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A Minimal Deployment Option for Multicast Listeners in PMIPv6 Domains
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Status of this Memo

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Abstract

This document describes deployment options for activating multicast listener functions in Proxy Mobile IPv6 domains without modifying mobility and multicast protocol standards. Similar to Home Agents in Mobile IPv6, PMIPv6 Local Mobility Anchors serve as multicast subscription anchor points, while Mobile Access Gateways provide MLD proxy functions. In this scenario, Mobile Nodes remain agnostic of multicast mobility operations.

Requirements Language

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 [RFC2119].

Table of Contents

1. Introduction

Proxy Mobile IPv6 (PMIPv6) [RFC5213] extends Mobile IPv6 [RFC3775] by network-based management functions that enable IP mobility for a host without requiring its participation in any mobility-related signaling. Additional network entities, i.e., the Local Mobility Anchor (LMA), and Mobile Access Gateways (MAGs), are responsible for managing IP mobility on behalf of the mobile node (MN).

With these routing entities in place, the mobile node looses transparent end-to-end connectivity to the static Internet, and in the particular case of multicast communication, group membership management as signaled by the Multicast Listener Discovery protocol [RFC3810], [RFC2710] requires a dedicated treatment, see [I-D.deng-multimob-pmip6-requirement].

Multicast routing functions need a careful placement within the PMIPv6 domain to augment unicast transmission with group communication services. [RFC5213] does not explicitly address multicast communication, whereas bi-directional home tunneling, the minimal multicast support arranged by MIPv6, cannot be applied in network-based management scenarios: A mobility-unaware node will experience no reason to initiate a tunnel with an entity of mobility support.

This document describes deployment options for activating multicast listener functions in Proxy Mobile IPv6 domains without modifying mobility and multicast protocol standards. Similar to Home Agents in Mobile IPv6, PMIPv6 Local Mobility Anchors serve as multicast subscription anchor points, while Mobile Access Gateways provide MLD proxy functions. Mobile Nodes in this scenario remain agnostic of multicast mobility operations. Accrediting the problem space of multicast mobility [I-D.irtf-mobopts-mmcastv6-ps], this document does not address optimization potentials and efficiency improvements of multicast routing in network-centered mobility, as such solutions would require changes to the base specification of [RFC5213].

2. Terminology

This document uses the terminology as defined for the mobility protocols [RFC3775] and [RFC5213], as well as the multicast edge related protocols [RFC3810] and [RFC4605].

The reference scenario for multicast deployment in Proxy Mobile IPv6 domains is illustrated in Figure 1.


```
                       +-------------+
                       | Content     |
                       | Source      |
                       +-------------+
                              |
                     ***  ***  ***  ***
                    *   **   **   **   *
                   *                    *
                    *  Fixed Internet  *
                   *                    *
                    *   **   **   **   *
                     ***  ***  ***  ***
                      /            \
                  +----+         +----+
                  |LMA1|         |LMA2|                 Multicast Anchor
                  +----+         +----+
             LMAA1  |              |  LMAA2
                    |              |
                    \\           //\\
                     \\         //  \\                    Unicast Tunnel
                      \\       //    \\
                       \\     //      \\
                        \\   //        \\
                         \\ //          \\
               Proxy-CoA1 ||            ||  Proxy-CoA2
                       +----+          +----+
                       |MAG1|          |MAG2|             MLD Proxy
                       +----+          +----+
                        |  |             |
```

```
             MN-HNP1 |    | MN-HNP2       | MN-HNP3
                    MN1  MN2           MN3
```

Figure 1: Reference Network for Multicast Deployment in PMIPv6

3. Overview

An MN in a PMIPv6 domain will decide on multicast group membership management completely independent of its current mobility conditions. It will submit MLD Report and Done messages following application desires, thereby using its link-local source address and multicast destinations according to [RFC3810], or [RFC2710]. These link-local signaling messages will arrive at the currently active MAG via one of its downstream local (wireless) links. A multicast unaware MAG would simply discard these MLD messages.

To facilitate multicast in a PMIPv6 domain, an MLD proxy function [RFC4605] needs to be deployed on the MAG that selects the tunnel

interface corresponding to the MN's LMA for its upstream interface (cf., section 6 of [RFC5213]). Thereby each LMA upstream interface defines an MLD proxy domain at the MAG, containing all downstream links to MNs that share this LMA. MLD signaling of the MN will be consequently forwarded under aggregation up the tunnel interface to its corresponding LMA.

Serving as the designated multicast router or an additional MLD proxy, the LMA will transpose any MLD message from a MAG into the multicast routing infrastructure. Correspondingly, the LMA will implement appropriate multicast forwarding states at its tunnel interface. Traffic arriving for groups under subscription will arrive at the LMA, which it will forward according to all its group/source states. In addition, the LMA will naturally act as an MLD querier, seeing its downstream tunnel interfaces as multicast enabled links.

At the MAG, MLD queries and multicast data will arrive on the (tunnel) interface that is assigned to a group of access links as identified by its Binding Update List (cf., section 6 of [RFC5213]). As specified for MLD proxies, the MAG will forward multicast traffic and initiate related signaling down the appropriate access links to the MNs. In proceeding this way, all multicast-related signaling and the data traffic will transparently flow from the LMA to the MN on an LMA-specific tree, which is shared among the multicast sources.

In case of a mobility handover, the (IP mobility unaware) MN will refrain from submitting unsolicited MLD reports. Instead, the MAG is required to maintain group memberships in the following way. On activation of a link connecting a new MN, the MAG sends a General MLD Query. Based on its outcome and the multicast group states previously maintained at the MAG, a corresponding Report will be sent to the LMA according to the proxy function. Additional Reports can be omitted, whenever multicast forwarding states previously established at the new MAG already cover the demands of the MN.

After Re-Binding, the LMA is not required to issue a General MLD Query on the tunnel link to refresh forwarding states. Multicast state updates SHOULD be triggered by the MAG, which aggregates subscriptions of all its MNs (see the call flow in Figure 2).


```
   MN1             MAG1             MN2             MAG2             LMA
   |                |                |               |                |
   |    Join(G)     |                |               |                |
   +--------------->|                |               |                |
   |                |     Join(G)    |               |                |
   |                |<---------------+               |                |
   |                |                |               |                |
   |                |     Aggregated Join(G)         |                |
   |                +================================================>|
   |                |                |               |                |
   |                |   Mcast Data   |               |                |
   |                |<================================================+
   |                |                |               |                |
   |  Mcast Data    | Mcast Data     |               |                |
   |<---------------+--------------->|               |                |
```

```
   |                |                |               |                |
   |                |      < Movement to MAG2 & PMIP Binding Update > |
   |                |                |               |                |
   |                |                |   MLD Query   |                |
   |                |                |<--------------+                |
   |                |                |               |                |
   |                |                |   Join(G)     |                |
   |                |                +-------------->|                |
   |                |                |               Aggregated Join(G)
   |                |                |               +===============>|
   |                |                |               |                |
   |                |   Mcast Data   |               |                |
   |                |<================================================+
   |                |                |               |   Mcast Data   |
   |                |                |               |<===============+
   |  Mcast Data    |                |               |                |
   |<---------------+                |  Mcast Data   |                |
   |                |                |<--------------+                |
   |                |                |               |                |
```

Figure 2: Call Flow of Multicast-enabled PMIP

These multicast deployment considerations likewise apply for mobile nodes that operate with its IPv4 stack enabled in a PMIPv6 domain. PMIPv6 can provide an IPv4 home address mobility support [I-D.ietf-netlmm-pmip6-ipv4-support]. Such mobile node will use IGMPv3 [RFC3376] signaling for multicast, which is handled by an IGMP proxy function at the MAG in an analogous way.

Following these deployment steps, multicast management transparently interoperates with PMIPv6. It is worth noting that multicast streams can possibly be distributed on redundant path, leading to duplicate traffic arriving from different LMAs at one MAG, and causing multiple

data transmissions from a MAG over one wireless domain to different MNs.

4. Deployment Details

Multicast activation in a PMIPv6 domain requires to deploy general multicast functions at PMIPv6 routers and to define its interaction with the PMIPv6 protocol in the following way:

4.1. Operations of the Mobile Node

A Mobile Node willing to manage multicast traffic will join, maintain and leave groups as if located in the fixed Internet. No specific mobility actions nor implementations are required at the MN.

4.2. Operations of the Mobile Access Gateway

A Mobility Access Gateway is required to assist in MLD signaling and data forwarding between the MNs which it serves, and the corresponding LMAs associated to each MN. It therefore needs to implement an instance of the MLD proxy function [RFC4605] for each upstream tunnel interface that has been established with an LMA. The MAG decides on the mapping of downstream links to a proxy instance (and hence an upstream link to an LMA) based on the regular Binding Update List as maintained by PMIPv6 standard operations (cf., section 6.1 of [RFC5213]).

On the reception of MLD reports from an MN, the MAG MUST identify the corresponding proxy instance from the incoming interface and perform regular MLD proxy operations: it will insert/update/remove a multicast forwarding state on the incoming interface, and state updates will be merged in the MLD proxy membership database. An aggregated Report will be sent to the upstream tunnel of the MAG when the membership database (cf., section 4.1 of [RFC4605]) changes. Conversely on the reception of MLD Queries, the MAG proxy instance will answer the Queries on behalf of all active downstream receivers maintained in its membership database. Queries sent by the LMA do not force the MAG to trigger corresponding messages immediately towards MNs. Multicast traffic arriving at the MAG on an upstream interface will be forwarded according to the group/source-specific forwarding states as acquired for each downstream interface within the MLD proxy instance.

In case of a mobility handover, the MAG will continue to manage upstream tunnels and downstream interfaces as foreseen in the PMIPv6 specification. However, it MUST assure consistency of its up- and downstream interfaces that change under mobility with MLD proxy

instances and its multicast forwarding states. To learn about multicast groups subscribed by a newly attaching MN, the MAG sends a General Query to the MN access link as it goes up. In case the access link between MN and MAG goes down, interface-specific multicast states change. Both cases may alter the composition of the membership database, which then will trigger corresponding Reports towards the LMA.

A MN may be unable to answer MAG multicast membership queries due to handover procedures. Such instance is equivalent to a General Query loss. To prevent erroneous query timeouts at the MAG, MLD parameters SHOULD be carefully adjusted to the mobility regime. In particular, MLD timers and the Robustness Variable (see section 9 of [RFC3810]) MUST be chosen to be compliant with the temporal handover operations of the PMIPv6 domain.

In proceeding this way, the MAG is entitled to aggregate multicast subscriptions for each of its MLD proxy instances. However, this deployment approach does not prevent multiple identical streams arriving from different LMA upstream interfaces. Furthermore, a per group forwarding into the wireless domain is restricted to the link model in use.

4.3. Operations of the Local Mobility Anchor

For any MN, the Local Mobility Anchor acts as the persistent Home Agent and at the same time as the default multicast querier for the corresponding MAG. It implements the function of the designated multicast router or a further MLD proxy. According to MLD reports received from a MAG (on behalf of the MNs), it establishes/maintains/removes group/source-specific multicast forwarding states at its corresponding downstream tunnel interfaces. At the same time it procures for aggregated multicast membership maintenance at its upstream interface. Based on the multicast-transparent operations of the MAGs, the LMA experiences its tunnel interfaces as multicast enabled downstream links, serving zero to many listening nodes. Multicast traffic arriving at the LMA is transparently forwarded according to its multicast forwarding states.

On the occurrence of a mobility handover, the LMA will receive Binding Lifetime De-Registrations and Binding Lifetime Extensions that will cause a re-mapping of home network prefixes to Proxy-CoAs in its Binding Cache. The multicast forwarding states require updating, as well, if the MN within a MLD proxy domain is the only receiver of a multicast group. Two cases need distinction:

1. The mobile node was the only receiver of a group behind the interface a De-Registration was received: The membership database of the MAG changes, which will trigger a Report/Done sent via the MAG-to-LMA interface to remove this group. The LMA thus terminates multicast forwarding.

2. The mobile node is the only receiver of a group behind the interface a Lifetime Extension was received: The membership database of the MAG changes, which will trigger a Report sent via the MAG-to-LMA interface to add this group. The LMA thus starts multicast distribution.

In proceeding this way, each LMA will provide transparent multicast support for the group of MNs it serves. It will perform traffic aggregation at the MN-group level and will assure that multicast data streams are uniquely forwarded per individual LMA-to-MAG tunnel.

4.4. A Note on Explicit Tracking

IGMPv3/MLDv2 [RFC3376], [RFC3810] may operate in combination with explict tracking, which allows routers to monitor each multicast receiver. This mechanism is not standardized yet, but widely implemented by vendors as it supports faster leave latencies and reduced signaling.

Enabling explicit tracking on downstream interfaces of the LMA and MAG would track a single MAG and MN respectively per interface. It may be used to preserve bandwidth on the MAG-MN link.

5. Message Source and Destination Address

This section describes source and destination address of MLD messages. The interface identifier A-B denotes an interface on node A, which is connected to node B. This includes tunnel interfaces.

5.1. Query

Interface	Source Address	Destination Address	Header
LMA-MAG	LMAA	Proxy-CoA	outer
	LMA-link-local	[RFC2710], [RFC3810]	inner
MAG-MN	MAG-link-local	[RFC2710], [RFC3810]	--

5.2. Report/Done

Interface	Source Address	Destination Address	Header
MN-MAG	MN-link-local	[RFC2710], [RFC3810]	--
MAG-LMA	Proxy-CoA	LMAA	outer
	MAG-link-local	[RFC2710], [RFC3810]	inner

6. IANA Considerations

This document makes no request of IANA.

Note to RFC Editor: this section may be removed on publication as an RFC.

7. Security Considerations

This draft does neither introduce additional messages nor novel protocol operations. Consequently, no new threats arrive from procedures described in this document in excess to [RFC3810] and [RFC5213] security concerns.

8. Acknowledgements

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