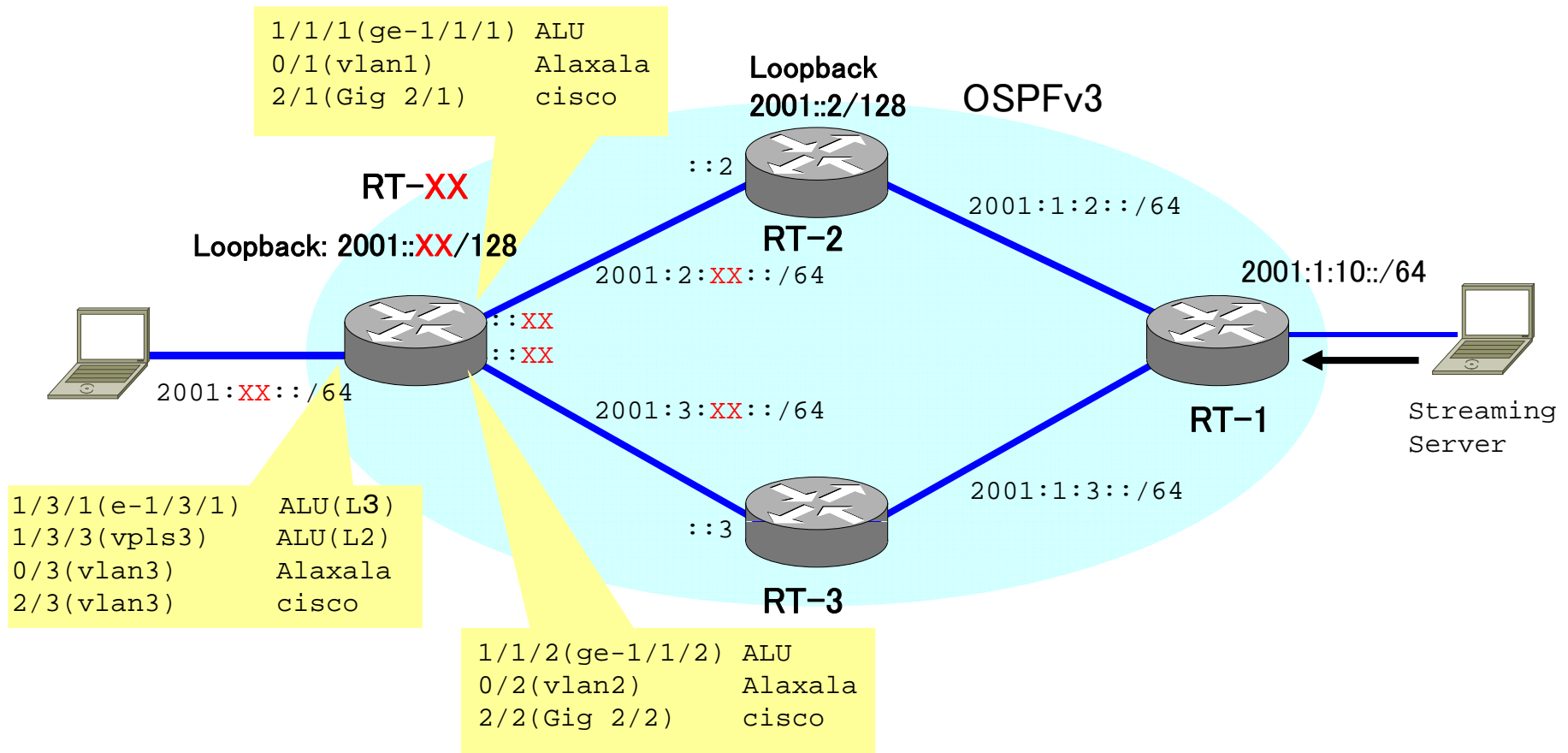




アドレッシング / Port

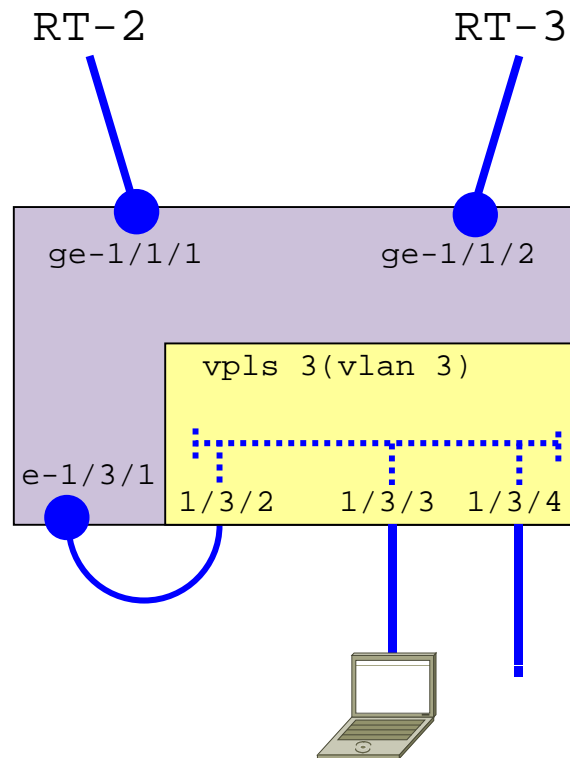
自身のRouter名: RT-XX
のXX部分を下記にあてはめて下さい。

Multicast Stream:
(2001:1:10::10, FF18::1:1) ASM用
(2001:1:10::10, FF38::2:1) SSM用

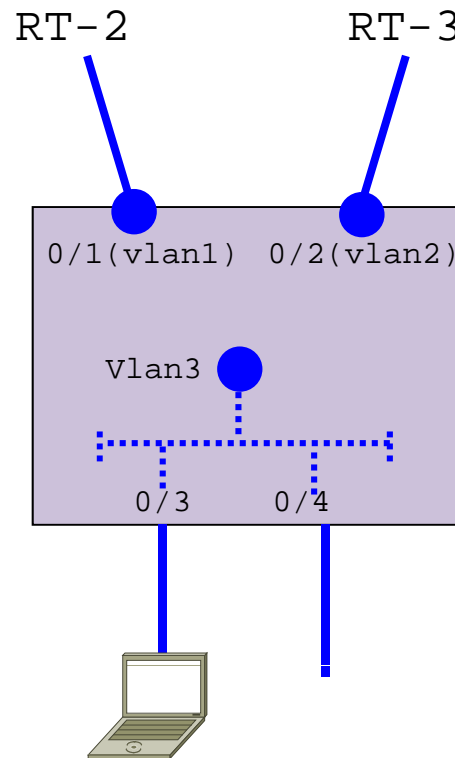


L2/L3内部構成

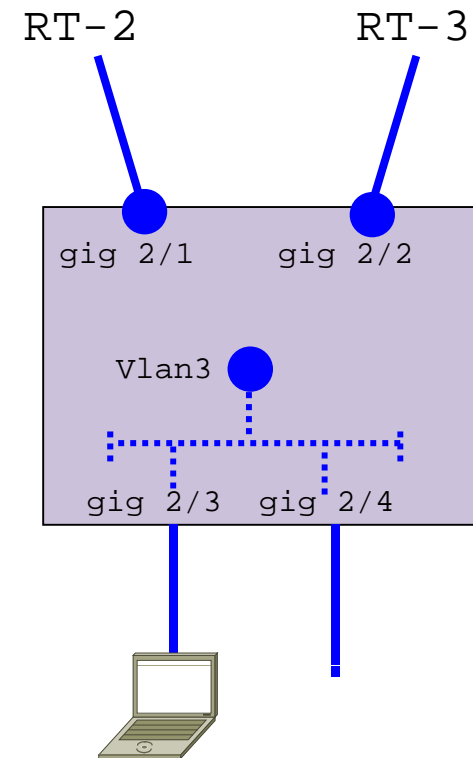
<Alcatel>



<Alaxala>



<Cisco>



ルータへのアクセス方法

- “TeraTerm” から ループバックアドレスへTelnet
#Host指定の所は [2001::XX] のように括弧でくる。

<ALU>

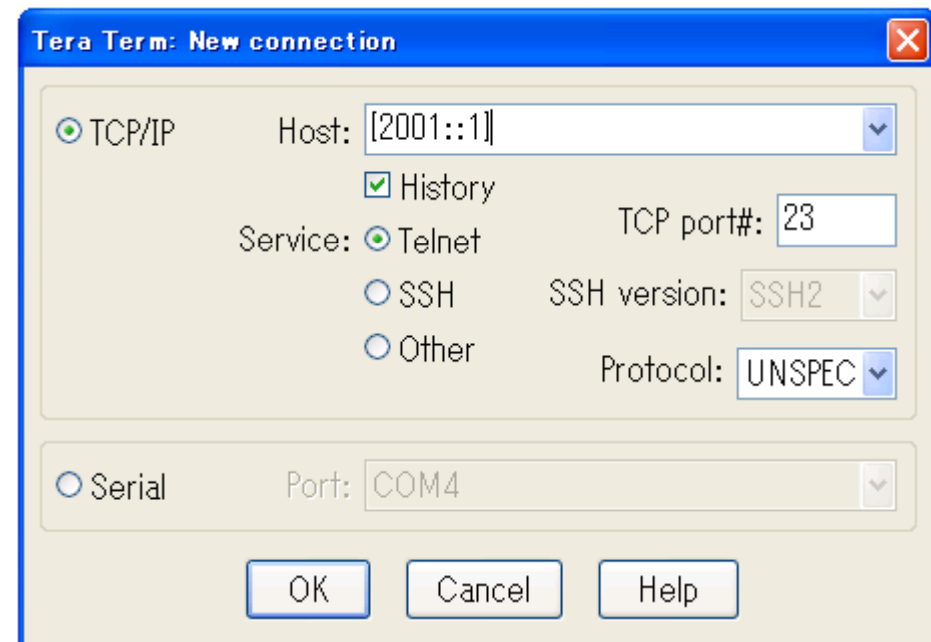
```
user/pass = admin/admin
```

<Alaxala>

```
user = operator  
enable password無し
```

<cisco>

```
login password無し  
enable password = cisco
```





基本的なConfig方法

- Alcatel : Enable modeからそのままconfig

```
ALU# configure router pim xxxxxxxx
```

- Alaxala : configモードに入って設定、保存してからExit

```
Alaxala# conf t
Alaxala (config)# ipv6 pim xxxxxxxx
! Alaxala (config)# save
Alaxala(config)# exit
Alaxala#
```

- Cisco : configモードに入って設定

```
cisco#conf t
cisco(config)#ipv6 pim xxxxxxxx
cisco(config)#exit
cisco#
```



Configの保存

- Alcatel :

```
ALU# admin save
Writing file to cf3:¥v6mcast-training
Saving configuration .... Completed.
```

- Alaxala :

```
! Alaxala (config)# save <Congigモードから保存>

Alaxala# copy running-config startup-config
Configuration file copy to startup-config? (y/n): y
```

- Cisco :

```
Cisco#copy running-config startup-config
Destination filename [startup-config]?
Building configuration...
[OK]
```



IPv6 unicast関連 確認コマンド(参考)

- Alcatel :

```
ALU# show router interface ipv6
ALU# show router route-table ipv6
ALU# show router route-table 2001::1
ALU# show router ospf3 <interface/neighbor/etc..>
ALU# ping 2001::1
```

- Alaxala :

```
Alaxala# show ipv6 interface
Alaxala# show ipv6 route
Alaxala# show ipv6 route 2001::1
Alaxala# show ipv6 ospf <interface/neighbor/etc..>
Alaxala# ping ipv6 2001::1
```



IPv6 unicast関連 確認コマンド(参考)

- Cisco :

```
cisco# show ipv6 interface
cisco# show ipv6 route
cisco# show ipv6 route 2001::1
cisco# show ipv6 ospf <interface/neighbor/etc..>
cisco# ping 2001::1
```



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Enable IPv6 Multicast Routing

Enable IPv6 multicast routing

- Alcatel : 不要
- Alaxala:

```
Alaxala# conf t
Alaxala (config)# swrt_table_resource l3switch-x
<IPv6 multicastが使用できるようにリソース割り当てを変更する>
Alaxala (config)# swrt_multicast_table
<multicast routingとsnoopingを同時に使用可能にする>
Alaxala (config)# ipv6 multicast-routing
<ipv6 multicast routingをEnableにする>
```

- Cisco :

```
cisco# conf t
cisco(config)# ipv6 multicast-routing
<ipv6 multicast routingをEnableにする>
```

Enable MLD router



Enable MLD router

- Alcatel :

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

- Alaxala :

```
Alaxala (config)# interface vlan 3  
Alaxala (config-if)# ipv6 mld router
```

- Cisco : 不要

“ipv6 multicast-routing”をEnableにした時点で全てのIPv6 interfaceでpim/mldはEnableとなる。



● Alcatel : MLD 確認

```
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::216:4DFE:FE56:25DB					

```
=====
```

```
Interfaces : 1
```

```
=====
```



MLD 確認

- Alaxala :

```
Alaxala# show ipv6 mld interface
Date 2000/02/13 19:30:58 UTC
Total: 1 Interface
Interface      Version  Flags  Querier                Expires  Group Count
Notice
VLAN0003      2        S      fe80::212:e2ff:fe08:6915  -        0
```

MLD 確認

- Cisco :

```
cisco#show ipv6 mld interface vlan 3
Vlan3 is up, line protocol is up
Internet address is FE80::213:5FFF:FE1C:F840/10
MLD is enabled on interface
Current MLD version is 2
MLD query interval is 125 seconds
MLD querier timeout is 255 seconds
MLD max query response time is 10 seconds
Last member query response interval is 1 seconds
MLD activity: 13 joins, 0 leaves
MLD querying router is FE80::213:5FFF:FE1C:F840 (this system)
MLD snooping is globally enabled
MLD snooping is enabled on this interface
MLD snooping fast-leave (for v1) is disabled
MLD snooping querier is disabled.
MLD snooping explicit-tracking is enabled
MLD snooping last member query response interval is 1000 ms
MLD snooping report-suppression is enabled
```



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Enable PIM



Enable PIM on interface

- Alcatel :

```
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
```

- Alaxala :

```
Alaxala(config)# interface vlan 1
Alaxala(config-if)# ipv6 pim
Alaxala(config-if)# exit
Alaxala(config)# interface vlan 2
Alaxala(config-if)# ipv6 pim
Alaxala(config-if)# exit
Alaxala(config)# interface vlan 3
Alaxala(config-if)# ipv6 pim
Alaxala(config-if)# exit
```

- Cisco : 不要

“ipv6 multicast-routing”
をEnableにした時点で全ての
IPv6 interfaceでpim/mldは
Enableとなる。

PIM interface 確認

- Alcatel :

```
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
=====
```



PIM Neighbor 確認

- Alcatel :

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

```
=====
```

```
PIM Neighbor ipv6
```

```
=====
```

Interface	Nbr DR Prty	Up Time	Expiry Time	Hold Time
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
```

```
=====
```




PIM interface 確認

- Alaxala :

```
Alaxala# show ipv6 pim interface
Date 2000/02/13 04:21:02 UTC
Interface      Component      Vif Nbr      Hello DR      This
                Count Intvl Address      System
VLAN0001      PIM-SM        1      1      30 fe80::212:e2ff:fe08:6915 Y
VLAN0002      PIM-SM        2      1      30 fe80::216:4dff:fe9b:a0fa N
VLAN0003      PIM-SM        3      0      30 fe80::212:e2ff:fe08:6915 Y
```



PIM Neighbor 確認

- Alaxala :

```
Alaxala# show ipv6 pim neighbor
Date 2000/02/13 04:23:18 UTC
Neighbor Address      Interface      Uptime  Expires
fe80::203:faff:feac:2432 VLAN0001      1hour    01:41
fe80::216:4dff:fe9b:a0fa VLAN0002      1hour    01:41
```



PIM interface 確認

- Cisco :

```
cisco#show ipv6 pim interface
Interface                PIM  Nbr    Hello  DR
                          Count Intvl  Prior

GigabitEthernet2/2  on   1      30     1
  Address: FE80::213:5FFF:FE1C:F840
  DR      : FE80::216:4DFE:FE9B:A0FA
GigabitEthernet2/1  on   1      30     1
  Address: FE80::213:5FFF:FE1C:F840
  DR      : FE80::216:4DFE:FE1D:D1B8
Vlan3                on   0      30     1
  Address: FE80::213:5FFF:FE1C:F840
  DR      : this system
```



PIM Neighbor 確認

- Cisco :

```
cisco#show ipv6 pim neighbor detail
Neighbor Address(es)      Interface      Uptime      Expires DR pri Bidir
Address-list Hello option included as type 24 and 65001

FE80::216:4DFF:FE9B:A0FA  GigabitEthernet2/2  3w0d        00:01:21  1  (DR)
2001:3:5::3

FE80::216:4DFF:FE1D:D1B8  GigabitEthernet2/1  3w0d        00:01:43  1  (DR)
2001:2:5::2
```

Configuring RP for PIM-ASM

Configuring RP for PIM-ASM

- Alcatel :

```
ALU # configure router pim
ALU >config>router>pim# rp ipv6
ALU >config>router>pim>rp>ipv6# static address 2001::2
<RPを2001::2に静的に設定する>
ALU >config>router>pim>rp>ipv6>static>address# override
<BSRよりもstatic-rpの設定を優先させるように”override”設定をする>
ALU >config>router>pim>rp>ipv6>static>address# group-prefix FF18::/16
<2001::2をRPとして使用するgroup-addressの範囲を指定する>
```

- Alaxala :

```
Alaxala(config)# ipv6 access-list asm-group
Alaxala(config-ipv6-acl)# 10 permit ipv6 any ff18::/16
<Access-List”asm-group”でgroup-addressの範囲を指定する>
Alaxala(config-ipv6-acl)# exit
Alaxala(config)# ipv6 pim rp-address 2001::2 asm-group
<RPを2001::2に静的に設定し、group-addressの範囲として”asm-group”を指定する>
```



Configuring RP for PIM-ASM

- Cisco :

```
cisco(config)#ipv6 access-list asm-group  
cisco(config-ipv6-acl)#permit ipv6 any ff18::/16  
<Access-List"asm-group"でgroup-addressの範囲を指定する>  
cisco(config-ipv6-acl)#exit  
cisco(config)#ipv6 pim rp-address 2001::2 asm-group  
<RPを2001::2に静的に設定し、group-addressの範囲として"asm-group"を指定する>
```

RP to Group mapping 確認

- Alcatel :

```

ALU # show router pim rp ipv6

=====
PIM RP Set ipv6
=====
Group Address                                Hold Expiry
  RP Address                                Type      Prio Time Time
-----
FF18::/16
  2001::2                                Static    1      N/A  N/A
-----
Group Prefixes : 1
=====
  
```

- Alaxala :

```

Alaxala# show ipv6 pim rp-mapping
Date 2000/02/13 19:17:06 UTC
Status : Not Candidate Rendezvous Point
Total: 1 route , 1 group , 1 RP
Group/Masklen          C-RP Address          Priority Uptime Expires
ff18::/16              2001::2                0 16hours  --:--
  
```




RP to Group mapping 確認

- Cisco :

```
cisco#show ipv6 pim group-map <ff18::>
<Group-addressから使われ方(SM or SSM, RP-Add等)を確認>

FF18::/16*
  SM, RP: 2001::2
  RPF: Gi2/1,FE80::216:4DFF:FE1D:D1B8
  Info source: Static
  Uptime: 15:51:35, Groups: 1

c6504#show ipv6 pim range-list
<RP-addressからGroup-addressを確認>
Static SSM Exp: never Learnt from : ::
  FF33::/32 Up: 3w2d
  FF34::/32 Up: 3w2d
  <省略>
  FF3D::/32 Up: 3w2d
  FF3E::/32 Up: 3w2d
  FF3F::/32 Up: 3w2d
Static SM RP: 2001::2 Exp: never Learnt from : ::
  FF18::/16 Up: 15:52:45
```

Configuring PIM-SSM

Configuring PIM-SSM

- Alcatel :

```
ALU # configure router pim
ALU >config>router>pim# ssm-groups
ALU >config>router>pim>ssm# group-range FF38::/16
<FF38::/16をPIM-SSMのGroup-address範囲として設定する>
```

- Alaxala :

```
Alaxala(config)# ipv6 access-list ssm-group
Alaxala (config-ipv6-acl)# permit ipv6 any ff38::/16
<Access-List”ssm-group”でgroup-addressの範囲を指定する>
Alaxala (config-ipv6-acl)# exit
Alaxala (config)# ipv6 pim ssm range ssm-group
<SSMのGroup-address範囲として”ssm-group” を指定する>
```

※または、“`ipv6 pim ssm default`”でも良い。この場合、FF3X::の全ての標準SSMアドレス範囲についてSSMがEnableとなる。

- Cisco : 不要

“`ipv6 multicast-routing`”をEnableにした時点でFF3X::の全ての標準SSMアドレス範囲についてSSMがEnableとなる。

Configuring MLD-Snooping



Configuring MLD-Snooping

- Alcatel :

```
ALU# configure service vpls 3
ALU >config>service>vpls# mld-snooping no shutdown
<vpls 3(VLAN3)でmld-snoopingをEnableにする>
```

- Alaxala :

```
Alaxala# interface vlan 3
Alaxala(config-if)# ipv6 mld snooping
<vlan 3 でmld-snoopingをEnableにする>
```

- Cisco : 不要

DefaultでEnableとなっている。

MLD Snooping status確認

- Alcatel :

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

MLD Snooping status確認

- Alaxala :

```
Alaxala# show mld-snooping
Date 2000/02/13 20:21:35 UTC
VLAN counts: 1
VLAN: 3
  IP address: fe80::212:e2ff:fe08:6915      Querier: disable
  MLD querying system: fe80::212:e2ff:fe08:6915
  Querier version: V2
  IPv6 Multicast routing: On
  Port(1): 0/3
  Mrouter-port:
  Group Counts: 0
```

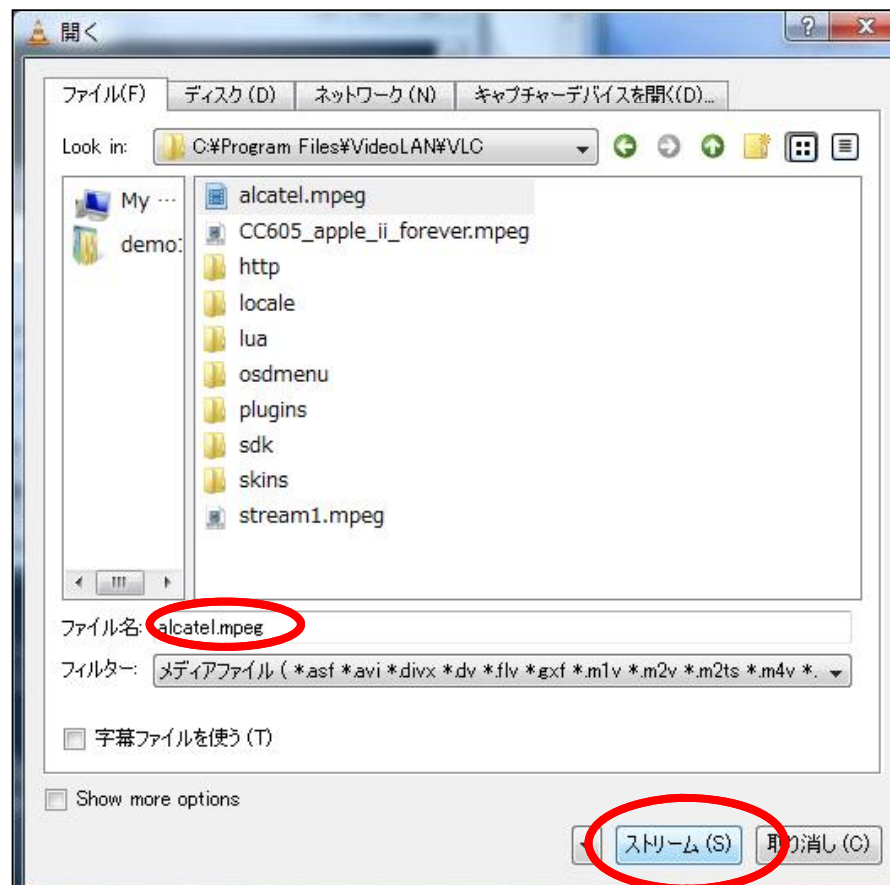
- Cisco :

```
cisco#show ipv6 mld snooping mrouter
vlan          ports
-----+-----
  3 Router
```

Streamの送信(VLC mediaplayer)

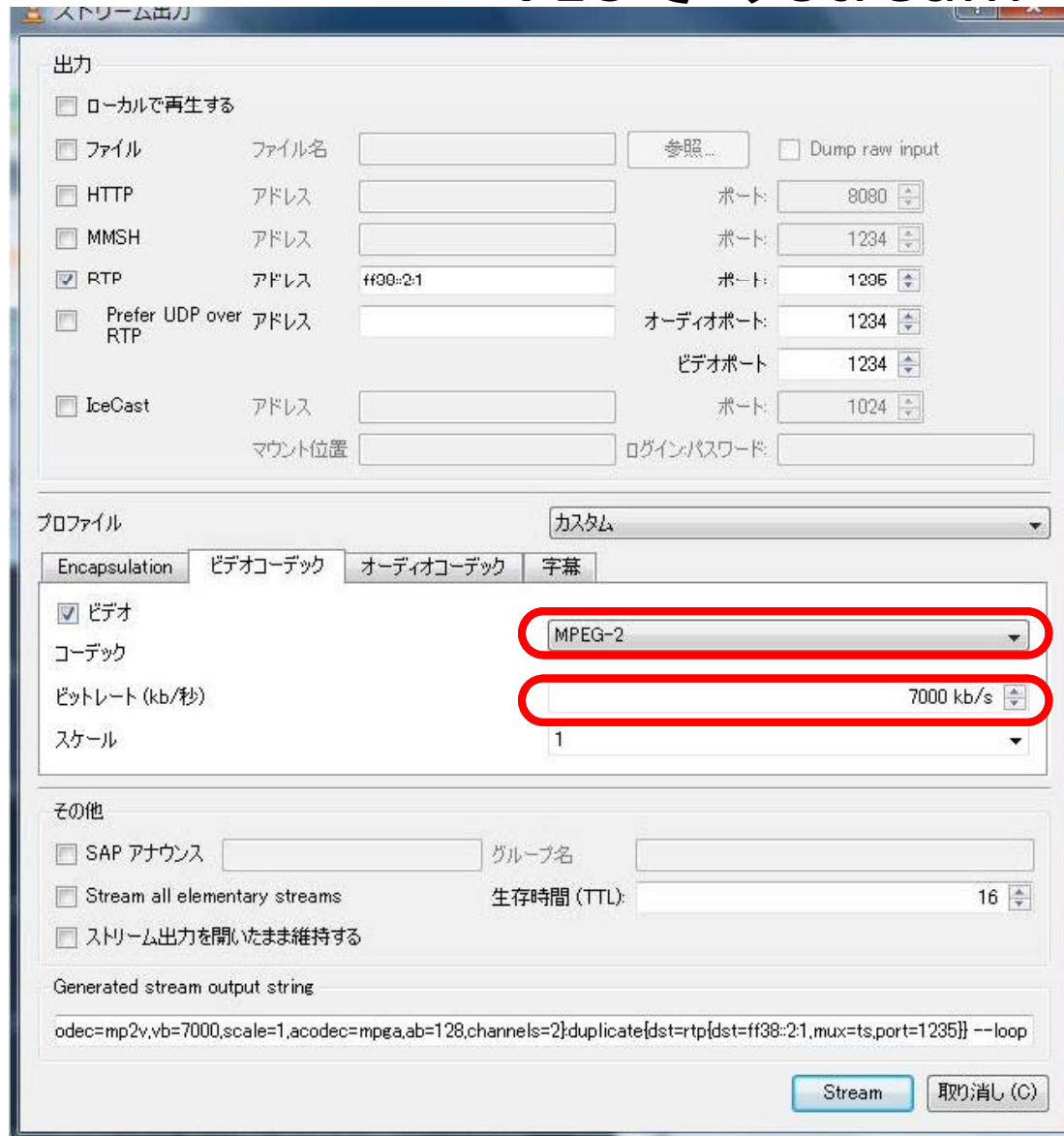
VLCでのStreamの送信(例)

1. "メディア" メニューから "ストリーミング" を選択
2. ソースとするファイルを選択後、"ストリーム"をクリック



VLCでのStreamの送信

4. ビデオ・オーディオコーデック、レートを指定



The screenshot shows the 'Stream Output' dialog box in VLC media player. The 'RTP' option is checked, and the address is set to 'ff38::2:1'. The video codec is set to 'MPEG-2' and the bitrate is set to '7000 kb/s', both of which are highlighted with red circles. The 'Generated stream output string' field contains the command: `oddec=mp2v,vb=7000,scale=1,acodec=mpga,ab=128,channels=2;duplicate[dst=rtp{dst=ff38::2:1,mux=ts,port=1235}] --loop`

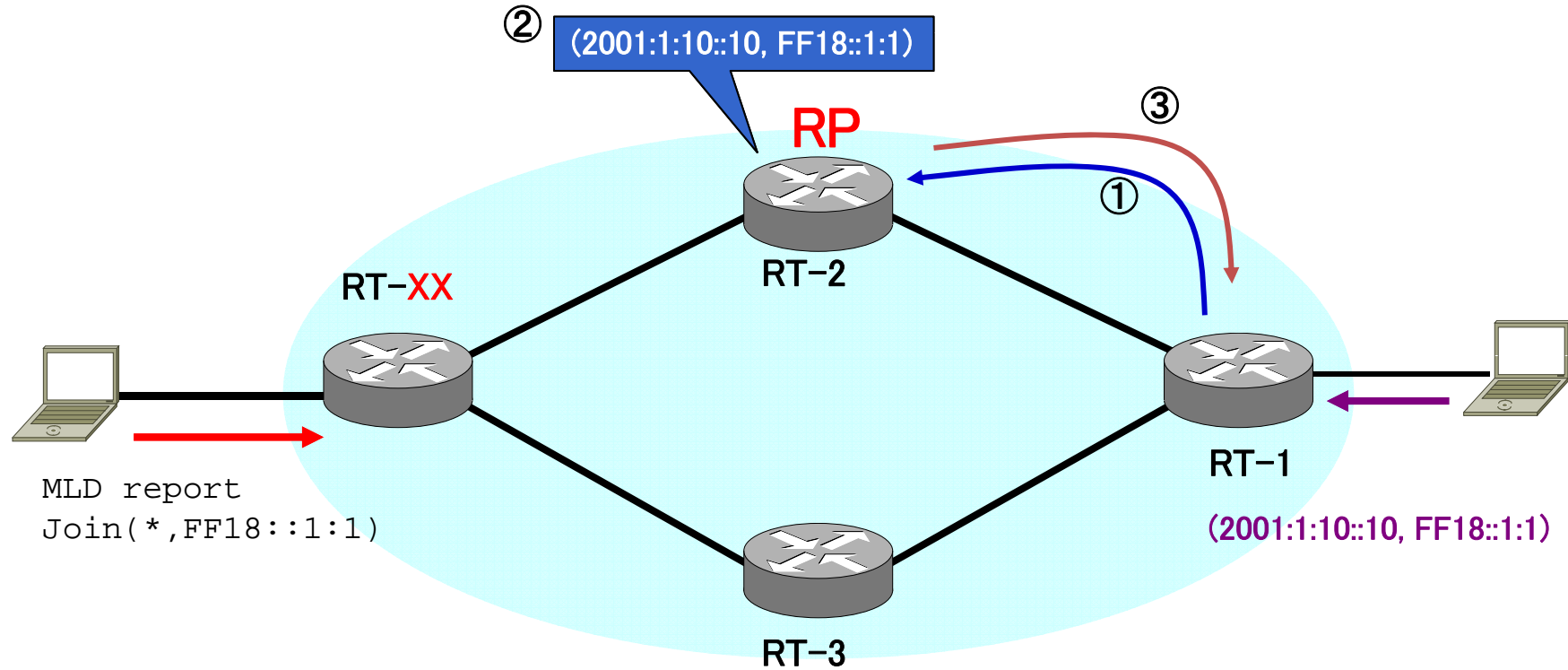


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PIM-ASM動作確認

ASM (S,G) 送信開始



- ① PIM Register PacketをRP(2001::2)へ送信 (Unicast)
- ② RPに(S,G)のEntryが作られる
- ③ RPからFirstHopRouterへRegister Stopを送信



RPの状態を確認

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

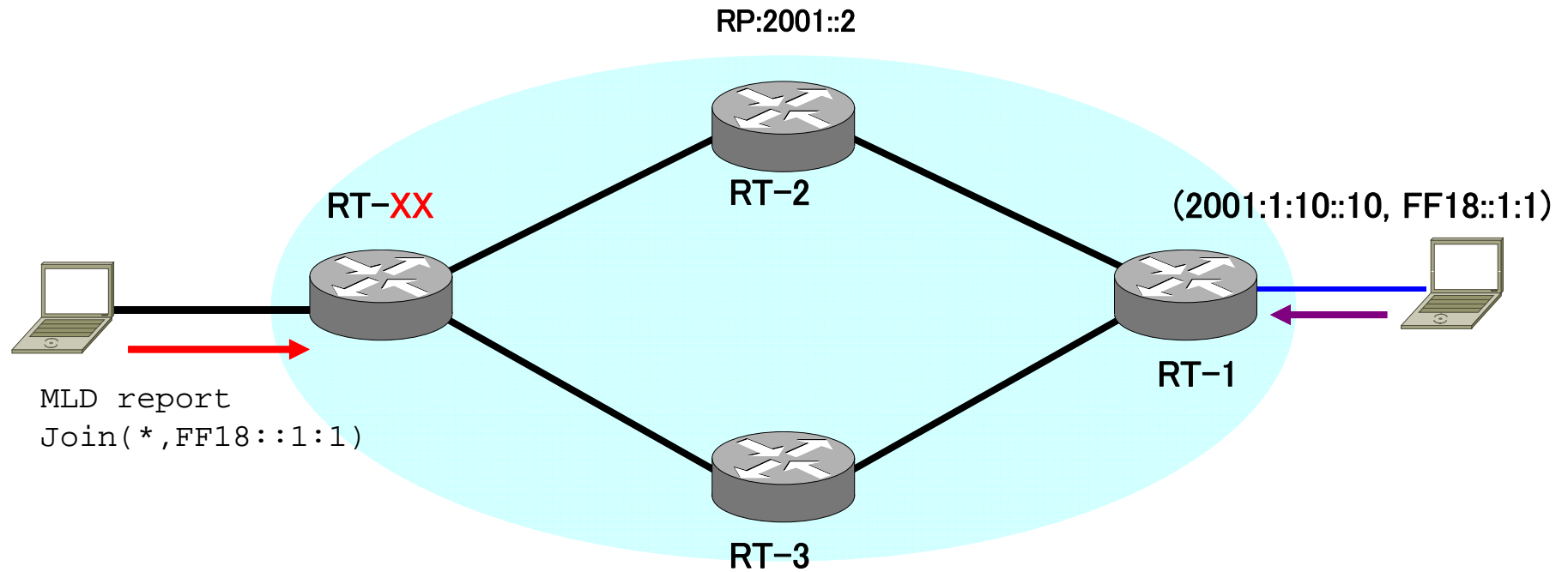
```
=====
PIM Groups ipv6
=====
```

Group Address	Type	Spt Bit	Inc	Intf	No.Oifs
Source Address	RP				
FF18::1:1	(S,G)			ge-1/1/4	0
2001:1:10::10	2001::2				

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

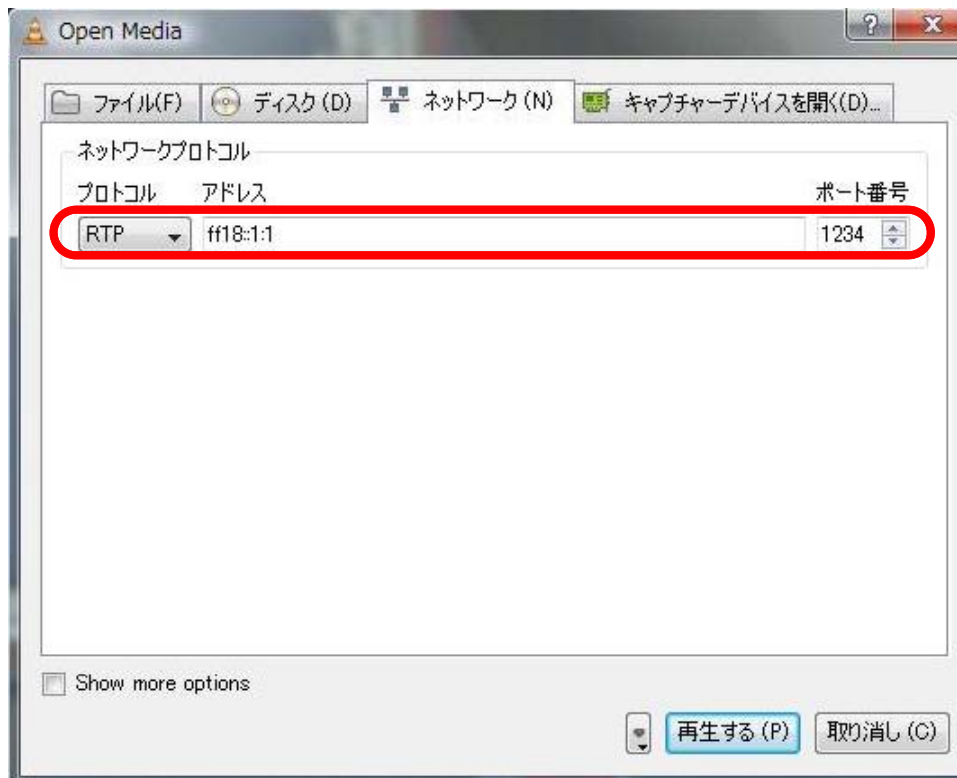


ASM groupへJoin



VLC Client GUIからJoin (ASM)

“メディア” メニューから “ネットワークストリームを開く” を選択
プロトコル、アドレス、ポートを指定し “再生する” をクリック



または、コマンドプロンプトから `vlc rtp://@[ff18::1:1]:1234`



動作確認

- ◆ MLD Entryは正しく出来ていますか？
- ◆ PIMの配信Treeはどのような状態になっていますか？ (Forwarding Entryは正しく出来ていますか？)
- ◆ (*,G) と (S,G)のRPF interface(Incoming interface)はどのような状態になっているでしょうか？
またそのような状態になった理由は？

- Alcatel : **MLD Entryの確認**

```
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
```

```
=====
```

- Alaxala :

```
Alaxala# show ipv6 mld group
```

```
Date 2000/02/13 22:16:09 UTC
```

```
Total: 1 group
```

Group Address/Source Address	Interface	Version	Mode	Last
------------------------------	-----------	---------	------	------

Reporter	Uptime	Expires	MLDv1
----------	--------	---------	-------

Time	MLDv2Time
------	-----------

ff18::1:1		VLAN0003	2	EXCLUDE
-----------	--	----------	---	---------

fe80::7d4c:d2a0:dfed:d2a3	17:50	03:30	--
---------------------------	-------	-------	----

:--	03:30
-----	-------

MLD Entryの確認

- Cisco :

```
cisco#show ipv6 mld groups detail
Interface:      Vlan3
Group:          FF18::1:1
Uptime:         00:03:27
Router mode:    EXCLUDE (Expires: 00:03:41)
Host mode:      INCLUDE
Last reporter:  FE80::7D4C:D2A0:DFED:D2A3
Source list is empty
```

PIMの配信Treeの確認

- Acatel :

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

```
=====
PIM Groups ipv6
=====
```

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

```
-----
Groups : 2
=====
```

PIMの配信Treeの確認

- Alaxala :

```

Alaxala# show ipv6 mroute
Date 2000/02/13 22:18:29 UTC
Total: 2 routes, 1 group , 1 source

(S,G) 1 route -----
Group Address                Source Address
ff18::1:1                    2001:1:10::10
  uptime 20:10    expires 03:05    assert 00:00    flags LT    protocol SM
  incoming: VLAN0002    upstream: fe80::216:4dff:fe9b:a0fa
  outgoing: VLAN0003    uptime 20:10    expires --:--

(*,G) 1 route -----
Group Address                RP Address
ff18::1:1                    2001::2
  uptime 20:10    expires --:--    assert 00:00    flags LR    protocol SM
  incoming: VLAN0001    upstream: fe80::203:faff:feac:2432
  outgoing: VLAN0003    uptime 20:10    expires --:--
  
```

PIMの配信Treeの確認

- Cisco :

```
cisco#show ipv6 mroute
Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group,
       C - Connected, L - Local, I - Received Source Specific Host Report,
       P - Pruned, R - RP-bit set, F - Register flag, T - SPT-bit set,
       J - Join SPT
Timers: Uptime/Expires
Interface state: Interface, State

(*, FF18::1:1), 00:03:16/never, RP 2001::2, flags: SCJ
  Incoming interface: GigabitEthernet2/1
  RPF nbr: FE80::216:4DFF:FE1D:D1B8
  Immediate Outgoing interface list:
    Vlan3, Forward, 00:03:16/never

(2001:1:10::10, FF18::1:1), 00:04:05/00:00:13, flags: SJT
  Incoming interface: GigabitEthernet2/2
  RPF nbr: FE80::216:4DFF:FE9B:A0FA
  Inherited Outgoing interface list:
    Vlan3, Forward, 00:03:16/never
```



Multicast Forwarding Entryの確認

- Alcatel : 該当コマンド無し
- Alaxala :

```
Alaxala# show ipv6 mcache
Date 2000/02/13 22:21:01 UTC
Total: 1 route
Group Address                Source Address
ff18::1:1                    2001:1:10::10
    uptime: 22:45      expires: 03:30
    incoming:
      VLAN0002
    outgoing:
      VLAN0003      <snooping>
```



Multicast Forwarding Entryの確認

- Cisco :

```
cisco#show ipv6 mfib FF18::1:1
<省略>
(*,FF18::1:1) Flags: C
  RP Forwarding: 0/0/0/0, Other: 0/0/0
  LC Forwarding: 0/0/0/0, Other: 0/0/0
  HW Forwd:    0/0/0/0, Other: NA/NA/NA
  GigabitEthernet2/1 Flags: A NS
  Vlan3 Flags: F NS
  Pkts: 0/0/0
(2001:1:10::10,FF18::1:1) Flags:
  RP Forwarding: 9336/0/1376/0, Other: 25/25/0
  LC Forwarding: 0/0/0/0, Other: 0/0/0
  HW Forwd:    265399/707/1376/7602, Other: NA/NA/NA
  GigabitEthernet2/2 Flags: A
  Vlan3 Flags: F NS
  Pkts: 0/9243/9
```




RPFの確認 <Alcatel>

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

```
=====
IPv6 Route Table (Router: Base)
=====
Dest Prefix                               Type      Proto     Age           Pref
  Next Hop[Interface Name]                Metric
-----
2001::2/128                               Remote    OSPF3     01d00h39m    10
      FE80::216:4DFF:FE1D:D1B8-"ge-1/1/1"  101
-----
No. of Routes: 1
=====
```

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

```
=====
IPv6 Route Table (Router: Base)
=====
Dest Prefix                               Type      Proto     Age           Pref
  Next Hop[Interface Name]                Metric
-----
2001:1:10::/64                            Remote    OSPF3     01d00h37m    10
      FE80::216:4DFF:FE9B:A0FA-"ge-1/2/1"  201
-----
No. of Routes: 1
=====
```



RPFの確認 <Alaxala>

```
Alaxala# show ipv6 route 2001::2
<省略>
* NextHop fe80::203:faff:feac:2432%VLAN0001, Interface: VLAN0001
  Protocol <OSPFv3 intra>
  Source Gateway ----
  Metric/2      : 2/-
  Distance/2/3: 110/1/0

Alaxala# show ipv6 route 2001:1:10::10
<省略>
* NextHop fe80::216:4dff:fe9b:a0fa%VLAN0002, Interface: VLAN0002
  Protocol <OSPFv3 intra>
  Source Gateway ----
  Metric/2      : 102/-
  Distance/2/3: 110/1/0

Alaxala# show ipv6 rpf 2001:1:10::10
Date 2000/02/13 22:55:25 UTC
RPF information for ? (2001:1:10::10):
If VLAN0002 NextHop fe80::216:4dff:fe9b:a0fa
```

RPF の確認 <Cisco>

```
cisco#show ipv6 rpf 2001::2
RPF information for 2001::2
  RPF interface: GigabitEthernet2/1
  RPF neighbor: FE80::216:4DFF:FE1D:D1B8
  RPF route/mask: 2001::2/128
  RPF type: Unicast
  RPF recursion count: 0
  Metric preference: 110
  Metric: 2

cisco#show ipv6 rpf 2001:1:10::10
RPF information for 2001:1:10::10
  RPF interface: GigabitEthernet2/2
  RPF neighbor: FE80::216:4DFF:FE9B:A0FA
  RPF route/mask: 2001:1:10::/64
  RPF type: Unicast
  RPF recursion count: 0
  Metric preference: 110
  Metric: 102
```



LHRで起きたこと(Debug例) - 1

MLD reportを受信、RP向けRPF Neighborへ(*,G)Joinを送信

```
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"
```



LHRで起きたこと(Debug例) - 2

Source向けRPF Neighborへ (S,G)Joinを送信

```
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"
```



LHRで起きたこと(Debug例) - 3

RP向けのRPF neighborへ (S,G)RPT-Pruneを送信

```
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"

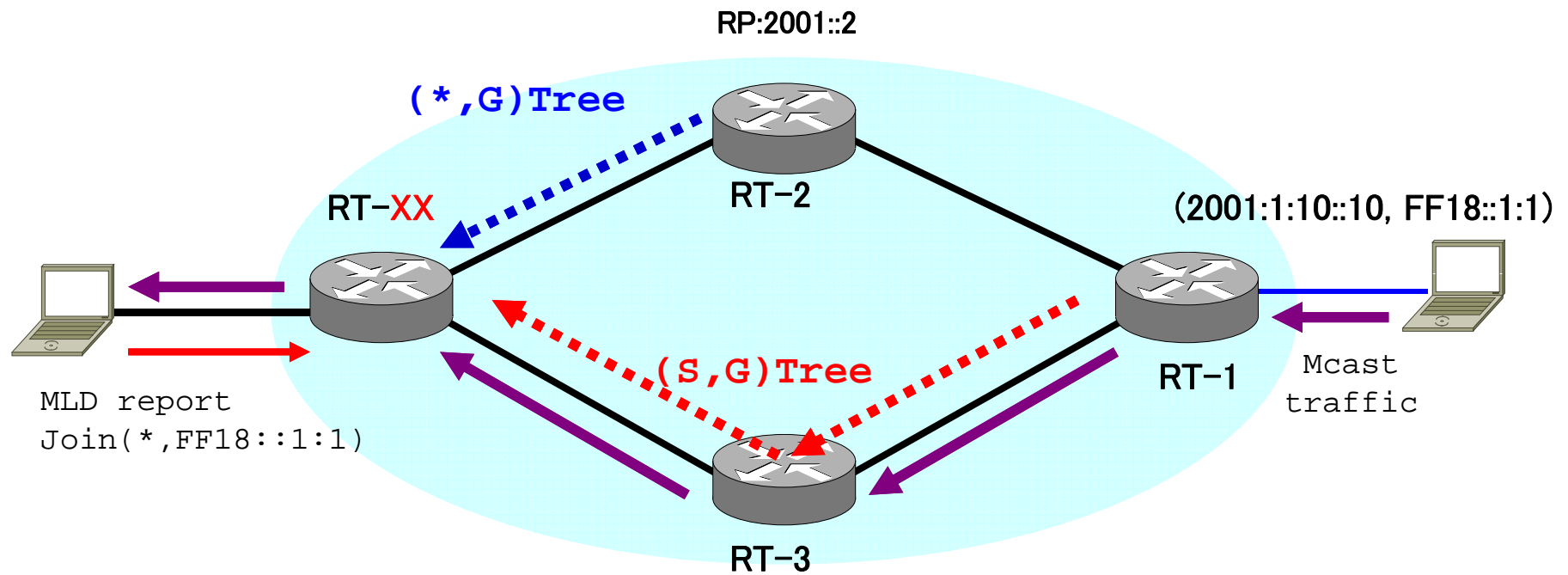
66 2009/11/07 16:24:45.55 JST MINOR: DEBUG #2001 Base PIM[Instance 1 Base]
"PIM[Instance 1 Base]: pimSGEncodeGroupSet
pimEncodeGroupSet: Encoding RPT Prune for source 2001:1:10::10"

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."
```



ASM GroupにJoinしている状態のTree





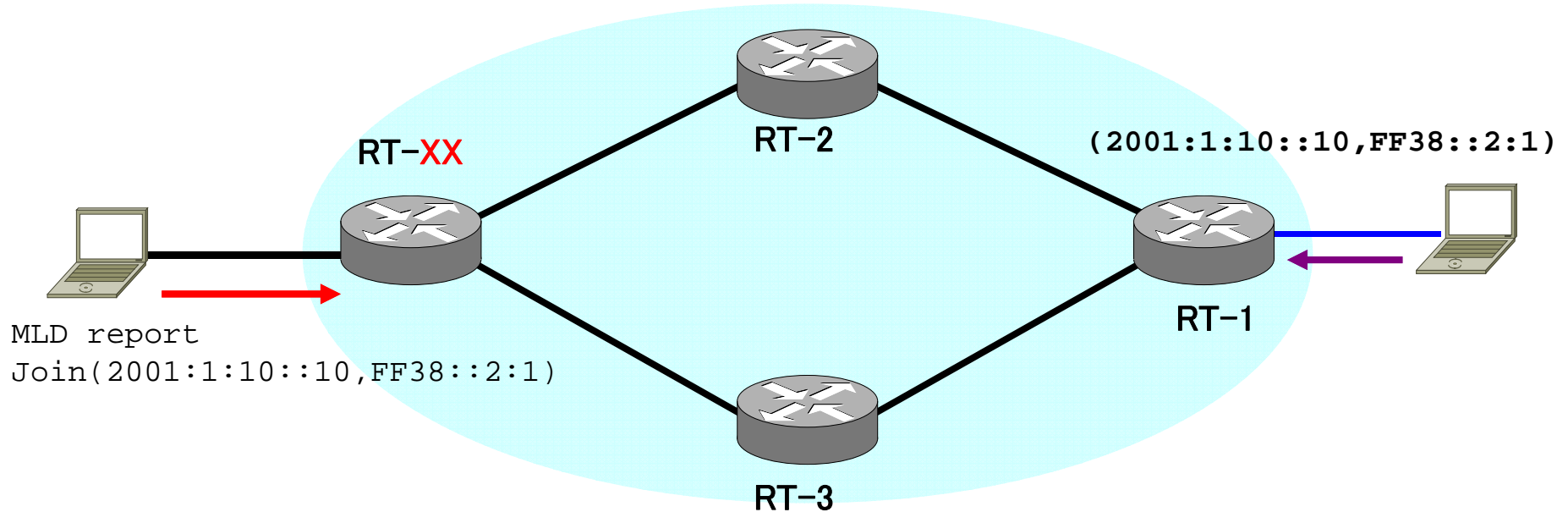
IPv4
EXHAUSTION

IPv6オペレータ育成プログラム

PIM-SSM 動作確認



SSM groupへJoin



- ◆VLC Client CLIからJoin (SSM)
コマンドプロンプト(vlcのディレクトリ)から
vlc rtp://[2001:1:10::10]@[ff38::2:1]:1235



- ◆ MLD Entryは正しく出来ていますか？ASMの場合とどのような違いがありますか？
- ◆ PIMの配信Treeはどのような状態になっていますか？ASMの場合とどのような違いがありますか？

MLD Entryの確認

- Alcatel :

```
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
```

```
=====
```

MLD Entryの確認

- Alaxala :

```
Alaxala# show ipv6 mld group ff38::2:1
Total: 1 group
Group Address/Source Address          Interface      Version Mode    Last
Reporter          Uptime Expires MLDv1
Time MLDv2Time
ff38::2:1                VLAN0003          2    INCLUDE
fe80::7d4c:d2a0:dfed:d2a3 05:04    ---:--    --
:--          --:--
    2001:1:10::10          -            -    -
fe80::7d4c:d2a0:dfed:d2a3 05:04    03:47
-            03:47
```

- Cisco :

```
cisco#show ipv6 mld groups ff38::2:1 detail
Interface:      Vlan3
Group:          FF38::2:1
Uptime:         00:00:22
Router mode:    INCLUDE
Host mode:      INCLUDE
Last reporter:  FE80::7D4C:D2A0:DFED:D2A3
Group source list:
Source Address          Uptime    Expires    Fwd  Flags
2001:1:10::10          00:00:22  00:03:57  Yes  Remote 4
```

PIMの配信Treeの確認

- Alcatel :

```
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
=====
```

PIMの配信Treeの確認

• Alaxala :

```
Alaxala# show ipv6 mroute ff38::2:1
Date 2000/02/13 23:34:23 UTC
Total: 1 route , 1 group , 1 source

(S,G) 1 route -----
Group Address                Source Address
ff38::2:1                    2001:1:10::10
    uptime 06:29    expires --:--    assert 00:00    flags L
protocol SSM
    incoming: VLAN0002    upstream: fe80::216:4dff:fe9b:a0fa
    outgoing: VLAN0003    uptime 06:29    expires --:--
```



PIMの配信Treeの確認

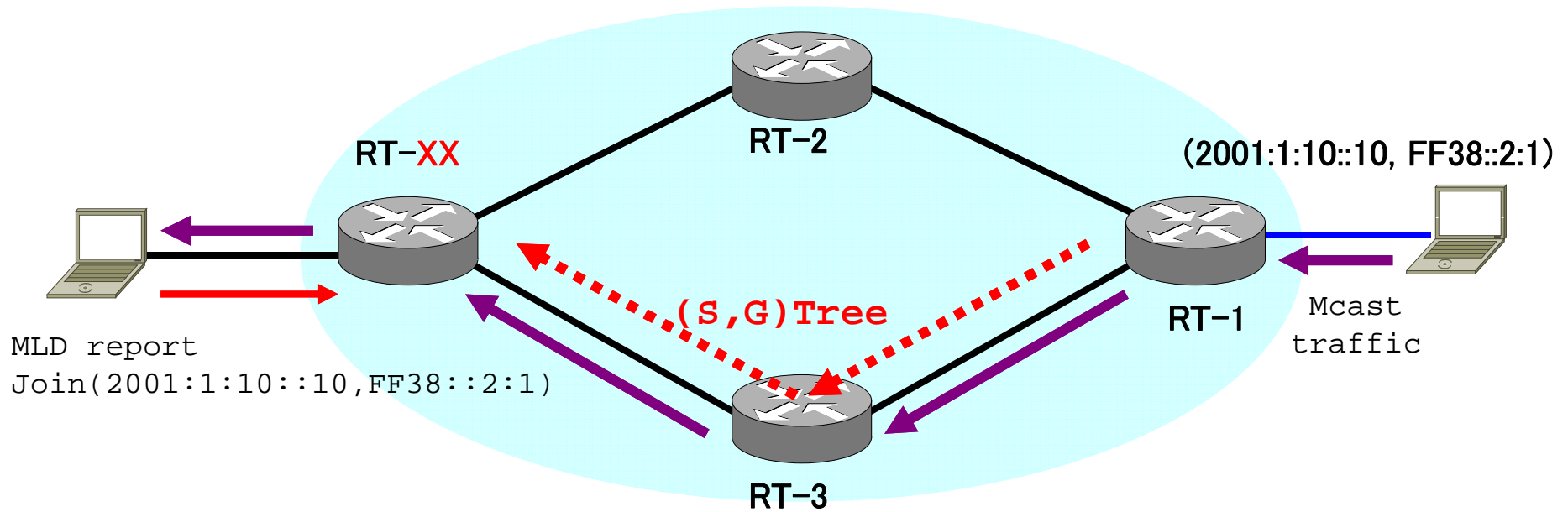
- Cisco :

```
cisco#show ipv6 mroute ff38::2:1
Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group,
       C - Connected, L - Local, I - Received Source Specific Host
Report,
       P - Pruned, R - RP-bit set, F - Register flag, T - SPT-bit set,
       J - Join SPT
Timers: Uptime/Expires
Interface state: Interface, State

(2001:1:10::10, FF38::2:1), 00:01:52/never, flags: sTI
  Incoming interface: GigabitEthernet2/2
  RPF nbr: FE80::216:4DFF:FE9B:A0FA
  Immediate Outgoing interface list:
    Vlan3, Forward, 00:01:52/never
```



SSM GroupにJoinしている状態のTree



(参考) たまに便利なコマンド

• Alcatel :

```
ALU # show router pim group ff38::2:1 detail
<省略>
Group Address      : FF38::2:1
Source Address     : 2001:1:10::10
<省略>
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

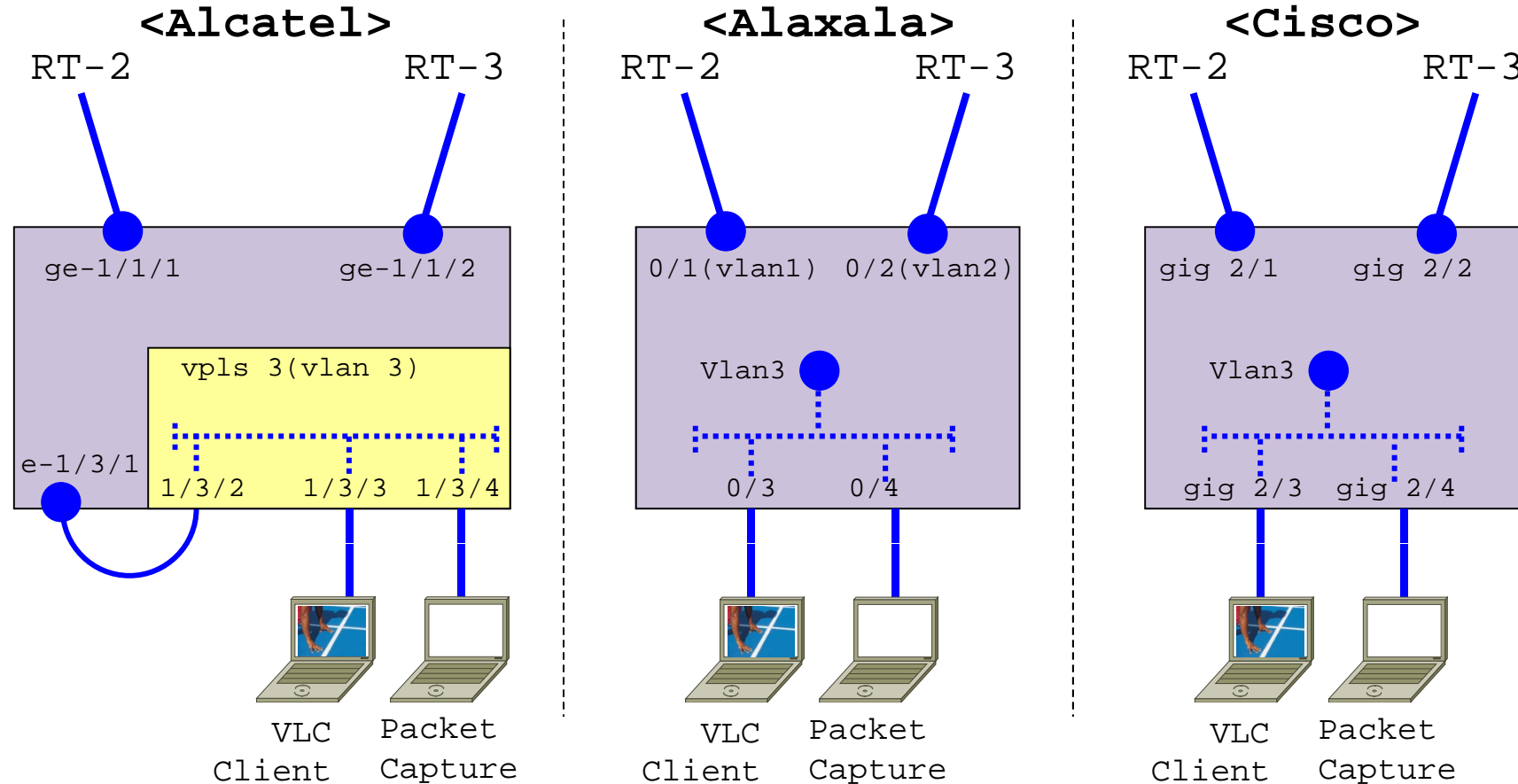
-----
Groups : 1
=====
```

• Cisco :

```
cisco#show ipv6 mfib active
Active IPv6 Multicast Sources - sending >= 4 kbps
Group: FF18::1:1
  Source: 2001:1:10::10
    RP Rate: 0 pps/0 kbps(1sec)
    LC Rate: 0 pps/0 kbps(1sec)
    HW Rate: 706 pps/7597 kbps(1sec)
```

MLD Snooping 動作確認

MLD Snoopingの確認



Clientと同一VLANに設定された別PortにPCを接続しPacket Captureを行い、Multicast Packetを受信しないことを確認



MLD Snooping entryの確認

- Alcatel :

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

```
Group Address
```

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 1/3/3
```

```
Group Address
```

Group Address	Mode	Type	From-VPLS	Up Time	Expires	Num Src	MC Stdbby
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
```

MLD Snooping entryの確認

- Alaxala :

```

Alaxala# show mld-snooping group
Date 2000/02/14 01:02:29 UTC
Total Groups: 2
VLAN counts: 1
VLAN: 3 Group counts: 2 IPv6 Multicast routing: On
  Group Address                MAC Address                Version  Mode
ff18::1:1                      3333.0001.0001            -       -
  Port-list:0/3
ff38::2:1                      3333.0002.0001            -       -
  Port-list:0/3

Alaxala# show mld-snooping port 0/3
Date 2000/02/14 01:02:33 UTC
Port 0/3 VLAN counts: 1
VLAN: 3 Group counts: 2
  Group Address                Last Reporter                Uptime    Expires
ff18::1:1                      fe80::7d4c:d2a0:dfed:d2a3    00:50     04:01
ff38::2:1                      fe80::7d4c:d2a0:dfed:d2a3    00:50     04:05
  
```

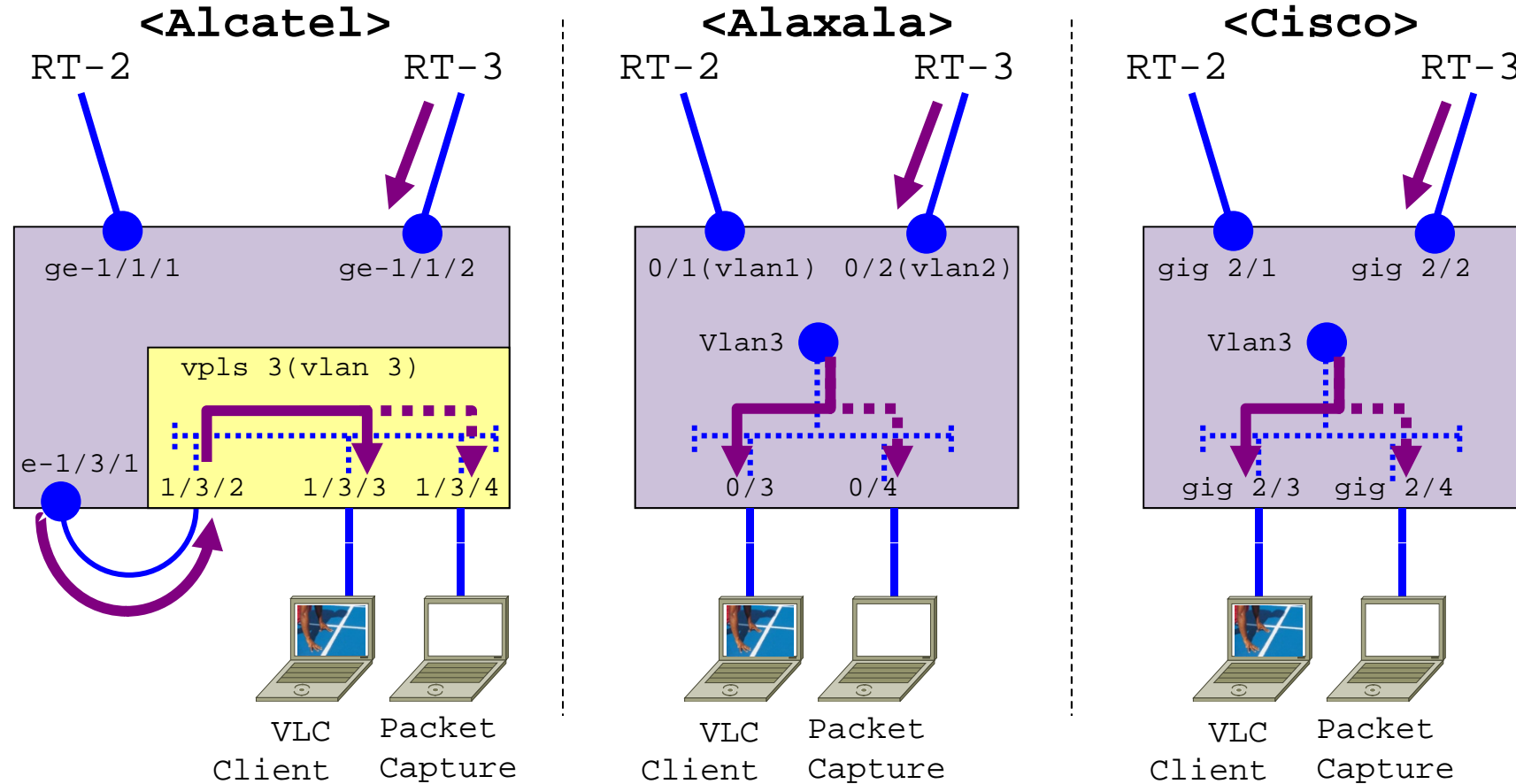
MLD Snooping entryの確認

- Cisco :

```
cisco#show mac-address-table multicast mld-snooping
```

vlan	mac address	type	learn	qos	ports
3	3333.0002.0001	static	Yes		- Gi2/3,Router
3	3333.0000.000d	static	Yes		- Gi1/2,Gi2/1,Gi2/2,Gi2/3 Router,Switch
3	3333.0000.0001	static	Yes		- Switch
3	3333.0001.0003	static	Yes		- Gi2/3,Router
3	3333.0001.0001	static	Yes		- Gi2/3,Router
3	3333.0000.0016	static	Yes		- Switch

MLD Snoopingの確認



MLD SnoopingをDisableにし、Multicast PacketがFloodされることを確認



Disabling/Enabling MLD-Snooping

- Alcatel :

```
ALU # configure service vpls 3 mld-snooping shutdown  
ALU # configure service vpls 3 mld-snooping no shutdown
```

- Alaxala :

```
Alaxala(config)# no ipv6 mld snooping  
Alaxala(config)# ipv6 mld snooping
```

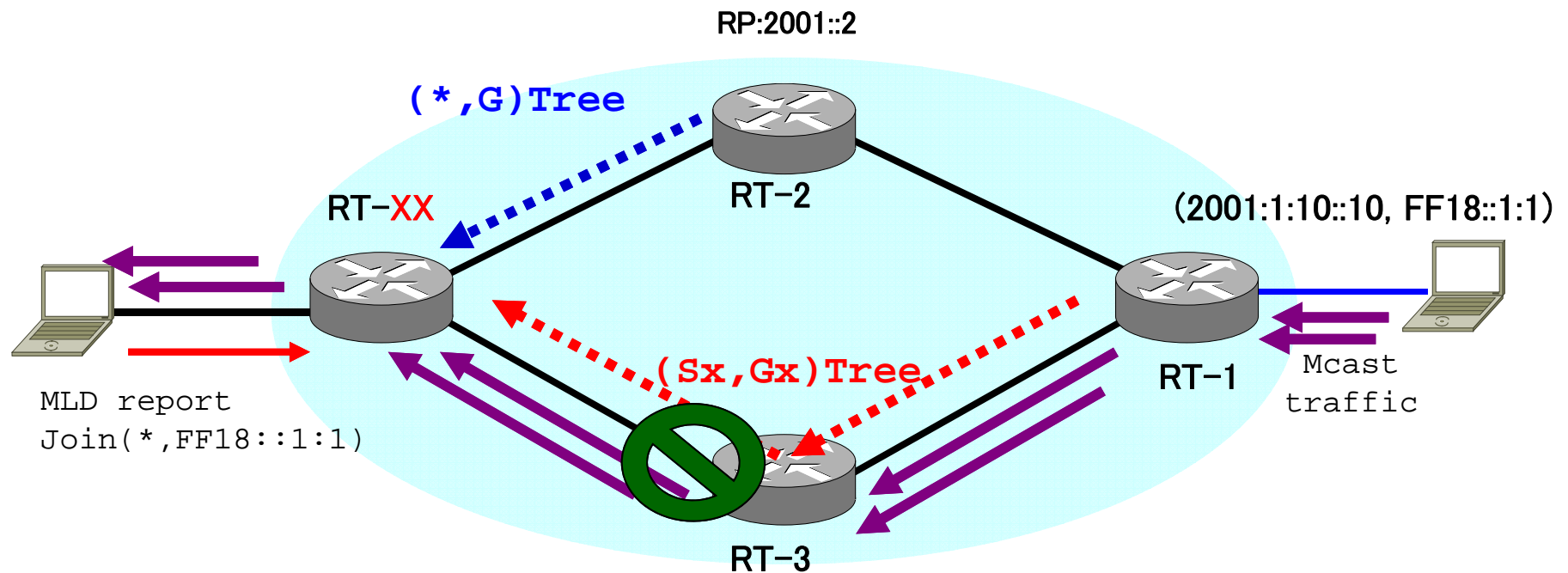
- Cisco :

```
cisco(config)#no ipv6 mld snooping  
cisco(config)#ipv6 mld snooping
```


PIMでのRouter Failover

PIMのRoute Failover

上位の経路をDownさせ、PIMでの経路の切り替わりを観察する。

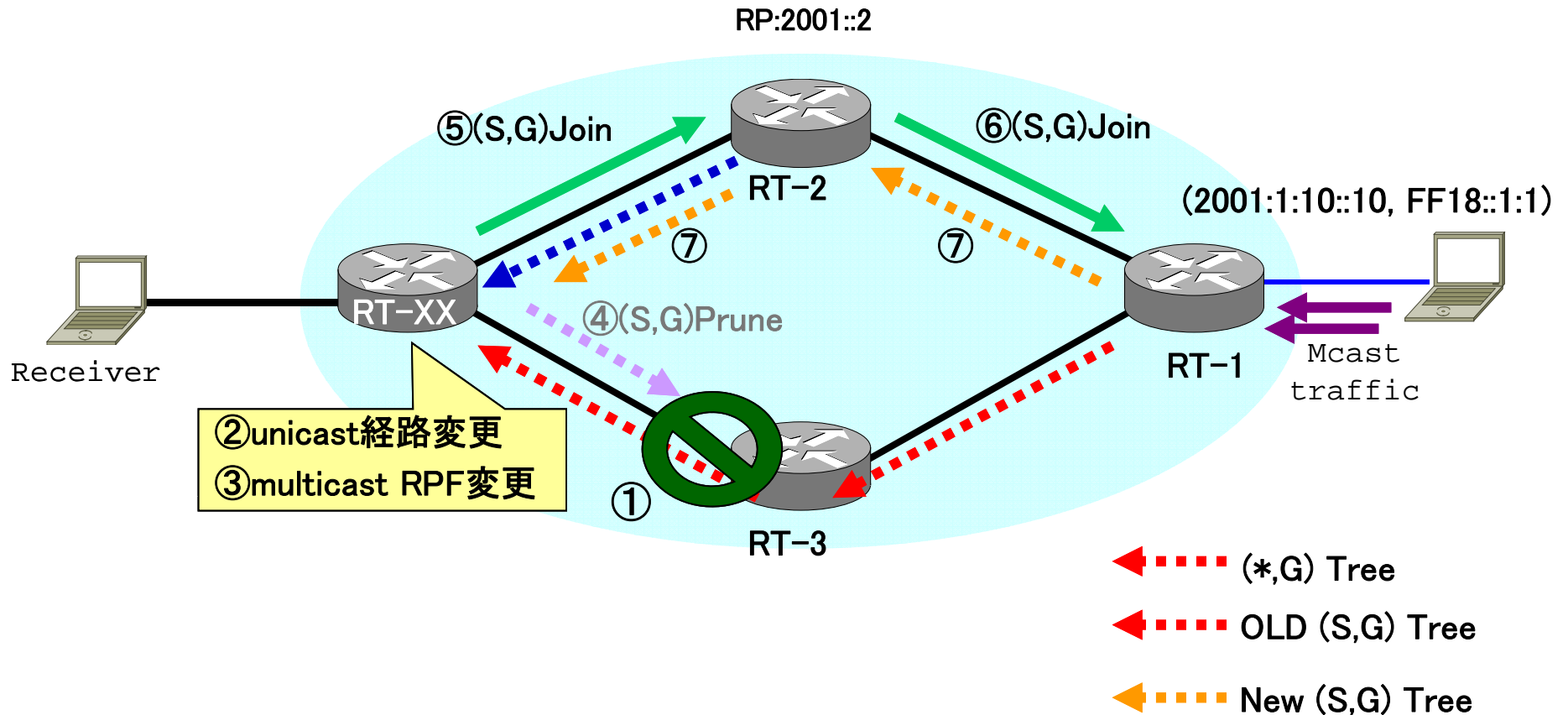


PIM 配信Treeがどのように変わったか？

show router pim group ipv6/ show ipv6 mroute で確認



PIMのRoute Failover 切り替え時のプロセス



Advanced Course

PIM DRの動作



PIM DR

下記コマンドでルータ～ルータ間のPortをno shutdown、
およびMLD-Snoopingでのmrouter portの設定をして下さい。

- Alcatel :

```
ALU # configure port 1/3/5 no shutdown  
ALU # configure service vpls 3 mld-snooping shutdown
```

- Alaxala :

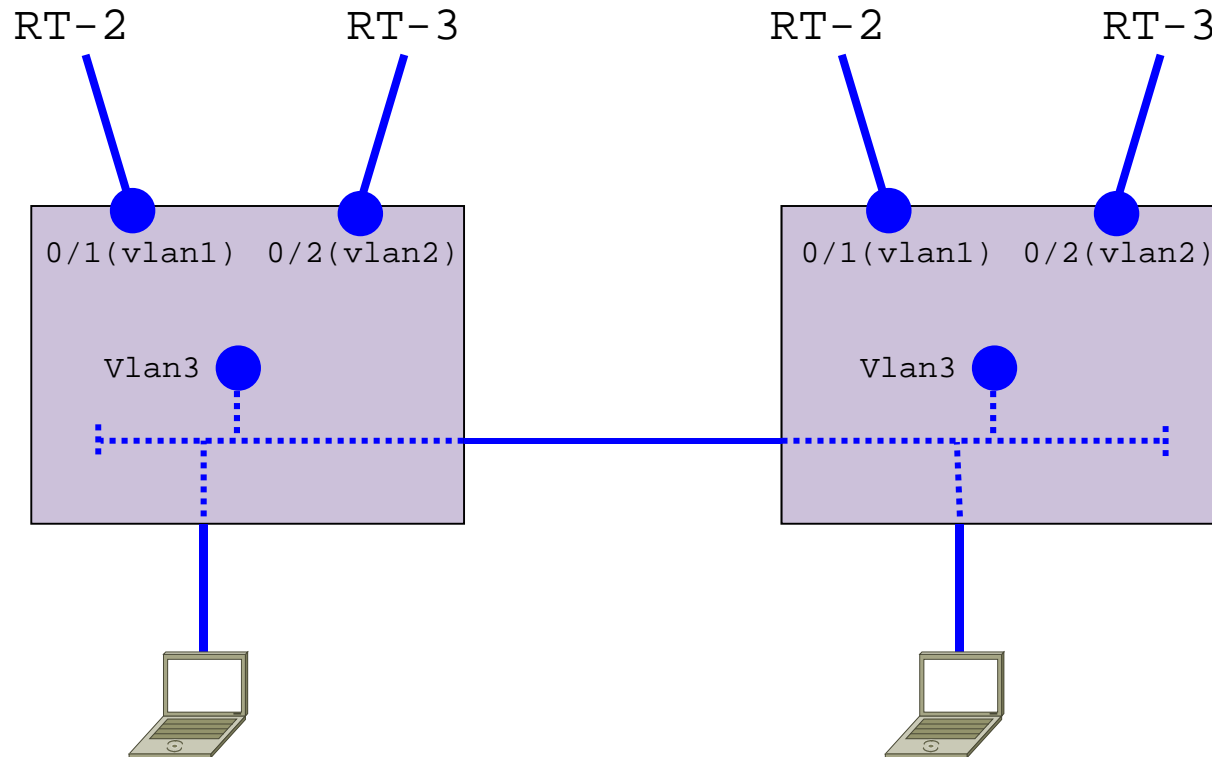
```
Alaxala(config)# interface gigabitethernet 0/5  
Alaxala(config-if)# no shutdown  
Alaxala(config)# interface vlan 3  
Alaxala(config-if)# ipv6 mld snooping mrouter interface gigabitethernet 0/5
```

- Cisco :

```
cisco(config)#interface gigabitEthernet 2/5  
cisco(config-if)#no shutdown
```



PIM DR



- ◆ どちらのRouterがPIM DRになっていますか？
- ◆ どちらのRouterがMLD Querierになっていますか？
- ◆ どちらのRouterがForwarderになっていますか？



Advanced Course

検証の際に便利な機能: Static MLD Join

実際にReceiverが居ない状態でも強制的にJoinさせることが可能
そのInterfaceの配下にClientが居る状態を静的にEmulate

Static MLD Join

- Alcatel :

```
ALU # configure router mld
ALU>config>router>mld# interface e-1/3/1
ALU>config>router>mld>if# static group ff18::1:1 starg
<interface上でASM Group(FF18::1:1)をStaticにJoinさせる。Source指定無しのため”starg”オプションを付ける>
ALU>config>router>mld>if# static group ff38::2:1 source 2001:1:10::10
<interface上でSSM Group(FF38::2:1)をStaticにJoinさせる。SSMのためSourceも指定する。>
```

- Cisco :

```
cisco(config)#interface vlan 3
cisco(config-if)#ipv6 mld static-group ff18::1:1
<interface上でASM Group(FF18::1:1)をStaticにJoinさせる。>
cisco(config-if)# ipv6 mld static-group ff38::2:1 2001:1:10::10
<interface上でSSM Group(FF38::2:1)をStaticにJoinさせる。SSMのためSourceも指定する。>
```


Static MLD Join

- Alaxala :

```
Alaxala(config)# ipv6 access-list asm-static
Alaxala(config-ipv6-acl)# permit ipv6 any host ff18::1:1
Alaxala(config-ipv6-acl)# exit
<JoinさせるGroup AddressをACL “asm-static”で指定する。(ASM用)>
Alaxala(config)# interface vlan 3
Alaxala(config-if)# ipv6 mld static-group asm-static
<interface上で”asm-static”で指定したGroupをStaticにJoinさせる。>
Alaxala# ipv6 access-list ssm-static
Alaxala(config-ipv6-acl)# permit ipv6 any host ff38::2:1
<JoinさせるGroup AddressをACL “ssm-static”で指定する。(SSM用)>
Alaxala(config)# ipv6 mld ssm-map enable
<ssm-mappingをEnableにする>
Alaxala(config)# ipv6 mld ssm-map static ssm-static 2001:1:10::10
<“ssm-static”で指定したGroup AddressにMapするSource Addrを指定(SSM Mapping)>
Alaxala(config)# interface vlan 3
Alaxala(config-if)# ipv6 mld static-group ssm-static
<interface上で”ssm-static”で指定したGroupをStaticにJoinさせる。>
```



Advanced Course

SSM mapping

特定のGroup Addressを特定のSource AddressにMapping
MLDv1 Clientしか無い>(* ,G)Joinしか出せない)がSSMをしたい場合等に有効

- Alcatel :

```
ALU # configure router mld
ALU >config>router>mld# ssm-translate grp-range ff38::2:1 ff38::2:1 source
2001:1:10::10
<Group AddressのRange(Start/End)とそれにMapするSource Addrを指定>
```

- Alaxala :

```
Alaxala(config)# ipv6 access-list ssm-static
Alaxala(config-ipv6-acl)# permit ipv6 any host ff38::2:1
<mappingさせるGroup AddressのRangeをACL “ssm-static”で指定>
Alaxala(config)# ipv6 mld ssm-map enable
<ssm-mappingをEnableにする>
Alaxala(config)# ipv6 mld ssm-map static ssm-static 2001:1:10::10
<“ssm-static”で指定したGroup AddressにMapするSource Addrを指定>
Alaxala(config-if)# exit
```

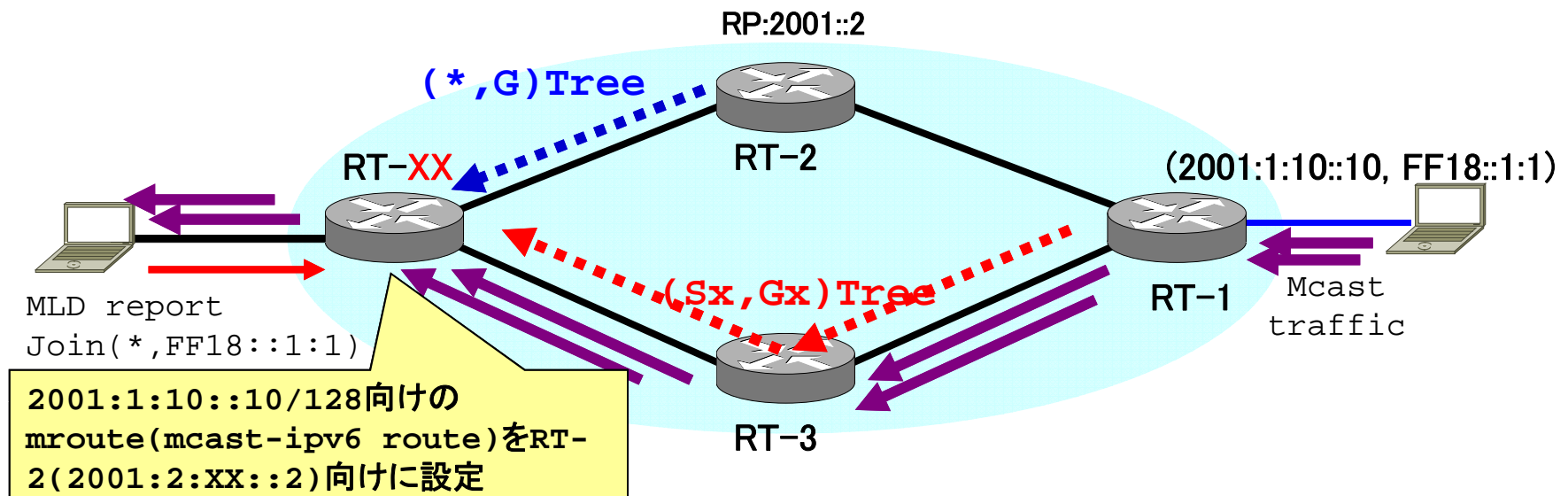
- Cisco :

```
cisco(config)#ipv6 access-list ssm-test
cisco(config-ipv6-acl)#permit ipv6 any host ff38::2:1
<mappingさせるGroup AddressのRangeをACL “ssm-test”で指定>
cisco(config)#ipv6 mld ssm-map enable
<ssm-mappingをEnableにする>
cisco(config)#ipv6 mld ssm-map static ssm-test 2001:1:10::10
<“ssm-static”で指定したGroup AddressにMapするSource Addrを指定>
```



(参考)何かのときに便利な機能: static mroute

Unicastの経路に影響を及ぼさずにMulticastのRouteのみを変更したい場合
MulticastのRPF決定にのみ使用されるstatic routeが使用できる。



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

```
cisco(config)#ipv6 route 2001:1:10::10/128 2001:2:XX::2 multicast
```



まとめ: Trouble Shootingの考え方

- まずはSourceがきちんとTrafficを出しているかを確認する。
 - TTLは1になっていないか？
 - Source/Group Addressは合っているか？
- Receiver側からSource/RP側へさかのぼって確認していく。
 - LHRでMLD Entryは正しく出来ているか？
 - LHRでPIM Neighborは正しく認識しているか？
 - LHRでPIM Entry(mroute)は正しく出来ているか？
 - LHRで意図したRPF Neighbor/Interfaceになっているか？
 - LHRからRPF NeighborへJoinを送信しているか？

↓

 - 上位のRouterでPIM Entryは正しく出来ているか？
 - 上位のRouterで意図したRPF Neighbor/Interfaceになっているか？
 - 上位のRouterからRPF NeighborへJoinを送信しているか？



Sourceまでさかのぼっていく

(参考) Debugコマンド

- Alcatel :

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

- Alaxala :

```
Alaxala# show tcpdump interface vlan 3 detail | grep multicast
Alaxala# show tcpdump interface vlan 3 detail | grep pim
Alaxala# show tcpdump interface vlan 3 detail | grep ip6
```

- Cisco :

```
cisco#debug ipv6 pim group
cisco#debug ipv6 mrib route
cisco#debug ipv6 mld group
```