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MAG Multipath Binding Option
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Abstract

The document [RFC4908] proposes to rely on multiple Care-of Addresses (CoAs) capabilities of Mobile IP [RFC6275] an Network Mobility (NEMO; [RFC3963]) to enable Multihoming technology for Small-Scale Fixed Networks. In the continuation of [RFC4908], this document specifies a multiple proxy Care-of Addresses (pCoAs) extension for Proxy Mobile IPv6 [RFC5213]. This extension allows a multihomed Mobile Access Gateway (MAG) to register more than one proxy care-of-address to the Local Mobility Anchor (LMA).

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1. Introduction

Using several links, the multihoming technology can improve connectivity availability and quality of communications; the goals and benefits of multihoming are as follows:

- Redundancy/Fault-Recovery

- Load balancing

- Load sharing

- Preferences settings

According to [RFC4908], users of Small-Scale Networks can take benefit of multihoming using mobile IP [RFC6275] and Network Mobility (NEMO) [RFC3963] architecture in a mobile and fixed networking environment. This document is introducing the concept of multiple Care-of Addresses (CoAs) [RFC5648] that have been specified since then.

In the continuation of [RFC4908], a Proxy Mobile IPv6 [RFC5213] based multihomed achitecture could be defined. The motivation to update [RFC4908] with proxy Mobile IPv6 is to leverage on latest mobility working group achievments, namely:

- o using GRE as mobile tuneling, possibly with its key extension [RFC5845] (a possible reason to use GRE is given on Section 3.2).

- o using UDP encapsulation [RFC5844] in order to support NAT traversal in IPv4 networking environment.

- o Prefix Delegation mechanism [RFC7148].

- o Using the vendor specific mobility option [RFC5094], for example to allow the MAG and LMA to exchange information (e.g. WAN interface QoS metrics) allowing to make appropriate traffic steering decision.

Proxy Mobile IPv6 (PMIPv6) relies on two mobility entities: the mobile access gateway (MAG), which acts as the default gateway for the end-node and the local mobility anchor (LMA), which acts as the topological anchor point. Point-to-point links are established, using IP-in-IP tunnels, between MAG and LMA. Then, the MAG and LMA are distributing traffic over these tunnels. All PMIPv6 operations are performed on behalf of the end-node and its corespondent node, it thus makes PMIPv6 well adapted to multihomed architecture as considered in [RFC4908]. Taking the LTE and WLAN networking environments as an example, the PMIPv6 based multihomed architecture is depicted on Figure 1. Flow-1,2 and 3 are distributed either on Tunnel-1 (over LTE) or Tunnel-2 (over WLAN), while Flow-4 is spread on both Tunnel-1 and 2.

```
     Flow-1
      |
      |Flow-2              _----_
      | |         CoA-1  _(      )_   Tunnel-1
      | |    .---=======(   LTE    )========\ Flow-1
      | |    |          (_      _)          \Flow-4
      | |    |            '----'             \
      | | +=====+                              \  +=====+    _----_
      | '-|     |                               \ |     |  _(      )_
      '---| MAG |                                 | LMA |-( Internet )--
      .---|     |                                 |     |  (_      _)
      | .-|     |                               / |     |    '----'
      | | +=====+                              /  +=====+
      | |    |            _----_             /
      | |    |    CoA-2  _(      )_ Tunnel-2 /
      | |    .---=======(   WLAN  )========/ Flow-2
      | |                (_     _)           Flow-3
      | |                  '----'            Flow-4
      |Flow-3
      |
     Flow0-4
```

Figure 1: Multihomed MAG using Proxy Mobile IPv6

The current version of Proxy Mobile IPv6 does not allow a MAG to register more than one proxy Care-of-Adresse to the LMA. In other words, only one MAG/LMA link, i.e. IP-in-IP tunnel, can be used at the same time. This document overcomes this limitation by defining the multiple proxy Care-of Addresses (pCoAs) extension for Proxy Mobile IPv6.

2. Conventions and Terminology

2.1. Conventions

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].

2.2. Terminology

All mobility related terms used in this document are to be interpreted as defined in [RFC5213], [RFC5844] and [RFC7148]. Additionally, this document uses the following terms:

IP-in-IP

IP-within-IP encapsulation [RFC2473], [RFC4213]

3. Overview

3.1. Example Call Flow

Figure 2 is the callflow detailing multi-access support with PMIPv6. The MAG in this example scenario is equipped with both WLAN and LTE interfaces and is also configured with the multihoming functionality. The steps of the callflow are as follows:

Steps (1) and (2): the MAG attaches to both WLAN and LTE networks; the MAG obtains respectively two different proxy care-of-addresses (pCoA).

Step (3): The MAG sends, over the WLAN access, a Proxy Binding Update (PBU) message, with the new MAG Multipath Binding (MMB) and MAG Identifier (MAG-NAI) options to the LMA. A logical-NAI (MAG-NAI) with ALWAYS-ON configuration is enabled on the MAG. The mobility session that is created (i.e. create a Binding Cache Entry) on the LMA is for the logical-NAI. The LMA and allocates a Home Network Prefix (HNP), that shall be delegated to mobile nodes, to the MAG.

Step (4): the LMA sends back a Proxy Binding Acknowledgement (PBA) including the HNP allocated to the MAG.

Step (5): IP tunnel (IP-in-IP, GRE ...) is created over the WLAN access.

Steps (6) to (8): The MAG repeats steps (3) to (5) on the LTE access. The MAG includes the HNP, received on step (4) in the PBU. The LMA update its binding cache by creating a new mobility session for this MAG.

Steps (9) and (10): The IP hosts MN_1 and MN_2 are assigned IP addresses from the mobile network prefix delegated by the MAG.

```
   +=====+ +=====+     +=====+      +=====+      +=====+         +=====+
   | MN_1| | MN_2|     | MAG |      | WLAN|      | LTE |         | LMA |
   +=====+ +=====+     +=====+      +=====+      +=====+         +=====+
      |       |           |            |            |               |
      |       |           |            |            |               |
      |       |           | (1) ATTACH |            |               |
      |       |           | <--------> |            |               |
      |       |           | (2) ATTACH              |               |
      |       |           | <---------------------->|               |
      |       |           | (3) PBU (MAG-NAI, MMB)                  |
      |       |           | ------------------------*-------------->|
      |       |           |                                         |
      |       |           |                                   Accept PBU
      |       |           |                               (allocate HNP,
      |       |           |                                  create BCE)
      |       |           | (4) PBA (MAG-NAI, HNP)                  |
      |       |           | <-----------------------*---------------|
      |       |           | (5) TUNNEL INTERFACE CREATION over WLAN |
      |       |           |-============== TUNNEL ==*==============-|
      |       |           |                                         |
      |       |           | (6) PBU (MAG-NAI, HNP, MMB)             |
      |       |           | -----------*--------------------------->|
      |       |           |                                         |
      |       |           |                                   Accept PBU
      |       |           |                                 (update BCE)
      |       |           | (7) PBA (MAG-NAI, HNP)                  |
      |       |           | <----------*--------------------------- |
      |       |           | (8) TUNNEL INTERFACE CREATION over LTE  |
      |       |           |-===========*== TUNNEL =================-|
      |   (9) ATTACH      |                                         |
      | <---------------> |                                         |
      |       |(10) ATTACH|                                         |
      |       |<--------> |                                         |
```

Figure 2: Functional Separation of the Control and User Plane

3.2. Traffic distribution schemes

When receiving packets from the MN, the MAG distributes packets over tunnels that have been established. Traffic distribution can be managed either on a per-flow or on a per-packet basis:

- Per-flow traffic management: each IP flow (both upstream and downstream) is mapped to a given tunnel, corresponding to a given WAN interface. Flow binding extension [RFC6089] is used to exchange, and synchronize, IP flow management policies (i.e. rules associating traffic selectors [RFC6088] to a tunnel).

- Per-packet management: the LMA and the MAG distribute packets, belonging to a same IP flow, over more than one bindings (i.e. more than one WAN interface). When operating at the IP packet level, different packets distribution algorithms are possible. For example, the algorithm may give precedence to one given access: the MAG overflows traffic from the primary access, e.g. WLAN, to the second one, only when load on primary access reaches a given threshold. The distribution algorithm is left to implementer but whatever the algorithm is, packets distribution likely introduces packet latency and out-of-order delivery. LMA and MAG shall thus be able to make reordering before packets delivery. Sequence number can be can be used for that purpose, for example using GRE with sequence number option [RFC5845]. However, more detailed considerations on reordering and IP packet distribution scheme (e.g. definition of packets distribution algorithm) are out the scope of this document.

Because latency introduced by per-packet can cause injury to some application, per-flow and per-packet distribution schemes could be used in conjunction. For example, high throughput services (e.g. video streaming) may benefit from per-packet distribution scheme, while latency sensitive applications (e.g. VoIP) are not be spread over different WAN paths. IP flow mobility extensions, [RFC6089] and [RFC6088], can be used to provision the MAG with such flow policies.

4. Protocol Extensions

4.1. MAG Multipath-Binding Option

The MAG Multipath-Binding option is a new mobility header option defined for use with Proxy Binding Update and Proxy Binding Acknowledgement messages exchanged between the local mobility anchor and the mobile access gateway.

This mobility header option is used for requesting multipath support. It indicates that the mobile access gateway is requesting the local mobility anchor to register the current care-of address associated with the request as one of the many care-addresses through which the mobile access gateway can be reached. It is also for carrying the information related to the access network associated with the care-of address.

The MAG Multipath-Binding option has an alignment requirement of 8n+2. Its format is as shown in Figure 3:

```
 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      |    If-ATT     |    If-Label   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|  Binding-Id   |B|O|            RESERVED                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 3: MAG Multipath Binding Option

Type

<IANA-1> To be assigned by IANA.

Length

8-bit unsigned integer indicating the length of the option in octets, excluding the type and length fields.

Interface Access-Technology Type (If-ATT)

This 8-bit field identifies the Access-Technology type of the interface through which the mobile node is connected. The permitted values for this are from the Access Technology Type registry defined in [RFC5213].

Interface Label (If-Label)

This 8-bit field represents the interface label represented as an unsigned integer. The MAG identifies the label for each of the interfaces through which it registers a pCoA with the LMA. When using static traffic flow policies on the mobile node and the home agent, the label can be used for generating forwarding policies. For example, the operator may have policy which binds traffic for Application "X" needs to interface with Label "Y". When a registration through an interface matching Label "Y" gets activated, the home agent and the mobile node can dynamically generate a forwarding policy for forwarding traffic for Application "X" through mobile IP tunnel matching Label "Y". Both the home agent and the mobile node can route the Application-X traffic through that interface. The permitted values for If-Label are 1 through 255.

Binding-Identifier (BID)

This 8-bit field is used for carrying the binding identifier. It uniquely identifies a specific binding of the mobile node, to which this request can be associated. Each binding identifier is

represented as an unsigned integer. The permitted values are 1 through 254. The BID value of 0 and 255 are reserved. The mobile access gateway assigns a unique value for each of its interfaces and includes them in the message.

Bulk Re-registration Flag (B)

This flag, if set to a value of (1), is to notify the local mobility anchor to consider this request as a request to update the binding lifetime of all the mobile node's bindings, upon accepting this specific request. This flag MUST NOT be set to a value of (1), if the value of the Registration Overwrite Flag (O) is set to a value of (1).

Binding Overwrite (O)

This flag, if set to a value of (1), notifies the local mobility anchor that upon accepting this request, it should replace all of the mobile node's existing bindings with this binding. This flag MUST NOT be set to a value of (1), if the value of the Bulk Re-registration Flag (B) is set to a value of (1). This flag MUST be set to a value of (0), in de-registration requests.

Reserved

This field is unused in this specification. The value MUST be set to zero (0) by the sender and MUST be ignored by the receiver.

4.2. MAG Identifier Option

The MAG Identifier option is a new mobility header option defined for use with Proxy Binding Update and Proxy Binding Acknowledgement messages exchanged between the local mobility anchor and the mobile access gateway. This mobility header option is used for conveying the MAG's identity.

This option does not have any alignment requirements.

```
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      |  Subtype      |  Reserved     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Identifier ...                      ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 4: MAG Identifier Option

Type

<IANA-2> To be assigned by IANA.

Length

8-bit unsigned integer indicating the length of the option in octets, excluding the type and length fields.

Subtype

One byte unsigned integer used for identifying the type of the Identifier field. Accepted values for this field are the registered type values from the Mobile Node Identifier Option Subtypes registry.

Reserved

This field is unused in this specification. The value MUST be set to zero (0) by the sender and MUST be ignored by the receiver.

Identifier

A variable length identifier of type indicated in the Subtype field.

4.3. New Status Code for Proxy Binding Acknowledgement

This document defines the following new Status Code value for use in Proxy Binding Acknowledgement message.

CANNOT_SUPPORT_MULTIPATH_BINDING (Cannot Support Multipath Binding): <IANA-4>

5. IANA Considerations

This document requires the following IANA actions.

- Action-1: This specification defines a new mobility option, the MAG Multipath-Binding option. The format of this option is described in Section 4.1. The type value <IANA-1> for this mobility option needs to be allocated from the Mobility Options registry at <http://www.iana.org/assignments/mobility-parameters>. RFC Editor: Please replace <IANA-1> in Section 4.1 with the assigned value and update this section accordingly.

- Action-2: This specification defines a new mobility option, the MAG Identifier option. The format of this option is described in

Section 4.2. The type value <IANA-2> for this mobility option needs to be allocated from the Mobility Options registry at <http://www.iana.org/assignments/mobility-parameters>. RFC Editor: Please replace <IANA-2> in Section 4.2 with the assigned value and update this section accordingly.

- o Action-3: This document defines a new status value, CANNOT_SUPPORT_MULTIPATH_BINDING (<IANA-3>) for use in Proxy Binding Acknowledgement message, as described in Section 4.3. This value is to be assigned from the "Status Codes" registry at <http://www.iana.org/assignments/mobility-parameters>. The allocated value has to be greater than 127. RFC Editor: Please replace <IANA-4> in Section 4.3 with the assigned value and update this section accordingly.

6. Security Considerations

This specification allows a mobile access gateway to establish multiple Proxy Mobile IPv6 tunnels with a local mobility anchor, by registering a care-of address for each of its connected access networks. This essentially allows the mobile node's IP traffic to be routed through any of the tunnel paths and either based on a static or a dynamically negotiated flow policy. This new capability has no impact on the protocol security. Furthermore, this specification defines two new mobility header options, MAG Multipath-Binding option and the MAG Identifier option. These options are carried like any other mobility header option as specified in [RFC5213]. Therefore, it inherits security guidelines from [RFC5213]. Thus, this specification does not weaken the security of Proxy Mobile IPv6 Protocol, and does not introduce any new security vulnerabilities.

7. Acknowledgements

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