Multihoming extensions for Proxy Mobile IPv6

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Abstract

This document provides extensions to Proxy Mobile IPv6 in order to support multihomed mobile nodes (MN). These extensions are intended to permit such mobile nodes to send and receive IP packets on
multiple interfaces in a simultaneous and possibly discriminated manner when attached to a PMIPv6 domain. A typical usage of these extensions is to perform downlink flow discrimination through multiple interfaces based on filtering rules (i.e. dedicate one MN interface to VOIP traffic and another MN interface to HTTP traffic).

The proposed extensions to PMIPv6 attempt to increment in a backward compatible manner the current PMIPv6 specification. In addition these extensions use, when possible, existing specifications related to multihoming support at IETF and conform to the problem statement of Netext Working Group.

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].
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1. Introduction

Proxy Mobile IPv6 (PMIPv6), specified in [RFC5213], provides network based mobility management to hosts connecting to a PMIPv6 domain. PMIPv6 introduces two functional entities, the Local Mobility Anchor (LMA) and the Mobility Access Gateway (MAG). The MAG is the first layer-three hop detecting MN attachment and providing IP connectivity. The LMA is the entity assigning one or more HNP to the MN and is the topological anchor for all traffic from/to the MN.

PMIPv6 allows a MN to connect to the same PMIPv6 domain through multiple interfaces. However in such a case, PMIPv6 requires each interface to be assigned a distinct IPv6 address and thus prevents from multihoming capabilities. [NETEXT] studies how to support multihoming in PMIPv6 and identifies three possible models regarding IPv6 address management:

- unique prefix per interface
- unique address per interface
- shared address across interfaces

[NETEXT] further describes topics associated with each model, in particular handover behavior and security aspects.

In the present version, this document solely focuses on the shared address across interfaces model. The focus is intended to match the case where a multihomed MN is known by its Internet peers under the same address while the PMIPv6 domain it is attached to can perform, on its own criteria, packets delivery through the suited MN interface. As a major consequence of this limited focus, only a single Home Network Prefix (HNP) can be associated to a multihomed MN in a PMIPv6 domain. The current focus can be extended in further releases of this document.

This document does not re-use the interface "handover" or "mobility" terminology that can be perceived as confusing in the multihoming context (where MN interfaces are used simultaneously). Instead, the document introduces the concept of multihoming group (a logical set of interfaces of a MN) and provides the support of elementary operations (addition, modification, removal) on a group entity for a MN. This terminology is expected to be more suited to the general multihoming paradigm. In a first step, a default multihoming group (id=0) is defined to represent all interfaces of a given MN.

The functional usage of multihoming MN capabilities in a PMIPv6 domain is defined by the present specification in a flexible and
multi-purpose manner. This allows for various traffic processing in a PMIPv6 domain with multihomed MN such as (not limited to): traffic blocking, traffic load-balancing or traffic dissemination. To achieve this flexibility, this document uses the concept of "filter" to denote a unitary criteria that can be managed between a MAG and a LMA in relationship with a MN interface. Unitary filters can be added, deleted and modified on a per multihoming group basis. Flexibility is achieved by allowing an arbitrary filter syntax (or grammar) as proposed in [MEXT]. The filter syntax is a matter of agreement between MAG and LMA entities. For the sake of understanding, the "flow" and "filter" terminology shall be considered equivalent.

The following figure depicts the general principles of PMIPv6 extensions for multihoming support as proposed by the present document.

---
\[Figure 1: Multihomed MN with PMIPv6 extensions\]
---

When MN activates if1, MAG1 selects the default multihoming group and perform proxy registration toward the LMA. MAG1 provides filters (flow1) during registration. LMA accepts proxy registration from MAG1 and allocates MN addr according to the shared address model. Since proxy registration is requesting multihoming support, LMA stores MAG1 filters that come along with delivery to pCoA1.

When MN activates if2, MAG2 selects the default multihoming group and...
perform proxy registration toward the LMA. MAG2 provides filters (flow2) during registration. LMA accepts proxy registration from MAG2 and allocates MN addr according to the shared address model. LMA stores MAG2 filters that come along with delivery to pCoA2.

Later on, LMA receive IP packets destined to MN addr. The LMA attempts to match each IP packet against filters (flow1, flow2) stored for the MN addr. When a filter match (flow1 or flow2), the LMA perform the action for the IP packet in the context of the matching flow. In particular if the IP packet is to be delivered, the LMA performs delivery using the pCoA associated to the filter (pCoA1 on flow1 or pCoA2 on flow2).

LMA behavior is extended to allow simultaneous transmission of downlink (DL) packets to the mobile node across multiple interfaces. No assumption is done on how the MN performs uplink (UL) packets transmission. The MN might either use a single interface for UL or select an interface according to existing or new mechanisms such as the ones being defined by the IETF MIF working group. The UL transmission of packets from multihomed MN is outside the scope of this specification.

Both LMA and MAG behaviors are extended to provide enhanced Proxy Binding management for multihomed MN. LMA shall support Binding Control Entries (BCE) of multihomed type. This includes the capability to refer to a multihoming group id (mhgid) and a set of filters in a BCE. This also includes mechanism to allocate a unique HNP per MN when multihoming is used. LMA shall support or delegate the downlink packet processing and delivery according to flow specifications. Both MAG and LMA shall be able to manage flows on a per multihomed MN basis. Downlink flows are created/deleted/modified at LMA level on MAG request using PBU/PBA exchanges. LMA does not operate flows on its own (unless it has been instructed by MAG) for the current release of the document.

2. Overview

This specification proposes to extend PMIPv6 to support multiple proxy CoAs per mobility session possibly associated with downlink transmission criteria using the flow concept.

Upon MN attachment the MAG determines if the MN should be provided with multihoming service and, if so, selects the flow configuration that should be put in place for delivery through itself. The MAG can learn this information through a policy store or using attachment-specific signalling. Any of the methods used by the MAG is however out of scope of this document. If the MAG determines that the MN can
use the multihoming service it forms a PBU as per [RFC5213] and adds a Multihoming Option (newly defined by this document) and possibly one or several Flow Identifier option(s) as defined in [MEXT]. The Multihoming option aims at identifying (MHGID) and parameterize the multihoming group to be created/updated/deleted by the LMA on MAG demand. The choice of identification of the multihoming group follows the following rule:

All PBUs with the same HNP and MHGID values belong to the same mobility session from the LMA perspective.

In the current revision of the document, only the default multihoming group is supported (id=0). In addition, multihoming group parameters are left for further study.

```
Mobility Session 1                   Mobility Session 1
+----------------------+              +---------------------+
| HNP1   PCoA1 MHGID0 |   ========>  | HNP1   PCoA1 MHGID0 |
+----------------------+              | HNP1   PCoA2 MHGID0 |
+---------------------+
```

Figure 2: Mobility session extended for multihoming

Figure 2 shows how the mobility session is extended to span the same HNP across multiple interfaces. This updates the text in [RFC5213] where each single interface is managed under a different mobility session. The MHGID, selected by MAG1 (corresponding to PCoA1) upon MN attachment, is stored at the LMA. When the MN attaches to MAG2 (corresponding to PCoA2) MAG2 selects its MHGID value. If both MAG1 and MAG2 MGHID and HNP values match then the LMA adds PCoA2 -- MHGID0 to the already existing mobility session.

The MAG treats the indication of multihoming as an explicit indication of adding flows to the PBU if any. Such flows can be learned for instance during MN access to the network.

Upon reception of a PBU containing indication for multihoming the LMA should perform a binding cache lookup and append the information to the found BCE. Filters, if present, are extracted from the PBU and processed by the LMA. The result of Filters processing is returned in the PBA by the LMA on an individual basis.

This is considered to be out of scope how the MN handles configuration of the same address on different interfaces.
3. Detailed flow charts

This section introduces detailed flow charts for multihoming setup, renewal, filters modifications and interface removal/addition.

3.1. Initial multihoming setup

Figure 3 shows the attachment of IF1 and subsequently the attachment of IF2. IF1 and IF2 belong to the same multihoming group ID (i.e. the default multihoming group id 0).

```
+-----+       +------+ +------+               +-----+
| MN  |       | MAG1 | | MAG2 |               | LMA |
+-----+       +-----+ +-----+               +-----+

<p>| MN[IF1] Attached MAG1 | MN_ID, PCoA1, | MN_ID, PCoA1, |
|                       | MHGID0, HI=1, | MHGID0, HI=1, |</p>
<table>
<thead>
<tr>
<th>Filters_1 RQ</th>
<th>-------------&gt;</th>
<th>Filters_1 RP</th>
</tr>
</thead>
</table>

RtSol -----> Bi-Dir Tunnel

<--Rtr Adv --|

<-----------------|  IP Address  |
| Configuration | MN_ID, PCoA2, |
|               | MGHID0, HI=1, |

MN[IF2] Attached MAG2 | Filters_2 RQ |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>MN_ID, HNP1, PCoA1,</td>
<td></td>
</tr>
<tr>
<td>MHGID0, HI=1,</td>
<td></td>
</tr>
<tr>
<td>Filters_2 RP</td>
<td></td>
</tr>
<tr>
<td>-------------&gt;</td>
<td></td>
</tr>
<tr>
<td>Array ---------&gt;</td>
<td>&lt;----- Rtr Adv --</td>
</tr>
</tbody>
</table>

```

Figure 3: Initial multihoming setup

3.2. Multihoming renewal

Figure 4 shows how binding renewal upon lifetime expiration is done.
3.3. Multihoming filters modification

Filters can also be modified upon reception of an internal or external MAG trigger Figure 5. From the PMIPv6 point of view, filters modification is carried by binding renewal semantics (HI=5). The target multihoming group is set by the MAG in the multihoming option (MHGID field). This allows MAG to modify at any time the downlink filters it is responsible for.
3.4. Multihoming interface removal

Figure 6 shows how to remove an interface from a multihoming group managed by a MAG for a given MN. The target multihoming group is set by the MAG in the multihoming option (MHGID field).

```
+-----+       +------+ +------+               +-----+
| MN  |       | MAG1 | | MAG2 |               | LMA |
+-----+       +------+++++ +------+               +-----+
\| HNP1, PCoA1, \| MHGID0, HI=4 \| LIFETIME = 0 \|
\| LINK going down \| \| \| \|
\|--|------------ PBU -------------->|\| HNP1, PCoA1, \|\| MHGID0, HI=4 \|
\| | \| \| \|
\|--|<------------- PBA ------------|MHGID0, HI=4 \|
```

Figure 6: Multihoming interface removal

3.5. Multihoming interface addition

Figure 7 addresses the case where the MN adds a third interface to the same multihoming group for a given MN. The target multihoming group is set by the MAG in the multihoming option (MHGID field).

```
+-----+       +-----+ +-----+ +-----+ +-----+
| MN   |       ( MAG1 ) | MAG2 | | MAG3 | | LMA |
+-----+       +-----++-----++-----++-----+
\| MN_ID, PCoA3, \| \| MNID0, HI=1, \| \| LMA |
\| MN[IF1] and MNF[IF2] attached to MAG1 and MAG2 \| \| Filters_3 RQ \| \| \|
\| \| \| \| \| \| \| \|
\|--|--- PBU -------------->|HNP1, PCoA3, \| \| MHGID0, HI=1, \| \| Filters_3 RQ \|
\| \| \| \| \| \| \| \|
\|--== Bi-Dir Tunnel =====\| \| \| \| \|
\| \| ==RtSol------------->\| \| \| \| \|
\|--<--------Rtr Adv------\| \| \| \| \|
```

Figure 7: Multihoming interface addition
4. Protocol Extensions

We provide in the following extensions to the protocol options as defined in [RFC5213].

4.1. Multihoming Option

Figure 8 shows the Multihoming option.
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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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|      Type     |    Length     |     MHGID     | ACT |   RFU   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

Type

TBA

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 2.

MHGID

This 8 bit field identifies the multihoming group the PBU/PBA refer to. The value 0 is reserved to the default multihoming group which includes all interfaces of a MN. Only value 0 is currently supported.

ACT

This 3-bit field is used to provide optional action to be performed by LMA upon removal of an interface from a multihoming group. The field shall only be set by the MAG when HI value in PBU is set to 4, otherwise the field shall be set to 0.

The following bit values are currently defined:

000: Reserved
001: Remove filters
010: Keep filters

RFU (Reserved for Future Use)

This 5-bit field is unused for now. The value MUST be initialized to 0 by the sender and MUST be ignored by the receiver.

Figure 8: Multihoming option

The following considerations on the ACT field apply. If 001 (Remove filters) is set on interface removal, the LMA shall remove all filters currently configured. This might result in downlink traffic disruption. If 010 (Keep filters) is set on interface removal, the LMA shall arrange to re-instantiate filters configured on the removed interface to existing filters (if any) of other interfaces of the multihoming group if any. This allows to avoid downlink traffic disruption. The implementation of this action at LMA level is not...
specified by the present document. However, a filter that has been re-instantiated on a interface should be advertised by the LMA with a specific status of Flow identifier option whenever a MAG perform a filter operation the interface.

4.2. Flow Identifier Option

The FID option defined in ID [MEXT] is used in the current specification to manage downlink packet delivery across interfaces of a multihomed MN. The option might be used by a MAG to create/modify/delete filter(s) on the LMA for a particular multihoming group of a MN. Upon successful processing and installation of filter(s) at LMA level an individual status (Status field) shall be returned to the MAG by the LMA. The LMA should later evaluate packets destined to a MN through filters installed by MAG(s) that are proxying the MN under the same mobility session. The LMA must perform the action(s) associated to the matching filter(s).

In case, the LMA re-instantiates flows on a multihoming interface group toward a MAG for a given MN, the LMA shall perform the following processing:

- Allocate a unique FID to the re-instantiated filter within the context of existing filters for the multihoming group of the MN toward the target LMA
- Set the PRO field to a new reserved value (2: flow binding re-instantiated by LMA) of [MEXT] as proposed by the current specification
- Copy FID-PRI and Action fields from the original filter into the re-instantiated filter

Since no notification mechanism is currently defined between MAG and LMA in [RFC5213], re-instantiated filter(s) will be returned by LMA only on MAG demand. This might happen when MAG renews PBU or create/modify/delete its own filters.

The format of the option is briefly recalled hereafter. The present specification proposes to extend the PRO field value in order to add the (2: flow binding re-instantiated by LMA) predefined value. The full specification of the option can be found in [MEXT]
5. MAG behavior

The MAG upon MN attachment performs all the steps as per [RFC5213]. In addition to this it MUST perform the following checks.

The MAG learns if the MN is requesting a HNP as part of a new mobility session or if it is requesting to attach a new interface as part of an already existing mobility session. The MAG retrieves the MHGID from e.g. MN’s profile as well as filters. The MAG can learn filters in an access-specific manner or alternatively via other infrastructure support. This is however out of scope of this document. In any case the MAG MUST encode the PBU including at least the Multihoming option as specified before and possibly one or more FID option(s).

The MAG can modify or delete filters attached to a multihoming group by sending a PBU carrying the filter operation(s) to be performed. It shall analyze individual results according to what is returned by the LMA. In addition, MAG should be prepared to handle filters that has been re-instantiated by LMA when MN has disconnected an interface belonging to the same multihoming group.

When MAG proxying a MN detects the MN has detached the related interface, MAG stops proxying the MN by sending a PBU with lifetime set to 0 and includes the multihoming option that identifies the target multihoming group of the detached interface as well as removal behavior regarding filters. MAG waits for successful PBA to release the MN access.

6. LMA behavior

The LMA should be modified in the BCE and conceptual data structures.
6.1. BCE modifications

The LMA binding cache lookup method should be extended to accommodate multihoming support. In case the LMA processes the Multihoming Option it SHOULD update existing mobility session as defined in [RFC5213]. In addition to this it MUST perform the following checks.

If the Multihoming option is present in the PBU, the LMA must allocate/update/delete the mobility session and the multihoming group ID it refers to. Flow filters received in the PBU shall be created/modified/deleted for the target Multihoming group ID and a result shall be return on an individual filter basis.

In addition, the LMA shall handle removal of interfaces from multihoming group according to MAG instructions. In particular, if a MAG instructs a LMA to remove an interface from a multihoming group but to keep filters, the LMA should re-instantiate filters on existing interface(s) of the multihoming group according to its own mechanisms.

If a LMA does not support multihoming extension (as a whole) or specific multihoming option, as proposed by the present document, it shall return a status code in PBA as defined in [RFC5213]. The later specification might be extended to include multi-homing specific statuses, such as:

MH_NOT_SUPPORTED_BY_LMA

MH_FILTERS_REINSTANCIATION_NOT_SUPPORTED_BY_LMA

7. IANA Considerations

This document makes no request of IANA.

8. Security Considerations

This document only extends existing options, no security issues are introduced.

9. Acknowledgements

10. References


10.1. Normative References


10.2. Informative References


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