Intro

- Multicast is inherent to the IPv6 protocol
- No broadcasts
  - Multicast used instead
- But some parts need to be configured
  - for building the multicast trees
  - for topology information (routing)
IPv6 multicast

Multicast addressing
MLD & MLDv2
PIM SM/SSM
Interdomain multicast

Multicast addressing

- Multicast addresses format: (RFC 3513)

<table>
<thead>
<tr>
<th></th>
<th>8 bits</th>
<th>4 bits</th>
<th>4 bits</th>
<th>112 bits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1111</td>
<td>1111</td>
<td>flags</td>
<td>scope</td>
</tr>
<tr>
<td>F</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 8 high order bits set to 1 → Addresses derived from FF00::/8 prefix
- flag field(4 bits):
  0RPT values
  - T = 0 for permanent addresses (Defined by IANA)
  - T = 1 for transient addresses
  - Bits P and R discussed later
- scope field → Makes it possible to limit the scope of the multicasting
  - 0 - Reserved
  - 1 - Node-local
  - 2 - Link-local
  - 3 - Subnet-local
  - 4 - Admin-local
  - 5 - Site-local
  - 6 - Organization-local
  - 7 - Site-multicast
  - 8 - Organization-multicast
  - 9 - Site-and-organization-local
  - 10 - Site-and-organization-multicast
  - 11 - Global (Internet)
  - F - Reserved
Multicast addressing

- Scopes must be configured on routers!
- Examples of IANA allocated addresses
  - Flag bits T=P=R=0
    - Flag = 0
  - Group ID 101 → NTP servers
    - FF01:0:0:0:0:0:0:101 : All the NTP servers on the sender’s host
    - FF02:0:0:0:0:0:0:101 : All the NTP servers on the sender’s link
    - FF05:0:0:0:0:0:0:101 : All the NTP servers on the sender’s site
    - FF0E:0:0:0:0:0:0:101 : All the NTP servers on the Internet

Reserved multicast addresses: examples [RFC 2375]

- Addresses available only for a given scope
  - FF02:0:0:0:0:0:0:1 : All the nodes of the link
  - FF02 :0:0:0:0:0:0:2 : All the routers of the link
  - FF05 :0:0:0:0:0:0:2 : All the routers of the site
  - FF02 :0:0:0:0:0:0: D : All the PIM routers of the link
  - ...
- Addresses available for all scopes
  - FFX0 :0:0:0:0:0:0:101 : Network Time Protocol (NTP)
  - FFX0 :0:0:0:0:0:0:109 : MTP Multicast Transport Protocol
  - ...
IPv6 multicast and Ethernet

- Ethernet is multicast capable (not always implemented)
- Requires 8th bit of MAC address to be set to 1
- For IPv6: @MAC = 33-33-xx-yy-zz-kk
- xx-yy-zz-kk are 32 lower bits of the IPv6 address
- Example:
  - MAC@ = 33-33-12-34-56-78

Solicited node multicast addresses (for NDP)

- Multicast address built from unicast address
- Concatenation of
  - FF02::1:FF00:0/104
  - 24 low order bits of the unicast address
- Nodes build their own IPv6 solicited node multicast address
- Nodes that know the IPv6 address of a host but not its MAC address can use the solicited node multicast address
  - NDP protocol (Neighbor Discovery Protocol)
  - Protocol for DAD management
- Avoids sending MAC broadcasts (FF-FF-FF-FF-FF)
- Example:

```
FF02:0000:0000:0000:0001:FF00:0000/104
FF02:0000:0000:0000:0001:FF24:87c1
33-33-FF-24-87-C1 -> MULTICAST MAC ADDRESS
```
Multicast addresses derived from unicast prefixes (RFC 3306)

- **Flag : ORPT**

<table>
<thead>
<tr>
<th>Flag</th>
<th>scop</th>
<th>reserved</th>
<th>Plen</th>
<th>Network prefix</th>
<th>Group ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>11111111</td>
<td>8 bits</td>
<td>4</td>
<td>4</td>
<td>8 bits</td>
<td>8</td>
</tr>
</tbody>
</table>

Flag : ORPT

- P=0  \(\rightarrow\) Address not based on the unicast prefix
- P=1  \(\rightarrow\) Address based on the unicast prefix

If P=1  \(\rightarrow\) T=1  \(\rightarrow\) FF30::/12 prefix
\((T=1 \text{ because not allocated by IANA})\)

Reserved : 0

Plen: Prefix length

Network prefix

Example:
- Prefix 2001:6600::/32  (RENATER)
- Address FF3E:20:2001:6600:0:0:1234:abcd

SSM addresses

- Are also RFC3306 addresses
- SSM addresses range: FF3X::/32
- Only addresses in FF3X::/96 should be used now. These are RFC3306 addresses with:
  - Plen = 0
  - Prefix = 0
- Example:
  - FF3x:1234:abcd /96
  - 1234:abcd being the Group ID
Multicast addresses allocation

- « Manual » choice of multicast address and port
- Dynamic
  - Session Announcement Protocol (SAP), ID
    - SDR implements SAP (not scalable for a global scope)
  - MADCAP, RFC 2730
    - Multicast Address Dynamic Client Allocation Protocol (too much complex, very few implementations and no deployment)
  - GLOP, RFC 2770
    - Useless as we have RFC 3306
- Multicast addresses derived from unicast prefixes (RFC 3306)
  - Any host can derive a multicast address from the network prefix where it is connected
  - Makes allocation easier
  - How to assign addresses to end user remains a problem

IPv6 multicast

Multicast addressing
- MLDv1 & MLDv2
- PIM SM/SSM

Interdomain multicast
Multicast Listener Discovery (MLD)

RFC 2710 (MLD version 1)
RFC 3810 (MLD version 2)

MLD

• Interaction protocol between
  - Multicast router on the link-local
  - Multicast hosts on the link-local
• Host can say: « I want to join group FF0E::1234 and receive the related flow »
• MLD <-> IGMPv2 <-> ASM only
• MLDv2 <-> IGMPv3 <-> SSM + ASM
• MLD messages are sent in ICMPv6 packets
MLD packet

IPv6 Header
next header = 0 (Hop-by-hop)

Hop-by-hop extension
Option = Router alert
Next header = 58 (ICMPv6)

MLD message
Message type: ICMPv6

MLDv1 message

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
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</tr>
<tr>
<td>0</td>
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<td>3</td>
</tr>
</tbody>
</table>

• Type : Messages types
  - General Query et Multicast-Address-Specific Query [130]
  - Multicast Listener Report [131]
  - Multicast Listener Done [132]

• Code : Set to 0 by sender and ignored then

• Checksum : for the complete packet (headers+MLD message)

• Maximum Response Delay : For query messages, time by which hosts must respond

• Reserved : Not used, set to 0 and ignored then

• Multicast Address : IPv6 multicast address or 0 according to the type of MLD message
MLDv1 : Join a group

- ff1e::2:4444
- ff1e::2:4444
- ff1e::5d:8888

Host 1
Host 2
Host 3

Send Report for ff1e::2:4444
Periodically send Multicast Listener Query to ff02::1

Send Report for ff1e::5d:8888

MLDv1 : Leave a group

- ff1e::2:4444
- ff1e::2:4444
- ff1e::5d:8888

Host 1
Host 2
Host 3

Send Multicast Listener Done for ff1e::2:4444 to ff02::2

Send Multicast Specific Query for ff1e::5d:8888
Send Query for ff1e::5d:8888
MLDv1 : Leave a group

DITCHE, Port Elizabeth, Sep. 2005

MLDv2 (RFC 3810)

- Management of group & sources
  - INCLUDE: to receive packets from sources specified in the MLDv2 message
  - EXCLUDE: to receive packets from all sources except the ones specified in the MLDv2 message
- 2 types of messages
  - Multicast listener query messages
  - Multicast listener report messages
- Interoperable with MLDv1
IPv6 multicast

Multicast addressing
MLDv1 & MLDv2
PIM SM/SSM
Interdomain multicast

PIM SM/SSM

- Protocol Independant Multicast
- No difference with PIM for IPv4
  - Except PIM messages are sent with link-local IPv6 address
- Creates multicast trees between senders and receivers (Diffusion trees)
- Not a routing protocol
- Relies on other routing protocols (MBGP, static...)
IPv6 multicast

Multicast addressing
MLDv1 & MLDv2
PIM SM/SSM

Interdomain multicast

Interdomain multicast

- Not an SSM problem. Source specific trees created from senders to receivers across domains
- ASM problem: was solved in the IPv4 world with MSDP (Multicast Source Discovery Protocol)
Interdomain multicast

- No one wants MSDP for IPv6, not manageable/scalable
- SSM IETF lobby
  - Some SSM apps already developed
- How to solve N -> M multicast?
  - Application / Middleware?
  - Not there yet [work ongoing]
- Embedded-RP – RFC 3956
  - One unique PIM domain with shared RPs
  - Embedded is a solution for group-to-RP mapping
  - Requires support in all PIM routers

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Embedded-RP

- **Flag : ORPT**

<table>
<thead>
<tr>
<th>11111111</th>
<th>flag</th>
<th>scop</th>
<th>res</th>
<th>rpad</th>
<th>Plen</th>
<th>Network prefix</th>
<th>Group ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 bits</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>64 bits</td>
<td>32 bits</td>
</tr>
</tbody>
</table>

Flag : 0RPT

- R=1 → Embedded-RP address
- If R=1 → P=1 → T=1
- FF7x::/16 addresses

- Res : 0
- Rpad : last 4 bits of the RP address
- Plen: Prefix length

**Network prefix**

E.g. RP address 2001:660:3001:104:8

Embedded RP