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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). This LMA (LMA2) can be considered to be a form of upstream multicast router with tunnel interfaces allowing remote subscription for the MNs.

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 interfaces 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------ >|          |
       |                     |          |          |
       |                     |==Multicast Tunnel ==|
       |                     |          |          |
       |<--MLD Query --------|          |          |
       |                     |          |          |
   MN requires multicast services       |          |
       |                     |          |          |
       |---MLD Report (G) -->|          |          |
       |                     |          |          |
       |                     |---- Aggregated ---> |
       |                     |    MLD Report (G)   |
       |                     |          |          |

       |                     |          |          |
       |< --------- 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. Unicast traffic will then flow between MN1 and LMA1.

For multicast traffic, a multicast tunnel may have been pre-configured between MAG1 and the multicast LMA (LMA2). Or the multicast tunnel may be dynamically established when the first MN appears at the MAG.

MN1 sends the MLD report message (when required by its upper layer applications) as defined in [RFC3810] in response to an MLD Query from MAG1. MAG1 acting as a MLD Proxy as defined in [RFC4605] will

then send an Aggregated MLD Report to the multicast anchor, LMA2 (assuming that this is a new multicast group which MAG1 had not previously subscribed to). Multicast traffic will then flow from LMA2 towards MN1.

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, for simplicity, 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. This message will be sent through a pre-established (or dynamically established) multicast tunnel between MAG2 and LMA2.

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.

As discussed above, existing MLD (and Proxy MLD) signaling will handle a large part of the multicast mobility management for the MN.

```
       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       |           |            |          |
        |            |           |            |          |
        |            |           |==Multicast Tunnel === |
        |            |           |            |          |
        |---------Rtr Sol------ >|            |          |
        |            |           |            |          |
        |<-----Rtr Adv --------- |            |          |
        |            |           |            |          |
        |            |           |            |          |
        |<---------MLD Query---- |            |          |
        |            |           |            |          |
        |---MLD Report (G) ----> |            |          |
        |            |           |            |          |
        |            |           |---- Aggregated -----> |
        |            |           |    MLD Report (G)     |
        |            |           |            |          |

        |            |           |            |          |
        |< --------- Multicast Traffic ---------------- >|
        |            |           |            |          |
        |            |           |            |          |
```

Figure 3 Multicast Mobility Signaling

3.4. Advantages

An advantage of the proposed dedicated multicast LMA architecture 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]). Other approaches, like the combined unicast/multicast LMA as proposed in [I-D.schmidt-multimob-pmipv6-mcast-deployment] also comply to a multicast tree topology but will have a more complex set of trees of which the sum, of course, will still be a tree.

Finally another advantage is that a dedicated multicast LMA minimizes replication of multicast packets, in certain scenarios, compared to [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, for a given multicast group. 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 in this scenario.

(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 |
                  +---+                   +---+
                    |                       |
                 +-----+                 +------+     Combined
                 | LMA1|                 | LMA2 |     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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