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              Support Multicast Services Using Proxy Mobile IPv6
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Abstract

   This document describes how multicast mobility services can be
   supported with Proxy Mobile IPv6 [RFC5213], Multicast Listener
   Discovery (MLD) [RFC3810], and Internet Group Management Protocol
   (IGMP) [RFC3376]. Specifically, this document analyzes scenarios for
   multicast listener mobility. It proposes the use of a dedicated Local
   Mobility Anchor as the topological anchor point for multicast
   traffic, while the Mobile Access Gateway serves as an IGMP/MLD proxy.
   There are no impacts to the Mobile Node to support multicast listener
   mobility.

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1. Introduction

   Proxy Mobile IPv6 [RFC5213] is a network-based approach to solving
   the IP mobility problem. In a Proxy Mobile IPv6 (PMIPv6) domain, the
   Mobile Access Gateway (MAG) behaves as a proxy mobility agent in the
   network and does the mobility management on behalf of the Mobile Node
   (MN). The Local Mobility Anchor (LMA) is the home agent for the MN
   and the topological anchor point. PMIPv6 was originally designed for
   unicast traffic.

   The Internet Group Management Protocol (IGMPv3) [RFC3376] is used by
   IPv4 hosts to report their IP multicast group memberships to
   neighboring multicast routers. Multicast Listener Discovery (MLDv2)
   [RFC3810] is used in a similar way by IPv6 routers to discover the
   presence of IPv6 multicast hosts. Also, the IGMP/MLD proxy [RFC4605]
   allows an intermediate (edge) node to appear as a multicast router to
   downstream hosts, and as a host to upstream multicast routers. IGMP
   and MLD related protocols were not originally designed to address IP

mobility of multicast listeners (i.e. IGMP and MLD protocols were
originally designed for fixed networks).

Supporting mobility of multicast traffic has been under discussions
within the MULTIMOB working group. This document focuses on
addressing multicast listener mobility using the PMIPv6 and IGMP/MLD
protocols. It proposes the use of a dedicated LMA as the topological
mobility anchor point for multicast traffic, while the MAG serves as
an IGMP/MLD proxy.

2. Conventions and Terminology

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT",
"SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this
document are to be interpreted as described in [RFC-2119].

This document uses the terminology defined in [RFC5213], [RFC3775],
and [RFC3810].

3. Solution

A PMIPv6 domain may receive data from both unicast and multicast
sources. A dedicated LMA can be used to serve as the mobility anchor
for multicast traffic. Unicast traffic will go normally to the other
LMAs in the PMIPv6 domain. This section describes how the multicast
LMA works in scenarios of mobile node attachment and multicast
mobility.

3.1. Architecture

Figure 1 shows an example of a PMIPv6 domain supporting multicast
mobility. LMA1 is dedicated to unicast traffic, and LMA2 is dedicated
to multicast traffic. Note that there can multiple LMAs dedicated to
unicast traffic (not shown in Figure 1) in a given PMIPv6 domain.
However, we assume a single LMA dedicated to multicast traffic in a
PMIPv6 domain (as shown in Figure 1).

Also in this architecture, all MAGs that are connected to the
multicast LMA must support the MLD proxy [RFC4605] function.
Specifically in Figure 1, each of the MAG1-LMA2 and MAG2-LMA2 tunnel
interface defines an MLD proxy domain. The MNs are considered to be
on the downstream interface of the MLD proxy (in the MAG), and LMA2
is considered to be on the upstream interface (of the MAG) as per
[RFC4605]. Note that MAG could also be an IGMP proxy. For brevity
this document will refer primarily to MLD proxy, but all references
to "MLD proxy" should be understood to also include "IGMP/MLD proxy"
functionality.

As shown in Figure 1, MAG1 may connect to both unicast and multicast
LMAs. Thus, a given MN may simultaneously receive both unicast and
multicast traffic. In Figure 1, MN1 and MN2 receive unicast traffic,
multicast traffic, or both, whereas MN3 receives multicast traffic
only.

```
                              +--------------+
                              |Content Source|
                              +--------------+
                                     |
                                     |
       ***   ***   ***   ***         ***   ***   ***   ***
        *    **    **    **    *      *    **    **    **    *
       *                      *    *                        *
       *   Unicast Traffic    *  *   Multicast Traffic   *
       *                      *    *                        *
        *    **    **    **    *      *    **    **    **    *
        ***   ***   ***   ***         ***   ***   ***   ***
             |                             |
             |                             |
             |                             |
           +-----+                     +------+
  Unicast  | LMA1|                     | LMA2 |    Multicast
  Anchor   +-----+                     +------+     Anchor
              \\                       // ||
               \\                     //  ||
                \\                   //   ||
                 \\                 //    ||
                  \\               //     ||
                   \\             //      ||
                    \\           //       ||
                     \\        //         ||
                      \\     //           ||
                     +-----+       +-----+
                     | MAG1|       | MAG2|     MLD Proxy
                     +-----+       +-----+
                      |    |          |
                      |    |          |
                    {MN1} {MN2}    {MN3}
```

          Figure 1 Architecture of Dedicated LMA as Multicast Anchor

3.2. Multicast Establishment

   Figure 2 shows the procedure when MN1 attaches to MAG1, and
   establishes associations with LMA1 (unicast) and LMA2 (multicast).

```
     MN1                     MAG1        LMA1        LMA2
      |                  (MLD Proxy) (Unicast) (Multicast)
 MN attaches to MAG1          |           |           |
      |                       |           |           |
      |------Rtr Sol----- ->|             |           |
      |                       |--PBU -- >|            |
      |                       |           |           |
      |                       |<-- PBA --|            |
      |                       |           |           |
      |                       |=Unicast= |            |
      |                       | Tunnel   |            |
      |<-----Rtr Adv ------ |             |           |
      |                       |           |           |
      |< ------ Unicast Traffic------ >|              |
      |                       |           |           |
 MN requires multicast services          |           |
      |                       |           |           |
      |---MLD Report (G) -->|             |           |
      |                       |           |           |
      |                       |---- Aggregated ---> |
      |                       |    MLD Report (G)    |
      |                       |           |           |
      |                       |==Multicast Tunnel ==|
      |                       |           |           |
      |                       |           |           |
      |< --------- Multicast Traffic ----------- >|
      |                       |           |           |
```

       Figure 2 MN Attachment and Multicast Service Establishment

   In Figure 2, MAG1 first establishes the PMIPv6 tunnel with LMA1 for
   unicast traffic as defined in [RFC5213] after being triggered by the
   Router Solicitation message from MN1. Also, MN1 sends the MLD report
   message (when required by its upper layer applications) as defined in
   [RFC3810]. MAG1 acting as a MLD Proxy as defined in [RFC4605] will
   then send an Aggregated MLD Report to the multicast anchor, LMA2.
   This will then trigger establishment of a multicast tunnel between
   MAG1 and LMA2.

[3.3](). Multicast Mobility

   Figure 3 illustrates the mobility scenario for multicast traffic.
   Specifically, MN2 with ongoing multicast subscription moves from MAG1
   to MAG2. Note that in this scenario MAG2 is connected only to LMA2
   (multicast) and does not receive unicast traffic. Of course, if it
   was desired to support unicast traffic, the architecture will easily
   allow MAG2 to also connect to LMA1 to support unicast traffic.

   After MN2 mobility, MAG2 acting in its role of MLD proxy will send an
   MLD Query to the newly observed MN on its downlink. Assuming that
   the subsequent MLD Report from MN2 requests membership of a new
   multicast group (from MAG2's point of view), this will then result in
   an Aggregated MLD Report being sent to LMA2 from MAG2.

   When MN2 detaches, MAG1 may keep the multicast tunnel with the
   multicast LMA2 if there are still other MNs using the multicast
   tunnel. Even if there are no MNs currently on the multicast tunnel,
   MAG1 may decide to keep the multicast tunnel for potential future
   use.

```
      MN2           MAG1         MAG2          LMA1        LMA2
       |         (MLD Proxy) (MLD Proxy)  (Unicast)(Multicast)
       |            |           |            |           |
   MN Attached      |           |            |           |
     To MAG1        |           |            |           |
       |            |           |            |           |
       |            |========= Multicast Tunnel ======= |
       |            |           |            |           |
   MN Detaches      |           |            |           |
     From MAG1      |           |            |           |
       |            |           |            |           |
       |            |           |            |           |
   MN Attaches      |           |            |           |
     To MAG2        |           |            |           |
       |            |           |            |           |
       |---------Rtr Sol------ >|            |           |
       |            |           |            |           |
       |<-----Rtr Adv --------- |            |           |
       |            |           |            |           |
       |            |           |            |           |
       |<---------MLD Query---- |            |           |
       |            |           |            |           |
       |---MLD Report (G) ----> |            |           |
       |            |           |            |           |
       |            |           |---- Aggregated -----> |
       |            |           |     MLD Report (G)    |
       |            |           |            |           |
       |            |           |==Multicast Tunnel === |
       |            |           |            |           |
       |            |           |            |           |
       |< --------- Multicast Traffic ---------------- >|
       |            |           |            |           |
       |            |           |            |           |
```

                   Figure 3 Multicast Mobility Signaling

[3.4](#). Advantages

   One of the main advantages of the proposed architecture of a
   dedicated multicast LMA, and MAGs acting as a Proxy MLD, is that it
   allows a PMIPv6 domain to closely follow a simple multicast tree
   topology for Proxy MLD forwarding (cf., sections [1.1](#) and [1.2](#) of
   [[RFC4605](#)]).

   Another major advantage is that a dedicated multicast LMA minimizes
   replication of multicast packets compared to a combined
   unicast/multicast LMA as proposed in [I-D.schmidt-multimob-pmipv6-

mcast-deployment]. Figures 4 and 5 illustrate this point visually. For this simple scenario, it can be observed that the dedicated multicast LMA topology (Figure 4) generates 6 packets for one input multicast packet. In comparison, the combined unicast/multicast LMA topology (Figure 5) generates 8 packets for one input multicast packet.

In general, it can be seen that the extra multiplication of packets in the combined unicast/multicast LMA topology will be proportional to the number of LMAs, and the number of MNs (in a given MAG) associated to different LMAs. The packet multiplication problem aggravates as more MNs associated to different LMAs receive the same multicast traffic when attached to the same MAG. Hence, the dedicated multicast architecture significantly decreases the network capacity requirements.

(Note that in Figure 4, it is assumed that MN1 and MN2 are associated with MAG1-LMA1, and MN3 is associated with MAG2-LMA2 for multicast traffic. In Figure 5, it is assumed that MN1 is associated with MAG1-LMA1, MN2 is associated with MAG1-LMA2, and MN3 is associated with MAG2-LMA2 for multicast traffic. In both Figures 4 and 5, it is assumed that the packets are transmitted point to point on the last hop wireless link.)

```
                        +--------------+
                        |Content Source|
                        +--------------+
                               |
                               |
                            +---+      Packet destined
                            | 1 |   for Multicast group "G"
                            +---+
                               |
       ***  ***  ***  ***       ***  ***  ***  ***
      *   **   **   **   *     *   **   **   **    *
     *                    *   *                     *
     *  Unicast Traffic   *   *  Multicast Traffic  *
     *                    *   *                      *
      *   **   **   **   *     *   **   **   **    *
       ***  ***  ***  ***       ***  ***  ***  ***
            |                         |
            |                      +---+
            |                      | 2 |
            |                      +---+
            |                         |
        +-----+                   +------+
  Unicast | LMA1|             | LMA2 |    Multicast
  Anchor  +-----+             +------+    Anchor
           \\                    //||
            \\                  // ||
             \\                //  ||
              \\              //   ||
               \\      +---+  +---+
                \\     | 3 |  | 4 |
                 \\    +---+  +---+
                  \\      //       ||
                   \\    //        ||
                    \\  //         ||
                     \\ //         ||
                   +-----+      +-----+
                   | MAG1|      | MAG2|    MLD Proxy
                   +-----+      +-----+
                    |    |         |
                 +---+ +---+    +---+
                 | 5 | | 6 |    | 7 |
                 +---+ +---+    +---+
                  |     |         |       All MNs in same
                  |     |         |       multicast group "G"
                 {MN1} {MN2}    {MN3}
```

Figure 4 Packet Flow in a Dedicated Multicast LMA

```
                    +--------------+
                    |Content Source|
                    +--------------+
                          |
                          |
                       +---+       Packet destined
                       | 1 |     for Multicast group "G"
                       +---+
                          |
       ***   ***   ***   ***   ***   ***   ***   *** ***
        *    **    **    **    **    **    **    **    **    *
       *                                                     *
       *                 Fixed Internet                      *
       *            (Unicast & Multicast Traffic)            *
        *    **    **    **    **    **    **    **    **    *
         ***   ***   ***   ***  ***  ***   ***   ***   ***
             |                         |
           +---+                     +---+
           | 2 |                     | 3 |
           +---+                     +---+
             |                         |
          +-----+                   +------+
          | LMA1|                   | LMA2 |     Combined
          +-----+                   +------+      Unicast/Multicast
            \\                      //  ||         Anchor
             \\                    //   ||
              \\                  //    ||
               \\               //      ||
             +---+        +---+  +---+
             | 4 |        | 5 |  | 6 |
             +---+        +---+  +---+
               \\        //      ||
                \\      //       ||
                 \\    //        ||
                  \\  //         ||
                +-----+        +-----+
                | MAG1|        | MAG2|     MLD Proxy
                +-----+        +-----+
                 |    |          |
              +---+ +---+     +---+
              | 7 | | 8 |     | 9 |
              +---+ +---+     +---+
                |    |          |       All MNs in same
                |    |          |       multicast group "G"
              {MN1} {MN2}     {MN3}
```
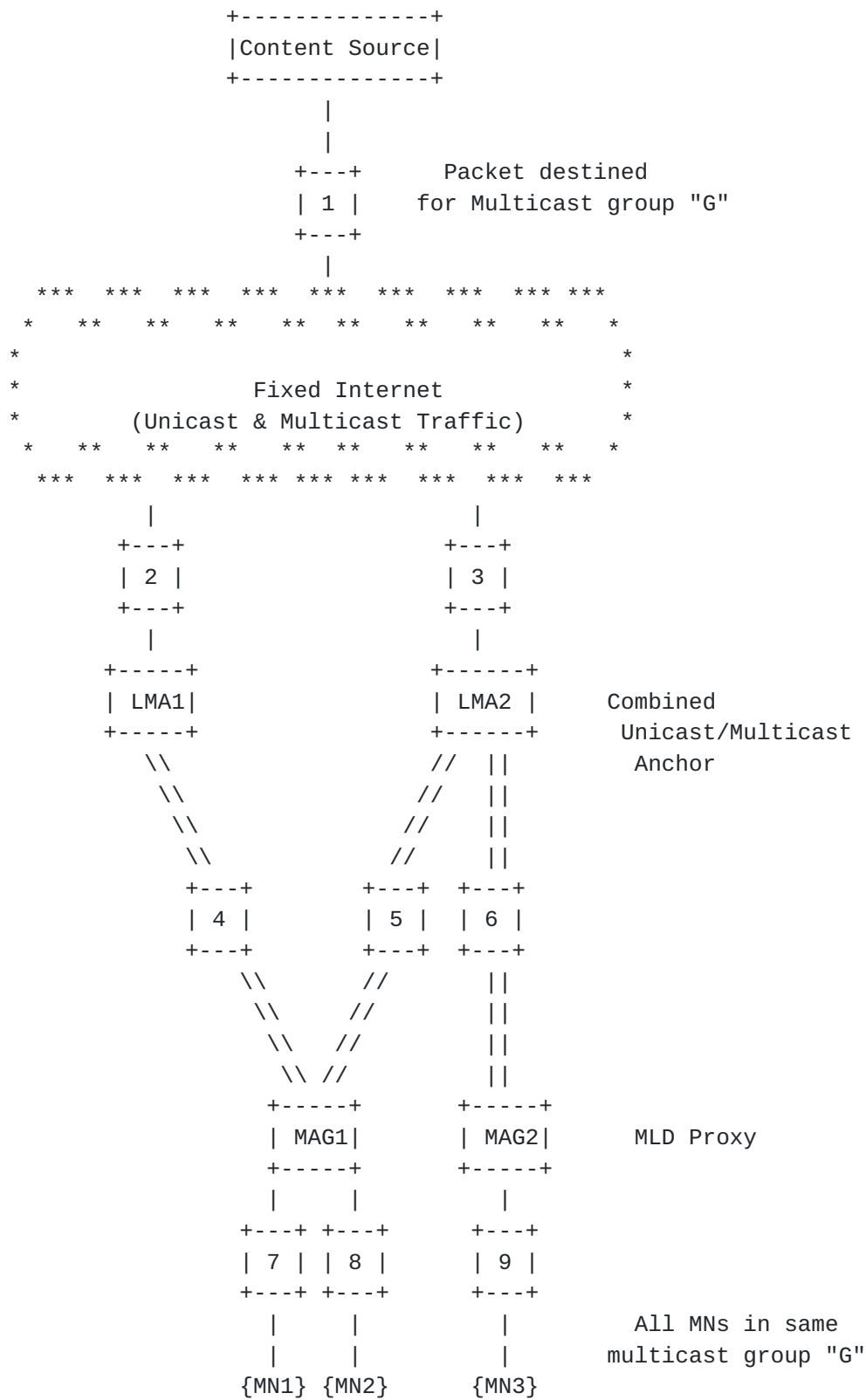
Figure 5 Packet Flow in a Combined Unicast/Multicast LMA

4. Security Considerations

This draft discusses the operations of existing protocols without modifications. It does not introduce new security threats beyond the current security considerations of PMIPv6 [RFC5213], MLD [RFC3810], IGMP [RFC3376] and IGMP/MLD Proxying [RFC4605].

5. IANA Considerations

This document makes no request of IANA.

6. References

6.1. Normative References

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