MULTIMOB Working Group J. Liu
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Routes Optimization for PMIPv6 Multicast
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Abstract

To support IP multicasting in PMIPv6 domain, MULTIMOB WG has issued several proposals including the base solution,dedicated schemes and direct routing which requires all communications to go through the local mobility anchor(LMA),the dedicated server and the native multicasting infrastructure ,respectively. As this can be suboptimal, localized routing (LR) allows multicast source attached to the same or different mobile access gateways(MAG) with mobile node to send multicast data by using localized forwarding or a direct tunnel between the gateways without any dedicated devices or dependence of the native multicasting infrastructure. This document describes multicast routes optimazition mechanisms for localized routing.The MAG and the LMA are the mobility entities defined in the PMIPv6 protocol and act as PIM-SM routers.

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1. Introduction

Proxy Mobile IPv6 (PMIPv6) [RFC5213] enables network-based mobility for IPv6 mobile nodes (MNs) that do not implement any mobility protocols. The Local Mobility Anchor (LMA) is the topological anchor point to manages the mobile node's binding state. The Mobile Access Gateway (MAG) is an access router or gateway that manages the mobility- related signaling for an MN. An MN is attached to the Proxy Mobile IPv6 Domain (PMIPv6-Domain) that includes LMA and MAG(s), and is able to receive data coming from outside of the PMIPv6-Domain through LMA and MAG.

Network-based mobility support for unicast is addressed in [RFC5213], while multicast support in PMIPv6 is not discussed in it. Since LMA and MAG set up a bi-directional IPv6-in-IPv6 tunnel for each mobile node and forwards all mobile node's traffic according to [RFC5213], it highly wastes network resources when a large number of mobile nodes join/ subscribe the same multicast sessions/channels, because independent data copies of the same multicast packet are delivered to the subscriber nodes in a unicast manner through MAG.

In order to deploy the multicast service in the PMIPv6 network, many schemes have been proposed:

The base solution described in [RFC6224] provides options for deploying multicast listener functions in PMIPv6-Domains without modifying mobility and multicast protocol standards. However, in this specification, MAG MUST act as an MLD proxy [RFC4605] and hence MUST dedicate a tunnel link between LMA and MAG to an upstream interface for all multicast traffic. It requires all the LMA to forward multicast packets to MAG via PMIPv6 tunnel which can be suboptimal.

[draft-zuniga-multimob-pmipv6-ropt-01]uses a multicast tree mobility anchor(MTMA) as the topological anchor point for multicast traffic, as well as a direct routing option where the MAG can provide access to multicast content in the local network.All the multicast traffic has to go through the MAG-MTMA tunnel which result in suboptimal multicast routing path like the base solution.And the direct routing solution needs native multicasting infrastructure as a requirement

[draft-asaeda-multimob-pmip6-extension-07]describes PMIPv6 extensions to support IP multicast communication for mobile nodes in PMIPv6-Domain.If the LMA is the upstream router for the channel(s) for the MAG, the MAG encapsulates PIM Join/Prune messages using the LMA-MAG bi-directional tunnel. The multicast data has to always go through the LMA-MAG bi-directional tunnel.It does solve the tunnel convergence problem and source mobility,But when multicast source is a mobile node in the same PMIPv6 domain,using the proposed scheme mentioned above, the routing path through a multicast anchor(LMA) tends to be longer,which results in non-optimal multicast routes and performance degradation.Figure 1 shows the Architecture of Multicast Deployment with listener and source in the same PMIPv6 domain,LMA will receive all multicast traffic originating from its associated MN-S through LMA-MAG2 bi-directional tunnel,and then forward to multicast listener MN through LMA-MAG1 bi-directional tunnel,causing non-optimal multicast routes.

```
                             Internet
                                :
                                |
                                |
                             +------+
                             | LMA |   Multicast Anchor
                             +------+
                                ||
                               //\\
                              //  \\
                             //    \\
                            //      \\
                           //        \\
                          //          \\
                         ||            ||
                       +-----+       +-----+
                       |MAG1|       |MAG2|
                       +-----+       +-----+
                         |              |
                         |              |
                      +-----+        +-----+
                      | MN |         |MN-S|
                      +-----+        +-----+
             Multicast Listener(s)     Multicast Sender(s)
```

Figure1 Architecture of Multicast Deployment with listener and source in the same PMIPv6 domain

In this document, we discuss how to establish optimized multicast routes for the deployment scenario provided by Figure 1. The proposed protocol assumes that both LMA and MAG enable the Protocol-Independent Multicast - Sparse Mode (PIM-SM) multicast routing protocol [RFC4601],and further MAG MUST operate as an "SSM-aware" router [RFC4604]. The proposed protocol supports seamless handover. It can cooperate with local routing and direct routing to deliver IP multicast packets for mobile nodes and source mobility. In this document, because multicast localized routing is mainly focused on, the detail specification of source mobility and is not described.

2. 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 [RFC2119].

The following terms used in this document are to be interpreted as defined in [RFC5213]; Home Address(HoA),Mobile Access Gateway (MAG), Local Mobility Anchor (LMA), Mobile Node (MN), Proxy Mobile IPv6 Domain (PMIPv6-Domain), LMA Address (LMAA), Proxy Care-of Address (Proxy-CoA), Proxy Binding Update (PBU), and Proxy Binding Acknowledgement (PBA).

Terms DR(Designated Router),MRIB(Multicast Routing Information Base),RPF(Reverse Path Forwarding),RPF Neighbor,SPT(shortest-path tree),PIM Join,Pim Prune,iif(incoming interface),oiflist(outgoing interface list),Source-Specific Multicast(SSM) are to be interpreted as defined in[RFC4601]

3. Overview

In the SSM case, the multicast receivers actively send the (HoA,G) subscribe message, for the LMA is just the topological anchor point of the source’s Home Address (HoA) in the PMIPv6 network.

```
                           Internet
                               :
                               |
                               |
                            +------+
                            | LMA |      Unicast Anchor
                            +------+
                               ||
                             //  \\
                           //      \\
                         //          \\  Unicast Tunnel
                       //              \\
                     //                  \\
                   //                      \\
                  ||                        ||
                +-----+                   +-----+
                |MAG1|=O=O=O=O=O=O=O=O=O=O|MAG2|
                +-----+                   +-----+
                  |     Multicast Tunnel     |
                  |                          |
               +-----+                    +-----+
               | MN |                     |MN-S|
               +-----+                    +-----+
       Multicast Listener(s)         Multicast Sender(s)
```

Figure2 Architecture of Optimized Multicast Routing

As shown in Figure 2, MN(the multicast receivers) and MN-S(the multicast senders) are both mobile nodes in the same PMIPv6 domain,they both have binding cache entry in the LMA. MN sends (HoA,G) subscribe message(MLD Report messages) specifying sender and multicast addresses to the access link to establish the SPT,the MN has to operate as an "SSM-aware" host [RFC4604] . On receiving the (HoA,G) subscribe message from the MN,the attached MAG1 sends a PBU-F message to LMA to find the CoA (i. e., IP address of MAG2) of MN-S. On the reception of PBU-F, the LMA responds with a PBA-F message including the CoA of MN-S to MAG1, after lookup of its binding cache entry. After acquiring the CoA of MN-S,MAG1 establishes bi-directional tunnel with MAG2,and sends PIM Join message to MAG2 through this tunnel,MAG1 and MAG2 establish the ralated muticast state for MN.So the MAG-based SPT is established successfully and the subsequent multicast data flow will be transmitted through the MAG-based SPT which is represented by "=O" in Figure 2.Unicast data flow will be transmitted through base PMIPv6 tunnel which is represented by "||" in Figure 2.

The tunnel between MAG1 and MAG2 is used for multicast packets(including signaling and data flow) transmission only.

As described in [RFC4601], on receipt of data from S to G on interface iif (incoming interface of the packet), the DR will firstly check whether the source is directly connected and the iif is identical to the Reverse Path Forwarding (RPF) interface. As shown in Figure 2 ,MAG2 is the DR of MN-S,MAG1 is the DR of MN.After tunnel establishment between MAG1 and MAG2, MAG1 add the tunnel route to the MRIB,the RPF check will be successful.

this draft considers that every MN demanding multicast-only services is previously registered in a PMIPv6 unicast domain to get a unicast IP address.

4. Protocol Operation

4.1. Add Route to MRIB

In PIM-SM, the MRIB is used to decide where to send Join/Prune messages. on receiving the MLD Report message from MN,the MAG of MN has to choose a RPF Neighbor that the MRIB indicates should be used to forward packets to,and then send the Join/Prune message to the RPF Neighbor.

After tunnel establishment between MAG1 and MAG2, MAG1 add the tunnel route to the MRIB,so the RPF Neighbor of MAG1 is MAG2,MAG1 send PIM Join/Prune message through this tunnel.

Once the multicast subscription information is retrieved from the pMAG, the LMA encapsulates it in the PBA message by using the TLV option "Active Multicast Subscription", and forwards the PBA message to the nMAG. Then, the nMAG can subscribe the multicast flow on behalf of the MN, if there is no other MN receiving it already at the nMAG."

When the MAG is connected with other PIM-SM router not over LMA, there’s no problem. PIM-SM establishes multicast routing path using RPF algorithm through reflecting MAG’s RIB.

But when the MAG is connected with several LMAs including PIM-SM, MRIB SHOULD get information from PMIP routing table but "MAG’s RIB doesn’t reflect PMIP routing" (Thomas and Hitoshi agreed it).

4.2. Optimized Multicast Route Establishment

This document provides the multicast routes optimization scheme.The procedures are described as follows and illustrated in Figure 3;

```
        MN            MAG1                LMA     MN-S       MAG2
         |              |                   |        |          |
         |--MLD Report->|                   |        |          |
         |  (S,G) join  |                            |          |
         |              |------PBU-F------->|        |          |
         |              |                   |        |          |
         |              |<------PBA-F-------|        |          |
         |              |Acquire CoA of MN-S|        |          |
         |              |                   |        |          |
         |              |                   |        |          |
         |              |                   |        |          |
         |              |<=====================================>|
         |              |   Establish multicast Bi-dir tunnel   |
         |              |                   |        |          |
         |              |                   |        |          |
         |      Add route to MRIB           |        |          |
         |              |                   |        |          |
         |              |                   |        |          |
         |              |                   |        |          |
         |      Update (S,G) state          |        |          |
         |           Set iif                |        |          |
         |              |                   |        |          |
         |              |                   |        |          |
         |              |             PIM (S,G) join |          |
         |              |=============Bi-dir tunnel============>|
         |              |                   |        |          |
         |              |                   |        |          |
         |              |                   |        |Update (S,G) state
         |              |                   |        |   Set oiflist
         |              |                   |        |          |
         |              |                   |      Multicast data
         |              |                   |        |--------->|
         |              |             Multicast data |          |
         |Multicast data|<============Bi-dir tunnel=============|
         |<-------------|                   |        |          |
```

Figure3 Procedure of establishing multicast Route

1.MN sends (HoA,G) subscribe message(MLD Report messages) specifying sender and multicast addresses to the access link.

2.On receiving the (HoA,G) subscribe message from the MN,the attached MAG1 sends a PBU-F message to LMA to find the CoA (i. e., IP address of MAG2) of MN-S.

3.On the reception of PBU-F, the LMA responds with a PBA-F message including the CoA of MN-S to MAG1, after lookup of its binding cache entry.

4.After acquire the CoA of MN-S,MAG1 establish bi-directional tunnel with MAG2.Refer to [RFC5213] for the detailed tunnel negotiation mechanism.

5.After tunnel establishment,MAG1 add the tunnel route to the MRIB,so the RPF Neighbor of MAG1 is MAG2.

6.If there are multicast channels the MN has subscribed but MAG1 has not yet subscribed, MAG1 establishes multicast state for MN,and sets the iif of the multicast state as MAG1-MAG2 tunnel interface.if MAG1 already subscribed the channel,MAG1 updates the iif of the multicast state as MAG1-MAG2 tunnel interface.

7.MAG1 joins the corresponding multicast channels by sending the PIM Join message to the RPF Neighbor MAG2 through the MAG1-MAG2 tunnel.

8.On the reception of PIM Join message from MAG1,If MAG2 has not yet subscribed the multicast channel ,MAG2 establishes multicast state for the channel,and adds the MAG2-MAG1 tunnel interface to the oiflist of the multicast state .if MAG2 already subscribed the channel,MAG2 updates the oiflist of the multicast state by adding the MAG2-MAG1 tunnel interface to the oiflist.

9.The subsequent multicast data flow will be transmitted through the optimized multicast route(MAG1-MAG2 bi-directional tunnel).

4.3. Optimized Multicast Route Deletion

```
        MN             MAG1                                    MAG2
         |              |                                        |
         |--MLD Report->|                                        |
         | leave (S,G)  |                                        |
         |              |                                        |
         |              |                                        |
         |With regard to MN-S,MN is the                          |
         |last multicast listener on MAG1                        |
         |              |                                        |
         |              |                                        |
         |              |                                        |
         | delete all the (S,G) state                            |
         |  ralating to MN-S on MAG1                             |
         |              |                                        |
         |              |                                        |
         |              |                                        |
         |              |                                        |
         |              |             PIM (S,G) prune            |
         |              |=============Bi-dir tunnel============>|
         |              |                                        |
         |              |                                        |
         |              |                                        |
         |              |                           update (S,G) state
         |              |                           update oiflist
         |              |                                        |
         |              |     Remove multicast Bi-dir tunnel     |
         |              |<=======================================|
         |              |                                        |
```

Figure4 Procedure of deleting multicast Route

1.MN sends (HoA,G) leave message(MLD Report messages) specifying sender and multicast addresses to the access link.

2.On receiving the (HoA,G) leave message from the MN,if MAG1 figure that MN is the last multicast listener subscribed to the MN-S,MAG1 perform the following steps,otherwise,MAG1 simply delete the multicast state of MN as normal.

3.MAG1 delete all the multicast state related to MN-S.

4.MAG1 remove the tunnel route from the MRIB and leave the corresponding multicast channels by sending the PIM Prune message to the RPF Neighbor MAG2 through the MAG1-MAG2 tunnel.

5.On the reception of PIM Prune message from MAG1,,MAG2 updates the oiflist of the multicast state by removing the MAG2-MAG1 tunnel interface from the oiflist.

6.Remove bi-directional tunnel between MAG1 and MAG2.Refer to [RFC5213] for the detailed tunnel negotiation mechanism.

5. Local Mobility Anchor Operation

On receiving a PBU-F message from MAG, the LMA must perform the following operations.

1. Check if the PBU-F message contains the F flag set to 1.

2. Find the CoA of MN-S by looking up the binding cache of LMA.

3. If the corresponding HoA-CoA entry is found in the binding cache, LMA will respond to MAG of MN with a PBA-F message containing a success indication. Otherwise, if not found, LMA will respond with the PBA-F containing a failure indication.

The responding PBA-F message from LMA to MAG of MN is constructed as follows.

1. Source address field in the IP header must be set to IP address of LMA

2. Destination address filed in the IP header must be set to IP address of the MAG of MN

3. The PBA message MUST include the CoA of MN-S.

6. Mobile Access Gateway Operation

The MAG MUST operate as an "SSM-aware" router. [RFC4604] provide the behavior of an "SSM-aware" router.

The PBU-F message from MAG to LMA MUST be constructed, as specified below.

1. Source address field in the IP header must contain the IP address of MAG.

2. Destination address filed in the IP header must contain the IP address of LMA.

3. The PBU-F message must include the HoA of MN-S.

On receiving a PBA-F message from LMA, MAG1(MAG of MN) MUST perform the following operations.

1. Check if the PBA-F message contains the F flag set to 1.

2. MAG1 MUST establish a tunnel with MAG2(MAG of MN-S) for muticast data delivery.

3.MAG1 MUST add route to Multicast Routing Information Base (MRIB) and send PIM Join/Prune messages through MAG1-MAG2 tunnel interface.

4.MAG1 MUST create/update multicast state for MN,the iif of the multicast state MUST be set to MAG1-MAG2 tunnel interface.

On receiving a PIM Join/Prune messages from MAG2-MAG1 tunnel interface,MAG2 MUST create/update multicast state for MN.

1.Add MAG2-MAG1 tunnel interface to the oiflist of the multicast state on receiving a PIM Join message from MAG2-MAG1 tunnel interface.

2.Delete MAG2-MAG1 tunnel interface from the oiflist of the multicast state on receiving a PIM Prune message from MAG2-MAG1 tunnel interface.

7. Mobile Node Operation

In this document,MN's MAG acquire MN-S's CoA from LMA according to MN-S's HoA,so A mobile node sends MLD Report messages including source and multicast addresses when it subscribes a multicast channel.

The MN MUST operate as an "SSM-aware" host . [RFC4604] provide the behavior of an "SSM-aware" host.

8. Message Format Extension

8.1. Proxy Binding Update with Source Address Finding Extension

```
     0                   1                   2                   3
     0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
                                    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                                    |            Sequence #         |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |A|H|L|K|M|R|P|F|    Reserved   |            Lifetime           |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                                                               |
    .                                                               .
    .                       Mobility Options                        .
    .                                                               .

    |                                                               |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure5 Proxy Binding Update with Source Address Finding Extension

A Binding Update message that is sent by MAG to LMA is referred to as the "Proxy Binding Source Address Finding" message. A new flag (F) is included in the Proxy Binding Update message with Source Address Finding extension (PBU-F). The rest of the Binding Update message format remains the same as defined in[RFC3775] and with the additional (R), (M), and (P) flags, as specified in [RFC3963], [RFC4140], and [RFC5213], respectively.

Source Address Finding Flag

A new flag (F) is included in the Binding Update message to indicate to LMA that the Binding Update message is a Source Address Finding message. In the normal PMIP operation, the flag must be set to 0.

The PBU-F message is transfered for finding the MN-S’s care-of address. The rest of the PBU message remains unchanged.

8.2. Proxy Binding Acknowledgement Message with Source Address Finding Extension

```
     0                   1                   2                   3
     0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
                                    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                                    |     Status    |K|R|P|F|Reserve|
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |           Sequence #          |           Lifetime            |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                                                               |
    .                                                               .
    .                       Mobility Options                        .
    .                                                               .

    |                                                               |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure6 Proxy Binding Update with Source Address Finding Extension

A "Proxy Binding Acknowledgement" message is sent from LMA to MAG in response to a Proxy Binding Update message. A new flag (F) is included in the Proxy Binding Acknowledgement message with Source Address Finding extension (PBA-F). The rest of the Binding Acknowledgement message format remains the same as defined in [RFC3775] and with the additional (R) flag, as specified in [RFC3963] and [RFC5213], respectively.

Source Address Finding Flag

A new flag (F) is included in the Binding Acknowledgement message to indicate to MAG that the Binding Acknowledgement message is a Source Address Finding message. In the normal PMIP operation, the flag must be set to 0.

When (F) flag is specified in PBA-F message, the mobility options field includes "MN-S’s care-of address"(Section 8.3).

8.3. Care-of Address Option

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
                                +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                                |   Type = TBD  |  Length = 16  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                                                               +
|                                                               |
+                       Care-of Address                         +
|                                                               |
+                                                               +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure7 Care-of Address Option

The Care-of Address field contains the care-of address of MN-S.

This option is valid only in PBA-F message. On the reception of PBU-F, the LMA responds with a PBA-F message including the Care-of Address Option.

9. Security Considerations

TBD

10. IANA Considerations

11. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

[RFC3775] Johnson, D., Perkins, C., and J. Arkko, "Mobility Support in IPv6", RFC 3775, June 2004.

[RFC3963] Devarapalli, V., Wakikawa, R., Petrescu, A., and P. Thubert, "Network Mobility (NEMO) Basic Support Protocol", January 2005.

[RFC4140] Soliman, H., Castelluccia, C., El Malki, K., and L. Bellier, "Hierarchical Mobile IPv6 Mobility Management (HMIPv6)", August 2005.

[RFC4601] Fenner, B., Handley, M., Holbrook, H., and I. Kouvelas, "Protocol Independent Multicast - Sparse Mode (PIM-SM): Protocol Specification (Revised)", August 2006.

[RFC4604] Holbrook, H., Cain, B., and B. Haberman, "Using Internet Group Management Protocol Version 3 (IGMPv3) and Multicast Listener Discovery Protocol Version 2 (MLDv2) for Source-Specific Multicast", August 2006.

[RFC4605] Fenner, B., He, H., Haberman, B., and H. Sandick, "Internet Group Management Protocol (IGMP) / Multicast Listener Discovery (MLD)-Based Multicast Forwarding ("IGMP/MLD Proxying")", August 2006.

[RFC5213] Gundavelli, S, Ed., Leung, K., Devarapalli, V., Chowdhury, K., and B. Patil, "Proxy Mobile IPv6", RFC 5213, August 2008.

[RFC6224] Schmidt, T., Waehlisch, M., and S. Krishnan, "Base Deployment for Multicast Listener Support in Proxy Mobile IPv6 (PMIPv6) Domains", April 2011.

[draft-asaeda-multimob-pmip6-extension-07] Asaeda, H., Seite, P., and J. Xia, "PMIPv6 Extensions for PIM-SM", October 2011.

[draft-zuniga-multimob-pmipv6-ropt-01] Zuniga, J., Contreras, L., Bernardos, C., and S. Jeon, "Multicast Mobility Routing Optimizations for Proxy Mobile IPv6", October 2011.

Authors' Addresses

Juan Liu
ZTE Corporation
RD Building 1,Zijinghua Road No.68
Yuhuatai District,Nanjing 210012
P.R.China

Email: liu.juan45@zte.com.cn

Wen Luo
ZTE Corporation
RD Building 1,Zijinghua Road No.68
Yuhuatai District,Nanjing 210012
P.R.China

Wei Yan
ZTE Corporation
RD Building 1,Zijinghua Road No.68
Yuhuatai District,Nanjing 210012
P.R.China

Email: yan.wei@zte.com.cn