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Localized Routing for Proxy Mobile IPv6

Abstract

Proxy Mobile IPv6 (PMIPv6) is a network based mobility management protocol that enables IP mobility for a host without requiring its participation in any mobility-related signaling. PMIPv6 requires all communications to go through the local mobility anchor. As this can be suboptimal, Localized Routing (LR) allows Mobile Nodes (MNs) attached to the same or different Mobile Access Gateways (MAGs) to route traffic by using localized forwarding or a direct tunnel between the gateways. This document proposes initiation, utilization, and termination mechanisms for localized routing between mobile access gateways within a proxy mobile IPv6 domain. It defines two new signaling messages, Localized Routing Initiation (LRI) and Local Routing Acknowledgment (LRA), that are used to realize this mechanism.

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1. Introduction

Proxy Mobile IPv6 [RFC5213] describes the protocol operations to maintain reachability and session persistence for a Mobile Node (MN) without the explicit participation from the MN in signaling operations at the Internet Protocol (IP) layer. In order to facilitate such network-based mobility, the PMIPv6 protocol defines a Mobile Access Gateway (MAG), which acts as a proxy for the Mobile IPv6 [RFC6275] signaling, and the Local Mobility Anchor (LMA), which acts similar to a Home Agent. The LMA and the MAG establish a bidirectional tunnel for forwarding all data traffic belonging to the Mobile Nodes. In the case where both endpoints are located in the same PMIPv6 domain, this can be suboptimal and result in increased delay and congestion in the network. Moreover, it increases transport costs and traffic load at the LMA.

To overcome these issues, localized routing can be used to allow nodes attached to the same or different MAGs to directly exchange traffic by using localized forwarding or a direct tunnel between the gateways. [RFC6279] defines the problem statement for PMIPv6 localized routing. This document describes a solution for PMIPv6 localized routing between two MNs in the same PMIPv6 domain. The protocol specified here assumes that each MN is attached to a MAG and that each MN’s MAG has established a binding for the attached MN at its selected LMA according to [RFC5213]. The protocol builds on the scenarios defined in [RFC6279].

2. Conventions Used in This Document

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 [RFC2119].

This document also uses the terminology defined in Section 2 of [RFC6279].

3. Initiation of Localized Routing

Since the traffic to be localized passes through both the LMA and the MAGs, it is possible, at least in some scenarios, for either of them to initiate Localized Routing (LR). In order to eliminate ambiguity, the protocol described in this document selects the initiator of LR based on the rules below.

3.1. MAG Behavior

The MAG MUST initiate LR if both of the communicating MNs are attached to it and the MNs are anchored at different LMAs. The MAG MUST NOT initiate LR in any other case.

3.2. LMA Behavior

The LMA MUST initiate LR if both of the communicating MNs are anchored to it. The LMA MUST NOT initiate LR in any other case.

4. Teardown of Localized Routing

The use of localized routing is not persistent. Localized routing has a defined lifetime as specified by the initiator; upon expiry, the forwarding MUST revert to using bidirectional tunneling. When localized routing ceases, the corresponding Localized Routing Entries (LREs) MUST be removed.

If the initiator of LR wishes to terminate localized routing before the expiry of the lifetime specified in the LRI message, it MUST do so by sending a new LRI message with the lifetime set to zero.

5. Scenario A11: Two MNs Attached to the Same MAG and LMA

In this scenario, the two Mobile Nodes involved in communication are attached to a single MAG and both are anchored at the same LMA as shown in Figure 1.

```
          Internet
             :
             |
             |
          +-----+
          | LMA |
          +-----+
             |
             |
             |
          +-----+
          | MAG |
          +-----+
            :   :
        +---+ +---+
        |MN1| |MN2|
        +---+ +---+
```

Figure 1

The LMA initiates a localized routing session by detecting traffic between two MNs attached to the same MAG. The exact traffic identification mechanism is not specified in this document and is left open for implementations and specific deployments. An example trigger could be that an application-layer signaling entity detects the possibility of localized routing and notifies the LMA about the two endpoints, and the LMA determines that the two endpoints are attached to the same MAG. Such a trigger mechanism offers localized routing at the granularity of an individual application session, providing flexibility in usage. It is also possible that one of the mobility entities (LMA or MAG) could decide to initiate localized routing based on configured policy. Please note that a MAG implementing the protocol specified in this document will not dynamically initiate LR in the same LMA case (i.e., by sending an LRI), but can statically initiate LR based on the EnableMAGLocalRouting configuration variable specified in [RFC5213].

```
      +----+      +----+      +----+          +----+
      |MN1 |      |MN2 |      |MAG1|          |LMA |
      +----+      +----+      +----+          +----+
        |           |           |               |
        |         data          |     data      |
        |<--------------------->|<------------->|
        |           |           |               |
        |           |    data   |     data      |
        |           |<--------->|<------------->|
        |           |           |          LR decision
        |           |           |  LRI(Opt1)    |
        |           |           |<--------------|
        |           |           |               |
        |           |           |  LRA(Opt2)    |
        |           |           |-------------->|
        |           |           |               |
        |        data           |               |
        |<--------------------->|               |
        |           |           |               |
        |           |   data    |               |
        |           |<--------->|               |
        |           |           |               |
        |           |           |               |
```

Opt1: MN1-ID,MN1-HNP,MN2-ID,MN2-HNP
Opt2: U=0,MN1-ID,MN1-HNP,MN2-ID,MN2-HNP

where U is the flag defined in Section 10.2.

Figure 2

After detecting a possibility for localized routing, the LMA SHOULD construct an LRI message that is used to signal the intent to initiate localized routing and to convey parameters for the same. This is a Mobility Header message and it MUST contain the MN-Identifier (MN-ID) and the Home Network Prefix (HNP) (as Mobility Header options) for each of the MNs involved. The LMA MUST then send the LRI message to the MAG (MAG1) where the two MNs are attached. The initiation of the LR procedure is shown in Figure 2.

The MAG (MAG1) MUST verify the attachment status of the two MNs locally by checking the binding cache. The MAG MUST then verify if the EnableMAGLocalRouting flag is set to 1. If it is not, the MAG has not been configured to allow localized routing, and it MUST reject the LRI and MUST send an LRA with Status code "Localized Routing Not Allowed". Please note that this does not update behavior specified in [RFC5213] but merely implements the LMA enforcement specified in Section 6.10.3 of [RFC5213]. If the MAG is configured to allow localized routing, it MUST then create LREs for each direction of the communication between the two MNs. The exact form of the forwarding entries is left for the implementations to decide; however, they SHOULD contain the HNP corresponding to the destination IP address and a next-hop identifier (e.g., the layer-2 address of the next hop). These LREs MUST override the Binding Update List (BUL) entries for the specific HNPs identified in the LRI message. Hence, all traffic matching the HNPs is forwarded locally.

If the MAG is unable to deliver packets using the LREs, it is possible that one of the MNs is no longer attached to the MAG. Hence, the MAG MUST fall back to using the BUL entry, and the LMA MUST forward the received packets using its Binding Cache Entry (BCE).

After processing the LRI message, the MAG MUST respond with a Local Routing Acknowledgment (LRA) message. This Mobility Header message MUST also include the MN-ID and the HNP for each of the communicating MNs, as well as an appropriate Status code indicating the outcome of LRI processing. Status code 0 indicates localized routing was successfully offered by the MAG. Any other value for Status code indicates the reason for the failure to offer localized routing service. When Status code is 0, the LMA sets a flag in the BCE corresponding to the HNPs to record that localized routing is in progress for that HNP.

5.1. Handover Considerations

If one of the MNs, say MN1, detaches from the MAG and attaches to another MAG (say nMAG), the localized routing state needs to be re-established. When the LMA receives the PBU from nMAG for MN1, it will see that localized routing is active for MN1. The LMA MUST hence initiate LR at nMAG and update the LR state of pMAG. After the handover completes, LR will resemble Scenario A21. The pMAG MUST follow the forwarding rules described in Section 6.10.5 of [RFC5213] and decide that it will no longer perform LR for MN1.

6. Scenario A21: Two MNs Attached to Different MAGs but the Same LMA

The LMA may choose to support local forwarding to Mobile Nodes attached to two different MAGs within a single PMIPv6 domain.

```
                Internet
                    :
                    |
                    |
                +-----+
                | LMA |
                +-----+
                    |
                    |
              +----+-----+
              |          |
           +----+     +----+
           |MAG1|     |MAG2|
           +----+     +----+
             :          :
           +---+       +---+
           |MN1|       |MN2|
           +---+       +---+
```

Figure 3

As earlier, the LMA initiates LR as a response to some trigger mechanism. In this case, however, it MUST send two separate LRI messages to the two MAGs. In addition to the MN-ID and the HNP options, each LRI message MUST contain the IP address of the counterpart MAG. When the MAG IP address option is present, each MAG MUST create a local forwarding entry such that the packets for the MN attached to the remote MAG are sent over a tunnel associated with that remote MAG. The tunnel between the MAGs is assumed to be established following the considerations mentioned in Section 6.2.

```
      +----+      +----+      +----+      +----+        +----+
      |MN1 |      |MN2 |      |MAG1|      |MAG2|        |LMA |
      +----+      +----+      +----+      +----+        +----+
        |           |           |           |             |
        |        data           |          data           |
        |<--------------------->|<----------------------->|
        |           |           |           |             |
        |           |         data          |    data     |
        |           |<--------------------->|<----------->|
        |           |           |           |             |
        |           |           |           |             |
        |           |           |       LRI(Opt1)         |
        |           |           |<------------------------|
        |           |           |           |             |
        |           |           |           |  LRI(Opt2)  |
        |           |           |           |<------------|
        |           |           |           |             |
        |           |           |        LRA(Opt3)        |
        |           |           |------------------------>|
        |           |           |           |             |
        |           |           |           |   LRA(Opt4) |
        |           |           |           |------------>|
        |           |           |           |             |
        |           |           |           |             |
        |           |           |           |             |
        |        data           |    data   |             |
        |<--------------------->|<--------->|             |
        |           |           |           |             |
        |           |         data          |             |
        |           |<--------------------->|             |
        |           |           |           |             |
        |           |           |           |             |
```

Opt1: MN1-ID,MN1-HNP,MAG2-IPv6-Address
Opt2: MN2-ID,MN2-HNP,MAG1-IPv6-Address
Opt3: U=0,MN1-ID,MN1-HNP,MAG2-IPv6-Address
Opt4: U=0,MN2-ID,MN2-HNP,MAG1-IPv6-Address

where U is the flag defined in Section 10.2.

Figure 4

In this case, each MAG responds to the LRI with an LRA message. All subsequent packets are routed between the MAGs locally, without traversing the LMA. If one of the MAGs (say MAG1) responds with a successful LRA (Status value is zero) and the other (say MAG2) responds with an error (Status value is non-zero), LR will still be performed in one direction (MN1->MAG1->MAG2->MN2), but the packets flowing the other way will take the LMA path (MN2->MAG2->LMA->MAG1->MN1).

The protocol does not require any synchronization between the MAGs before local forwarding begins. Each MAG begins its local forwarding independent of the other.

No synchronization between the MAGs is required because each MAG initiates LR in one direction. After the LMA instructs MAG1 to initiate LR, packets from MN1 to MN2 will take the path MN1->MAG1->MAG2->MN2 while those from MN2 to MN1 will take the path MN2->MAG2->LMA->MAG1->MN1 until the LMA instructs MAG2 to initiate LR as well. A MAG will forward a packet towards either another MAG or its own LMA; therefore, there would be no duplication of packets.

6.1. Handover Considerations

If one of the MNs, say MN1, detaches from its current MAG (in this case MAG1) and attaches to another MAG (say nMAG1), the localized routing state needs to be re-established. When the LMA receives the PBU from nMAG1 for MN1, it will see that localized routing is active for MN1. The LMA MUST then initiate LR at nMAG1 and update the LR state of MAG2 to use nMAG1 instead of MAG1.

6.2. Tunneling between the MAGs

In order to support localized routing, both MAGs SHOULD support the following encapsulation modes for the user packets, which are also defined for the tunnel between the LMA and MAG:

- o IPv4-or-IPv6-over-IPv6 [RFC5844]
- o IPv4-or-IPv6-over-IPv4 [RFC5844]
- o IPv4-or-IPv6-over-IPv4-UDP [RFC5844]
- o TLV-header UDP tunneling [RFC5845]
- o Generic Routing Encapsulation (GRE) tunneling with or without GRE key(s) [RFC5845]

MAG1 and MAG2 MUST use the same tunneling mechanism for the data traffic tunneled between them. The encapsulation mode to be employed SHOULD be configurable. It is RECOMMENDED that:

1. As the default behavior, the inter-MAG tunnel uses the same encapsulation mechanism as that being used for the PMIPv6 tunnel between the LMA and the MAGs. MAG1 and MAG2 automatically start using the same encapsulation mechanism without a need for a special configuration on the MAGs or a dynamic tunneling mechanism negotiation between them.

2. Configuration on the MAGs can override the default mechanism specified in Option 1 above. MAG1 and MAG2 MUST be configured with the same mechanism, and this configuration is most likely to be uniform throughout the PMIPv6 domain. If the packets on the PMIPv6 tunnel cannot be uniquely mapped onto the configured inter-MAG tunnel, this scenario is not applicable, and Option 3 below SHOULD directly be applied.

3. An implicit or explicit tunnel negotiation mechanism between the MAGs can override the default mechanism specified in Option 1 above. The employed tunnel negotiation mechanism is outside the scope of this document.

7. Scenario A12: Two MNs Attached to the Same MAG with Different LMAs

In this scenario, both the MNs are attached to the same MAG, but are anchored at two different LMAs. MN1 is anchored at LMA1, and MN2 is anchored at LMA2. Note that the two LMAs are part of the same Provider Domain.

```
                    Internet
              :                  :
              +------------------+
              |                  |
           +-----+            +-----+
           |LMA1|             |LMA2|
           +-----+            +-----+
              |                  |
              |                  |
              +------------------+
                       |
                       |
                       |
                    +-----+
                    | MAG |
                    +-----+
                     :   :
                  +---+ +---+
                  |MN1| |MN2|
                  +---+ +---+
```

Figure 5

Hence, neither LMA has a means to determine that the two Mobile Nodes are attached to the same MAG. Only the MAG can possibly determine that the two Mobile Nodes involved in communication are attached to it. Therefore, localized routing MUST be initiated by the MAG.

The MAG sends an LRI message containing the MN-ID, HNP, and the counterpart LMA address to each LMA. Each LMA makes a decision to support local forwarding independently based on configured policy for the corresponding LMA. Each LMA MUST respond to the LRI message with an LRA message. If the initiation of LR on the LMA was successful, the Status value in the received LRA would be set to zero. After the MAG receives both the LRA messages, each with the Status value set to zero (success) from the two different LMAs, the MAG will conclude that it can provide local forwarding support for the two Mobile Nodes.

```
      +----+      +----+      +----+      +----+        +----+
      |MN1 |      |MN2 |      |MAG |      |LMA1|        |LMA2|
      +----+      +----+      +----+      +----+        +----+
        |           |           |           |             |
        |        data           |   data    |    data     |
        |<--------------------->|<--------->|<----------->|
        |           |           |           |             |
        |           |   data    |          data          |
        |           |<--------->|<----------------------->|
        |           |           |           |             |
        |           |           |           |             |
        |           |           | LRI(Opt1) |             |
        |           |           |---------->|             |
        |           |           |           |             |
        |           |           |        LRI(Opt2)        |
        |           |           |------------------------>|
        |           |           |           |             |
        |           |           | LRA(Opt3) |             |
        |           |           |<----------|             |
        |           |           |           |             |
        |           |           |        LRA(Opt4)        |
        |           |           |<------------------------|
        |           |           |           |             |
        |           |           |           |             |
        |           |           |           |             |
        |        data           |           |             |
        |<--------------------->|           |             |
        |           |           |           |             |
        |           |    data   |           |             |
        |           |<--------->|           |             |
        |           |           |           |             |
        |           |           |           |             |

      Opt1: MN1-ID,MN1-HNP
      Opt2: MN2-ID,MN2-HNP
      Opt3: U=0,MN1-ID,MN1-HNP
      Opt4: U=0,MN2-ID,MN2-HNP

      where U is the flag defined in Section 10.2.
```

Figure 6

7.1. Handover Considerations

If one of the MNs, say MN1, detaches from its current MAG (in this case MAG1) and attaches to another MAG (say nMAG1), the current MAG MUST immediately stop using the LRE and MUST send all packets originated by the other MN (MN2) towards its LMA (in this case LMA2).

8. Scenario A22: Two MNs Attached to Different MAGs with Different LMAs

This scenario will not be covered in this document since PMIPv6 does not define any form of inter-LMA communication. When a supported scenario, such as Scenario A12, morphs into Scenario A22, the node that initiated the localized routing session MUST tear it down in order to prevent lasting packet loss. This can result in transient packet loss when routing switches between the localized path into the normal path through the LMAs. In applications that are loss sensitive, this can lead to observable service disruptions. In deployments where Scenario A22 is possible, the use of localized routing is NOT RECOMMENDED when packet-loss-sensitive applications are in use.

9. IPv4 Support in Localized Routing

PMIPv6 MNs can use an IPv4 Home Address (HoA) as described in [RFC5844]. In order to support the setup and maintenance of localized routes for these IPv4 HoAs in PMIPv6, the MAGs MUST add the IPv4 HoAs into their LREs. The MAGs MUST also support encapsulation of IPv4 packets as described in [RFC5844]. The localized routing protocol messages MUST include an IPv4 HoA option in their signaling messages in order to support IPv4 addresses for localized routing.

If the transport network between the PMIPv6 entities involved in localized routing is IPv4-only, the LRI and LRA messages MUST be encapsulated similar to the PBU/PBA messages as specified in [RFC5844]. The encapsulation mode used SHOULD be identical to the one used to transport PBU and PBA messages.

10. Message Formats

The localized routing messages use two new Mobility Header types (17 and 18). The LRI message requests creation or deletion of the localized routing state, and the LRA message acknowledges the creation or deletion of such localized routing state.

10.1. Localized Routing Initiation (LRI)

The LRI messages use a new Mobility Header type (17). The LMA sends an LRI message to a MAG to request local forwarding for a pair of MNs. The MAG may also send this message to request the two LMAs for offering local forwarding as described in Section 7.

```
 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 #          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|         Reserved              |           Lifetime            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
.                                                               .
.                        Mobility options                       .
.                                                               .
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Sequence Number: A monotonically increasing integer. Set by a sending node in a request message and used to match a reply to the request.

Reserved: This field is unused and MUST be set to zero.

Lifetime: The requested time, in seconds, for which the sender wishes to have local forwarding. A value of 0xffff (all ones) indicates an infinite lifetime. When set to 0, indicates a request to stop localized routing.

Mobility Options: MUST contain two separate MN-ID options, followed by one or more HNPs for each of the MNs. For instance, for Mobile Nodes MN1 and MN2 with identifiers MN1-ID and MN2-ID, and Home Network Prefixes MN1-HNP and MN2-HNP, the following tuple MUST be present in the following order: [MN1-ID, MN1-HNP], [MN2-ID, MN2-HNP]. The MN-ID and HNP options are the same as in [RFC5213]. The LRI MAY contain the remote MAG IPv6 address option, which is formatted identically to the HNP option, except that it uses a different Type code and the Prefix Length is always equal to 128 bits (see Section 10.1).

The LRI message SHOULD be re-transmitted if a corresponding LRA message is not received within LRA_WAIT_TIME time units, up to a maximum of LRI_RETRIES, each separated by LRA_WAIT_TIME time units.

10.2. Localized Routing Acknowledgment (LRA)

The LRA messages use a new Mobility Header type (18). A MAG sends an LRA message to the LMA as a response to the LRI message. An LMA may also send this message to a MAG as a response to the LRI message as described in Section 7.

```
     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 #           |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |U|  Reserved   |   Status      |           Lifetime            |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |                                                               |
    .                                                               .
    .                        Mobility options                       .
    .                                                               .
    |                                                               |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Sequence Number: Copied from the sequence number field of the LRI message being responded to.

'U' flag: When set to 1, the LRA message is sent unsolicited.

The Lifetime field indicates a new requested value. The MAG MUST wait for the regular LRI message to confirm that the request is acceptable to the LMA.

Reserved: This field is unused and MUST be set zero.

Status: 8-bit unsigned integer indicating the result of processing the Localized Routing Acknowledgment message. Values of the Status field less than 128 indicate that the Localized Routing Acknowledgment was processed successfully by the mobility entities(LMA or MAG). Values greater than or equal to 128 indicate that the Localized Routing Acknowledgment was rejected by the mobility entities. The following Status values are currently defined:

0: Success
128: Localized Routing Not Allowed
129: MN Not Attached

Lifetime: The time, in seconds, for which local forwarding is supported. It is typically copied from the corresponding field in the LRI message.

Mobility Options: When Status code is 0, MUST contain the [MN-ID, HNP] tuples in the same order as in the LRI message. When Status code is not 0, MUST contain only those [MN-ID, HNP] tuples for which local forwarding is supported. The MN-ID and HNP options are the same as those described in [RFC5213].

11. New Mobility Option

11.1. MAG IPv6 Address

The MAG IPv6 address mobility option contains the IPv6 address of a MAG involved in localized routing. The MAG IPv6 address option has an alignment requirement of 8n+4.

```
 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     |   Length      |   Reserved    | Address Length|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                                                               +
|                                                               |
+                       MAG IPv6 Address                        +
|                                                               |
+                                                               +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Type

51

Length

8-bit unsigned integer indicating the length of the option in octets, excluding the type and length fields. This field MUST be set to 18.

Reserved (R)

This 8-bit field is unused. The value MUST be initialized to 0 by the sender and MUST be ignored by the receiver.

Address Length

This field MUST be set to 128.

MAG IPv6 Address

A 16-byte field containing the MAG's IPv6 address.

12. Configuration Variables

The LMA and the MAG must allow the following variables to be configurable:

LRA_WAIT_TIME: This variable is used to set the time interval, in seconds, between successive retransmissions of an LRI message. The default value is 3 seconds.

LRI_RETRIES: This variable indicates the maximum number of times the initiator retransmits an LRI message before stopping. The default value for this variable is 3.

13. Security Considerations

The protocol inherits the threats to [RFC5213] that are identified in [RFC4832]. The protocol specified in this document uses the same security association as defined in [RFC5213] for use between the LMA and the MAG to protect the LRI and LRA messages. This document also assumes the preexistence of a MAG-MAG security association if LR needs to be supported between them. Support for integrity protection using IPsec is REQUIRED, but support for confidentiality is OPTIONAL. The MAGs MUST perform ingress filtering on the MN-sourced packets before encapsulating them into MAG-MAG tunnels in order to prevent address spoofing.

14. IANA Considerations

The Localized Routing Initiation (described in Section 10.1) and the Localized Routing Acknowledgment (described in Section 10.2) have each been assigned a Mobility Header type (17 and 18, respectively) from the "Mobility Header Types - for the MH Type field in the Mobility Header" registry at http://www.iana.org/assignments/mobility-parameters.

The MAG IPv6 Address has been assigned a Mobility Option type (51) from the "Mobility Options" registry at http://www.iana.org/assignments/mobility-parameters.

15. Contributors

This document merges ideas from five different draft documents addressing the PMIP localized routing problem. The authors of these drafts are listed below (in alphabetical order).

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