IPv6 Multicast
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>Flag</th>
<th>Scope</th>
<th>Group ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>F</td>
<td>112 bits</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
  - 8 - Organization-local
  - E - Global (Internet)
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
  – FF0X :0:0:0:0:0:0:101 : Network Time Protocol (NTP)
  – FF0X :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-FF)
- Example:

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

- **Flag : 0RPT**

<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>4</td>
<td>4</td>
<td>8 bits</td>
<td>8</td>
<td>64 bits</td>
</tr>
</tbody>
</table>

Flag : 0RPT

- **P=0** → Address not based on the unicast prefix
- **P=1** → Address based on the unicast prefix

If **P=1** → **T=1** → FF30::/12 prefix

*(T=1 because not allocated by IANA)*

**Reserved : 0**

**Plen**: Prefix length

**Network prefix**

Example: prefix 2001:660::/32 (RENATER)

address FF3E:20:2001:660:0:0:1234: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
Where and when?

MLD packet

<table>
<thead>
<tr>
<th>IPv6 Header</th>
<th>Hop-by-hop extension</th>
<th>MLD message</th>
</tr>
</thead>
</table>
| next header = 0 (Hop-by-hop) | Option = Router alert
Next header = 58 (ICMPv6) | Message type: ICMPv6 |
MLDv1 message

- **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

Where and when?

Send Report for ff1e::2:4444

Periodically send Multicast Listener Query to ff02::1

Send Report for ff1e::5d:8888
MLDv1 : Leave a group

Where and when?
MLDv1: Leave a group

Where and when?
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…)

Where and when?
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
## Embedded-RP

### Flag: 0RPT

<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

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*Where and when?*
Embedded RP

Where and when?